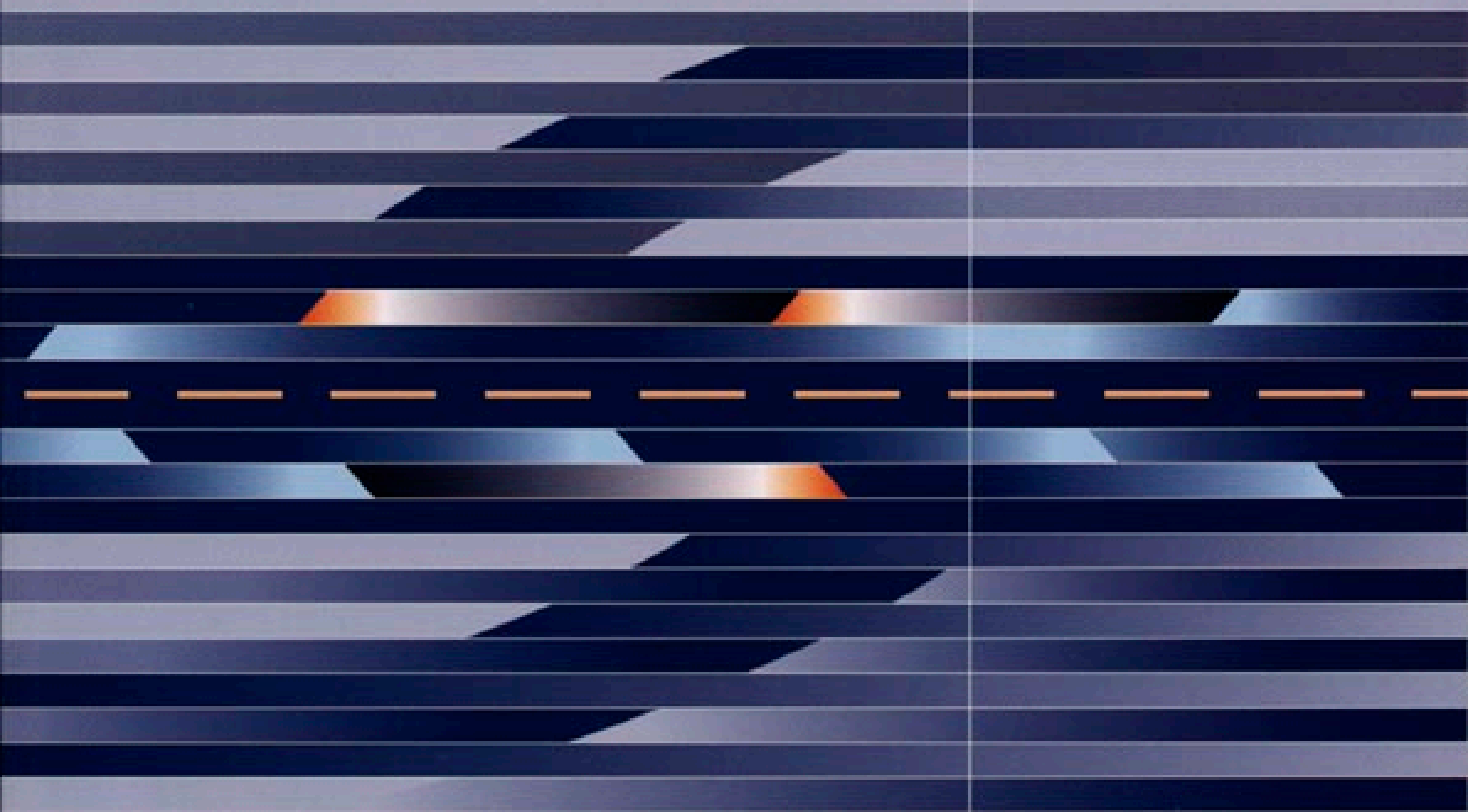
Telektronikk
1.2003

Intelligent Transport Systems



Contents

Intelligent Transport Systems – ITS

Special

Status

Telektronikk

Volume 99 No. 1 – 2003
ISSN 0085-7130

Editor:
Ola Espvik
Tel: (+47) 913 14 507
email: ola.espvik@telenor.com

Status section editor:
Per Hjalmar Lehne
Tel: (+47) 916 94 909
email: per-hjalmar.lehne@telenor.com

Editorial assistant:
Gunhild Luke
Tel: (+47) 415 14 125
email: gunhild.luke@telenor.com

Editorial office:
Telenor Communication AS
Telenor R&D
NO-1331 Fornebu
Norway
Tel: (+47) 810 77 000
email: telektronikk@telenor.com

Editorial board:
Berit Svendsen, CTO Telenor
Ole P. Håkonsen, Professor
Oddvar Hesjedal, Director
Bjørn Løken, Director

Graphic design:
Design Consult AS, Oslo

Layout and illustrations:
Gunhild Luke, Åse Aardal and Britt Kjus, Telenor R&D

Prepress and printing:
Optimal as, Oslo

Circulation:
3,200

telenor

Guest Editorial

ENDRE SKOLT

Endre Skolt (44) is Research Director of the Wireless communication section in Telenor R&D. He has a Master degree in electrical engineering from NTNU in 1983. He joined Telenor in 1987 after two years of post-graduate studies in Beijing, China. 1987–1997 he did research in mobile systems and intelligent networks. In the period 1997–1999 he worked as a consultant for Saudi Telecom in Riyadh, Saudi Arabia. He has been active in international research projects and standardisation, in particular with the development of intelligent network standards.

endre.skolt2@telenor.com

ERTICO, a European non-profit organisation for the implementation of Intelligent Transport Systems (ITS) and services defines the goal of ITS in this way:

> *"The ultimate goal of ITS is to make the individual traveller better informed and able to make intelligent transport decisions. ITS can make every journey quicker, more comfortable, less stressful, and safer".*

Urbanisation across continents is causing a dramatic increase in the flow of goods and people. In all big cities around the world people are stuck in traffic congestions, the number of traffic accidents with fatal outcome is increasing, the environmental effect from transportation is devastating. It should be obvious that using information and communication technologies should have the potential to improve the flow of traffic, hence reducing pollution and the rate of traffic accidents.

In Europe, Japan and North America – ITS has been on the agenda for at least 10 years. Road authorities, car industries and service providers have launched a large number of projects. Thus, we strongly believe that ITS soon will emerge as a very important business area for the Information and Communication Technology sector.

The European Commission has launched several research programs in the ITS area. In the 6th research programme, the focus is on "Integrated Safety", "Virtual Mobility Environments" and "Vehicles and Mobility". Of special interest is a recommendation from an expert group to start work on pan-European standards for interactive services and public access to databases for road maps covering all Europe.

Japan has for some time taken this challenge seriously, and the government has invested an enormous amount of money into ITS. Accumulated from year 2000 until 2015, the total value of the ITS market is estimated to 500 billion US$. The telecommunication and information industry is expected to play a central role in this market. To underpin this, a well-known American ITS consultant stated the following during a presentation at Kjeller, Norway some time ago:

> *"ITS is developing into a new area for wireless-service growth and increasing revenues for telecom operators, who will be the primary beneficiaries of ITS services".*

Therefore, ITS should be looked at as an opportunity in the advanced Norwegian telecom market. The population has the spending power to adopt new technologies and services. Mobile and Internet penetration is among the highest in the world. Difficult driving conditions during long winters and large road infrastructure could be reasons for ITS becoming a success.

The main objective of this publication is to give light to some key issues in the ITS area, give some perspectives on ITS from a Norwegian viewpoint and discuss issues that hopefully will impact the future path. In particular the telecom operators' interest and perspectives in ITS will be addressed. Some of them are:

- What is driving the progress in ITS?
- What is the market potential for ITS?
- Is there a business for the telecommunication operator?
- What types of ITS applications are likely to emerge?
- What are the user needs?

Enjoy your reading.

Front cover:
Intelligent Transport Systems

Although appearing as moving over the physical geography the basic virtue of an ITS-entity's journey is its interaction with the information landscape. Information is offered to – and created by the ITS-entity all the way, thus enabling people onboard to tailor a fulfilling travel experience.

The artist Odd Andersen visualises the track of a moving ITS-entity as a dotted road line through zones within which various communication media – with their allocated bandwidths – are available. The colourful short stripes indicate the particular kinds of information that might usefully be communicated to/from the ITS-entity within the communication zones.

Ola Espvik, Editor in Chief

A Side Mirror View to Road Telematics

JAN A AUDESTAD

Jan A Audestad (61) is Senior Advisor for Telenor Corporate University. He is also Adjunct Professor of telematics at the Norwegian University of Science and Technology (NTNU). He has a Master degree in theoretical physics from NTNU in 1965. He joined Telenor in 1971 after four years in the electronics industry. 1971 – 1995 he did research primarily in satellite systems, mobile systems, intelligent networks and information security. Since 1995 he has worked in the area of business strategy. He has chaired a number of international working groups and research projects standardising and developing maritime satellite systems, GSM and intelligent networks.

jan-arild.audestad@telenor.com

1 In the Driver's Seat

About 100,000 new cars are sold per year in Norway. This provides us with a simple model for estimating the business potential of road telematics or intelligent traffic systems (ITS) in Norway.

New cars have become computer platforms where the computers monitor signals from a large number of sensors to detect faulty operation of the car and to optimise the operation of the engine: mixing of air and fluid, timing of the combustion sequence, and reducing the amount of pollutants in the exhaust.

Suppose that every car is equipped with a GSM terminal in order to support remote maintenance and monitoring of the car. Then the total number of mobile subscribers is doubled in Norway. Since GSM communications are used for special purposes (remote monitoring and maintenance) generating little traffic on the radio connection, it is likely that the total revenue of mobile communication is less than doubled. Nevertheless, there is a huge business opportunity associated with computerising the car.

New lorries and some expensive makes of private cars are equipped with GSM communication and it is expected that cars in the medium price range will soon follow suit: all these vehicles already contain formidable computer platforms. Within a few years mobile communications will be common in all types of vehicles.

It is reasonable to assume that only new cars are equipped with mobile communication devices during the manufacture of the car: it is simply too expensive to retrofit old cars with such capabilities. On the other hand, it is cheap to install the device in new cars. Then there is a potential for 100,000 new mobile subscribers per year in Norway; that is, if all new cars are equipped with mobile terminals. These subscribers are of a special kind: they are there not because of the market efforts of the mobile operators but because the car manufacturer has installed radio technology (GSM, UMTS, WLAN or whichever other mobile technology that exists) in the car for the technical operation of the vehicle – the owner of the car may not even know that the mobile terminal exists. Thus there is a new type of subscriber that behaves in a different way than other subscribers. Let us see why.

The car manufacturer may include the communication capability as part of the total price of the car. From the viewpoint of the car manufacturer, communication is not more peculiar than the wheel rim: both are there to meet certain requirements for driving that particular car. Therefore, the car manufacturer may like to increase the total price of the car in order to incorporate telecommunications. The car manufacturer will then probably ask for a price offer from each mobile operator in the country of manufacture[1] and choose the cheapest or the most flexible offer. The price may be an amount that will cover all future communications with that car for its whole lifetime. This is simply the present value of the expected usage of telecommunications. Suppose that the mobile operator values the communication to NOK 1000 per year and assumes a discount rate of 10 %, then the net present value of all future communication requirements of the car will be NOK 10,000. This is then the price that the car manufacturer must add to the price of the car.

The revenue potential in Norway is then 1 billion NOK per year if every new car is equipped with this facility.

However, there is a crux to this reasoning. The 1 billion NOK may not be paid to any mobile operator in Norway. It may be paid to an operator in the country of manufacturing, e.g. Germany. When the car is sold in Norway, it simply roams to a Norwegian operator, and if the car never places a call, there will be no income whatsoever for the Norwegian operator! Therefore, the 1 billion NOK may be the income of other mobile operators.

For the mobile operator in the country of manufacture life is not simple either. Because there are several mobile operators in each country, they have to compete for these contracts, but in each country only one of them will win the contract. However, there are nevertheless so few mobile operators in each country that the market is not ideal but is an oligopoly making the fight

[1] *Of course, the car manufacturer may have a commercial agreement with an operator in another country if this operator is cheaper. Roaming will take care of the technicalities.*

for the contract fierce. Let us illustrate the problem the mobile operators are facing by moving the game to a familiar playing ground. In Norway there are two GSM operators. Each operator observes that one of the following scenarios will unfold. Winning the contract to equip all cars with GSM means that the smaller operator (NetCom) in due course becomes the dominating mobile operator. If Telenor wins the contract, the position of Telenor will be even more dominating than it is today. In practice, Telenor becomes a monopoly. The game that the two operators then are forced to play is the most dangerous of all business games, namely the prisoner's dilemma, where all players are likely to lose ([1], [2]) because the operators must underbid each other until one of them loses because of lack of finance.

More than 30 million cars are manufactured each year. The total value of telecommunications for these cars is then more than 300 billion NOK per year. In countries with large automobile manufacturers such as Germany, this represents huge revenues for the mobile operators in these countries causing a severe price pressure on the competition for contracts with the car industry. This is so because it is the car manufacturer who selects the mobile operator and not the person buying the car. The contract is thus not for one car but perhaps for a whole production series of one million cars.

Of course, the picture is much more complex than described above. However, even with more exact market estimates and more nuanced business models the reasoning will lead to the conclusion that this business is not controlled by the mobile operators: the driver's seat is occupied by the car manufacturers. There is no simple way in which the mobile operator can gain access to this market.

The estimated cost of road accidents in Norway is 25 billion NOK [3] per year. This includes 5 billion NOK of direct insurance payments and 20 billion NOK social costs (injuries and deaths). In Japan the estimated cost is about 500 billion NOK per year. These figures of course depend on how social costs are computed. These vary from country to country depending on factors such as culture, political system, demography, and gross national product.

These huge sums are the motives for all the various actions taken to reduce road accidents. The actions taken include building safer roads and safer cars. In its extreme, reducing accidents is centred on building the driverless car. This includes building roads and communications systems that keep the car to the road in such a way that two cars never collide. The car is then steered by computers and not by people. The less extreme direction is the one taken in Japan where roads are equipped with sensors such that the car can detect when it leaves the lane and take corrective actions by overruling the manual steering.

The point here is that whichever method is used for making the road safer, communications is required between the road and the car. This again requires a comprehensive communications system along the road consisting of optical fibres, switching devices and radio access systems (GSM, UMTS, WLAN, Bluetooth or whatever is the most efficient and cheapest system) for communication between sensors, communication with control centres and communication with the cars. Extending the reasoning a little further, this implies that a new communication infrastructure is built along the roads. This may not even be expensive because ducts used for street lighting can also carry communication fibres, and radio base stations can be mounted on street lamps. Furthermore, roads lead to where people live or work. The roads and the streets can then be used for building a new telecommunications infrastructure. This development is not under the control of the telecom operator extending broadband to the home.

Road authorities and companies offering various types of traffic management may then occupy the driver's seat.

Payment systems include automatic payment of road toll, parking charges, and other taxes for using private cars. The motives for road payment are several. One motive is that the users of new roads, bridges and tunnels should pay what it costs to use them. A second motive is that the owners of land should get paid for the use of it. A third motive is to reduce access to cities in order to reduce pollution, reduce noise, reduce land usage and make the city a better place to live. The fourth and probably the most important motive is to increase government income in order to improve a stressed economy.

Road payment systems also require telecommunications involving interaction with banking networks.

The decision to construct these systems is taken by road authorities, city councils and governments. The telecom operators are not involved in the decision process. The decision makers may even decide to build an infrastructure independent of that of the telecom network. The decision makers may also outsource the building and operation of the system to a telecom operator. Alas, that may be our competitor!

Therefore, even if there is much telecom traffic involved in road payment, no revenues may find their way to the telecom operator. So again we see that the telecom operator does not occupy the driver's seat.

Finally, there are entertainment and information services. The telecom operators will earn money by providing telecommunications channels for delivering electronic games, entertainment and information to occupants of cars, provided that such services exist. Creation and design of entertainment and information services is not the core business of the telecom operator and should therefore be discouraged from entering such businesses [4]. How much the telecom operator may earn from entertainment and information services depends therefore critically on how good the service providers are at designing such services and how well the telecom operator and service providers cooperate in order to offer them at an acceptable price.

So even in providing information and entertainment the telecom provider will find that although he is in the driver's seat, he does not occupy the seat alone.

The following sections will go deeper into some of the aspects just mentioned. Some of these aspects exist in embryonic form already or belong to the near future; other aspects apparently belong to the far future. However, we should by now have learned that sometimes the development goes much faster or takes different routes than we expect. An example of the former is the decoding of the human genome; an example of the latter is the World Wide Web that not only changed dramatically many of the old concepts of telecommunications but also led to one of the worst economic crises we have ever seen.

2 The Car as a Mainframe Computer: Automotive Sensor Technology

During the last few years, an important evolution of the sensor and actuator technologies has taken place, called micro-electromechanical systems or MEMS. One of the drivers of this development has been the automobile industry. Other industries driving the technology forward are the medical industry, the military industry, the chemical industry and the industries involved in energy management.

MEMS are sensors and actuators that are micromachined on silicon wafers. The advantage of such devices is that mechanical detectors and actuators, chemical reactors, synthesisers and analysers, and electrical, magnetic and thermal detectors can be built together with random-access memories, PROMs and CPUs on the same wafer. Examples of MEMS are detectors, valves and pumps integrated in one package for micro-dosage of medicine, video cameras complete with micro-lenses on a single silicon chip, micro-spectrometers for chemical analysis, gyros for monitoring the position and action of the airfoils of military aircraft, and accelerometers for releasing the airbag in cars.

Examples of MEMS devices and various ongoing research and manufacturing activities concerning MEMS are described in [5]. One example taken from [5] is a MEMS designed for automatic building control (Figure 1).

The system consists of two chips: the detector chip and the neural network control chip. The latter collects all measurements from the detector chips and computes a situation report that is sent to a controller (not shown in the figure) over the Internet. The detector chip contains sen-

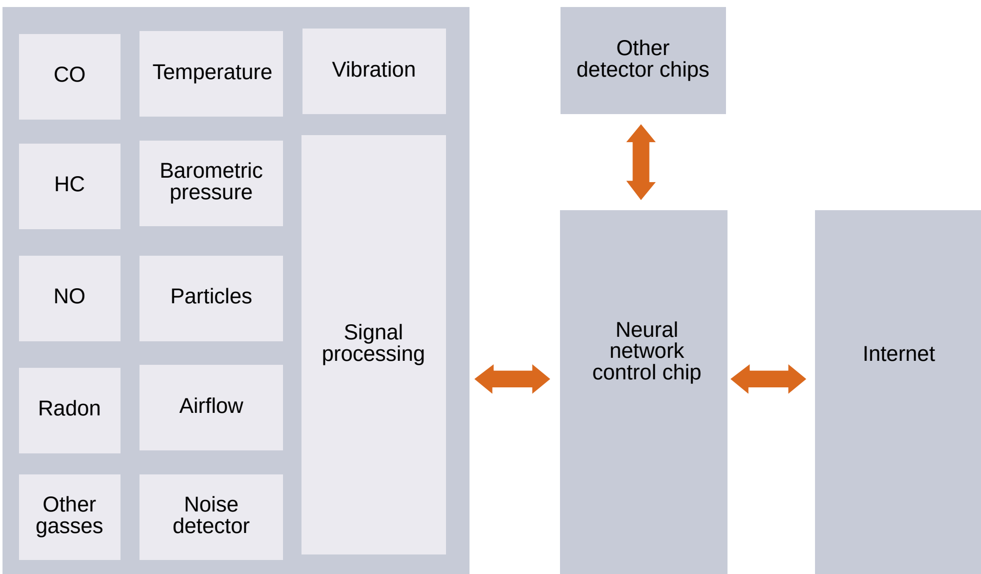


Figure 1 Example of MEMS

sors that provide a picture of the climate of the building. Each room of the building may contain one or more detector devices.

The detector chip contains thermometer, chemical sensors for detecting gasses (CO, HC, NO, radon and others), mechanical detectors for measuring barometric pressure, airflow, noise and vibrations, nuclear detector for measuring particle content, and electronic signal processing device for receiving, multiplexing and digitalisation of the signals from the detectors and for forwarding the result to the neural network control device. Even this formidably complex device is cheap when it can be produced in large numbers.

The automobile industry is the largest industry utilising MEMS. Examples of devices already produced for applications in cars are:

- Accelerometer for the airbag;
- Gauge for measuring engine-oil pressure;
- Thermometers for measuring internal and external temperature;
- Engine fuel-level meter.

Future devices and devices being tested include:

- Gauges for measuring the level and pressure of break fluid and transmission fluid;
- Contamination measurement of engine oil and exhaust gases;
- Gauges for measuring tyre pressure;
- Position monitoring of crankshaft, camshaft and throttle;
- Motor vibrations monitor;
- Optimum management of injection system and ignition system;
- Monitoring safety related features: suspension, seat occupancy, dynamic behaviour of vehicle, anti-collision radar and object avoidance system;
- And several other functions.

What is important to observe is that the car is becoming a computer platform as illustrated in Figure 2. The car will then contain a local area network (Ethernet) where all sensors (S) are interconnected with processors (µP = microprocessor), actuators (A) and communications and navigation devices. This evolution is driven jointly by the automobile industry and the semiconductor industry: the automobile industry producing safer and more efficient cars, and the semiconductor industry developing small, cheap

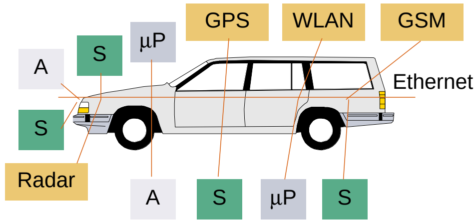


Figure 2 The vehicle as computer and communication platform

and reliable MEMS components. The technology strategist Paul Saffo claims that the semiconductor industry will be the industry driving the evolution of the ICT industry during the first decade of the 21st century [6]. The reason is that machine-to-machine communication supporting complex remote-control systems such as driverless vehicles and automated management of buildings require new ways of thinking about telecommunications: it is the availability of MEMS and other micro-miniature devices that will determine the future of the telecom business. The telecom operators, the computer industry and the information producers have all had their day taking their turns at the wheel during the 1970s (human-to-human communications), the 1980s (embryonic computer-to-computer communications) and the 1990s (human-to-information systems communications), respectively.

In automotive systems, communications is required for remote monitoring, downloading of new computer software, and preventive maintenance of the vehicle. This requires communication with computers in the factory of the manufacturer or in the garage of the dealer.

3 Science Fiction? Driverless Cars and Internet Along the Autobahn

We just saw that the automobile is becoming a computer and communication platform with formidable capacity. This capacity can be utilised in order to change our view completely concerning what is possible to achieve in the future.

In principle it is possible to construct driverless cars. It is not more complex than putting sensors along the road so that the vehicle can trace them in order to keep on the right side of the road and, as an extra safety precaution, equip all vehicles with anti-collision radars and obstacle avoidance systems in order to avoid running over objects, pedestrians, cyclists and animals in the road. The system also requires software and algorithms that can manage road crossings, exits, stops, diversions, traffic jams and parking. These are difficult problems but they are solvable on today's computers if we put together enough resources on system design, development of algorithms and programming.

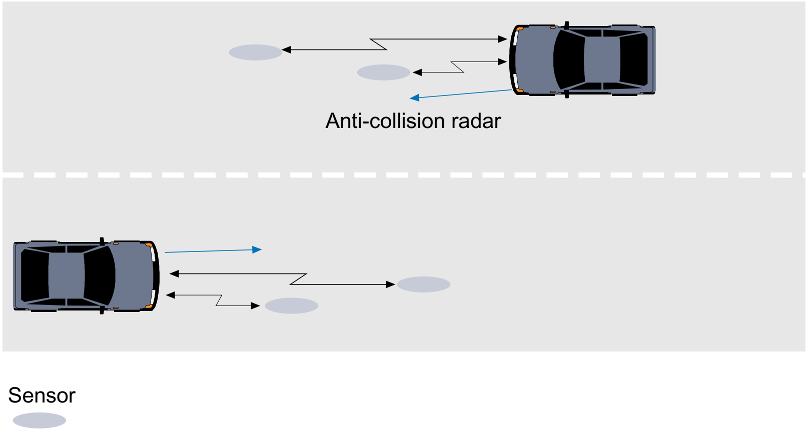
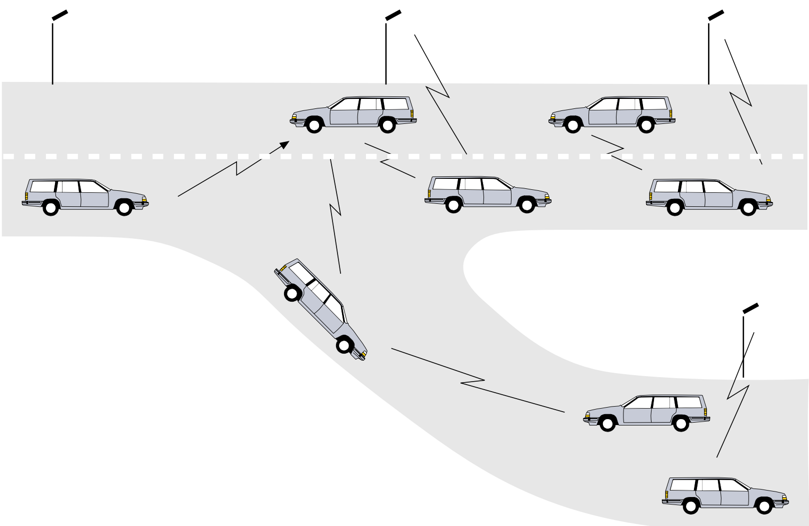


Figure 3 Road with electronic fence

Figure 4 Internet along the Autobahn



Computerised systems can be made much safer than systems run by computers. The machine is only thinking about performing the tasks defined in the software programs; it is not subject to diversions, disturbances or distractions that can take the human attention away from the road long enough to cause an accident. Nevertheless, most of us prefer a human being to be in charge of the airplane, train or bus we enter – we feel safer that way though (except for the bus) this is an illusion. We never reflect the fact that on most of the route the autopilot steers the plane – on many airports even the landing is automatic and conducted by computers, and that computers are in charge of the TGV, the Shinkansen and other extremely fast train. In order to illustrate our belief in human infallibility the Space Shuttle of NASA was automatic except for lowering the landing wheels of the shuttle at re-entry into the atmosphere [7]. This was by far the most dangerous activity during the whole mission!

A simple and practical way in which we can start exploring automatic driving is the following one. In Japan they are planning the introduction of this system.

Again we put sensors in each lane and let the car trace the sensors. However, the driver can overrule the automatics in order to change direction at road crossing or to leave the road. Then we do not need to develop, maintain and operate all the complex algorithms and software of the driverless car. In this system, the sensors form an electronic fence between lanes, and the software in the vehicle is designed in such a way that it prohibits the vehicle from entering the wrong lane in case the driver falls asleep or feel indisposed. The motive behind this idea is to reduce the number of road accidents, thus reducing the cost of society and industry. Combined with anti-collision radar in the car, it is expected that the objective to reduce the number of accidents will be met. The system is shown in Figure 3.

Another idea that has come up is to develop an Internet along roads. The concept is illustrated in Figure 4. Since the vehicles are becoming computer platforms with communication capabilities, the platform in each vehicle can be used as a relay station for forwarding information from one vehicle to the Internet. The Internet access points can be located in lighting poles. The base of the pole can contain the base station electronics: the base station is not bigger than this. The antenna elements fit easily in at the top of the mast.

The technology required is the same as has been used for a long time in military packet-radio systems. Similar technologies are used for Bluetooth and in experimental radio systems for anarchistic communications.

Challenging problems are to analyse the routing capabilities and the connectivity of such systems; that is, what is the likelihood that a communications path from one vehicle to an access point of Internet exists at any time. We are then faced with the mathematics of dynamic random graphs; that is, graphs where the number of nodes (i.e. cars and base stations), the location of nodes and the connectivity between nodes change with time. Apparently, very little is known about such mathematical objects. One problem is to estimate the density of base stations so that the probability that a particular vehicle cannot access the network is below a given limit. Other questions are associated with the overall connectivity in such graphs, for example, what are the critical densities of nodes (traffic density on the road) when connected components, trees and cycles emerge in the graph, when is the graph totally connected, and how many such connections are likely to exist on average between each node and the network. Complex technological problems are associated with the procedure and algorithms for handover of calls from one car to another in this highly dynamic system. If the diameter of a "cell" in this system is 1 km and the car is driving at a

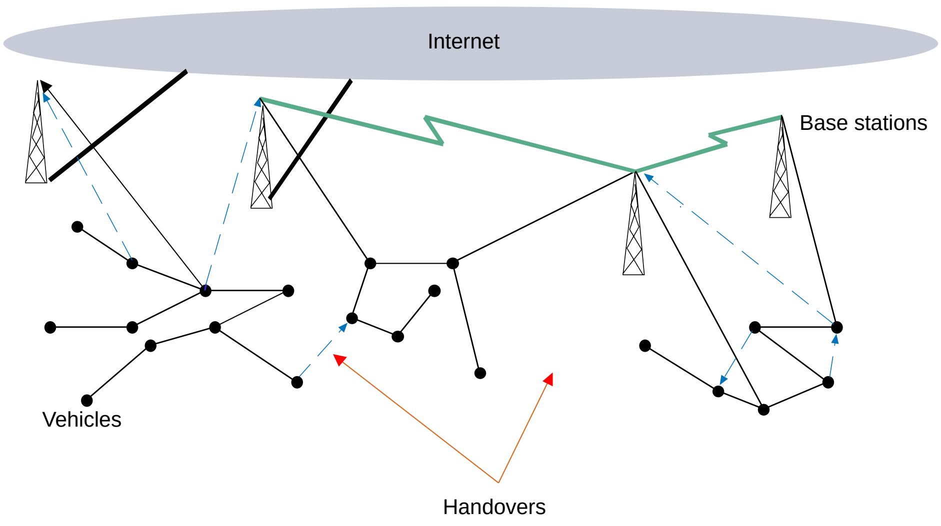


Figure 5 Dynamics of the connectivity graph

speed of 100 km/h, then the car is within one cell for about 36 seconds so that handover must take place more often than this. Two cars meeting each other at this speed can only communicate for 18 seconds at most. In many cases then, we may expect that the time between successive handovers of calls from one car to another or from one car to a base station is only a few seconds, making the system highly dynamic and extremely complex to make. Figure 5 illustrates the dynamics of the network.

Yes, the problem is complex, but it is solvable. Moreover, I would be much surprised if no one starts experimenting with such systems soon because they represent such a vast technological challenge: scientific curiosity is what brings technology forward, not the market economy.

The reason driverless cars and inter-vehicle communication are important is that the roads are infrastructures that can be enhanced to offer telecommunications not only to the users of the roads but also to the community at large. One obvious reason is that roads lead to where people live and to where industries are located. If telecommunication systems are required for the operation of the road and for offering road telematic services, these systems can easily be extended to offer services to homes, industries and the society in general, thus becoming a competitor to the systems of the telecom operators if they choose not to cooperate with road authorities.

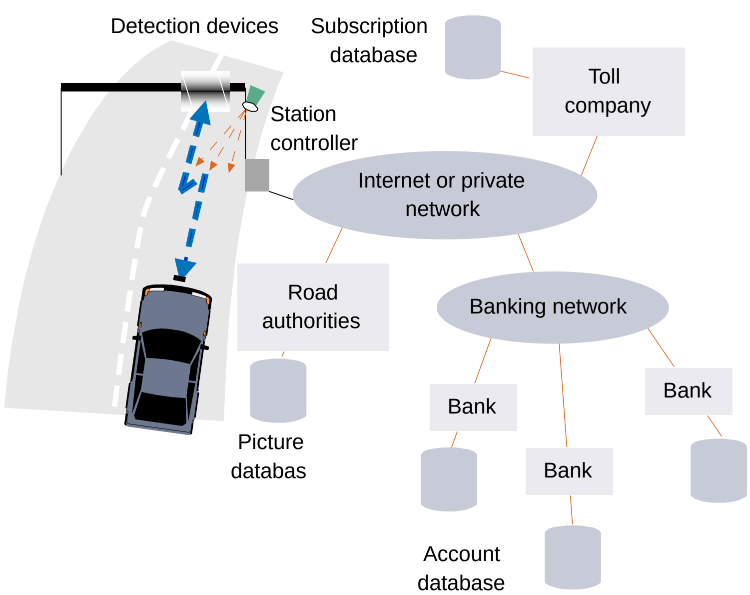
4 The Road as Cash Register: Payment Systems

Road telematic infrastructure is required also for less exotic applications than driverless cars and Internet along the road. Figure 6 shows the main components of a toll road.

The system contains a detector for reading the subscription or payment token in the car, checking the validity of the token, withdrawing money and transferring it via the banking network. If the car is not equipped with a token or the token is not valid, a picture is taken of the licence plate of the car and transferred to the pertinent authorities for follow-up. Parking systems, ticket systems, and systems for paying other road taxes are designed in a similar way.

Most existing systems are local; that is, serving a single toll station or car park or a set of toll stations or car parks in a local area. Subscription and automatic payment are therefore usually agreed with one owner or operator of such systems so that manual payment is required elsewhere. However, one evolution is to develop a common European system for automatic road payment with automatic transfer of money between authority of subscription and toll station owner. The token may then resemble electronic wallets and micro-payment cards offering secure and anonymous payment [8].

Figure 6 Road payment system



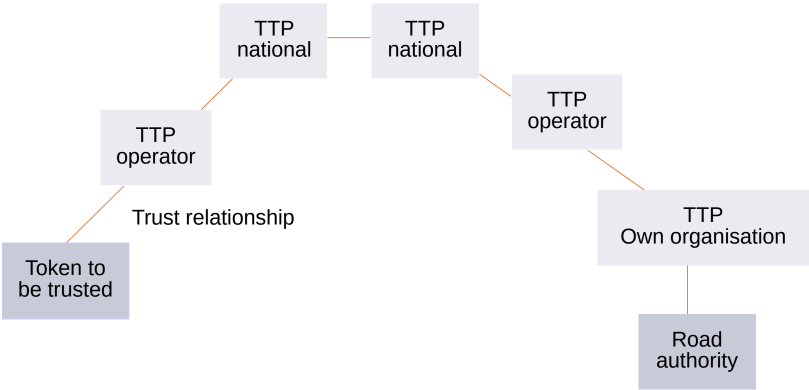


Figure 7 Network of trust

The major problem related to the design and operation of distributed toll systems is that a number of different companies and organisations must cooperate. This includes primary actors such as road authorities, banks and credit institutions, owners and operators of toll stations and parking areas, manufacturers of equipment, installation and maintenance companies, and telecom operators. The individual businesses of these parties are easy to understand and separate. The business depends on the ordinary aspects of cooperation and competition.

It is harder to understand and manage secondary players such as governments, standards organisations and organisations offering trust and information security.

Governments define the conditions for establishing the system. This sounds simple but is not, because governments may disapprove of the idea of cooperation for some irrational reason. It took four years of discussions at high political level before it was generally accepted that GSM terminals could roam in and out of certain countries. The reason was that the terminal contained encryption of the signals sent on the radio path – a requirement defined by the same governments. The problem was that it was forbidden to export equipment containing encryption devices, a regulation that went back to the time when encryption was a pure military enterprise. However, just as difficult is the cooperation within standards organisations to develop a universal standard. Agreeing on a common standard is usually the most time-consuming effort in the development of any new system.

In addition we have to worry about information security since money is involved. Money can be transferred safely using the international banking network. However, authentication of electronic wallets and micro-payment cards registered in different countries and with different public and private organisations require a network of trust that does not yet exist. It is easy to establish trust within a single country or between organisations that are used to cooperate. However, establishing trust on a wider scale is far more difficult. A network of trust may have the configuration as shown in Figure 7 with a complex hierarchy of trusted parties (TTP = Trusted Third Party) where international trust can only be achieved between trusted parties at a national or governmental level. This means that a foreign road authority accepts the payment token only if it is certified by a national TTP recognised by its own national TTP. Trust is a complex mix of technology, business and law that has not been sorted out yet.

5 Entertaining the Backseat Driver, Enlightening the Front Seat Driver

The problem with entertainment and information services is how to get the user to pay for the information. The problem is that the user often finds it unacceptable to pay for information services and entertainment on the Internet. There seems to be two reasons for this: the user receives much information from the Internet without paying anything extra and is not capable of distinguishing one information offer from another; if extra payment is charged for receiving certain information, the user does not find the information of such value that he or she is willing to pay extra for it.

The problem is the same independent of where the user is located when information is required: sitting in a car is not different from receiving the information anywhere else.

The business of providing information and entertainment is illustrated in Figure 8. There are two parties involved in the process: the information provider and the telecom operator. The only way the user can get hold of the product is via the systems of the telecom operator. The common business model is shown in Figure 8 A). The telecom operator is paid for the usage of the network and the information provider must get paid for what is required in order to survive as a business. The problem is that the price the user must pay is the sum of the two payments. The business model seems to offer much profit to the telecom operator. However, this is, of course, the case only if the information provider is capable of selling the product. This is just what seems to fail in most business models involving information providers on the Internet.

An alternative business model is shown in Figure 8 B). The user pays only for using the network of the telecom operator. The telecom operator pays the information provider for delivering the information and thus increasing the traffic and the profit of the telecom network. If the users are accessing the information, the network provider will increase its revenue. The profit per access will be smaller in B) than in A) but the overall usage of the network may increase so much that the total profit is big.

This business model is hardly seen in telecommunications (except when information is delivered for free) though it is common in commerce: you never pay the shopkeeper for entering the shop and the producers of the goods separately for the value of each good you buy. In telecommunications, the information is the good and the telecom provider is the shop. Of course, the telecom operator will only do business with information providers that offer information that the users really want. This is the same as with the shopkeeper: goods that do not sell are removed from the shelves.

It will be hard to find any information service that will survive in business model A) above. It is probably simple to find services that are profitable both for the information provider and the telecom operator if business model B) above is explored.

6 Is There Any Business for Us in Road Telematics?

Figure 9 summarises the earlier sections. The figure contains systems required for road payment, provision of entertainment, automatic surveillance and preventive maintenance of vehicles, fleet management, navigation, rescue operations and communication. Roads then represent an important telecommunication system with many business opportunities. The problem is to identify the right opportunities and the business model that provides us with the most money. The discussion above has shown that this is a real challenge.

We have seen that the future business potential of road telematics is of the same order of magnitude as mobile communications today. This includes communications in closed networks such as fleet management systems for taxis and public transport. There may be lucrative businesses for the telecom operators in this area when new fleet management systems are required.

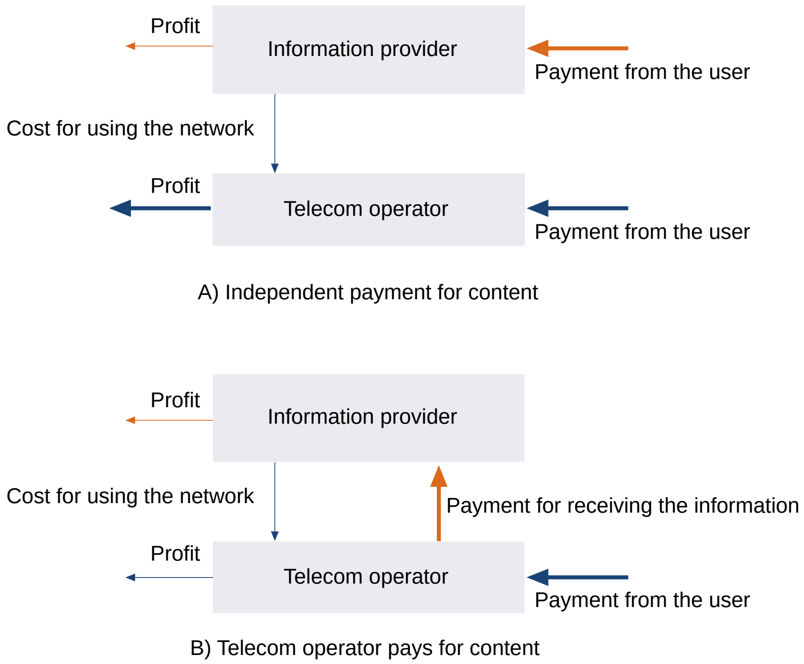


Figure 8 Business relationships between information provider and telecom operator

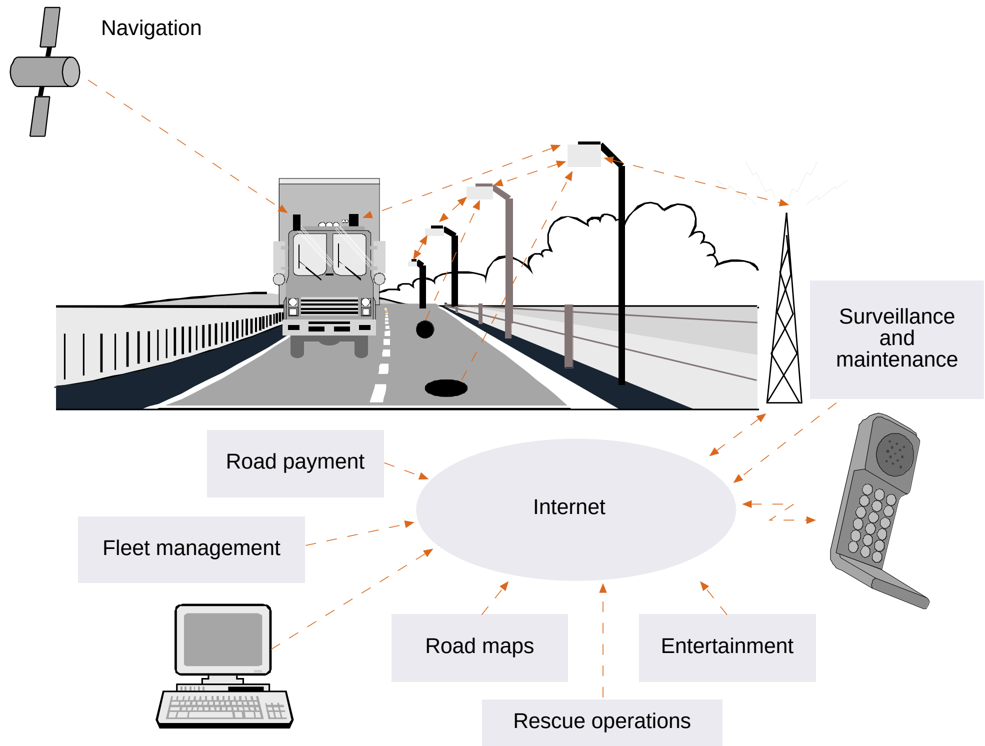


Figure 9 Road-telematic system

Road telematics also represents a risk for telecommunications operators because much of the current telecom infrastructure can be replaced by new infrastructure built along roads for other purposes than road telematics. Similar threats from cable television systems and the electricity companies have not yet materialised. These systems are still too expensive.

Another issue is whether or not road telematics will generate new markets with market externalities. Before answering that question let me recapitulate what network externalities is all about. An idealised description of normal markets is that the market growths is proportional to the number of potential customers not having bought the product already; i.e.

$$dC / dt = k(1 - C)$$

where C is the relative number of customers having bought the product, $1 - C$ is the relative number of potential new customers, and k is a constant of proportionality. If there are market externalities, then the potential number of new customers, again assuming the same idealised market model, is also proportional to the number of customer already having bought the product; i.e. the differential equation becomes (with m as constant of proportionality):

$$dC / dt = mC(1 - C)$$

Therefore, in order to look for network externalities we must convince ourselves that the change in market size (dC / dt) can be proportional to the market size in the idealised model.

Looking more closely at the road telematic markets we have described above, there is little that indicates that network externalities exist. The market for the computerised cars depends only on the skills of the manufacturers and ordinary competition rules where every manufacturer must in due course follow the development in order not to lose market shares. Implementing road payment systems has nothing to do with markets. On the contrary, it is done in order to collect money to compensate for land usage, for reducing pollution and for improving road safety.

When it comes to provision of entertainment and information, there is nothing that indicates that providing these services to drivers and passengers of cars leads to new network externalities.

Road telematics is thus a difficult area in which to make business. The business potential is huge but so are the problems.

References

1 Mérö, L. *Moral Calculations: Game Theory, Logic, and Human Frailty*. New York, Springer, 1998.

2 Binmore, K. *Fun and Games: A Text on Game Theory*. New York, D.C. Heath, 1992.

3 Lovett, H et al. *Businessplan: ITS Your Time.* NTNU, Master of Telecommunications Strategy thesis, 2002.

4 Audestad, J. Challenges in Telecommunications. *Telektronikk*, 98 (2/3), 159–182, 2002.

5 Soloman, S. *Censors Handbook*. McGraw-Hill, 1999.

6 Saffo, P. Closing speech of the *Biannual Conference of the International Telecommunications Society (ITS)*, Stockholm, 1998.

7 Mr. Feynman Goes to Washington: Investigating the Space Shuttle Challenger Disaster. In: Feynman, R P. *What Do* You *Care What Other People Think: Further Adventures of a Curious Character.* New York, HarperCollins, 1992

8 O'Mahony, D, Peirce, M, Tewari, H. *Electronic Payment Systems.* London, Artech House, 1997.

ITS is an Application Area of the New Telco Core

EINAR FLYDAL

Einar Flydal (53) is Senior Adviser working with corporate strategy at the Telenor headquarters. He is cand.polit. from the Univ. of Oslo (UiO), 1983, in political science, and Master of Telecom Strategy from the Univ. of Science and Technology (NTNU), Trondheim, 2002. Apart from 1985–1993, when working with IT in education and with small IT companies, Flydal has worked with Telenor in a variety of fields since 1983. He has also worked as radio freelancer on minorities and music, on statistical indicators at the Chair of Peace and Conflict Research, and on work organisation on oil platforms at the Work Research Institute, Oslo. His present professional interests are environment, CSR, innovation, and ICT.

einar.flydal@telenor.com

Introduction[1]

In this paper we approach the subject of ITS from two perspectives – as a converging development of the telco businesses and the transportation sector; ITS being in the intersection of these two developments. Further we argue that the developments in telecom, as well as in the area of transportation of people and goods, require that at least the major telcos somehow get involved. As tides within ICT development shift between vertical integration and segregation, both in technical and/or business terms, the more general infrastructures will continue to be essential parts of the datacom business towards which telcos develop. ITS applications that utilise such infrastructures will become omnipresent and drive a further development of the technical platforms. As applications will influence the user's choice of networks, ITS will become increasingly important even for the most focused network operators.

The Term "ITS"

ITS – Intelligent Transport Systems – usually denotes various blends of technologies, systems, application areas, market channels and purposes related to road and transportation, i.e. a vague term with just family resemblance. Hence, ITS can be defined along several axes describing e.g. components (ICT), means to increase cost/benefit in traffic, its functional localisation (in vehicles, in terminals or server parks, in physical infrastructure, on human or other physical bodies, in organisational bodies, etc.) and its application before, during, or after travel.

ITS as defined by some autoritative bodies may serve as an illustration of the "commonsensical" content of the term (Figure 1). It does not exactly help to avoid confusion that the term "telematics" – once designed to denote the convergence of telecommunications and informatics – also has been appropriated to be used as a synonym, eventually delimited to cars ("road telematics").

Any actual ITS application or component thereof may thus involve various ingredients at any level from physical infrastructure and up: specific physical networks, e.g. for short-hold communication with a vehicle along some transport corridor, production platforms, and application and data collection used for making this entity of subsystems a system for, say, automatic lanewidth regulation. "ITS" may as well be used to classify an application which is just pure software running on general IT hardware, like a tram information service, adding value to other systems, e.g. a fleet management system and a geographic information database, delivering it over distribution channels at hand, like standard mobile phones. Even computer gaming for the back seat passengers is sometimes included by the term ITS.

Accordingly, in the wide sense of the term, ITS will become omnipresent, as it is close to being synonymous to "mobile data communications" carrying any kind of application – as long as the context is somehow linked to travel or mobility. Such defined, it is a truism that ITS might heavily influence (the design of) networks as well as service production platforms. It is equally true that application vendors and users may play on mechanisms that permit choices between alternative network operators and platforms; the network and production platform is an input commodity.

The unavoidable strategic options for the network/platform operator will be to extend control along the value chain, and/or regain input factor

---

1) *The author should excuse himself for the lack of references in this paper: The points and views put forward have been unsystematically collected through two decades of work in the telco and IT business, as well as through being a student in the Telenor Master Programme of Technology Management and Telcommunications Strategy, University of Polytechnics (NTNU), Trondheim, 2001–2002. Important sources for inspiration and understanding of the ICT development on which much of this paper is based, have been David Isenberg (e.g. Isenberg 1997; Denton, Menard & Isenberg 2000), since 1997 continously hammering on the need for a mindshift in telecom; Øivind Fjeldstad & Charles Stabell (Stabell & Fjeldstad 1998) by constructing a taxonomy of value configurations drawing attention to important strategic implications for network economies like telcos; Jan Audestad with his clearminded and simple interpretations of the business implications of the extreme complexities of the ICT business and its transformations (Audestad 1998); and George Gilder (Gilder 2000) with his praise – though to me naivistic – of the business and welfare opportunities in the Gigabit realm. This paper being general in perspective, the same author is responsible also for some more down to earth and practical oriented papers elsewhere in this issue of* Telektronikk. *With the kind help of prof.em. Bjørn Berland they have all become considerably more readable than would otherwise have been the case.*

Figure 1 Mainstream taxonomy of ITS and stakeholders

Stakeholders of general interest usually mentioned:	Generally used classification:
Public authorities (road, traffic, transport, police, local government, telecommunications)	Advanced Traveller Information Systems
Infrastructure operators (transport, telecommunications)	Advanced Traffic Management Systems
Transport sector (service providers, operators, users and their associations, motorway operators, freight and logistics)	Advanced In-vehicle Technologies
Industry (automotive, electronics, information technology, telecommunications, civil construction)	Freight & Fleet Management Systems
Finance and insurance (insurance companies, banks, investment houses, payment clearers)	Advanced Public Transport Systems
	Emergency Management Systems
	Electronic Payment Systems
	Advanced Safety Systems
(EU T-ET classification)	http://www.itsworldcongress.org/itsite.htm?whatis.htm

monopoly, and/or reduce margins – or to simply pull out. For all but the last, a presence in ITS development – in this broad sense – is of strategic importance. Alternatively, "deep pockets" are required to buy an active position at a premium price when markets are established.

Below we are mainly concerned with applications to improve the flow of personnel, goods and traffic in the broad sense. Accordingly, we exclude ITS from, say, entertainment and mobile speech telephony as such.

However, the platforms and the acquired data may serve many purposes – even simultaneously. And new applications repeatedly appear – re-drawing the boundaries between what we conceived to be established markets. Consider the scenario – the kid's "Grand Theft Auto" software game in the back seat gets its map data from the navigation system on Dad's dashboard. Not only is realism added, but a market merge of substantial impact takes place – for the telcos as well as for the road authorities!

Strategic Challenges and the ITS Option

The fluidity of markets and technologies within ICT – in a world increasingly without geographical hindrances – makes strategic choices extremely complex for the owners of (several) infrastructures and service platforms, as well as to the service providers.

As computing gets increasingly mobile, and tele- and datacom becomes embedded in products and services that are invisible and irrelevant to the user, the buyer and/or even the market channel, many mutually connected standard business strategy questions come to the foreground:

- How to avoid becoming squeezed by position in the value chain – by integration along the chain, by horizontal expansion or by monopolising the position?
- How to avoid being/becoming a commodity supplier – i.e. how to maintain some degree of monopoly to allow for higher margins?
- How to compensate for becoming a commodity supplier – by volume, efficiency gains, new markets, or innovation of products and business models? (Or even by creative book-keeping?)
- How to adjust for efficiency gains leading to reduced overhead capacity – by contraction or expansion? And eventually along which dimension?

The tactical approach is how to maintain the customer grip.

In the limited context of telco and ICT strategic perspectives, ITS is just another field of opportunities: ITS engagements may offer promising options to answer the questions above. In the same business perspective, it has to be answered whether such engagements in ITS are more cost-effective than engagements in other areas and, if so, within which time horizon?

Historical figures or business records can only to a modest degree answer such complex questions about new products, markets and business landscapes. With so many parameters, among which some would be teleological (i.e. prescriptive/ intentional), there may be a host of right answers – all depending on timeframes, wills and wishes.

More may be gained from studying the scene and its backdrop than historical performance against a different backdrop. Here we will briefly view the compact versions of economists' thinking, and technology development within telecom. With this in mind, we will also look at what happens within the transport industry.

What should hopefully appear to the reader is that:

- transportation undergoes a fundamental reform where ITS is the name of the enabling technology;

- ITS applications are based on a network economy value creation mode; and that

- ITS draws heavily on a dichotomy – essential in the future of the ICT business: The omnipresent stupid network – wether fixed or radio-based, stable or spontaneous, and, on the other hand, the technically independent applications – getting born, living and dying outside the net.

Derivation from Economists' Thinking – ITS as a Third Party Income Booster

Essential practical experience of economists, theoretical views on network economic value systems and regulation of natural monopolies are presented below:

- Monopolies become inefficient as time passes, and should be forced into competition (even the threat of introducing competition may help).

- In a perfect competitive market, product price would be equal to marginal cost. Hence in a perfect competitive market – should it exist – business is uninteresting. To make a real profit, some degree of monopoly (i.e. market imperfection) is needed.

- In network economic value creation systems (like telco, bank, airline companies and similar network operations), marginal costs are next to nil, as almost all costs are fixed. Competition therefore easily destroys such value creation systems.

- Hence, network economies have the characteristics of "natural monopolies" and should be protected against such destructive competition.

- To hinder a network monopoly to reap a monopoly profit, it must be under some regulation as to permissible margins. The network operator must accept it as a business of – in the long run – relatively low, but stable, margin.

- To be permitted to "live" from the monopoly, the network operator must open up for third parties, both upstream and downstream. Hence, as demand is created by upstream value addition (applications), the network operator should stimulate upstream value addition by third parties, and their access to infrastructure at fair prices.

- Telco networks are traditionally built to meet peak demand, and to carry the costs for that capacity through income from the mean demand. The unused capacity has a cost that must be carried somehow.

- Added network use that fills up the gap from mean consumption to peak consumption, means net income to the operator. To fill this gap seems a smart move for the network operator. Alternative ways to achieve it are:

  - Under the old innovation regime it meant in-house development, integration and control, preferably by using network elements to produce the application (called "VAS", i.e. Value Added Service).

  - Under the prevailing innovation regime it means helping 2nd and 3rd parties to create services and develop markets. This must be done by a high degree of co-operation, i.e. concerted action, complementary partners, and competition at all levels. Absolute control or domination is as destructive as is absolute competition.

  - Some parts of the telco business are under the old innovation regime, juridically, technologically, as well as mentally – some parts are under the new. Hence, both strategies are needed, but they are not equally suitable or equivalent in any given situation: The new regime offers new opportunities, which do not exclude the old one.

These views are not all generally accepted, but they increasingly seem to gain ground. Even the present liberalistic era is being reshaped. Respected authorities and NGOs claim that the societal costs of exposing natural monopolies to competition, whether they be roads, jails, water and power supply, or telcos, railroads and airlines, may by far exceed the advantages (e.g. Stiglitz 2002). Also, it is increasingly understood that the same kind of value production may be suitable for competition in the urbanisation of California, Brazil and the Netherlands, but may be a natural monopoly in rural India, the US Midwest, Northern Norway, and in the French countryside. The long-lasting debate on how telco networks should be owned – by business, by government or as commons – is a derivative from these very same points.

Accordingly, in the economists' perspective, ITS is just one of many possible areas for such business growth initiatives, and just one of many possible application markets that might thrive on the top of an open natural monopoly infrastructure: Initiatives can be in-house, by helping partners or 3rd parties develop the market. There may be fields where absolute control of larger chunks of the value creation is fine or even necessary for some initiative to get momentum, and fields where it is detrimental to some or all of the stakeholders.

The rationale behind less control over the value creation system is not purely economical, but also political: According to prevailing normative regulation theory (Tirole & Laffont 1993), the price that the holder of any monopoly business should pay, is to provide it for society as a utility, i.e. free for all to build business upon.

One of the most valuable growth initiatives a network operator can take is to initiate the creation and spread of services to increase traffic. If its value creation has the character of natural monopoly, the network operator should in the long run fight for being accepted as one, with the implications it has on margins and openness.

Lesson from ICT Development Trends: ITS is Just Applications of What Happens Anyhow

In retrospect, the integration of telecom and IT – coined "telematics" by the French – was in its infancy ten years back, and has since then developed enormously. Some main changes and lessons learned are set out below:

- Costs for bit transport continue to fall due to technology development and capacity build out, and there are no ends to either development in sight. Pressure on widening the bottlenecks, i.e. mainly the access networks, is both a cause and a consequence.

- Bottlenecks are widened or circumvented with technologies driving the industry towards commodity business models, vanishing business, and low margins (e.g. dark fiber, XDSL, WLAN, and "spontaneous networks").

- It has become rational to move services out of the networks: After a few decades of increasing intelligence embedded in the networks (the era of IN), the networks now become "stupid", in the sense of them knowing next to nil of what applications they carry, for whom, and between where.

- Mesh structured networks, through which the traffic flows – split in packets routed independently by decentralised decisions (packet switch the Internet way), replace the old trunk structure with its central control over reserved communication circuits (circuit switch the telco way).

- With the descent of circuit switching and the arrival of abundant capacity, the historical justification and practicality of duration and distance as pricing parameters for network access, lose ground. What can be priced in a *competitive* network market is the (percieved) value of access to / use of the network, in terms of how much it contributes to the admission and attractiveness of specific services. Under a monopoly anything goes, as long as the regulator does not do its job; i.e. to enforce "cost plus a reasonable margin" pricing – whether achieved by competition or by *ex ante* provisions[2)].

- The network concepts of telco business made service level guarantee technically and practically feasible (like PSTN, ISDN, XDSL, VPN, etc) – to the price of vertical integration and a high degree of monopoly.

- This advantage is, however, increasingly unsustainable as QoS can be achieved in many ways, e.g. bandwidth affluence, in quality mechanisms outside the networks, and in network segregation – all mechanisms that restrain the role of the telco network operator and the traditional telco business model. Hence, as "stupid" and "empty" mesh networks take over, a classic within social economic theory – "the problem of the commons"[3)] – seeks for new technological as well as regulatory foundations within tele- and datacom.

- As applications are increasingly based on interaction between computers – with the network as a passive utility, computing gets increasingly dispersed and mobile. In other words: interacting IT subsystems are increasingly movable and moving, and hence dependent on communication between variable locations and over a variable distance, i.e. on some variety of radio communication.

- Ever more of the activities of daily life (ADL) are ported to the digital networks. Which means more traffic, as well as demands for better functionalities at the network, platform

[2)] *The possible products involving telecom as input factor are unlimited in range, but their possibilities to carry involved telecom costs would vary enormously. Uniform pricing kills many growth opportunities, as willingness to pay for some product or service is not related to the cost to offer the service through the network, but to the attractivity of the end-user application it enables. In a network economy, i.e. marginal cost being nil, pricing the telecom input factor should reflect the end-user's willingness to pay. It is good business as well as good regulatory practice to fill up the network, i.e. through service creation making ADL (Activities of Daily Life) ever more net based. It may also mean a different regulatory scheme, permitting differentiated pricing – even for basic services.*

[3)] *I.e. how to maintain quality of services in a natural monopoly infrastructure owned by all, but supervised and maintained by no explicit control system.*

and application levels (like bandwidth, omnipresence and context dependent interpretation). It also reinforces the perception of the networks as a kind of utility, free for all to use as an input factor in own value creation, i.e. a kind of commons, from which you can expect a lot without bothering about it.[4)]

- In this process, terminals, networks, applications and content foreign to the telco business model, e.g. incompatible to the traditional pricing principles, gradually invade the telco business realm, and provoke changes. It is a multidirectional process at many different speeds.

- The consumption of telecommunication as an end product is losing its share of the communication volume. What is consumed will increasingly be a product or service with telecom/datacom embedded and invisible to the user. This implies that e.g. the end product decreasingly is voice telephony and increasingly a dish washer, a logistics system, a ball pen, a surgical tool, or a virtual eye for the blind – improved through network connectivity. (Even the traditional network embedded application "voice telephony" is these days transformed to a terminal application, using any network present as a shere accidental utility.)

Many of the statements above were highly controversial, considered irrelevant, or "mind blowing" within telco fora 10 years ago. Now they seem commonly accepted. They are of course still highly debatable as to the tactical questions of growth rate, timing, technical implementations, business models, smart tactical moves, what should be considered reasonable regulation, as well as the societal impact of such a development.

The statements clearly point out that tele- and datacom networks are bound to lose what we might call their "organisational overhead carrying capacity" as price models change, margins fall, other players take their shares of the traffic growth over to other networks, and services get network transparent and independent.

To maintain income levels under such circumstances, the network operators as well as the service providers have a fairly limited set of options: significant increases of volume, maintain or get some degree of monopoly, substantial reduction of costs, and move into new markets.

As to the traditional telcos, this situation drives the telcos to transform themselves: First, i.e. from the late 80s, they tried expanding – whether along the value chain, through the value network, to neighbouring markets, to faster innovation, and into the attackers' markets. Then they started spinning out, or transforming into businesses where own assets and core competencies could be used, like electrical installations, property management, factoring, etc. At present, after huge successes as well as failures and capital scarcity, they are also retracting to their "business core", focusing on high efficiency. When to stage such transformations – irrespective of alternative chosen – is a major business strategic concern: Without expanding into new fileds, it means making the impossible choice between "milking a sinking ship"[5)], or killing a profitable business to prepare for a new and smaller one.

ITS is also in this perspective of ICT development just one among several arenas that offer to the established ICT business a suitable lever in the process of bringing about such a change:

The ICT development described above is visible in the core of today's ITS applications. Hence, ITS is also a suitable lever to proactively transform old business, and adapt to a new business landscape – dramatically different to the traditional telco and IT world.

The telcos cannot enter this field alone: The incumbent technologies as well as businesses involved in transport of people and goods are from worlds unknown to the tele- and datacom businesses. Thus, for technological as well as business reasons, co-operation is needed. Hence, there is a need for value creation modes based on co-operation, not the antagonist behaviour favoured by the competitive market ideal.

Transforming Transport: ICT as Enabler, ITS is the Name

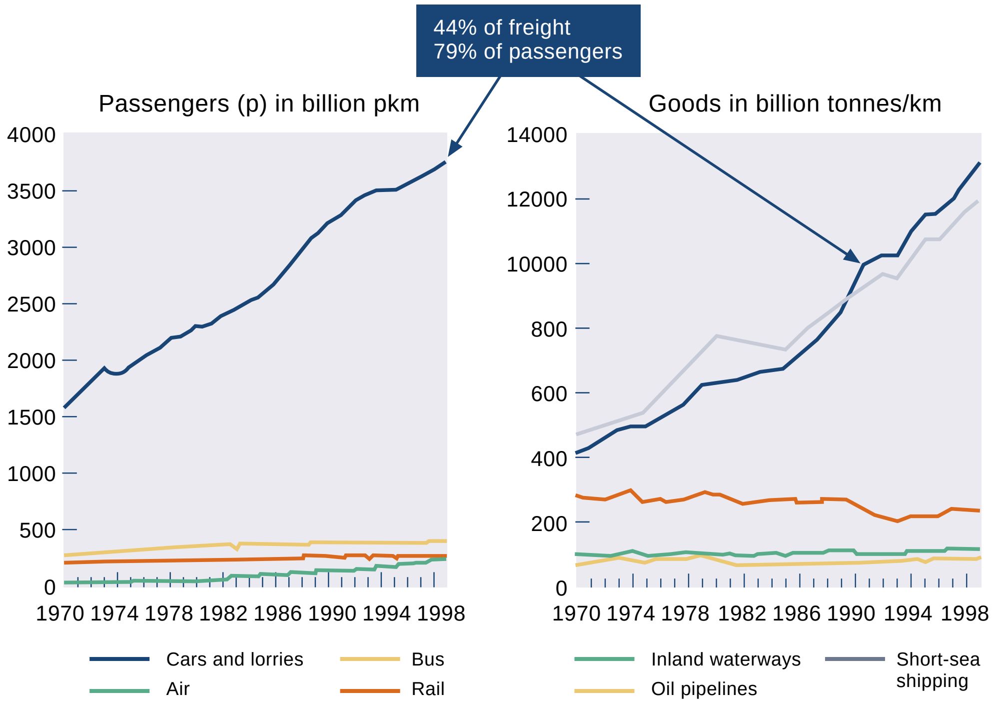
The volume of travel – work related, for leisure, personal and goods transport – increases dramatically. The reasons are many – not least the affluence in our part of the world – population increase, urbanisation, economic liberalism and globalisation, and transport means becoming cheaper.

---

4) *Most clearly, this development is seen in the development of general standards – OSGI (Open Services Gateway Initiative, see www.osgi.com) being one – creating standard interfaces between any network and any application in transportation, housing, industrial production, and general social interaction. Thereby showing the telecom industry its future – and more modest – role as utility provider.*

5) *The metaphor mix would be less absurd if we could use the expression "milking a sinking sheep"!*

Figure 2 Development of passengers and goods transport – EU[6)]



For most of the previous century, the private car was enthusiastically received because it offered mobility and flexibility, as was the bicycle based transport revolution some decades earlier. Now, however, the problems caused by the private cars – in general, but particularly in the cities – fill the political agendas and drag down the budgets.

As demonstrated in a long range of studies (e.g. in Martin Lawson's paper in this issue of *Telektronikk*), even the newest modern public transport is unapt for regaining essential shares of the transportation needs of the modern, multi-centred urbanisations, and is deemed to continue to lose in competition with the far more flexible private car. Accordingly, public transport loses ground by 1.5 % per year in industrialised countries. In urban areas of 1 million or more inhabitants, the share of private car in transport ranges from approximately 60 % in Asia, 80 % in the EU, 92 – 93 % in Canada and Australia, to 98 % in the USA. The steady reduction of the public transport share seems deemed to continue, causing most cities of any size to suffocate – pollution and health having become important concerns (WBCSD, 2001), and energy consumption for transportation increases 2 % or more yearly.

The forces at play against traditional public transport are much stronger than the various revitalisation efforts for public transport staged by local authorities, citizen movements, and governmental or regional white papers.

A host of development projects have been undertaken to seek technological as well as non-technological tools for rebalancing traffic modes, making traffic flow more efficient, as well as relieving some of the detriments.

For decades many incremental improvements to ease traffic flow have been tried – electric cars, automatic elevated rail systems, traffic information centres and systems, distance work, car sharing, separate lanes for public transport, toll systems, etc. But the increasing traffic trend continues. Politicians and governments are trying to make road capacity meet demand, restrict urban road traffic, and to entice or force commuters to use public transport.

This situation has created a vast market for politically endorsed improvements to transport efficiency – nowadays under the name of ITS. This political ambition gives ITS a meaning extending the more technologically based ones: *ICT applications being intelligent in the sense that they contribute to solving real societal problems by making traffic flow more efficient.*[7)]

Through ITS, such defined, transportation is reshaped through a mix of private and political initiatives in the particular direction of making traffic flow more efficient. Simultaneously, all other kinds of ICT based applications to be used on the move are developed. Wether they increase traffic flow, are neutral, or even increase traffic volume (e.g. through the so-called

[6)] *Illustration from foil set to White paper European transport policy for 2010: time to decide (Commission of the European Communities, 2001)*

[7)] *Such defined only, mobile computing is no necessary attribute of ITS, neither is any other specific technical element: Traffic light systems would be included, as well as a system of laws and prescriptions dictating a more efficient distribution of transport between the various modes.*

"rebound effect"[8]), may be context dependent. A set of main development features are depicted below:

- Vehicles as well as traffic paths (roads, guideways, air corridors, etc) are increasingly subject to ICT based fleet management in milder or harsher versions from traffic lights to automatic fleet guiding or automated rails.

- To favour the use of other transport modes – bicycles, data traffic (distance work), or various public transport modes – ICT based surveillance and toll systems are used to impose restrictions on the use of private cars.

- Vehicles are becoming equipped for individual navigation supported by ICT in the form of maps, POI (points of interest), traffic information, etc.

- The service and maintenance market is made mobile and ICT based. For example, vehicle repair shops lose functions as ICT based systems for more efficient vehicle operations, e.g. vehicle diagnostics, location services (e.g. for stolen cars), alarms, etc, are installed on board the vehicles – with incident logs, service manuals, and communication with relevant bodies (producer, car repair shop, insurance company, car service provider, authorities, etc).

- Production systems previously localized in a stationary facility (e.g. health services, pizza production, and fish processing), or based on co-ordination between a home base and mobile units (fire fighting, rescue operations, beer and gas distribution, etc), redistribute the roles: More production and co-ordination take place in the vehicles, implying a new need for information, information processing, and information redistribution (patient journals and medical records, baking temperature as a function of distance left to customer, etc).

- Public transport – generally suffering under the weight of heavy equipment, high costs and strong traditions – gets ICT support in the form of fleet management systems, route optimising tools, and service programs: Information services to the public transport passengers are improved. Public transport is co-ordinated with narrower margins.

- The detrimental effects of physical transport – in terms of pollution, time wasted, etc – are increasingly watched by ICT systems.

- All the above are in various and unexpected ways becoming increasingly interlinked and true time based, as when true time air pollution surveillance results are used to set the road toll level at the city toll booths.

- While the various cybercar and road telematics projects around the globe try to turn private cars and trucks into fleets with the aid of ICT, visionaries within public transport try the opposite; i.e. to make public transport more private and flexible to regain ground for public transport: They try to replace the traditional corridor based transport mode by the far more flexible mesh network distributed routing system of the private car. The name is PRT, presented elsewhere in this issue of *Teletronikk*. The enabling technology is ICT applied on mobile computing and fleet management in a mesh network, i.e. an application of ITS.

- Even infrastructures for transport – roads, rails, and the like – get increasingly intelligent: The rail or road pushes the vehicles up to their right speed (e.g. baggage handling, LIM based trains and rollercoasters). The infrastructure warns against ice, registers wear and tear, and changes the number of lanes according to traffic density.

- New income streams are created as operation of the transport system, be it a private car or a road network, gets crammed with ICT. Accordingly, the role of the contractor shifts its emphasis from limited period stone and steel construction work towards organising for the procurement of ICT hardware and software installation and maintenance, as well as the procurement of services for the lifetime of the system.

Where ITS Already is, the ICT Business Follows

We see that ITS is thriving in a particular corner of a business and technology landscape in which the whole ICT business wants to graze.

We also see that ICT increasingly is enabling technology for modern transport as it is envisaged to develop: Radiobased data networking, mobile as well as fixed computing, geographic positioning, location as well as user specific information, sensoring as well as pneumatic logic steering, fleet management and data exchange between all such building blocks are among the input factors to constitute the platform on to which the activities of daily life is

[8] *The "rebound effect" denotes the lost gain that occurs when the gain from some environmental measure is used to increase rescource use, e.g. when better traffic flow is used to visit more stores.*

presently being ported. (The way Telenor over a period did approach this field, is described in a separate paper in this issue of *Telektronikk*.)

We also see that the ICT applications we are talking about take place over all kinds of networks varying in intensity and bandwidth demands: Low intensity communication between the tyres and the car control system, high bandwidth demanding bursts to catch the picture of a person, frequent low intensity broadcasts between vehicles in a network, steady high bandwidth to make a hospital take over a patient "seamlessly" from the ambulance. Dream-ware a few years back – reality in 2002.

We can even easily see that this is a landscape of very different products, sizes, and players: mass products as well as the tailor-made, huge applications as well as the tiny, consumers, SMEs, OEMs (car manufacturers), transportation industry and government.

Hence, dealing with ITS seems unavoidable for ICT companies: ITS will just catch on, and the telco networks, service platforms, and services will be involved at some level. As datacom turns into a general infrastructure for datacom and mobile computing, ITS will just happen on top of it.

The providers of the various infrastructures on which ITS shall build, may not be aware of it happening at all. They will simply be fit, or not so well fit, for the various demands on infrastructure of the various ITS applications. Hence, ITS is just yet another area where the network provider will have to choose whether his business now and in the future is best served by staying with the networks only – if so, with which of them, or by entering the field with niche specific competence to open markets, and hopefully, through gaining a competitive advantage in the understanding of the demands, become a preferred provider of any combination of suitable networks, suitable production platforms, or even content.

There is no context independent or *a priori* answer to such a row of options – apart from one:

As an endurable business idea, to stay with the networks only needs a strategy for assuring that just those networks are the preferred ones among the many alternatives that may be present where mobile computers stroll. In practice, such a strategy would imply taking an active part in developing and closely following the field of ITS, as well as its users and initiators.

Literature

Audestad, J. Telecommunications and Complexity. *Telektronikk*, 94 (3/4), 2–20, 1998.

Commission of the European Communities. *European transport policy for 2010: Time to decide*. Whitepaper, COM (2001) 0370. Brussels, 2001. URL: http://europa.eu.int/comm/energy_transport/en/lb_en.html

Denton, T, Menard, F, Isenberg, D. *Netheads versus Bellheads: Research into Emerging Policy Issues in the Development and Deployment of Internet Protocols.* Final report for the Federal Department of Industry, Ottawa, 2000. URL: http://www.tmdenton.com/netheads3.htm.

Gilder, G. *Telecosm: How Infinite Bandwidth Will Revolutionize Our World.* New York, The Free Press, 2000.

Isenberg, D. *The rise of the stupid networks.* 1997. February 18, 2003 [online] – URL://www.isen.com

Stabell, C, Fjeldstad, Ø. Configuring value for competitive advantage: on chains, shops and networks. *Strategic Management Review Journal*, 19, 1998.

Stiglitz, J. *Globalisation and its discontents*. New York, Norton & Co., 2002.

Tirole, J, Laffont, J-J. *A Theory of Incentives in Procurement and Regulation.* Cambridge, MIT Press, 1993.

WBCSD. *Mobility 2001 – mobility at the end of the twentieth century and its sustainability.* Project report prepared for the Sustainable Mobility Working Group of the World Business Council for Sustainable Development by the Massachusetts Institute of Technology and Charles River Associated Incorporated. WBCSD, 2001.

Standardisation and Trends – Why is Standardisation of ITS Needed?

STEINAR H ANDRESEN AND KNUT EVENSEN

Steinar Hidle Andresen (59) is Professor at the Department of Telematics, the Norwegian University of Science and Technology, Trondheim. His research interests include Network and service aspects of Mobile/Cellular systems and Wireless LANs, Communication services for emergency services, Architecture and protocols within the Intelligent Transportation Systems, Network Intelligence and Mobility Management. Andresen has broad system knowledge within the above areas, plus specialist's knowledge in some of the fields: switching networks, communication protocols, electronic localisation techniques and some formal description techniques (e.g. ASN.1).

steinar.andresen@item.ntnu.no

Knut Evensen (42) obtained his MSc in Telematics from the Norwegian Univ. of Science and Technology (NTNU) in 1981. In 1985 he joined Micro Design R&D department in Trondheim. He became involved in ITS international R&D projects and standardization efforts in 1988, and is currently the section manager responsible for this field in Q-Free. Knut Evensen holds several formal positions in ISO and CEN related to development of advanced ITS communication standards.

knut.evensen@q-free.com

1 Introduction

The human demand for transport has influenced both our ingenuity and our environment. The demand for water transport in early times resulted in impressing aquaducts, and since Roman times roads have influenced the landscape. In modern times railroads and roads for motor vehicles have had a profound impact on our environment. Bridges and tunnels allow constructions of carriageways never thought possible, resulting in efficient and impressive traffic arterials. But is there not also a downside? Sure, the motorized movement (and even the parking) of cars and big lorries has caused increasing congestion, pollution, and a sheer demand for space not compatible with medieval villages and towns.

This has resulted in excessive land use and in many countries and urban "sprawl"; housing and urban settlements invading the countryside fostering more traffic.

Then enters ITS (Intelligent Transportation Systems) also called Transport Telematics, what is it? Can it have any impact? It will and already today, like it or not, most new cars have many computers and literally hundreds of motors and actuators. Modern cars come with a wiring corresponding to a local area network. Combine this with technology from cellular and wireless networks, navigation means like GPS and the signal processing capacity of modern circuitry; then you will see that a revolution is bound to happen. What would be the impact? Well, that is difficult to say, but the sheer volume of the traffic in question makes even small improvements favourable. If a modern navigation system can save 7 % of mileage (a number obtained more than 6 years ago in London) this will have an instant impact on the bottom line for the distribution firm in question. So far we have mostly seen incremental improvements on "traditional" transport means, but the future may also foster widespread use of more revolutionary systems as depicted in the PRT (Private Rapid Transport) systems reported elsewhere in this issue.

In this article we will focus on on-road traffic, both for personal mobility and goods transport. This kind of traffic has perhaps more than any other thing influenced our environment and landscape (construction of roads, interchanges, bridges, tunnels, car parks).

2 Why Standardisation is Needed

The aim of ITS is to make transport

1 More efficient, both in terms of its influence on energy usage and environmental impact, as well as the money and time budget;

2 Safer, reducing the number of accidents in transport especially reducing the number and degree of serious damage to individuals. Recent developments have shown the need for anti-terrorist usage;

3 More user friendly and enjoyable.

When trying to implement the ITS means it is worth mentioning the different views held by the car makers on the one side and the authorities and the general public on the other: Both sides may subscribe to the aims given above, but the car makers tend to concentrate on the characteristics and equipment of their own cars, more than on the infrastructure and general picture.

Standardisation is an old remedy used to facilitate widespread introduction of an intended practice. As can be deduced from the comment above, it is a process more likely to be driven by authorities and public interest groups. Within this field the general business landscape is somewhat confusing as legacy car producers team up with Microsoft and cellular communication operators or equipment makers to launch new services and features. This is known as ad-hoc or industrial standards.

However on a regional scale standardisation efforts was started in the late 80s and formalised within the ISO standardisation framework in the 90s.

For automotive traffic, this work is structured within the auspices of ISO Technical Committee TC 204 "Transport Information & Control Systems" which draws participant members from the following 22 countries: Australia, Austria, Canada, China, Czech Republic, Denmark, France, Germany, India, Iran, Ireland, Italy, Japan, Korea, Malaysia, The Netherlands, Norway, The Russian Federation, Sweden, United Kingdom and USA and observing membership from about 26 more nations (among them Finland).

The TC 204 is responsible for standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the transport information and control systems (TICS) field. (With the omission of in-vehicle transport information and control systems which is taken care of by ISO/TC22.)

ISO/TC 204 is responsible for the overall system aspects and infrastructure aspects of transport information and control systems (TICS), as well as the coordination of the overall ISO work program in this field including the schedule for standards development, taking into account the work of existing international standardization bodies.

The TC204 has formal liaisons to other standardization bodies like:

• ISO/TC22	Road Vehicles
• ISO/TC23/SC19	Tractors and Machinery for Agriculture and Forestry – Agricultural Electronics
• ISO/TC104/SC4	Freight Containers – Identification and Communication
• ISO/TC211	Geographic Information and Geomatics
• ISO/IEC JTC1	Information Technology

These are all termed "internal liaisons". The following "external liaisons" are also established:

• ITU	The International Telecommunications Union, and
• CEN/TC 278	Road Transport and Traffic Telematics

CEN 278 has the responsibility within Europe for the overall co-ordination of Road Transport and Traffic Telematics (or RTTT) systems.

The committee has a number of groups and subgroups with scopes as given below.

ISO TC204 Working Groups

- **WG 1 Architecture** (has provided a number of standards)
  The mission of WG1 is to provide ISO TC204, its Working Groups, related bodies, and those involved in the TICS sector with a reference model of Conceptual Reference Architecture(s) that show the structure and interrelationships of the sector and to provide timely and appropriate definitions of Terminologies by means of glossaries and dictionaries, which explain, in plain language and with the minimum of jargon, the terms in use in TICS. In all of this work, the overall objectives of TC204 to provide cost efficient enabling structures are paramount.

- **WG2 Quality And Reliability Requirements** (inactive)

- **WG3 TICS Database Technology** (UML is used)
  The mission is to provide:
  - Geographic Data File – The definition of an application independent standard for interchange of TICS database;
  - Data models used for the storage of Vehicle Navigation and Travelers Information Systems database compiled from geographic data file;
  - Standards used for specifying the location referencing procedures for the geographic database;
  - Standards that will specify the formats and procedures for publishing updates of geographic database used in TICS applications.

- **WG4 Automatic Vehicle and Equipment Identification – AVI/AEI** (architecture is provided)
  The aim of this group is to:
  - Establish long term guiding principles for all levels of interoperability that are necessary for AVI/AEI including Intermodal and Multimodal transport chains;
  - Standardisation of a system architecture, including numbering scheme architecture, reliability and accuracy criteria and environmental parameters;
  - The development of standards based on perceived user requirements for AVI/AEI, including Electronic Licence Plate and Intermodal/Multimodal transports.

- **WG5 Fee and Toll Collection** (architecture is provided)
  Standardisation of information, communication, and control systems in the field of fee and toll collection systems for urban and interurban surface transportation.

- **WG6 General Fleet Management** (merged with WG7)

- **WG7 General Fleet Management and Commercial/Freight** (work in progress, lacking architecture)

Definition of standards in the areas of Fleet Management and Commercial/Freight operations systems to improve the management and safety of these fleets and facilitate the interaction between the vehicles/freight/operators and the local, national and international authorities within the intermodal and multimodal environments.

- **WG8 Public Transport/Emergency** (no architecture available)
  Define standards for public transport and Emergency services, including bus stop numbering, in-vehicle networks, emergency services, etc.

- **WG9 Integrated Transport Information, Management and Control** (providing architecture. Using UML)
  - Define the systems that will operate to provide end-users with integrated transport information, management, and control;

  - List the intended functionality of those systems. Where there is a need in terms of safety of users, the interoperability of the systems, or compatibility between systems.

- **WG 10 Traveller Information Systems** (providing Architecture)
  This working group is concerned with the timely delivery of accurate, relevant information to travellers, in a form suitable for them to use. This encompasses the broad range of travel modes in urban, interurban, and rural transportation. Travellers should have easy access to complete information about their travel alternatives and accurate information on current and expected travel conditions to enhance their mobility.

- **WG11 Route Guidance and Navigation Systems** (determines plans to provide architecture)
  Route Guidance provides orientation to the driver and gives route recommendations on how to reach a destination. The systems may also consider the actual traffic situation in providing routes and may also make recommendations regarding alternate travel modes. When routes are generated in the infrastructure, the in-vehicle system receives the calculated routes via a communication link.

- **WG12 Parking Management/Off Road Commercial** (inactive)

- **WG13 Man Machine Interface** (inactive, work transferred to ISO TC22)

- **WG14 Vehicle/Roadway Warning And Control Systems** (may be using UML, no deliverable identified)
  Includes the standardization of devices of systems that contribute to any one or more of the following purposes: avoiding crashes, increasing roadway efficiency, adding to driver convenience, reducing driver workload, improving the level of traveller safety, security, and assistance by using information about the driving environment.

- **WG15 Dedicated Short Range Communications for TICS** (subsumed into WG5 architecture)
  Dedicated Short Range Communications (DSRC) describes data exchange between roadside stations (e.g. Beacon, interrogator, and leaky feeder) and vehicles if equipped with onboard-unit (OBU).

- **WG16 Wide Area Communications Protocols and Interfaces** (provided in CALM architecture, see below)
  WG16's area of focus is wide area data exchange between Control Centers and User Devices in support of TICS applications. Initially WG16 concentrated on message structure and protocol specifications independent of communication medium (e.g. sub-carrier technologies, cellular, PCS, satellite, SMR). WG16 will not define application data elements.

3 What is Obtained So Far?

USA and Japan have had a large scale investment in ITS for many years, resulting in a comprehensive framework in each region. The European standardisation organisation CEN has TC278 groups which have teamed up with corresponding ISO TC204 groups, and hence influenced the international standardisation work quite a lot. In parallel with this the EU Commission under the KAREN (alter FRAME-ITS) has supported the development of a European system architecture. This "framework" is later implemented into a diverse set of national architectures that hopefully are in harmony with each other. The European countries shown in Table 1 have their own ITS architecture project finalized or in progress.

The generally used scheme is to subdivide all the architectures into the following main parts:

- Functional/logical architecture;
- Physical architecture; and
- Implementation architecture (including market packages).

A simplified view of the US logical architecture is shown in Figure 1 [5] (Source: (US) Executive Summary, prepared by the Architecture Development Team, Iteris, Inc. Lockheed Martin). The architecture defines the functions ITS must perform in support of a traveller's requirements, not

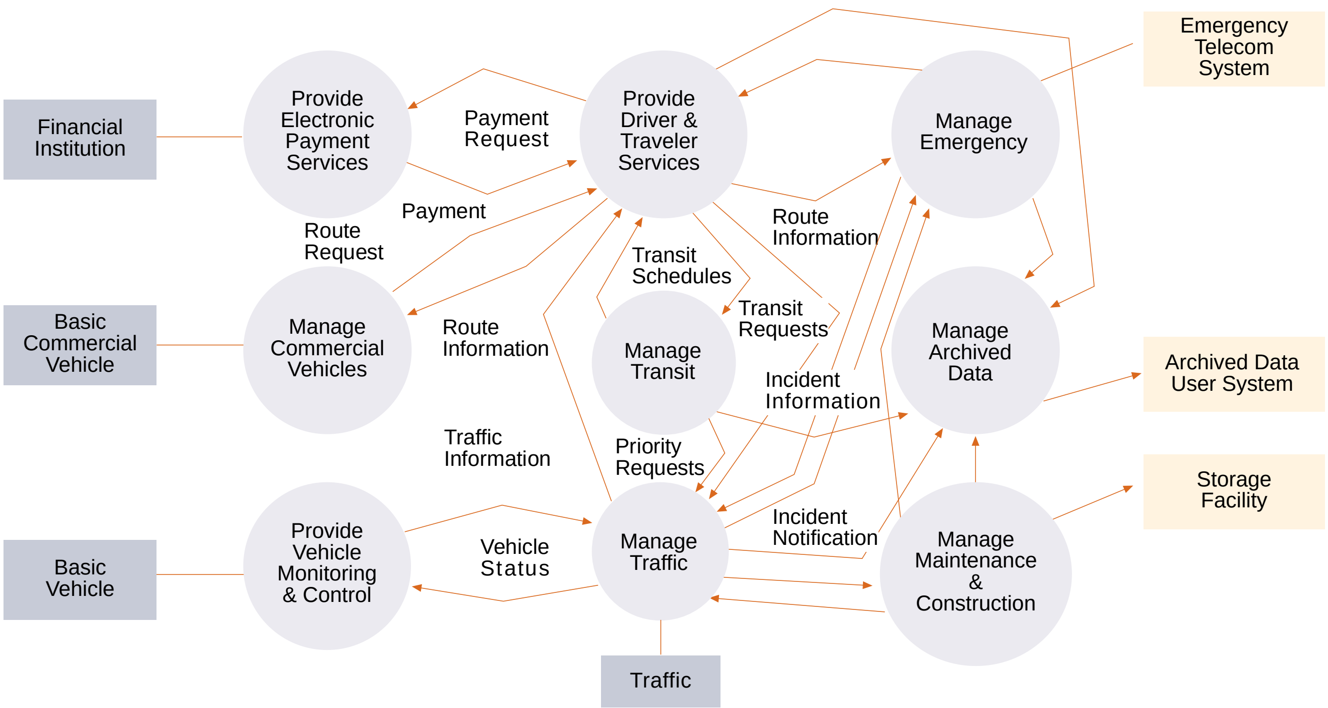
Table 1 European Architecture Projects [1]

Country	Project name	Comments
France	ACTIF = L'architecture cadre des STI (Systeme Transport Intelligence) en France.	Is well developed, developed based on the KAREN reference model. 50 % financed by the EU. The results are published and taken into use.
The Netherlands	De AVB = Architecture for traffic management and Control	Is well developed. The authorities offer courses for various user groups.
Finland	The National Transport Telematics Architecture – TelemArk	Finalised in January 2001.
Italy	ARTIST = Architettura Telematica Italiana Per Il Sistema Dei Trasporti	Draft no 2 issued July 2002. The final report in November 2002. The work is harmonised with the French ACTIF.
UK (Partly)	UMTC = Urban Traffic Management & Control	Concentrates on traffic management in urban areas.
Norway	ARKTRANS (System architecture for inter-modal management of goods and passenger transport) [2]	Under development, special emphasis on the inter-working between different transport modes (car, train, ship and air transport). The work has connections also to THEMSIS [3] and WATERMAN-TS [4] (thematic Networks EU projects).

the functions of the traveller. A financial institution that processes tolls is outside of the architecture, whereas the ITS components that detect vehicles and collect tolls are inside. Existing broadcast media for the transmission of traveller information are outside of the architecture, but the elements that provide ITS traveller information to the media are inside. The other architectures exhibit similar structures.

External actors can either be real users (yellow) or the auxiliary systems to facilitate the services (in dark blue)[1]. The light blue dishes represent different service classes.[2] The 21 main service

Figure 1 The US logical ITS Architecture – (Simplified Top Level Architecture)



1) *The colouring scheme is introduced here in this article for clarification.*
2) *The word "transit", in the US, refers to public transportation systems, i.e. in this context it (most likely) means bus and light rail systems.*

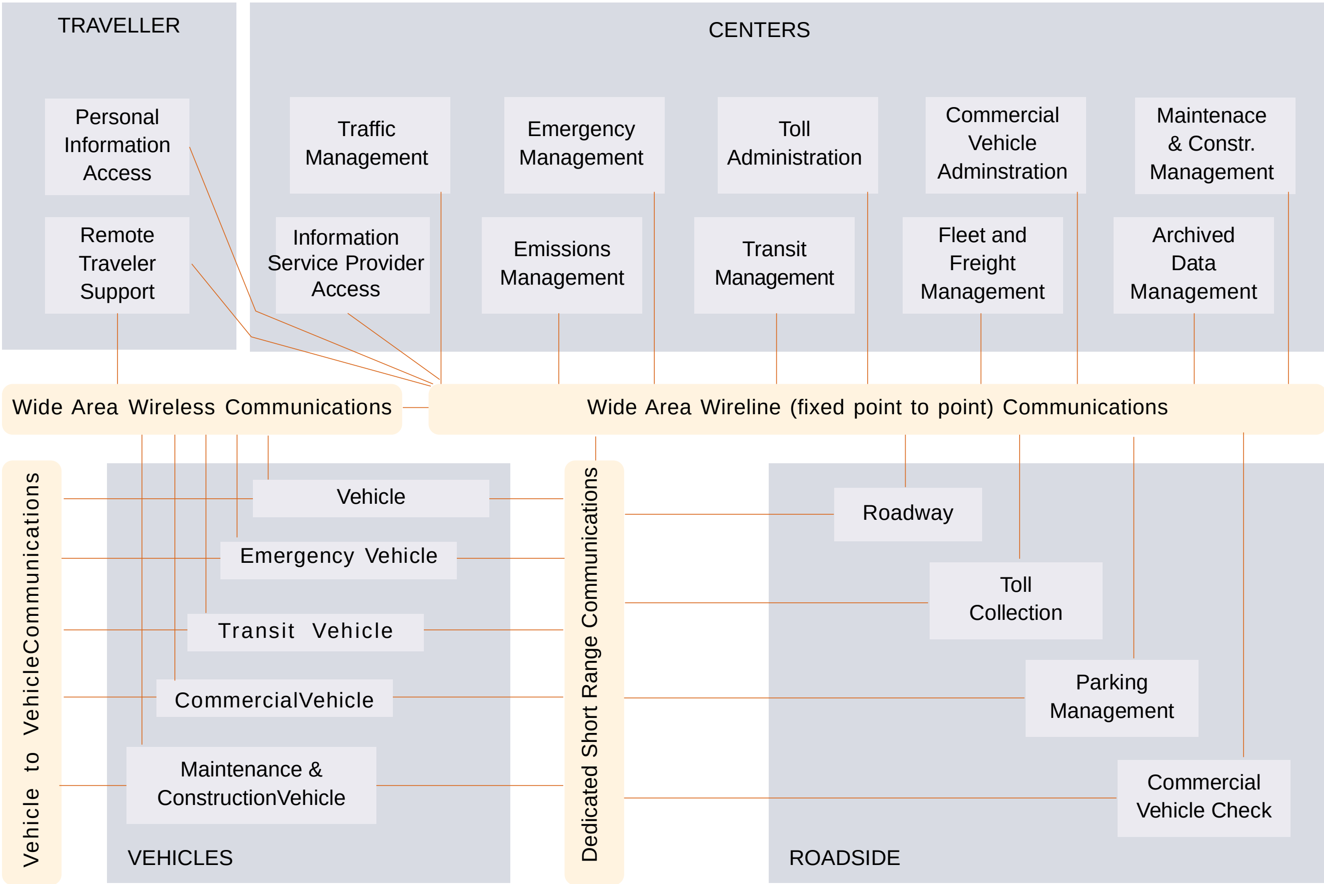


Figure 2 The US Physical ITS Architecture

subsystems (light blue boxes) contained in the US Physical architecture are shown in Figure 2. These subsystems can broadly be divided into four classes as illustrated by the larger coloured boxes (denoted functional blocks in the standard) named "Traveller", "Centers", "Vehicles" and "Roadside". The specific choice of twenty-one service subsystems represents a lower level of partitioning of functions that is intended to capture all anticipated subsystem boundaries for the present, and 20 years into the future. Figure 2 is often referred to as the "sausage diagram", referring to the shape used for the communications services connecting the functional blocks. The thin lines represent the main information paths and type of information exchanged.

4 About the Merger of Automotive, Communication and Computer Industries

A modern car has many hundred motors, sensors, actuators and many computers. The top models usually have several interconnected networks between all the computers and microcontrollers. In-vehicle standards (responsibility of the ISO/TC22 Road Vehicles committee) try to harmonize the utilisations of control means and practices within the vehicle. With so much electronics, no wonder efforts are under way to harness the possibilities in a comprehensive platform for safety, driving efficiency, maintenance and entertainment.

Regarding safety, for example automatic airbag deployment notification could furnish a nearby emergency centre with location and time in order to provide assistance on time.

One interesting issue that ought to be mentioned (writing for a telecom journal) is a surprising decision made last year by the US standardisation group and then by the corresponding ISO TC204, working group, when they voted in favour of using the IEEE 802.11a R/A (roadside applications) as the preferred technology to provide the national interoperability for DSRC Public Safety-based applications. Simultaneous with this DaimlerChrysler Research and Technology North America demonstrated a Mercedes Benz with 802.11a capability and a concept of "Info-Fueling" [6].

The annual meeting of ITS America this year featured a session "Next-Generation ITS Radio communication Services: Impact on Public Safety". The session discussed the clear delineation that is now emerging between next-generation Broadband ITS Radio communication Services that are intended to provide a long and medium-range communications capability and Dedicated Short-Range Communications (DSRC) limited to short-range devices. The panel discussed the significant activities, both RF and infrared, being treated by ISO/TC204 regarding Continuous Air-interfaces Long and

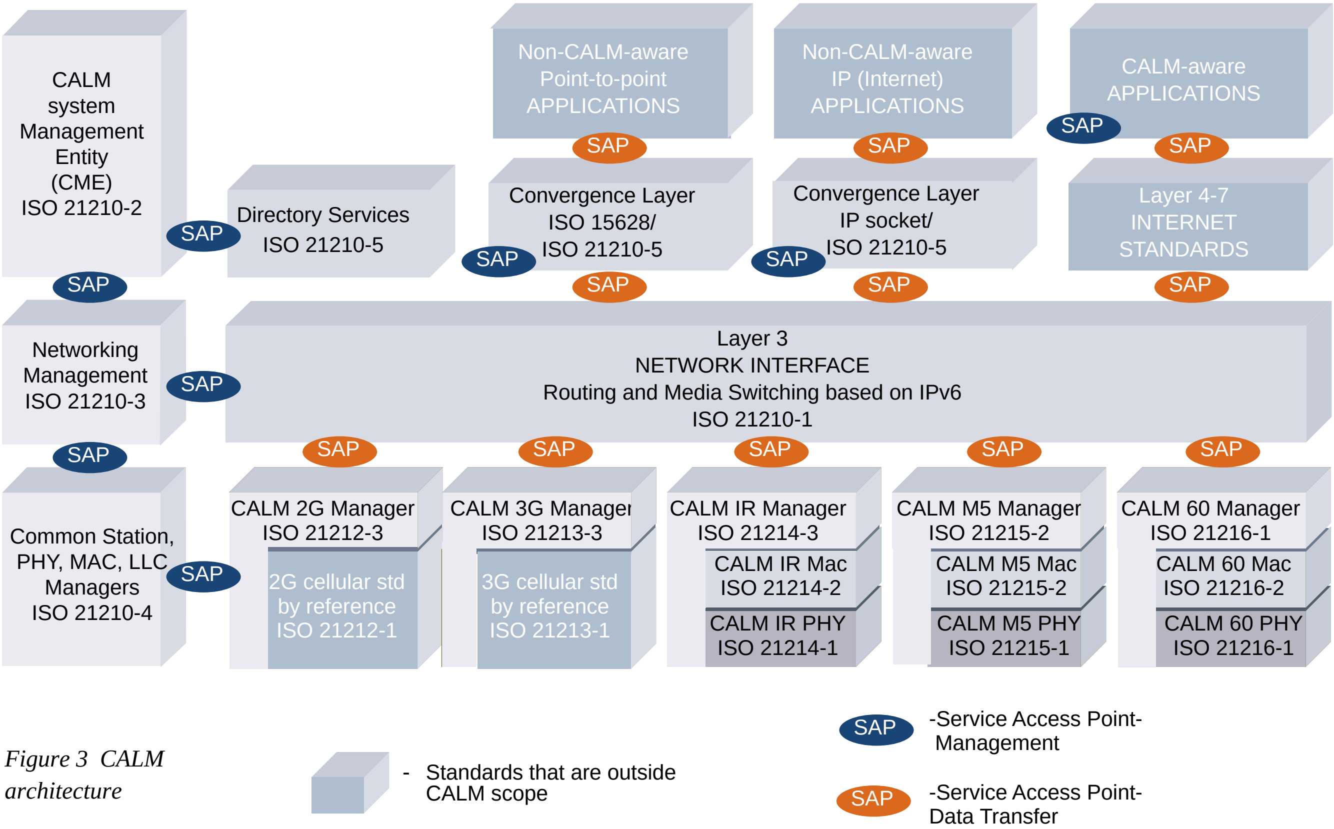


Figure 3 CALM architecture

Medium range (CALM) networks and DSRC. In addition to commercial applications, the panel also discussed ITS Public Safety-based applications that have priority in this spectrum. The WG 16 of TC204 has produced a document where CALM M5 (Continuous Air-interfaces Long and Medium Range – Microwave 5 GHz) standards are integrated into a general ITS communication architecture and the IEEE standards committee has agreed on (Dec. 6, 2001) the following project groups, that will work on details in the 802.11a R/A standard:

- **P1609.1** (SCC32) Standard for DSRC (Dedicated Short Range Communications) Resource Manager
- **P1609.2** (SCC32) Standard for DSRC Application Layer
- **P1609.3** (SCC32) Standard for IP Interface for DSRC
- **P1609.4** (SCC32) Standard for DSRC Resource Manager

Other activities seem to pick up on the new communication possibilities. There is a group of vehicle manufacturers (VSC, the Vehicle Safety Consortium) consisting of the seven largest vehicle manufacturers globally, which are looking at the possibility of reducing traffic accidents by CALM-type communication. The group is yet to publish its findings, but they have more than fifty applications defined. This ranges from simple things like electronic brake-lights and electronic road signs, to more esoteric applications where all vehicles are continuously transmitting their position and vector for other vehicles to build a collision avoidance model. It is interesting to note that this is sponsored by the US DoT, and that they may make some of these functions mandatory as basic safety features in the future.

The protocol architecture is illustrated in Figure 3 and the set of assumed services in Figure 4.

The CALM architecture shows several functional elements. At the lower layer, there are several media that will be used.

From the right-hand side, we have 60 GHz millimetre wave communication. This is a future medium that most likely will be integrated with Doppler-radar to facilitate platooning, or vehicles automatically driving after each other as an electronically connected train. The benefits of 60 GHz is the high data rate (one gigabit/s or more) and the very low link latency. Drawbacks are the short communication distance and high technology costs for 60 GHz. The task has recently been taken up by Japan which has extensive research on this.

The next medium is the 5 GHz medium. This medium is based on IEEE 802.11a that has been slightly modified for global use and the mobile environment. Performance parameters for this

PUBLIC / SAFETY

- APPROACHING EMERGENCY VEHICLE ASSISTANT
- EMERGENCY VEHICLE SIGNAL PREEMPTION
- VEHICLE BASED PROBE DATA COLLECTION
- TRAFFIC INFORMATION
- CURVE SPEED ASSISTANCE
- STOP LIGHT ASSISTANT $ INFRASTRUCTURE
- INTERSECTION COLLISION WARNING/AVOIDANCE
- COOPERATIVE COLLISION WARNING [V-V]
- OPTIMAL SPEED ADVISORY
- COOPERATIVE VEHICLE SYSTEM § PLATOON
- RAILROAD COLLISION AVOIDANCE
- INFRASTRUCTURE BASED TRAFFIC MANAGEMENT
- VEHICLES AS PROBES
- WORK ZONE WARNING
- ROAD CONDITION WARNING
- ROLLOVER WARNING
- LOW BRIDGE WARNING
- LOCATION BASED PROBE DATA COLLECTION
- TRANSIT VEHICLE DATA TRANSFER (gate)
- TRANSIT VEHICLE SIGNAL PRIORITY
- EMERGENCY VEHICLE VIDEO RELAY
- MAINLINE SCREENING
- BORDER CLEARANCE
- ON-BOARD SAFETY DATA TRANSFER
- VEHICLE SAFETY INSPECTION
- DRIVER'S DAILY LOG
- TRANSIT VEHICLE REFUELING MANAGEMENT

PRIVATE

- ACCESS CONTROL
- DRIVE-THRU PAYMENT
- PARKING LOT PAYMENT
- DATA TRANSFER / INFOFUELING
  - ATIS DATA
  - DIAGNOSTIC DATA
  - REPAIR-SERVICE RECORD
  - VEHICLE COMPUTER PROGRAM UPDATES
  - MAP and MUSIC DATA UPDATES
  - VIDEO UPLOADS
- DATA TRANSFER / CVO / TRUCK STOP
- ENHANCED ROUTE PLANNING and GUIDANCE
- RENTAL CAR PROCESSING
- UNIQUE CVO FLEET MANAGEMENT
- DATA TRANSFER / TRANSIT VEHICLE (yard)
- TRANSIT VEHICHLE REFUELING MANAGEMENT
- LOCOMOTIVE FUEL MONITORING
- DATA TRANSFER / LOCOMOTIVE

Internet Applications!

ATIS: Advanced Traveler Information Systems
CVO: Commercial Vehicle Operations
Red: Long Range Applications (up to 1000 meters)
White: Medium/Long Range Applications (90-300 m)
Black: Medium Range Application (Up to 90 meters)

Figure 4 CALM applications

medium is from 6 Mbit/s at several hundred metres up to 54 Mbit/s at 30 metres. The medium is used for both vehicle-to-vehicle communication carrying safety data, and for vehicle-to-roadside communication carrying other data like Internet access. This particular medium is amongst the most interesting part of CALM, and a version or subset of it will be selected for US deployment. One interesting aspect is that the vehicle can connect to a normal 802.11a access point even when parking in your home garage. This group is led by one of the authors of this article.

CALM InfraRed (IR) is a medium that is specifically developed for CALM and ITS. It uses 850 nm in-coherent light with a data rate of 1 Mbit/s upwards, and communication distance from 10 metres upwards. The main benefit is that IR is not under regulatory control yet.

UMTS or 3G is also part of the CALM scope as a convergence layer is created on top of the UMTS protocol stack will interface the common Service Access Points. This is being done in liaison with ETSI, the European Telecom Standardisation Institute.

Also 2/2.5G cellular, more commonly known as GSM/GPRS, are part of the scope. Also here the normal communication stacks of ETSI are used, but an additional convergence layer is being defined as an interface to the SAPs.

Each of the media have their own management to control the behavior, such as frequency and power control.

The binding "glue" in this architecture is the network layer. One of the first decisions were to use IPv6 which is the new Internet standard that removes the old problems of limited numbering space. It also added a lot of very useful facilities for mobile environments like Quality of Service, Security, Mobility addressing, etc.

The "intelligence" in the architecture is the CME, or CALM Management Entity. This module will record the capabilities of each connected medium in terms of data rate, QoS, cost etc, and then match this with the requirements from the applications running on top of the stack. It will also decide on heterogeneous handover in case a homogenous handover at the MAC layer is not possible.

Figure 5 shows some of the applications that were included from the start. Since this time, many new safety applications have been introduced, and the case of Internet in the vehicle has

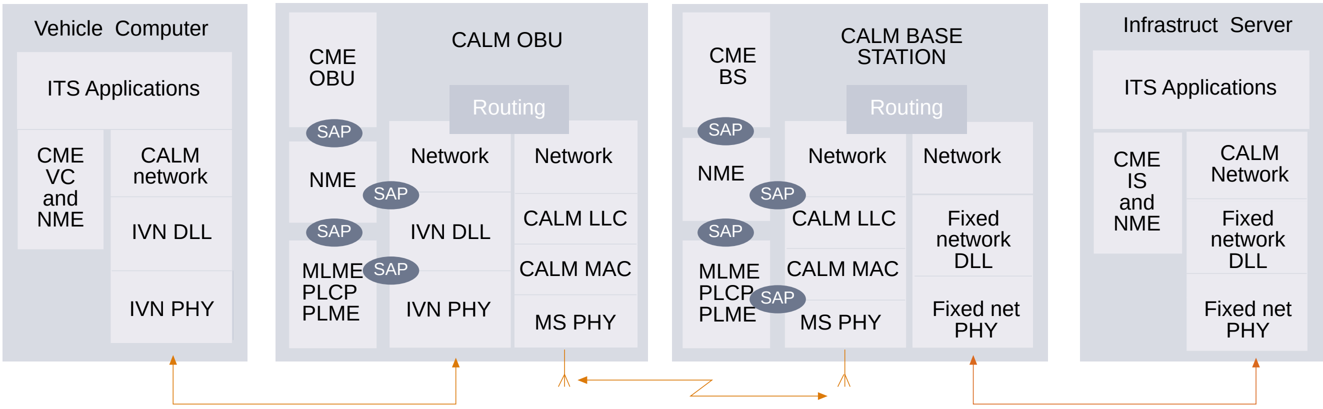


Figure 5 ITS vehicle – Infrastructure communications based on CALM

been strengthened. Note that in this figure, the range is up to 1000 metres (from access points).

The concept of CALM in the vehicle is relatively simple. The car manufacturers (or OEMs) have their own data buses in the vehicle. The different media boxes are connected to this bus, and one or more computers that use the media are also connected. One interesting aspect is the connection to the engine/traction control networks. This means that the ITS functions can get hold of information about road traction/temperature and other safety info to broadcast to approaching vehicles. It also means that car manufacturers may have service access to the systems on-board, for instance to check the status or to download new firmware revisions to the on-board computers.

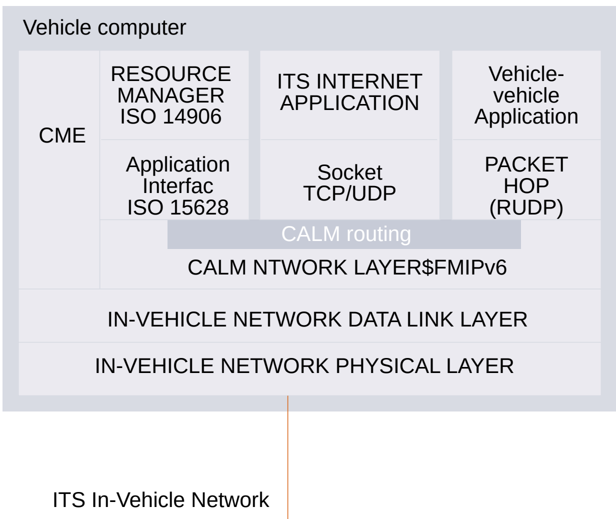
Figure 5 illustrates the protocol hierarchy in the CALM-Vehicle infrastructure. Please note that direct peer-to-peer communications between vehicles also should be possible.

Figure 6 illustrates a sample physical implementation of the communications. Note that in this case there may be several parallel communication parts.[3)]

5 Conclusion

Although it is still "early dawn" in the age of ITS, there are already many success stories:

- Improved, more efficient public bus systems in London, Bologna, Flanders, Barcelona, Brussels, Geneva, Rouen, Madrid, Hampshire [7];
- Advanced travellers' information systems – to drivers in France, England and Scotland, Germany and others countries [8];



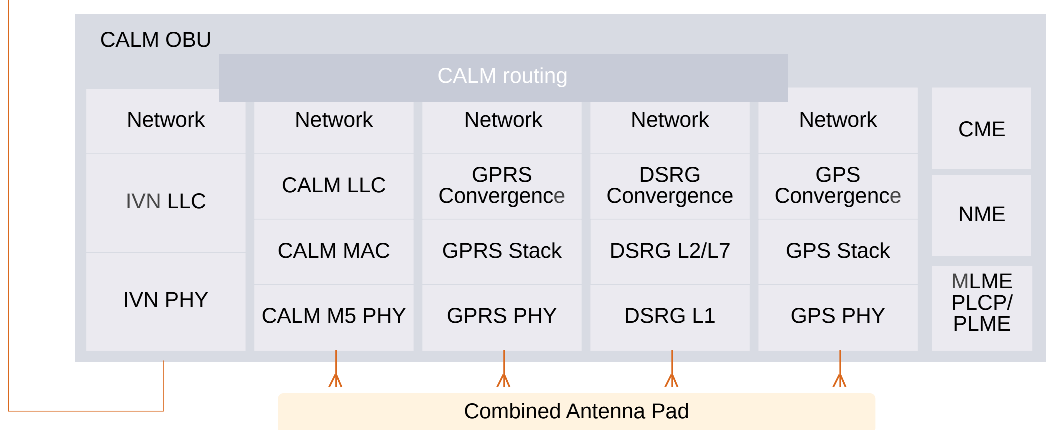


Figure 6 Sample in-vehicle implementations with CALM, and other communication interfaces (UTRA will be added in future)

[3)] *Figures 4, 6 and 7 were presented by Knut Evensen at The ITS World Conference, Chicago in October 2002. Figure 4 is rendered here in an updated version. Figure 5 was presented at ITS America's annual meeting, April 2002.*

- Traffic surveillance and control systems, also utilised to control pollution;
- TR4005 COMETA – COMmercial vehicle Electronic and Telematic Architecture – A common ITS framework for Freight and Fleet management in Europe [9].

And not to forget a Norwegian success story:

- The AutoPASS tolling system owned by the Norwegian Public Roads Authority. Although the system is primarily intended for road tolling, it also forms a platform for an advanced national ITS architecture.

So the bundling of computers, communications and physical transport is here to stay. It is too early to make specific assumptions about potential new and innovative transport schemes, but the area represents many possibilities both for improving the environment and – for doing business. What is clear, though, is that these services demand a telecommunication infrastructure, which should service the control and monitoring of road environment, traffic and weather, and also to an increasing extent wireless access. Hence, it would be quite natural to look into schemes that somehow establish common "information highways" along the main roads in order to satisfy such demands, combining the best features of ITS and (short to medium range, high capacity) wireless communications. In most countries, however, public authorities (like the state, county or city) own the roadways, whereas private enterprises serve the telecom business. Hence this version of "information highways" is not likely to be implemented on a large scale very soon. In areas where private enterprises influence the process, commercial pressures may drive the process faster (Build-operate-transfer and Public-Private Partnerships).

There is a quest for a "killer application" for these new services. What it will be, is still not clear, but three areas are promising:

- The first one may be safety. With the vast number of fatal accidents only in the EU area, even a small percentage of saved lives will defend the results from a socio-economic viewpoint. People are also willing to pay for safety, and history shows that a safety option will become the default in vehicles within a couple of years. (Think about safety belts, air bags, anti blocking brakes and so on.)
- The second likely candidate to get these architectures going is Internet access in vehicles. Ubiquitous access to the network now has become a requirement; the public will not accept lower service in their vehicles than elsewhere.
- The third option is the one most often quoted: Electronic Fee Collection. Payment services are already very widespread in many countries, and the type of communication interfaces and infrastructure that EFC is using can easily be applied for other services as well. The Norwegian AutoPASS system delivered by Q-Free is a good example of this, since the system from the outset was planned for many ITS applications.

References

1 *FRAME, Forum for the European ITS Framework Architecture* . February 18, 2003 [online] – URL: http://www.frame-online.net/. This site also contains links to various national projects (choose "links").

2 *The Norwegian ARKTRANS project.* February 18, 2003 [online] – URL: http://www.informatics.sintef.no/projects/arktrans/arktransweb/

3 *Themis*. February 18, 2003 [online] – URL: http://themis-network.org/

4 *WATERMAN-TS*. February 18, 2003 [online] – URL: http://www.waterman-ts.net/.

5 *National ITS Architecture.* February 18, 2003 [online] – URL: http://itsarch.iteris.com/itsarch/. Executive summary, URL: http://itsarch.iteris.com/itsarch/html/menu/documents.htm

6 NetworkWorldFusion. *Comdex – Wireless LAN-enabled cars.* April 25, 2003 [online] – URL: http://www.nwfusion.com/news/2001/1113wlancx.html. (More recent entries can be found on the web by search using "InfoFueling" as search string.)

7 *Automatic Bus Depot Management (Bologna, Italy)*. February 18, 2003 [online] – URL: http://www.ertico.com/its_basi/succstor/automat.htm
Countdown – Real-time Bus Stop Information (London, UK). February 18, 2003 [online] – URL: http://www.ertico.com/its_basi/succstor/countdow.htm

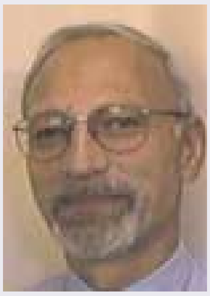
8 *European success stories.* February 18, 2003 [online] – URL: www.ertico.com/its_basi/succstor/success.htm

9 *TR4005 COMETA – COMmercial vehicle Electronic and Telematic Architecture.* February 18, 2003 [online] – URL: http://www.cometa-project.com/uk/ ukproj0c.htm

ITS Research Activities in Telenor

TORE A. WORREN, SIGRID S. BYGDÅS, KNUT KVALE, ELIN MELBY AND TORE URNES

The Intelligent Transportation System (ITS) field has a wide scope that covers vehicles, transportation, computer technology, and more. Past decades have seen developments driven mostly by the public sector, focusing on road and traffic administration, in addition to safety and pollution. The ITS project in Telenor R&D takes a somewhat different perspective. We focus on the traveller, and our mission is to identify services that assist, advice, and entertain travellers. This article presents four challenges of human-centred ITS and elaborates on two of them: distraction free user interfaces and highly dynamic, localized information spaces.



Tore Arthur Worren (53) graduated from the Norwegian Institute of Technology (NTH), Trondheim in 1979. He worked with Telenor R&D from 1980 to 1987, and then again from 1998 till the present day. In the period between he worked with Telenor Mobile and with Teleplan. He is now working in the Future Wireless World in Telenor R&D, with the radio aspects of UMTS as well as GSM. His current activities in Telenor R&D are on its ITS project.

tore-arthur.worren@telenor.com

Introduction

This article presents a research project initiated by Telenor R&D aiming to support the needs of travellers two to five years into the future. Typical travellers include operators of vehicles, passengers of public transportation, and pedestrians. Note that during a single journey, a traveller may use a combination of different modes of transportation in sequence. Unlike traditional Intelligent Transportation System (ITS) projects that often focus on tasks such as administering roads or optimising traffic flow, our project is more human-centred, aiming to assist, advice, or entertain future travellers. We believe human-centred ITS holds great promise of enhancing the travel experience, making travel more efficient and enjoyable. Figure 1 depicts our vision of human-centred ITS through a collection of fictional usage situations.

The needs of future travellers are a key driving force behind our work. To uncover likely needs of future travellers, we have conducted user surveys and developed scenarios. In addition, we are building prototypes demonstrating possible future services that cater for travellers. It is our hope that evaluations of such prototypes can help to further illuminate travellers' needs and how they can be met.

Human-centred ITS poses a wide range of research questions, covering technical, economical, and socio-political issues. We therefore decided to limit the scope of our work to the following set of questions:

- Does human-centred ITS present interesting business opportunities for Telenor?

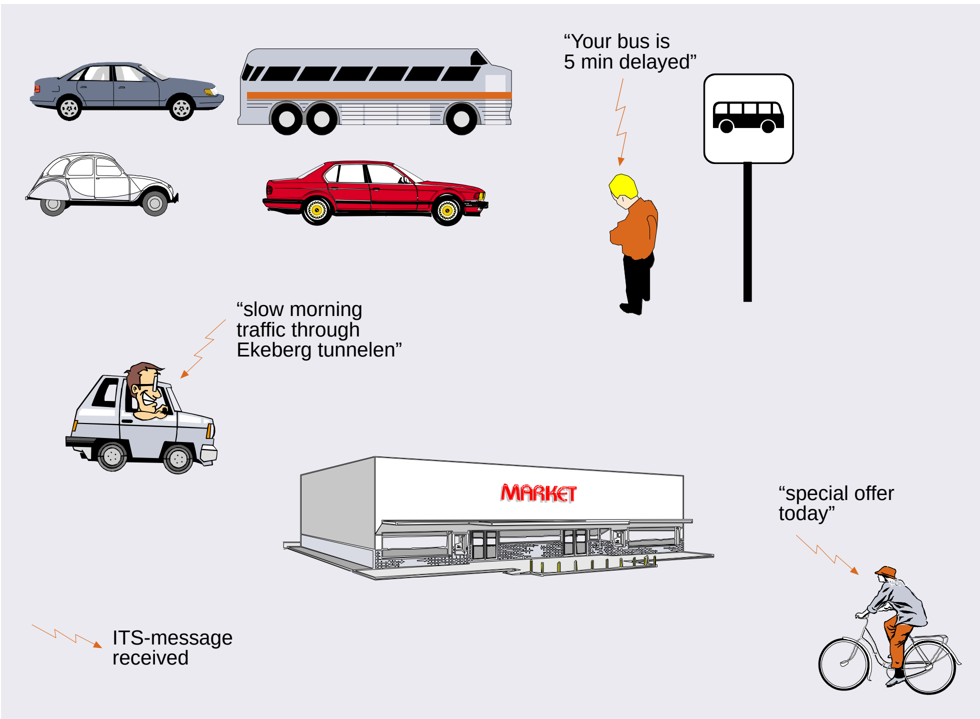


Figure 1 Human-centred ITS offering advice, aid and entertainment to travellers

Sigrid S. Bygdås (38) is Research Scientist in the P2P Computing research programme at Telenor R&D. She graduated from the University of Tromsø with in MSc in computer engineering and joined Telenor R&D in 1992. She spent several years researching development efficiency related to software development methods and tools, and took part in the development of a method for organization-dependent systems planning. In 1999 she started experimenting with Java applications on wireless devices, investigating software infrastructure within the domains of context awareness and mobile computing. Her current research concerns both use and middleware aspects of spontaneous, local, mobile networks.

sigrid-steinholt.bygdas @telenor.com

- How can we offer information to travellers in a distraction-free manner?
- Do user profiles and context-awareness contribute to the usefulness of services?
- How can local information resources become available to travellers?

Potential business opportunities is of course a very important motivation for focusing on ITS. The business model for human-centred ITS is likely more complicated than business models currently employed by network operators and service providers. Generally, there are at least three main tasks or roles: information (i.e. content) creation, information adoption, and information access. Telenor's role in a future ITS market is unclear. One possibility is that Telenor's involvement will change over time, initially helping to kick-start the market through covering multiple roles but later focusing on a single role such as access network provider. A more elaborate discussion on this topic can be found in [1].

User interfaces will be a key to the success of human-centred ITS. User interfaces allow travellers to access information and interact with services during their journey. The design of user interfaces for travellers, and in particular for operators of vehicles, is more challenging than designing traditional user interfaces. This is because such interfaces must use the traveller's attention sparingly so as not to become a distraction or nuisance, and in turn compromise safety. New advances in user-interface technology, such as automatic speech recognition and translucent head-up displays, may become important components in future user interfaces for travellers.

There is always a risk of overloading the traveller with information. It is therefore paramount that information be filtered according to the preferences or needs of the user, but also according to the user's situation, i.e. context. A traveller may be in different modes at different times, and is probably not interested in the same information while on vacation as when travelling to work. We believe that techniques based on user profiles and context-awareness hold much promise as a means of tailoring information delivery to the needs of travellers.

We envision a future where information technology plays a bigger part in everyday life and where people, devices, and ordinary objects such as cars and buildings become information resources. Such a situation differs from today's in that information and services become more dispersed, i.e. take on a less centralized, more anarchistic nature. Future travellers will likely benefit from discovering and accessing such information resources, in particular those that are tied to or located in the immediate physical surrounding. This points to a need for proximity networking in addition to today's ubiquitous, global communication infrastructure. We are currently investigating whether direct inter-vehicle communication could serve as a platform for proximity networking.

The limited duration and resources of our project prevent us from arriving at firm answers to the four questions that were described above. Our aim in this article is to motivate and report on our initial effort at addressing two of the questions, namely how information can be offered to travellers in a distraction-free manner and how information resources in the proximity can be made available to travellers. For more information on the remaining two questions, we refer the interested reader to the final research report of the project [1]. The rest of this article is organized as follows. We start by presenting a small scenario illustrating possible future traveller needs and services attempting to address such needs. Then we review recent developments in the area of user interface technology for travellers, in particular for operators of vehicles. Next we describe a concept, information bubbles, based on highly dynamic, localized information spaces. We suggest how the information bubbles concept may be realized on top of a platform for direct inter-vehicle communication and also present a simple prototype service. Finally, we offer our concluding remarks.

Service Aspects

We are developing user scenarios to help identify possible needs of the future traveller. It is important to evaluate services there will be a demand for, user requirements to the services, as well as technological implications. One of the scenarios could describe a family on holiday with their car:

Ivar (9), Lise (12), Mum and Dad are on holiday. They have no particular plans for this week, just want to drive around and see what's happening. A search profile reflecting their preferences for points of interest this week is entered into the car computer, or CC as they call "him". Their profile consists of one preference for each family member: Horses (Lise), swimming (Ivar), places to eat (Dad), and no traffic noise (Mum).

While on their way, Ivar watches a cartoon on the screen in the seat in front of him. Lise watches the road, trying to get rid of her car sickness. She has just chatted with a girl in another car. Both girls love horses, so they chatted for a long time, too long Lise realized. "Can we stop, please?" she asks. Mum is driving. Dad

Knut Kvale (39) is Research Scientist at Telenor R&D and Professor II at the Stavanger University College. He graduated from the Norwegian Institute of Technology as Siv.Ing. (M.Sc.) in 1987 and Dr.Ing. (Ph.D.) in 1993. Knut Kvale joined the Speech Technology Group of Telenor R&D in 1994. From September 1998 he has been the Research Manager of this group.

knut.kvale@telenor.com

Elin Melby (32) is Research Scientist at Telenor R&D. She graduated from the University of Oslo as Ph.D. (Dr.Scient.) in 2000 and in 2001 joined Telenor R&D where she has been working with mobile radio communications, location technology and intelligent transport systems. In 2002 she graduated as Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

elin.melby@telenor.com

Tore Urnes (34) is Senior Research Scientist at Telenor R&D. He graduated from the Norwegian Institute of Technology as Siv.Ing. (MSc) in 1992 and from York University in Toronto, Canada as PhD in 1998. Tore Urnes joined Telenor R&D in 1998 and works on middleware, application concepts and user interfaces for mobile computing systems.

tore.urnes@telenor.com

reads the newspaper. "I'm hungry", Ivar says. Dad puts away his paper and asks CC to find a suitable place for a break. CC finds a riding school nearby. There's a café there too. Mum asks for navigation aid, and CC explains on the way.

They spend some hours at the riding school before they move on. Lise is happy. She even met the girl she had chatted with. They will keep in touch. Mum has found a peaceful overnight stop and asked CC to reserve rooms. Some excellent bathing facilities are near this overnight stop, and they decide to spend the entire next day there. Dad asks CC to reserve rooms for one more night. After a while CC reports that there were no vacant rooms for a second night, but "he" has found an alternative overnight stop with vacant rooms. It is still near the bathing facilities. Mum asks for a description of the place and CC reads available info. A video of the place appears on the screens. It looks like an idyllic place and they decide to stay both nights there. Dad tells CC to perform the necessary cancellations and reservations.

On their way to the overnight stop, Ivar downloads a game recommended by a kid in an oncoming car. Ivar usually exchanges game information with other kids when he is travelling. He has never heard of this game before and wants to try it out immediately. Lise and Dad play chess. Lise now uses the screen in the back of the seat in front of her. This way she can keep an eye on the road too, protecting herself from car sickness.

"Cheapest petrol for the next 20 minutes", CC suddenly announces. "I'll bet it's the only service station for the next 20 minutes", Dad says, "but we do need some petrol soon, so we have no choice this time." "Let's search for a cheaper one", Lise suggests and Dad agrees. They find a station offering petrol at a lower price only five minutes past the first one, and choose that one. "Oh, all this advertising information, I'm turning it off!", Mum says, and orders CC not to read any more of this type of information. For the rest of the holiday they therefore only get personal messages and greetings. The children's grandmother sends a greeting from her cottage. She really looks great and the weather is fantastic. She says she looks forward to their arrival next week.

This is an example of a simple user profile, reflecting the preferences of more than one person in the car. The passengers have individual needs which are quite different from the driver's. In this scenario, the travellers request services like entertainment, which can be downloaded along the road or taken from e.g. DVDs; chatting with people with similar interests (profile) in other cars; information seeking through user profiles regarding so-called points of interest (POI); navigation help; room reservation; and information interchange between people in cars nearby. Location-based advertising is also pushed to the travellers but can easily be turned off. Some of the services are delivered through an interactive speech interface.

To deliver wireless, real-time ITS services, the solution requires some kinds of suitable radio access networks. In the near future, most ITS services will use GSM in combination with WLAN IEEE 802.11b and Bluetooth. Within the timeframe of the project, UMTS is expected to be fully operational together with IEEE 802.11b and 11a (20 Mb/s). The technical solution of the different services, as well as the access network-related questions are assumed to be in the pipeline. New terminals designed for the services we foresee in a 3G network will also be more suitable for ITS type usage: Larger colour displays, possibility to download software, etc.

Location-based services will be essential, and the possibility to locate the user is necessary to deliver many of the services to the user. Location technology is therefore important. However, this is not ITS specific and is heavily worked on in other fora (e.g. [2]), both for GSM and for the other network-based access technologies. Solutions for accuracies in the range 5 – 50 metres are in the development pipeline [3]. Systems capable of positioning to a decimetre level or better are currently not in place. When using an ITS system, the user is extremely vulnerable to incorrect or misleading information, so correct information is a key issue. This is mostly related to the content creation and has not yet been addressed by our project.

Distraction-Free User Interfaces

With today's technologies like GSM for communication, GPS for positioning, digital maps for navigation – the ITS technology is ready for the mass market. However, there are many remaining tasks yet to be solved. One of the most challenging problems, from a research point of view, is the user interface for car drivers.

To drive a car in complex and fast-changing traffic requires full concentration to sort out relevant information in a "jungle of impressions". Thus, for car drivers it is of crucial importance that new information and communication technologies and services make driving *simpler and safer*, and *not* introduce more distraction.

User interfaces can never be totally distraction free, since the interaction will catch some attention and leave somewhat less focus on the driving task. It is however important to keep the distraction to a minimum. Ideally, the user interfaces of the equipment and services should be designed to provide the drivers with natural and intuitive access to all the technology and information needed at various stages of driving.

Our goal is to develop truly conversational interfaces that allow for a natural interaction with computers. Since human communication is *multimodal*, natural user interfaces to ITS services should also be multimodal.

Conventionally, five modes or senses are distinguished in human communication: audio, smell, touch, taste and vision. For human-machine communication three modes are especially important (see e.g. [4], [5], [6], [7] [8]):

- Audio, e.g. speech and other 'meaningful' sounds, like music and earcons[1)];
- Vision, e.g. text, graphics and moving pictures;
- Touch, e.g. buttons and knobs with tactile feedback, pushbuttons on a terminal or touch-sensitive screens.

Appropriate presentation formats for the driver depend on the *type of information* (e.g. maps are by nature graphic and should be looked upon, whereas short messages may be listened to), and the *current driving situation* (heavy city traffic versus long-distance countryside driving with the cruise control switched on).

For safe driving it is required to keep both hands on the steering wheel and eyes on the road. Thus, information and communication involving hands and eyes should be kept at a minimum. We have to use other modalities such as speech and haptic[2)] interfaces. One other possible alternative to traditional displays is head-up displays, which are well known from the military industry [11], [12]. There are cars utilising this technology, but currently limited to the far high-end segment.

Many car manufactures have adopted the "eyes-on-the-road, hands-on-the-wheel" philosophy, as they work to incorporate new electronic capabilities into automobiles. Speech technology, i.e. automatic speech recognition (ASR) and text-to-speech synthesis (TTS), which makes it possible to converse with terminals [13], plays a key role in realizing this philosophy. ASR and TTS technology can be used in cars, e.g. to control in-car components such as radio and CD player by voice commands, and converse with a PDA and ask it to schedule meetings, receive and set up phone calls, etc. For instance, some 2003 models of the Honda Accord will be equipped with an ASR with about 150 English-language commands in the so-called "Touch by Voice" navigation system (see more details in [14], [15]). However, although great progress has been made in ASR in the last few years, the current ASR technology is still not robust, reliable or accurate enough for *advanced* in-car speech-based services. A major technical challenge is to identify and extract the speech signal from the signal of multiple noise sources. There are about 20 different sources of noise in a car [16].

In our project we will further explore how to design user interfaces to help the travellers in our ITS concept.

Information Bubbles

Scenario-derived services point to a need for three approaches for vehicular communication: Road-based communication infrastructure, wireless cellular communication infrastructure, and direct inter-vehicle communication, see Figure 2. An example of the first approach is a road with built-in sensors able to detect stationary

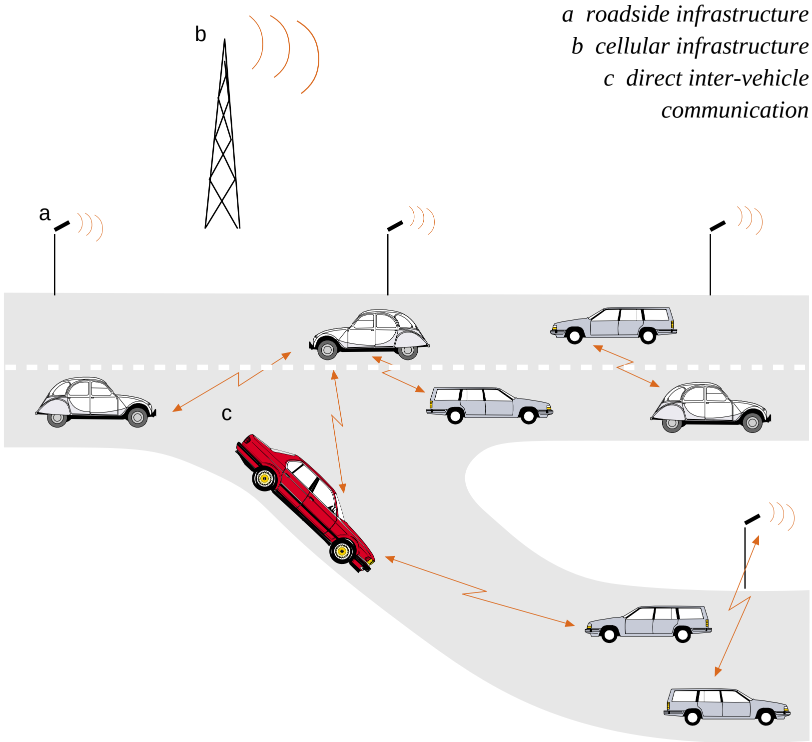


Figure 2 Three approaches to vehicular communication:
a roadside infrastructure
b cellular infrastructure
c direct inter-vehicle communication

[1)] *Earcons are the auditory equivalent of icons and can be defined as "non-verbal audio messages that are used in the computer/user interface to provide information to the user about some computer object, operation or interaction" [9].*

[2)] *The term haptic interface is often used for a force reflecting device which allows a user to touch, feel, manipulate, create, and/or alter simulated three-dimensional objects in a virtual environment (see e.g. [24], [10]).*

traffic (e.g. due to an accident). The sensor infrastructure could be associated with an information service capable of distributing information to cars heading towards the stretch of road in question, indicating that the drivers may benefit from choosing an alternative route. The need for the second approach to vehicular communication can be motivated by services such as a point-of-interest (POI) search service, helping travellers find the nearest bus stop or suitable overnight accommodation. The approach based on direct inter-vehicle communication is well suited for services involving people, vehicles, objects or information in the proximity. One possible service of this type is the exchange of information about driving conditions with oncoming vehicles. Other service examples include chatting or playing multi-user games with passengers in nearby vehicles. Direct inter-vehicle communication also creates an opportunity for roadside beacons advertising events or special offers to travellers, e.g. “watch our historical play at the local museum this afternoon” or “cheapest petrol in town”. Such beacons may also be used to communicate with travellers or vehicles beyond the reach of direct inter-vehicle communication, e.g. “car accident just behind the next bend”.

We focus on the direct inter-vehicle communication approach in this article, in particular how it can serve as an enabler of highly dynamic, localized information spaces. We find this approach interesting because it does not require heavy infrastructure, and it is quite a novel research field. More pros and cons of the three approaches to vehicular communication are found in [17].

Dynamic, Localized Information Spaces

The vehicular communication approach based on direct inter-vehicle communication holds great promise as a platform for highly dynamic information spaces tied to the immediate geographic surroundings of travellers. We envision a future where physical entities such as humans, vehicles, roads, and stationary or portable devices of all kinds become information resources. We further assume that a traveller being present at a certain location at a certain time may be interested in information resources tied to physical entities in the proximity. In other words, we can think of a highly dynamic information space following the traveller that reflects information resources currently available at the present location. We propose the term *information bubble* to denote such an information space.

The information-bubble concept is well suited for interacting with local information resources. An information resource can be content, such as information about road conditions or points of interest, storage for leaving messages to other vehicles, and presence, i.e. who is available for communication now. The concept also suggests an extremely dynamic information landscape that is ideal for supporting spontaneous interactions between travellers, vehicles, and other entities. A third benefit of the information bubble concept is its support of information timeliness. Compared to a traditional World Wide Web search on the Internet, where a search engine collects static information from servers typically days or weeks in advance, the information bubble can make new information available instantly.

Proximity Networks

The key to the realization of our information bubble concept in a human-centred ITS setting is direct inter-vehicle communication. We believe that direct inter-vehicle communication can be realized without any fixed infrastructure along the roadside as long as interactions are restricted to vehicles in the proximity of each other. Such proximity networks can be based entirely on self-organizing ad-hoc radio networks. Interactions carried by proximity networks may therefore benefit from very low cost, high bit rates, low delay, and robustness. The highly dynamic, self-organizing nature of a proximity networking platform tied to moving vehicles dictates the need for an architecture capable of detecting and reacting to changes in a timely and efficient manner. Decentralized peer-to-peer architectures possess many of the necessary features for handling extreme dynamism [18]. The marriage of ad-hoc radio networks and peer-to-peer architectures therefore holds great promise as an enabler of direct inter-vehicle communication [17].

Two recent research projects, the CarTalk project sponsored by the IST programme of the European Union’s Fifth RTD Framework [19] and the German FleetNet project [20], aim to develop a platform for direct inter-vehicle communication. A key component of FleetNet is the adaptation of UTRA TDD radio hardware for direct inter-vehicle communication. During the development phase, FleetNet plans to conduct field trials of platform and services with real cars equipped with IEEE 802.11 wireless LAN components. Many of the proposed applications that may be supported by a platform for direct inter-vehicle communication are focusing on improving safety and traffic flow on highways. However, since the success of such applications requires that a considerable percentage of vehicles be equipped with necessary technology, some suggest that initial focus instead should be on applications for entertainment and leisure and with support for inter-working between ad-hoc and infrastructure-based communication approaches [21].

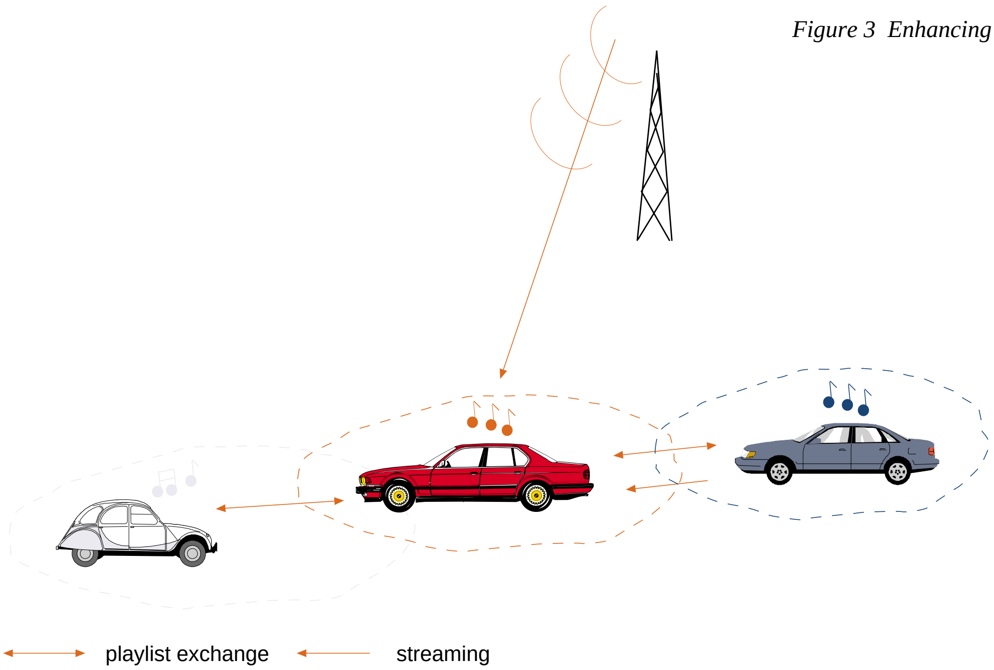


Figure 3 Enhancing musical entertainment experience:
- spontaneous interaction
- playlist exchange
- streaming

Play-list Exchanger Prototype

As part of the work on the information bubble concept, researchers at Telenor R&D have developed a simple proof-of-concept prototype that may be suited to enhance the music listening experience of travellers. Today, travellers rely on broadcast radio or on a limited number of personal CDs or tapes for musical entertainment while on the move. Our information bubble prototype exposes travellers to new musical impulses, i.e. new artists or songs, within a favourite genre. Basically, a traveller can associate a play list of favourite songs with his or her music device (e.g. an in-car player or a portable device). Whenever two music devices encounter each other, i.e. when their information bubbles overlap, they exchange play lists. Therefore, during the course of a journey, travellers will likely encounter a range of different play lists. Notification of play list encounters may be governed by pre-compiled profile detailing musical preferences, allowing less interesting play lists to be ignored. When an interesting play list is discovered, the traveller may choose to start streaming the corresponding songs. Each song has a URL as meta-data that points to a streaming server for that song, typically the server will run on the play-list owner's music device. As long as the connection with the streaming server is not broken, the user will be able to enjoy the song on the play-list owner's player. However, should the connection be cut, e.g. when the streaming server moves out of the information bubble, the streaming will stop. Alternatively, songs from play lists could be downloaded instead of being streamed, or one could perform a handover to UMTS and move the streaming session to a commercial music streaming service, see Figure 3.

We need to stress that issues pertaining to business models and copyright need to be resolved prior to launching a service similar to our play list exchanger prototype. Much effort is currently directed toward finding viable business models for music distribution over data networks that do not compromise the rights of copyright holders. The outcome has yet to be seen, though.

Challenges

We have argued that the information bubble concept exhibits several desirable characteristics and at the same time does not depend on huge infrastructure investments. However, the concept does pose several challenges that need to be addressed, including ensuring data quality, performing appropriate information filtering, and protecting privacy. A detailed treatment of these challenges falls outside the scope of this article; the interested reader is referred to [1]. When data obtained in the information bubble are employed in safety applications, ensuring the integrity and quality of such data becomes paramount. Telenor can take the role as trusted third party for this type of applications. The section on distraction-free user interfaces above stressed the importance of ITS systems not demanding a high load, cognitive or otherwise, on users, in particular on drivers. Due to the intrinsic anarchistic nature of information bubbles, i.e. they naturally support open, free-for all information spaces with a very low barrier to participation, it becomes increasingly important to filter out irrelevant information. Work on the GeoNotes system [22] suggests that personal profiles may be used to filter information in open, location-based information spaces. It is very important that privacy issues be thoroughly considered prior to designing and deploying information systems involving direct inter-vehicle communication. The potential for breaching privacy boundaries and norms is obvious. Examples of commonly held expectations about privacy may be that one assumes solitude when travelling on an empty road or that one expects one's driving habits to be largely unknown to strangers. Direct inter-vehicle communication presents the possibility of every vehicle or traveller becoming a surveillance entity.

Conclusions

Mobile network operators are already present in the ITS market due to the close relationship between transportation and mobile communication. Telenor, with several decades of experience as a provider of mobile telephony in Norway, currently offers numerous ITS-related services. As pointed out in [23], it is important that existing ITS services be developed further. Our project supports this notion and suggests that a more human-centred approach is the right path towards a larger ITS market. The human-centred approach calls for a shift away from surveillance and control, towards user support and entertainment in combination with 'nice to have' gadgets. Our project puts travellers' needs on centre stage and tries to sketch the contours of a mass market for ITS. In terms of business opportunities, human-centred ITS poses several interesting challenges since success depends on data quality, as well as system properties such as delay. The capability to deliver a high quality service is a prerequisite for the users' willingness to pay.

At this stage, our analysis points at some key questions that need to be addressed in order to make human-centred ITS a reality. In this article we have presented four such questions and reported on our progress towards addressing two of them, namely how might we arrive at user interfaces resulting in less distraction and how might we help travellers discover and interact with nearby information resources. We suggest that new ITS services will include peer-to-peer computing and ad-hoc networks, in addition to the traditional access networks like GSM. We also point to speech technology as an important component in future user interfaces of ITS services.

References

1 Worren, T A et al. *ITS – opportunities for Telenor?* Fornebu, Telenor R&D, 2002. (R&D report R 58/2002)

2 Pettersen M, Melby E, Worren T A. *An evaluation of different location techniques – Forced Handover – E-OTD – A-GPS.* Fornebu, Telenor R&D, 2002. (R&D report R 37/2002)

3 *The Federal Communications Commission.* Enhanced Wireless 911 Requirements (E911). May 2, 2003 [online] – URL: http://www.fcc.gov/911/enhanced/

4 Oviatt, S et al. Designing the user interface for multimodal speech and gesture applications: State-of-the-art systems and research directions. *Human Computer Interaction,* 15 (4), 263–322, 2000.

5 *Multimodal and Multilingual Services for Small Mobile Terminals.* Heidelberg, EURESCOM Brochure Series, May 2002. December 3, 2002 [online] – URL: http://www.eurescom.de/public/projects/P1100-series/P1104/default.asp

6 Almeida, L et al. The MUST guide to Paris – Implementation and expert evaluation of a multimodal tourist guide to Paris. In: *Proc. ISCA Tutorial and Research Workshop (ITRW) on Multi-Modal Dialogue in Mobile Environments (IDS 2002)*, 49–51, Kloster Irsee, Germany, 2002.

7 Boves, L, den Os, E (eds.). *Multimodal services – a MUST for UMTS.* April 10, 2003 [online] – URL: http://www.eurescom.de/public/projectresults/P1100-series/P1104-D1.asp

8 Kvale, K, Warakagoda, N D, Knudsen, J E. Speech-centric multimodal interaction with small mobile terminals. In: *Proc. Norsk symposium i signalbehandling (NORSIG 2001),* pp. 12-17, Trondheim, Norway, 2001.

9 *All about Earcons*. April 10, 2003 [online] – URL: http://www.dcs.gla.ac.uk/~stephen/generalearcons/generalearcons1.shtml

10 *Haptic Research Summary*. April 10, 2003 [online] – URL: http://haptic.mech.nwu.edu/HapticResearch.html

11 Barfield, W, Dingus T A. *Human factors in intelligent transportation systems.* New Jersey, London, Lawrence Erlbaum Associates, 1998. (ISBN 0-08058-1433-7)

12 *Enforcer Technology, Inc.* November 8, 2002 [online] – URL: http://www.copweb.com/hudppp/index.htm

13 Huang, X, Acero, A, Hon, H-W. *Spoken language processing – A guide to Theory, Algorithm, and System Development.* Prentice Hall, 2001. ISBN 0-13-022616-5

14 Speech recognition update, *News and analysis of speech recognition markets, products,*

and technology, No. 110, p 1, August 2002. (ISSN 1 070-857x)

15 *IBM technology gives new Hondas a voice.* IBM press release 29 July 2002. April 10, 2003 [online] – URL: http://www-3.ibm.com/software/swnews/swnews.nsf/n/lsco5chsx8

16 Moyers, G. Industry Leader Focus: Taking the Noise Out of a Noisy World. *Speech Technology Magazine*, March/April 2001.

17 Chisalita, I, Shahmehri, N. Active Support for Traffic Safety Applications through Vehicular Communication. In: *Proc. Intl. Workshop on Trends and Recent Achievements in Information Technology*, Cluj-Napoka, Romania, May 16-18, 2002.

18 Kortuem, G. Proem: A Peer-to-Peer Computing Platform for Mobile Ad-hoc Networks. In: *Proc. Advanced Topic Workshop on Middleware for Mobile Computing*, Heidelberg, Germany, November 16. Co-located with the IFIP/ACM Middleware 2001 Conference, November 2001.

19 *CarTalk 2000 Project Overview.* February 18, 2003 [online] – URL: http://www.cartalk2000.net/

20 *FleetNet Project Overview.* February 18, 2003 [online] – URL: http://www.fleetnet.de/

21 Michael, L B et al. Combined Cellular/Direct Method of Inter-Vehicle Communication. In: *Proc. IEEE Intelligent Vehicle Symposium, IV 2000,* Detroit, USA, October 2000, 531–539.

22 Espinoza, F et al. GeoNotes: Social and Navigational Aspects of Location-Based Information Systems. In: *Proc. Ubicomp 2001: Ubiquitous Computing, International Conference,* Atlanta, Georgia, September 30 – October 2. Berlin, Springer, 2001.

23 Asmunsvaag, B, Flydal, E. ITS Services development in Telenor – history and some indications on future direction. *Telektronikk*, 99 (1), 41–58, 2003. (This issue)

24 *Office of Training Technology (OTT)*. April 10, 2003 [online] – URL: http://www.ott.navy.mil/index.cfm?RID=TTE_OT_1000022

Evolution of ITS in Japan in the Last and Next Decades

HARUO OZAKI

Haruo Ozaki (44) is an associate professor at the Department of Civil and Environmental Engineering, Faculty of Engineering at Toyo University, Japan. His major interests are in the fields of road traffic engineering and telematic applications to transport.

ozaki@eng.toyo.ac.jp

During the last decade, Japan has focused on nationwide ITS service deployment. The public sector has taken the lead in large national programs to implement nationwide ITS services. In this article, it is suggested that the fast progress seen in Japan is based on the historical accumulation of physical and data infrastructures. The fast evolution is also due to an ambitious national master plan and the national architecture for ITS.

Three targets for the ITS evolution are discussed for the next decade. ITS for pedestrians is blooming with the large increase in personal mobile terminals. ITS to support regional needs is another future area. Finally, it is mentioned that probe systems have the potential to open a new stage of ITS.

1 Features during Last Decade

The public sector has led the deployment of ITS in Japan. Two national ITS systems, VICS and ETC, are now widely served.

1.1 VICS [1]

The Vehicle Information and Communication System (VICS) service started its operation in 1996. VICS is a kind of on-trip driver information service, which provides drivers with real-time traffic conditions, incidents, temporary traffic regulations, and availability of parking facilities. Drivers can obtain VICS information through on-board units.

In order to provide the updated traffic information to on-board units, three interfaces are prepared: radio wave beacons, infrared beacons, and FM multiplex broadcasting.

- Radio wave beacons are installed mainly on expressways for short-range communication. They use 2.4997 GHz frequencies and operate one-way communication from the roadside to vehicles.
- Infrared beacons are installed on normal highways and streets. They operate short-range two-way communication between roadside and vehicles.
- FM multiplex broadcasting is delivered from broadcasting stations to vehicles for wide area communications.

VICS compatible on-board units can generally be purchased for between 100 and 200 thousand yen depending on the optional choices of either three interfaces.

However, customers regard VICS as very cost-effective. An initial investment of only 300 yen for on-board units includes a user's contract with the VICS service. Once on-board units are equipped, customers can receive updated road traffic information without any extra charge. So VICS has been widely accepted so far.

As for the VICS compatible on-board equipment, five million units have been delivered to the domestic market as of September 2002. This accounts for a 50 % diffusion rate of ten million users of on-board navigation devices including VICS-incompatible stand-alone models that have been released since the 1980s.

The service is operated by the newly established non-profit organization (VICS Center) for this purpose. It is scheduled that nationwide coverage of VICS service will be completed spring 2003.

The success of VICS is due to the small cost perceived by the user. However, the author should also emphasize that the system is based on the good physical and data infrastructures. There has been a long history of collecting road and traffic information and delivering it to the public in Japan.

Let us review some examples in the Tokyo area. Tokyo Metropolitan Expressway Public Corporation provides 200 kilometers of toll road network services in the capital area. Daily, more than one million vehicles are observed on the expressway network. The public corporation is responsible for the traffic surveillance and control. In this network, more than four thousand vehicle detectors are installed in order to monitor real-time traffic conditions. The collected data are processed for use in the control of the traffic flow by tollgate closures or by information provisioning through many variable message signs (VMSs) along the routes.

On normal highways and streets, the police departments manage road traffic including traffic signal controls and parking controls. Law enforcement is also under the jurisdiction of police departments. Tokyo Metropolitan Police Department manages the normal street and road network in Tokyo with more than 16 thousand vehicle detectors installed at the roadside.

Road administrators and police departments in the country have been very active in collecting, processing, and providing road and traffic information since the1960s. They started independent information provisioning through their own facilities; however, the non-profit organization, Japan Road Traffic Information Center (JARTIC) was founded in 1970 in order to provide travelers and drivers with combined road and traffic information. JARTIC information has been much appreciated by the public through radio and TV broadcasts. Real-time information delivered on the web started in July 2000. [2]

Figure 1 illustrates the whole picture of data flow of road and traffic information in Japan. The innovative VICS relies on JARTIC data. Road and traffic managers entrust the JARTIC and VICS Center with road and traffic data free of charge. JARTIC also sells road and traffic information to private information service providers (ISPs). Several private ISPs have been established; so far, however, their business performances have not been satisfactory.

1.2 ETC

The Japanese deployment of Electronic Toll Collection (ETC) systems appeared rather late compared to the rest of the world. The ETC service officially started in March 2001 after a one year test operation within selected small areas.

The Japanese expressway service is provided by toll systems. ETC is introduced for the replacement of the manual payment and is now operated solely for the automatic transaction of tolls.

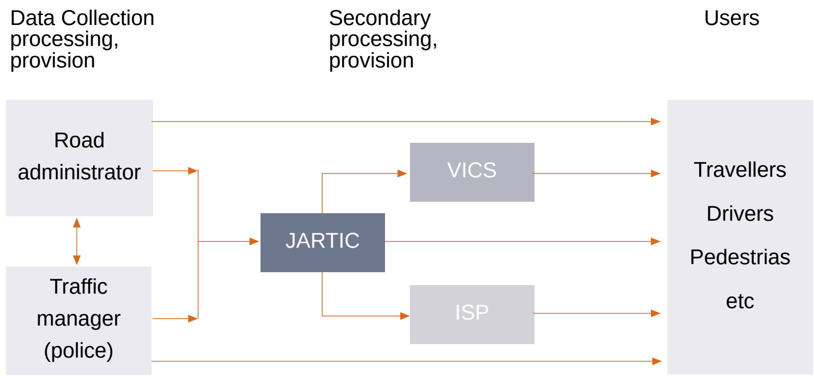


Figure 1 Data flow of road and traffic information in Japan

The transaction process is operated through two-way dedicated short-range communication (DSRC) between roadside units and on-board equipment. The 5.8 GHz band is standardized for this interface among intercity and intracity expressway operators.

The toll is rather high in Japan. The intercity expressway service is nationally operated by Japan Highway Public Corporation and is extended to seven thousand kilometers of network. The rate of intercity toll is dependent on the five categories of vehicle types and mileage of usage, for example, 24.6 yen per kilometer for the small compact cars and 40.59 yen for heavy commercial vehicles. A high charge rate and the variations in vehicle types are reasons why Japanese ETC selected the active two-way communication through DSRC.

The items exchanged by DSRC communication are certificate ID, vehicle type, IC card ID, tollgate ID and so forth. Privacy regulations normally apply for these items. So the non-profit organization, Organization for Road System Enhancement (ORSE) has been established as a public manager of security [3]. The ORSE manages the standards for ETC operation and discloses the security key data to limited parties

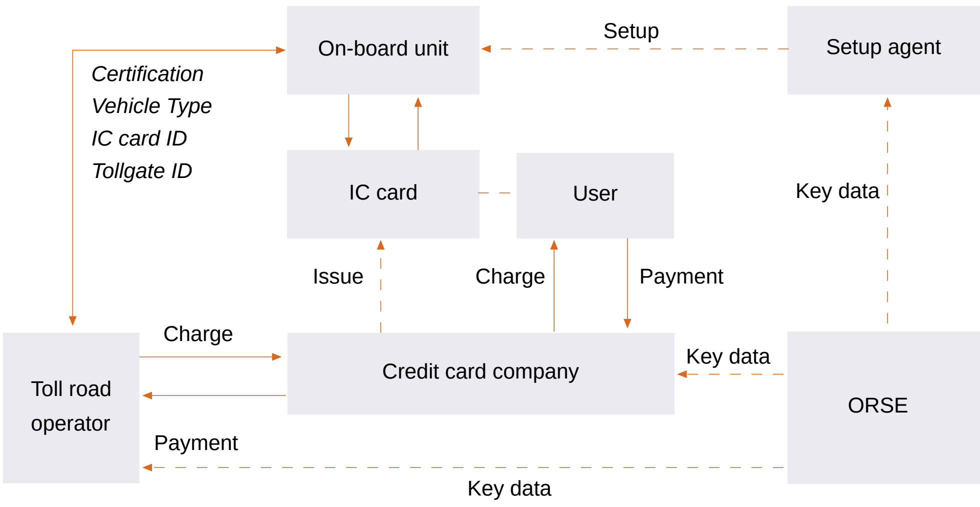


Figure 2 Framework of ETC Service in Japan

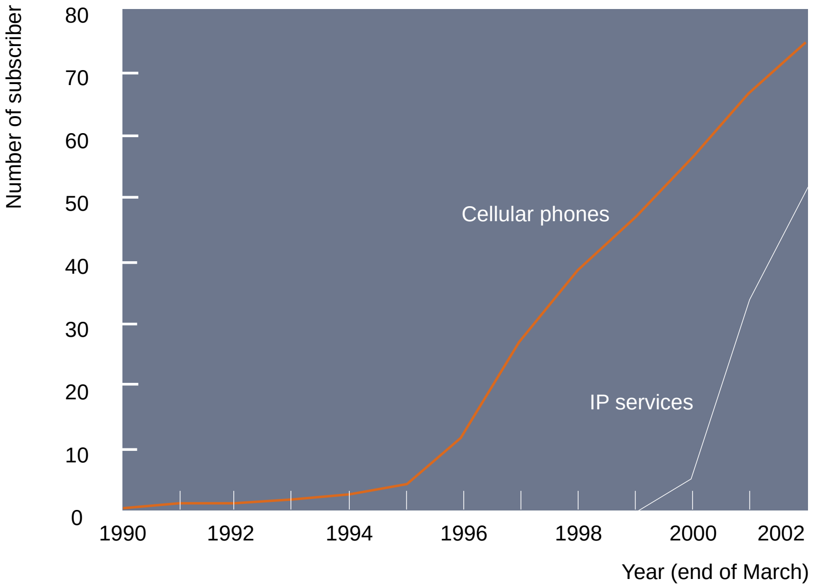


Figure 3 Yearly increase of mobile terminal subscribers [7]

within the ETC system. The framework of ETC is illustrated in Figure 2.

The penetration of on-board units has been rather slow. 500 thousand on-board ETC units had been accepted by October 2002. An installation setup procedure is needed for the on-board equipment. Users of ETC should also prepare IC cards for automatic transactions.

At the early deployment stage, the 5.8 GHz band DSRC is limited for the toll collection services. However, there are so many ideas to expand the use of 5.8 GHz band DSRC for other applications. The Japanese DSRC standard was revised as ARIB STD-T75, "Dedicated Short-Range Communication System ARIB Standard", in September 2001 [4]. It allows a wider usage of DSRC, such as drive-through types of purchase and data communications.

The present deployment of roadside units by the toll road operators is based on an older DSRC standard. It is mentioned that the migration to the newer standard may be one of the issues to further enhance DSRC services.

1.3 National Plans for ITS

Public led ITS programs are supported by the national plans. Among various related ones, two major plans are reviewed here.

1.3.1 National ITS Master Plan [5]

The "Comprehensive Plan for ITS in Japan" was announced in 1996 by the ITS related national government ministries. It describes the visions and missions for the development and deployment of ITS in Japan. It presents nine areas of ITS development and timetables of research, development and deployments until the year 2015. The nine areas are the following.

- Advances in navigation systems;
- Electronic toll collection systems;
- Assistance for safe driving;
- Optimization of traffic management;
- Increasing efficiency in road management;
- Support for public transport;
- Increasing efficiency in commercial vehicle operations;
- Support for pedestrians;
- Support for emergency vehicle operations.

1.3.2 National ITS Architecture [6]

The "System Architecture for ITS in Japan" was published in 1999 by the same leading national government ministries as the master plan. The architecture is based on 172 ITS services to be operated in the country under the nine ITS development areas. The national architecture also proposes that ITS services in Japan have close relations with non-transport sectors.

2 Prospect for Next Decade

All nine areas nominated in the national master plan are assumed to enter into the deployment stage from the 21st century. We have seen that nationwide VICS and ETC are good practices that work well according to the plan. It is natural that the next targets are the remaining areas. The public sector will continue to take the lead; however, the private sector should have all the possibilities to explore another stage.

2.1 ITS for Pedestrians

There are more than 70 million cellular phone terminals used among the Japanese population of 127 million. Out of the 70 million mobile phones, 50 million terminals can access Internet Protocol services, such as e-mail or www browsing, as shown in Figure 3. Consequently, a large portion of the personal terminals in the market have the capability to provide ITS services for travelers. One of the applications related to transport is location based information services to pedestrians.

Some mobile network operators provide location identification services by applying advanced techniques such as GPS or intensity measurement of electronic field generated by wireless base stations.

Another area of location based ITS is support for physically impaired users, which is a field where research and development activities are much focused. Example: Warning for blind persons needs very high precision for locating potential danger spots. There are several alternatives for identifying a precise location; conventional GPS, differential GPS, pseudolite or pseudo GPS satellites are examples. Wireless LAN using Bluetooth techniques and DSRC tags embedded beneath the ground are other candidate technologies.

The national government is now leading a comparative study of alternative techniques in co-operation with private companies to develop domestic minimum required standards for pedestrian ITS. Experimental deployments were tested in 2001. The result of the study will contribute to the fast deployments of interoperable services within the country.

2.2 Regional ITS

The ITS deployment in Japan has been focused on the expansion of nationwide services during the last decade. It is expected that ITS will be applied for various services for transportation problems on a regional basis.

The national government is prepared to support regional initiatives for the ITS deployments. During the period from 1997 through 1999, five regions were selected for ITS experiment initiatives. The results were very favorable according to the assessment of benefit, cost, and users' acceptance. Since then, more regions have become interested in ITS developments and established regional ITS promotion agencies.

In 2002, ITS Japan, the national ITS promotion society, published the "Guideline for Developing Regional Architecture" in order to support regional ITS planning and development. The objectives of developing regional architecture are:

- Accelerating the implementation of ITS by installing the systems shared by regional stakeholders;
- Achieving an adequate installing and operating cost by a proper integration of systems; and
- Developing systems that reflect the regional needs and conditions efficiently.

The city of Toyota is selected as the test area of regional architecture development using the Guideline. As a tentative result of the test development, the stakeholders' responsibilities for installing and operating the systems are well clarified. It is becoming recognized that regional architecture is an effective tool for ITS deployments among regional stakeholders.

2.3 Probe Systems

The number of personal mobile terminals and on-board units in vehicles are expected to increase. Now vehicles and pedestrians are not only information receivers but also transmitters of transport related data. In this situation, probe systems are fast beginning to draw attention. Traffic related data are collected utilizing all the probes, vehicles and pedestrians, on the roadway.

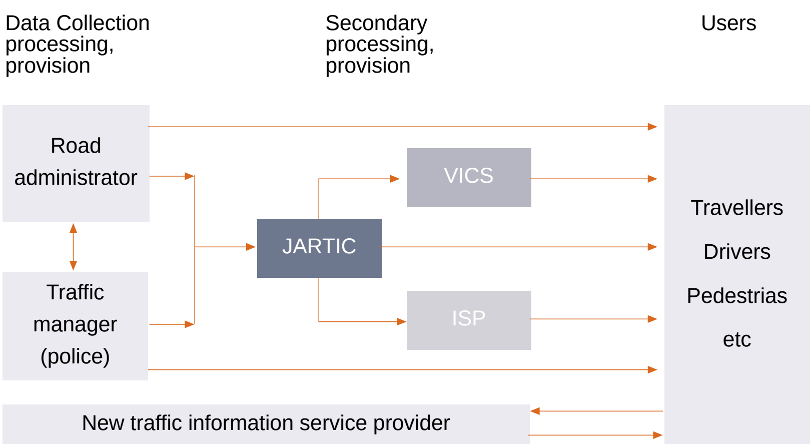
Primitive types of probe vehicle systems have already been in use for some time. One example is the public transport location service. The positions of buses are identified either by GPS or roadside beacons. The data are utilized for the estimation of arrival time at bus stops, which are notified through mobile terminals or VMSs. This service is very attractive to bus riders because the timetable is often unreliable due to traffic congestion. Similar systems can be found on the advanced support for dispatch of taxis or commercial vehicles.

Internet applications are suggested as new ideas to the ITS framework. The enhanced probe system is now regarded as a good test site to introduce Internet Protocol version six (IPv6). In 2001, more than one thousand taxicabs participated in the test trials, which resulted in a successful probe system showcase in Nagoya city, where the ITS World Congress is to be held in 2004 [8].

Probe systems have some issues to be dealt with. For example, in order to transmit data from probes, they need to be equipped with additional devices. There are privacy issues as well. However, it has good potentials for adding something new to ITS. The traffic conditions monitored by running vehicles can supplement the data that have been publicly collected by conventional roadside vehicle detectors as shown in Figure 4. Moreover, they may override the existing roadside based data collection and provision scheme.

The Japanese Road Traffic Law was revised in 2001 so as to allow road and traffic ISPs to serve future forecasts of traffic conditions. The probe system has a good possibility to support innovative business models in ITS.

Figure 4 Projected framework including probe systems



References

1 *VICS Center*. February 21, 2003 [online] – URL: http://www.vics.or.jp/eng/

2 *JARTIC*. February 21, 2003 [online] – URL: http://www.jartic.or.jp/ (in Japanese)

3 *ORSE*. February 21, 2003 [online] – URL: http://www.orse.or.jp/english/

4 *ARIB*. February 21, 2003 [online] – URL: http://www.arib.or.jp/english/

5 *Comprehensive Plan for ITS in Japan*. February 21, 2003 [online] – URL: http://www.mlit.go.jp/road/ITS/

6 *System Architecture for ITS in Japan*. February 21, 2003 [online] – URL: http://www.its-jp.net/

7 *Telecommunications Carriers Association.* February 21, 2003 [online] – URL: http://www.tca.or.jp/index-e.html

8 *Internet ITS Project*. February 21, 2003 [online] – URL: http://www.internetits.org/en/

ITS Services Development in Telenor – History and Some Indications on Future Direction

BJØRN ASMUNDVÅG AND EINAR FLYDAL

Bjørn Asmundvåg (54) holds his formal degrees from marketing and business economics. 1980–1990 he was employed in Siemens; from 1990 in Telenor Mobile. Bjørn Asmundvåg has taken active part in the development of platforms and businesses that now constitute the bases of Telenor's ITS products and services, as well as several other products/services drawing on the same platforms. He was for example responsible for the mobile data services 1990 to 1995, and later for the stablishment of ELVEG and Transport Telematikk, mentioned in the paper.

bjorn.asmundvaag@telenor.com

Einar Flydal (53) is Senior Adviser working with corporate strategy at the Telenor headquarters. He is cand.polit. from the Univ. of Oslo (UiO), 1983, in political science, and Master of Telecom Strategy from the Univ. of Science and Technology (NTNU), Trondheim, 2002. Apart from 1985–1993, when working with IT in education and with small IT companies, Flydal has worked with Telenor in a variety of fields since 1983. He has also worked as radio freelancer on minorities and music, on statistical indicators at the Chair of Peace and Conflict Research, and on work organisation on oil platforms at the Work Research Institute, Oslo. His present professional interests are environment, CSR, innovation, and ICT.

einar.flydal@telenor.com

Introduction

In this paper we trace the story of ITS – *Intelligent Transport Systems* – business development in Telenor. To understand our concept of ITS, we refer to our paper "Why should a telco engage in ITS?" in this issue of *Telektronikk*: The term "ITS" is "unscientific" in the sense of being imprecise and commonsensical. ITS covers a broad field, mainly denoting information- and communication technology (ICT) and applications serving to improve personnel or goods traffic flow, and will be used here in such a broad sense. The area of ITS, in some environments covered by the confusing term of "telematics" or "road telematics", has come to constitute a separate field only gradually.

In the more general picture, ITS is about a transformation from fixed to mobile omnipresent and ubiquitous communication, from centralised to distributed and dispersed computing, and from embedded content provision to content provision separated from, loosened from, and – in its extreme – unrelated to the infrastructure on which it travels, technically or commercially.

It is since long evident that the impact of this general evolution upon the traditional telco and ICT businesses has been, is, and will continue to be profound. ITS is in this respect just a particular area of application, bundle of technologies, or markets that emerge as this transformation takes place. From such a perspective, the history of ITS within Telenor may be read as a history of just some steps along a profound change of the business.

All new technologies and their applications do have a beginning. It is a paradox that in a business using ever more memory and realtively less paper in its production, history gets ever shorter. Hence, the beginning is lost in the mist. Our historical account of ITS in Telenor and its predecessor the Norwegian Televerket, a directorate under the national Ministry of Communication, relies heavily on subjective memory, and not on any formal research work. As the authors have both been working in Telenor for quite some years, and the one has been involved in much of what is described below, we nevertheless hope that our story is not too biased. However, as telecom is a generic, non-application specific technology, and as the ITS concept is quite broad, many activities relevant for ITS are *not* covered in this paper. Such omissions are due to our unawareness and do not express any particular opinion about the initiatives omitted.

The story of what actually happened is much simpler, both for the reader to make sense as well as for the writers to depict, when seen against its historical backdrop. That is where we begin.

The Large Picture: From Monopolistic, Integrated and Fixed Access-Based Welfare to Competitive, Layered and Mobile-Based Business

The traditional concept and business model of telecom was shaped around 150 years ago: The basic business model of telcos is selling telephony access between the fixed terminal points A and B by the minute through a wired closed circuit between them. Technically as well as businesswise, this value creation is about selling timesharing access to infrastructure (the network) and to a service (speech telephony) closely interwoven and inseparable from the physical network.

Our professional forefathers formed the networks the way technology, experience and organisational capabilities invited them to: They started with point-to-point connections which evolved into star formed shapes, assembling the individual wiring to each subscriber access point to a central connection point to provide for connections all-to-all (the exchange/switch/hub). These meeting places, where services could be hooked up, were located where all traffic would have to pass, i.e. in the center of the town. The local starshaped access networks got connected. Junctions (mergers and demergers, or muxes and de-muxes) were introduced. Now, the access networks got connected through trunk lines of higher capacity. Just like irrigation systems, trunk roads, main railroads, and the main barge channels in the previous centuries had mimicked river systems, or the paths of ants, telco networks followed the same networking model to carry the application of real time speech between two endpoints.

As for speech protocol, i.e. when, for what purpose or how people should talk, it was subject to advice, but not much control, from the telcos. (Advice like "To be used only by the Managing Director", "Talk slowly and distinctly!", or "Always start the conversation by introducing yourself!" were commonplace until telephony got commonplace in the 1950s.)

Much can be told about how this 150 year old technology and business model of telegraphy and telephony developed and got differenciated into a range of products. Particularly in the post-World War II period, several networks were built with characteristics tailored to suit particular application areas where legal safegarding, technology, signalling systems and application characteristics like duration, data volumes, and protocol differed. The characteristics were closely interwoven and reflected in the pricing structures – like for telegraphy, telex, teletex, and for the various circuit or packet switched data services tailored for the very different needs of, e.g. applications for banks and fuel station pumps. The service mixes and levels were achieved by mechanisms embedded in the network equipment, and assured by a monopoly or certification system comprising the network as well as the terminal equipment, like phones, telex terminals, or modems; i.e. there was a high degree of vertical product integration and control.

So, the idea is old that equipment for quite other purposes than speech or sound – e.g. exchanging pictures or controlling a hydropower station – should communicate using the telephony speech service to convey sounds used for other purposes than speech. The equipment at each end of the wire would exchange sounds but would interpret them according to their own conventions (signalling system & protocol), with the speech network serving them the signalling opportunity in the role of a passive carrier of the electric signals or their acoustic equivalents. As such equipment developed into standard (though high cost) products and were able to handle the dialing automatically and carry out its sessions without any human interference, it became obvious that any kind or amount of information could be conveyed at a distance. The road was opened for all sorts of information cooperation, remote control, distance work, global finance operations, distribution of information products, etc.!

End 1970s to late 1980s, faxes, e-mail, etc., came about as consumer products and services. But computing power and data storage was scarce. Computing power was added in the switches in the 80s and 90s, and IN (Intelligent Network) mechanisms appeared. IN permitted applications to be embedded in the switches, so that user terminals (whether they appeared as phones or computers) could start them by sending certain control codes "into" the telecom network. The network – with its millions of terminals – thus became a vast computer with common computing power and data storage, and the perspectives were overwhelming! Such "value added services" (VAS) – a very "net centric" term – opened for new revenue streams based on the Telecom authorities' networks. (As hotel, amusement park and mailbox services would add value to the Road authorities' roads. Or sales of coffee on board would add value to the Rail authorities' public transport system.) Accordingly, the network got a much higher value both as an income source and as a creator of social wellfare.

As computing power and data storage got into the terminals and prices were dropped, it became ever clearer that as long as the telcos delivered the dial tone, anything could be transmitted over speech telephony without the telco's consent or knowledge – technically, but not necessarily legally. The telco's role was to become reduced. These new perspectives caused political debate in Norway as elsewhere, about the future and reach of the telecom monopoly, not the least to which extent VAS should be a monopoly area or subject to competition in an open market. Re-regulation of the telecom sector started world wide, ending the monopoly era and stimulating competition on the emerging services. The countermeasures were for Telenor as for other telcos to exploit IN and other mechanisms embedded in the network, climb up the value chain by creating new businesses based on the network, and expand geographically.

Whether through the use of IN or not, a world of services – infinitely more cost efficient than by other communication means – could be made available, to the profit of everyone. Application development started within all imaginable areas of life.

Applications for *movable* units like medical doctors, trains, trucks, etc, were nourished by just that enthusiasm, but considered to belong – as communication relying on wireless technologies – to the radio realm. The early Telenor ITS activites are therefore to be found there, in the radio systems division.

The Start: General Mobile Radio Communication Services

Telecom involvement with mobility may be said to start with the coming of mobile telephony. Until then, radio communication between mobile units, or between a fixed and a mobile one, could only be done using radio *broadcast*, i.e. non-switched, mostly local private radio networks. Such networks were in particular widespread for fleet management, e.g. for the routing of service cars and trucks, in Norway as elsewhere.

A broadcast service that developed into the typical telecom public service realm, was paging:

The Norwegian Televerket introduced paging by end 1984, with 60 % country coverage from the very start; i.e. practically all populated areas. The paging system put in operation permitted short text messages to be transmitted one way. All pagers "listen" to all broadcast calls, but an adress tag makes only the right pager fetch the message, while the others neglect it.

In addition to being an end-user application, paging provided platforms for applications of all kinds without fixed access to the telecom network, e.g. for remote control of house heating or alarms from automatic systems like sewage pumps etc. (As GSM with SMS has taken over most such paging applications, the public paging service will be put to a halt in Norway in 2003, whilst local, closed paging systems are still widespread, e.g. in hospitals.)

The first switched public radio communication system in Norway came with OLT (Open Land-mobile Telephone service) in 1966. In 1981 NMT – the Nordic Mobile Telephone system – was launched, a common undertaking of the Nordic countries, the Netherlands and Switzerland. The NMT network was among the most advanced mobile networks at the time, and made the consortium behind it forerunners in mobile communications: The success of the Nordic telcos as well as companies like Ericsson and Nokia in mobile communication can be traced back to the NMT initiative, not the least to the in-house understanding created as to how mobile telecom would catch on in the years to come. This was exactly the period when de-regulation was expected, and the national state-run telcos began to look for new income streams.

Early in the 1980s, the Televerket R&D people became aware that things were happening within mobile data communication: Particularly in the USA, mobile data communication caught on in the form of private, closed radio broadcast networks used for dispatching, i.e. fleet management, e.g. within metropolitan police forces. For the Norwegian Televerket, as well as for quite a few other telcos, the wish to participate in this development was strong.

As soon as mobile telephony was available, applications involving communication between computers "on top of speech telephony" – as described in the previous section – were tried out. The targets were all kinds of mobile professionals. However, noise from the mobile telephony system made such applications highly vulnerable if based just on an analogue system like NMT and primitive modems with loudspeakers and acoustic couplers to the mobile phone handset. Better things had to come around. And they did.

MOBITEX Trials, Mobile Datacom 1989 – 1994

Telenor's engagement in more dedicated ITS applications arose with the coming of a mobile data network. A set of initiatives were taken through the telco IGOs to develop a radio based packet switch data network. It was done under the name of MOBITEX – a packet switched narrowband radio network for datacommunications only – as a co-operative undertaking between several telecom monopolies, organised through ITU (the International Telecommunications Union).

The Swedish Televärket Radio AB – with its strong ties to Ericsson AB, played a central role. Also Finland and Canada and the Norwegian Televerket were very active members of what early became MOA – the MOBITEX Operators' Association (www.mobitex.org), with Ericsson in the lead of network development.

Some countries started rolling out their Mobitex networks in 1989: Sweden, Finland, and Canada built fully operational networks with extensive coverage. Around 1992 – 1993, also USA, UK, Australia, the Netherlands and Belgium built large networks in the most densely populated areas, if not of full countrywide coverage. In countries like Great Britain, the Netherlands and Belgium, coverage is today next to 100 %. In a few countries, private MOBITEX networks were built later, and are still in operation. In all, according to MOA, there are 30 MOBITEX networks in operation around the world, in 23 countries on 6 continents.

In Norway, Televerket from 1989 built a test network around the most densely populated area around the Oslo fjord, and application projects were started as described below. However, the mobile datacom development projects within Telenor were put on hold around 1994, as it was decided not to offer MOBITEX as a public service: GSM was expected to take over as the infrastructure of future packet switched mobile services, and to make service creation by far more efficient. Hence, it was difficult at the time to see how MOBITEX could cover the costs of a wider roll-out in a country with a small and dispersed population and relatively little road traffic.

With hindsight, GSM applications and dedicated terminals developed much slower than expected. The MOBITEX network in Norway was closed down in 1998 after migration of applications and a few hundred users over to GSM.

MOBITEX is still in extensive use and in sale in other countries, both in countries with extensive GSM coverage, and in others. New applications and dedicated terminals for MOBITEX are still launched, e.g. for mobile Internet browsing in Canada, mobile POS (Point Of Sales) in Korea, parcel tracing in the USA, car thieves tracking in England, taxi fleet management in Singapore, and bus information systems in Paris.[1)]

The Norwegian MOBITEX Trials

There was a close cooperation between these telcos through MOA as to both technical standards, market and applications development, and as to getting third parties involved in service application development. It was clearly understood that such development could advantageously be carried out in cooperation within MOA to help the market develop. Application areas of MOBITEX were thought to be next to limitless, with fleet management, information dispatch, and telemetry in the focal point.

Market research carried out by the Institute of Transport Economics (TØI) for the Televerket within the goods transport sector strongly indicated that the transport business was very inefficient, with only 15 – 20 % capacity use due to sub-optimal routing. Thus, product development within mobile data communication for traffic was considered to be of high value for the transport business, the service providers, as well as for society as a whole. It seemed well suited to address real needs, thereby creating a market.

The Norwegian MOBITEX trials involved a host of third parties – in all somewhat 30 partners – and to build experimental applications on contract for the around 50 end-users, or to seek business on their own or in cooperation with their fellow partners.[2)] In some instances the test applications were converted into lasting applications and business both within and outside of Televerket was created:

- A major hospital and rescue centers was involved in testing out info handling to/from mobile units in emergency operations. This involved info for better coordination of rescue operations, as well as the transmission of patients' personal data from hospital to the ambulances and the patients' emergency status from the ambulance to the hospital while underway to the hospital.

- A fire brigade was involved in trials with in-vehicle reception of info on addresses and buildings before arrival on emergency site.

- A range of goods, messaging and mail distribution companies were involved in fleet management trials; i.e. involving transmission of orders and task completion confirmations between command centers and drivers.

- Public transport companies were involved in fleet management systems and traffic information systems for operators as well as for passengers.

- Local public utility services in Oslo (water and sewage) were involved in telemetry – remote reading of various measurement equipment, e.g. for water levels and flow.

- Softdrink vending machines were developed to communicate their needs to be refilled by sending a notice to the operator when stock fell below a set number. The application was in full operation by 1992. (In 2001 it was re-invented with much publicity as a GSM service.)

- Surveillance of armoured transports of valuables was tested out in cooperation with a bank and a guard service company.

- Televerket itself tested job dispatch within field services, and identified large efficiency potentials. The study later formed the basis for a profound reorganisation of the field service.

- Alarm companies were involved in testing alarms at remote sites without access to fixed lines, like alarms for water levels, car or boat thefts, etc.

At the time, such communication mostly had the form of text messages distributed from control centers to in-vehicle printers or displays. Although primitive compared to today's graphic user interfaces, the applications were advanced, and are still central in application portfolios within all the areas listed. Contemporary press was stunned by the achievements of modern telecommunications.[3)]

Costs and Benefits

At the time the MOBITEX trials started, the Norwegian Televerket, as well as most telcos, was a governmental non-competitive body serving social goals politically defined. Financing of market development projects was not decided on business economic criteria only. It was the "Zeit-

---

[1)] *See http://www.ericsson.com/network_operators/mobitex/case.shtml for examples.*

[2)] *Among others: Ullevål sykehus, Transportsentralen, TollpostGlobe, Posten, Fact, Coca Cola Norway, regional rescue centers, alarm service suppliers, Securitas, Kreditkassen, Oslo local administration (water utilities),*

[3)] *A range of studies document the work, and new income streams from mobile data were created. MOA issued a paper ("MOA news") about its activities. We have not entered into such search for sources.*

geist"; i.e. it was commonly understood and found reasonable to expect, that such infrastructure and service development would be financed by Televerket and other public bodies for the benefit of society at large, and carried out in close cooperation with the in-house research institute, equipment vendors, and user interest groups. Accordingly, the project management of the MOBITEX trials, as well as the telco share, were 100 % financed by Televerket itself as a governmental institution. It was led and carried out through the in-house Radio department, later to become the business unit of Telenor Mobile Communications, and the in-house research institute (now Telenor R&D). The partnering companies and institutions would carry their own costs, alternatively get financing from other sources – or even support from Televerket.

But deployment projects were increasingly subject to cost/benefit analyses. The MOBITEX roll out business plans were at the agenda at the corporate top management several times before they were, as mentioned, turned down for economic reasons.

We take for granted that the balance sheets for the investments made in the MOBITEX application trials are lost in the mist of history: As a public service, Telenor at that time was not set up for accounting on costs and benefits of such initiatives in any consolidated way, scattered as they were around in the organisation. In addition, as the goals at the time were not just financial in any strict business economic sense, and the income of such initiatives only show up in the long run, even a rough assessment of the most direct business results from the MOBITEX activities in the period 1980 – 1994 seems impossible and nonsensical.

However, the MOBITEX projects created an arena of users as well as of service providers for ITS and other mobile applications. The extensive network of users and business partners later constituted an important constituency as ITS application building for the GSM network finally began.

Televerket's engagement in mobile datacom was in this respect a kind of "learning option": an investment in competence building within a field that could later turn out to become important business. Similarly it may be argued that a substantial benefit of the MOBITEX trials was that the management accumulated the experience and market understanding necessary to halt MOBITEX deployment.

The halt of the MOBITEX deployment led to a loss of momentum. But new initiatives soon took over, based on the experience gained.

Electronic Maps – a New Platform for ITS Services, 1995 – 1997

A "Transport Demonstrator" Named ELVEG

As one could see from the MOBITEX trials, information related to geography, whether constant or dynamic, played an essential role in the applications. Together with optimation models, such geographic information would form various kinds of applications of huge commercial as well as societal interest, like

- *Fleet management systems* for distributors of goods;

- Support info systems for *emergency services* and crisis management;

- *Navigation systems* for individual route planning and real time *position tracking*.

A basis for such application development would have to be a database on roads and other geographical information, i.e. a digital road map, to which relevant information – like information on adjacent buildings – could be added, or extracted in various formats – like textual reports, maps, or other. Such information could then be stored in "layers" for specific information sets, and switched on or off, just like in CAD applications. For navigation or fleet management, some kind of optimation engine would then be needed to figure out the smartest route.

The dream of making such applications available commercially and distributed, was not new. It was a shared dream within traffic planning, research, government, as well as commerce. As mentioned previously, research in Norway and elsewhere indicated a huge potential for savings. The news was that the telco now had a network that could handle dynamic information dispatch even to mobile units, and a community of test users established through previous initiatives. Not least, the IT business now had affordable hardware in which such systems could be embedded.

In 1995, Telenor took the initiative – in close cooperation with the *Norwegian Public Roads Administration*, the *Norwegian Mapping Authority* – to establish a three year pilot project to develop a "transport information demonstrator", named "the ELVEG project". It was to consist of an electronic road map, some applications based on the road map data, a system description, and an organisational setup for the establishment of such application services on a commercial basis. The *Research Council of Norway* contributed approx. 7 MNOK (mill NOK). Telenor's share

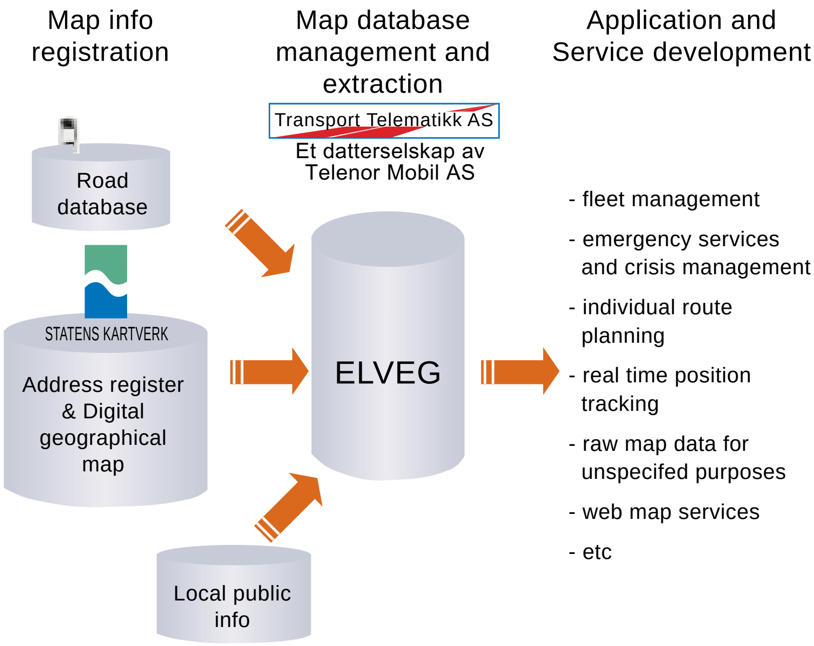


Figure 1 The ELVEG production chain

of the costs was around 10 MNOK – mainly personnel costs, amounting to less than 1/4 of the total project costs, including seed money to attract the entrepreneurial spirits.

The resulting "electronic map database" made up the platform for the application areas mentioned above, soon to result in the commercial creation of such "value added services" (VAS). Again, application developers and service and harware providers were invited into the project to develop fleet management software in cooperation with some emergency service centers. The network of pilot users built up through the MOBITEX trials became highly instrumental. Eventually, new companies were set up with seed money (see below) to provide the missing links in the production chain.

The production chain is illustrated in Figure 1.

Pilot systems within fleet management, emergency services, navigation, and position tracking – of varying degrees of sofistication – were tested. Mostly, fleet management was based on manned command centers which would find the optimal route and dispatch it to the truck fleets engaged within e.g. oil, beer, parcels, or timber distribution. Functionally it was much along the concept made up during the MOBITEX era, although now on a newer technological platform:

New generations of mobile equipment had come to the market. On board the trucks one could now use GSM mobile phones as entry device to the datacommunication. GPS handsets could be used for geopositioning. PCs and PC applications would be used to recieve messages from the dispatch center as well as map data for an in-car navigation system. And even printers and fax machines for their various purposes. Vehicles were on their way to become mobile high tech offices, knit together with the head office in ways formerly unthinkable.

The ELVEG transport demonstrator project resulted in a range of product ideas at various locations along the value chain. Application ideas were all free for participants to grab or share, as normally is the case with such initiatives of mixed public and private funding.

Resulting Services and Derived Business

Telenor had during the ELVEG project built up a substantial capacity and knowledge on the integration of map data, management of the database, and on data extracts for VAS creators. But only a fraction of roads and maps had been recorded during the project period. Therefore, a first goal was to complete the database. By 1999, practically all roads in the country down to 50 m length had been recorded, together with other information relevant to the drivers, like speed limits, boggy and height limits, road names, house numbers, lakes, areas, railroads, etc.

The project organisation built for the purpose, became the company *Transport Telematikk AS*. As shown in Figure 1, its business simply became to continue the role Telenor had taken in the ELVEG production flow: data integration, management and distribution for the various VAS providers.

Based on ELVEG, some software houses and in-house IT departments in large enterprises developed fleet management applications. Users were of the same kind as previously: large transporters/distributors – breweries, oil distributors, forestry transporters, and the (governmental) postal service.

Emergency and rescue information systems are too different to be served by such developers. Thus a system developer had to be developed for that specific area. With the use of venture capital, Telenor established the company *Locus AS* (see Figure 2). Locus is at present an important supplier of fleet management applications integrating ELVEG data and communication solutions for emergency and rescue centers, for dispatch centers, transportation of valuables, etc.

As to in-car navigation, Transport Telematikk became the main supplier of map data to the dominant European digital map suppliers, TeleAtlas and NavTech. TeleAtlas and NavTech in their turn furnish CDs to the car navigation system developers, like Bosch-Blaupunkt, Siemens-Sony, and Phillips, each of them suppliers to their specific car producers.

During the years to follow, Transport Telematikk launched a host of new products, many of which are function specific interfaces to ELVEG or subsets, or extensions based on tools developed later; i.e. they serve as production tools for application developers. The “Map hotel” is a case in point: Modules for the management of own data sets to be combined with ELVEG data sold to VAS and web developers. Map data are also sold – as “raw material” – for unspecified use, e.g. to competitors and other VAS developers. The Swedish company T-kartor AB may serve as a customer example: On the top of ELVEG data, it has launched the M@P product range for managing and displaying a range of map formats and the presentation of complex combinations of data sets (see Figure 3).

Figure 2 Locus AS: fleet management system provider, originally built to service rescue centers

Motives

Behind Telenor’s involvement was a combination of interests. Still, with the culture of government prevailing, an engagement in exploiting the new mobile networks, digital maps and GPS for better transport planning, was a kind of social obligation – with Telenor being among the few in the Norwegian society with muscle and mind able to initiate such development activity. However, such perspectives prevailing in part of the organisation, it was nevertheless also considered to be good business:

Within telcos, the governing paradigm of the time was value added service (VAS) creation. The entire ELVEG initiative may be understood as an initiative to increase traffic in the networks by service creation. VAS based on IN (Intelligent Network) mechanisms had created new growth in the telco sector worldwide. Digital maps and navigation was just one more step along the road, with realtively more of the application located in the terminals, but still generating traffic in the telco network. The commercial interest of the telco was in accellerating a development which might happen anyhow, but not necessarily if nobody took the lead. Eventually, by doing so, Telenor would help build the new industry, wether or not Telenor would earn back its investements from network traffic or from services.

Perspectives would be different through the eyes of other partakers. For the business entrepreneurs higher up the value chain, the map database and communication network was infrastructure – rescources to be provided by someone, but for them more or less to be taken for granted. For them, the interest was in designing and servicing a fleet management system, or in equipment sales. For public authorities, a motive was to get more cost effective public services, fullfilling their raison d’étre. It would also mean challenging professional work, and in part also open for new sources of income.

Such differing perspectives were not contradictory. On the contrary, they are the glue of cooperative, multi-disciplinary projects.

Costs and Benefits

The accumulated Telenor spendings on the ELVEG project are in the magnitude of 20 MNOK, half of which were spent on establishing the map database service company Transport Telematikk AS[4]. There has only been

Figure 3 M@P: Service creation on the basis of ELVEG map data and functionalities

---

[4] *The company, numbering 12 persons, was established as a separate business unit under Telenor Mobile Communications in 1999. From the business proposal leading to the establishment, one may read that the costs supposed to incur from establishing the company and running it until figures went into black, would amount to 7 MNOK. The real figure turned out to be in the range of 10 MNOK when the company got in black by 2001.*

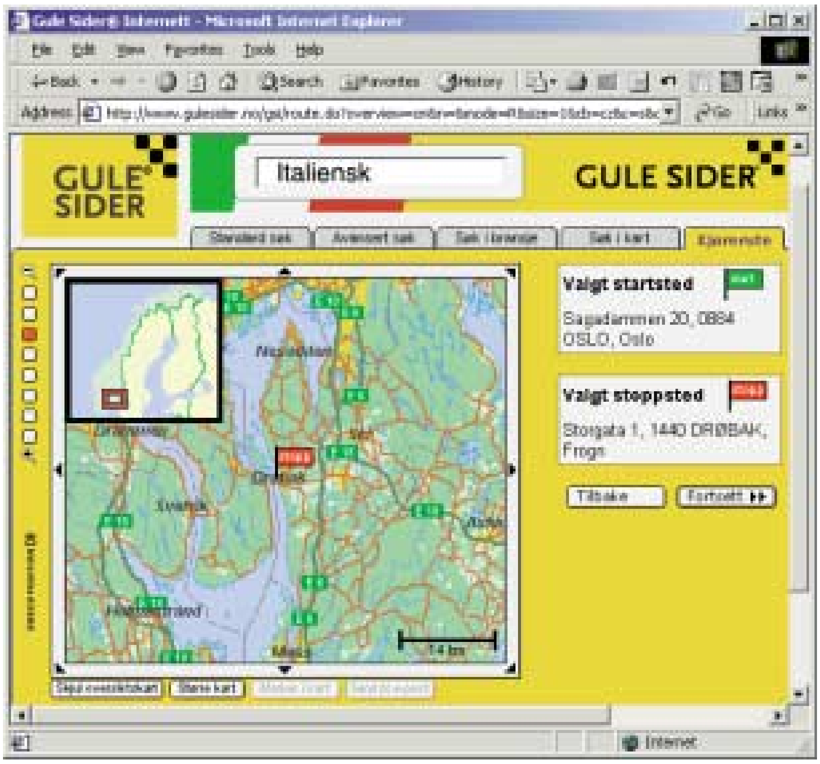
a negligible income from the companies created. However, we believe there are few investments in Telenor with a higher payoff, for the following set of reasons, conforming to the thinking of the time, is largely based on traffic generated, not solely the income from VAS as such or from application development and sales:

Preponed income: That is, income arriving earlier because of the ELVEG project. Such incomes – e.g. from GSM traffic to and from the trucks – are hard to assess, as they are hard to sort out from traffic that would have happened anyway. Nevertheless, rough accounts indicate that by 2001, the GSM airtime generated from vehicles involved in fleet management directly attributable to the ELVEG project, was in the range of 40 MNOK/year. This income alone, which can be regarded as net income, is twice the Telenor investment.[5)]

New income streams: Transport Telematikk AS now runs in the black, but income is negligable. However, as we shall see later, several other companies have based considerable new business on the ELVEG data. Telenor is a major shareholder in some of these companies. We have not examined their income further.

Indirect income: ELVEG map data find their way into a host of applications. Making these applications more attractive, the ELVEG data indirectly increase online time and airtime. Examples of online applications are real estate web marketplaces and the yellow pages (Figure 4). They are also bought by local government planning offices, and even for more exotic use, like in the traffic planners' simulation tools.[6)] The data for such use are also distributed via the telco network, hence traffic in the fixed telephony network is created.

Figure 4 Yellow pages with travel planner



There is no way of tracing such traffic income connections to ELVEG. It should, however, be evident that it is substantial and manyfold the original investments: Just 25 minutes added surfing a year per inhabitant is enough to equal Telenor's entire accumulated expenditures.

It should thus be evident that value creation systems should be assessed as a whole, and not partwise by examining the balance sheet of each business unit in isolation: If assessed only by the *direct* income streams created, the picture is quite different.

The ELVEG project could also be assessed as a practical lesson of relations building. The project conformed to the co-operation model then and now found necessary to open new markets for infrastructure businesses – cooperation along the value chain all along to the users:

The infrastructure provider initiates and provides a long term business perspective, while capital scarce small entrepreneurs contribute with creativity and enthusiasm, research institutes supply brain work and assure the general knowledge build up by publishing results, and finally, governments impose the use of open standards, partial funding and impartiality.

A very practical result of this concerted project model was that important players could agree on technical standards to be used. Thereby, an infrastructure open for service creators, sufficiently large to get momentum, was established. The gains, both in reduced development costs, in earlier network traffic, as well as in the number of applications, should be counted in MNOK.

At the time of the ELVEG project, assessments were done regarding societal and user advantages. While preparing for this paper we have hardly found any traces of them. However, a presentation slide series from 1997[7)] reveals the main quantitative, and indeed very positive findings:

5) *In a network economic value creation system like telco network operations, marginal costs are nil, thus the entire sum can be considered net income to a degree it would otherwise not have come.*

6) *Hamre Tom N: GISNETT – Fra ELVEG-data til nettverksmodeller med kobling mot GIS, TØI, notat 1170/2000, Oslo 2000.*

7) *Barlaup Torhild L: Evaluering av Transportdemonstrator-prosjektet, TØI, November 1997, slides.*

- Payback on investment: 8 – 12 months;
- Efficiency gains: 30 % increase in 1 year;
- Cost savings: 2 – 10 %;
- Turnover: trippled turnover and doubled vehicle fleet over 5 years without increase in administrative expenses.

As to qualitative results, participants mention in particular better service, safety and quality of service, less pollution and time lost. But also that "more development was to be done" to make the equipment and solutions work as intended.

Thus, the findings underpin what was common wisdom at the time, and still is: That the gains from ITS at all levels seem to be substantial.

Later, ELVEG data also became the essential input factor for new income streams that we shall meet in the next section.

The Next Step: SPIDER – Finding the Smartest Route

SPIDER was initiated as a development project between Telenor Mobile Communications and the research institute SINTEF[8)], department for Applied Mathematics.

During the ELVEG project the need became clear for an advanced route planner, including a mechanism for optimizing transport delivery trips. SINTEF had at the time created some basic modules for route optimization. A product that could optimise routing for delivery jobs was thus in sight. SPIDER was developed to find the shortest route between several destinations.

The project started in 1997, and lasted for some 18 months. SPIDER was tested out with a major transport company.[9)] The result showed that by route optimization 30 % of the distance travelled could be saved, thereby reducing transport costs by 25 %.

SPIDER has later been commercialized as a product consisting of several modules providing functionality for transport planning and cost optimization. It is one of the world's fastest and most efficient routing tools. Today, it is used for route planning within a number of companies with goods transport fleets.

A spin-off company of SINTEF, Green Trip AS (www.greentrip.com), has the business idea to distribute and further develop SPIDER. SPIDER is also a central tool for several VAS providers offering routing as part of their applications.

Costs and Benefits

The total project costs of the SPIDER development were modest, and parts of the costs were carried by the Norwegian Research Council. Telenor invested the rest, but mainly in-house manpower. Partners carried own costs connected with implementing SPIDER in their own applications.

All rights to SPIDER are with SINTEF, which distributes the SPIDER products internationally through its spin-off company GreenTrip AS. GreenTrip AS partners with much the same companies as have been active all along. Thereby the cluster formed through these various projects is reinforced.

The SPIDER project contributed to the development of more advanced travel planners, in the next run stimulating the general use of mobile data communication as well as more cost efficient and less polluting traffic. The direct and indirect gains to Telenor – or society at large – of the SPIDER project are not possible to estimate. A project of less than 1 MNOK, its influence on transportation and the use of ITS does not have to be large to be easily defendable in pure business terms.

Adding Time Sensitive Location Specific Data – and a Web Based Multi-Format Service Platform

"ICT in Road Traffic" – an Information Integration and Distribution Project

The project "ICT in road traffic" (1999 – 2001) was a research project inititated and managed by Telenor Mobile Communications. The Norwegian Research Council contributed to it with some financial support under the LOGITRANS research programme. (The funding was in its entirety used to finance parts of the work carried out by SINTEF.)

In the "ICT in road traffic" project, the results from the previous projects were carried further: The aim of the project was to establish a high quality traffic information service both with regard to content as well as to the user interface. In practice, it meant that even temporary information – e.g. about a car accident, temporary diversions, or a blocked road – should be possible to register and to manage for a limited time, and that data should be presented to the users in ways that were compatible to their roles as drivers. More technically speaking, it meant to add time sensitive location specific data, and to

---

[8)] *The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology.*

[9)] *Tollpost Globe.*

streamline the entry, maintenance and distribution functions.

Accordingly, information would have to come from several sources – e.g. road authorities, traffic police and the general public, it would have to be co-ordinated and checked out, it should be accessible with mobile devices like mobile phones among others, and it should be distributed only to those who wished it, or to whom it was of relevance. It should also have a format which minimized the risk of endangering or disturbing the reciever, i.e. in many or most occations a driver while driving.

The ELVEG datasets together with the established map engine constituted the infrastructure over which it was all concieved.

Participants in the projects were the radio station *P4* – with its havy focus on traffic information, the research institute SINTEF previously mentioned, the *Norwegian Automobile Association* (NAF), the *Norwegian Public Roads Administration*, and *Bravida Geomatikk* (a Telenor subsidiary described in more detail below).

NAF and the Norwegian Public Roads Administration were to supply the service with content from their information services.

The radio station P4 was to develop an application for online entry of traffic information in their radio studio, to be instantly transmitted to Bravida Geomatikk, where it would enter a separate POI (Points Of Interest) database. From there, it would be extracted and distributed to the users over the mobile network as SMS or in other datacom formats.

SINTEF's mission was to test – by the use of its car driving simulator – the way users reacted to various contents and display formats, as well as to technically describe the production system to be set up (Rødseth et al.: *IKT i vegtrafikken*, SINTEF report STF22 A02313, 2002).

Results – Costs and Benefits

The project accomplished its goals: The production system was established and put into operation, first with P4 as sole content provider, later also including content streamed from NAF and from the Norwegian Public Roads Administration. Some services have been on test for some time, and some of these were softly launched in October 2002.

There are accordingly no relevant data for any empirically based benefit analysis. The entire project has been in the range of 5 – 7 mill NOK, for which the Norwegian Research Council granted around 2.5 mill NOK, mostly used for financing research and other services at SINTEF.

Telenor costs have been around 1 MNOK in investments and 0.5 mill NOK in internal costs for manpower etc. The other partners, Bravida Geomatikk, P4, the Norwegian Road Authorities, and the automobile association NAF have carried their own development costs as their costs as pilot users.

As we see, in all the later projects we have described, the role of Telenor has not been the financer with deep pockets but more the initiator or midwife – by taking the initiative and building the value network necessary to produce a service that, in addition to creating value for the other participants in the value network as well as for society at large, also creates value for the Telenor core business, the network traffic business.

As described above, the production flow established for these new traffic information services came to revolve around the Telenor affiliate company Bravida Geomatikk. Below follows a section describing the production system – with a focus on the Bravida geographic information integration and distribution concept – *GeoWEB*.

Bravida's GeoWEB

As Telenor in the latter half of the 1990s spun out its network installation services into the company Bravida, it also let go of various service units closely connected to the installation services, like alarm, location and mapping registration and archiving services.

These services had in the previous years been through a considerable modernization, in particular the central archives for geographical information about the entire national telecom grid and its connected installations, which had become highly modernized. Capitalizing on its competence from telco networks planning and maintenance, Bravida could thus build a business unit – Bravida Geomatikk – re-assembling various telemetrics and mapping services, archives to data conversion services, data management and analysis, as well as distribution.

This very same production chain and organisation – including its web based customer interface in operation since 1997 – could be used for adding value to ELVEG data. As the above mentioned "ICT in road traffic" project was established, Bravida Geomatikk was the natural place to look for a partner.

Together with Telenor Mobile Communications, Bravida Geomatikk now developed a general data entry tool to be accessible also for content

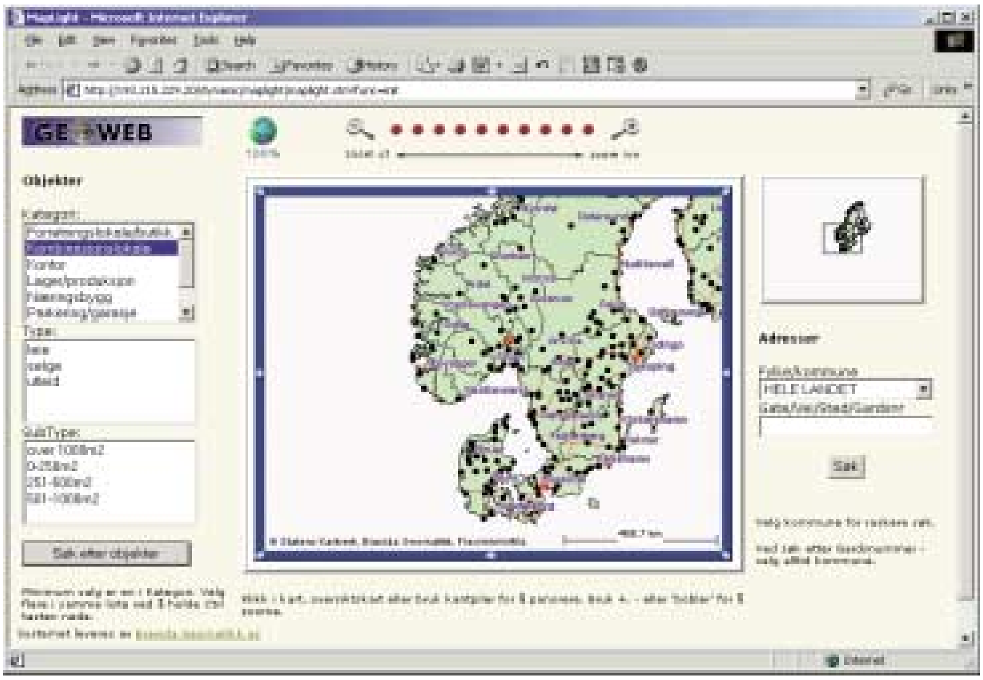
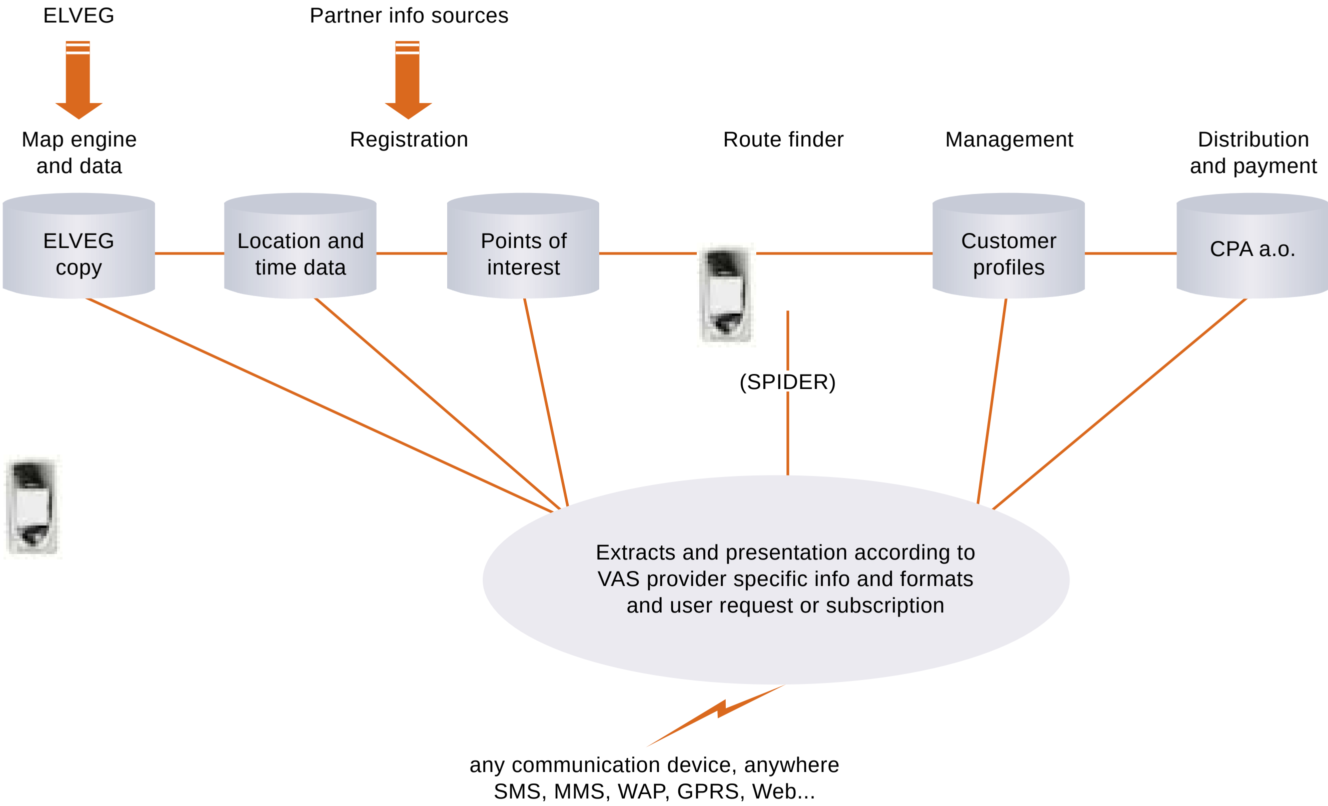


Figure 5 Looking for real estates and property in the Nordic countries through GeoWEB

providers in general. Also, a POI database, compatible with ELVEG, was established. Hence, Bravida took on a role of handling incoming time sensitive data and to present them "on top of" maps generated from ELVEG data. Through web interfaces permitting "skins" of any imaginable kind, Bravida Geomatikk opened for a customer defined "look and feel"; i.e. mechanisms for differentiation of the end product (see example in Figure 6).

As services are not viable without some kind of income stream, an income stream from sales of the services to end users had to be established; i.e. a system for subscriptions, ordering, distribution and payments. By basing the distribution mechanisms on Telenor Mobile's CPA platforms (Content Provider Access – a platform for payable services for 3rd party service providers), all mobile phone users irrespective of their network operator could be reached: The CPA plat-

Figure 6 The GeoWEB system



form ensures the 3rd party service providers a mechanism for payable service distribution in formats like SMS, WAP, MMS, etc, and is well established. (The web, WLAN and other distribution networks require other mechanisms or income models.)

Figure 6 describes the GeoWEB in-house production system as of today with its two main traffic information entry points. It may be seen as just an extension of the ELVEG production system described earlier. However, the connections indicated are grossly simplified: The production system is very complex in all its data flows.

The GeoWEB production system soon came to include a range of information services and formats. The extreme flexibility as to the possible content and "skins" of end products tells us that the GeoWEB brand first of all will be seen "back stage" by VAS providers drawing on GeoWEB mechanisms to exploit this "engine of limitless variation".

Expectations are that GeoWEB will be the core of a highly efficient traffic information service platform, opening for a wide variety of content suppliers, of personalized information services, of output formats, and of delivery via a wide range of infrastructures. Time will show. Income from the SMS and similar information services so far have been negligible, as one must expect at such an early stage.

With reference to our introductory comments, the GeoWEB production process pushes the paradigm shift which has long been seen to transform the telecom business one step forward: The entire GeoWEB production system is in principle open both at the input and output ends, and independent of traditional telco mechanisms all the way if the web and WLANs are used for the access.

Such technical solutions, with a correspondingly open value system are sometimes said to belong to *the 3rd telematics generation* – i.e. service focused value creation systems in which multiple service providers are able to generate and operate services which can be remotely downloaded to the user's platform, and where there is no strict dependence on specific communication carriers: To the distribution systems implemented, new communication services can be added *ad lib*. In such a framework, network infrastructures and their embedded payment mechanisms (like the CPA) are considered accidental – i.e. they are just an input factor that may be easily substituted whenever a better alternative shows up.

Romantically unrealistic as such a 3rd telematics generation would seem a few years ago, it has become harsh reality to all telco network service providers with the success of Microsoft MSN. GeoWEB uses the same concept and the Smart Travel project, described below, carries this development just another step further towards omnipresence and network independence.

Sm@rt.Travel – New Netbased Services for Travelling

Sm@rt.Travel (2000 – 2001) was a fairly small project but with a with huge potential. In some ways it tops a three stage development chain:

With the transport demonstrator project, the ELVEG digital map had been established, and some demonstration solution had been developed. With the "ICT in road traffic" project, Telenor together with its public and private partners had established

- The mechanisms for collecting, managing and distribution of dynamic traffic information;
- An IT structure for dynamic geographic information of interest (POI);
- An advanced route planning tool (SPIDER);
- Co-operation, organizationally as well as technically, between the three, and made the results accessible over a range of output channels and formats, fixed and mobile, textual descriptions as well as graphical maps.

Sm@rt.Travel took the concept somewhat further, basing itself on ELVEG, POI, SPIDER, the production chain, and the multi-format output strategy.

If the previous two projects may be accused of focusing on technology, this could definitely not be said about Sm@rt.Travel. The whole project was about developing value added services based on these established mechanisms:

By this time, the use of the Internet World Wide Web had become widespread. Business as well as private people were spending ever more time surfing the net, and it was clearly seen that ever more of people's everyday activities were being ported from non-ICT platforms – like walking to the library to borrow a book or to the station to check the timetable – to the digital networks. It was also clear that substantial value could be added to many net based services if the content on web pages could be combined or made clearer with the help of maps, route planners, and geographic information of specific interest (POIs). For example, shops could show where they were situated. Chains stores could show their outlets. Tourists could find nice views, hotels, and preferred scenery – or the optimal routing provided the lunch under way should be in a fish restaurant!

Sm@rt.Travel addressed just this potential. Within two years and around 5 MNOK, essential work had been carried out within the project:

- Specific POIs for relevant data for specific target groups were set up by the pilot participants, much in the form of converting catalogued information to a digital database, by "geocoding" it, i.e. connecting it to time and place specific coordinates.
- Applications were formed in cooperation between the specific pilot participants:
  - The specific POIs were made compatible to ELVEG;
  - Mechanisms for user specific profiling (e.g. family/holiday/business travel, etc.) were built, so that only the relevant POIs would be searched;
  - The route planner SPIDER was developed further to cater for other perspectives on optimization more relevant than traditional fleet management.
- POI groups of interest to specific pilot information providers (Norwegian Automobile Association and two regional tourist associations) were established and data registered.
- A travel planner combining personal profile, POI and ELVEG data was developed with two interfaces: for use on the web from a PC – typically pre-travel use – or via mobile datacom for the PDA (personal digital assistant) – typically for travel use.
- Interfaces with synthetic speech and speech recognition for PDAs were prototyped and tested.
- Position information from GPS and GSM was integrated into the PDA application.

Telenor Mobil AS and Telenor R&D Tromsø branch had the lead in the management of the project. The project could profit on the many projects previously carried out by this regional division of Telenor R&D: Focus had for many years been on the particular needs for ICT supported means for co-operation at a distance. In a region characterized by long distances, scarce population and harsh climate this focus had since long been combined with extensive co-operation between the Telenor R&D branch and governmental bodies, local as well as regional.

In the Sm@rt.Travel project, we find project participants and contractors from Northern Norway only. There are just two exceptions: the nationwide automobile association NAF and Bravida Geomatikk AS, which we both know from the projects described previously:

- The foundation "Utviklingssenteret i Midt-Troms", an inter-authority business and social development center focusing on ICT and its distance cooperative potential;
- The regional tourism promotion organisation "Destinasjon Midt i Troms" (www.dmit.no);
- The travel promotion organisation "Kystriksveien Reiseliv AS";
- The Regional college in Finnmark;
- The University of Tromsø; and
- NORUT IT[10], an R&D institute specialized in Information and Communication Technology related to Earth Observation.

Costs, Results and Expectations

Of the entire project costs of approximately 5 MNOK, the Norwegian Research Council covered around 2.5 MNOK[11], which was spent on development work, mainly within NORUT IT. Telenor's own costs were in the range of 0.5 MNOK, in the form of internal manpower. The other pilot participants contributed with another 2 MNOK in own internal costs.

As with earlier projects described, the goals for such projects are many, and may be highly varied for the different parties involved. Overall evaluations are thus hardly meaningful.

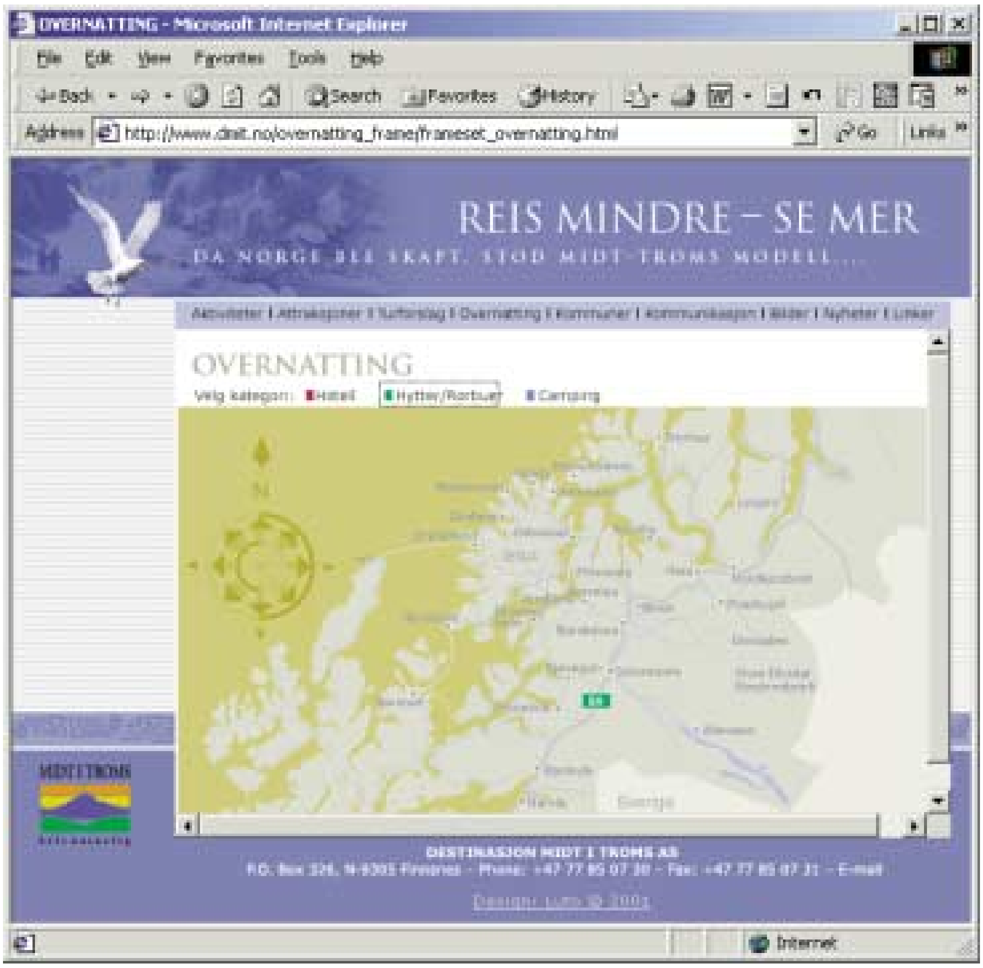
Sm@rt.Travel services have gone public stepwise during the fall 2002. A strictly commercial evaluation from the part of Telenor would have to account for 0.5 MNOK. A commercial evaluation of the entire project will for still some time suffer from the fact that lead time from development to product, and further until use eventually catches on in volumes that can commercially defend investments, is a matter of years.

---

[10] *NORUT Group LTD consists of five research institutes in Tromsø and Narvik, Northern Norway. The company collaborates closely with the University of Tromsø and the Regional College in Narvik, which are also among the owners. The NORUT Group has 220 employees whose applied research and development encompass a wide variety of interdisciplinary fields.*

[11] *Under the research programme "Services, trade and logistics", earlier named TYIN.*

Figure 7 Travel information site with tourism POIs



Also, income generated will appear at many locations in very different business units: Fixed telephony uptime for Internet browsing, mobile telephony positioning, SMS and MMS, mobile datacom uptime, map and POI services – the income generated appears at various business units, will only to some minor extent be attributable to specific services and will not be aggregated under any heading making them attributable to Sm@rt.Travel, or even to ITS as such.

To evaluate the project thus takes more of a qualitative judgement about its function as a lever to more use of online info services. For the authors the evaluation seems easy: The developed services – as well as other services that were concieved during the project – are in the pipeline towards production. And the evidence is that such services will catch on and boost net traffic in general – whether fixed or mobile:

- The company mPower AS – a spin-off from Telenor R&D – has been established to forward some of the services developed.

- NAF is developing its new website, where some of the developed services will be found, among them traffic and travel relevant info distribution for PDAs.

- The company TransportNett, a web based transport service supporter and broker has since its launch April 2000 integrated several of the Sm@rt.Travel applications in its services. The site (www.transportnett.as) accordingly offers its clients to enter pick up and delivery locations in maps, as well as to use the route planner and a very straightforward fleet management tool online, including tracking the vehicles through the means of GSM positioning information. Plans are for traffic info services to also be included. These services are already in use by a few transport companies (Figure 9).

- Elements from Sm@rt.Travel are in use in the IBIS project in the city of Trondheim, i.e. in the bus fleet management, as well as in the associated traffic info services for bus riders.

- Several other business opportunities for the Sm@rt.Travel applications are seen and stepwise tested out. As an example, Telenor Connect AS, a Telenor subsidiary focusing on radio networks and applications for emergency services as well as on fleet management and info services for city bus companies and their riders, is currently considering the use of Sm@rt.Travel bulding blocks in its services.

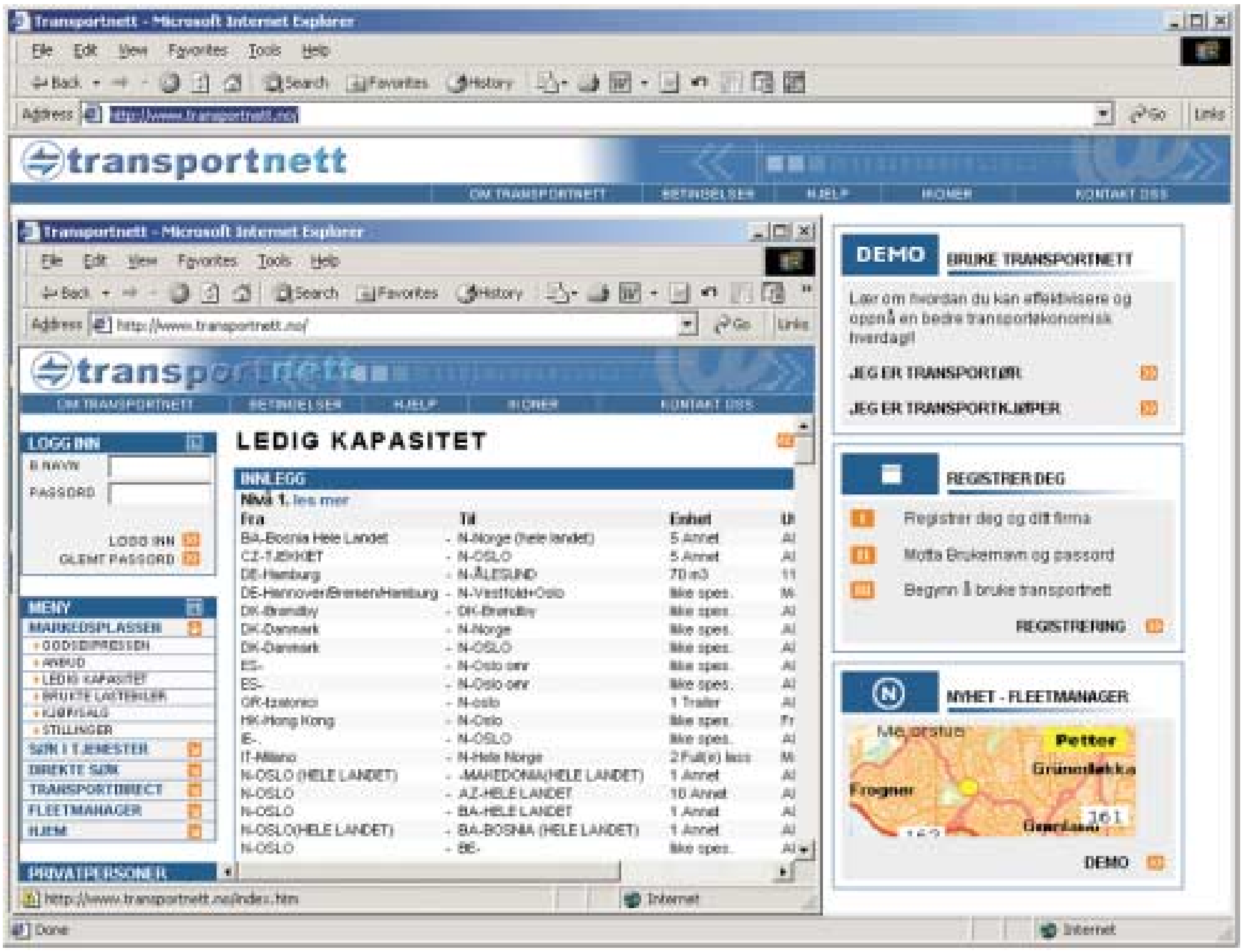


Figure 8 The TransportNett fleet manager: integrating maps, POIs, GSM positioning and SPIDER

Sm@rt.Funk

The project Sm@rt.Funk was basically a project to adapt the Sm@rt.Travel applications and data to the particular information and access needs of the disabled, as well as to add other data of particular relevance. By such measures, disabled people would hopefully get better access to information and services within travel, tourism and transport – enhancing their possibilities of actively taking part in societal life.

Among the main challenges were to get the data categories and data sets relevant for the various kinds of handicaps, as well as to get the user interfaces functional.

The data were based on an accessibility guide for the city of Tromsø published by the local handicap organisation. Almost 300 locations in the city center were mapped with respect to a set of accessibility criteria and the locations were registered as POIs with Bravida Geomatikk AS. The resulting information was distributed as a web page for PC format, a PDA picture, as WAP, SMS and synthetic speech.

The user profiles had to be accommodated to be relevant for needs connected to various disabilities, like “no steps outside/inside”, “contrasting colours wall vs. floor”, etc., and a service to tell the user his position was added, distributable also to relevant helpers.

The project lasted 14 months, and was carried out by many of the same partners as in Sm@rt.Travel, only with the added partnering of the local handicap organisation, Norges Handikapforbund, Tromsø branch.

Results, Costs and Benefits

Total project costs were in the range of 3 mill NOK, of which the National Research Council took on half, spent on the contractors NORUT IT and Telenor R&D. Costs carried by Telenor Mobile Communications were in the range of 100,000 NOK.

Among the main achievements were

- A description of a framework and arcitecture for universal access (for the disabled as well as for the not-disabled);
- The building of a demonstrator POI base for the city of Tromsø, and applications with par-

ticular regard to movement and vision disabilities;

- Piloting of Sm@rt.Funk services on the web over fixed access as well as the mobile Internet.

So far, the projects have not resulted in any applications in full operations. However, they have created new knowledge and understanding of the possibilities of using ICT to include, not to exclude, the handicapped. The Sm@rt.Funk project has also brought together people who might carry on the continuous process of keeping society accessible also for the disabled, and has brought forward ideas on several new applications and further development projects.

Next Step in Geographical Info Integration: Real Time Integration with Map Data

In further development work now taking place in several units in Telenor, work is carried out to integrate real time data, e.g. a friend's position, with more static map data, and even in combination with spontaneous networking.

It has been reported in the newspapers that the most recent US tank units use such technologies to "see" each other's vehicles and to coordinate operations even at zero visibility. As such technologies get commonplace and cheap, they will pave the way for a range of applications where real time movements can be integrated with more static information: Moving cars – or parcels – can be followed on maps, not just on a radar screen or when passing electronic gates. The escaped pet dogs' movements could be traced relative to POIs and static map data. Criminals could be watched, but also become watchers themselves. Finally, "electronic herding" may become a new phenomenon to get used to, even within the urban context.

In the Telenor R&D labs, experiments with such applications are at present going on, not least connected to spontaneous peer-to-peer networking technologies.

A Different Order of Magnitude: The ITS Stories We Tend to Forget "Because it isn't Telecom"

In the previous sections of this paper, we have by and large traced a development starting in the Radio systems department of the old telecom administration into ever more sofisticated information handling for distribution via earth based radio network services (mostly mobile GSM, but increasingly WLAN) to – and from – mobile units. As far as related to traffic, fleet management, etc, such systems may be subsumed under the fashion term of "ITS". In volumes, this development has not resulted in important visible income contributions on the Telenor balance sheet. However, as we have argued, they may be more than justified by their gains for society, as well as by their positive effects on network traffic.

Being close to the telco core technologies, and easily identifiable to any consumer used to a mobile handset, to private cars, maps, and public info services, it is not astonishing that the field described is what has got most attention in the general media as well as in everyday life of the telco: We understand it because these solutions are visible in everyday life, and we understand how income is – or is not – created.

However, there are also other stories that should be told if Telenor's engagements within the fields of IT supported traffic handling should be described; e.g. stories about ship navigation systems made possible through an early Telenor engagement in satellite systems. Newspapers were at the time filled with the wonders of what the new technologies – integrating satellite radio communication, earth based telecom, and computer networking – could do for the ship, the seafarers, the owners, the passengers, etc. Is that not ITS? Or stories about Telenor engagements in sensoring systems for airbags and tyre air pressure – is that not ITS?

We shall round up this walk through of ITS in Telenor with describing briefly what is at present in our understanding the most important such story that we telco people tend to forget – because "in a way it isn't telecom":

It is the story about the evolvement of professional mobile radio networking within professional fleet management, and its present merger with modern info management. The company in charge of this field within the Telenor corporation is Telenor Connect.

Professional Mobile Radio and Modern Info Management – Telenor Connect

As the company Transport Telematikk and its derivatives within geographical information systems may be said to constitute a development branch from the early Radio Systems department's engagement in MOBITEX (see above), Telenor Connect may be seen as the result of a different development branch: professional mobile radio systems.

The professional mobile radio people constituted a more network and hardware oriented culture. Theirs was the field of the public services which could not be adequately served by the public mobile and fixed telecom networks: emergency services like fire brigades, police and health services, and transportation systems in tunnels, underground, or out of reach of fixed lines, NMT and GSM. In the days of monopoly, it had been the responsability of the Televerket to serve alarm centers with the telecom and radio services needed (as well as the systems for emergency phone numbers). Such responsibilities were not a question of costs, but of societal role and the obligations of the state institution. Important for society as they surely were, such activities nevertheless were "hidden in a corner", and seemed even more marginal and costly in the new mindset of competitive business.

Within these fields there were much to do: Through large scale R&D in the health sector within which Televerket played a central part, one had seen the possible gains for the public health sector by the use of ICT and started a long term reorganisation. One had now seen similar possibilities for better service creation through ITS systems coming up, and numerous initiatives were taken to duplicate the process started within public health. The ITS projects mentioned were parts of such efforts, resulting e.g. in applications for the management of ambulances, fire brigades, etc. (Figure 9).

Command center	In-Vehicle
• Identification of caller's location	• Job orders and other messages
• Map and POI, e.g. water supply pipes	• Map with display of own position and job location
• Search on address or location name	• Transmission of status messages
• Shows objects and events	• Transmission of position to command center
• Communication with vehicle and order transfer	• Alarms
• Vehicle position and status display	• Time registration
• Integration with administrative software	

Figure 9 Example of ELVEG application for fire brigades

The huge potential was thought to be found in better communication between command centers and mobile units on emergency missions, in better integration of information from the various administrative units, in better presentation, e.g. as dynamic POI on maps, and – not least – in better coordination between the emergency services mentioned. It seemed clear in the early 1990s that the country was heading towards a thorough reorganisastion of the structures as well as the support systems within emergency services.

In a competitive market such obligations, with their organization, routines and mindsets, were slowly to be transformed to suit the role of a player in a competitive market, though under special regulation. Both Televerket and the public institutions were bewildered in their new roles and the process took its time – with large reforms in the organisation of emergency centers and their ICT systems in limbo.

After the Telenor mobile telephony business streamlined its activities in 1999, activities related to professional mobile radio communications – within closed as well as licensed radio networks – gradually became collected and organized as a separate business. Over the years this unit, that was to become Telenor Connect in 2002, had aquired radio network and equipment expertise from the remainder of pioneering industries within the field, among others whole or parts of the Norwegian companies Lemkuhl, EB, Nera, HydroSystems, as well as the Swedish Ericsson Public Safety AB (2000) and the Danish Infocom ITS (2001), the latter a specialist in management and information systems for bus fleets.

Telenor Connect thus became the Telenor specialized body for the fields of

- Information and management systems related to Public Safety fleet management, integrated with alarm centers and control rooms and in-vehicle equipment;
- Information and management systems related to public transport, including fleet management, traffic info to travellers, ticketing, etc.;
- Closed licensed radio networks – from tunnel size to countrywide – and interactions with public broadcast, mobile and fixed line tele- and datacom networks.

Accordingly, the business areas are divided into transportation communication (TransCom), public safety (Public Safety), railroad communication (RailCom), communication systems for tunnels – like safety radios and FM public broadcast (TunnelCom), and communication systems for waterworks and energy utilities (HydroCom).

Telenor Connect counts at present around 150 employees with activities in the Scandinavian countries and England. In Norway, Telenor Connect is at present closely involved in a few large ITS system developments, of which we shall just mention a re-organisation of public safety – with a reduction from the present 350 command centers to a handful. The project includes a country wide TETRA closed mobile radio network for Public Safety purposes (in pilot operation since February 2001). No longer a public responsibility of the telco, the network will be operated under a kind of PPP (Private Public Partnership) long term agreement.

Results, Costs and Benefits

Telenor Connect is a 100 % Telenor owned company, considered a venture operation. Within its field it is subject to the mechanisms that are pointed out several times in the papers in this ITS issue of *Telektronikk*, and that goes for ITS business in Norway as well as in other countries:

The market only takes off when large players, among them relevant public authorities, are able to cooperate and to follow up projects and identified gains with decisions. Thus, the potential in terms of projects in the Norwegian market was in 2002 estimated at 120 MNOK, but only a fraction was reached.

How long to wait? When will the market take off? In consumer driven markets, the market "takes off" when the consumers want to buy. In the business of complex systems, trespassing the borders between public and private, professionals and the general public, the market does not "take off" that way. There can be nothing to buy until it is created by concerted action across such borders. That is demanding both as to the "staying power" of the business as well as to the capability at the part of government to let word be followed by action.

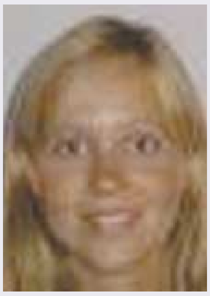
Conclusion

A large corporation is like a maze. Too large to grasp the entire system seeing it from the bottom up, and too deep to really understand how things work and are done if seen from the top. In addition, under the influence of shifting environment, this maze is constantly reshaped, and past actions, motivations and results are reinterpreted if not just forgotten.

An attempt to grasp and describe the history of ITS in Telenor can therefore be just that – an attempt. The authors had an interesting time fighting to get an overview of a history in which the one had a key role, and the other had just noticed parts of it as a shadow play. We hope we succeeded in conveying our findings, and help you see some parts of the puzzle. Thank you for the company!

A New and Pleasant Way of Traveling

JORUNN KAASIN AND DO VAN THANH



Jorunn Kaasin (24) is a Master of Science in Telematics from the Norwegian University of Science and Technology, graduating summer 2002. Her master thesis focused on next generation of mobile applications, where she used Java 2 Micro Edition (J2ME) to develop a prototype of a first generation location based chat service for mobile phones. Jorunn has been working in Accenture since September 2002, in charge of a small competency group focusing on J2ME.

jorunn.kaasin@portalen.no

Do Van Thanh (45) obtained his MSc in Electronic and Computer Sciences from the Norwegian Univ. of Science and Technology (NTNU) in 1984 and his PhD in Informatics from the University of Oslo in 1997. In 1991 he joined Ericsson R&D Department in Oslo after 7 years of R&D at Norsk Data, a minicomputer manufacturer in Oslo. In 2000 he joined Telenor R&D and is now in charge of PANDA (Personal Area Network & Data Applications) research activities with a focus on SIP, XML and next generation mobile applications. He also holds a professor position at the Department of Telematics at NTNU in Trondheim. He is author of numerous publications and inventer of a dozen patents.

thanh-van.do@telenor.com

1 Introduction

This article presents a simple service that can make a journey by car more enjoyable by letting the traveller communicate with others having the same destination. The strength of the service lies in the fact that it does not require the user to have any particularly advanced devices but a regular PDA or a Java-enabled phone. Another interesting aspect is that all the users are allowed not only to receive information about their itinerary but also to contribute actively in the collection and updating of information. The service is a typical example showing how IT and telecommunications can be used in a simple manner to provide improvement in the transport sector.

People traveling with cars (or other vehicles) may be interested in getting information about the area they are traveling in, be it information about a new road, diversions because of traffic accidents or road work, or simply to get explanation of a route if a map is out of reach.

Some solutions already exist, like radio programs dedicated to traveling people, informing about things to pay attention to when driving. These programs are most widespread and useful in big cities, and the information given will therefore not satisfy everyone. Even if you are in one of these cities, the information might be useless if you are not in the specific area where the information is relevant. The same is the case when a driver is on a long distance trip and listens to a radio program passing on traveling information for drivers in the whole country. Another drawback is that these radio programs are generally only broadcast during holidays, or in rush hours.

The Intelligent Transport System (ITS) is aiming to solve these problems. A client running the service should be available for downloading to the user's mobile device over the air and installed with little or no interaction from the user. The terminal must support J2ME CLDC/MIDP [1]. Figure 1 illustrates a situation where this service could be useful for other travelers.

It could be also interesting to the travelers to get statistics about a certain trajectory or route at a certain date and time. For example, what is the traffic situation between Oslo and Trondheim at 10 a.m. on a Saturday.

2 Description of the Service

The idea of this service is to let traveling people communicate with others in the same area or with the same destination target. For instance, if a user is driving a car in a specific area and wants to get information about the traffic there, they can join a group representing this area and receive information or ask questions to everyone registered in that group, or only to one specific user in the area. The difference between unicasting and multicasting of messages will be described later. Another example is the case of a user traveling from Oslo to Trondheim who may need to exchange information with other travelers making the same journey. Figure 2 shows a scenario were a user is looking for a gas station in a specific area.

The call outs are actually text written on a mobile terminal for instance by a passenger.
In principle the application could be controlled both by speech and physical interaction from the user, since a user behind the wheel will not be able to write messages by hand while driving. Speech recognition is on its way, but there is still a long way to go, and as a result this version of the prototype will only realize the possibility to send text.

The association of a user to a group could be decided based on location information supplied by for example Global Positioning System (GPS). Such a solution allows the device to find information about the location without the intervention of the user. Unfortunately, this is a scenario for the future, but this prototype will just as well be a location-based service. In contrast to using GPS or similar technology called second generation of location-based equipment, this service will be of first generation. This means that the user is responsible for typing in the location to join a suitable group.

As the service is location based, groups basically represent locations, but could in practice represent other areas of interest. In this way the service becomes a generic service that can be used for much more than the initial thought.

To use this service the user must log on to the service with a user name and then decide whether to join a public or private room. In a public room the messages will be sent to every member of the group, while in the private room there will be exchange of messages between two

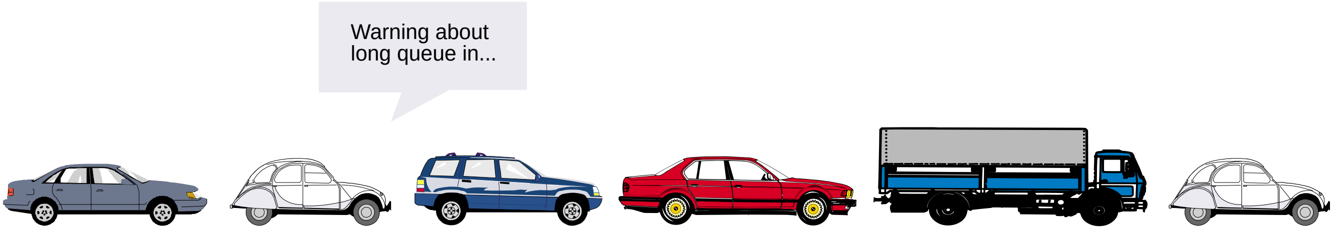


Figure 1 A user informing other users about queue in an area

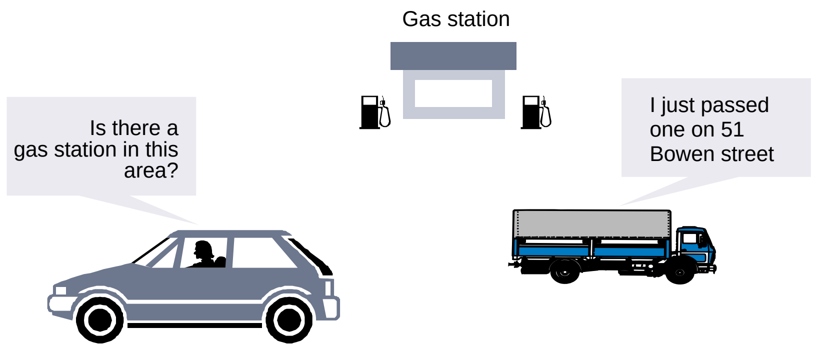


Figure 2 Example of service usage

persons in the same group. The user then selects one of the users in a contact list, and sends an instant message to this user. The two last figures have illustrated examples of messages that could be sent in a public room. Figure 3 shows a scenario where it could be favorable to be in touch with other persons traveling the same route, and where instant messaging would be the preferable chatting mode.

To be able to communicate with others in the same area the users have to join a group representing this specific area or distance. Either the user accesses a list of possible groups that exist and selects one of them, or the user searches for a group by a name. If the group does not exist a new group can be created.

3 Service Requirements

In the analysis phase of the system development the requirements are identified. Functional requirements specify what the system should be able to do; i.e. the functionality, without focusing on the physical implementation. Non-functional requirements are the implementation requirements that focus on factors like performance, robustness, reliability, etc. UML's use-case diagrams [2] will describe how a system will look to potential users. A use-case is a collection of scenarios initiated by an entity called an actor (a person, a server, etc.), and each functional requirement is described by a use-case.

Figure 3 Example of usage when chat mode is private

The actors identified in the ITS environment are:

- *The initiator:* This is the main user in the environment and is the user holding the mobile device and using the client in the ITS.

- *The receiver:* The initiator can connect directly to another user using ITS. This other user is called the receiver.

- *The peer group:* This is an abstraction of all possible users in the ITS environment. When "peer group" is used in the use case diagrams it signals that all users in a group are involved to fulfill a requirement.

3.1 Functional Requirements

This section describes the requirements that are made to the functionality of the prototype application. The functional requirements will be described by text, and illustrated with use case diagrams. Each functional requirement is assigned an identity in the format F-<number>, where <number> is a sequential number.

- *F-1 Login:* Users shall be authenticated prior to service usage. The user is required to log on to the service at start up. The login includes an authentication of the user based on username.

- *F-2 Modus of communication:* The user can choose whether to be in the public mode of communication, where messages are received and sent to the whole group, or in private mode, where the messages are exchanged between two users participating in the same group. The users select between the two modes before joining a group.

- *F-3 Change mode of communication:* When the user is connected to a group, the user shall be able to change the communication mode from public to private or the other way

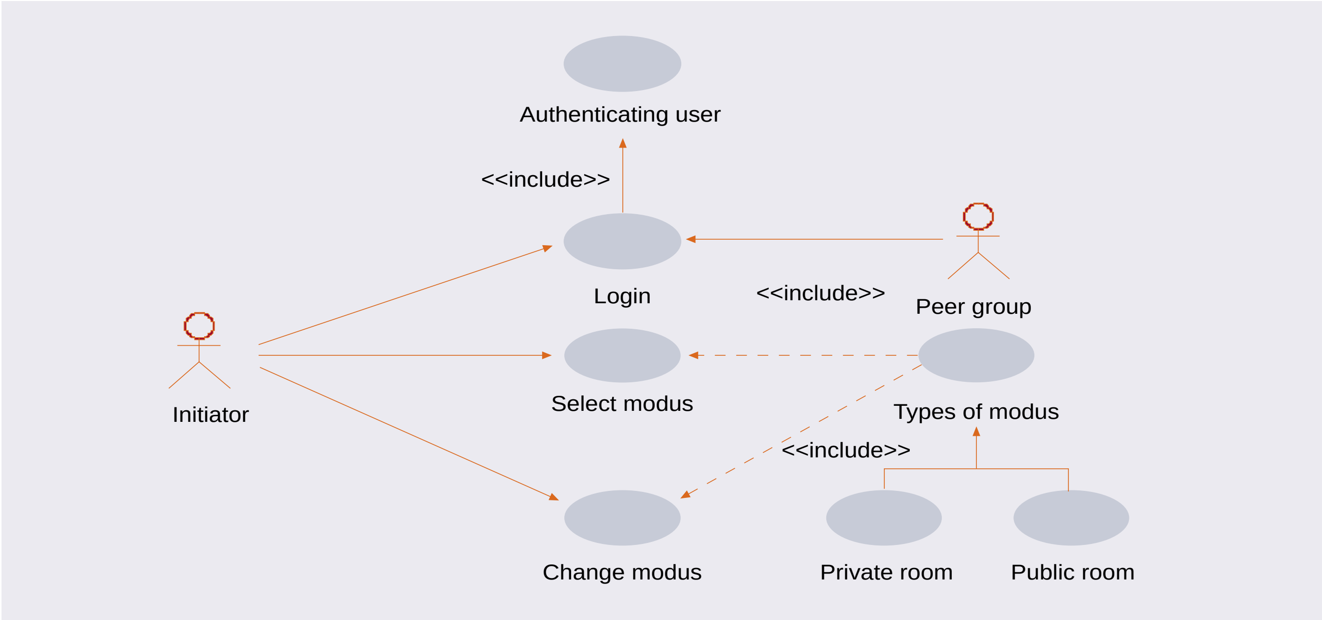


Figure 4 Use case diagram for login and chat mode

around. Figure 4 shows the use case diagram for F-1, F-2, and F-3.

- *F-4 Send message:* The user shall be able to send messages to a group (public mode), or to a specific person in the contact list (private mode).

- *F-5 Receive message:* The user shall be able to receive messages from members of the current group when in public mode, and from members in the contact list when in private mode.

F-4 and F-5 are illustrated in Figure 4. When the user is in private mode, the sending and receiving of messages involve a second user (the receiver), while in the public mode the message is sent to and received from the whole group (the peer group). A message to be sent can be both a new message or a reply to an incoming message when in private mode.

- *F-6 View group list:* The users shall be able to view a list of groups. The list consists of the groups of interest for the user.

- *F-7 Join group:* The users shall be able to join a group. The users can join a group by selecting one of the groups in the group list.

- *F-8 Change group:* The users shall be able to switch from one group to another. This includes disconnecting from the previous group and joining a new group.

F-6, F-7 and F-8 are shown in Figure 6. In addition, a requirement for editing the group list is shown. This is covered in the next requirements.

- *F-9 Edit group list:* The users shall be able to edit the group list, by deleting groups and adding new groups. This means editing the local list located in the user's database.

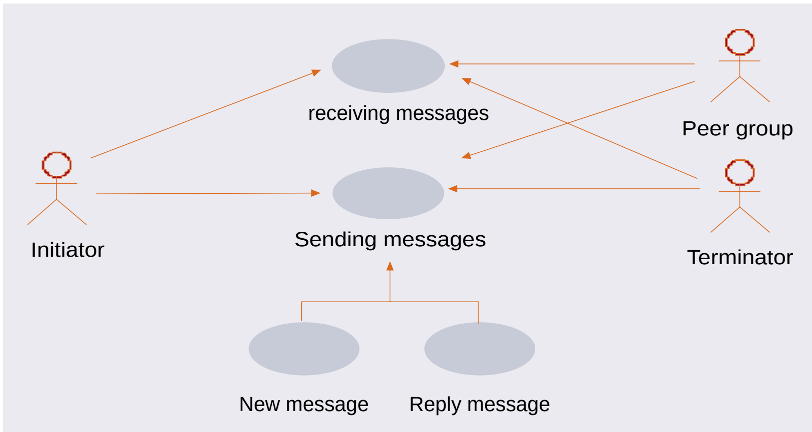
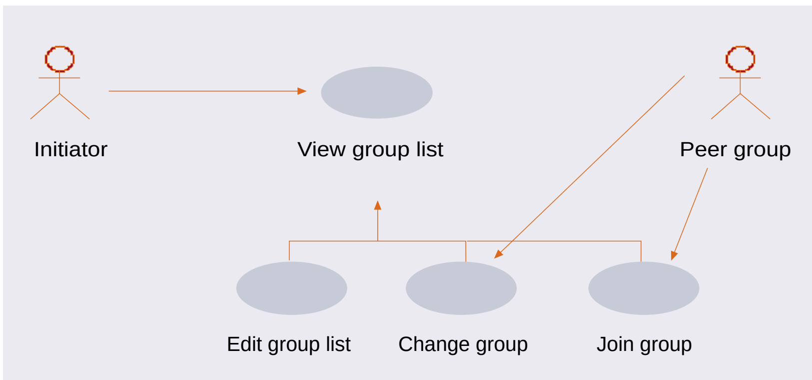


Figure 5 Use case diagram for sending and receiving messages

Figure 7 shows F-9 and also the next requirement, F-10 Add group, which is a sub requirement of F-9.

- *F-10 Add group:* Users shall be able to add new groups. This includes first of all searching for the group in the network, and if the group does not exist, creating a new group.

Figure 6 Use case diagram for viewing the group list



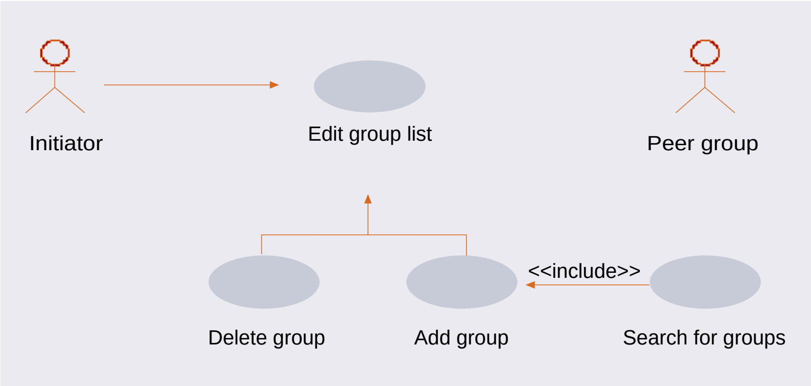


Figure 7 Use case diagram for group list viewing and editing

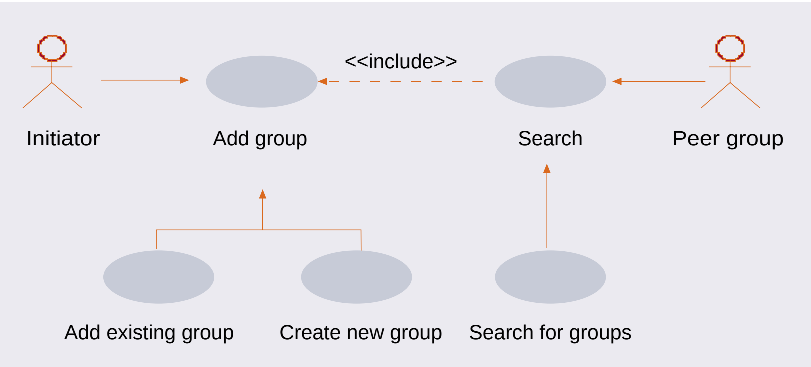


Figure 8 Use case diagram for adding a group

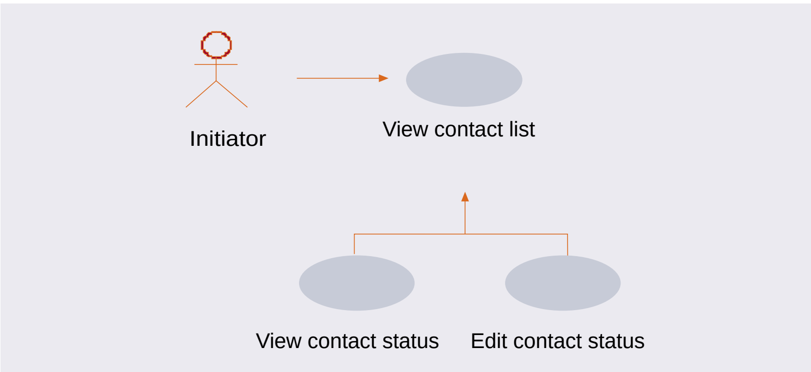


Figure 9 Use case diagram for viewing the contact list

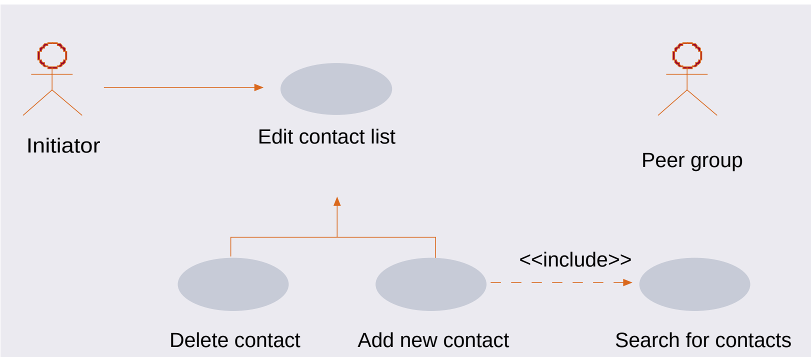


Figure 10 Use case diagram for editing the contact list

F-10 is illustrated in Figure 8. When the user wants to add a group a search among the existing groups is initiated. If no group is found a new group is created.

- *F-11 View contact list:* The user shall be able to see a list of personal contacts. This list will only contain the contacts that are online and participating in the same group as the user.

Figure 9 illustrates this and shows that the user may edit the list. This is explained in the next requirement.

- *F-12 Edit contact list:* The user shall be able to edit the contact list, either by deleting contacts or adding new ones by searching for contacts in the group.

F-12 is illustrated in Figure 10 and is identical to the use case for requirement F-9.

3.2 Non-Functional Requirements

The non-functional requirements for the ITS include both general requirements for the development and some performance attributes. Performance attributes are included to be able to validate the technology but are not of vital importance for this prototype. Later versions should seek to fulfill these requirements. Each non-functional requirement is assigned an identity in the format NF – <number>, where <number> is a sequential number.

- *NF-1 Network technology independence:* The network technology shall be hidden from the user and be independent of the application so that any network technology can be used. Network technologies can be client-server protocols and peer-to-peer technology. One should easily be able to change a JXTA for J2ME implementation with for instance an HTTP and central server implementation.

- *NF-2 Run in SDK and JWT:* The prototype should run both in the Software Development Kit (SDK) and the Java Wireless Toolkit from Sun.

- *NF-3 Run on a J2ME compatible device:* The prototype should be able to run on a cellular phone or PDA supporting J2ME, for instance the Motorola Accompli 008 [3].

- *NF-4 Usability:* The user should be able to use the service application without training and should get to know it within 10 minutes.

- *NF-5 Security:* Information that is exchanged in private room should be encrypted and not be available for others than the two parties of the conversation.

- *NF-6 Availability:* The user should be able to connect to the network and register with the service in 90 % of the cases.

- *NF-7 Reliability:* The service should run without problems for 12 hours without the user needing to restart the application. If disconnected, the user should be able to continue the session when logging on within 5 minutes.

- *NF-8 Cost:* The user should be able to control the cost of the service usage, for instance by choosing how often to poll for incoming messages.

- *NF-9 Response time:* The user should receive response from the relay within the poll interval (which can be set by the user).

4 Service Design

This section will go through the design phase, and the class-, state-, sequence-, and collaboration diagrams of UML will illustrate this. A class diagram shows how the classes of a system relate to one another, while the state diagram focuses on the state changes in just one object. State diagram for the client will be presented here. While the sequence diagram shows how objects communicate with each other over time, collaboration diagrams show how objects interact according to space.

4.1 The Architecture

The architecture is dependent on the network technology used. This prototype will use the JXTA network technology [4], and the JXTA for J2ME package that is designed for J2ME enabled devices.

Mobile devices, represented as cell phones in Figure 11, are dependent upon a relay/proxy server on the Internet to connect to the JXTA network. The proxy servers are responsible for forwarding messages to the appropriate ITS client by sending it to the relay server where that particular client is registered.

Network technologies used for transport will influence the way a mobile terminal will connect to the relay. Figure 12 shows a scenario for a cell phone using GSM or GPRS. The client will then have to connect via a wireless link to a terminal access server before connecting to a proxy server. This is the most likely scenario for drivers, but a goal for the future is that the phone itself could decide the most appropriate transport technology to use at any given time and place and change this when appropriate.

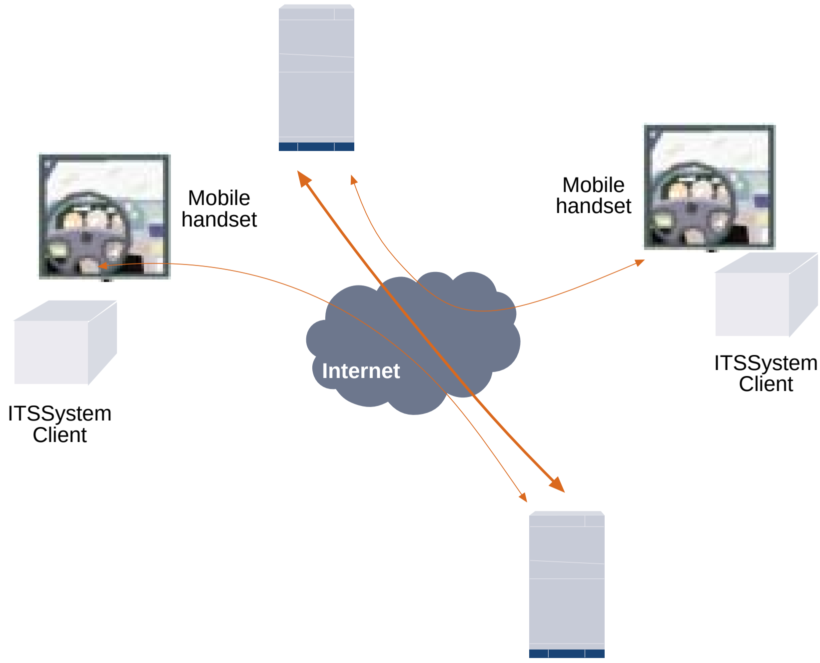


Figure 11 The architecture of the ITS

4.2 Class Diagrams

The service consists of three main classes; the NetworkClient, the DatabaseClient, and the ITSClient. NetworkClient is responsible for the network connection, while the DatabaseClient is responsible for interacting with the database on the mobile device. ITSClient is the main class and takes care of the interaction with the user through a graphical user interface (GUI), and uses NetworkClient and DatabaseClient to obtain necessary information.

The overview class diagram for the system, hiding attributes and operations (methods), is illustrated in Figure 13. The responsibility for implementing the different parts is also shown in this diagram.

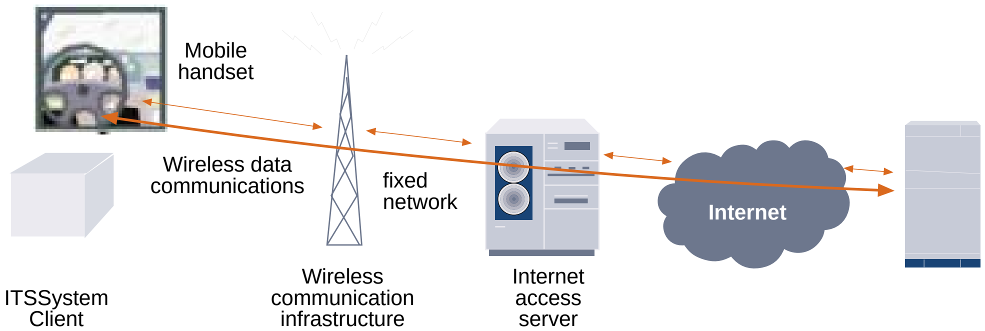
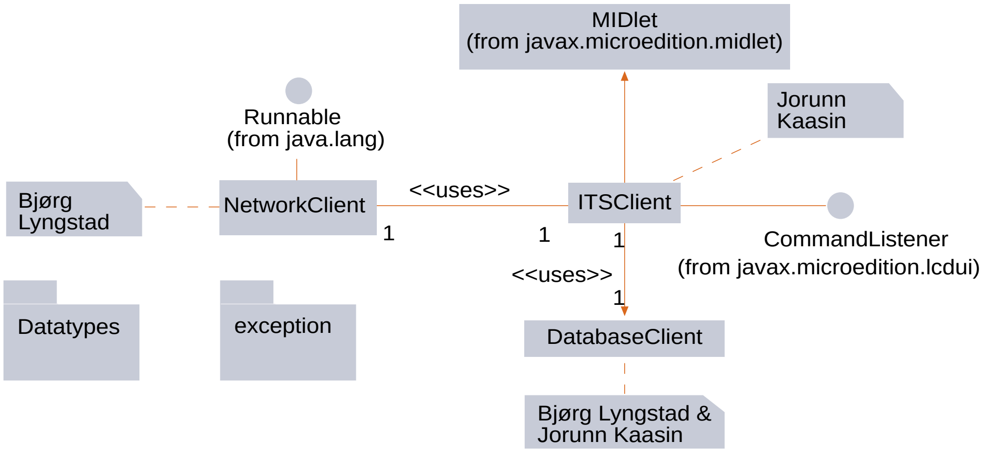


Figure 12 A cell phone connecting to the relay

Figure 13 Overview of class diagram for ITS



NetworkClient

- <<static>> <<final>> ADVANCEDSEARCH : int = 2
- <<static>> <<final>> SIMPLESEARCH : int = 1

- closeNetworkConnection()
- joinGroup(groupName : String, groupId : String) : boolean
- leaveGroup() : boolean
- run()
- searchContact(contact : String) : boolean
- searchContacts(contactList : String[]) : boolean
- searchForGroup(groupName : String, searchType : int) : void
- sendMessage(msg : ITSMessage) : boolean
- setPollInterval(seconds : int)
- NetworkClient(client : ITSClient, relayAddress : String, relayPort : int, clientName : String)
- <<static>> getInstance(client : ITSClient, relayAddress : String, relayPort : int, clientName : String) : NetworkClient

Figure 14 Detailed view of NetworkClient

Every interaction with the network is done through the `NetworkClient`. This class will be implemented using JXTA for J2ME and will then be able to interact with any device on the JXTA network. `NetworkClient` takes care of the basic tasks associated with peer group membership, like group- and user discovery, and the joining and creation of groups.

Since the only supported protocol in MIDP for communication over the network is HTTP, the `NetworkClient` uses a JXTA relay. At specified intervals it asks the relay if messages have arrived for the user. `NetworkClient` implements `java.lang.Runnable` and creates a thread for the task of polling the relay. The public attributes and methods of `NetworkClient` are shown in Figure 14.

The non-functional requirement NF-1 states that the system should be independent of the network. The realization of the `NetworkClient` fulfills this requirement, since it hides the interaction with the network for the user, and the exchange of data inside the system is system-specific, not network specific. Communication and exchange of information and data is done using an ITS specific datatype called ITSMessage, included in the `Datatypes` packages. The class diagram for `ITSMessage` is shown in Figure 15.

The `ITSClient` extends the `MIDlet` class of J2ME, and since `MIDlet` is the basic unit of execution in MIDP, `ITSClient` is responsible for the application entry and leaving of states during the midlet's whole life cycle. The different states are pause, active and destroyed. To react to the different command actions received from the user, `ITSClient` implements the `CommandListener` interface.

Figure 15 The datatype ITSMessage

ITSMessage

- <<static>> <<final>> CONTACTINFO : int = 2
- <<static>> <<final>> GROUPINFO : int = 1
- <<static>> <<final>> MESSAGE : int = 3

- ITSMessage(content : String, receiver : String, sender : String)
- ITSMessage(content : String, receiver : String, sender : String, type : int)
- getContent() : String
- getReceiver() : String
- getSender() : String
- getType() : int

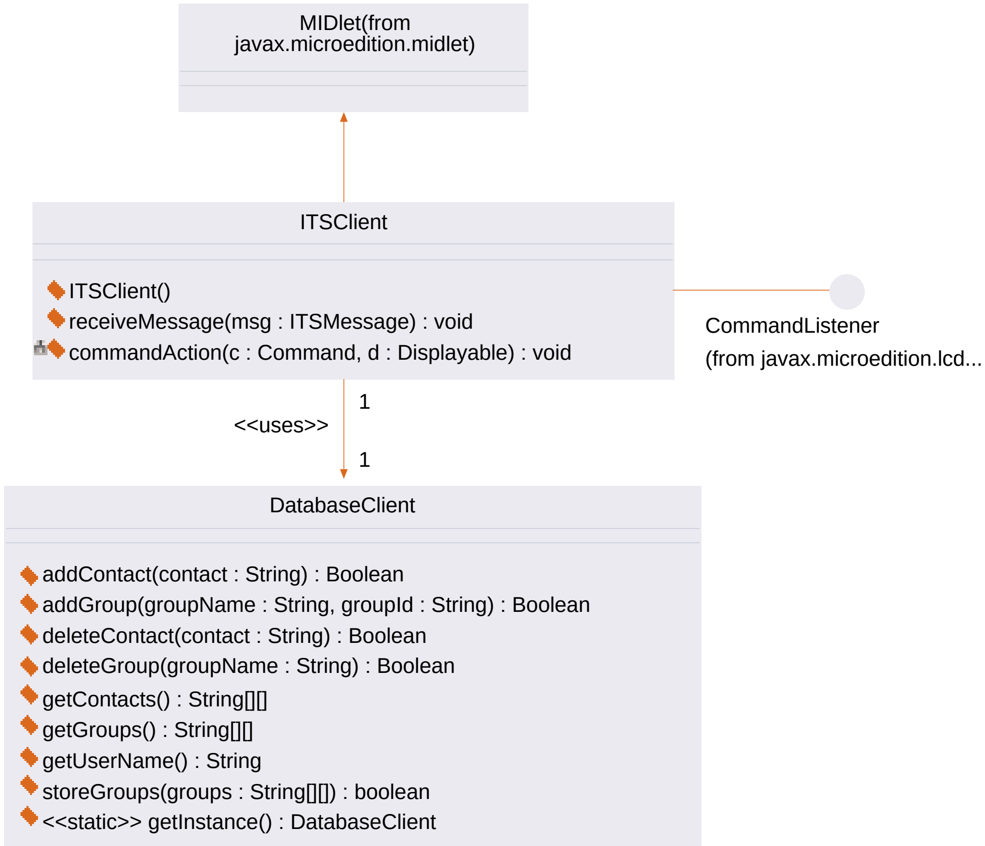


Figure 16 Detailed view of the ITSClient and the DatabaseClient

The `ITSClient` will implement the graphical user interface and includes all the methods used to create the screens with the appropriate text, buttons, lists and textboxes. `ITSClient` will use the `DatabaseClient` to retrieve and store information to the database, and use the `NetworkClient` to communicate with the JXTA network. The only public method, beside the constructor and inherited methods, is `receiveMessage(ITSMessage)`. The `NetworkClient` calls this method when an incoming message has arrived for the user. The class diagram for the `ITSClient` and the `DatabaseClient` is illustrated in Figure 16.

The `DatabaseClient` uses the Record Management System `(javax.microedition.rms)` of MIDP to achieve a mechanism for MIDlets to persistently store data and later retrieve it. `RecordStore` is the class representing the collection of records that contributes to the database. The database will consist of contacts, contact ids, groups, and group ids.

To make the `ITSClient` more independent of the network and storage retrieval of data, some ITS specific exception classes are introduced. The hierarchy is shown in Figure 17.

4.3 State Diagram for the `ITSClient`

Figure 18 shows the state diagram for the `ITSClient`. Regular UML syntax is used, so square brackets represent conditions and the oval ones represent states.

The state diagram can to a certain degree be translated directly to the screen flow illustrated later in this section, but the states concerning communication in private mode is then left out.

From the diagram it seems that it is only possible to receive messages (that is, messages from

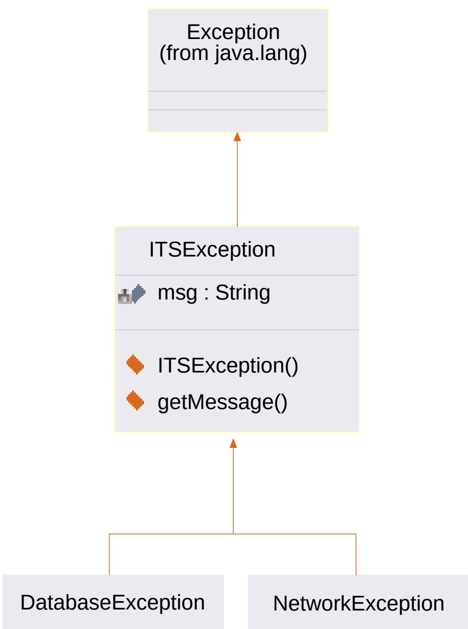


Figure 17 The exceptions in the ITS

Figure 18 State diagram for ITSClient

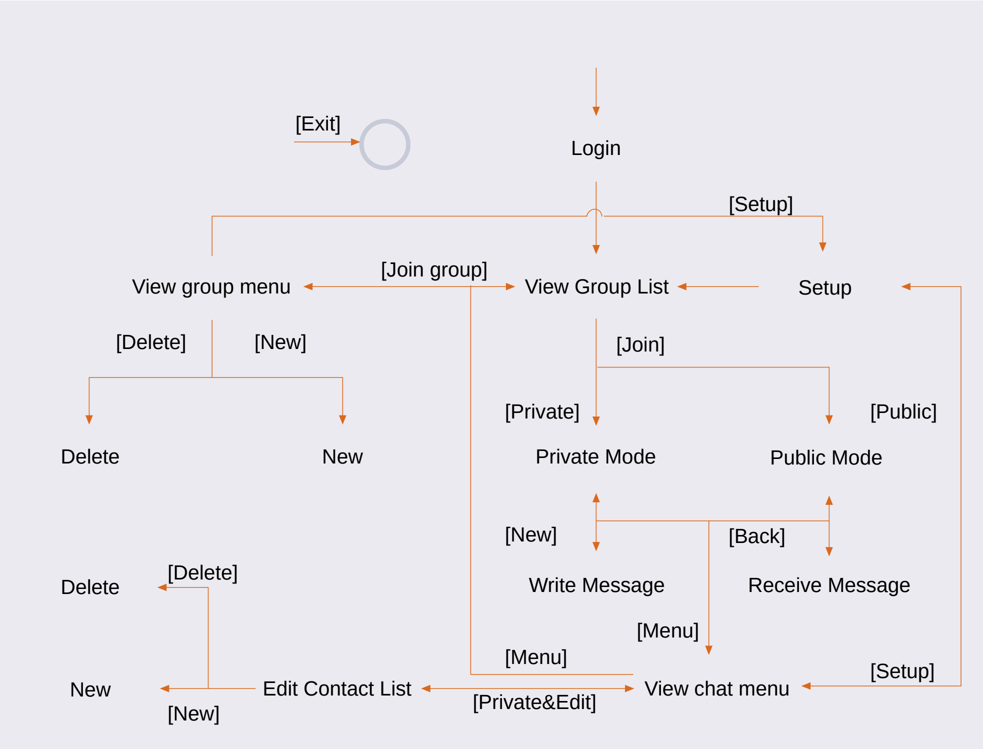
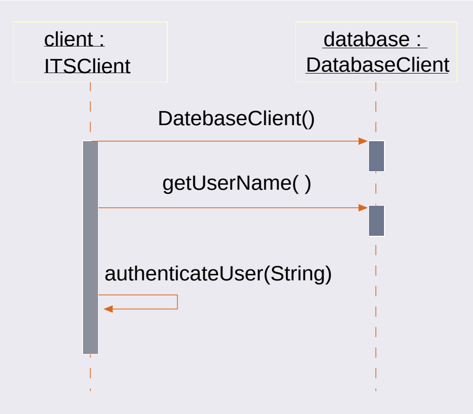


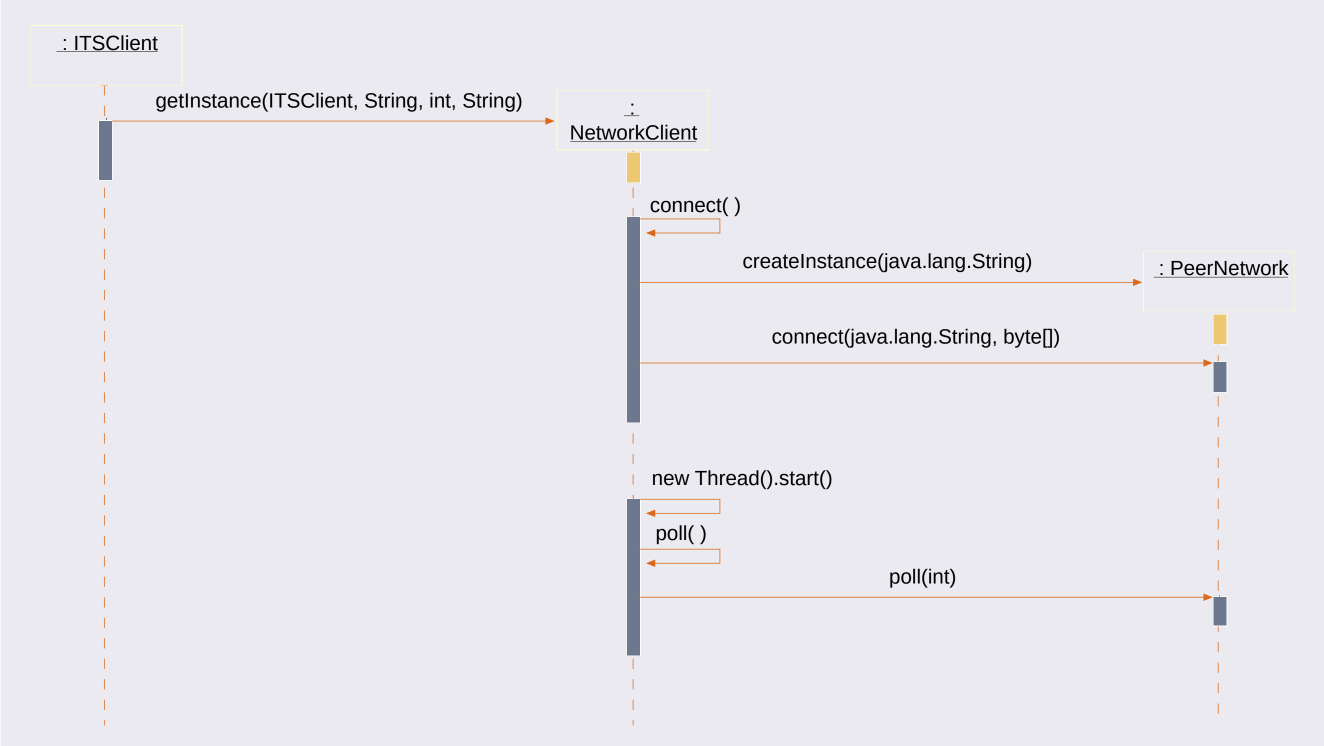
Figure 19 Sequence diagram for login and authentication



other users) when the user is either in the states of private or public mode. This is not totally correct, since the user can also receive messages when viewing the chatting menu or writing a new message, but the messages will only be visible when returning to the communication screen, either in public or private mode.

When the user is in the state called "View group menu", no groups are joined, and the user gets the possibility to edit the group list, to join a group or to view and edit the setup.

Figure 20 Sequence diagram showing how to connect to the network



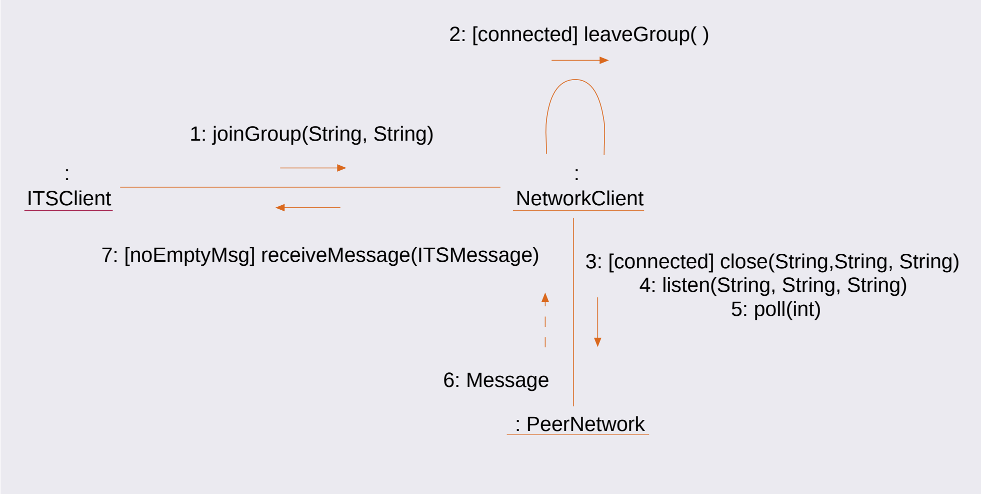


Figure 21 Collaboration diagram showing the sequence of joining a group

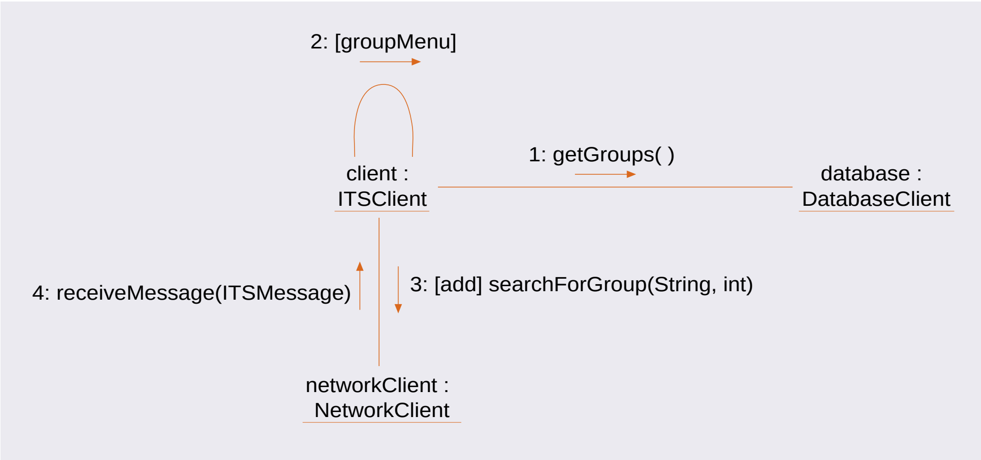


Figure 22 Collaboration diagram for viewing and editing a group list

In "View chat menu" the user sees a menu, much the same as the group menu, but with some other selection options. The "View chat menu" state gives the user a possibility to select among several alternatives:

- Change group
- Add group
- Search contact (if in private mode)
- Delete contact (if in private mode)
- Setup

In this way the user can always add new or delete existing groups or contacts and edit the setup easily.

This diagram does not consider possible error situations. "Exit" will always end the program.

4.4 Sequence- and Collaboration Diagrams

Sequence diagrams and collaboration diagrams illustrate the interaction between objects in a system, in time and space respectively. Since these diagrams show the exact same information, this chapter will illustrate some of the communication that occurs between objects with sequence diagrams and others with collaboration diagrams.

Figure 19 shows the login sequence involving the `ITSClient` and the `DatabaseClient`. `ITSClient` must first create an object of `DatabaseClient` and then retrieve the user name from the database, used to authenticate the user. Where the username shall be set and where to keep it has some alternative solutions that will be covered in chapter 5.

For `ITSClient` to connect to the network it has to create an object of `NetworkClient`. This is shown in Figure 20. `NetworkClient` will create an instance of `PeerNetwork`, one of the classes of the JXTA for J2ME package, and then make this connect to the network by calling `connect()`. To be able to receive messages, the `NetworkClient` must poll the relay, and this is done using a thread that is initialized and started when the `NetworkClient` is initialized.

The joining of a group is illustrated in Figure 21. The numbers in the collaboration diagram indicate the messages' order in the sequence, and conditions are represented by square brackets. When the user decides to join a specific group, the `NetworkClient` will start listening to the pipe where messages from the group are sent [4]. If the user is already a member of a group, the `NetworkClient` will call `leaveGroup()`

before starting to listen to the new pipe representing the new group.

To retrieve messages from the proxy the NetworkClient polls the proxy with the polling frequency set by the user. If the relay has received some messages to the client, this message is forwarded to the ITSClient as an ITSMessage.

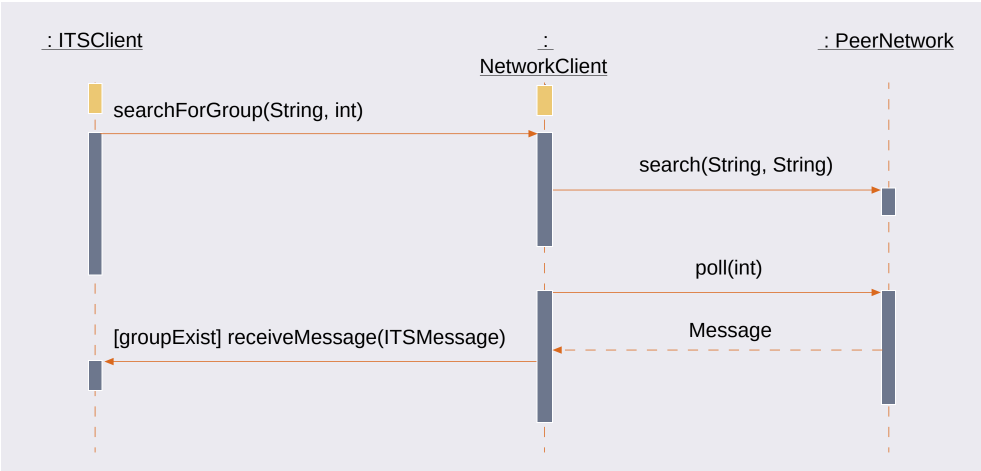
Figure 22 illustrates the viewing and editing of a group list. The first thing happening is that the client gets the groups from the database. The second operation (2) is executed if the user chooses to view the group menu. Adding a new group involves a call to the searchForGroup()-method of NetworkClient, which asynchronously returns an ITSMessage with groupName and groupId. If the user chooses to delete one of the groups, this group is removed from the internal group list of the ITSClient. The changes will be reflected in the database after storing the list to the database when closing the program.

Adding a group to a group list may involve a number of steps. When the ITSClient calls network.addGroup(groupName, typeOfSearch), the NetworkClient must first check whether the group already exists or not. The sequence for adding an existing group is shown in Figure 23.

When a user wants to add a group to the group list, he will supply a group name and indicate whether the group must have the exact same name or a similar name to the supplied group name. The NetworkClient will then initiate a search to find the id to the group or similar groups. When searching for similar groups, the resulting groups are added to a result list that the user can examine later. From this list the user can choose the group to be added to the group list, and then later choose to join the group.

If the NetworkClient receives a message containing information about a suitable group, this information is passed to the ITSClient. If the search was for an exact match, the group is added to the group list. If no message about an appropriate group is received within a prede-

Figure 23 Sequence diagram for adding an existing group



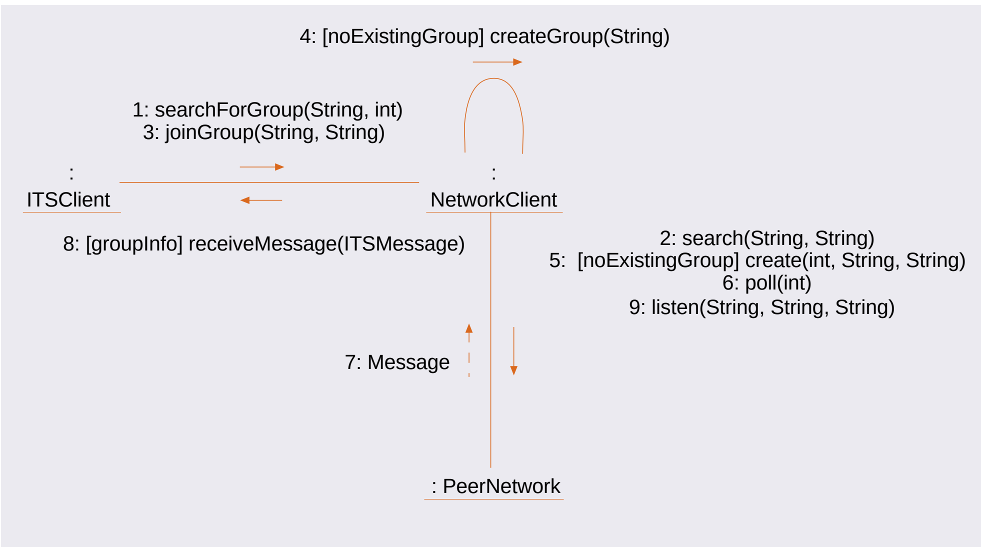


Figure 24 Collaboration diagram for adding a non-existing group

fined time interval, the group is considered non-existing, and a new group will be created if the user chooses to join the group at a later time. This is illustrated in Figure 24.

If a user chooses to participate in private communication instead of public, the list of contacts is selected from the database. Since only the contacts which are reachable in the same group as the user will be presented to the user, the client needs to check which contacts are participating in that group at this moment. This is done by calling the method in `NetworkClient` called `searchContacts()`. For each contact that is online, the client will receive a message containing information about the contact, and the contact is added to the user's visible list. This is illustrated in Figure 25.

If the user chooses to delete one of the contacts, this contact is removed from the internal contact list of the `ITSClient`. The changes will be reflected in the database after storing the list to the database when closing the program. On the other hand, if the user wants to add a new contact, the `NetworkClient` needs to search for the contact in the JXTA network, which in turn will return information about the contact to the `ITSClient`. The contact is added to the internal contact list and stored in the database upon closing the application, as shown in Figure 27.

When the user is participating in either a public or private room, it can start sending and receiving messages. This is shown in the collaboration diagram of Figure 26.

When the user wants to end the application, the client will tear down the connection to the network through the `NetworkClient`. The `NetworkClient` will unsubscribe from the pipe it has been listening to. This is illustrated in Figure 27.

5 User Interface

To get a better understanding of the ITS, Figure 28 shows the flow between the different screens in the ITS. The screens illustrate the user interface and will only show screens supported in version 1.0 and only the screens that are actually used by the users. This screen flow should also

Figure 25 Sequence diagram for editing a contact list

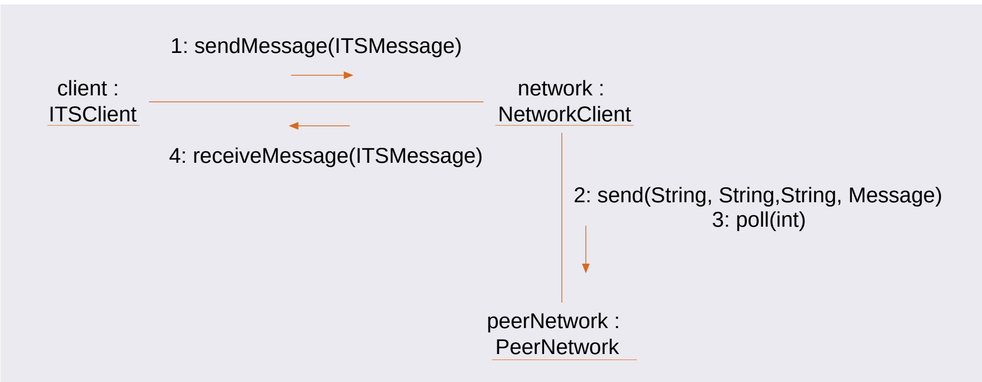


Figure 26 Collaboration diagram for sending and receiving messages

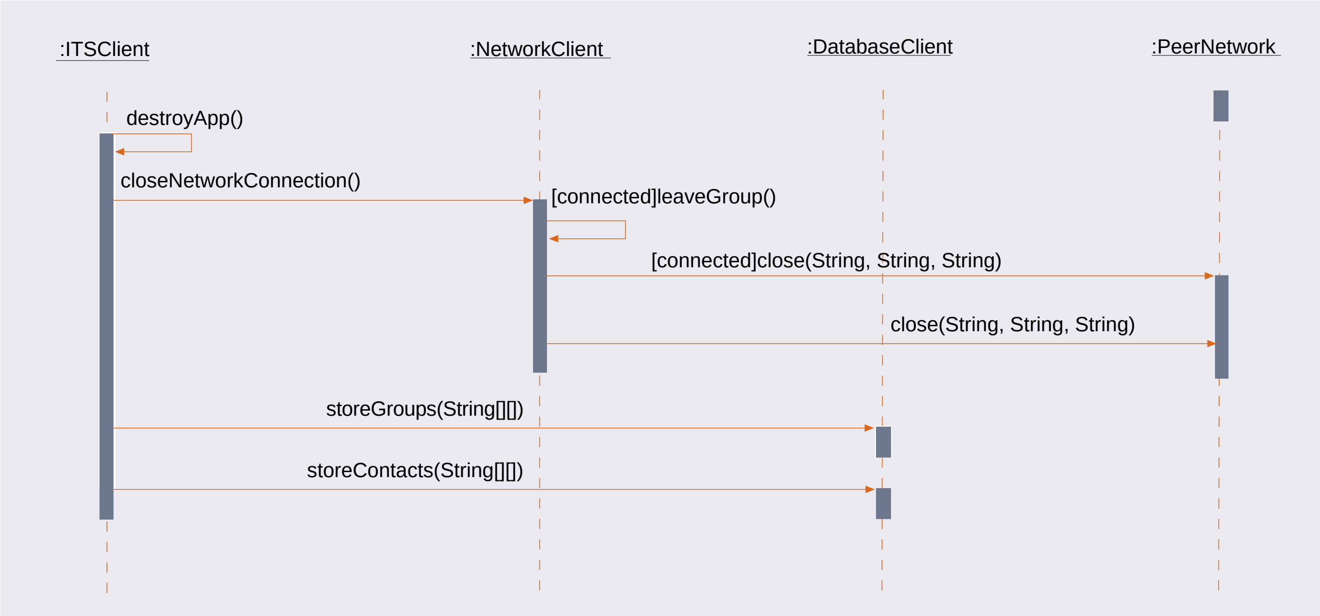


Figure 27 Sequence diagram for closing a connection

be viewed by possible customers, to test the usability of the program.

One error-screen is shown as an example where the user gets an error message stating that the group name entered is not valid. This screen can appear when other error situations occur, but then with a different message according to the situation. The reason for the message in the example is that the user is trying to add a group when no name is written in the text field.

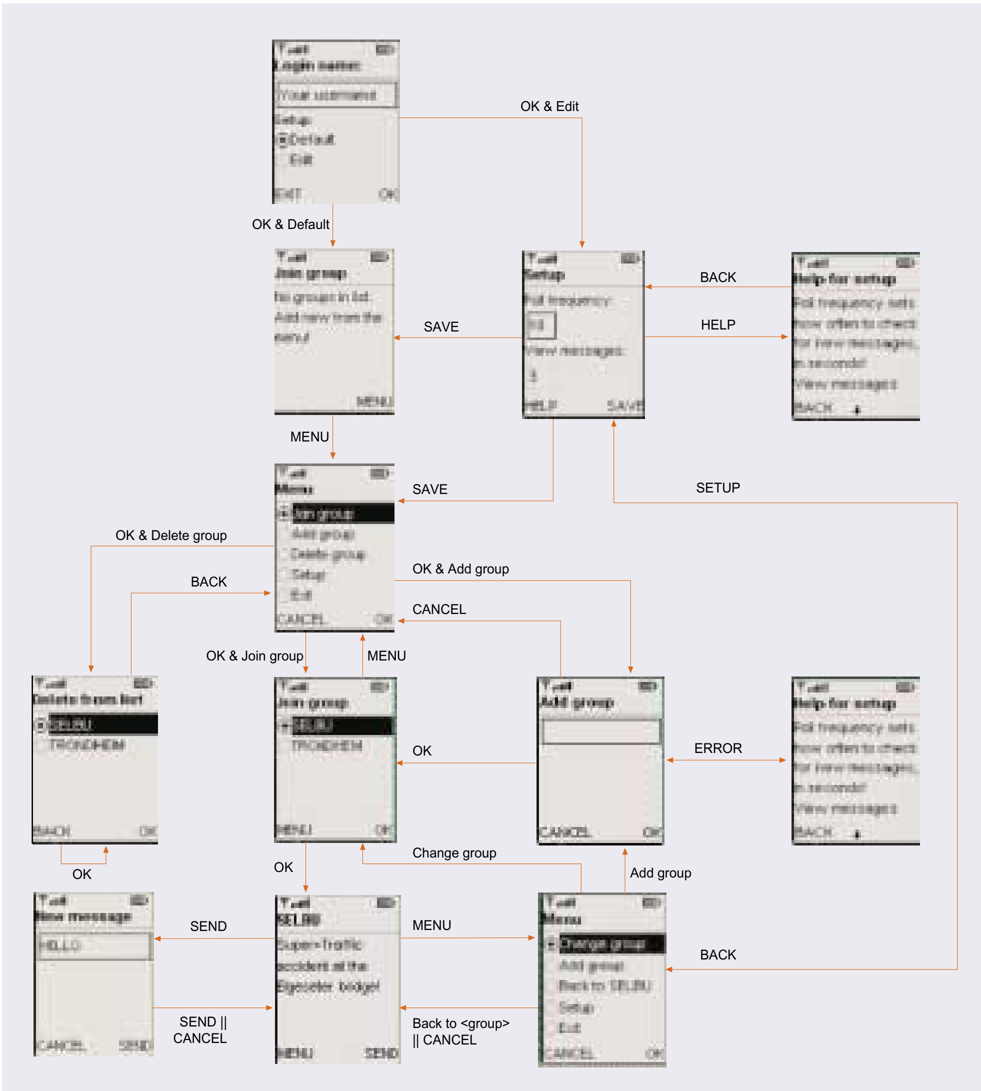


Figure 28 Screen design for current ITS

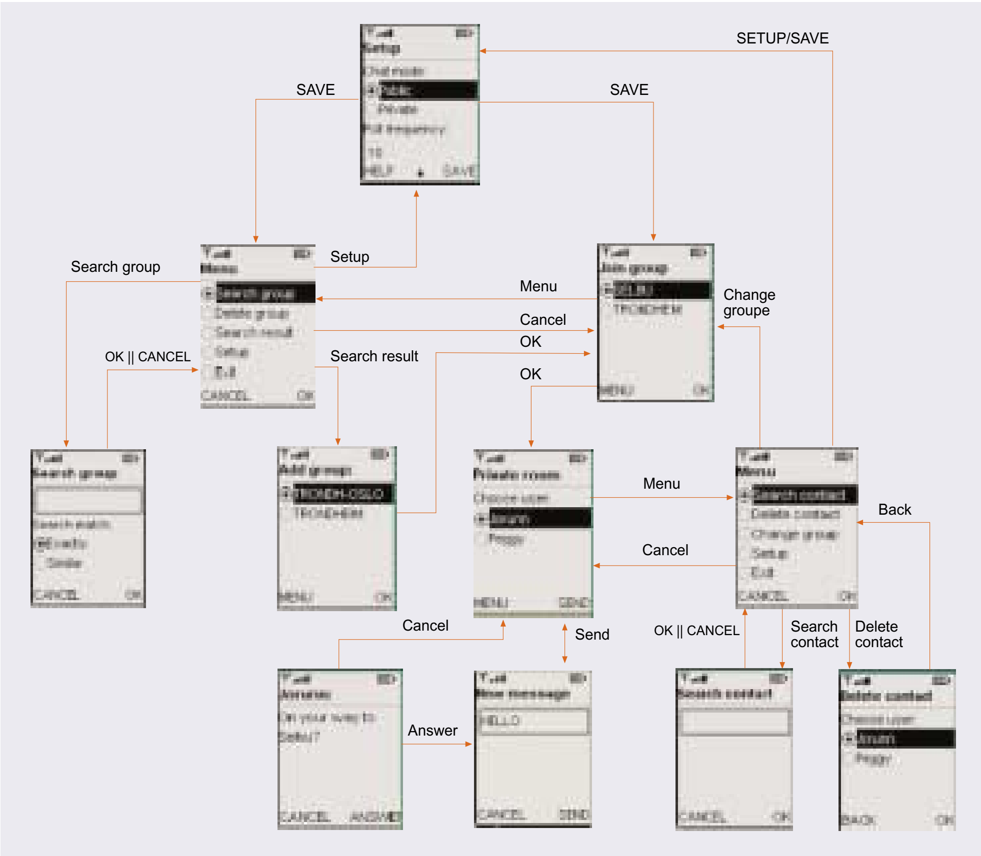


Figure 29 Screen design for future versions of ITS

The screen with the title "Join group" is shown twice in the diagram. The reason for this is that when no groups exist a message is viewed in the screen stating: "No groups in list. Add new from the menu!" Since no groups exist, the possibility to join a group by clicking OK should not be present and the OK button is therefore not shown in this case. The same screen will appear if the user chooses "Delete group" from the menu when the group list is empty. When there are groups in the list, the other screen is shown with the group list and the possibility to join one of the groups.

In later versions, additional fields and screens will be part of the system. Since private communication is supported, the setup screen will have an additional field for choosing between private and public mode. Joining and editing of groups will be similar for private and public communication, but the adding of new groups or contacts will be different. The reason for this is that the JXTA proxy does not currently support searching of groups or contacts. In ITS 1.0, adding a group means adding it to the local group list, and when joining the group it is checked whether the group already exists or not. Future versions should change this functionality to a search procedure where the user can choose to search for a group or contact with the exact same name as the entered name, or to get a search result of groups or contacts with similar names.

In private mode the user will get a list of online contacts after joining a group, and the menu will include options for editing the contact list in addition to most of the existing options. There will also be a screen where received messages are printed and the user gets the possibility of answering the message. Figure 29 illustrates the screen flow for a future version of ITS. Some of the screens from the previous screen flow are left out, since there are no changes.

6 Usage Scenarios

This section illustrates the usage of the ITS with only three scenarios, although ITS has many more useful scenarios for travelers.

Scenario 1:

Jane travels through Oslo by car every day to get to work. Often there are road works or other hindrances on the way, which may lead to delays for Jane. In order to avoid taking these routes Jane uses ITS and logs on to the group “Oslo Sentrum”. Here she can get information about traffic delays in “Oslo Sentrum” and can inform other participants if she meets any hindrances or has other kind of relevant information.

Scenario 2:

Mike is going to visit a friend in the smaller town of Sandefjord. His friend passed him a map, but Mike forgot to bring it, and when he arrives in Sandefjord, he has no idea where to find his friend’s apartment. Instead of admitting to his friend that he is lost, Mike uses ITS and logs on to the group Sandefjord. There he asks about a description of the way to the specific address. He gets the description and shows up at his friend’s apartment when he was supposed to.

Scenario 3:

Lisa and John are travelling from Oslo to Skien for the first time. They decide that they want to stop for some food and perhaps look around in the area during the trip. Since none of them are familiar in the neighbourhood they use the ITS and log on to a group called Oslo-Skien. They post a question about recommended wayside stops with both good food and nice surroundings. Some other people are travelling the same route and the couple get several different tips. In addition they get information about queues and smart shortcuts to take.

7 Conclusion

In this version of ITS the service is actually a chatting service which could be used in other occasions as well. By using location based technology the service could be more specific for the domain it was actually intended for. Many improvements must have been made to the system to make it really useful, and this chapter will make some suggestions for future versions of the system. Some of the solutions are not yet possible because of missing or incomplete technology.

Location Based Technology

Ideally, the application should be able to figure out where the users are situated and join the appropriate group based on this information. If more than one group is available, the user should be asked to choose between the given groups for the area. In this way the user should be able to use the service without knowing the location.

Such a solution could be achieved by use of Global Positioning System (GPS), or other positioning systems. Next generation of mobile communication, like UMTS, will include positioning.

Speech

Another improvement of the system would have been if the user could control the application by use of speech. In the current version, the driver is dependent on passengers to send and retrieve information. With the introduction of speech recognition and speech control, a driver on his own would be able to use the prototype. This could be very useful for truck drivers, for instance, who drives mostly on their own.

Control by speech should also include the received message to be given by the terminal by speech and not only by text. The user should be able to choose the type of control and communication, either speech or text.

8 References

1 *Java 2 Platform, Micro Edition.* March 4, 2003 [online] – URL: http://java.sun.com/J2ME

2 Booch, G, Rumbaugh, J, Jacobson, I. The Unified Modeling Language – User Guide. Addison Wesley Longman Inc. (ISBN 0-201-57168-4)

3 *Motorola*. March 4, 2003 [online] – URL: http://www.motorola.com

4 *Project JXTA.* March 4, 2003 [online] – URL: http://www.jxta.org

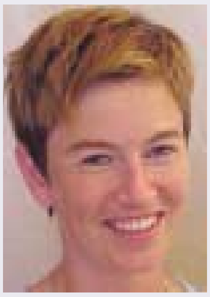
ITS Your Time

HILDE LOVETT, ELIN MELBY, NINA MYREN AND JOHN STEEN NIELSEN

"ITS Your Time" is a *central mediator of information to the road traveller* and will build up a value network of drivers, cars and content providers. It is an autonomous platform on which content suppliers in the start-up phase can deliver traffic- and travel-related information to road travellers. Later, also direct sharing of information between cars and drivers will be possible. The information will be delivered on existing terminals, i.e. mobile phones, PDAs and special-purpose car terminals. The information will be provided according to a personal profile and the current location of the user or on user request. *"ITS Your Time"* is a concatenation of Intelligent Transport Systems (ITS) and focus is on the time of the traveller. The vision is to *make the traveller able to use time better!*

Hilde Lovett (38) is Senior Research Scientist at Telenor R&D. She graduated from the University of Oslo as Cand.Scient. in Informatics in 1989. After working at the Norwegian Computing Center (NR) and Center for IT Research in Denmark, she joined Telenor R&D in January 1999. She has been working with research with an emphasis on distributed systems and multimedia, as well as project- and research management. In 2002 she obtained a Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

hilde.lovett@telenor.com



Elin Melby (32) is Research Scientist at Telenor R&D. She graduated from the University of Oslo as Ph.D. (Dr.Scient.) in 2000 and in 2001 joined Telenor R&D where she has been working with mobile radio communications, location technology and intelligent transport systems. In 2002 she graduated as Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

elin.melby@telenor.com

Introduction

"ITS Your Time" is a project resulting from the Master of Telecommunication Strategy program of Telenor Corporate University, ending in May 2002. This article is based on the business plan around the concept of *"ITS Your Time"* [1].

Information to the road traveller is relevant while planning the trip and during the trip. There is no easy way to obtain information relevant for the road traveller in Norway. The radio provides only general information, the web services are difficult to find and hard to navigate between, the WAP services are technically unstable and with a lot of outdated information. For the SMS services, the commands are hard to remember and the format is unsafe to use while driving.

A user analysis of car drivers [2] indicated that there is a need for a more efficient way to deliver dynamic traffic information to road users, including pre-trip and on-trip information. The information should be tailored to the driver's situation and location, and information overload should be avoided. Road users are interested in sharing information with other road users, provided that they can stay anonymous.

In the car traffic safety is the dominating prerequisite. The hands and the eyes of the driver should mainly be occupied with driving, and the requirement for good user interfaces, like voice, sensing, and big-button interfaces, becomes crucial. The car industry and telematics service providers are among those searching for the "killer applications" to the car and the car users, see [3].

The ITS Your Time Concept

"ITS Your Time" is a system that collects, processes and distributes personalized information to the road traveller during and before the trip via a selection of channels and is a mediator of all information relevant for road users. Besides static and dynamic traffic information, there could be information about public transportation and Points Of Interest (POI), such as hotels, restaurants, shops and services. *"ITS Your Time"* also helps travellers to utilize their time better by supporting access to e-mail, intranets, etc.

"ITS Your Time" could become the *central Norwegian information medium for road travellers*. To achieve this *"ITS Your Time"* must build up a value network of car drivers, cars and content providers. While building up the network, *"ITS Your Time"* will primarily mediate information from content providers to road users. When the number of users reaches what would be the critical mass in a network with direct externalities, information sharing also between drivers and between cars can be introduced to obtain better services.

Dynamic location-based information is essential, and the system must offer the network of car drivers and cars the possibility to communicate efficiently. Cars can work as information sensors and carriers and individually generated traffic information will become increasingly important. *"ITS Your Time"* will become an autonomous system without central control.

The user interface is a key success factor for *"ITS Your Time"*. Relevant information will be easy and safe to access via multi-modal user interfaces. This could mean advanced speech interface, sensing interface, big-button interface, icons on the windscreen, a combination of these, etc. User profiles will ensure tailored information satisfying the user's needs. Intelligent agents can help find information on request, modify it and "serve" it to the user's preferences.

For example, when in the car, you can choose to get information only about the traffic situation in the area you are, or where you are heading, and get the information presented by voice and/or on a map on your PDA. The driver may ask: "I'm in Lillestrøm, on my way to work, I would like

Nina Myren (37) is studying Media Science at the University of Oslo. She holds an MSc from the Norwegian University of Technology (NTH) from 1990. After working with ESA (European Space Agency) in Holland she joined Telenor Satellite in 1993. She has been working with project management within the Space Systems Division and was heavily involved in the planning, purchase and hand-over of the Telenor owned Thor satellites. In 2002 she graduated as Master of Telecom Strategy at the Norwegian University of Science and Technology (NTNU). Autumn 2002 she was managing a business development study for IP services over satellite.

nina.myren@sensewave.com

John Steen Nielsen (44) is IT Architect at Telenor Networks. He holds a Master of Technology Management in Telecom Strategy from the Norwegian University of Science and Technology (NTNU), Trondheim and a BSc EE from Teknikum (KTH), Copenhagen, Denmark. Before joining Telenor, John Steen Nielsen worked for Groupe Bull in Oslo, and in Paris, France.

john-steen.nielsen@telenor.com

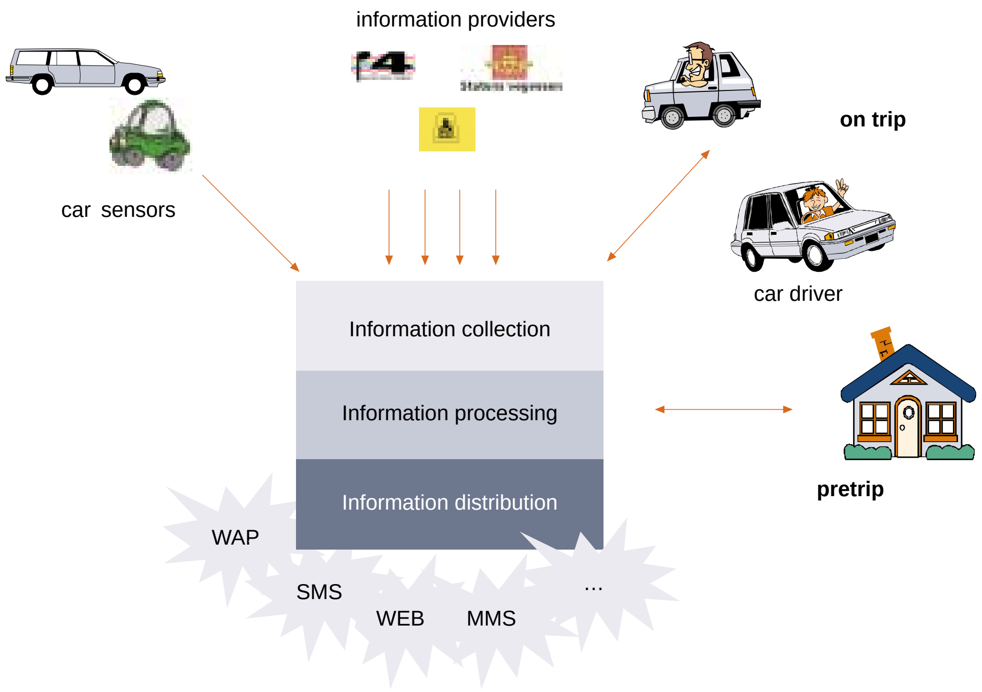


Figure 1 "ITS Your Time" concept model

to know the best route and estimated time to Fornebu", and the intelligent agent will provide the requested information.

Figure 1 is a reference model of the system, and we can describe the functionality of each activity group as follows:

Information Collection

"ITS Your Time" can provide access to information from content and service providers, from individual drivers (about incidents, e.g. children playing or car accidents, etc.), and from car sensors (the road temperature, average speed, traffic video, etc.).

Content Providers can easily add their content themselves via Applications Programming Interfaces (API).

Information Processing

"ITS Your Time" will keep user profiles with a static part containing user routines, preferences and interests, and a dynamic part containing user location, current plans and destination. The traveller can plan their travel and easily make changes during the trip.

"ITS Your Time" will identify and retrieve the relevant information based on the profiles, changes in location or direct user requests. The information will be provided on the user preferred format, e.g. as a voice message.

The users may be members of different networks or clubs (e.g. NAF – the Norwegian Automobile Association, SAS Eurobonus – the Scandinavian Airlines System Frequent Flyer program). If the user has special membership rights *"ITS Your Time"* could also support these rights; i.e. include exclusive information or services. The system will provide a central point where the usernames and passwords for memberships are stored, and relieves the user from remembering the many sets of usernames and passwords.

Information Distribution

"ITS Your Time" will support and target users of mobile phones, PDAs with wireless modems, built-in terminals in cars, and PCs. Based on the user profile and situation, the best suited distribution channel will be chosen, e.g. WAP, SMS, MMS, voice mail, or Web.

Value Propositions for the User

"ITS Your Time" will provide the user with a single point of receiving all relevant information while planning a trip and while on the road. The time spent on the road or in the traffic can be reduced by pre-trip or on-trip information and the user can improve her travel-time estimate. She can plan the workday schedule better and make arrangements accordingly. Based on traffic information, the driver can adjust departing time and choose among alternative routes and travel modes.

The time spent in the car can be utilised more efficiently. By access to ICT solutions, the user may optimise the time on the road, e.g. by accessing e-mail, calendars, e-commerce, language courses, entertainment, etc.

By getting dynamic traffic information the user will be able to make better decisions while in the traffic, and frustration will be reduced by relevant and timely information, e.g. about the reasons for congestion.

Drivers will be able to share their traffic insight with others through *"ITS Your Time"* by warning about traffic incidents or dangers (e.g. a moose or cattle on the road). Also automatic sharing of information that the cars have collected (e.g. average speed or road temperature) will be possible.

The information will augment its value for the user by being combined with other relevant information sources; these could for example be SAS, NSB (The Norwegian State Railways), and P4 (Norwegian countrywide radio station).

Value Propositions for Society and Public Authorities

Interactive information services to targeted road users will improve traffic flow and increase safety, e.g. if the drivers receive and report road accidents, fallen trees, etc.

Today the road authorities spend resources on sensors monitoring the traffic. *"ITS Your Time"* will develop a new and better approach for data collection by using the cars as sensors and information carriers. This can be location-based information about road conditions, traffic flow, incidents, etc. The provided dynamic information, which can also be used for statistical purposes, will reduce the need for development and support of complex infrastructure along the roads.

Value Propositions for the Content and Service Providers

The content and service provider will reach the road traveller easily and efficiently by publishing the content in a one-format way, and letting *"ITS Your Time"* distribute it over the user-adapted channel, tailored to the traveller's context, qualifications, location, interests, and travel purpose.

Furthermore, combining information from complementary content owners will increase the value of the information from one content provider, and content and service providers will be able to communicate with their customers rather than an anonymous mass. For example, information from SAS about a delayed flight will add value to information about traffic congestion on the E6 motorway to Oslo Airport Gardermoen.

"ITS Your Time" will give content and service providers the means for customer billing and settlement by, e.g., integrating access to one of the CPA platforms. In addition, generation of new income streams can be possible via time-, position- and interest-based branding and advertisement.

Implementation

The main challenge in building a value network with direct externalities is to reach critical mass of active users. To bypass this problem in the initial phases *"ITS Your Time"* will primarily mediate information from content providers to the road users. Not before a certain number of active users is reached, can services that allow information to flow between people on the road, their cars, and service providers be introduced.

"ITS Your Time" can be managed as a *corporate program* within ITS, consisting of a long-term portfolio of research projects and a specific short-term project, as illustrated in Figure 2. A more thorough description of the organisation can be found in [1].

Possible Short-Term Implementation

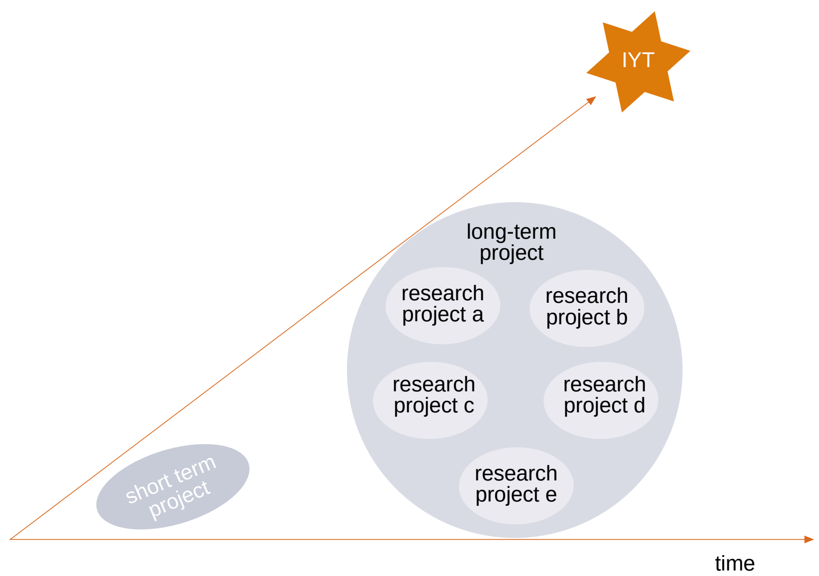
This section describes one tentative short-term implementation solution of *"ITS Your Time"* based on the technology of today. There will also be other possible solutions.

The *"ITS Your Time"* service platform supports different types of services and content on an open application programming interface and will have access to multiple different types of infrastructure.

Open Standards

The architecture should make an extensive usage of standard specifications and protocols. The Web-Services concept [4] is a possible set of such standards:

Figure 2 "ITS Your Time" corporate program



- XML – Extensible Markup Language for information exchange;
- SOAP – Simple Object Access Protocol, for "transport" of XML messages;
- UDDI – Universal Description, Discovery and Integration – a directory of Web Services available on a private or public net (Internet);
- WSDL – Web Services Description Language, which is used in relation to the UDDI service to describe the different services available.

Collection of Information

Collection of information could be based on an integration architecture using the Web Services model [4]. Through this, *"ITS Your Time"* will enable a flexible and easy way to integrate different information providers. This approach will be attractive and non-excluding for the information providers.

"ITS Your Time" concentrates on applications for existing terminals; i.e for today, mobile phones and PDAs with GSM/GPRS modules for wireless communications. The interface for the collection of information from the users may be voice reports, alternatively "large buttons" on a PDA touch screen. Terminals that are built into the car could also be supported. Voice interface can allow for the recognition of commands.

Processing

The central platform could be based on a standard software package conformant with an open strategy for Java and XML. The processing platform would also contain a geo-spatial database for storage of information. The processing platform will typically provide different facilities like:

- Profile service and storage;
- Locator service, for GSM positioning (users with GPS receivers will provide their position directly);
- Lookup service, for lookup of information for the user.

Distribution

The information distribution should use existing channels available towards the user terminals, such as GSM, GPRS and Internet. The usage of WLAN zones could be included as a standard extension of the Internet, thus offering users of PDAs and Mobile PCs with WLAN card additional connectivity.

Text-To-Speech (TTS) functions can be implemented to deliver voice messages to the users. The functions can be delivered through Interactive Voice Response (IVR) capabilities of the central server. The distribution of voice can be supported as e.g. a voice call to the user's mobile phone, and if the user does not accept the call the message can be delivered to the answer-

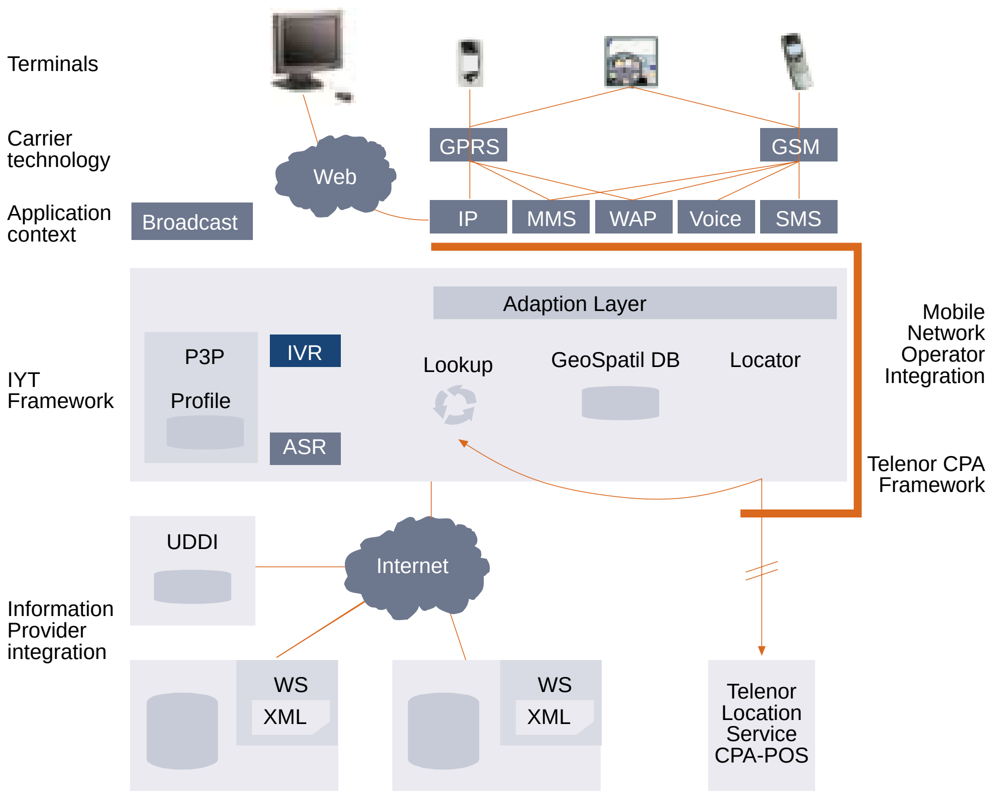


Figure 3 Example of architecture

ing service (if enabled by the user). Alternatively, the voice message can be delivered as an attached file to the e-mail account of the user depending on the user profile.

Architecture

The architecture presented in Figure 3 is an example of how *"ITS Your Time"* functionality can be developed using open standards and common components.

The architecture is divided into the following layers for description:

- User terminals
- Carrier technologies
- Application context
- *"ITS Your Time"* framework
- Information-provider integration
- Telecom-operator integration

User Terminals

The terminals representing the targeted devices for *"ITS Your Time"* are GSM/GPRS mobile phones, PDAs using GPRS, built-in terminals (in cars) and Internet connected PCs.

Carrier Technologies

GSM, GPRS, Internet and WLAN technologies will be supported as a first approach, while other technologies such as UMTS, DAB and DVB may be included at a later stage.

Application Context

The application context will include different applications, like HTTP, SMS, MMS, WAP and voice messages.

ITS Your Time Framework

The framework could be based upon a J2EE platform and contain the following basic services:

- User profile registration, including the usage of Platform for Privacy Preferences Project (P3P) [4];
- The "locator" service for tracking the user position in the GSM network;
- The "lookup" service for finding relevant information for the user from the information providers;
- An adaptation layer that initiates the different conversions, e.g. text-to-speech, content to WAP, etc.;
- A geo-spatial database for keeping an online and real-time picture of the information of highest priority (accidents, major situations, etc.);
- The interactive voice response and automated speech recognition functions.

Information Provider Integration

"ITS Your Time" should use Internet standard protocols for the integration of the information providers, e.g. using XML.

Conclusions

As of today, there is no focal point for traffic related information in Norway and the means of both publishing and receiving dynamic traffic information are poor. As the *central mediator of information to the road traveller "ITS Your Time"* will allow drivers, cars and content providers to build a value network and exchange information. This network will be able to carry all relevant information to and from the road users and be beneficial for the road user, the content and service providers and society alike.

References

1 Lovett, H et al. *Business plan – ITS Your Time.* Trondheim, NTNU, May 2002. (Master thesis)

2 Lovett, H et al. User Analysis of car drivers. *Telektronikk*, 99 (1), 2002, 78–82 (this issue)

3 Lovett, H et al. The telematics business landscape. *Telektronikk*, 99 (1), 2002, 83–89 (this issue)

4 *W3C – Web Services Activity.* March 7, 2003 [online] – URL: http://www.w3c.org/2002/ws/ and
W3C – Platform for Privacy Preferences (P3P) Project. March 7, 2003 [online] – URL: http://www.w3.org/P3P/

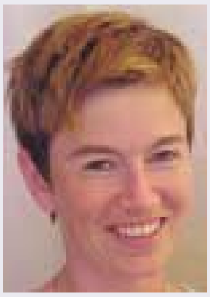
User Analysis of Car Drivers

HILDE LOVETT, ELIN MELBY, NINA MYREN AND JOHN STEEN NIELSEN

The user analysis has given a general understanding of what the car driver is interested in with regards to information and communication services. The user analysis showed that there is a demand for pre-trip and on-trip information, static, as well as dynamic traffic information about incidents that could cause delays, and information about alternative routes. Drivers are willing to share information with other drivers as long as they stay anonymous, and preferably, their cars could automatically provide information. The user analysis also showed that it is important to avoid information overload. An easy and safe-to-use interface is crucial for car-driver services. Good voice and multi-modal interfaces are necessary. The users were also interested in solutions for utilising the time spent in the car in a better way.

Hilde Lovett (38) is Senior Research Scientist at Telenor R&D. She graduated from the University of Oslo as CandScient in Informatics in 1989. After working at the Norwegian Computing Center (NR) and Center for IT Research in Denmark, she joined Telenor R&D in January 1999. She has been working with research with an emphasis on distributed systems and multimedia, as well as project- and research management. In 2002 she obtained a Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

hilde.lovett@telenor.com



Elin Melby (32) is Research Scientist at Telenor R&D. She graduated from the University of Oslo as Ph.D. (Dr.Scient.) in 2000 and in 2001 joined Telenor R&D where she has been working with mobile radio communications, location technology and intelligent transport systems. In 2002 she graduated as Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

elin.melby@telenor.com

Goal and Approach

"ITS Your Time" [1] is a project resulting from the Master of Telecommunication Strategy program of Telenor Corporate University, ending in May 2002. This article summarises the findings from the qualitative part of the user analysis performed in the *"ITS Your Time"* project.

The goal of the user analysis in *"ITS Your Time"* was to validate an initial set of hypotheses about a concept for sharing of traffic information and to get indications of user needs for professional and private car drivers.

Particular focus-group discussions were performed with the purpose to better understand how drivers relate to each other, the needs they have for information, communication, and coordination among themselves, and how telematics can improve safety, efficiency, and possible other properties and issues of driving. The findings are summarised in Section "Results from the focus groups".

In addition to the focus groups, *"ITS Your Time"* had informal discussions with representatives from different players in the transportation and ITS arena, such as public authorities, professional and industrial bodies, and research bodies. The results of these discussions are given in Section "Results from the discussions with relevant players".

Section "Findings with respect to the hypotheses" summarises the findings with respect to the initial set of hypotheses. The full user analysis is documented in [1].

The initial set of hypotheses of *"ITS Your Time"* were:

- There are needs and business opportunities for ICT-supported, direct cooperation between drivers of vehicles.
- Safety and efficiency in traffic can improve when interaction (communication, information, and coordination) between car drivers improves.
- Spontaneous networks with respect to interests and geography can improve this interaction.

Method

We had informal discussions with drivers in focus groups in addition to other relevant players in the ITS area. The focus-group analysis is based on input from people who are on the road a lot, both professional and private.

The discussions were facilitated with drawings and toy vehicles, signs and animals, see Figures 1 and 2. This helped the discussion partners to explain and explore their ideas.

The focus groups were carried out as two in-depth discussions with drivers in the usability lab of Telenor Mobil at the IMAX theatre at Aker Brygge, a shopping and dining district of Oslo harbour. The groups had two and three facilitators, respectively, leading the discussions through a prepared list of questions regarding stressful and frustrating traffic situations, possible solutions to these situations and other traffic problems, and the hypothesis of *"ITS Your Time"*. The sessions, which lasted for two hours, were followed from a control room separated by a one-way mirror. Minutes were taken in shorthand, and the sessions were video taped. In both groups four different drivers participated, three male and one female, aged between 30 and 60. Neither of them knew each other or the facilitators from before. Different categories of drivers were covered in the selection of participants, both people from the transportation business, people depending on transportation to execute their work, and regular drivers and/or commuters. Two of the participants came from the NAF (Norwegian Automobile Association) road patrol. One of them was a former taxi driver at Oslo Taxi, now in charge of the drivers. The other was also a motorcyclist. The other profes-

Nina Myren (37) is studying Media Science at the University of Oslo. She holds an MSc from the Norwegian University of Technology (NTH) from 1990. After working with ESA (European Space Agency) in Holland she joined Telenor Satellite in 1993. She has been working with project management within the Space Systems Division and was heavily involved in the planning, purchase and hand-over of the Telenor owned Thor satellites. In 2002 she graduated as Master of Telecom Strategy at the Norwegian University of Science and Technology (NTNU). Autumn 2002 she was managing a business development study for IP services over satellite.

nina.myren@sensewave.com

John Steen Nielsen (44) is IT Architect at Telenor Networks. He holds a Master of Technology Management in Telecom Strategy from the Norwegian University of Science and Technology (NTNU), Trondheim and a BSc EE from Teknikum (KTH), Copenhagen, Denmark. Before joining Telenor, John Steen Nielsen worked for Groupe Bull in Oslo, and in Paris, France.

john-steen.nielsen@telenor.com

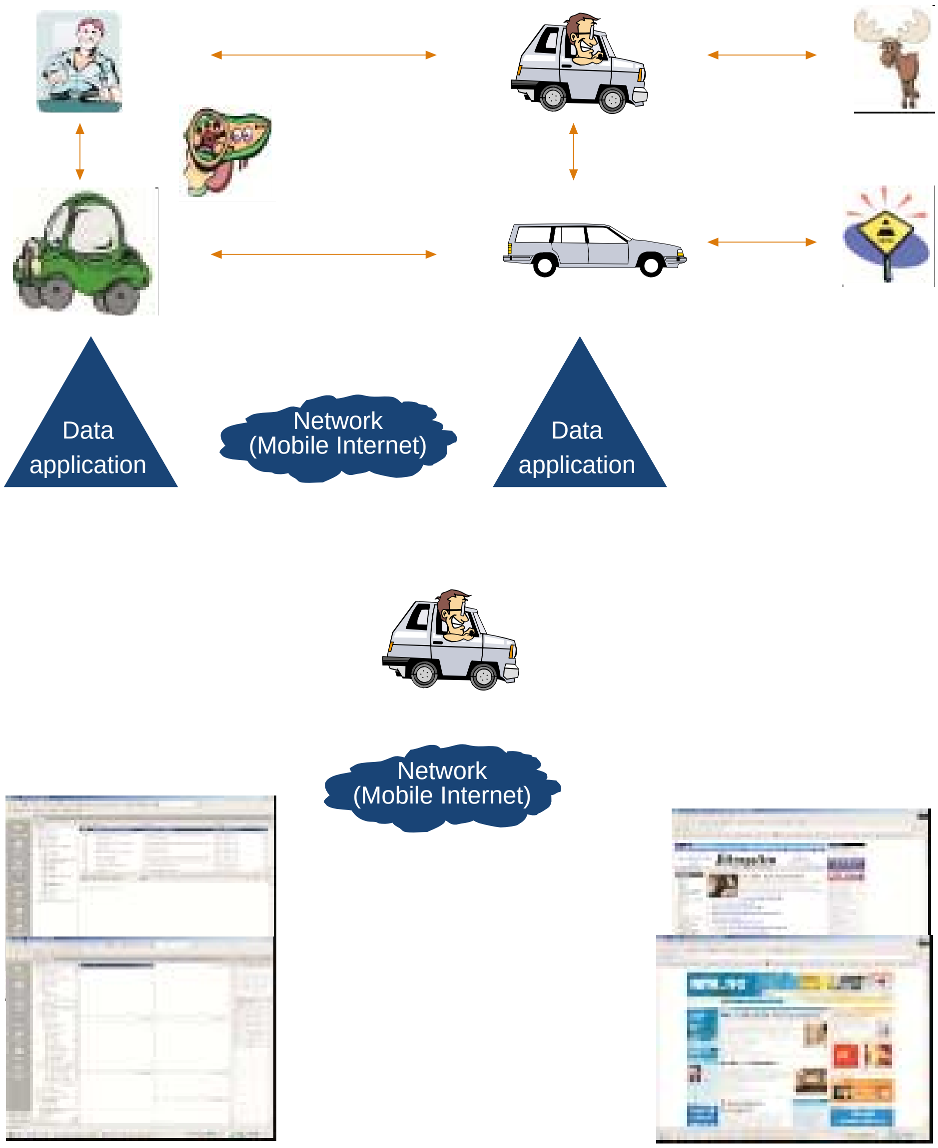


Figure 1 The initial concept ideas

sional drivers were a truck driver owning 16 trucks, a driving instructor, and a telecom installer from Bravida (www.bravida.no).

Results from the Focus Groups

After analysing the data material we have found the following main results from the focus groups. For illustration, some quotes from the discussions are included.

Unsatisfactory Services Today

> *"It is annoying to get traffic messages from the radio, because they only inform about queues which have been there in 20 years!"*

> *"When something comes on the radio it's already history."*

People are not satisfied with the traffic-information services provided by radio, neither P4/NRK nor RDS. The radio channels give general information, covering a wide area, and thereby give too much information of low interest. Often the information is provided too late.

Desired Applications

> *"Information that can improve safety in traffic must be provided to the public very fast."*

> *"It would be nice if one could ask the car where there is a multi-storey car park or vacant parking."*

> *"We are constructed in such a way that the frustration decreases if we are able to make a choice."*

Figure 2 Toys illustrating a stressful traffic situation

With regard to efficient transportation from one place to another, all participants in the focus groups expressed a need to get timely dynamic information about incidents concerning a relevant geographical area that could cause delays, and information about how to get around it.

People wish to have a forecast of how long it will take to drive from one place to another and the driving conditions to be expected.

The drivers wants to have pre-trip, in addition to on-trip traffic information to be able to plan the trip or find alternatives to the regular route, transport modes, or even decide not to go at all. They would like to have dynamic navigation systems, which can be updated with real-time road information regarding congestion, accidents, and possible other incidents concerning the specified geographical area, and thereby suggest an alternative route. The information about what causes a queue is valuable in itself and helps reduce frustration.

Drivers especially want to be warned about unexpected incidents. Many queues are regular every-day congestions, which most drivers are familiar with. It is perceived as annoying to receive information about well-known situations, and urgent messages may drown in a large quantity of general information. It is desirable to get information differentiated on types of journeys. A commuter, for example, has different needs for information than someone on vacation in a new place.

The drivers want to have pre-trip, in addition to on-trip traffic information to be able to plan the trip or find alternatives to the regular route, transport modus, or even decide to not go at all. To get information of all possible transportation modes would be ideal for optimising this system.

"I play games on my Palm when I am in queue."

There were diverse opinions regarding the possibility of getting access to more ICT, such as office applications, games, etc., from the car. Especially the professional drivers were sceptical to the increased working pressure and the possible decreased traffic safety this could cause, while the commuters were more positive to the possibilities of more efficient use of the time spent in the car. More ICT facilities would probably lead to more use (whether the driver liked it or not) and less attention to the traffic. This might be unproblematic in congestion. Some of the drivers, however, stated that low attention to the traffic often caused even worse congestion.

Sharing Information

"I always use my hazard lights when I meet a car going in the opposite direction if there is a dangerous situation, for example if I have seen a moose at the roadside."

"When that female taxi driver was raped in Hobøl, she managed to push the alarm button and warn the taxi centre. There they could see her GPS position and notify the other drivers. There was a taxi driver who drove out and found her, not the police."

"Imagine the old man with a hat, he would get 60 calls telling him he was driving too slow …"

"I'm just by principle against making more surveillance possible."

Drivers are definitely positive to giving and receiving information from other drivers. To warn, or be warned by others – e.g. of dangerous situations, such as kids playing close to the road, sudden inferior driving conditions, or obstacles on the road – is perceived as valuable. However, they are not eager to give other drivers tips about smart devious roads (which could make these roads more crowded).

The drivers are however concerned that information produced by other persons may be very uncertain due to subjectivity. Another worry is that the process of warning others could take too much focus away from the driving.

There seems to be a need to get information from other cars, typically to "look ahead to the front of a queue". However, a possible opening for direct talking to a person in another car is perceived as negative, as it would probably cause a lot of scolding. The wish to talk to an unknown person in the traffic seems often to be motivated by anger. It is decisive for the willingness of information sharing that the provided information is anonymous. People do not fancy the possibility of surveillance.

Management and Presentation of Information

> *"Voice-managed navigation system with dynamic data would have been nice. In addition there must be a display to be able to control whether the navigation is wrong."*

> *"There should have been a telephone with larger buttons; rather, they tend to get smaller and smaller – you can't even see the numbers or letters!"*

> *"If you could talk to the equipment in the car, traffic safety would improve."*

The control of the system must be very simple. It should not cause any hazardous traffic situations neither to provide information to others nor to receive the preferred information from the driving computer. In addition to the safety aspect, it is important to break through the ease-of-use barrier. As much as possible of the information-sharing process should be automatic.

It is essential to avoid information overload. Filters and agents reflecting the geographic area and the situation (e.g. routine or tourist mode) of the driver are extremely important. The time delay between an incident and the time the information reaches the user should be as short as possible.

The possibility that the computer in the car can contain more information than the driver is exposed to sounds appealing. For example, the driver could ask about the speed limit, and the computer would answer on request. It was suggested that a computer in the car with interface with large buttons, display, and voice steering could solve the safety issues.

Some users indicated that aggregated information could be utilised for forecasts, which would be very useful. Others meant that the information presented to the user should to a great degree be basic so that the user himself could make conclusions based on them.

Huge amounts of false and untrue information are considered a possible threat to the usefulness of the concept. A reasonable "reward and penalty" system is required.

Other Findings

> *"Professional drivers use their mirrors very much even when they drive their private car – few private drivers do that, they look mostly ahead, use their mirrors very little, and believe that they are alone on the road."*

The discussions displayed that there is a conflict of interest between the private and professional drivers, especially between truck drivers and car drivers.

> *"If people get engine trouble inside a tunnel, they don't dare to leave the car and use the SOS telephone … Instead they call relatives from their own cell phone to ask what to do, before they finally call the alarm centre. At the centre, they can't know where the driver calls from."*

Many people are in general poor users of the existing channels for communicating information to other drivers. These channels also include indicator lights, warning triangles, etc.

Results from the Discussions with Relevant Players

Professional and industry bodies want to use ICT as a possibility to strengthen their competitive position. A good and intuitive user interface is essential when introducing new services to car drivers. A new system must be easy to use and it should be compatible with what the professional users already have in their cars. It is generally believed that there is a need for dynamic traffic information.

The public authorities have their main focus on traffic safety, and any introduction of ICT should be used to achieve better safety.

Research institutions have slightly different approaches to the ITS field. Some have a more traditional ITS attitude with focus on safety and usability, but believe that people in the traffic will be interested in exchanging traffic information. Others are focusing on the road users as people who are using the road as more than a space for transportation, looking into several activities including location based entertainment and peer-to-peer applications.

There seems to be a general agreement that the user interface is very important.

Findings with Respect to the Hypotheses

Regarding our set of hypotheses, we will discuss each part with respect to the results of the user analysis.

1 *"There are needs and business opportunities for ICT-supported, direct cooperation between drivers of vehicles."*

On the basis of the user analysis there are indications that there is a need and interest in the market for personalised, position-based traffic information.

2 *“Safety and efficiency in the traffic can improve when interaction (communication, information and coordination) between car drivers improves.”*

The discussions showed that the user interface is extremely important with respect to safety and the willingness to use an ITS system for the driver. It must not take the driver’s attention away from the main task of driving the car. The user interface must be intuitive and easy to learn and use. Speech interface is the most feasible modality, but multi-modality, i.e. combinations of audio and visual interfaces including signs and icons should also be considered.

Besides, studies have shown that ITS solutions may have a positive effect on traffic safety [2]. The road authorities have stated a belief that ITS can contribute to well informed road users and thereby a safer road traffic [3].

3 *“Spontaneous networks with respect to interests and geography can improve the interaction between drivers.”*

There already exist networks among drivers who share interests. For example, *Politiet.net* (http://www.politiet.net) distributes information about technical controls, speed limits, etc., provided by the drivers.

There seems to be a difference between professional and private drivers regarding the belief in social spontaneous networks. Professional drivers like truck drivers already have social networks between them where they agree to meet for lunch, signal speed controls, etc. They seem to be positive to the idea of expanding these networks by the use of ICT.

Conclusions

The thoughts of the focus group turned out to be very valuable to *“ITS Your Time”*. They gave valuable input on how drivers cooperate in the traffic and their needs for improvements giving useful indications about how future services for traffic information and collaboration should be developed. On the basis of the user analysis the *“ITS Your Time”* concept and business model were further developed [1].

References

1 Lovett, H et al. *Business plan – ITS Your Time.* Trondheim, NTNU, May 2002. (Master thesis)

2 Elvik, R. *Bedre trafikksikkerhet i Norge. En analyse av potensialet for å bedre trafikksikkerheten, trafikksikkerhetstiltaks kostnadseffektivitet og nytte-kostnadsverdi.* Oslo, TØI, 1999. (TØI-report 446/1999.)

3 Samferdselsdepartementet. *Strategiplan: Trafikksikkerhet på veg 2002–2011.* March 7, 2003 [online] – URL: http://odin.dep.no/sd/norsk/publ/veiledninger/028001-990127/index-dok000-b-n-a.html

The Telematics Business Landscape

HILDE LOVETT, ELIN MELBY, NINA MYREN AND JOHN STEEN NIELSEN

Hilde Lovett (38) is Senior Research Scientist at Telenor R&D. She graduated from the University of Oslo as CandScient in Informatics in 1989. After working at the Norwegian Computing Center (NR) and Center for IT Research in Denmark, she joined Telenor R&D in January 1999. She has been working with research with an emphasis on distributed systems and multimedia, as well as project- and research management. In 2002 she obtained a Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

hilde.lovett@telenor.com

Elin Melby (32) is Research Scientist at Telenor R&D. She graduated from the University of Oslo as Ph.D. (Dr.Scient.) in 2000 and in 2001 joined Telenor R&D where she has been working with mobile radio communications, location technology and intelligent transport systems. In 2002 she graduated as Master of Telecom Strategy from the Norwegian University of Science and Technology (NTNU).

elin.melby@telenor.com

This paper describes the status and important trends in the global telematics market. Some distinctive characteristics of the Norwegian market are discussed, and players that are shaping the telematics business landscape of Norway are identified.

Introduction

"ITS Your Time" is a project resulting from the Master of Telecommunication Strategy program of Telenor Corporate University, ending in May 2002. This article is based on the business-landscape analysis performed in the business plan for the concept of *"ITS Your Time"* [1].

For more than a decade governments and road authorities in the U.S., Europe and Japan have searched for activities within ITS that should reduce traffic congestion and improve road signage, etc. The activities were mainly focused on road furniture and control systems. As time has passed, the car has become more like a computer in itself, and as the wireless technology has become mature, the ITS focus has for many players turned into road telematics, often termed just telematics. There is no single definition of telematics, but the following covers most of it: Telematics is the wireless exchange or delivery of communication, information and other content between the automobile and/or occupants and external sources [2].

There is a great level of anticipation among industry players regarding the potential of the telematics market size; however, there is also a large degree of uncertainty, and future projections range from a worldwide market in 2010 of USD 13–100 billion [3].

Telematics services can be divided into numerous applications, ranging from safety and security applications to Internet browsing and entertainment applications. Figure 1 shows some applications and summarizes the user values with respect to frequency of use [3].

Global Telematics Market

The main players in the telematics market can be divided into eight groups, as seen in Figure 2: Wireless Network Providers, Telematics Service Providers, Car Manufacturers, Content Providers, Content Aggregators and Portals, Hardware and Software Providers, Standardisation Organizations, and Public Administration.

Wireless network providers are important players in this market because all services rely on a wireless connection.

The telematic-service providers (TSP) often includes a company in the car industry, a wire-

User value perception	Frequency of use: Little	Frequency of use: Frequent
High	**Good value – little usage** Accident assistance Airbag deployment notification Roadside assistance Stolen vehicle recovery Concierge services Remote door unlock	**Good value – frequent usage** Navigation Real time traffic reports Voice-driven emails and SMS Parking location Route selection Location-based services (m-commerce)
Low	**Little value – little usage** Intelligent ordering of replacement parts Remote diganostics Internet based seatback entertainment Game on demand Remote immobilization	**Little value – frequent usage** Audio on demand General traffic information Internet browsing Service booking Automated tolling

Figure 1 Value perception of services vs. frequency of use

less operator and a hardware manufacturer (e.g. WirelessCar).

The TSP aggregate content and services, which they offer to different car manufacturers. The services are today mainly linked to luxury cars with special-purpose telematic units, like GPS and GSM phones, built into the car. Services like airbag monitoring, road assistance, remote door un-lock, and others, are offered by the TSPs. The services are typically delivered through dedicated call centres.

The TSP is often regarded as the car manufacturers prolonged arm and generates additional revenue based on the car. It is often linked to the customer relationship management (CRM) system of the car manufacturer, and will eventually link to their service and support systems.

Car manufacturers like Mercedes, Oldsmobile and BMW have delivered telematic solutions to high-end cars for several years already. During the last few years even cheaper cars from Volkswagen, Volvo, etc. are delivered with mobile-data equipment.

The development of telematics in Europe, the U.S. and Japan has so far been driven by the car industry, which for a long time has expected to gain new revenues by capturing a part of the market [4]. This would be welcome for an industry experiencing growing competition, accelerating consolidation processes and facing price erosion and margin pressure. The car manufacturers have moved upwards in the value chain to become service and content providers, taking advantage of the fact that many telematic solutions are integrated in new cars.

Even public authorities have an interest in telematics. Traffic congestion is an increasing problem in large cities around the world. Intelligent transportation systems and telematics can help increase road network efficiency and reduce travel time, number of accidents, pollution, etc. [5].

Telematics are developing in parallel in Japan, the U.S. and in Europe. The European market comprises multiple languages and multiple cultures, which results in a fragmented market. Language barriers have to be overcome in order to introduce pan-European services. There is a lot of inter-country travelling, and the penetration of GSM handsets and the use of SMS are high. The focus of telematics is travel information, real-time traffic information and navigation, but safety and security are also important. Information on websites and cell phone usage are driving forces in the European market [2].

The U.S. market is more homogeneous, but has a large land mass and spotty wireless coverage with four different mobile-phone systems. The main telematics focus is on safety and security; driver distraction and privacy protection. Safety systems are driving forces. There are 3 million telematics-enabled automobiles, a number that is much larger than the European and Japanese markets [2].

Japan is a homogenous market, with a very high density of cars and difficult navigation. The main telematics focus has been navigation and real-time traffic information, and there are three different (non-cellular) systems in use for receiving this information. Japan has a long-term ITS vision and Government investments in ITS are very important. The penetration of packet-based mobile phones is high [2].

The Car as a Wireless Terminal

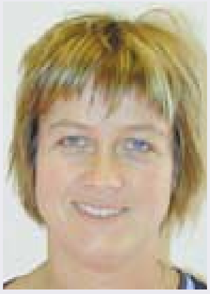
Large hardware and software providers like Hewlett-Packard, Microsoft, Blaupunkt and Toshiba are developing solutions for the car. Hi-fi producers like Philips and Sony are establishing new solutions for audio systems integrated in multimedia car platforms. The entertainment business is establishing services specialised for use in cars. There is an industry convergence towards ICT and entertainment technologies being combined into a single user experience.

The price of a global positioning system (GPS) module is decreasing and will soon become affordable for most people. In the future most cars will come with built-in GPS receivers.

All cars are equipped with many different kinds of sensors, like collision and pressure sensors, and cameras are getting common.

Many cars have screens and other equipment installed, such as navigation systems. Since the communication equipment is changing rather rapidly compared to how often people buy new cars, it is likely that portable equipment will be very important, and probably a combination of built-in and portable devices will be the solution. The most critical issue regarding terminals is what standards will be chosen by the different car manufactures.

There may be several SIM cards in the car: In the vicinity of the engine – for theft alarms, remote service and control; built into the car telematics system – coupled to navigation, information, and entertainment systems; the user's own SIM card – put in a built-in GSM device in the car; portable user equipment – mobile phones and PDAs with GSM/GPRS; on the cargo – for condition surveillance and tracking.



Nina Myren (37) is studying Media Science at the University of Oslo. She holds an MSc from the Norwegian University of Technology (NTH) from 1990. After working with ESA (European Space Agency) in Holland she joined Telenor Satellite in 1993. She has been working with project management within the Space Systems Division and was heavily involved in the planning, purchase and hand-over of the Telenor owned Thor satellites. In 2002 she graduated as Master of Telecom Strategy at the Norwegian University of Science and Technology (NTNU). Autumn 2002 she was managing a business development study for IP services over satellite.

nina.myren@sensewave.com

John Steen Nielsen (44) is IT Architect at Telenor Networks. He holds a Master of Technology Management in Telecom Strategy from the Norwegian University of Science and Technology (NTNU), Trondheim and a BSc EE from Teknikum (KTH), Copenhagen, Denmark. Before joining Telenor, John Steen Nielsen worked for Groupe Bull in Oslo, and in Paris, France.

john-steen.nielsen@telenor.com

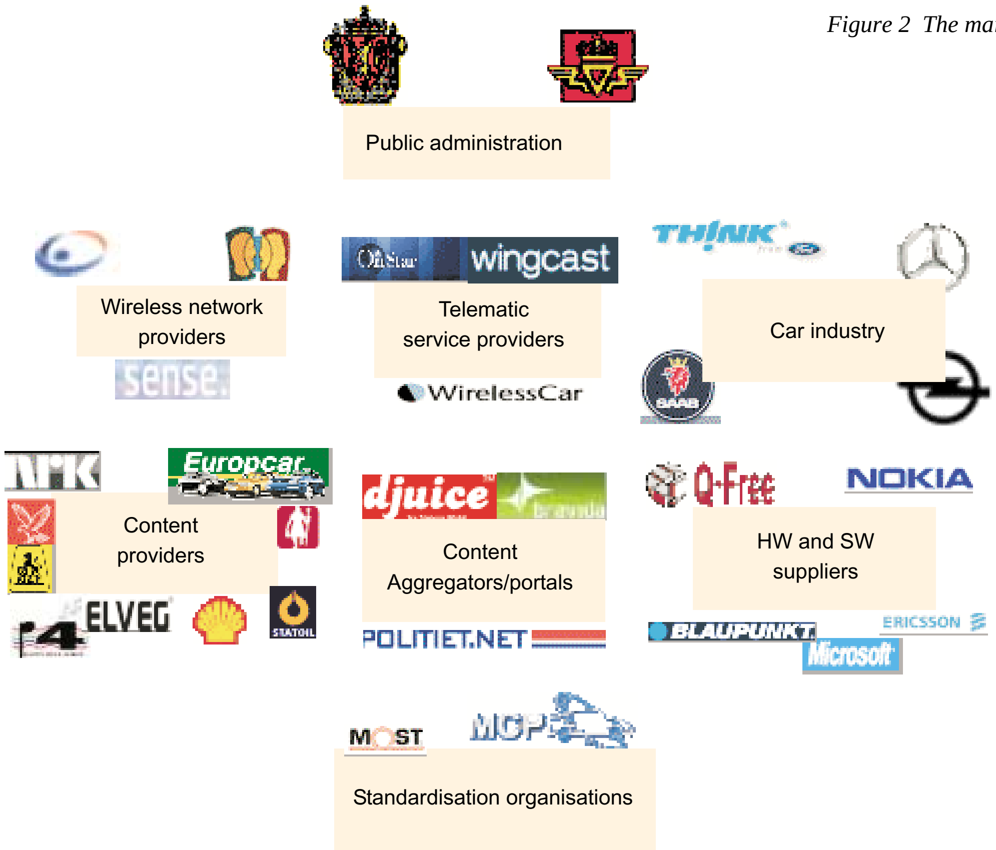


Figure 2 The main players in the telematics market

Other coming technologies and services include:

- Processing and storage of data information in the car
- Authentication in the car
- DAB / DVB / UMTS / WLAN
- Ad-hoc car computing
- mCommerce (SmartPay)
- Voice over IP
- Ambient Intelligence

There will probably be strong restrictions on the driver's use of information and communication technology (ICT) while driving. This will enforce multi-modal (listen/look/feel) user interfaces, which ensures safety in all driving conditions.

ITS and telematics is developing into a new area for wireless-service growth and increasing revenues for operators, who will be the primary beneficiaries of telematics services [4].

Norwegian Telematics Market

Except for the electric car *TH!NK*, Norway has no car production. It is a large, sparsely populated country with few citizens, few large cities, and limited congestion problems on an international scale. Therefore, it is unlikely that global players with no relations to Norway will start major telematics initiatives here. However, Norway is a high-technology market and Norwegians are known to have spending power and be quick to adopt new technologies. Hence, easily exportable services will probably reach Norway after a few years' delay. The largest car supplier to the Norwegian market, Volkswagen, e.g., offer their German customers email, time manager, SMS services, and electronic cards.

Norway has difficult topography, extreme winter conditions and a huge infrastructure of "small" roads. Therefore, information about road conditions is highly valued by Norwegian drivers. The Public Roads Administration (Statens vegvesen), however, is experiencing big problems building and maintaining measurement equipment in the road infrastructure.

The mobile and Internet penetration in Norway is among the world's highest and UMTS networks are being built. The communication infrastructure necessary for ITS is in place.

The car as a mobile terminal has come far technologically, but has not reached the Norwegian mass market. So far, the market has been reduced to a few business segments within transportation, whereas the private market has not yet been thoroughly targeted.

There is a lot of information to the travellers on the road that has no efficient way of reaching the car driver today. This is map information, points of interest, stores and places along the road, static and dynamic traffic information, location-based incidents, connecting public transport, etc. It is difficult to find the information services needed, and the quality of the services varies. The main services use Web, SMS, WAP, radio and text TV, and much of the content is outdated, contains errors or has difficult user interfaces. As for the SMS services, the commands are difficult to remember and are not well integrated with WAP portals, which could improve navigation. The use of SMS is unsafe in a driving situation.

There is no Norwegian speech database optimised for use in noisy surroundings, such as cars. Voice interface is essential to ensure the safety of use of a telematic system.

The rest of this chapter is dedicated to the investigation of different players, which we have identified to have an important impact on the Norwegian telematics market. They are listed according to the groups of Figure 2.

Wireless Network Operators

Telenor

Telenor has several scattered activities within ITS, and Telenor R&D has started a project aiming to make ITS a strategic focus area of Telenor.

Telenor Mobil (TnM) and partners have developed several telematics solutions for the Norwegian market.

NetCom

NetCom is owned by Telia, who is a partner in WirelessCar in Sweden. In cooperation with Siemens and Oslo Taxi NetCom has established a system that routes a customer calling for a taxi direct to the nearest driver.

Mobile Virtual Network Operators

Mobile virtual network operators (MVNO) can take a position in the telematics market by offering value added services, being content aggregators, or cooperating with strong international players from the car industry.

WLAN Operators

Since prices of WLAN equipment are low and still falling, it is expected that the population of WLANs will be spread relatively rapidly via small and medium size businesses and advanced private users. This creates an opportunity for the network operators to create services and rent out Internet access through their WLAN. This is a new infrastructure with broadband hot spots, which can also be utilized within the telematics market.

Telematics Service Providers

There are no TSPs in Norway. There are, however, several international initiatives and some of them may become important for the development in the Norwegian market.

OnStar

The U.S. telematic-market leader OnStar delivers all telematic services on GM vehicles. OnStar is defined on closed, proprietary hardware and software architecture. They offer their services by subscription in the U.S. and pay-per-use in Europe.

WirelessCar

WirelessCar is a joint venture between Volvo, Ericsson and Telia based in Gothenburg [6].

They plan to offer connectivity to customer-care centres, roadside and emergency assistance, access to Internet services, vehicle software, and remote diagnostics. WirelessCar offers pan-European and U.S. coverage.

The Gothenburg region has emerged as a global telematic centre – “Telematics Valley”, which is a forum for regional networking and communication, and a cooperative effort for global promotion of Western Sweden as a region of telematics expertise. Among the partners are Ericsson, Saab, Volvo Car Corporation, Volvo Global Trucks, and WirelessCar. Both GM and Ford have chosen Gothenburg as the location for their centre of competence regarding telematics.

Car Industry

Automobile Manufacturers

The automotive industry is experiencing increased competition, price erosion, and margin pressure. To meet the new market situation, the car manufacturers are trying to use ICT in order to satisfy and thereby create a stronger relation to their customer – the car driver. All major car companies have some telematics related activities, which are in the first place addressed to the high-end markets. The development within the telematics field has put a lot of pressure on the car manufacturers to position themselves.

Traditionally, the car manufacturers were making money from selling cars with good technological quality. Now, the trend is that their business models focus more on customer care, service and ICT integration, and alliances. The car industry goes through accelerated consolidation processes to meet the tough competition, and they invest heavily in telematics. It is, however, unclear how they can gain from their telematics spending.

The largest car manufacturers present in the Norwegian market are Volkswagen (12 %), Opel (11 %), Ford (10 %), and Toyota (10 %). For the next few years, Norwegians are expected to buy 100,000 new cars a year [7].

Car manufacturers, together with network providers and others, provide communication, emergency, and warranty services for the car and the car driver (e.g. WirelessCar in Sweden, see *Telematics Service Providers* above).

Cars are already equipped with several sensors, terminals and computers, and the industry is searching for ways to utilize these functionalities. Remote diagnostics and service is already possible for some cars.

TH!NK Mobility (owned by Ford Motor) Company, manufacture battery-operated electronic vehicles, among which is the electric car *TH!NK city*. TH!NK city is the only car manufactured in Norway. TH!NK and partners joined a research project to build a mobile ICT system for electronic rental cars, where all communication to/from the vehicle and driver should be channelled through a control centre [8].

Automobile Dealers and Garages

Besides TH!NK, the automobile dealers would be the link to the international manufacturers. As the car becomes more electronic, and certain car services can even be done remotely through a communication channel like GSM, the car garages should be interested in positioning themselves in the telematics market.

Content and Service Providers

There are very many different providers of information and other types of content relevant to the car driver. We have investigated a few of them.

Petrol Stations

Petrol stations can expand their services to car drivers by offering e.g. downloading of entertainment, Internet access, etc., by installing WLAN zones at the stations.

Parking Companies

Guidance to the nearest vacant parking space is an interesting service for many drivers. Solutions for mobile payment (SmartPay) of parking is already introduced in Norway.

Insurance Companies

Insurance companies have strong interests in road safety and reduction of accidents and thefts.

Hotels, Restaurants and Shops

Hotels, restaurants and shops are potential suppliers of location-specific information in order to attract customers. Location-based advertising and electronic booking systems will make it easier for people on the road to be informed of hotel vacancies and special offers.

Public Transport Companies

It is believed that ICT will play an important role in making bus transportation better able to compete with other means of transport such as private cars. In addition to fleet management and office-support systems for the driver, the system could also provide information and entertainment to the traveller. The vision is inter-modal transportation systems that can advice the customer on how to choose the optimal transportation route. They can therefore be providers of public transportation information, which is important for an optimal ITS system.

Broadcasting Companies

Several radio channels focus on the road segment and are both generators and distributors of traffic information. In a market analysis performed by ScanFact on request from Telenor Privat/Mobil in 1999 regarding a traffic-information system, almost 90 % of car drivers were found to use some source of traffic information every day.

Automobile Clubs

Automobile clubs such as NAF (The Norwegian Automobile Association) and Viking Redningstjeneste offer various services to car owners, such as help in emergency situations, car tests, legal support, call centre and information. These organizations will be able to improve their services by using ITS/Telematics services.

Content Aggregators and Portals

There are several content aggregators and portals in the Norwegian telematics market.

Internet sites today mainly provide pre-trip route descriptions, route planning, locations and information of points of interest and marketplaces. With an improved mobile Internet access all these services can be available also while on the road, opening a new market segment.

Bravida Geomatikk has developed solutions for registering of dynamic points of interest with time stamps for validity and linkage to the electronic route planner ELVEG (www.elveg.no). One of the applications gives road information, where the user for example can calculate the fastest or shortest route between given addresses. The driving route is shown on a map. Points of interest along the road, e.g. cafés, museums and petrol stations, can be shown as icons in the map, and more information about a point of interest can be obtained by clicking on the icon. Bravida offer these services on PDAs with GSM/GPRS communication and are developing the service with regard to positioning of the user and user profiles. They also offer different SMS services, e.g. road information regarding specific roads in cooperation with the countrywide radio station P4, Telenor Mobil, and The Public Roads Administration.

Other initiatives such as *Politiet.net* collect and transmit traffic information to and from road users via SMS.

Hardware and Software Providers

Hardware providers include manufacturers of portable and in-car equipment. The trend in the car industry is that the car manufacturers are including basic telematic equipment in the cars. However, there will be a competition between built-in and portable devices, because the lifetime of a car is much longer than that of personal digital equipment. Types of hardware include:

- GPS
- SIM cards
- Screens and terminals (PDA, mobile phone, DSRC tags)
- Car Audio / Video / Entertainment system
- Navigation systems
- Sensors

Norwegian HW suppliers like Q-free, Polydisplay and SensoNor are direct or indirect players on the ITS arena. Q-Free delivers dedicated short-range communications (DSRC) equipment for the international ITS market. Their main business as of today is automatic toll-road payment, but the Q-Free system has possibilities for several value-added services.

Hardware, software and consultancy companies like Microsoft, HP and Accenture develop central service platforms for delivering mobile content. The platforms can have different modules such as content management, authentication, payment, e-mail, etc. There are no specific Norwegian initiatives, but important players are represented in Norway.

The Microsoft automotive solutions are based on Windows CE and the portability features of this operating system (OS). The Microsoft .NET and the Windows CE platform enable the building of a distributed architecture. The implementation can use a number of different communication media for local or remote interactions [9].

Standardisation Organizations

The standards for telematics are not yet settled, but a number of professional and industrial bodies are formed in relation to the automotive industry, in order to define and promote standards. A few of them are briefly described below. There is no large Norwegian activity in this area, except *ARKTRANS*, which is a project for establishing a multi-modal information standard with respect to transportation.

IDB Forum is a trade association for chip designers and car component manufacturers. IDB is short for ITS data bus. IDB Forum promotes IEEE 1394 firewire as an alternative to link-different devices on an ITS bus in the car. They promote different interfaces for the interconnection with the bus structure, e.g. BlueTooth, and work in close corporation with AMI-C (see below) [10].

MOST was initiated by a few car manufacturers: Audi, BMW, DaimlerChrysler and OASIS SiliconSystems in Europe. They also work in close cooperation with AMI-C. MOST will use a plastic fiber-optical ring structure in the car instead of the traditional wirering [11].

OSGi’s members include leading service and content providers, infrastructure and network operators, software developers, gateway and set-up box suppliers, consumer electronics and wired and wireless device suppliers, and research institutions. The OSGi members are cooperating to define and promote open specifications for the network delivery of managed services to remote systems, including gateway software for use in cars. This will enable the distribution and installation of new software packages (JAVA) to deliver services and content directly from the provider to the end user. In this context, a clear line is drawn between the service provider (SP), content provider (CP), and the network operator (NO) [12].

AMI-C is an organisation initiated by Fiat, Ford Motor Company, GM, Honda, Nissan, PSA Peugeot Citroën, Renault, Toyota and their component suppliers. They aim at creating consensus on common requirements for information and entertainment systems in cars. Besides the cooperation with some of its peer organisations, AMI-C also cooperates with ERTICO – the EU ITS initiative [13].

The multimedia car platform (MCP) is a project preparing the inclusion of a PC platform in the car. The main part of the platform is from the multimedia home platform (MHP) specification and thus links to the digital-broadcasting industry for video and audio (DVB/DAB) [14].

Related Research Activities

ITS Oslo was a cooperation project between public authorities, private companies and R&D bodies aiming to improve transport and traffic in the Oslo area by means of ICT. They identified several business opportunities within ITS:

- Intelligent electric car
- Vehicle control
- Park & Ride
- Goods tracking
- Travel-time measurements and traffic analysis
- Car sharing
- Transport card – a new ticketing system

ERTICO [5] is a Europe-wide non-profit public/private partnership for the implementation of intelligent transportation systems and services in the EU.

EU has defined the concept of *"Ambient Intelligence"* [15] where people will be surrounded by intelligent intuitive interfaces embedded in all kinds of objects and an environments that are capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.

Government and Public Administration

Public authorities are an important player in the ITS field because of their responsibility for transportation, safety and regulation.

In the National Transportation Plan the authorities have stated that they see the value of and want to invest in ITS. The authorities will use dynamic data for monitoring and managing the traffic, and for climate surveillance. Telematics will play a role in traffic information and emergency notifications and, hence, increase road safety.

It is in the interest of society that traffic data are available for both public and private use. More efficient use of the road infrastructure will give socio-economic benefits through time saving and reduced pollution.

The Road Traffic Act, paragraph 23b, is a general Prohibition law against the use of electronic equipment in vehicles. The law states that the Ministry of Transport and Communication can regulate more closely to prohibit such equipment when it may disturb the driver. The use of screens in the dashboard is likely to be banned, at least when driving. Moving text on RDS radios is already banned. Displays in Volvos are automatically turned down when the speed exceeds 4 km/h. Also SMS messages and even mobile phones as such will be prohibited in cars if proven to be a threat to traffic safety.

The Public Roads Administration builds and operates the roads and the infrastructure along the roads. With regard to road safety, security and traffic flow, which is a major concern, they operate several sources in order to retrieve information about the traffic situation, including sensors and cameras by the roadside and messages from road users. The Public Roads Administration is responsible for roadside signage for both static information (e.g. speed limits) and dynamic information (e.g. road closures because of incidents).

References

1 Lovett H et al. *Business plan – ITS Your Time*. Trondheim, NTNU, May 2002. (Master thesis)

2 Juliussen, E, Magney, P. *World Wide Telematics: Regional Markets and Forecast*. Minnetonka, MN, Telematics Research Group, 2002.

3 Boeke, J. *European Car Telematics – who will capture most value?* Cambridge, University of Cambridge, September 2001. MBA Dissertation.

4 Kearney, A T. *Telematics presentation*. Kjeller, October 2001.

5 *ERTICO*. March 10, 2003 [online] – URL: http://www.ertico.com

6 *WirelessCar*. March 10, 2003 [online] – URL: http://www.wirelesscar.com/intro.html

7 *Statistisk sentralbyrå*. March 10, 2003 [online] – URL: http://www.ssb.no/emner/10/12/20/bilvrak/tab-2001-06-18-05.html

8 *ITS Oslo, Forprosjektrapport*, August 2000. April 9, 2003 [online] – URL: http://194.248.43.210:8080/upload/ITS%20Oslo%20-%20Sluttrapport.PDF

9 *Microsoft – Windows CE for Automotive*. March 10, 2003 [online] – URL: http://www.microsoft.com/automotive

10 *IDB Forum*. March 10, 2003 [online] – URL: http://www.idbforum.org

11 *MOST Cooperation*. March 10, 2003 [online] – URL: http://www.mostcooperation.com/

12 *OSGi – Open Services Gateway initiative*. March 10, 2003 [online] – URL: http://www.osgi.org

13 *AMI-C*. March 10, 2003 [online] – URL: http://www.ami-c.org

14 *Multimedia Car Platform*. May 6, 2003 [online] – URL: http://www.aramis-research.ch/e/7229.html

15 Ducatel K et al. *ISTAG Scenarios for Ambient Intelligence in 2010. Final Report*. IPTS-Seville, February, 2001.

Introduction to the PRT Section

EINAR FLYDAL

Einar Flydal (53) is Senior Adviser working with corporate strategy at the Telenor headquarters. He is cand.polit. from the Univ. of Oslo (UiO), 1983, in political science, and Master of Telecom Strategy from the Univ. of Science and Technology (NTNU), Trondheim, 2002. Apart from 1985–1993, when working with IT in education and with small IT companies, Flydal has worked with Telenor in a variety of fields since 1983. He has also worked as radio freelancer on minorities and music, on statistical indicators at the Chair of Peace and Conflict Research, and on work organisation on oil platforms at the Work Research Institute, Oslo. His present professional interests are environment, CSR, innovation, and ICT.

einar.flydal@telenor.com

The highly innovative and disruptive idea of PRT – Personal Rapid Transit – is presented in Lowson's paper in this issue of *Telektronikk*. Its close relation to ITS, understood as means to make transport more cost-efficient, accessible and less dangerous to humanity, should be evident from Lowson's paper.

Ed Anderson, the grand old man of PRT has through his extensive production of papers related to the design of the various elements of PRT systems, theoretical studies as well as pedagogical notes created much of the foundation on which the whole concept is founded. As defined by the design criteria set forth by Anderson, PRT has been wished, planned and promised for years by the most respected and experienced people in public transport. The literature is truly overwhelming. Public transport systems with several of the PRT design criteria have also been developed, designed, implemented and tested, with success in some respects, failures and revisions in others.

In spite of massive efforts no true PRT has materialised in any full-scale working facility in public service. Many stories could be told to explain this fact, not the least about political plays, unrealistic enthusiasm, the "not-invented-here" syndrome as well as the co-operative traditions within transport and its commercial and professional legacy.

In many respects similar stories could have been told from the early days of the steam engine, the automobile, the telephone, and from the shift from the now 150 year old technology and business models of telephony circuit switching to packet switching – the basis for Internet.

The papers in this section are all about or related to PRT. Together with Lowson's paper in the previous section, they hopefully relay to the interested reader the relevance of PRT within a general perspective of ITS. They should serve to demonstrate that PRT is a field within ITS where much of the telecom and IT competencies on networks, routing and control systems can be applied, and that the parallels between PRT and telecom may be stronger than perceived at first sight.

Business boundaries and the perceived core competencies of companies are constantly being redefined by the impact of ICT. However, the impact of ICT also seems to hold the promise of converting PRT from vision to practical solution.

The present papers should show that there are still practical and theoretical challenges, which is the flip side of the coin: The challenges still to be solved are exactly why the field of PRT still is innovative and offers entrepreneurial opportunities in the service of business as well as urban well-being.

The papers you find in this section were compiled and/or written during the fall 2002. Telenor's engagement in PRT since then has changed considerably: Through a Letter of Intent signed March 2003, Telenor, together with Norwegian industrial partners (Statkraft SF and Interconsult AS) and the Korean steel corporation POSCO Group Ltd, has stated its intentions to take part in the option rich development of an international Joint Venture company – with the purpose of developing a PRT system and build international business within PRT. At the moment of writing, a first phase Design and Engineering study has developed the basis for the detailed engineering works and control systems development, including the build of a test track, to be carried out in the second phase Design and Engineering during second half of 2003, but the transition to Second phase has still not been taken. The strategy behind involves the Fornebu area future public transport system, where Telenor – with its headquarters in the area – has a particular (in-)vested interest. A PRT system installed in the area where Telenor has its headquarters would not only be attractive for Telenor as a property developer and industrial engine, but a market opener world-wide – and make the advantages of comfortable, fast and toxic emission free public transport highly visible.

In a world where environmental problems abound in all cities, and traditional public transport seems unable to cope with it costwise as well as to users' attraction, the business of applying modern networks philosophy within public transport seems a promising case. That task cannot be done without simultaneously harvesting the beneficials of ICT development. Also, if we are right in the view that the core of ITS is also the core of telecom to be, the business case of PRT is not strictly about PRT alone, but about building new core competence for future ICT business and business development.

Sustainable Personal Transport*)

MARTIN LOWSON

Martin Lowson is Professor of Advanced Transport at the University of Bristol and CEO of Advanced Transport Systems Ltd., Bristol. Martin Lowson has a background from the space industry, and is behind the ULTra Consortium (http://www.atsltd.co.uk/), developing a PRT system that has gained well deserved attention in Europe, and will run for a full-scale application in the centre of Cardiff, Wales, in 2005.

martin@lowson.net

Transport by conventional means involves energy use, resource use and emission output which cannot be regarded as sustainable. Current transport is dominated by the car. This provides the flexible personal transport required by modern forms of cities, but is widely recognised as unsustainable. Current public transport is poorly accepted. Unfortunately, analysis also shows that current forms of public transport offer little, or even negative, benefit in sustainability over the car.

A new transport system has been devised to meet the need for transport which is both effective and sustainable. ULTra (Urban Light Transport) is an innovative form of Personal Rapid Transit (PRT). In contrast to previous forms of public transport, there is no waiting, no stopping and no transfers within the system. In many circumstances, it can offer better transport than available by other means. ULTra has been designed to demanding sustainability requirements. Typically, ULTra provides a reduction by a factor of three in energy use and emissions output over existing forms of transport.

ULTra is also complementary to existing forms of transport. By providing a network link to major rail or bus stations, it can improve the attraction of current transport services. Evaluations undertaken for the Department of Transport and supported by recent questionnaire studies, suggest that a comprehensive ULTra system could attract 25 – 30 % of present car drivers.

ULTra is now undergoing engineering development funded by the DTLR (Department of Transport, Local Government and the Regions). Cardiff County Council have received funding commitments by the National Assembly of Wales which will lead to implementation of a system by 2005. It is believed that the system offers a new approach to public transport with a real prospect of significant gains in effectiveness and sustainability.

Introduction

As pointed out in Thomson's seminal book, *Great cities and their traffic* [1] "Cities are made up essentially of buildings *and* transport". Modern life, and in particular modern cities, cannot exist without a supporting transport system.

At the turn of the last century, the capabilities offered by train and tram controlled the form of the city. Cities were strongly focussed on a single city centre, and transport links concentrated on radial routes to and from the centre provided the key to the functioning of the city 100 years ago. But changes in culture, the economy, social relationships, beliefs, values and technology must also lead to changes in cities and their transport.

Today all cities are of multi-centre form. All cities have retail parks and industrial estates which are some distance from the old city centre. Such developments have only been possible because of the car. Indeed, the overriding force in urban development for the past 50 years has been the car. New forms of urban landscape have been created which can only be served effectively at present by car based transport.

A second major change from Victorian times is the strong emphasis on achieving a satisfactory environment throughout the city, and the associated requirement for transport which is sustainable. It is widely recognised that transport is a dominant contributor to present urban environmental problems. There is an urgent need for transport solutions which are environmentally acceptable and match the transport needs of the new structure of the city.

In the UK, only 11 % of all trips (excluding walk/bicycle) are taken by public transport, although this rises to 16 % for commuting trips, cf National Transport Statistics [2]. In the US, the proportion of public transport trips is only 3 %. Passenger levels experienced in locations other than the centres of the largest cities demonstrate that current types of public transport are unable to meet the dispersed personal travel demand characteristic of current forms of multi-centre city. It is essentially impossible to satisfy these very diverse personal transport needs by versions of the old forms of corridor based public transport which served Victorian cities so well.

Table 1 gives data from Brinkoff [3] on all cities in Europe with populations over a million. This data is based on official censuses and reflects the particular political boundaries defined by each of the cities. All of these cities will serve a total travelling population considerably larger than (typically double or more) the census population figure given. Note that London is more than

*) *This article is a reprint from* Municipal Engineer *ISI, issue 1, p 73–82, 2001.*

Table 1 European cities with census populations over 1M

City	Population
London	6,638,109
Berlin	3,425,759
Madrid	2,881,506
Rome	2,643,581
Paris	2,125,246
Hamburg	1,704,731
Vienna	1,609,631
Barcelona	1,505,581
Milan	1,300,977
Munich	1,205,923
Naples	1,002,619

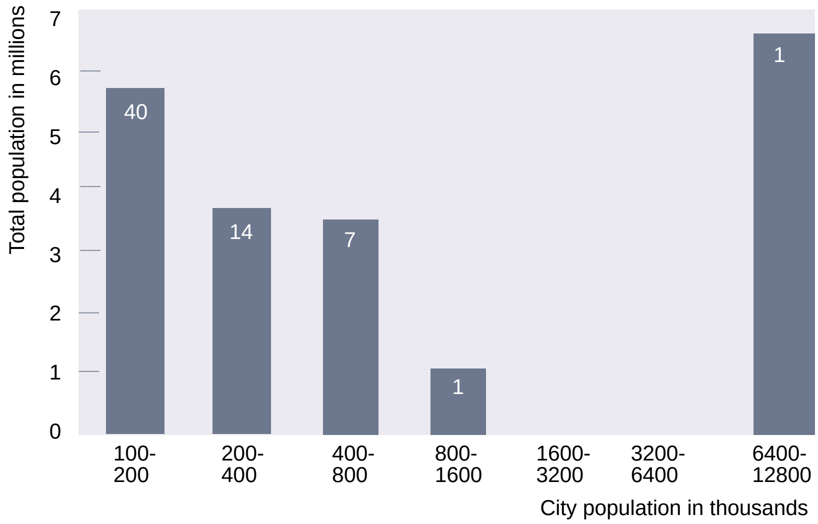


Figure 1 UK population against size of city

double the size of any other European city and about seven times the next largest UK city.

Figure 1 shows a census based distribution of the 21.6M people who live in UK cities over 100,000 in population as a function of city size. Again, these cities will have travel service areas probably double their census populations. It can be seen that the great majority of the UK population live in cities and towns which are of modest scale.

In the largest cities such as New York or London, the older types of corridor-collective transport remain highly effective. Remarkably, public transport in New York accounts for just over one third of all public transport in the US. The National Transport Statistics [2] show that 85 % of transport to work in Central London is undertaken by traditional public transport. For London as a whole, this figure reduces to 50 %. However, as shown by the figures quoted above, London is highly atypical, on both a UK and a European basis. London transport requirements and experiences are anomalous. Transport solutions which meet London needs do not provide helpful guidance for National transport policy.

The dominant transport system in virtually all cities in the Western World is the car. Present day forms of city are determined by the capability of the car to offer flexible anywhere to anywhere transport on demand. The National Travel Survey [4] shows that 83 % of all commuting trips and 90 % of business trips have only a single passenger in the car. The great majority of trips are undertaken by individuals travelling alone. Thus, transport in collective groups is mismatched to the travel demands of a modern city. Collecting passengers together for mass transport leads to significant inefficiencies, especially for off peak travel.

It is suggested that the principal problem of current approaches to transport is forcing transport solutions which were effective in meeting the problems of the nineteenth century to meet those of the twentyfirst. The current requirement is for a flexible system which can respond effectively both to personal travel needs and to the crucial desire for sustainability.

2 Problem Description

2.1 Overall Considerations

In a modern city the local transport plan is recognised as a key element of the overall strategy to develop the city as a thriving and vibrant location for living and working. Cities now recognise that

- there is increasing concern over environmental and health issues, particularly emissions arising from vehicle sources;
- supply of road space can no longer be matched to demand;
- a shift to public transport should be encouraged;
- economic and social regeneration require increased accessibility;
- an integrated framework is needed to spread increases in trips over all modes of transport.

Thus cities seek to reduce the need to travel, especially by car, and in planning for the communities of the future look for sustainable development patterns and approaches which combat social exclusion.

The key feature of the transport strategy which emerges from this policy is one of integration, looking for all modes to contribute towards a transport system which is better both for the user and for those who are non-users. Thus sustainability arguments are now at the forefront of policy decisions. Unfortunately, existing forms of public transport, except in very particular circumstances, are mismatched to these policy needs.

2.2 Sustainability: Comparative Figures

Analysis of the sustainability of conventional transport reveals unexpected results. Figure 2 is taken from data in Coffey and Lowson [5] and presents an estimate of typical actual use of primary energy by various modes of transport. This measure does not include life cycle issues such as construction, etc. This would require separate accounting, but generally would not have a major effect on relative assessments. The data are presented as average energy usage in MJoules divided by the number of passengers typically carried. Thus, for example the car data uses the average 1.6 passenger per car level for UK car usage.

The key conclusion from Figure 2 is that most forms of transport, whether public or private, have similar levels of energy use. It can also be seen that the most energy effective forms of transport at present are buses and multiple unit trains. This is despite the bus having on average only a 20 % passenger load factor.

Surprisingly, LRT figures show an average increase in energy use per passenger carried compared to cars. The figures were based on actual levels of energy use and passengers carried on the Newcastle and Manchester metros. Since this data could be controversial, a recalibration has recently been undertaken (this work will be published separately). The most recent UK data gives a slightly worse energy use for LRT. Energy use figures for transport modes over the whole of US have also been derived [6]. These have been found to be essentially equivalent to those given in Figure 2. Thus it is believed that Figure 2 continues to provide a good basis for comparison.

The modest differences between the various types of transport shown in Figure 2 suggest that transfer from car to conventional forms of public transport is unlikely to provide major benefits in sustainability. This analysis suggests that major gains are only likely to arise from a new approach matched to personal travel requirements and explicitly designed for improved sustainability.

3 The ULTra Solution

3.1 Basic Concept

ULTra offers a new approach to the transport problems of the 21st century. An initial description of the system was presented by Lowson in [7], an updated description was given in [8]. A picture of the first prototype vehicle is shown in Figure 3. ULTra has been designed to provide significant benefits for both the user and the non-user of the system. The concept has arisen from systematic analysis of the needs of modern transport. The analysis suggested that the optimum system should offer transport which

- is available on demand;
- goes non-stop from start to destination;
- is easily accessible and offers a full choice of destinations;
- is strongly environmentally friendly;
- is low cost;
- has demonstrably high safety together with personal security;
- integrates well with other forms of transport.

3.1.1 Available on Demand

ULTra is an automatically controlled, personal taxi system of four-seat vehicles that run on their own segregated guideway network. Transport is available on demand at any of a series of stations distributed around the city like cab ranks. Passengers can have exceptionally high confidence in the ability of ULTra to convey them to their destinations without delay. The empty vehicle management system ensures that a vehicle is nearly always available at the cab-rank as required. Simulations of the full Cardiff applica-

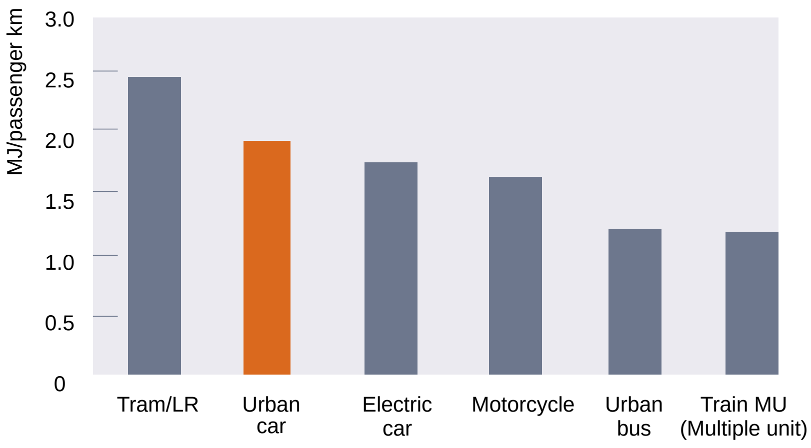


Figure 2 Comparative energy use per passenger km

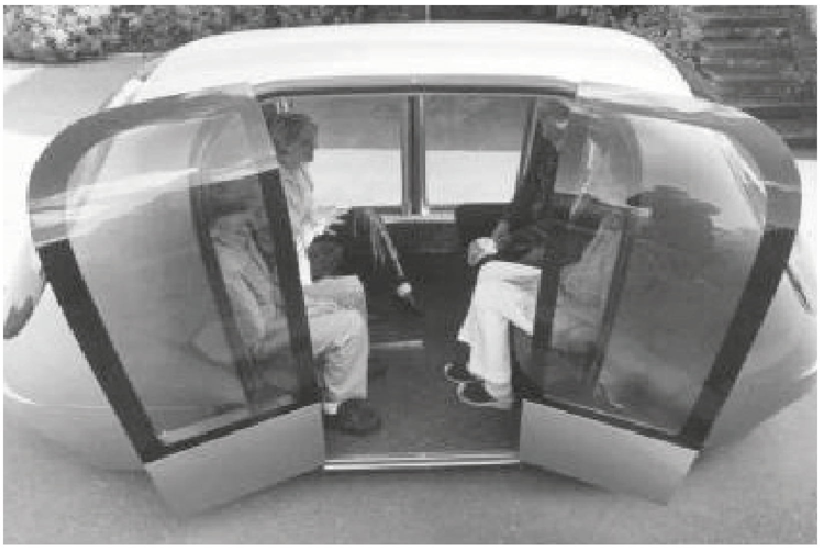


Figure 3 Prototype vehicle

tion at peak periods have shown that nearly all passengers (>90 %) would obtain immediate service from a waiting vehicle. Wait times in all applications studied to date are comfortably within the design target of 90 % of all trips met within a minute.

3.1.2 Non Stop

Because all stations are off-line, there is no need for vehicles to stop during their journey. Maximum speed has been limited to 40 kph (25 MPH) to improve safety, but trip times are still reduced by a factor of between two and three compared to cars or buses in a congested city centre, or to light rail.

3.1.3 Accessible

ULTra provides car levels of flexibility and response to non car owners, including the young and the old. In the City Centre or under other conditions of congestion ULTra provides a far better transport service than is available from the car, or any current form of public transport. A smart card system permits any user to request direct transport to any other station on the network.

ULTra provides significantly increased accessibility for those with a wide range of disabilities as shown by Davey and Lowson [9]. There is no change in level between platform and vehicle floor and the vehicle door has been designed to facilitate entry. Appropriate lifts are provided for any high level stations. The vehicle design can accommodate a wheelchair and companion, and wheelchairs can be turned around inside the vehicle. Following discussions with the mobility group of DTLR, special emphasis will be put on providing a system which meets the needs of the partially disabled (eg. those who are partially sighted or have movement difficulties).

3.1.4 Environmentally Sustainable

As discussed earlier in the paper, sustainability issues are critical for 21st century transport. ULTra offers massive reductions in energy, emissions output and resource usage compared to existing types. Because ULTra is electrically powered there is zero emission in the city, but in any case overall energy and emissions are significantly reduced. The average system energy usage is 0.55 MJ per passenger km. This can be compared with figures between 1.2 and 2.4 shown for conventional forms of transport in Figure 2. The typical benefit compared with cars is over a factor of three. Importantly, in peak periods when cars (and buses) are restricted by congestion this benefit rises to a factor of around eight. This energy saving translates directly into reduced CO_2 emissions.

Resource usage is also considerably reduced because of the small scale of the system. Typically, resource usage is down by a factor of between six and ten. This provides significant benefits in cost as well as in sustainability.

There is now a consensus, eg. Bouwmann [10], Dürr H-P [11], that a sustainable level of energy use is 1.8 kWhr per hr. This is based on an evaluation of the energy constraints of solar radiation on the earth's surface. Since ULTra uses 2 kW continuous power and will carry an average 1.6 passengers, this means that, uniquely for powered transport, ULTra meets agreed sustainability criteria.

Because ULTra is of considerably lower power than other forms of transport there is a significant reduction in noise from the vehicles. Initial measurements during vehicle drive-by give 43 dBA at 2.5 m from the vehicle, with the noise being indistinguishable at 10 m against a background noise of 35 dBA.

3.1.5 Low Cost

Designs undertaken by Arup show that infrastructure construction costs for the overhead guideway are less than for the equivalent footbridge, and for at-grade track less than the equivalent footpath. This is because the system loadings are less than the pedestrian crush loads required for footway design. This also means that the system can be run into buildings designed to existing floor loading codes with no structural change. The structural design and cost predictions have been confirmed in the build of the prototype system, described in Section 5.1. Complete system cost also includes other infrastructure such as stations, together with vehicles, control systems and support such as ticketing and CCTV (Closed Circuit Television). These costs vary considerably with details of the application but typical costs for a complete system in a variety of applications have been around £5M per km of guideway. A further discussion is given in section 5.

3.1.6 Safety and Security

Safety is the prime design requirement for any transport system. ULTra is designed to exceed the best safety standards of modern public transport, ref. Lowson and Medus [12]. The detailed concept safety paper developed by Advanced Transport Systems Ltd has received a "Letter of No Objection" from HM Rail Inspectorate. By providing an effective form of transport, which will encourage existing car users to use safer public transport, ULTra can be projected to provide significant benefits in terms of fatalities, and serious or slight injuries. For the Cardiff application, analysis of existing statistics suggests that the benefit of the ULTra system would be a saving of around 50 accidents a year.

ULTra offers significant benefits in personal security. All trips are only undertaken with companions chosen by the traveller. During peak periods 90 % of trips are available immediately on demand. Off peak, this figure rises to 100 % since vehicles can be assured to be available at all stations. Thus, the risks associated with waiting for public transport are virtually eliminated. Further, all stations will be under continuous coverage by CCTV, with direct links to the controller available from all vehicles and from all stations.

3.1.7 Integrated Transport

ULTra is complementary to existing forms of transport. By providing a network link, with on-demand access, to major bus and rail stations or to park and ride sites, it will improve the attractiveness of these modes. Thus, ULTra can contribute to improved transportation both directly and by enhancing the appeal of other modes.

3.2 Other System Features

3.2.1 Network

As noted above, ULTra runs on its own guideway network with offline stations. Typically, the network is arranged in a series of loops serving key transport locations around the city. These loops are combined by merge/diverge sections. In combination with off-line stations this provides non-stop travel. Track is passive, and switching is achieved by in-vehicle steering using an electronic guidance system. Stations have spacings similar to bus stops. The network form allows the guideway to be one way, providing important benefits in cost and visual intrusion. A variety of application studies have been completed, eg. Medus and Lowson [13], and it is typically found that, to provide reasonable accessibility, individual tracks need to be spaced at around 500 m separation, or about every sixth side road.

System capacity is governed by allowable vehicle headways. These are in turn governed by acceptable emergency stopping distances. The vehicle will be equipped with seat belts, but it is prudent to design emergency deceleration profiles so that passengers remain on their seat even if they are not wearing their safety belt. Analysis supported by practical tests has shown that an acceptable stop from 25 MPH (11.2 m/s) for an unrestrained passenger can be achieved in 10.2 m [14]. This permits a target mature headway of 1 second for the system, although initial operations are planned with margins of over a factor of two on this headway.

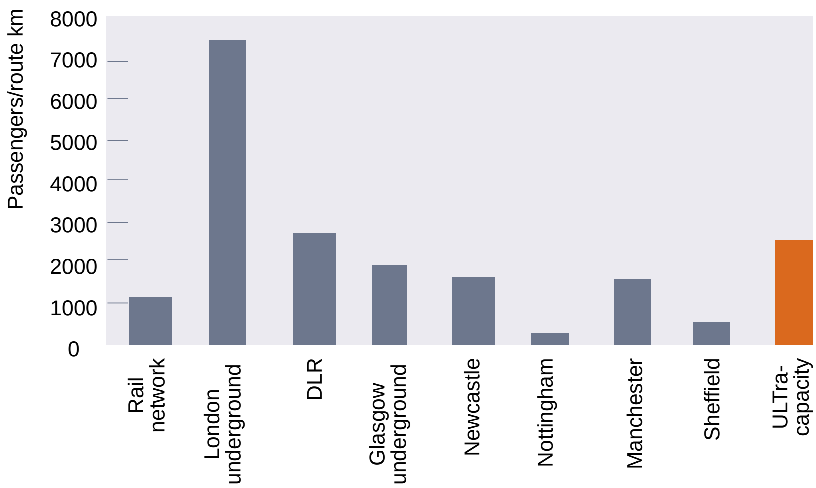
Operation of the network is based on a synchronous system with fixed "slots" for each vehicle at the prescribed headways. This requires free routes to be identified from start to destination through all merges before launch of a trip from the station. Extensive simulations have been done to optimise the synchronous control process, including development of effective empty vehicle management algorithms. It is found that around 65 % of the available line capacity can be used. However, in nearly all applications the critical factor on overall system capacity is found to be the stations rather than the line. Multi berth stations permitting a throughput of up to 500 vehicles per hour have been devised.

3.2.2 Mass Transit Capability

ULTra is also a mass transit system. In its mature form at 1 second headway and an assumed 65 % utilisation it will carry over 2,300 vehicles per hour in each lane, each of which can take up to four people. This compares with typical figures of about 1000–2000 vehicles in a single lane of sideroad or motorway respectively, while a single ULTra lane occupies one third of the ground space required by a conventional road. Typical passenger loads can be assumed the same as cars. This averages 1.6 but reduces in peak periods to about 1.4. For the Cardiff application typical trip lengths are 1.3 km. Thus ULTra offers a peak passenger carrying capability of over 2,500 per hour per lane. As shown in Figure 4, this single lane capacity offers a useful margin over the average peak hour loads per route km experienced by current rail based public transport systems, other than the most intensely used heavy rail or underground systems. These figures are based on data from the National Travel Statistics [2]. This capacity is not a "crush load"; passengers in ULTra are always conveyed in comfort.

The system is not designed to meet the most intense mass transit needs of the largest city centres like London or New York, where only underground or equivalent systems can meet the requirement. However, ULTra provides an

Figure 4 Peak hour loading estimates



excellent and exceptionally cost-effective match to the needs of cities with populations below 2 million.

3.3 Implementation Studies

A variety of implementation studies have been carried out both for DTLR and for local councils. Medus and Lowson [13] examined three key issues in the planning of ULTra networks: visual intrusion, severance (the restriction of movement of non-users) and the identification of possible routes.

It was found that guideway in the city centre normally requires to be elevated in order to avoid severance. In order to minimise visual intrusion the guideway system has an overhead depth of only 0.45 m and has been judged to be acceptable in initial questionnaire evaluations (see section 5.2 below). Strategies to minimise the visual intrusion of the system include use of at grade track where possible and integration with existing street furniture. There will be cases where visual intrusion issues become important. However, this has not emerged as a critical issue in system evaluation studies to date.

The use of existing transport rights of way was shown to allow a significant proportion of track to be placed at grade in typical applications. This provides cost and visual intrusion benefits together with low added severance.

Direct comparison of the ULTra system was made with a previously proposed light rail system for South Bristol. A complete and detailed analysis allowed comparative figures to be developed. The approach was to examine in detail the consequences of substituting ULTra technology for LRT technology along exactly the same alignment.

In many cases, it was found that using ULTra technology simplified the integration process when compared to LRT technology. This is principally due to the reduced scale of the ULTra system compared to a traditional LRT system. In some areas, it was found that the ULTra track required elevation to avoid conflict with pedestrian and/or vehicular movements at ground level. Elevated track needs to provide 5.7 m clearance for free vehicular access. A number of short tunnels were also required for the same reason. The LRT system also had the same conflicts, but in most cases the LRT decision was to operate at street level, using signal controlled intersections. ULTra did not utilise street running because of the use of automatic vehicles. The entire route was therefore systematically reconsidered for ULTra. Approximately 54 % of the track could be placed at grade, 44 % elevated and 2 % underground. This amount of track at grade provides considerable benefits in cost and aesthetics with little added severance.

The full assessment of ULTra along the South Bristol LRT alignment enabled a financial and economic comparison to be made. The results of this are summarised in Table 2 and discussed below. Note that both sets of figures are based on the original estimates and would require upward revision if repeated today.

Table 2 Financial and economic comparison between ULTra and LRT

Description	LRT	ULTra
Total Capital Cost (£M)	110	50
Infrastructure (£M)	70	27
Vehicles (£M)	30	13
Operating Costs (£M)	5.4	3.9
Revenue (£M)	5.8	8.9
Trading Profit (£M)	0.4	5.0

The LRT estimates are those reported in the study undertaken for Bristol City Council. The changes in infrastructure costs are principally due to the change in vehicle size. The LRT infrastructure needs to support 200 person / 40 tonne vehicles, while the ULTra infrastructure only needs to support 4 person vehicles weighing less than 1 tonne. This provides significant cost savings. The reduced vehicle costs come from a combination of reduced size and the economies of larger production numbers. ULTra vehicles use well-developed automobile component technologies, which provide additional cost savings. ULTra also has lower predicted operating costs, because the vehicles have no drivers and very low energy costs.

The overall number of passengers per year is projected to be higher with the ULTra system. This is because the ULTra system is projected to be more attractive to car drivers. In a number of other detail studies of modal split using cost of time models [15], it has been found that transfer rates of 25 – 30 % from the car can be achieved. This compares to 7 – 8 % for the LRT. The reason ULTra is more attractive to car drivers is that waiting times are minimal, in most cases zero. This compares to 5 to 10 minutes for the LRT. Also journey times are typically half those of the LRT system.

Increased passengers/year provides greater revenue to the system and, combined with reduced operating costs, this means the expected trading profit for ULTra is £5.0M per year compared to only £0.4M per year for the LRT based system. A £5.0M trading profit means that ULTra has the opportunity to repay its capital costs whereas the LRT system would be dependent on a 100 %

capital grant from the government. This was the reason the South Bristol LRT system was not pursued.

A wide variety of other comparative studies have shown that ULTra is typically one third the capital cost of the equivalent light rail system while also providing a significantly improved transportation service. In all cases, it has been found that the full cost of mature ULTra systems can be met from the fare box.

Generally, it has been found that ULTra can be fitted into the majority of urban environments. There is no problem with gradients of 15 % or more, and the small scale of the system provides a variety of additional opportunities not available to larger forms of public transport. For example, as noted previously, the low loading of the ULTra guideway means that it can be routed directly through existing buildings with no requirement for any structural reinforcement.

A study recently undertaken for Cardiff County Council has shown that ULTra is particularly well suited to application in Cardiff to link the existing City Centre with new developments in the Bay area. Council policy envisages 50 % of all trips to the Bay area being undertaken by public transport in the longer term. ULTra provides a valuable new capability to assist meeting this important policy objective. Because ULTra is complementary to other forms of public transport it can encourage modal choice in favour of public transport by providing a network link to serve public transport corridors. The study suggested that between 3 % and 10 % of existing car users could transfer to public transport once an ULTra link is available. Additional policy options on parking and traffic management to reduce car use would enhance this process.

The study demonstrated that ULTra can provide effective and environmentally attractive solutions to the transport needs of Cardiff City Centre and the Bay area. The work showed that provision of an ULTra system in the Centre and Bay areas will attract new users onto conventional public transport. A business analysis showed that the system is viable, without using arguments about secondary economic benefits.

However, an analysis using NATA (New Approach to Transport Assessment) guidelines was also completed using DETR [16] recommendations for costs. NATA is normally used for assessment of the benefits of roads and some assumptions are not necessarily appropriate for the ULTra system. Additional relevant recommendations are given by the DETR [17, 18]. An assessment was undertaken to provide an estimate of the value of the social benefits arising from implementation of the ULTra scheme in Cardiff. Significant benefits were projected from time savings, congestion relief and lessening of accidents together with a small benefit from energy saving. Additional health benefits were projected to accrue from reduction of emissions, but these are not normally included in a NATA assessment.

The overall ratio of Benefit to Cost was found to be 6.2. As noted, the scheme is also projected to make a commercial profit from operation.

4 Other Systems

There are many alternative approaches to future transport. In the author's view there are many other applications where novel ideas will offer more effective solutions to current transport problems than reworking of solutions which date back to the Nineteenth Century. ULTra is an example of a class of systems known as Personal Rapid Transit (PRT). A wide variety of PRT systems have been examined since the 1960s. An exceptionally complete archive of current and older ideas, both PRT and other concepts, can be found at the innovative transportation technologies website run by J Schneider, http://faculty.washington.edu/~jbs/itrans. Many of these ideas are conceptual only, but systems which are currently under test and/or operation include

- *Austrans:* http://www.aebishop.com/ This is a higher speed (120 kph) system based on a modified rail technology with 9 passenger vehicles;

- *Cybercars:* http://www.cybercars.org/ Several systems of automatically controlled cars have been demonstrated by INRIA in Versailles, France. These are intended to operate on conventional roads;

- *Cybertran:* http://www.cybertran.com/ This is intended for high speed (up to 240 kph) longer distance links offering 6–20 passenger cabs and off line stations;

- *Morgantown PRT:* http://faculty.washington.edu/~jbs/itrans/morg.htm This operates with fully automatic cabs on a dedicated guideway. It has been running successfully for 20 years and has now carried 50 million passengers without incident. Although called PRT, the cab capacity is 21, and it is in reality a collective-corridor system linking two parts of a University campus. Nevertheless, it does demonstrate that a fully automatic demand responsive system can be technically successful;

- *Park Shuttle:* http://faculty.washington.edu/jbs/itrans/parkshut.htm 10 passenger automatic buses are in passenger carrying operation in Rotterdam and at Schipol airport on short routes (<1 km);

- *RUF:* http://www.ruf.dk/ This Danish system claims to offer a combination of high speed and high capacity transport in cities. RUF is a "dual mode" solution in which vehicles can operate both automatically on track and under driver control off track. (It is proposed that ULTra will offer dual mode capability at a later stage.)

- *Serpentine:* http://www.serpentine.ch/ This Swiss automatic system has been in limited passenger carrying operation in a park in Lausanne. It consists of small low speed (15 kph) vehicles intended to operate on a dedicated part of a conventional road.

5 Current Project Position

5.1 Engineering Tests

The ULTra system is currently undergoing prototype testing on two tracks; a simple track in Bristol and a more complex 1 km guideway with overhead sections in Cardiff. Initial results have been very encouraging. Vehicle and track have been successfully integrated and circuits of the guideway have been completed under fully automatic control. Figure 3 shows the first prototype vehicle. Figure 5 shows another vehicle on the Cardiff test track.

Substantial interest has been expressed in the system worldwide. In-depth studies, supported by the EC under the EDICT programme, have started on potential applications in four European Cities: Cardiff, Eindhoven Stockholm and Rome.

5.2 Results of an Initial Questionnaire Survey

A survey was undertaken at a public exhibition of the prototype ULTra vehicle in Bristol in September 2001. Questionnaires were completed by 138 people of whom 44 % were male and 56 % female. These results must be treated with caution since there is no operating experience on which the answers can be based. A selection of the questions put together with the answers in percentage terms are provided in Table 3.

The responses to questions 1 to 4 relate to the appearance of the system. No respondent felt that the vehicle appearance was poor, indeed the majority thought the vehicles would look excellent. Response to the interior arrangements was also very positive although not as strongly positive as the external appearance. The visual appearance of the elevated structure was regarded generally as good, with 29 % rating it excellent.

It is especially noteworthy that the response to the elevated track in Bristol gave a notably positive response, with no definitely negative responses and only 16 % being unsure.

The answer to the fifth question suggests that ULTra would find ready acceptance as a transport mode. Comparing the answers to the fifth and sixth questions, it can be seen that the figures for the potential usage of ULTra are typically double the current usage of public transport in each of the first three categories. It appears that ULTra does offer a significantly more attractive form of public transport.

It will be seen from Question 6 that 60 % of the respondents either never or very occasionally use public transport. An analysis of their replies to Question 5 "If an ULTra system were available I would probably use it" gave the results shown in Table 4.

It is clear that users who are unwilling to use existing public transport would be very prepared to use ULTra. This questionnaire result closely matches results of the modal shift analysis pre-

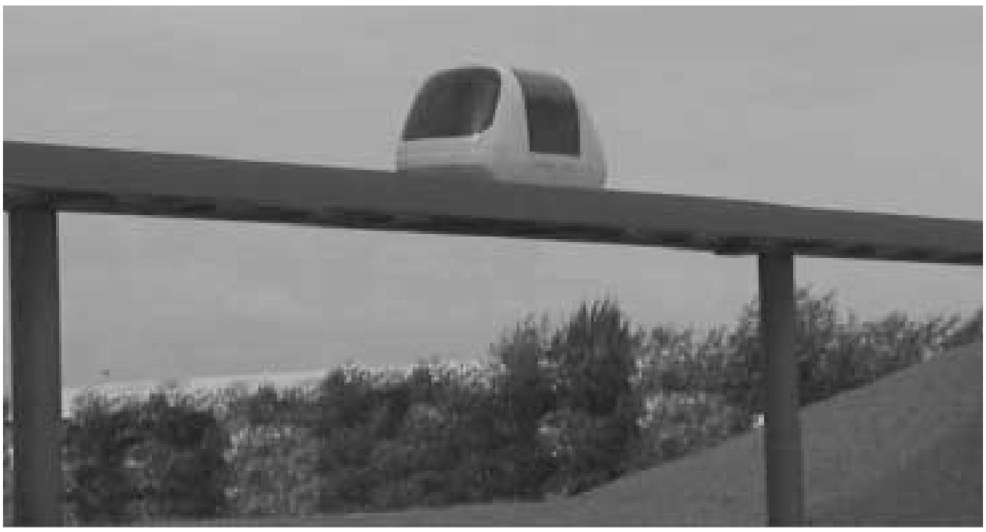


Figure 5 Vehicle on Cardiff test track

Question	Response				
	Excellent: %	Good: %	Average: %	Poor: %	Awful: %
1. How do you feel the ULTra vehicles would look in Bristol?	53.6 %	37.0 %	8.0 %	0.0 %	0.0 %
2. How do you rate the internal arrangements of the ULTra cab?	31.9 %	58.0 %	5.8 %	0.7 %	0.0 %
3. How do you rate the visual appearance of the elevated track?	29.0 %	41.3 %	22.5 %	2.2 %	0.0 %
4. How do you feel about an ULTra elevated track in Bristol?	No problem: %	Probably OK: %	Not sure: %	Could be difficult: %	Definitely negative: %
	55.8 %	26.8 %	12.3 %	3.6 %	0.0 %
5. If an ULTra system were available I would probably use it	Several times a day: %	A few times a week: %	Several times a month: %	Very occasionally: %	Never: %
	23.2 %	44.9 %	21.7 %	8.7 %	1.5 %
6. I use public transport in Bristol	Every day: %	Twice a week: %	Once a week: %	Very occasionally: %	Never: %
	10.1 %	15.9 %	11.6 %	47.1 %	13.0 %

Table 3 Response to an initial questionnaire

viously undertaken for DETR, which suggested that between 25 and 30 % of current car users could be attracted from car use onto an ULTra system

Other questions covered fares. 62 % of people were willing to pay a higher fare than the bus to use ULTra. The mean acceptable per vehicle fare is £1.68. Since financial analyses for Cardiff were based on a fare of £1 per vehicle, this response is most encouraging.

5.3 Initial Application

The National Assembly of Wales has approved a bid by Cardiff County Council which will allow the Council to support the first stage in the implementation of ULTra. The first stage will enable the system to be operated between the Bute Street railway station and the Inner Harbour, Wales Millennium Centre, National Assembly of Wales and County Hall. Progress on the link between the Bay and the City Centre will be done in parallel, possibly as a public/private partnership project. It is envisaged that vehicles could be operating in the Bay area by early 2005, with the City Centre being connected during 2005 if the partnership approach is successful. The estimated costs of the complete 7.7 km scheme are £39M. Projected passenger levels are 5M per year.

Cardiff is particularly suited to the ULTra system because regeneration has totally changed the transportation requirements. The docks area, a former industrial zone, is now a prestigious business and residential centre but one which is, at present, disconnected from the main city centre. Journeys between the two centres are already causing a variety of difficulties. Analysis shows that ULTra offers an effective solution, contributing to the objective of 50 % of passenger trips to the Bay area being delivered by public transport in the medium term.

Several times a day: %	A few times a week: %	Several times a month: %	Very occasionally: %	Never: %
25.6 %	37.8 %	24.4 %	12.2 %	0.0 %

Table 4 Potential use of ULTra by present non-public transport users

6 Conclusions

Meeting the challenge of providing sustainable mobility will require consideration of innovative solutions. Existing forms of public transport are mismatched to the form of present cities, which have been shaped by the capabilities of the car. There is a need to examine public transport which can equal or better the convenience of the car, but at considerably reduced environmental impact.

The ULTra system has been conceived to meet this requirement. It can be regarded as an automatic personal taxi system, since it responds to individual demands and passengers only share trips with chosen companions. This feature makes it uniquely attractive as a public transport system. Because ULTra retains many of the qualities of car-based transport – privacy, immediate access, non-stop travel – it can appeal to users who are unwilling or unable to change to current modes of public transit. Transport choice models supported by questionnaire analysis suggest that 25 – 30 % of current car users would be prepared to transfer to an ULTra system. It is also a system which is complementary to existing forms of public transport. By providing a network link, it can improve the attractiveness of existing modes.

Evaluations show that ULTra can be integrated into the urban environment at densities which provide a useful service but also minimise adverse impacts. In particular, the use of existing transport rights of way allows a significant proportion of track to be placed at grade, with little added severance, thereby providing cost and visual intrusion benefits. Studies show that ULTra can provide an immediate benefit for use on routes being considered for tram systems. It is projected to be financially viable. Evaluation of overall economic benefits following NATA principles indicates a Benefit to Cost ratio of 6.2.

The system has many novel features for urban transport that relate directly to improving the quality of urban life. It is currently undergoing engineering tests with a view to first application in Cardiff in 2005. Further details can be found at www.atsltd.co.uk.

References

1 Thomson, J M. *Great cities and their traffic*. Gollancz, 1977.

2 Department of the Environment, Transport and the Regions. *Transport Statistics Great Britain 2000*. London, The Stationery Office, 2000. ISBN 0-11-552263-8

3 Brinkhoff, T. *City Population*. March 10, 2003 [online] – URL: http://www.citypopulation.de/

4 Department of Transport, Local Government and the Regions. *Transport Statistics Bulletin National Travel Survey 1998/2000 Update July 2001*. London, DTLR, 2001.

5 Coffey, R, Lowson, M V. A comparative analysis of energy consumption and emission of urban transport systems. In: *Urban Transport and the Environment II*. Baldasano Recio, J M and Sucharov, L J (eds.). Southampton, Computational Mechanics Publications, 1996. ISBN 1-85312-451-6

6 Lowson, M V. The ULTra Personal Rapid Transit System. *Proceedings of SAE International Congress*, Detroit, March 2002. Paper 2002-01-0174

7 Lowson, M V. Personal Public Transport. *Proceedings of the Institution of Civil Engineers Transport*, 135, Aug 1999, 139–151.

8 Lowson, M V. The ULTra PRT System. *Proceedings of the ASCE 8th International Conference on Automated People Movers*, San Francisco, July 2001.

9 Davey, N H, Lowson, M V. *Accessibility issues for people with disabilities in a future transport system.* Bristol, Advanced Transport Group, University of Bristol, 1996. Working Paper 96/2.

10 Bouwmann, M E.. *Tracking transport systems.* Groningen, Geo Press, 2001. ISBN 90-71971-68-6

11 Dürr, H-P. Sustainable equitable economics. The personal energy budget. In: *The world at the crossroads.* Smith, P B et al. (eds.). London, Earthscan Publications, 1994, 39–56.

12 Lowson, M V, Medus, C E. Initial Safety Considerations for an Advanced Transport System. In: *Safe Systems*, Anderson and Redmill (eds.). Springer Verlag, 1997.

13 Medus, C E, Lowson, M V. Planning PRT Networks: The Case of ULTRA. *Proceedings of ASCE APM Conference*, Copenhagen, June 1999, 256–261.

14 Featherstone, C T, Lieven, N A J, Lowson, M V. Passenger simulation to determine safety limits during emergency decelerations. *Proceedings of International Congress*, Detroit, March 2002. Paper 2002-01-1124 SAE.

15 Lowson, M V. *Combined Study of Modal Split and Economics for an ULTra System.* Bristol, Advanced Transport Group, University of Bristol, 1997. Working Paper 97/9.

16 Department of the Environment, Transport and the Regions. *Transport Economics Note: Values of time and vehicle operating costs*. London, DETR, 1999.

17 Department of the Environment, Transport and the Regions. *Guidance on the Methodology for Multi-Modal Studies, Vols 1 & 2.* London, DETR, 2000. Ref AILT 1079.

18 Department of the Environment, Transport and the Regions. *Highways Economics Note, No 1: 1999 Valuations of the benefits of prevention of road accidents and casualties.* London, DETR, 1999.

PRT – Personal Rapid Transport – and a Telenor Involvement

EINAR FLYDAL, ERIK BACH, ERIK FENSTAD, JAN ERIK HAGELUND, UNNI HALLERAKER, JAN ORSTEEN, DAG SANNE AND ERLING WIIK

Einar Flydal (53) is Senior Adviser working with corporate strategy at the Telenor headquarters. He is cand.polit. from the Univ. of Oslo (UiO), 1983, in political science, and Master of Telecom Strategy from the Univ. of Science and Technology (NTNU), Trondheim, 2002. Apart from 1985–1993, when working with IT in education and with small IT companies, Flydal has worked with Telenor in a variety of fields since 1983. He has also worked as radio freelancer on minorities and music, on statistical indicators at the Chair of Peace and Conflict Research, and on work organisation on oil platforms at the Work Research Institute, Oslo. His present professional interests are environment, CSR, innovation, and ICT.

einar.flydal@telenor.com

Erik Bach (33) is Research Scientist in Telenor R&D with a background within social anthropology from the University of Oslo. In Telenor R&D he is currently working on self regulating systems like Peer-to-Peer computing. Bach is mostly involved with the social aspects of ICT systems. As a part of R&D's research projects he is analysing disruptive technologies and their impact for Telenor as an ICT supplier. Besides his engagement in Telenor, Bach is a partner in Kulturstudier INC, which promotes academic studies in India and Vietnam.

erik.bach@telenor.com

Telenor, the incumbent telco and an ICT corporation, is at the time of writing active in forming a consortium to prequalify for a PPP (public private partnership) contract, actively seeking to solve the special technologial and other challenges to be solved to have a PRT system built in the area. Why?

A group of Telenor employees on a Master's degree study in telecom strategy 2001–2002 used their project work within ITS (Intelligent Transport Systems) to carry out an analysis of the PRT concept and its feasibility, and to explore the business opportunities involved. Also, in parallel and close cooperation, a feasability study for the construction and operation of a PRT system in the Lysaker – Fornebu area was carried out for the Telenor management.

This paper presents the main findings and the present status of the two projects as of October 2002. The authors were engaged in one or both of them.

The Case: An Automatic Elevated Public Transport System to be Built

The Lysaker area (see Figure 1) is a bottleneck along the so-called West corridor in/out of Oslo, with offices housing about 20,000 employees in a compact belt along the motorway. Public transportation in the area, as well as on the attached peninsula, was since long a concern for the public authorities.

In 1996 these daily jams also became relevant to Telenor, as Telenor decided to build its new headquarter on the peninsula: There, on the site of the old Oslo airport, Fornebu, the ambitions are to develop an ICT industrial center and a new dwelling area. Telenor has now moved in. A transportation solution was of course a prerequisite and Telenor has been an active partner to the authorities in finding environmentally friendly transport solutions untill a rail-based public transport system is operative in 2006.

For the businesses involved as well as for the local and regional government, the ambitions have been high as to giving the entire development a profile of being innovative and environmentally friendly. The development of the Fornebu area has thus represented a unique opportunity to bring forward innovation in all areas and levels, and still does. Correspondingly, the regulating authorities have demanded the development to be "environmentally sustainable"; i.e. strong measures should be taken to avoid pollution and to find energy saving means. There has been, and still is, extensive cooperation between the public authorities and the local property developers, employers and property owners to develop good solutions for the area. As the first large employer moving into the area, Telenor easily gets the role of locomotive in this process.

The new traffic ensuing from the development, with around 36,000 new travellers a day in/out

Figure 1 The West corridor at Lysaker, the peninsula with Telenor's new headquarters, and the suggested APM track

Erik Fenstad (34) is Strategy Advisor for Delivering services in Telenor Networks. He holds a Master of Science degree in Industrial Economics and Technology Management from the Norwegian University of Science and Technology (NTNU) in1995. He also holds a Master of Technology Management degree in Telecommunications Strategy from NTNU in 2002. He joined Telenor Networks in 1996, and has since worked with supply chain management.

erik.fenstad@telenor.com

Jan Erik Hagelund (46) is a Business Administration Manager in Norkring AS, a company in Telenor Broadcast. Jan Erik holds a BSc Honours degree (1985) and an MBA from Heriot Watt University (1993) and a Master of Telecommunications Strategy (NTNU/TCU) (2002). His current job is within marketing and sales of terrestrial broadcast solutions. Former positions in Telenor include a short period at Telenor R&D before joining the Satellite Division in 1986, where his area of responsibility was both in the technical-, financial- and sales and marketing areas, within both broadcasting and business communications. His main interest is within corporate strategy/finance.

Jan-Erik.Hagelund@telenor.com

as well as within the area, will add to the already substantial traffic jams along the Oslo West transport corridor, were private cars come to a nearly complete standstill in rush hours. Various measures and restrictions have been implemented such that a substantial percentage of the employees and other travellers to and from the area will have to go by public transport.

Accordingly, a new public transport system had to be developed, either by extensions of existing bus, tram or train lines from Lysaker and out on the peninsula, or by developing some kind of feeder system to the Lysaker terminal. The property owners and developers, such as Telenor, will all have to pay their share. Telenor is thus, although a private corporation within ICT, an evident stakeholder in the process of providing for public transport. Also, the national government has – in its quest for more innovation and local involvement – expressed its interest in having the large employers in the area actively engaged in the development and operations of the public transport solution for the area.

Over several years, the authorities have worked out noumerous white papers and studies on the various public transport alternatives. In short, the local government decided summer 2002 on an automatic elevated rail system for the area. Basically, such systems are unmanned – but otherwise conventional – tram systems shuttling back and forth on an elevated guideway. They are close to being commodity products, ranging from heavy large trains called APM (Automatic People Mover), to fairly lightweight systems for groups of some 20 people (GPM, for Group People Mover).

So, the alternative chosen is mainly a feeder system for the area, with its pivotal point at the Lysaker terminal, where trains, busses, and a future extension of the Oslo subway network meet. The political debate is still intense – both as to level of integration between the APM and the various other transport systems, and to the financing involved. In Figure 1, the red line roughly indicates the APM track as proposed in the government white papers; extensions decided by the politicians have been added in brown.

An APM feeder system runs independently of traffic jams at grade. Hence, it can move faster than trams between the stations. It can also be made small with frequent departures, or made large with departures more rare. It can be noisy or silent, and it may become more or less dominating as a new visual element in the area. In part due to automation and other technological elements and in part due to local topography, it can also be substantially cheaper than conventional tram or train extensions in investments as well as operations. Running on electricity, it would also have practically no local emissions.

The traffic development indicates that it is mandatory to find solutions – for this area as elsewhere – that are environmentally sustainable, cost efficient to the local governement and taxpayers, as well as attractive to the public.

However, a general problem of public transport is that year by year it loses ground to the private car. Together with parking restrictions and traffic jams, an APM system should be so attractive and with so smooth transfers that people would leave their car at home and travel by public transport. The white books indicate that it will be a tough task even though the alternative transport modes are not much better.

The system construction and operation will be under a PPP (Private Public Partnership) regime; i.e. with an SPC (Special Purpose Company) to build and operate the system on a 15 – 20 year contract. The terms for the PPP are not known at the time of writing. Prequalified tenderers will hand in their offers some time fall 2003, and the first section of the system is scheduled to be in operation from 2006.

A PRT System Will Do a Better Job – at Lower Costs

PRT is the acronym for Personal Rapid Transport (called "Transit" in the USA). The PRT design criteria have been developed to address what over time have become the weakest parts of public transport. Hence, the design addresses the changes in city structures, cost pictures for public transport input factors, as well as consumers' alternatives.

The concept of PRT has been refined over a period of more than 30 years, both through theory and tracks – with more or less successful tests and real installations on the way. At this stage of conceptual development, the concept of PRT includes a set of mutually dependent design criteria, which are contrary to conventional public mass transport thinking:

- The guideway has the shape of a mesh network, consisting of unidirectional rings connected with passive switches – as opposed to the "A to B and back" tram or rail line.
- Vehicles are automatically routed through the network from departure to destination with no transfers – as opposed to tram or rail systems with fixed stops and transfers between lines.
- Vehicles are small and light, for use by the individual or up to 3–5 persons, and are used

Figure 2 Artist's impression of a PRT system (source: www.cities21.org)

Unni Halleraker (39) has been working for Telenor since 1997, currently as Financial Director in Telenor Networks. She holds a MSc in Business from the Norwegian School of Economics and Business Administration (1986) and a Master of Telecom Strategy and Technology Management from the Norwegian University of Science and Technology (NTNU (2002).

unni.halleraker@telenor.com

as taxis – as opposed to large and heavy rail systems used for simultaneous transport of passengers with different departures and destinations.

- Vehicles wait at stations and depart on demand, as a taxi – as opposed to the trams' fixed schedules.

- All stops (i.e. stations) are located at side-tracks – as opposed to stations along main guideway, blocking for traffic to flow.

- Along the main tracks, vehicles run at headways down to around 1.5 seconds, and at constant speed, e.g. 40 km/h, independent of other traffic – as opposed to 15–20 km/h mean speed for trams and busses in city centers, frequently impeded by other traffic.

- Vehicles and structural elements are designed to be lightweight, and with no passenger standing – as opposed to the heavy structures resulting from the heavy "light rail" systems transport mode.

Such a system may look as in Figure 2, which shows an artist's impression. Note that such systems can be light enough to be fixed to building walls or be laid over ordinary office building floors.

Though contrary to our conceptions of mass public transport as they may seem, such systems have amazing capacities. Figure 3 shows the theoretical capacities of a PRT system guideway with headways (distance between front of vehicles) larger than frequently found on the motorways in the morning rush – at twice the speed. The table shows that as to the *theoretical* capacity of the guideway, the capacity needed for the Fornebu – Lysaker area rush hours (2,800 pass./hour) can easily be met by a PRT system, even with the taxi standard of 1.2 passengers per vehicle. However, implementations – i.e. control systems, switches, stations, public safety requirements, traffic patterns, and much more – decide to which extent the teoretical capacity of the guideway can be maintained in real operations.

Headway (secs)	**Number of passengers**				
	1	1.2	2	3	4
1.5	3600	4320	7200	10800	14400
2	2400	2880	4800	7200	9600

Figure 3 Passenger capacity per hour as function of headway and passengers per vehicle

Jan Orsteen (55) holds an MSc from the Norwegian University of Science and Technology and has done business studies at BI Norwegian School of Management. He has extensive experience from transportation planning in public service and consulting companies. At present, Jan is independent consultant in transport planning and business management after having held senior positions in the major consulting companies in Norway, such as Norconsult. He was also a founder and CEO of ViaNova, a leading company in transportation planning and related software development. Jan Orsteen has also been project manager of several studies in the transportation sector, particularly around Oslo.

Figure 4 The FlyBy guideway proposal (yellow) and extensions (brown)

During our feasibility studies spring 2002 and later, we did a PRT concept study for the Fornebu – Lysaker area under the work name of "the FlyBy rail". The network outline is shown in Figure 4. Approximate extensions to cover political decisions and wishes summer 2002 are also shown (brown lines), but not yet included in our estimates.

To identify the specific properties of such a FlyBy PRT implementation, we have walked through many of the (often enthusiastic and optimistic) PRT studies available, and done conservative estimates and calculations for a system installation. In Figure 5 a summary of our findings are compared to equivalent information as to the APM elevated rail case study carried out for the local government project white books (Akershus fylkeskommune 2001 and 2002).

Although we have used leading traffic planner expertise and made use of (revised) calculation models from several system developers, we consider our findings to be non-conclusive, and due to be revised when the design is more detailed. Also, as there is no experience from factual operation, figures must be understood as best estimates at the time of writing. However, even with large margins, our analyses come out clearly favorable to the FlyBy PRT system over an APM system. Some very important topics depend on the specific implementation, and others on the will of public authorities. Hence, they are still open, as indicated in the table.

Extensive theoretical, concept, and empirical studies, as well as project studies for specific urbanisations have been carried out concerning societal costs and gains, technologies, safety, etc. The picture conveyed through these studies is fairly congruent to the above claims (e.g. Andréasson, Johanson & Tegnér 2002).

Yes, It Can Be Done – And Almost Is

A major finding of our feasibility study was that PRT now seems technologically feasible, despite historical evidence. But organisationally it seems still challenging:

More than a hundred automatic elevated rail systems for public transport are in operation around the world. None are PRT in the strict sense of the term defined above. The literature on PRT is extensive and the number of project studies for cities small and large around the world is impressive. Several systems have been built around various projects as test sites and are no more in operation: ARAMIS in Paris, Cabinentaxi in Hamburg, CSV in Japan, PRT2000 in Chicago. The Morgantown GRT, West Virginia, USA, however, built in 1971, has transported more than 25 million passengers and has 99 % uptime in a hilly and snowy town.

There is also a substantial literature analyzing why the various PRT initiatives so far have failed (e.g. Latour 1997, Rydell 2002, Burke 1979). Roughly, they identify the same set of reasons for failure that often follow trajectory disruptive new concepts: The launch of immature technology, the "Not invented here!" arrogance, unclear business models, strifes around ownership to ideas, compromises ruining critical features, resistance to a new mindset, etc.

Behind the failed projects one also finds detrimental political plays in government and the

Dag Sanne obtained his BCom from the Norwegian School of Economics and Business Administration and worked for IBM from 1968 to 1994, the last 7 years in corporate management. He has managerial experience from sales and marketing, but also from system development, technical service, administration, human resources, information and public contact. From 1991 to 1994 Dag Sanne was responsible for the down-scaling of IBM in Norway while also taking care of IBM's commitments in the 1994 Lillehammer Olympics. In 1992 he took the lead in establishing Birkebeinerlaugets Bedriftsutvikling, where he went on to become chairman and, after leaving IBM, managing director.

sanne@bbu.no

Erling Wiik (44) graduated from the Norwegian University of Science and Technology (NTNU) in 1983 and holds a Masters degree in Technology management, Telecommunications Strategy (2002). He has worked in Telenor since 1986 within management, strategy and architecture for the operation of Network Management Systems. He is currently working as Senior Project Manager in Telenor Networks, Operations Divison, at present in a project on IT server consolidation within the Telenor corporation.

erling.wiik@telenor.com

Parameter	PRT compared to APM
Investments costs	Down approx 1/3.
Operations costs	Down approx 25 %
Capacity	Rush hour demand met by 1.5 sec headway and 3 passengers/vehicle.
Travel times	Mean travel time down 1/3 to 1/2
Wait times	No wait outside rush; max 1 minute during rush. With APM 1 to 5 min.
Energy consumption	1/5 to 1/6 of APM/"light rail".
Visual and sensory intrusion	Smaller, leaner, more silent, more spread out, but more frequent.
User attractiveness	Higher due to smoother transfer at Lysaker terminal.
Passenger requirements	Same or better level, but: room for weelchair, no standing, no skis.
Realism to meet timeframe (2006)	Clearly feasible, as APM.
Area coverage	Substantially better – Compare on maps.
Extensions	Easier, faster and cheaper build outs as long as traffic is fairly balanced.
Flexibility of investment	Higher – as stepwise build out is practical.
Mean overall travel speed	Fixed speed approx 40 km/h. For APM around 20 km/h, decreasing with length travelled.
Limitations caused by weather (wind, snow, ice, cold)	Solutions exist. Depend on implementation.
Mean time between failures (MTBF)	Depends on implementation. Still open.
Safety	Depends on implementation. Higher risk spread. Still open.
Safety regulations	High risk for PRT, as safety regulations for rail systems are designed with very different concepts in mind. Still open. For APM: no risk.
Overall vulnerability to operation stops	Depends on implementation. Still open.
Proximity to white book concept	PRT is closer to wished functionalities. Only APM is analyzed.

Figure 5 The FlyBy case – performance on relevant parameters

clumsiness of large corporations – with an organisational maze and culture killing off innovation. According to some (Rydell 2002) there are even proofs of direct – and illegal – obstruction from the part of incumbent transportation systems suppliers, mobilizing laws and regulations to be used against their intentions.

However, the preconditions for implementing PRT are now all changed: The concept of PRT has been refined. The political pressure to search for new and environmentally sustainable solutions to urban congestion is now of a different order of magnitude than only a few years back. Also, what can be done at affordable price with today's off-the-shelf technology was not imaginable just 10 years back. Hence, Martin Lowson, himself a developer of the ULTra PRT to be in operation by 2005 in Cardiff, can list quite a few PRT systems under development in his paper (Lowson 2002, this issue of *Telektronikk*).

In fact, there are implementations of transport systems very close to PRT already at hand: The baggage handling system at the Oslo airport (Gardermoen) – a world first of its kind and later duplicated at several airports – satisfies the above mentioned design criteria of a PRT system – apart from some criteria linked to handling people, not luggage!

After a series of consultations fall 2002 with relevant transport engineers to address particularly the problems of snow and ice, we have been able to identify solutions that seem to make even these problems fully managable as to rails,

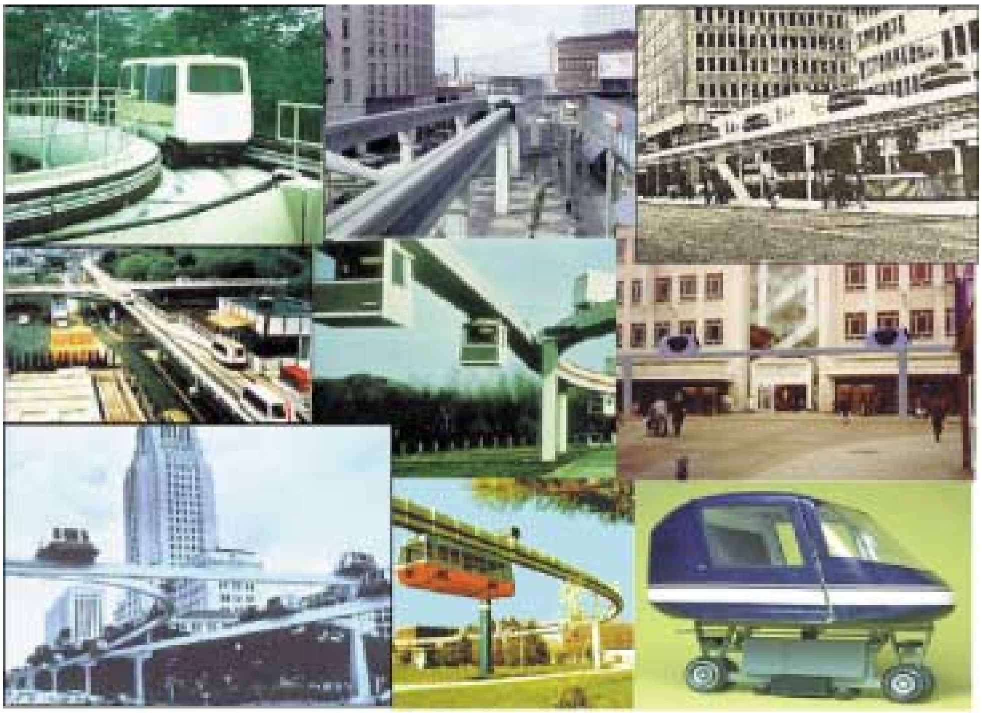


Figure 6 Some examples from the development towards today's PRT concept

switches, propulsion, steering systems and brakes – even without the use of heating or chemicals. The development of a full PRT system to be in operation by 2006 thus seems technologically fully feasible.

The remaining should thus be a question of commercial conditions, organisation, financing, and will.

The Business Case – PRT as an ITS Application

PRT caught our interest for several reasons:

One of them was the ease with which the FlyBy enterprise, once established, could be duplicated at other locations in Norway as well as abroad. Hence, development costs in the FlyBy case could be considered the entry ticket to a new business and new markets.

Another reason was the PRT idea as a business that really matters, as it addresses real problems that urgently need solutions. Yet another reason was that PRT, in the context of FlyBy, is a relatively low risk operation: The costs up until a tender can be handed in seem modest considered as an eventual major business development project.

But not least, PRT caught our interest because of its close relation to the core elements within Intelligent Transport Systems (ITS), a growth area within ICT. In PRT, the technical core elements are stuff like automation, "failure safe" fleet management software for optimation of dynamic systems in true time, sensors, positioning information (e.g. GPS), radio communication, lightweight, and safety overdesign.

These core elements are common to ITS, as they are to the ICT business. As shown in Berland 2002 (this issue of *Telektronikk*), central system design thinking within ICT – mobile computing and the Internet in particular – is easily and fruitfully transposed to PRT fleet management systems. The very same core elements and the dynamic system design thinking are however foreign both to the traditions of businesses of public transport and construction.

The core of PRT – ICT components for automation – are no longer unproven, nor expensive, nor bulky or heavy. On the contrary they are conventional ICT technology. Applying standard ICT elements on a new area where the market for years has been seeking solutions, means following the text book theory of entrepreneurialism: It still, but for a limited time only, offers first mover advantages for innovative enterprises.

But as always with innovations, there is a risk: The PRT business models are unclear, or at least different from traditional public transport. The patterns of investments, operations and modifications are different. Even the reliability criteria need to be different and will need standards and benchmarking to be well thought through: For example, how do you measure uptime in a mesh network based on best effort? The definition established for the traditional network is not applicable. It needs an overhaul not to create backwardish resistance – precisely as when the Internet met the established telco business with its "toyish" new and lean structures.

If PRT were conventional to the industry, there would be no risk, nor any first mover advantage, nor any trajectory disruptive change in the development of urban transport.

The FlyBy Consortium

The Telenor corporate management has so far only considered PRT to be of substantial value to the attractiveness of the Fornebu area and to society at large, not as a business idea for the corporation.

Accordingly, the Telenor initiative is limited to taking the lead in the establishment of a consortium that could qualify for the tender process with a PRT proposal. At the moment of writing, the consortium consists of just two partners, Telenor and Statkraft, the latter being a 100 % government owned incumbent hydroelectricity producer.

Statkraft is a shareholders' company with ambitions to become an important supplier of "green" electricity, whether produced from hydropower turbines, windmills, or hydrogen fuel cells. For Statkraft, the FlyBy project is a show case opportunity for "green" electricity supply, as well as an opportunity to contribute to moving public transport in the direction of "greener" transportation modes. Applying its methodology for environmental impact certification, we see that even public transport may get its product declarations as to environmental impact.

As of mid October 2002, talks with several PRT system suppliers have been going on for months. However, none have so far been chosen, as none were found to have solutions on the drawing board that could master the required combination of climate, PRT features and implementation schedule. By a major overhaul of our thinking around PRT, we believe now to have found the relevant technical solutions, and a list of relevant suppliers of all main elements has been established. Hence, more concrete plans, evaluations and estimates can be worked out.

The prequalification round scheduled to start by February 2003, will reveal essential elements of the PPP (public private partnership) terms. It is thus a natural milestone and eventually an exit point.

To continue after "beauty contest", the consortium must get more partners. Talks with candidate partnering companies have been going on for some time, but have so far not concluded. As uncertainty reduces step by step, the project will hopefully attract the financial partners necessary for the work to be carried on until handing in a tender fall 2003.

Conclusions

The ICT business has an opportunity – as well as a social obligation – to help introduce PRT, and thereby contribute to breaking the trend of public transport losing ground. By implication, it means that players foreign to public transport should seek to cooperate with the sector's incumbents, alternatively challenge them by entering their markets. As the demand is there already, and estimations indicate that PRT may give substantially better economy than the alternatives, the business models will come.

We have found that the impediments are no longer technological, nor connected to costs of investments or operations. They now depend on willingness to bring about change!

Literature

Bane til Fornebu. Oslo, Akershus fylkeskommune, 2002. ("Silingsrapporten")

Kollektivbetjening av Fornebu, tilleggsutredning til konsekvensutredning av januar 2000. Oslo, Akershus fylkeskommune, 2001. ("Høringsrapporten")

Andréasson, I, Johanson, J, Tegnér, G. *Lean Transit System for a Sustainable City.* Stockholm, Ecomitech AB, 2002

Andréasson, I. *Innovative Transit Systems, Survey of current developments.* Gothenburg, Logistik centrum, 2001. (Vinnova report VR 2001:3.)

Berland, N J. Designing PRT control systems by Internet Protocol thinking – comments on Ed Anderson's paper. *Telektronikk*, 99 (1), 117–120, 2003.

Burke, C G. *Innovation and Public Policy: The Case of PRT*. Lexington, MA, Lexington Books, 1979.

Latour, B. *ARAMIS – or the love of technology.* Cambridge, MA, Harvard Univ. Press, 1997.

Lowson, M. Sustainable personal transport. *Telektronikk*, 99 (1), 91–100, 2003.

Rydell, E W F. *The Transportation Renaissance*. Xlibris Corp., 2002. (www2.xlibris.com)

Control of Personal Rapid Transit Systems

J. EDWARD ANDERSON

The problem of precise longitudinal control of vehicles so that they follow predetermined time-varying speeds and positions has been solved. To control vehicles to the required close headway of at least 0.5 sec, the control philosophy is different from but no less rigorous than that of railroad practice. The author's conclusion is that the preferred control strategy is one that could be called an "asynchronous point follower". Such a strategy requires no clock synchronization, is flexible in all unusual conditions, permits the maximum possible throughput, requires a minimum of maneuvering and uses a minimum of software. Since wayside zone controllers have in their memory exactly the same maneuver equations as the on-board computers, accurate safety monitoring is practical. The paper discusses the functions of vehicle control; the control of station, merge, and diverge zones; and central control.

J. Edward Anderson is Chairman, President & CEO of Taxi 2000 Corporation. He holds a PhD degree in aeronautics and astronautics from Massachusetts Institute of Technology, a MSME degree from the University of Minnesota and a BSME degree from Iowa State University. His career includes structural analysis at NASA and design of instruments, autopilots, navigation systems, and spacecraft at Honeywell, Inc. He was for 30 years Professor of Mechanical Engineering at Univ. of Minnesota and at Boston Univ. He has led development work on PRT since 1968. In the 1970s he chaired three international conferences on PRT. In total he has published 95 papers on subjects related to PRT and has been the principal designer of the Taxi 2000 PRT system. He is a Fellow of the American Association for the Advancement of Science.

jeanderson@taxi2000.com

Introduction

The problem of closed-loop automatic longitudinal control of a single vehicle constrained to follow a guideway at a specified time-varying speed and position within adequate accuracy has been solved by several investigators [1, 2], and analytical equations for the required speed and position gains have been derived [3]. The architecture of checked redundant microprocessor control for automated transit vehicles has been developed and has been shown to be able to achieve a safety record as good as or better than a modern rapid rail system [4]. The major challenge in PRT control has been to control a large fleet of vehicles operating at fractional-second headway and merging and diverging in and out of stations and between separate branches in a network of guideways with an acceptable level of safety, comfort, and dependability, while meeting other essential criteria. A great deal of work has been done on this problem over the past few decades. Much of the published work can be found in conference proceedings [5, 6, 7, 8], and in results of the Urban Mass Transportation Administration's Advanced Group Rapid Transit Program [9, 10]. While the AGRT system was designed for 3-sec headway, much of the work is directly applicable to PRT. Together with the work of The Aerospace Corporation PRT Program [11] and the DEMAG+MBB Cabintaxi PRT Program [12], one can obtain an excellent perspective on the field.

In a short paper, it is not possible to describe any appreciable portion of this work; however, it is more useful to give a synthesis of conclusions reached concerning the means of controlling a PRT system, which have been built on the shoulders of prior investigators. I first discuss the criteria any PRT control system must meet. Then, it is necessary to discuss the problem of safe achievement of adequately low time headway between vehicles and how the safety philosophy must differ from standard railroad practice. Next is a discussion of strategies of control of many vehicles in a network. With this background, the next topics are the information that must be available on board the vehicles and at various wayside points, the sensing and communication requirements, and the mathematics involved. I do not discuss lateral control because, in most PRT systems, it is achieved passively by wheels running against lateral surfaces.

Control Criteria

Line and Station Throughput

Analysis of PRT networks in many applications has shown that fractional-second headways are both needed and attainable. The 1974 UMTA Administrator Frank Herringer, in testimony before a committee of the Congress of the United States, said: "A DOT program leading to the development of a short, one-half to one-second headway, high-capacity PRT system will be initiated in fiscal year 1974." [13] This statement was a result of consensus among workers in the PRT field in consultation with the Research and Development staff of UMTA on the need and practicality of headways as low as 0.5 sec. Off-line stations must be designed to meet expected input and output flows, and the system must be designed to prevent excessive congestion at merge points and destination stations.

Safety

A PRT system must provide a level of safety in terms of injuries per 100 million miles at least as good as a modern rapid rail system, and preferably better – better because the improvements provided by PRT in all areas must be good enough to justify the development cost. To achieve this level of safety, the on-board and wayside computers must be checked redundant.

Dependability

The term "dependability" is less often used than "availability", which is measurable in conventional transit systems as the percentage of trains that arrive at stations when expected. Dependability is the ratio of person-hours not delayed due to failures to the number of person-hours of operation. It is a more meaningful criterion and, in PRT, can easily be measured and updated trip by trip by a central computer [14]. In a recent PRT program I was involved with, it was specified that the undependability (1 – dependability) should be no more than 3 person-hrs of delay per 1000 person-hrs of operation. From our analysis, if the safety criterion is met, the undependability will be at least an order of magnitude less.

Ride Comfort

Longitudinal maneuvers must be performed in such a way that International Standards Organization ride comfort standards on acceleration as a function of frequency are met. As to maneuvers, the most recent federal standards on ride comfort that would be applicable to vehicles in which all passengers are seated were set by the National Maglev Initiative Office. They restrict acceleration to 0.2 g and jerk to 0.25 g/s in normal operation. The maximum emergency-braking deceleration depends on whether or not passenger constraints are provided. If not, the criterion must be that the passenger not slide off the seat in an emergency stop.

Changing Conditions

The control system must be able to reduce cruising speed in high winds and must be able to cope with any unusual situation, such as a stopped vehicle, that would require vehicles to slow down or stop away from a station.

Dead-Vehicle Detection

There must be a means to detect a dead vehicle on the guideway, however remote that possibility may be. Each vehicle must transmit its speed and position at frequent intervals to a wayside computer – a zone controller. If the zone controller suddenly does not receive the expected signal, it must be programmed to remove the speed signal for all vehicles in that link and transmit this information to the next upstream zone controller. Each vehicle's control system is configured to command reduction in speed to a creep speed if the zone controller's speed signal is not received. A finite creep speed permits vehicles ahead of the failed vehicle to move safely to the next zone, it reduces anxiety, and with seated passengers is safe. Magnetic detectors are placed at specified intervals along the guideway to inform the zone controller of passage of a vehicle. Thus, if a vehicle passes one of these markers and not the next, the location of the dead vehicle is approximately known. Then, because the passengers are seated and can be protected, and the vehicle can be protected by appropriately designed shock-absorbing bumpers [15], a creeping vehicle can be permitted to advance until it soft engages with the dead vehicle, whereupon the position of the dead vehicle becomes known and an appropriate failure strategy can be engaged.

Interchange Flexibility

The simplest interchange is a Y, with either two lines entering and one exiting or vice versa. Such an interchange gives the least visual impact at any one point, but it requires that vehicles first merge, then diverge, which creates a bottleneck after a merge. Desiring to obtain maximum possible throughput, The Aerospace Corporation used two-in, two-out, multilevel interchanges, which permit vehicles to diverge first and then merge. With such interchanges, the input and output capacity of the lines is the same, hence the worst that can happen is that a vehicle may have to be diverted from the direction it would normally go. Thus the control system does not have to be concerned with sending too much traffic along a particular line. If Y-interchanges are used, control is more complex and is discussed below. Since Y-interchanges are often necessary, the control system must permit them.

Vandalism and Sabotage

A system in which the control functions are distributed and the wayside computers are protected, for example in safe rooms under the stations, will be less susceptible to damage than a system in which a central computer plays an essential role. To minimize the consequences of failures of any kind, distributed control is preferred. The required central-computer functions should be such that the worst that can happen if it fails is that the system will operate less efficiently.

Modularity

The control units should be easily exchangeable so that down time is minimized.

Expandability

The control system should be designed for easy expansion of the system.

Principles of Safe, High-Capacity PRT

The Headway Equation

The minimum safe spacing between vehicles is the longest emergency stopping distance minus the shortest failure stopping distance. It is given by the equation

$$H_{min} = Vt_c + 0.5V^2\,(1/A_e - 1/A_f) \qquad (1)$$

in which V is the line speed, t_c is the time constant for brake actuation, A_e is the minimum emergency braking deceleration, and A_f is the maximum failure deceleration. Strictly speaking there should be a term added involving the rates of change of deceleration (jerk), but the emergency jerk can be made high enough so that jerk does not add to H_{min}. If L is the length of the vehicle, the minimum time headway, using the above equation, is

$$T_{min} = (L + H_{min})/V$$
$$= L/V + t_c + 0.5V(1/A_e - 1/A_f) \qquad (2)$$

This equation shows, first, that PRT vehicles should be as short as possible. With careful design, a length of 2.6 m is practical. A typical operating speed is 13 m/s, in which case the first of the four terms in T_{min} is 0.2 sec. Boeing work [16] showed that vehicles can transmit their speeds and positions as frequently as once every 40 msec. To command emergency braking requires two such transmissions. The braking time constant, once a signal is received must be very short. With the right technology, 100 msec is practical. Therefore, with some extra allowance, assume t_c = 0.2 sec. If the minimum line headway is to be 0.5 sec, the bracketed term in equation (2) can thus be no more than 0.1 sec – practically zero. This means that *in a fractional-second-headway PRT system, the design must be such that the minimum emergency deceleration must be as high as the maximum reasonably possible failure deceleration*.

The most recent indication of the practicality of close-headway control is an announcement by the National Automated Highway System Consortium [17] that in 1997 "10 specially outfitted Buick LeSabres will take part in the first test of an automated highway". A companion article on the same page says that these 200-inch long autos will operate at a spacing of only 6 feet at "50-plus miles an hour". This works out to a time headway of 0.309 sec. At 30 mph the headway would be 0.515 sec.

Departures from Railroad Practice

In railroad practice, trains may be so long that the first term in equation (2) may be several times the term $V/2A_e$. Also, at grade level, it is easiest for some foreign object or another train to quite suddenly appear ahead. In the worst case the train ahead theoretically stops instantly, in which case the fourth term in equation (2) is zero. Relative to the size of the term L/V, this is not a severe assumption and is conservative. In railroad practice it is standard to design for the so-called "brick-wall" stop in which A_f is infinite.

A railroad block-control system depends in emergency situations on a vital relay that virtually never fails. Its failure is likely to cause a collision, but such a failure is so rare that it is assumed never to occur. What is implied is that the probability that the vital relay fails when it is needed is so low that it is acceptable. There is no other choice. *In any moving system the simultaneous occurrence of two very improbable major failures may set up the conditions for a collision.*

In railroad practice the philosophy is that if one train is to stop instantaneously, the train behind must be able to stop in a short enough distance to avoid a collision. In PRT, the philosophy must and can be that if one vehicle stops instantaneously, someone is already killed. Therefore, one must and can design the system so that, barring a calamitous external event, it is "impossible" for one vehicle to stop instantaneously. Just as in railroad practice, "impossible" has the meaning stated in the paragraph above.

This failure philosophy requires careful analysis of every circumstance in which a sudden stop could theoretically occur. There are only two: 1) Something falls off a vehicle or a foreign object appears that wedges the vehicle in the guideway and causes it to stop very quickly, and 2) a collision with the junction point of a diverge. Making the first of these possibilities acceptably remote requires careful design and an inspection procedure that frequently assures that nothing is coming loose. Experience with road vehicles gives a feeling for the possible frequency of such an occurrence, which almost never happens to a well maintained vehicle. By more detailed analysis than possible here it can be shown that by proper design a diverge collision will require two simultaneous highly improbable failures plus a rare "Act of God" event.

If there are many vehicles on a guideway, there are two additional possibilities for a sudden stop. One is a runaway vehicle entering a station and failing to stop before colliding with a standing vehicle, and the other is a merge collision. By use of checked-redundant vehicle control, such as developed by Boeing, it is practical to design the control system in such a way that the mean time between over-speed failures continuing to a station collision is at least a million years. It can be shown that a merge collision would require two such failures in very close proximity in space and time, which places its MTBF (Mean Time Between Failures) in a range more remote than the estimated life of the universe.

In a PRT system designed as indicated above, there are no sudden stops; however, there may be on-board failures that require emergency braking. Equation (2) shows that to achieve safe fractional-second headway, one vehicle cannot be permitted to stop quicker than the vehicle behind. This requires closely controlled, constant-deceleration braking regardless of the condition of the guideway, which rules out systems that rely on braking through wheels because in rainy or snowy weather the coefficient of friction may vary along the guideway. This is the safety-related argument for the use of linear electric motors. Another important reason for use of linear electric motors (with an appropriate guideway design) is to eliminate the need for guideway heating and to permit the use of low-friction running surfaces. It may be noted that it is quite likely best to decelerate at the normal rate if an on-board failure is detected. Trying to decelerate too rapidly may cause more problems than it solves.

The final factor in the difference between PRT and railroad practice is that PRT vehicles are light enough so that reasonably sized bumpers can absorb a great deal if not all of the collision energy, and all passengers are seated. By using data from auto safety practice, a PRT vehicle therefore can and should be designed so that even a collision need not cause injuries [15].

Control Strategy

General Considerations

Adequately tight control of the speed profile can be attained by using proportional-plus-integral ($P + I$) control based on tachometer feedback. A vehicle must be able to perform any one of the following maneuvers:

- Speed change from given speed and acceleration to new speed;
- Slip given distance forward or backward from line speed;
- Slip given distance from acceleration maneuver;
- Slip given distance from slip maneuver;
- Advance given distance in station from rest or from deceleration maneuver;
- Emergency stop.

Code must be written so that the time-varying speed and position profiles of any of these maneuvers with any set of desired parameters can be calculated in the on-board computer and used as commands to the controller. If during each computational or time-multiplexing interval a wayside zone controller transmits a speed signal to all vehicles in its domain and at certain command points can transmit to a specific vehicle a maneuver command with a parameter (the desired speed, distance to slip, etc.), the vehicle has all the information it needs to perform the maneuver. Moreover, by calculating the speed profile in parallel, the zone controller has all of the information it needs to monitor the execution of the maneuver. If a vehicle moving at line speed moves away from the desired time-varying position, the integral portion of the $P + I$ controller corrects the position. If the tachometer drifts, as it will, magnetic markers along the guideway provide the basis for correcting the tachometer constant. If the speed of a vehicle at a certain time is in error in excess of a preset amount, the zone controller assumes a fault and removes the speed signal from its domain. The vehicle controller is programmed to command creep speed if it does not receive the speed signal, so any failure, even at merges, causes a safe reaction.

We now have a system in which the vehicles each closely and reliably follow commanded speed profiles and are simultaneously monitored for failures by wayside zone controllers. On this basis it is possible to describe the maneuvers needed to operate the system. This discussion is based on extensive experience with a comprehensive PRT-network simulation. We first consider the progress of an occupied vehicle from the point a passenger group enters to the point that they arrive at their destination, then we consider movement of empty vehicles.

Movement of an Occupied Vehicle

Let's join a group traveling together to the same destination by choice. We either have a magnetically coded ticket with the destination recorded on it because we take the same trip every day, or we must approach a ticket machine to punch in a destination, pay a fare, and receive a ticket. With a valid ticket we approach the forward-most available vehicle in a line of vehicles and insert the ticket into a stanchion in front of the stopped-and-ready vehicle. This action flashes the origin and destination station to a central computer which has in its memory the estimated arrival times of all vehicles moving through the system. If our vehicle is expected to arrive at its destination station at a time when the station is full and cannot receive another vehicle, we are informed that we must wait a specified time before we can try again. Generally this will be a very small time and the central computer will prioritize the unfulfilled demands for service.

When the ticket can be accepted, the station computer so informs us, unlocks our vehicle's door, and transfers the memory of the destination to the on-board computer. We enter our vehicle, sit down and when ready one of us closes the door. Thereupon the door is automatically locked. If our vehicle is not in the forward-most loading berth, it must wait until the vehicle or vehicles ahead move out. If it cannot yet be commanded to line speed because an opening is not yet available, it is commanded to advance as far forward as possible.

The station zone controller meanwhile is examining the flow passing the station for an opening. The vehicles on the main line maintain separations at or greater than the minimum separation permitted by equation (1). Note that there need at this point be no synchronization. If there is no traffic on the main line a vehicle can be commanded to accelerate to line speed at any time it is ready. As traffic on the main line builds up, say with the approach of the morning rush hour, vehicles pass stations at any spacing down to the minimum allowed.

To create an opening for our vehicle, the moment the zone controller commands our vehicle to line speed it may command a mainline vehicle too close ahead to slip ahead if possible and a mainline vehicle too close behind to slip back. If slipping of the mainline vehicle back would cause the headway between it and the vehicle behind it to fall below the minimum, the zone controller would within a few milliseconds cause that vehicle to slip back too, and so on upstream. If there would be too much slipping of upstream vehicles or if the slipping of downstream vehicles has propagated into the station area, our vehicle would wait until there is an acceptable opportunity to accelerate out of the station, thus preventing excessive congestion of vehicles in the system.

When an opening appears, our vehicle is commanded to accelerate out of the station, either from rest or from a station-advance maneuver. While our vehicle is accelerating, a vehicle ahead may be caused to slip because of a conflict at a downstream merge point. If that happens and if our vehicle would reach line speed too close behind the vehicle ahead after it is through slipping, our vehicle is commanded to slip the necessary amount while accelerating and, if necessary, the mainline vehicles behind it will be commanded to slip by the amount needed to maintain minimum headway.

Next, suppose our vehicle approaches a line-to-line merge point. As it passes a command point at a predetermined location upstream of the merge junction, the cognizant wayside zone controller, having in its memory the positions, speeds and slip-maneuver data for each vehicle within this merge zone, gives maneuver commands needed to resolve any conflict. If the vehicle ahead on the other branch of the merge is too close, the zone controller commands it to slip ahead if possible, or if not, it commands our vehicle to slip back. Slipping ahead is practical only if the minimum line headway is less than about one second, otherwise the maximum travel distance to slip is excessive. If our vehicle is commanded to slip back it may slip into the headway domain of the vehicle behind on the same leg of the merge, in which case that vehicle and possibly vehicles behind it are commanded simultaneously to slip necessary amounts. Since our vehicle may thus already be slipping when passing the command point, the on-board maneuver algorithm is designed so that it can cause additional slip of a slipping vehicle. Such operations have been found by simulation to be completely stable.

After passing the merge point, suppose our vehicle next approaches a diverge point. At a predetermined command point upstream of the diverge, the cognizant zone controller requests our destination, which is transmitted through a transmission medium to the zone controller. The diverge zone controller has in its memory a switch table giving the left or right switch command for each station in the network from that diverge point. By fiber optic line, the central computer can transmit revised switch tables to various diverge-point zone controllers every few seconds if necessary to avoid excessive congestion in certain downstream links. The zone controller transmits the right or left switch command to our vehicle, which then acts on the command.

Next suppose our vehicle approaches a station. As soon as it has passed a merge or diverge point, it is handed off to a new zone controller which asks for and receives its destination. If this station is not our destination, the zone controller commands our vehicle to switch in the direction opposite the station off-line guideway. If this station is our destination, the zone controller does not give a switch command immediately but waits until our vehicle reaches a switch command point at the farthest downstream point at which the switch can, with a tolerance, be safely thrown. The wait is necessary because the station may have been full when our vehicle first entered the domain of the cognizant zone controller, but the last position in the waiting queue on the station off-line guideway may have cleared a few moments later.

When our vehicle reaches its destination station's switch command point, the zone controller commands it to switch in the direction of the station if there is an available berth, and if not commands it to switch away from the station. If the zone controller commands our vehicle to switch into the station, it assigns it a berth so that the next vehicle will find that this berth is reserved. Our vehicle switches if necessary and continues forward at line speed to a deceleration command point. At this point, if one or more positions downstream of the assigned berth have cleared, a new farther-forward position is assigned, the old one is cleared, and our vehicle is commanded to decelerate along a speed profile that first reduces the speed to a predesignated station speed and then moves the vehicle forward, usually at station speed, until it must decelerate at the comfort rate to stop at the assigned position. If, at any time during the deceleration maneuver, the zone controller has advanced a vehicle out of the position or positions ahead of the assigned position, it reassigns our vehicle to the forward-most empty or to-be-empty position and revises the deceleration maneuver accordingly.

If our vehicle must stop at one of the waiting positions upstream of the station unloading and loading berths, it waits until the zone controller can command it to advance into a loading berth. If, any time during the station-advance maneuver, the berth ahead of the previously assigned berth clears, the station-advance maneuver is revised to dock our vehicle at the new forward-most free berth. When our vehicle stops, the door automatically unlocks. Because of the expense, weight, and reliability problems of automatic doors, my advice is to use a hinged door that opens manually, but, because it is inevitable that someone would not bother to close the door after leaving the vehicle, the door must close automatically. By slightly rotating the hinge line from the vertical, gravity will close the door, and, to tighten it against a weather seal, a common curved solenoid catch can be activated. The catch is released as soon as the vehicle stops. If a person in the vehicle had fainted and can't open the door, a handle on the outside of the door permits it to be opened. With a hinged door, the floor of the vehicle must be slightly above the floor of the station, but not enough to cause difficulty for a wheelchair.

The reader may note that some PRT designers have proposed that there be separate loading and unloading platforms. This doubles the station length, reduces the throughput, and with the small passenger groups characteristic of PRT it does not significantly reduce the time required for unloading then loading.

Synchronous, Quasisynchronous and Asynchronous Control

In the early 1970s, the discussion of PRT control virtually always started with a discussion of the relative merits of synchronous, quasisynchronous, or asynchronous control. In a purely synchronous control system, a vehicle that is ready to leave a station waits until it has a confirmed reservation through every merge point and at the destination before being dispatched. Such a system was discarded because it is inflexible in a slow-down or stoppage on the main line; and, if the number of merges that must be negotiated exceeds three or four, the wait time becomes excessive [18]. The quasisynchronous system was therefore proposed to permit vehicles to maneuver to resolve merge conflicts.

In his book, Dr. Jack Irving, while advocating quasisynchronous control, commented that the essential point is that a wayside computer command and monitor maneuvers, just as described above. Until reaching a merge point, there is no need to synchronize the flow, and to do so in advance results in more maneuvering than necessary. As in the scheme described in the above paragraphs, whenever a vehicle arrives at the merge command point, if there is an approaching conflict, a merge-point zone controller either commands the conflicting downstream vehicle on the other leg of the merge to slip ahead if possible, or if not to slip the vehicle that has just arrived at the command point back. There is no need at merges to synchronize with specific clock times. We have also found that the described strategy requires less software than quasisynchronicity.

Such a scheme is asynchronous except for the technicality of having to synchronize merging of certain vehicles with respect to one vehicle, but not with respect to a clock. In the 1970s, asynchronous control usually implied car following, in which each vehicle is controlled based on the position and sometimes the speed of the next downstream vehicle. As pointed out above and by Dr. Irving, car following is not necessary. It complicates the control problem and is difficult for the necessary wayside monitor because the monitor does not know independently the profile of the maneuver. In the terminology used in the 1970s, the system we prefer could be called an "asynchronous point follower".

Movement of Empty Vehicles

During the night when there is little or no traffic on the system, most of the vehicles are stored at strategically located storage barns and the rest are stored at stations so that, as in elevator service, passengers don't need to wait anxiously on deserted platforms, but instead vehicles that are ready to leave immediately wait for passengers. The number of vehicles required to wait at each station must be determined by an operational study.

As passengers start arriving at stations, the waiting empty vehicles are used up and more must be ordered. Based on operational experience, a flow of empty vehicles can be started in anticipation of passengers. In any case, once the number of vehicles in a station that have not been given destinations plus the number within a specified time of arrival is less than the number of passengers waiting, the station computer signals to the central computer via fiber-optic line that it needs an empty vehicle. Other stations will have surplus empty vehicles either because they have no passengers and there are more vehicles in or approaching the station than the specified minimum, or because the flow of occupied vehicles in and approaching the station exceeds the flow of passenger groups entering the station from the street. In the later case, it will sometimes be necessary to dispatch an empty vehicle while a passenger group is approaching it in order to permit occupied vehicles to enter the station and unload. In this case, the passenger group will be informed by computer voice that another vehicle will be docking in a few seconds. As soon as a station has a surplus vehicle its computer so informs the central computer and dispatches the surplus vehicle to the next station.

When an empty vehicle reaches the switch command point of a station, if the station does not need an empty vehicle its computer waves it off to the next station. If this station could use an empty vehicle, it would like to call this one in, but there may be a greater need for it at a downstream station. So, the central computer, having a knowledge of the number of empty and occupied vehicles in each link in the network and of the number and wait time of passenger groups waiting at each station, has the basis for determining whether each station should accept or wave off needed empty vehicles. Since the situation is updated every few seconds, no passenger group need wait much more than at other stations. The average wait time can be reduced by increasing the number of empty vehicles in the network, but at the expense of increased congestion and system cost.

The major decision points for distribution of empty vehicles are the diverge points. Here, as already mentioned, the central computer, with knowledge of the whole system, can, by fiber-optic link, direct left or right switch commands for the next empty vehicle. Such frequent updating of empty-vehicle commands at the last possible moment is a far easier problem to solve than the general transport problem.

Information Transfer

With the above described control strategy, the information that must be fed to the vehicle computer is the vehicle's actual speed and position; the cruising speed, which could be a function of wind or position in the guideway; and, at command points described above, the number of a maneuver with a parameter. The information required by each wayside zone controller is all vehicle positions and speeds in its domain including hand-off of the state of each vehicle as it enters its zone, and any information about anomalies. The information needed by the central computer is the maximum passenger wait time at each station, the stations at which there are surpluses or deficits of empty vehicles, the number of empty and occupied vehicles in each link, the destinations of and the departure times of all vehicles commanded to leave stations, the arrival times, the distance each vehicle has traveled, the distance traveled at which each vehicle is due for maintenance or cleaning, the location of and data on any faults in the system, and the weather conditions.

To perform the required data transfer there must be a continuous and noise resistant means for data transfer between vehicles and zone controllers, such as the three-wire communication line developed by Boeing [19, 16], a series of magnet markers to signal passage of vehicles, and fiber-optic links between the central controller and all zone controllers. At predetermined intervals (Boeing used 40 msec), each vehicle must transmit to the cognizant zone controller its vehicle number, speed, position, destination on call from the zone controller, and any data about faults. The wayside zone controller must be able to transmit to all vehicles in its domain a continuous cruise-speed signal, and it must be able to transmit parameterized maneuver commands and switch commands to specific vehicles when needed.

Boeing engineers [20] found that incremental wheel angle encoders with a resolution of 0.04 foot per pulse were sufficient as the basis for computing both position and speed. Position measurement consisted only of counting pulses, but the calculation of speed was "considerably more complex and, to a large extent, dictated the Programmable Digital Vehicle Control System configuration" they selected. The vehicle must also be equipped with sensors to detect the magnetic markers and to transmit to and receive data from the communications line.

Mathematics

Maneuver Equations

Parameterized equations are needed for all of the maneuvers required to run a PRT system as described. This is not an easy task, but once the algebra is worked out and verified, as we have done, it is available forever. The equations can easily be programmed into the memory of the on-board and wayside computers, which then permit accurate control and monitoring of each vehicle with a minimum of data transfer.

Curved-Guideway Equations

In the above discussion, reference was made to the location of certain command points. Determination of the positions of all such points requires a complete understanding of the equations of curved guideways and their use in minimization of off-line guideway lengths and distances between branch points.

Empty-Vehicle Movement

A general scheme of the points and times in the system where empty vehicles are to be redirected has been given and the use of decision algorithms has been suggested. In relatively small systems, these are quite simple, but the challenge is to optimize such algorithms as the network grows. Some good work [11] has been done on this problem, but more is needed.

Conclusions

Analysis, simulation and hardware experience has shown that the problem of precise longitudinal control of vehicles to follow predetermined time-varying speeds and positions has been solved. To control vehicles to the required close headway of at least 0.5 sec, the control philosophy is different from but no less rigorous than that of railroad practice. Available results show that a PRT system can be designed with as good a safety record as any existing transit system and, because of the ease of adequate passenger protection, quite likely better.

With maneuver equations derived in easily programmable form, one has the basis for the control of a fleet of PRT vehicles of arbitrary size. The author's conclusion is then that the preferred control strategy is one that could be called an "asynchronous point follower". Such a system requires no clock synchronization, is flexible in the face of all unusual conditions, permits the maximum possible throughput, requires a minimum of maneuvering and a minimum of software. Since each vehicle is controlled independently, there is no string instability. Since the wayside zone controllers have in their memory exactly the same maneuver equations as the onboard computers, accurate safety monitoring is practical. To obtain sufficiently high reliability, careful failure modes and effects analysis must be a key part of the design process, and the control computers must be checked redundant. Work of the federal Advanced Group Rapid Transit Program showed a decade ago how that can be done in a very satisfactory manner.

References

1 Garrard, W L et al. State-of-the-Art of Longitudinal Control of AGT Vehicles. *Proceedings – Conference on Advanced Transit and Urban Revitalization – An International Dialogue, Advanced Transit Association*, Indianapolis, 1978.

2 Lang, R P, Freitag, D B. Programmable Digital Vehicle Control System. *28th Vehicular Technology Conference*, 1978. IEEE Technical Paper.

3 Anderson, J E. Longitudinal Control of a Vehicle. *Journal of Advanced Transportation*, 31, 1997.

4 Milnor, R C, Washington, R S. Effects of System Architecture on Safety and Reliability of Multiple Microprocessor Control Systems. *34th Vehicular Technology Conference*, 1984. IEEE Technical Paper.

5 Anderson, J E (ed.). *Personal Rapid Transit II.* University of Minnesota, Audio Visual Library Services, 1974.

6 Gary, D. A., Garrard, W. L., and Kornhauser, A. L. 1976 (Ed.). 1976. Personal Rapid Transit III, Audio Visual Library Services, University of Minnesota.

7 Kornhauser, A L (ed.). *Proceedings – Conference on Advanced Transit and Urban Revitalization – An International Dialogue*. Indianapolis, Advanced Transit Association, 1978.

8 Mahan, R, Tucker, R, Grasso, L M (eds.). *Proceedings – Conference on Automated Guideway Transit Technology Development*. Washington, D.C., U.S. Department of Transportation, 1978. UMTA-MA-06-0048-78-1.

9 Womack, W. *Vehicle Longitudinal Control and Reliability Project Summary*. Washington, D.C., U.S. Department of Transportation, 1979. UMTA-IT-06-0148-79-10.

10 Greve, W E, Haberman, D E, Lang, R P. *Advanced Group Rapid Transit Vehicle Control Unit Design Summary*. Washington, D.C., U.S. Department of Transportation, 1985. UMTA-WA-06-0011-84-3.

11 Irving, J H et al. *Fundamentals of Personal Rapid Transit.* Lexington, MA, Lexington Books, D C Heath and Company, 1978.

12 Hobbs, V J et al. *Development/Deployment Investigation of Cabintaxi/Cabinlift System*. Washington, D.C., U.S. Department of Transportation, 1977. Report No. UMTA-MA-06-0067-77-02, NTIS Report No. PB277 184,

13 Herringer, F. 1974. *Department of Transportation and Related Agencies Appropriations, Hearings before a Subcommittee of the Committee on Appropriations*. House of Representatives, 93rd Congress, Part I, page 876.

14 Anderson, J E. Dependability as a Measure of On-Time Performance of Personal Rapid Transit Systems. *Journal of Advanced Transportation*, 26, 201–212, 1992.

15 Anderson, J E. Safe Design of Personal Rapid Transit Systems. *Journal of Advanced Transportation*, 28, 1–15, 1994.

16 Nishinaga, E I, Colson, C W. A Vehicle Collision Avoidance System Using Time Multiplexed Hexadecimal FSK. *33th Vehicular Technology Conference*, 1983. IEEE Technical Paper.

17 Holusha, J. A Smart Road Starts to Take Shape in California. *New York Times*, September 1, 1996, p. 25A.

18 Anderson, J E. Synchronous or Clear-Path Control in Personal Rapid Transit Systems. *Journal of Advanced Transportation*, 30, 1–3, 1996.

19 Nishinaga, E. Digital FSK (Frequency Shift Keyed) Receiver Capable of Operating in High Impulse Noise Environments. *31th Vehicular Technology Conference*, 1981. IEEE Technical Paper.

20 Lang, R P, Warren, D J. Microprocessor Based Speed and Position Measurement System. *33th Vehicular Technology Conference*, 1983. IEEE Technical Paper.

Designing PRT Control Systems by Internet Protocol Thinking –
Comments on Ed Anderson's Paper

NILS JACOB BERLAND

In his paper from 1998, reprinted in this issue of *Telektronikk*, Ed Anderson presents his design criteria for a PRT control system. For most of the period in which the idea of PRT has developed, the computing and networking technology for building a PRT control system were less mature and hence the thinking related to the design of control system was naturally affected by this. As no PRT system for other than restricted test tasks has so far been set into operation, there still does not exist any ready-made software and hardware for controlling a PRT system. Further, there are no standards, neither for operating such a system, nor for solving the interconnect problems that arise if two or more such networks were to exchange vehicles.

In this short comment we look for similarities between some of the PRT proposals and the Internet Protocol. This similarity may be exploitable when designing and building an actual PRT control system. Specifically, it is a goal to set the issue of PRT in the context of telecommunication. We outline how a control system for PRT, meeting Anderson's design criteria, could actually be implemented by adapting the thinking, huge competence and technology base existing for IP networks. What we propose is not new to the PRT designers, but hopefully the IP way of thinking can bridge two professional and business cultures that have or at least should have a lot in common.

However, the IP networks metaphor is not the only way to design a PRT system. We will also briefly touch an alternative to the IP metaphor. Needless to say – the alternative also has parallels in existing designs of telecommunication systems.

Nils Jacob Berland (41) received his PhD (Dr.Scient.) in Computer Science in 1993. In addition to his work for Telenor R&D in the area of security he has also worked with scenario-based planning and business development in other units of Telenor. In 1998 he started the consulting company Pantarei AS where he is still employed. He holds positions as part-time associate professor at the Norwegian University of Science and Technology, Trondheim, and at Molde University College. His professional interests are distributed systems and optimisation, and control systems for smart homes.

njb@pantarei.no

Distributed Control System Thinking

The thinking on software control systems for PRT started many years ago, when IT systems were thought of in more centralised terms and implemented with heavier building blocks and fewer commodity products than today. Some PRT designs and implementations are thus fairly parallel to designs of computer and telecom networks from the same period, e.g. being based on full synchronisation of the network and time slots, with a central control system allocating time slots to each vehicle. Later came various modifications, implying an increasing degree of distribution of computing power and decision making competence to the various basic elements of the system: vehicles, stations and intersections. (An overview of such principles is found in the PhD thesis of Markus Theodor Szillat: A Low-level PRT Microsimulation, PhD dissertation, University of Bristol, April 2001.)

The evolution towards distributed control is also reflected in Ed Anderson's paper. Each vehicle, station and intersection in a PRT system is supposed to be unmanned and more or less make its own decisions related to routes and operation. This requires a distributed control system combined with mobile computing and intensive communication.

Distributed control systems have been around for years and have been the domain of telecom operators and a few other big companies or government agencies. Generally such systems have been expensive, but now cheaper computers and open standards for distributed computing make them more feasible. Consider the case of air traffic control. Air traffic control has until now relied on ground control of airspace, and aircraft following strict corridors and time slots. However, now the United States Federal Aviation Authority has proposed the concept of "free flight" where the task of separation assurance is delegated to each aircraft. It is even argued that "free flight" will reduce costs and improve efficiency and capacity.

Mobile computing has also been around for years – NASA's spacecraft may be the prime example. Demand for mobile computing based on small computers connected through some kind of radio network has more or less exploded, and devices complete with software for radio based connectivity through GSM, WLAN or Bluetooth are ubiquitous. NASA's mobile computing was certainly not affordable, but now almost everyone can buy mobile computing equipment.

One of the factors that drive the development of mobile computing and distributed control systems – aside from the demand for services – is the availability of Internet Protocols and appropriate tools. IP and networks have transformed the way distributed systems are designed. This will probably be the case for PRT systems too: The first control system to meet Anderson's design criteria will in all probability be based on IP technology and implemented as a closed IP network.

However, a PRT system in itself can also be viewed as a (closed) IP network where the vehicles moving about in the networks resemble packets that move about in an IP network. The Internet has proven its reliability and fault tolerance by using protocols with distributed control or no control at all. IP has thus become an important metaphor for distributed control of large systems.

The IP Metaphor

IP networks have some nice properties such as distributed control, no single point of failure and gradual decrease in performance with increasing load. Probably the most basic properties of an IP network is that all information is split into packets and the purpose of the network is to route such packets from source to destination. Routers make the decisions where packets should go based on information embedded in each packet and partial information of the state of the network. Hence, packet switching and partial network information are important keywords. When a fault occurs or a line is not working in the direction for the packet to be sent, the packet will be routed around the problems.

The well known problems of delays and packet losses is normally an effect of the Internet being susceptible to demand bursts exceeding the capacity (bandwidth) of specific segments or routers, or to unstable hardware. An IP network designed as a closed network with a maximum capacity, calibrated for a defined demand, and with controlled hardware, should meet the reliability and safety levels analogous to those required for transport of personnel and goods. Accordingly some of the properties of IP networks may be used for the design of PRT control systems as well. Regard the following IP analogy for PRT:

Each vehicle acts as a packet and each intersection in the network (in PRT normally conceived of as a merger or demerger) acts as a router. As routers in an IP network, each intersection is numbered and only needs to know the direction to send vehicles given their destination. This will work for the problem of getting a vehicle from A to B. However, as with IP networks, the real solution for PRT is more complex.

Safety

Things may happen in the IP domain that would not be acceptable in the PRT domain: retransmissions, packet losses, etc. This indicates that there will be parts of the IP analogy that do not make sense at all for PRT. Collision detection has to take place *a priori*, and definitely not *a posteriori*. Thus, it has to take the form of detection of a collision possibility, issue a warning, and take measures to avoid it. A control system for a PRT circuit has to be designed so that errors are more or less impossible, i.e. highly improbable conforming to a framework of public transport. "Packet retransmission" and other relaxed methods of IP are to be excluded. Further, it implies that monitoring the results is one thing – making decisions in advance to avoid them is a very different but essential thing.

Two principles should apply:

- Only make decisions – in advance – that are in accordance with the rules and the present situation;

- Always monitor the present state of the system, and take appropriate action if there is anything wrong, factual or expected.

Transmissions, Terminals and Stations

In IP, the transmission of packets within a segment is for all practical purposes instantaneous. Therefore, it is satisfactory to transmit a single packet at a time. This is not the case for PRT, as vehicles spend time in a network segment. There may therefore be a number of vehicles within a given segment at a time. This requires co-ordination between the vehicles within a segment, e.g. by vehicle-to-vehicle anti-collision systems. However, according to the principles outlined above, the vehicles within the network segment should manage this by themselves.

As in IP networking, dynamic alternative routing must also be implemented, at least in potential bottlenecks.

When a packet in an IP network has reached its destination, everything is fine and the application or operating system of the receiving host (the terminal relative to the network) can take over. In PRT however, when a vehicle enters its destination, the problem of stations begins. In terms of the IP analogy, a station would be a terminal running "an application named station" as far as the network concerns handed over and forgotten. Stations do still pose some real problems, as we see in Anderson's paper, as does the distribution of vehicles between stations according to demand. IP may not have the most relevant answers to this problem complex.

A Hybrid Approach

A hybrid approach for PRT – relative to IP – would be to make vehicles act as routers. This requires that each vehicle also has available the entire routing table for the present network. For IP this does not make sense as the Internet for all practical purposes is infinite, but for a PRT network it makes perfect sense: A routing table for a fairly large PRT network can be downloaded into each vehicle in seconds through a WLAN connection. This of course makes it necessary to keep the routing tables of all vehicles up-to-date, which in turn implies that all problems related to segments and intersections are broadcast to all vehicles immediately. A hybrid solution may imply the following – in accordance with the principles given above:

- Let all or most decisions be made by each vehicle, given appropriate inputs. These may be routing tables, radio beacons in the tracks, etc.
- Let segments within a given network continuously monitor all aspects of traffic flow.
- Let mergers supervise that no collision can take place and in case of conflict overrule the vehicles' decisions.

Decisions made by each vehicle should be designed so that the system would run with this alone as long as no errors occur. In the real world however – errors do occur. The monitoring software should detect conflicts and errors and take appropriate action. Monitoring of each section and components may even use standard network management tools developed for management of large IP networks.

Interconnect

Interconnect in the context of PRT is the exchange of vehicles between different PRT networks. If a passenger wants to go from one PRT network to another network this must be supported by the system.

Naming and numbering will obviously require specific attention as this has proved to be very important for IP networks (the Domain Name System and migration to IPv6 has proven this).

For a PRT approach similar to IP networking, vehicles will simply be routed to the proper destination.

For the hybrid approach interconnect is quite straightforward – at least in principle. Upon entering a different network a complete routing table for the network – if not preloaded – will be downloaded through WLAN.

For both approaches there will of course be a complexity related to returning vehicles to their "home network" if this is an issue.

Centralised Control With Fixed Time Slots

A PRT system designed on principles from IP networking will have at least two undesired properties: Network congestion may slow down vehicles in the tracks, and there is no way to predetermine exactly how long time a ride will take. In theory, such a system is unpredictable.

Another completely different approach – and definitely in dissonance with the above IP analogies – is for each and every vehicle to set up a complete route, with time slots, etc. from source to destination before ever leaving a station. Such an approach is not new to networking: It is in principle the circuit switching of networks. In such a system, once a vehicle has left the station, delays due to congestion should be impossible as long as all vehicles keep their schedules. So all routes are predictable – as long as no errors occur in the tracks. However, with this approach, vehicles are not permitted to leave a station before there is capacity in the network in the form of an empty slot, and the master scheduler has allocated a complete route. The ULTRa system mentioned by Lowson uses this kind of scheduling on its test track, and is supposed to use it when it becomes a public service. Actually the control system of ULTRa is based on technology from the company Frog Navigation Systems B.V.

One problem with such a scheme is how the system copes with errors, e.g. a fault at a segment. Specifically the problem is what to do with vehicles that have already left the station and are trying to keep their schedules. Two possible solutions are that vehicles have to get or request a new route if the previous is not possible anymore or that the vehicles change mode to dynamic routing.

The success of a PRT system based on pre-allocated routes will be dependent on the size of the system and reliability on the components of the total system. Hence, a large system based on pre-allocated routes with many problems and hence, vehicles that have to be rescheduled may not perform well compared to asynchronous routing. For example, the speed variance resulting from spins and slides on snow and ice could easily halt the scheduling of many vehicles and result in intensive data communication and reallocating work as many new routes would have to be set up continuously.

Interconnect in the context of centralised control has to rely on a hand-over of control from the scheduler of one network to the scheduler of another network.

Conclusion

The “circuit switched analogous” control system employed by ULTRa performs in the real world, e.g. for the automatic container handling at the harbour of Rotterdam, for airport parking lots, automatic bus shuttles and on the ULTra test track in Cardiff, Wales.

As of today, the “packet switched analogous” control system of Ed Anderson’s Taxi2000 – using the code intended for the final Taxi2000 control system still to be developed – stands the test in simulations of huge systems such as designs for the city of Cincinatti, USA, and others.

Almost certainly a control system for any PRT installation will be implemented with IP networks. In addition, at least some of the algorithms and principles that guide the design of a PRT control system may be based on at least some of the principles behind IP.

The eventual success of one approach above another will depend on available software, competence and the problems that have to be solved initially. Further, the trade-off between the flexibility and scaling properties of an IP analogous PRT control system and the simplicity and the deterministic properties of a circuit switched analogous PRT control system is a matter that cannot be settled at a principal level. It has to be done by practical engineering.

We have not looked at to which extent the design thinking will collide with regulatory bodies’ thinking of how safety measures should be implemented. As the IP thinking made the old understanding of “99,999 % uptime” inapplicable, the very design criteria of PRT and its control systems may be in conflict with the approval criteria of regulators.

Vulnerability of the Telecommunications Infrastructure

JAN A AUDESTAD

Jan A Audestad (61) is Senior Advisor for Telenor Corporate University. He is also Adjunct Professor of telematics at the Norwegian University of Science and Technology (NTNU). He has a Master degree in theoretical physics from NTNU in 1965. He joined Telenor in 1971 after four years in the electronics industry. 1971 – 1995 he did research primarily in satellite systems, mobile systems, intelligent networks and information security. Since 1995 he has worked in the area of business strategy. He has chaired a number of international working groups and research projects standardising and developing maritime satellite systems, GSM and intelligent networks.

jan-arild.audestad@telenor.com

1 Scenarios

Early one morning the telecommunications system fails in the major business areas of New York City. The failure affects first the fixed telephone service. After having attempted to restart the network, the Internet services also start malfunctioning for inexplicable reasons. The mobile system of one of the major operators soon becomes overloaded, and eventually it breaks down completely. One of the major cable networks offering both Internet and television services starts malfunctioning leaving large parts of the city without news services so that they can no longer receive information on what is going on. The reason for the breakdown is not clear. Is it caused by overload? Is it caused by errors propagating from one network to another? Is it caused by technical failure or by an electronic attack by a hostile power?

This event, if it lasts for some hours or days, may cause many problems. People are no longer able to communicate or receive news explaining the situation. Panic and riots may be triggered. Banks, stock exchange brokers and other operators in the financial market may have to close down their operations because they can no longer transfer money and information electronically. Shops, airlines and many other businesses cannot serve their customers because they cannot effectuate orders, verify credit cards and so on.

Is this situation just as devastating for society as major natural catastrophes? How long can the situation last before it becomes a national catastrophe? What is the probability that it may happen? The scenario has not happened yet at a scale described above. However, the series of outages of the telephone network experienced in the USA during the summer of 1991 is a prewarning of what may happen. Note that this outage occurred before the World Wide Web had been implemented. We may just speculate about the impact of such an outage today.

Several stockbrokers experience inexplicable behaviour of their computers during an active period on the stock market: they are not able to obtain reliable information from the stock exchanges. The access to customers is also interrupted from time to time. The reason is an attack from one broker who wants to capture as much of the market as possible. This is a denial of service attack where the origin of the attack cannot be traced. In 2000 this attack actually happened to an Internet broker who later went bankrupt. The attack lasted only for a few hours but long enough for the company to lose their customer base [1].

The event happened to a much lesser extent in the 1950s where shipbrokers used electronic weapons to deny competitors services. The shipbrokers did their service mainly by use of telex and the attack was based on the requirement that telex machines had to give priority to incoming calls over outgoing calls. This facility was built into the telex machine by the manufacturer and could not be changed by the user. The trick was then to broadcast trash to all the telex machines of the competitors as soon as rumours of a freight came up blocking the capability of the competitors making outgoing calls. The situation became so tricky that the ITU had to abandon the priority requirement.

Some e-commerce customers discover that their bank accounts are occasionally debited by small amounts of money for goods they have never ordered. Investigations show that the problem is common and many customers are subject to the fraud. Most of the customers do not discover the fraud because the amounts are small and infrequent.

This situation has occurred and it is believed that organised crime masterminded the attack.

The above is just a few examples of how vulnerable the society has become because of the dependence of telecommunications in all areas of our lives. The problem will be outlined in more detail below. First, observe that the problem we are discussing is also one of information technology and the use of computers in general.

This manuscript is written on a PC that is not connected to any network. It is safely located at home so that no one can tamper with the machine and the files and computer programs it contains using electronic means. But is this true? Once in a while I have to retrieve information through the computer at my office and bring it home on diskette. The computer at the office may contain viruses that are not discovered by the virus detection program. The diskette may then act as a carrier of the “disease” infecting my computer at home. This has happened to my computer, causing a lot of trouble and loss of time. Similarly, someone may have placed an

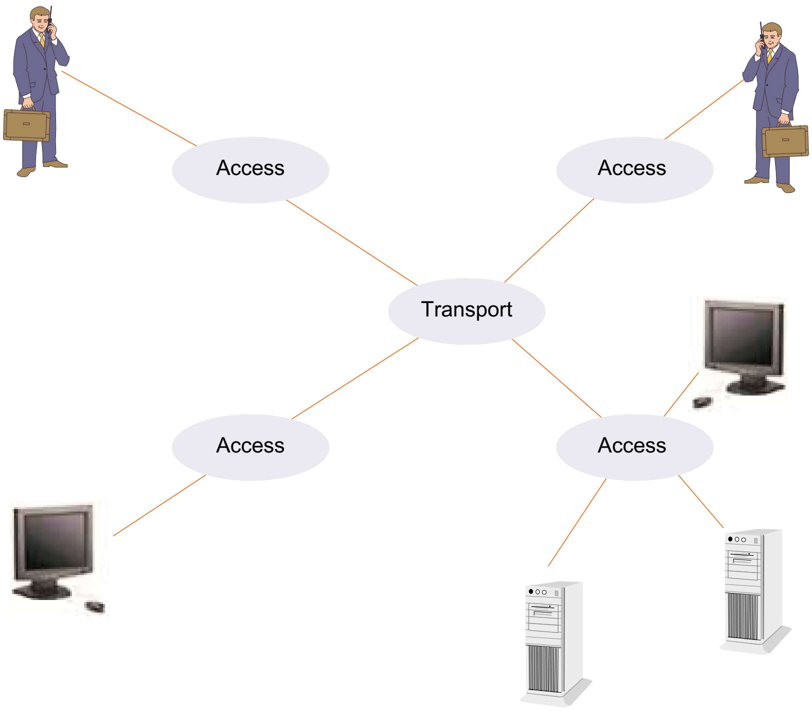


Figure 1 Network configuration

electronic gadget in the tree outside the house picking up the electronic signals generated by the computer. Such spying devices exist and they can be bought by anyone.

2 Structure of the Telecommunications Network

The telecommunication system consists of parts as shown in Figure 1: access network to which the terminals are connected, and transport network interconnecting the access networks. There may be more than one access network in one geographical area offering the same or different capabilities. Examples of access networks are the local area telephone network, the GSM network, and the Internet access network (that is, the network between single users and the routes or between servers and the routers).

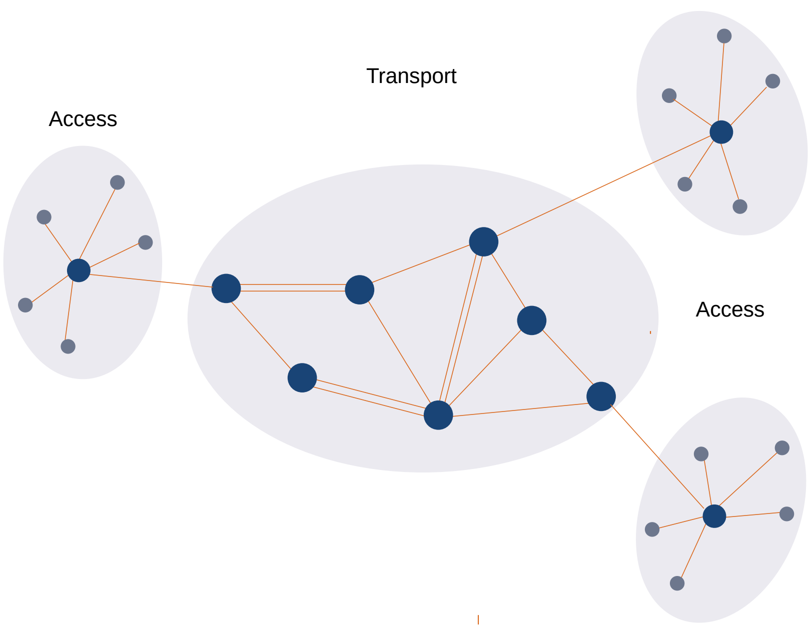


Figure 2 Star and mesh networks

Figure 2 shows another aspect of the networks. The transport network is a mesh network where there exist several paths between nodes. Some of the individual links are duplicated for two reasons: to improve the reliability of the network and to provide more traffic capacity between the nodes. The access networks are usually star networks where the customers (small circles) are located at the end of the rays of the star. This gives rise to a range of reliability measures as illustrated in Figures 3 and 4.

If the central node of the star of the access network fails, all the customers connected to that node will lose contact with the communication network (se the right hand side of Figure 3). If the node contains many users, the failure will be serious. This is the case for fixed networks in cities and in mobile systems like the GSM. In GSM, each network operator offers independent services and roaming between competing operators in the same geographical area is usually prohibited. The disruption of service of one GSM exchange will then affect all users in the geographical area covered by this exchange. In the largest systems, the number of users affected may be several hundred thousand persons if one exchange fails. Satellite systems like Inmarsat contain several earth stations functioning as central nodes in the star. If one earth station fails, the customers may use another station. This may reduce the capacity of the system but the connectivity survives. On the other hand, if the satellite fails, no customer in the coverage area of the satellite will be able to access the system.

Failure in the mesh network (to the left in Figure 3) may have similar effects if the node that fails is a gateway to an access network. The customers may use different access networks in some cases, for example, if they are subscribers of fixed network services and mobile services, they may use the alternative technology if one of the networks fails. This is not always possible. One example is the Internet when the telephone or ISDN access fail. Usually, it is not possible to use the GSM system as an alternative network in this case.

The situation is different for the transport network. In Figure 3, the failure affected the access network severely. However, it did not affect the remainder of the network except that the traffic handling capacity may be reduced. The same applies if links fail in the transport network (see Figure 4). Because of the connectivity in the mesh, the calls can be rerouted so that the overall connectivity of the network is retained. A link failure in the access network will usually affect only one or a few customers depending upon the structure of that network. Note that the discussion above applies to all network configurations. The Internet is in no way different from the telephone network. Networks supporting transaction services may be more secure than other networks in the way links are duplicated, but when they fail, they fail as described above. It is only the consequences of the outage that are different.

The probabilities of different types of failure, the number of customers affected, and the time required for restoration of service are parameters that may be used to define a measure for the vulnerability of the network. The vulnerability may be expressed in various ways using different definitions and methods. The area is complex and will not be considered further here.

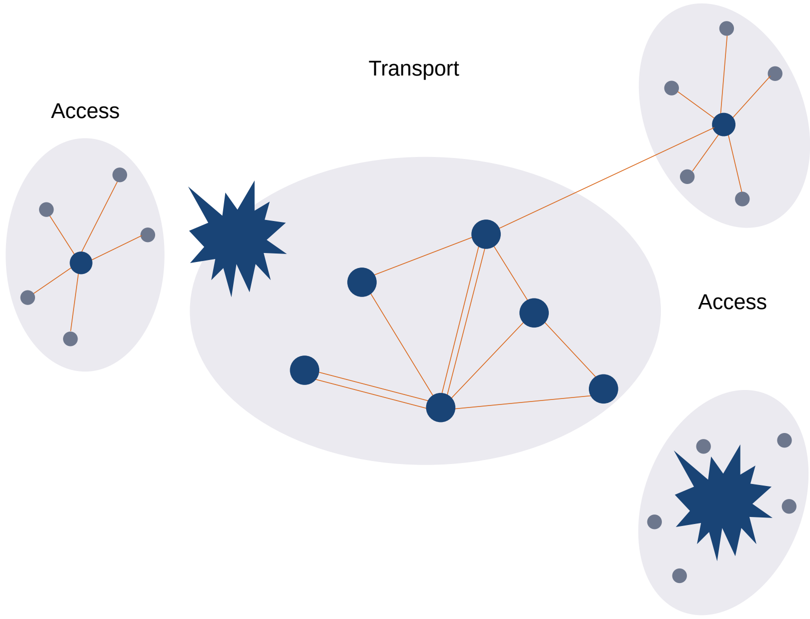


Figure 3 Failure affecting the access

3 Evolution Leading to Vulnerability

The telecommunications network has undergone dramatic changes during the last ten years. Before 1990, the network offered mainly two-person communication. There was generally one type of subscription for residential customers. This was telephony. Each exchange in the access network was small so that an outage had impact on few customers. Of course, outage of network nodes was serious even then. Natural disasters led to the development of radio systems that could be used in distress situations in order to coordinate rescue work because the fixed network became overloaded by traffic from anxious people.

Data networks were poorly developed and were used mainly as closed networks within enterprises and government. However, the first illegal accesses into data networks were observed during the 1980s. The hackers penetrated the network via poorly protected access ports into the packet data networks called PADs (PAD = Packet Assembly/Disassembly allowing users with dial-up modems to access the data networks from the telephone network). The art of hacking included the stealing of passwords by skimming through wastebaskets in factories and offices during the evening and night, or patiently trying thousands of alternative passwords and user names until a match was detected. The hackers entered computer facilities via holes in the operating system (for example Unix) utilising the fact that if they were able to get into one machine, they could often penetrate other machines because computers calling other computers were often not authenticated. The motives of the hackers were several: mere fun and excitement, access to free computer resources, stealing information, or damaging computer installations.

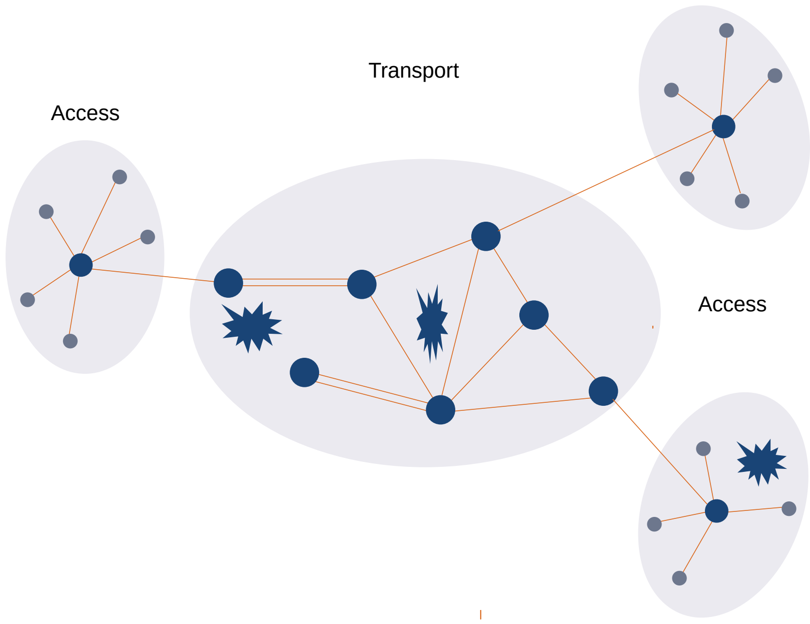
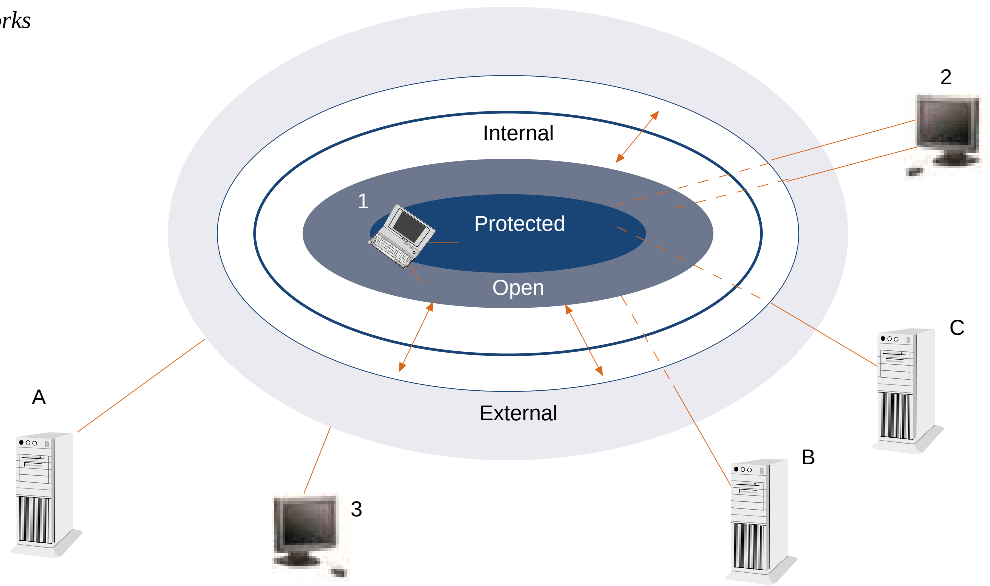


Figure 4 Failure in the mesh network and on single connections in the access network

The first viruses were developed during the same period. The whole idea started as an innocent game called “core ware” that gained wide publication by *Scientific American* in the column “Mathematical Games”. The purpose of the game was to produce two or more computer programs that could replicate, move from one memory location to another, hide, self-repair, and destroy the software of the opponents. Nobody could then imagine that this became a dreadful weapon of computer terrorism. Many of the early attacks on computer systems were performed on the Internet. This was the research network that existed before the Web made it go public. Many of the systems in this network

Figure 5 Interconnection of networks



were sloppy with regard to security and as thus an easy prey for hackers.

One discomforting observation is that it is impossible to construct a computer program that can discover and destroy all viruses. This is hard mathematical fact. The best we can do is to develop a virus protection program when we know the virus or some signature of it. The same mathematical theory also proves that it is impossible to construct a computer program that can debug and remove every programming fault in an arbitrary program. This leaves us in a situation where we cannot protect ourselves against clever virus attacks and against programming errors that sometimes may cause an exchange or other machine in the network to stop functioning.

The Web changed the attitude towards computer networks. The configuration of computer networks is explained in Figure 5. The core of this configuration is the data network of a company (called *Internal* in the figure). The internal network consists of two main sectors: one which is open for, for example, electronic mail, and one that is closed and only accessible by employees. The protected part of the network may consist of several sub-sectors open for different groups of employees. There are usually two types of user of the internal network: users that are located on the premises of the company (1), and users that are located outside these premises (2) and accessing the internal network via the external network. On the other hand, there are users not being employees of the company (3) that access the internal network for electronic mail and information that is publicly available (server B). The internal users may also access external servers (A) for information. Finally, there are servers in the protected part of the network (C) that are accessible only for authorised personnel in the company.

This configuration raises the following question. How can we avoid external users being able to penetrate into the protected part of the network? We see that this problem is not trivial because the company allows distant working (user 2). These employees have access to the protected part of the network. The problem is that the access is from a public network so that the private network must be able to distinguish between different external users. The most common protection is use of passwords, often combined with call-back facilities. Call-back is used as a simple means of authenticating the user. First the user accesses the data system and identifies himself. He then clears the connection and the system is calling the user back in accordance with stored address information. As the number of users increases, the likelihood of poor passwords also increases and it becomes easier to penetrate the protected sectors. It has also been reported that the security of call-back systems is not always strong enough. During the last couple of years, smartcards have been developed for cryptographic authentication of the remote users. This improves the protection radically.

One security threat of this type is concerned with the TCP ports that direct the information contained in the TCP package to the computer program that is capable of interpreting and servicing the content. There are ports for file transfer, HTTP, e-mail, TELNET, a variety of test services, and whichever other communication protocol and communication service the network supports. The TCP ports offer a primitive binding service between communication peers. Altogether it is possible to define 130,000 ports.

Security is implemented differently at different ports: on some of them security may be absent altogether. One popular pastime for hackers is to scan the ports in different local networks or equipment in order to detect weak security that can be penetrated.

A new security threat is concerned with the use of PDAs and beaming where information, e.g. files, is passed between computers using the Bluetooth technology and infrared communication. PDAs and beaming are effective means for circumventing firewalls, access control and other protection systems: you can use your PDA to pick up information from someone in the street and load it onto your computer when you reach your office. The data file may have been loaded onto your PDA without you knowing it. These technologies are so new that effective protective systems against misuse have not been developed.

Another development that influences the reliability of society is that telecommunications is used increasingly as a production factor in other products. Some examples are:

- transaction services for banks and other financial institutions where telecommunications is used for managing transactions and transferring money;

- e-commerce where telecommunication is used for browsing, ordering, payment, and sometimes delivery of goods;

- intelligent buildings where telecommunications supports operations for remote sensing of room temperature and break-in, control of ovens and heaters, and payment of energy usage;

- intelligent traffic systems where telecommunications is used for payment of road usage, parking and public transport.

All these applications are either in common use or will be so soon. The common denominator for these services is transfer of money. These services are therefore open for attack in order to learn account numbers and security codes, use fake accounts or divert payment transactions.

Examples posing other problems are:

- intelligent traffic systems used for road traffic management where an outage may lead to traffic congestion;

- intelligent buildings where interruption of telecommunications services may affect heating control and security of homes and factory premises;

- alarm services where disruption of service may cause important warnings not to be disseminated and burglar alarm systems to be disabled[1)];

- logistics using telecommunications for coordination of operations and fleet management where failures may cause inefficiency and loss of business;

- booking systems where malfunction of the telecommunications systems may cause irregularities of air transport;

- telemedicine where interruption of services may reduce the capabilities of hospitals and, in the worst case, interrupt remote medical treatment causing danger of life;

- cooperative work in and between companies where failure of telecommunications services may cause economic losses;

- business-to-business e-commerce where the network is used for managing purchase and delivery of raw material, semi-products and parts, managing logistics and product delivery, and managing cooperation between companies sharing the production of the same goods and services. This is estimated to become a business in the multi-trillion dollar class [1].

These are just some examples. The point is that the infrastructures knitting together the increasingly more complex public and private enterprises require telecommunications and computers. The performance of the infrastructure relies then on third parties: manufacturers of telecommunications equipment, computer manufacturers, software manufacturers and telecommunications service providers. Also in the case where an enterprise operates its own private network, the transport links interconnecting geographically separate parts of the network are usually leased from a telecommunications operator. The reliability of the infrastructure of the company then depends on the reliability of service offered by telecommunications operators and the dependability of equipment and software installed in the local area network.

The general evolution of sensor technology will increase this vulnerability for several other reasons:

1) *Burglar alarm systems test that the alarm gauge is operational at regular intervals (order of minute) in order to detect tampering with the device and the connection. However, a failure of the telecommunication system may disrupt so many individual alarms that the security firm is overloaded.*

- Smart dust about one cubic millimetre big has been developed. The dust contains battery, solar cell, transmitter and receiver, sensors and processor [2]. The device has been able to communicate over 21 km. The team at the University of California, Berkeley, is now developing distributed intelligence over the dust particles in order to study swarm behaviour. This device has many peaceful applications in meteorology, for pollution warning and for work in difficult areas. However, it is also ideal for espionage and illegal surveillance.

- Lego has developed bricks containing sensors and communication platforms. From these bricks we can build robots and various other advanced toys. However, they may also be used for illegal purposes.

- Video cameras have been developed that are so small that they can be hidden in the stem of spectacles. They may be hidden anywhere when used illegally.

- It is possible to monitor and remotely control patients by fitting them with sensors. This obviously offers many advantages for the chronically ill. However, what are the dangers of equipping a patient with a remotely controlled defibrillator? When can we expect to see the headline: "electronically stabbed by a GSM phone"?

All infrastructure – not only that mentioned above – of the society is becoming dependent on telecommunications. Examples are sewage works and water supply systems where telecommunications are used for remote supervision, control and management. Failures may cause pollution and inefficient delivery of fresh water. The core of the signal system of railways is telecommunications allowing the signals and the traffic to be managed remotely. The grid of control stations and radio beacons required for air traffic control is connected by telecommunications systems. The same applies for the management of the electricity grid and the power stations. A telecommunications failure of the control system may shut down the delivery of electric power.

Railway companies, air traffic control authorities, electricity companies and so on often own their own telecommunications networks. This does not make the problem less serious; it just changes the responsibility: if the telecommunication services are bought from a third party, this party is to blame; if the network is owned by the company, one can only blame oneself. There is a common belief that these systems are closed; that is, the systems have no contact with the external telecommunications network. It is indeed likely – if not certain – that these networks contain an open part offering e-mail and Internet services for some users of the protected network. The company may also offer information services and other electronic services to the public: the electricity company may offer access to tariffs and electronic payment services; the railway company may offer timetables and booking services; and the air traffic control network may be open for retrieval of information and be interconnected with airline companies. The important point is that each of these companies offers the same network for all operations, including both restricted internal operations and external operations. We shall see below how networks containing public and restricted access may be protected.

4 Accidental Failures

The telecommunications systems may fail for several reasons. One type of failure may be called accidental. The fault can be caused by equipment failure, power outage, or natural disaster. Let us discuss each of these events.

Equipment failure may occur anywhere in the system: in network nodes, in transport sections, in support systems, access circuits, or in the equipment at the user premises. These failures will have different impact on the system, and different precautions are taken in order to reduce the impact of the failures as much as possible.

Network nodes are exchanges in the telephone network/ISDN[2)] or routers in the Internet. We saw in Section 2 that a failure in this part of the network may have small consequences for the users. The same applies to the transport sections. The reason is that this part of the network is a mesh network. The main exception is the case where the failure affects the access network in such a way that the connectivity with the rest of the network is interrupted. In the telephone network, the reliability of equipment is high: the unavailability of resources is of the order of 0.01 %. This implies that the outage must be less than 1 hour per year. These objectives are met by duplicating critical equipment, designing complex autonomous recovery mechanisms for the software, and automatically rerouting the traffic when errors occur.

The problem we are facing now is that the exchanges and the transmission systems can serve more users and traffic so that fewer of them are

[2)] *Usually we do not distinguish between these types of network: the ISDN is usually regarded as the evolution of the telephone network. In the text, the term telephone network also comprises the ISDN.*

needed. The number of exchanges in the Norwegian telephone network has been reduced by a factor of 10 during the last decade while the traffic has doubled. Even fewer exchanges may do the task. Only one tenth of this number of exchanges is needed to serve traffic of about the same magnitude in the GSM network. The consequences of a failure are therefore becoming more severe since more users are affected each time it happens. In order to meet the overall requirements, each exchange must be more reliable. The problem is not becoming simpler because the growth in traffic and new services is so fast that the software of exchanges must be upgraded often. Minor upgrades are done several times a year while major upgrades are done at intervals of two to three years. The probability for failure is then increasing though the methods used for upgrading the exchanges without disturbing their normal mode of operation are clever.

The survivability of the Internet is different. The network consists of a large number of routers that are autonomously responsible for figuring out how the surrounding network is configured. The interconnectivity is then in a way anarchistic. Because of the density of routers and leased lines interconnecting them, the effect of an outage of a single router or the disruption of a single leased line is insignificant. If the fault lasts for a long time, the autonomy mechanisms will also cause the network to reconfigure so that packets are no longer attempted toward the failing router or link.

The telecommunications network is made independent of failure of the electricity delivery. Major equipment and nodes contain back-up power in terms of batteries, flywheels, and diesel generators that start automatically when a power failure is detected. Batteries and flywheels are also inserted between the telecommunications equipment and the electricity grid in order to protect against transients on the power system that may damage sensitive electronic equipment. The ultimate threat is that the outage of electric power is so long that the diesel fuel is used up.

Earthquakes, floods, landslides and other natural disasters can also cause disruption of service. In Japan, cables and fibres suspended on poles are used for local and long distance transmission of signals. The reason is that even small tremors may damage cables or fibres buried in the ground. The poles provide enough suspension to avoid this problem. In some areas of Indonesia, radio systems are used in place of cable systems because the vegetation is growing so fast that the roots may tear buried cables apart.

The local networks in enterprises pose a different problem. The reliability of these networks is usually much less than that of equivalent equipment in public networks. Because of the complexity and the dynamics of the software it contains, it cannot easily be made fault tolerant by duplication of functions and standby equipment. Reliability of private networks has been poorly understood and the cost of an unreliable network is usually not included in the cost calculation of the company. The capital cost of the equipment is easy to calculate but the cost of unreliability is not. This gives an imbalance in the incentives for choosing the right equipment and software in the local network and to offer good enough protection [3]: the management may be more concerned with reducing the capital cost than increasing the efficiency.

5 Warfare

The first books on information warfare have been written [4]. Information warfare includes all types of attacks on the information infrastructure: broadcast, newspapers, electronically stored information, computer systems, single computers, and telecommunications systems. This definition comprises then the attack on all infrastructure of society, not only attack on the information systems. The reason is – as explained above – that there is no longer a clear demarcation line between information infrastructure and other infrastructure.

The attack may be against nations, enterprises and persons.

The motives behind information warfare are many: political destabilisation and warfare, terrorism, political and industrial espionage, destruction without motives, and theft of money, information and properties. The evolution of the World Wide Web that started in 1993 has made it easy for anyone to access the network and utilise weaknesses in protection systems to penetrate the information systems. The worrying thing is that information warfare operations are going on on all levels from involving nations to attacks against individuals. Information warfare is thus changing the battlefield and the operations from large-scale military operations to wars conducted by one person or small groups. In fact, one person may send out logical bombs on the Internet that are not easy to detect and are timed to “explode” at a predetermined time. This may cause vast damage to society. Such large-scale damage has not happened yet. However, worms on the Internet (Code Read) and viruses (I love you) have caused considerable damage and economic loss to enterprises: the costs have been extremely difficult to determine and different estimates are different by two order of magnitude or more.

It is wise to include all the different types of attack under the heading of information warfare irrespective of whether the attacks are initiated by nations, terrorist groups, or individuals. One reason is that the resources required to make much damage are cheap and simple, and well within the capabilities of a single person. Another reason is that it is often impossible to detect whether the attack is performed by a single person or by a nation, and to identify the motive behind it.

It may require much skill to perform attacks on the political level because the expected results of the war are so complex. The same weapons can be used against nations, enterprises and individuals. The war only differs in scale and motive. The weapon is the use of infectious software.

6 Information Weapons

As mentioned in Section 3, it is mathematically impossible to produce countermeasures that protect against every type of attack. At least 50,000 different viruses and related infectious software are known today. Most of these are innocent programs not causing harm, except that of flashing the signature of the creator. Some of them may cause much damage and may infect from one machine to another.

The infectious programs can be classified as follows:

- *Viruses* are self-replicating programs that attach themselves to host programs in the infected machine. The virus program can only be executed together with the host program. The virus may be received on diskettes, CDs, or by electronic mail.

- *Bacteria* are also self-replicating but they are independent of a host program. The bacterium usually works such that it replicates and fills the available memory in the computer. The growth is geometric; that is, when executed, the bacteria multiply in accordance with some algorithm. In contrast, the number of viruses cannot exceed the number of suitable host programs in the computer.

- *Worms* spread from one computer to another on a network. The worm is autonomous and is programmed to establish communication links to other computers. The worm may be replicating in the same way as bacteria. While the bacteria affect the computational power of single computers, the worm is designed for paralysing the whole network.

- *Trojan horses* are apparently legitimate programs that contain functions for creating compilers for producing object codes of viruses, logical bombs and other hostile programs. The Trojan horse may be installed in the computer or software when manufactured. This makes it so difficult to detect the hostile program.

- *Logical bombs* are programs that become infectious after a certain time or when a given logical state occurs in the computer. The bomb may be triggered by external actions. Bombs are often concealed in Trojan horses. When the bomb "explodes" it may act as a bacterium wasting computational power, a virus removing essential information from the computer, or a worm starting its exodus toward other computers on the platform.

- *Trap door* is software that ensures covert access to the system ensuring that access is open for the intruder. The function may be combined with scanner software detecting, storing and forwarding information. The scanner may be placed in a Trojan horse and the trap door installed when the equipment is manufactured.

- Finally we have *fake viruses*. These are strictly not malicious software in the narrow sense of the word. The fake virus is often a virus warning received by mail containing a recipe describing how you get rid of the virus. If you follow the instructions, you may end up with a computer where all the content on the C drive has been deleted.

Viruses have been subject to considerable evolution since they were introduced in the early 1980s. The first viruses consisted mainly of a replicating code. These viruses are easy to detect by looking for their signature[3)]. The next development was to store the virus in encrypted form and decrypt it just before execution. Some viruses require some invariant part in order to store the encryption code. Such virus still leaves a detectable signature. Some of the encrypted viruses use encryption that changes the form of the stored replica so that they cannot easily be detected by searching for static traces of the virus. The virus is called polymorphic because it can take several forms. Such viruses can only be detected from the behaviour of the computer since they do not leave any identifiable signature. Viruses were designed to operate in a certain computer environment (DOS, Windows or UNIX). Recently, it has been reported that polymorphic viruses that adapt to different environments have been constructed. These viruses are called meromorphic since they can change their form in accordance with the operating system of the computer.

[3)] *The invariant part of the virus program.*

One argument against using infectious software in information warfare is that the attacker may be infected in the same way as the enemy. The argument is the same as for biological warfare. However, the situation is different [5] for two reasons. The attacker knows the infectious code and may provide "vaccines" (that is, programs detecting and destroying the infectious code) for its own machines. This may be difficult for attacks on a national level but feasible for attacks conducted by companies, terrorist groups or single persons. The attack may also be directed and only effective if certain characteristics of the infected system are detected. For example, such characteristics may be associated with the keyboard: if the letters æ, ø, å are included on the keyboard, the attack may be effective toward Denmark and Norway; if ç and ë are common, the attack may be effective toward countries where the French language is used.

The mobile agent technology may make the computer systems even more open for attack. A mobile agent is a program that resides in one machine but can be replicated in another machine (or be moved from one machine to another) in order to perform some specified task. The task may be to buy goods at different electronic stores searching for the lowest prise or the shortest delivery time. There is much research going on in this field and the technology will no doubt be implemented. However, the security issues are still a concern.

The weapons may be delivered via the network where the Trojan horse containing the infection may be delivered by e-mail, web pages or programs retrieved from the network. One problem is that the source delivering the information may be regarded as clean. However, the source could have been infected earlier with a dormant virus. The hostile programs may also propagate in such a way that they contain logical conditions so that they are not activated until they reach the final host.

The weapon can also be delivered in the original software. An exchange in the network may contain backdoors scanning for information transfer between certain calling or called numbers. If the hostile program is triggered, the backdoor program may store the relevant information or divert it to an external monitor. The weapon could have been installed by one of the employees of the manufacturer of the system coerced to do it. The weapon may also be installed later via wiretap access, during maintenance or by an unfaithful employee.

The smart dust and other micro-sensors are not making the situation more comfortable. ActiveX and Java offer excellent opportunities for making worms and Trojan horses difficult to guard against.

The attacks may be levelled against unprotected communication links for the purpose of eavesdropping. The attack may be against weak access control and authentication systems. Even if an access is protected against access attempts by preventing that several passwords are tried against the same user name, there are other methods where the attempts may be randomised over many user names and passwords. The passwords of many users are simple for mnemonic reasons because they are based on names and other data associated with the person.

Even disclosure of who a person or enterprise is communicating with, can be useful information in industrial or political espionage. This type of traffic analysis is possible even if the content of the message is encrypted. During the cold war, traffic analysis was used extensively in order to monitor the building up of hostile relationships or for disclosing lines of command.

Attacks may also be directed against messages such as altering the content or replaying the message later. This is an attack against data integrity.

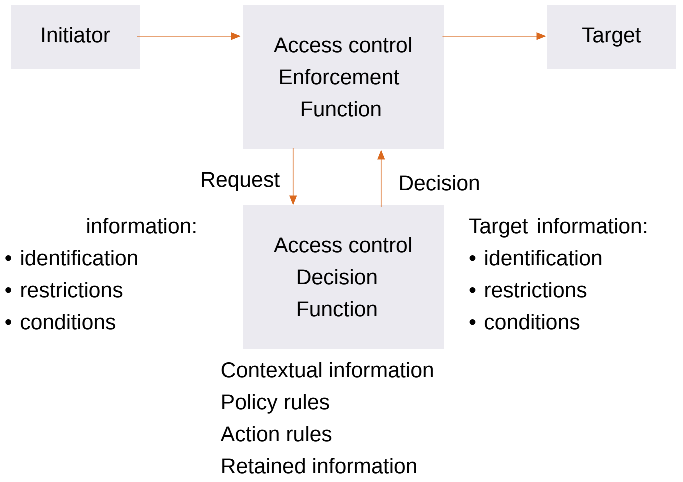
The identity of legitimate users may be stolen. This is often done in systems where the identity is not checked against other tokens. The motive can be to avoid identification of who is taking part in criminal operations. The authentication mechanism in the GSM system was designed in order to avoid this illegal use of the system.

7 Countermeasures

There are several countermeasures against information warfare [6]: access control, cryptography and firewall. Some of these technologies are not fully implemented in all systems for several reasons: cost and availability of equipment, unawareness of the security threats, and misconception of the security level required for protecting the enterprise.

Access control is used to ensure that only parties allowed to communicate are given access to the system. Different access control requirements exist for the originator of the connection, the destination and the network supporting the connection. The access control includes secure identification of the user by authentication. Access control requirements are also restrictions: who am I allowed to call, who can call me, over which network can the call be made, and which services can be associated with the call. In public networks, the access by another network is generally not checked. It is taken for granted that the access is genuine and not performed by an

Figure 6 Access control



intruder masquerading as another network[4]. Until recently, this type of activity has been assumed to require economic and technical resources so that this type of security attack would not present any problem. This picture is changing: anyone can own and operate an Internet router and then by definition be a network operator.

The configuration of an access control system is shown in Figure 6. We have introduced the terms initiator and target for the communicating entities. This terminology is often used in security literature and may represent users (persons, machines or software) or network elements requiring authorisation. The access control is distributed and it may consist of several entities. For simplicity (and in accordance with convention), the distributed system is represented as two entities only in the figure.

The distributed entities of the access control system are called *access control enforcement function* and *access control decision function*. The access control enforcement function accepts or denies the call dependent on information received from the access control decision function. The access control decision function consists essentially of databases. The information required for this purpose is:

- Initiator information includes secure identification of the initiator, restrictions and conditions related to the particular service and application. Identification may be enhanced by use of authentication of the initiator by simple passwords or tokens, or by cryptographic methods. Restrictions and conditions may be related to called numbers, constraints concerning the cost of the call, type of service and location of the user (in mobile systems). The restrictions and conditions are there to protect the initiator and the network against illegitimate usage and attacks.

- Target information is similar to the initiator information. The call is only allowed if the initiator information and the target information are not contradictory. For example, the initiator and the target are not interconnected if the initiator is allowed to call the target while the target is not allowed to receive calls from the initiator. This situation occurs if an unauthorised party (initiator) tries to access the protected part of a local network (target).

- Contextual information can be time of access and location of initiator or target. One example is that the access conditions may be different if the initiator accesses the restricted system from a computer at the premises of the enterprise or from home.

- Action rules are the conditions related to the action. For example, the target may either access a database for retrieving the information (read action) or for changing the information (write action). The read action may be open for everyone while the write action may be restricted to some users.

- Retained information represents the outcome of previous access events. If the access has been denied before, this information can be used to deny new access to the same target without further analysis. The information may also be used to simplify subsequent accesses if other essential conditions have not changed from one access to the next.

- Policy rules indicate which data and protection mechanisms are required for allowing the access, for example that the enterprise of the initiator will only allow access to targets that

---

[4] *There have been attacks on public networks based on this lack of access control (also called blue-boxing and black-boxing). The masquerading utilises security weaknesses in old signalling systems such as Signalling System No 5. The motive has been cheap long distance calling.*

are authenticated by strong cryptographic algorithms. Policy rules may also specify how access should be handled in fault situations, for example, only permitting access from certain initiators.

One example of problems caused by insufficient access control is the congestion caused in the international telephone network in Japan in the 1980s. Children in Europe and the USA were calling answering machines in Japan with the purpose of listening to the automatically generated message in Japanese. This completely meaningless pastime became a craze in many ways similar to the SMS. The children were generating so much traffic that legitimate calls to Japan were blocked. These machines were installed for test and maintenance purposes, and in accordance with international regulations, calls to these numbers were not charged. Lists of the numbers were spread among the children in several countries and the Japanese operators had to ask for new regulations where the calls were charged in order to mitigate the problem. No other access control was possible at that time. This was just children's play – even more amazing than the SMS craze. Similar attacks could have come from unfriendly groups as an act of information warfare. This illustrates how important access control is even in order to stop simple attacks.

Secure authentication cannot be achieved unless methods based on cryptography are employed. Cryptography is also used for other protective purposes such as preventing disclosure of information and ensuring that the integrity of the information is retained. The data may be protected in several ways:

- Encrypting the information means that the information bits are changed in a systematic way such that an intruder cannot recover the information unless knowing the key used for encryption. Again, we have to be careful because someone – some person within some company – must manufacture the key, or at least develop the algorithm producing the key. This means that it is possible for disloyal manufacturers, employees or criminals to create keys that can be broken. Such information can be valuable for third parties wanting to steal information. Therefore, encryption algorithms, encryption equipment and key production systems must only be purchased from trusted sources. But who can really be trusted in the current economic climate?

- By appending a message-dependent code field to the information (hashing), an intruder cannot alter the content (insertion, deletion and substitution of information) without being detected unless the intruder also knows how to alter the appended code field. This is what is called protection of the integrity of the information and is just as important as confidentiality. One common example is the hashing algorithm used for authenticating credit cards. The hashing code is derived from information such as the account number and the PIN code.

- The message can contain certificates confirming that the identity and signature of the initiator of the message have been issued or at least authenticated by a trusted party. The signature and the certificates are derived using cryptographic algorithms and encryption keys.

- The message may contain the time when it was produced and the time it expires (time-stamping) or a nonce that is very unlikely to take the same value in different messages. The intruder can then not gain access to the system or the information by replaying old messages; if the same nonce appears twice, the second message is discarded because it may be a replay of earlier message.

All these methods will make it difficult for intruders and attackers to manipulate information passed in a telecommunications system and to gain access to protected parts of the end-systems.

Firewalls are protections between open and protected parts of a network. The firewall may consist of a number of features depending on the security policy of the enterprise. Note that the main problem is often not the technology of constructing firewalls but non-existing or insufficient security policies. The firewall combines access control, encryption, integrity management and incident reporting. However, the firewall may not give the desired protection if some of the security requirements are relaxed or the technology used is too old. ActiveX and Java make it easy to hide hostile code. The protective mechanisms may not be able to cope with these new languages, in particular since the programs may be appended to other software the system may accept such as e-mail and web pages.

Then there is the problem of the different ports into the system each requiring a firewall of its own because the protection requirements are different for different applications. There are individual ports associated with every application that can be accessed: e-mail, remote log-on, web, video access, MPEG access, test accesses and so on. Altogether about 137,000 port addresses can be defined, making the access very complex and difficult to manage.

In order to obtain a high level of protection, the access control should be based on cryptographic authentication. Use of passwords – even if they are changed often – may not provide the required protection against massive attacks. Authentication may be required several times during a session in order to avoid address spoofing. The addressing in data systems is not secure and addresses may be picked up and used in datagrams containing hostile code.

Proxies or brokers may be installed in the firewall acting as filters. The proxy represents an application and ensures that no messages are passed directly to the internal parts of the network. The purpose of the proxy is to implement security policies without altering the internal functions. For example, if authentication is required before the message is admitted, the proxy will execute the function. Similarly, the proxy may check timestamps, nonces, signatures and certificates. The proxy may also manage encryption of the messages.

Furthermore, the firewall may contain extensive procedures for detecting incidents such as attempts of internal and external security intrusion, denial of service attacks, messages containing virus or other infectious code, and system failure.

8 Conclusion

Is there any sector of society that is independent of telecommunications? Probably not. This is one of the most important problems we are facing in the third millennium. Most of the infrastructure of society depends on computers. The computers are interconnected in order to perform cooperative tasks. The exploitation of these capabilities is new – less than ten years old. The exploitation of the capabilities was a result of the commercialisation of the World Wide Web.

During the last ten years the storage capacity of dynamic random access memories (DRAM) has doubled eight times, that is, increased by a factor of 256. The clock frequency of computers has increased by a factor of seven during the same period. The size of the DRAM and the clock frequency are good measures of the computing power of the computer. During the next decade, the capacity per DRAM and the clock frequency will again increase by factors of 256 and 7, respectively. Moore’s law has yet not failed.

Computers are everywhere: in the car, in the refrigerator, in the thermostat, in the radio. The manufacturing firms and service industries will stop functioning without them. No oil production takes place without the aid of the computer. Gasoline is refined from this oil using computers. All commerce requires the assistance of computers; air transport will come to a halt without this ubiquitous device; and newspapers or television programs can be neither produced nor delivered to the homes without the aid of it. All the computers are interconnected forming an enormous web of information links. Every computer can access every other computer. The reliability of the web, and of society will then depend on the reliability of these communications links and on how well the individual machines are protected against attack: hostile, accidental or just for fun.

In consequence, if the computers controlling the infrastructure fail, important functions in society fail as well. This gives a new perspective on the planning of the infrastructure of society. There are few regulations focussing on the security and the reliability of the web of computers the whole society depends on. Is the technological development going too fast for the political and legal systems?

In Turkey and Taiwan, the civil engineers recently had to take the blame for the loss of lives caused by earthquakes. Some of them have probably been prosecuted for ignorance and the use of inferior construction practices. When will the first telecommunications and the computer engineer be prosecuted because the protective systems he or she had designed were not able to protect us against the “grand computer disaster”? Or perhaps the charge is against the managers, the politicians and the governments that did not take security seriously enough and put enough money into research that could have prevented the catastrophe?

References

1 Clark, D L. *Enterprise Security: The Manager’s Defence Guide.* New York, Addison-Wesley, 2003.

2 News item in *New Scientist*, 28 August 1999.

3 Yourdon, E. *Rise and Resurrection of the American Programmer.* New York, Prentice Hall, 1998.

4 Waltz, E. *Information Warfare Principles and Operations.* New York, Artech House, 1998.

5 News item in *New Scientist*, 18 September 1999.

6 Menezes, A J, van Oorschot, P C, Vanstone, S A. *Handbook of Applied Cryptography.* Heidelberg, CRC Press, 1997.

Status

Introduction

PER HJALMAR LEHNE

Per Hjalmar Lehne (44) obtained his MSc from the Norwegian Institute of Science and Technology in 1988. He has since been with Telenor R&D working with different aspects of terrestrial mobile communications. 1988–1991 he was involved in standardisation of the ERMES paging system in ETSI as well as in studies and measurements on EMC. His work since 1993 has been in the area of radio propagation and access technology, especially on smart antennas for GSM and UMTS. He has participated in the RACE 2 Mobile Broadband Project (MBS), COST 231, COST 259 and COST 273. His current interests are in use of MIMO technology in terrestrial mobile networks and on access network convergence, where he participates in the IST project FLOWS.

per-hjalmar.lehne@telenor.com

We have in previous issues of *Telektronikk*'s status section discussed the work and role of the *International Telecommunications Union (ITU)*, see for example issues 4.1999 and 1.2001. In this issue, *Einar Utvik* and *Anne Lise Lillebø* have made a report from the highest body of the Union, the *Plenipotentiary Conference (PP)*.This is the top policy making body of ITU and meets every four years. Last year, PP-02 met in Marrakesh, Morocco. Norway's delegation consisted of 12 people, of which two were from Telenor. Telenor is a so-called Sector Member of ITU's three sectors (ITU-T, ITU-R and ITU-D). The structure of ITU is shown in the figure below. The report presented here is very comprehensive and some items and decisions are worth mentioning. For the first time, Norway has become Council member from Region B (Western Europe) from 2002 – 2006. Mr *Willy Jensen* from the Norwegian Post and Telecommunications Authority will be Norway's Councillor.

On the whole, the impression is that reforms of the ITU progress very slowly. It seems very difficult for the Member States to agree on decisions. This also makes the work on making ITU more attractive to the private sector very difficult.

But there are also positive decisions and recognition of important matters. The *World Summit on the Information Society (WSIS)* was launched at PP-98 and endorsed by the UN General Assembly with the purpose of developing a common vision and understanding of the information society. WSIS is primarily a policy making forum under the patronage of the UN Secretary General and probably has its most important task towards the developing part of the world.

Another important item was the introduction of the gender perspective as a new element. In this context, it is worth mentioning that Ms *Ingunn Yssen* was appointed from Norway as a Senior Gender Advisor to the *Telecommunications Development Bureau (BDT)* from Sept 1, 2002. There was also a special session on Gender Issues at PP-02 chaired by Ms *Eva Hildrum*, Director General from the Ministry of Transport and Communications.

Two regional initatives received whole-hearted support: *New Partnership for Africa's Development (NEPAD)*, and *The Agenda for Connectivity in the Americas and Quito Action Plan*. Also PP-02 agreed on assistance to 'Countries in Special Need' (the Federal Republic of Yugoslavia, Afghanistan, Bosnia and Herzegovina). A more delicate question has been the assistance and support to the Palestinian Authority, but it was in fact agreed that an action plan from 1994 should be continued and enhanced.

It seems that ITU has still an important role in the global society, not so much for the part of the world which has a well developed telecommunications infrastructure and service level, but very much for the developing countries in order to ensure a good development to the benefit of trade and industry as well as the general public.

Structure of the ITU (from www.itu.int)

ITU Plenipotentiary Conference PP-02, Marrakesh, 23 September – 18 October 2002
An overview of main results of the conference

EINAR UTVIK AND ANNE LISE LILLEBØ

Einar Utvik (62) worked in Televerket/Telenor ASA from 1970 to 2003. His responsibilities included general and policy matters related to inernational organisations. He has been a member of the Norwegian delegation to ITU's Plenipotentiary Conferences in 1982, 1989, 1992, 1998 and 2002.

eutv@online.no

Anne Lise Lillebø (54) is Adviser, Telenor Corporate Communications. Her main responsibilities include general and policy matters related to international standardisation organisations. She has been a member of the Norwegian delegation to ITU's Plenipotentiary Conferences in 1989, 1992, 1994, 1998 and 2002. She holds a Master of Arts degree from the University of Oslo.

anne-lise.lillebo@telenor.com

1 ITU – Historical Background

The International Telecommunication Union – ITU – was established as an intergovernmental organisation in 1865 with the aim of streamlining interconnection of the national telegraph networks. Norway was one of the 19 "founding fathers". In 1947 ITU became a Specialized Agency of the United Nations. ITU's main objective is to promote connectivity and interoperability between its member countries and to foster the development of all kinds of telecommunications worldwide.

Right up to the1980s the members of the ITU were mainly administrations and government agencies responsible for the operations of telecommunications and for regulatory measures within the telecommunication field in their respective countries. With the separation of the regulatory and operational functions and the gradual liberalisation of the operational activities in a large number of ITU's Member States, the present situation is very different from the environment when the basic features of the Union were drawn up. However, we find that this change is not sufficiently reflected in the way ITU is organised and managed.

Following the liberalisation of the telecom sector in Norway, Telenor has for the past ten years been a so-called Sector Member of ITU's three sectors – the Telecommunication Standardization Sector (ITU-T), the Radiocommunication Sector (ITU-R) and the Telecommunication Development Sector (ITU-D). Norway is a Member State of the ITU, and the Norwegian Post and Telecommunications Authority is responsible for the day-to-day management of ITU related activities in Norway.

2 ITU Plenipotentiary Conference

ITU's Plenipotentiary Conference – PP – is the top policy-making body of the Union and meets every four years. The PP is the key event at which ITU Member States decide on the future role of the organisation, drawing up a strategic plan and deciding on the budget. The PP is an intergovernmental conference where only sovereign Member States of the ITU have the right to send delegations. Each Member State has one vote. A number of international organisations and Sector Members may attend the PP as observers.

The ITU Plenipotentiary Conference 2002 was hosted by Morocco and was held at the Palais des Congrès in Marrakesh from 23 September till 18 October 2002. Some 162 delegations representing Member States participated with approximately 1700 delegates. In addition there were observers from the United Nations and their specialised agencies, regional telecommunication organisations, intergovernmental organisations operating satellite systems and Sector Members. ETNO – the European Telecommunications Network Operators' Association – was represented as an observer.

2.1 The Tasks of the PP

The agenda of the conference appears in Article 8 of ITU's Constitution. The PP shall, i.a.:

Palais des Congrès, Marrakesh

- determine the general policies for fulfilling the purposes of the Union, draw up the policy and strategic planning of the Union;
- establish the budget of the Union for the next plenipotentiary period (four years) including the upper limit of the contributory unit;
- approve amendments to the ITU Constitution (CS) and Convention (CV) based on proposals from Member States;
- elect the senior management of the Union including the Secretary-General, the Deputy Secretary-General, the Directors of the three Bureaux of the Sectors, the members of the Council and the members of the Radio Regulations Board (RRB).

2.2 Structure and Chairmanship of the Conference

The Conference elected His Excellency Mr Nasr Hajji, Secretary of State to the Prime Minister in charge of Posts, Telecommunications and Information Technologies, Morocco, as chairman of the PP-02. The Conference also elected six Vice-Chairmen of the Conference, as well as Chairmen and Vice-Chairmen of the six committees and the Working Group of the Plenary (WG Plen).

The conference is required by statute to set up four committees, i.e.: steering committee, credentials committee, budget control committee and editorial committee. In addition the PP-02 resolved to set up two substantive committees; Committee 5 to deal with policy, reform and legal matters including examining proposals for amendments to the CS and CV, Committee 6 being responsible for the Union’s financial plan, and a Working Group of the Plenary (WG Plen) on general matters such as the Strategic Plan, digital divide, the Internet and the Information Society, gender issues and the World Summit on the Information Society (WSIS) (see box below).

3 Norwegian Delegation to PP-02

The Norwegian Delegation to the PP-02 was chaired by Mr Per Sanderud and Mrs Eva Hildrum from the Ministry of Transport and Communications. Representatives from the Norwegian Post and Telecommunications Authority, the Norwegian Embassy in Rabat, Morocco, and Telenor were also members of the delegation. Telenor was represented by Mr Einar Utvik and Ms Anne Lise Lillebø.

4 Nordic and European Preparations for PP-02

4.1 NITU

As member of the ITU Council, Denmark has been responsible for coordinating the preparations for the Plenipotentiary Conference on the Nordic level through the informal group NITU (Nordic ITU cooperation) where both the private

Structure – Chairmen and Vice-Chairmen of the Conference

Chairman of the Conference	H.E. Mr Nasr Hajji (Morocco)
Vice-Chairmen of the Conference	Mr S. Chepkong’a (Kenya) Mr M. Goddard (United Kingdom) H.E. Mr D. Gross (United States) Mr K. Mori (Japan) H.E. Mr M. Mulla (Saudi Arabia) H.E. Mr L. Reiman (Russian Federation)

Committees	Chairman
Committee 1 Steering Committee	Composed of the Chairman and Vice-Chairmen of the Conference and of the Chairmen and Vice-Chairmen of the other committees and Working Group of the Plenary
Committee 2 Credentials Committee	Mr V. Grigorascu (Romania)
Committee 3 Budget Control	Mr E. Owusu-Adansi (Ghana)
Committee 4 Editorial Committee	Ms M.T. Alajouanine (France)
Committee 5 Policy, Reform and Legal Matters	Mr A. Wong (China)
Committee 6 Administration and management	Mr B. Gracie (Canada)
Working Group of the Plenary (WG Plen) General Matters	Ms L. Shope-Mafole (South Africa)

Norwegian delegation to PP-02

Member	Function	Affiliation
Mr Per Sanderud Secretary General	Head	Ministry of Transport and Communications
Ms Eva Hildrum Director General	Head	Ministry of Transport and Communications
Mr Jens C. Koch Director of Legal Affairs	Deputy Head	Ministry of Transport and Communications
Mr Willy Jensen Director General	Deputy Head	Norwegian Post and Telecommunications Authority
Mr Eugen Landeide Director	Delegate	Norwegian Post and Telecommunications Authority
Ms Anne Marie Storli Director of Public Relations	Adviser	Norwegian Post and Telecommunications Authority
Mr Knut Smaaland Special Adviser	Adviser	Norwegian Post and Telecommunications Authority
Ms Hilde Ognedal Legal Adviser	Delegate	Norwegian Post and Telecommunications Authority
Mr Ole S.E.M. Holthe Ambassador	Adviser	Norwegian Embassy, Rabat, Morocco
Ms Torunn Viste First Secretary	Delegate	Norwegian Embassy, Rabat, Morocco
Mr Einar Utvik Deputy Director	Delegate	Telenor ASA
Ms Anne Lise Lillebø Adviser	Delegate	Telenor ASA

Members of the Norwegian delegation: Jens C Koch, Deputy Head, Ministry of Transport and Communication; Anne Lise Lillebø, Telenor; and Hilde Ognedal, Norwegian Post and Telecommunications Authority

and public sectors are invited. Telenor has taken part in these preparations together with the Ministry of Transport and Communications and the Norwegian Post and Telecommunications Authority.

4.2 ETNO

ETNO – the European Telecommunications Network Operators' Association – has prepared for the PP-02 through its Working Group ITU (WG ITU) where Telenor has been actively contributing to the work of the group. ETNO prepared a position paper highlighting issues of prime importance to ITU's European Sector Members to be used as briefing for its members in their national preparations for the PP and as a guidance for ETNO members during the PP-02. ETNO also published an article in ITU News issued prior to the Conference. A written statement mirroring this article regarding ETNO's position on reform of the ITU was also distributed to the participants at the PP-02.

4.3 CEPT

European telecommunication regulators and authorities have coordinated their preparations for the PP-02 through CEPT (Conférence Européenne des Administrations des Postes et Télécommunications), Europe's regional telecommunications organisation for telecommunication authorities. A permanent and largely autonomous body, the CEPT ECC WG ITU, has been established to plan and coordinate European preparations for Council and the PP. The WG's Project Team, WG PT ITU, chaired by Mr Knut Smaaland, Norwegian Post and Telecommunications Authority, prepared comprehensive briefing material for the PP-02 and developed 25 ECPs – European Common Proposals – which were all submitted as formal proposals to the PP-02.

4.4 EC

The European Commission (EC) has participated as councillor in the CEPT WG ITU and the European Union has recognised CEPT as the competent body to carry out European preparations for ITU conferences.

4.5 Co-operation CEPT and ETNO

CEPT and ETNO have formally agreed to exchange observers in connection with the PP preparatory work and there has been a very good co-operative climate between ETNO and CEPT. This cooperation has been of great value to European Sector Members in order to voice their views to the European Member States of the ITU. Only Member States can send delegations to the PP, whereas Sector Members may participate as observers without the right to speak or submit contributions.

5 Major Decisions of the PP-02

ITU top management team 2003 – 2006

Secretary-General	Mr Yoshio Utsumi, Japan
Deputy Secretary-General	Mr Roberto Blois, Brazil
BR Director	Mr Valery Timofeev, Russian Federation
TSB Director	Mr Houlin Zhao, China
BDT Director	Mr Hamadoun Touré, Mali

5.1 General

Although most of the 25 European Common Proposals – ECPs – were accepted, European Member States and Sector Members noted the poor progress in reform issues which were mostly transferred for further review in a number of Council Working Groups. The conference adopted a financial plan with a significant imbalance between the expected income and the required expenditure. There was great reluctance to seriously consider financial efficiency measures or prioritisation of activities.

5.2 Elections

The election of the Union's five highest-ranking officials, the members of the RRB (Radio Regulations Board) and the members of the Council attracted much interest at the PP. The PP decided that the elections should take place in the second week of the conference.

5.2.1 Elected Officials

The following officials were re-elected for a second term: Mr Yoshio Utsumi, Japan, Secretary-General (no other candidate), Mr Roberto Blois, Brazil, Deputy Secretary-General (clear majority against Mr Boussaid, Algeria), Mr Houlin Zhao, China, TSB Director (no other candidate), Mr Hamadoun Touré, Mali, BDT Director (no other candidate).

5.2.2 Election of the BR Director

Mr Robert Jones, Canada, had served as Director of the Radiocommunication Bureau for two consecutive terms (since 1994) and could not stand for re-election. There were four new candidates for the BR Director: Mr K. Arasteh, Islamic Republic of Iran, Mr F. Bigi, Italy, Mr M. Johnson, United Kingdom and Mr V. Timofeev, Russian Federation. Despite considerable efforts, we regret to note that the CEPT members did not succeed in agreeing on a single European candidate for the post of the BR Director.

Mr Timofeev, the Russian Federation, was elected BR Director with a clear majority in the second round.

5.2.3 Council Elections

The ITU Council has 46 seats (25 % of the membership) representing the 189 Member States of the Union and meets once a year. The Council members represent the whole membership in the interval between Plenipotentiary Conferences. The Council seats are grouped in five administrative regions and each region is entitled to a number of seats as follows:

- Region A – Americas (8 seats)
- Region B – Western Europe (8 seats)
- Region C – Eastern Europe (5 seats)
- Region D – Africa (13 seats)
- Region E – Asia/Australasia (12 seats)

For Region B there were ten candidates for eight seats and in Region C eight candidates for five seats. Once more it is noted that CEPT did not manage to agree on a number of candidates to Regions B and C equivalent to the number of seats. If a common understanding among the CEPT countries had been reached, Europe would be in control of which countries should represent Europe in Council.

For the first time Norway was a candidate to a seat on the Council, following an agreed system of rotation among the Nordic countries. Denmark is stepping down from the Council after having served for two PP periods, i.e. eight years. According to a recent Nordic agreement, Norway will serve for one PP period of four years (if elected), and next time Finland will be a Nordic candidate for the Council.

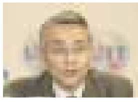
Norway was elected to Council in Region B with 113 votes. It is expected that Mr Willy Jensen, Director General of the Norwegian Post and Telecommunications Authority will be Norway's Councillor.

UK, who was a Council member for the past four-year period, and Slovenia failed to be elected in region B. It was remarkable to note that the UK was not re-elected to Council despite its active and constructive participation in major areas of the work of the ITU, and this caused great concern among many delegations. Armenia, Slovakia and the Ukraine did not get sufficient votes to get a seat on the Council in Region C.

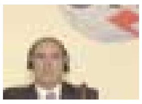
5.3 Reform: Streamlining the Working Methods of the Sector – Increased Sector Independence

5.3.1 Management of the T-Sector to be under the Control of the WTSA

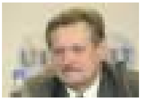
The CEPT countries had submitted an ECP (Common European Proposal) aiming at giving more authority and increased responsibility to



Yoshio Utsumi, Secretary-General



Roberto Blois, Deputy Secretary-General



Valery Timofeev, BR Director

Houlin Zhao, TSB Director

Hamadoun Touré, BDT Director

ITU's top management 2003 – 2006. Source: ITU

Elected Council members in Region B (Western Europe)	Elected Council member in Region C (Eastern Europe)
Germany	Russian Federation
Portugal	Romania
Switzerland	Bulgaria
Spain	Poland
France	Czech Republic
Norway	
Turkey	
Italy	

the WTSA (World Telecommunication Standardization Assembly) for the management of the work and the working methods of the ITU-T Sector. Instead of having a number of provisions in the basic instruments specifying details of the work in the T-Sector as is the case today, Europe proposed to transfer these provisions to the authority of WTSA which would allow the Standardization Assembly greater flexibility to review and enhance the work of the Sector and to ensure that the ITU-T meets the requirements of all stakeholders taking part in the work. This flexibility would contribute to maintaining ITU-T as an efficient organ for technical standardisation. CEPT underlined that the proposals did not require any changes to the structure of the Union.

Eva Hildrum, Head of Norwegian delegation, casting her vote

The members of ETNO, including Telenor, had given high priority to this proposal, which is in line with the ETNO policy to improve working methods and increase efficiency, particularly in the T-Sector. However, the European proposals on the transfer of provisions relating to ITU-T to WTSA were treated together with a proposal from Australia and a proposal from a number of Arab countries. Both contributions proposed major changes to the present structure of the Union. We regret that it was not possible to achieve a consensus on the European proposal despite considerable endeavours from Sweden and other countries. The European proposals were amalgamated with the Australian and the Arab proposals into a complex compromise package:

The first element of this package was a Resolution *"Review of the ITU Structure"* in which PP instructs *the Council to establish a group to review the functions of the three ITU Sectors*.

The group shall, on the basis of the annex to Resolution COM5/11 and contributions by Member States and Sector Members:

- Review the functions of the three Sectors in the light of the changes that have occurred in the operation and regulation of the telecommunication sector at the national level, and define the respective roles of the ITU constituents;
- Consider the obligations of Sector Members that are not recognized operating agencies and recommend appropriate measures;
- Study the current structure, working methods and procedures of the ITU Sectors and make recommendations as appropriate.

The findings of the group may be used in the preparations for the next PP in 2006.

The biggest challenge was on defining whether this group should be restricted to Member States only or whether it should be open also to Sector Members. The compromise reached is that the group is open to both Member States and Sector Members; however, *"when considering its conclusions and recommendations, the meetings of the group shall be limited to Member States"*. We note that Sector Members are not admitted when decisions are made and we believe this is a step backwards. This is yet another example which shows that the Member States of the ITU are not prepared to take Sector Members onboard when reviewing the structure of the Union and the compromise did not send the right message to the private sector. Although attempts are made to allow increased involvement of Sector Members in ITU activities, the resistance against private industry in an intergovernmental organisation is still powerful.

The reform process has been going on for more than ten years now, and another group to consider the structure, working procedures etc., will postpone any decisions for at least another four years. Only a very limited number of Sector Members were active in the work of the last Working Group on Reform (WGR) and we are not convinced that the Sector Members will queue up for this new group where their voice is not wanted when recommendations and decisions are to be made.

Second element: "Other groups". A new article in the CS was adopted (CS145 A) together with consequential amendments in the CV, laying down that Sector Assemblies and the World Telecommunication Development Conference (WTDC) may establish and adopt working methods and procedures for the management of the activities of their respective sector, including the possibility to establish and terminate *other groups* than Study Groups. These *other groups* will not be authorised to adopt Questions or Recommendations. In a number of provisions in the CV the words "Study Groups" were replaced by the words "Study Groups and *other groups*". The WTSA may, if the membership agrees, establish such *other groups* which may apply other working methods than those in force for Study Groups (although it is explicitly stated in the CV that all methods must comply with the present provisions in the CS/CV). The possibility of creating other groups may open for increased flexibility for example in the T-Sector along the lines requested by ETNO and others in the work of reforming the ITU. It will be up to the membership to utilise this possibility, especially within the T-Sector.

5.3.2 Evolving Role of the WTSA

The PP agreed on a resolution relating to the WTSA (World Telecommunication Standardization Assembly) where the membership is encouraged to "further develop working methods and procedures for the purpose of improving the management of ITU-T's standardisation activities". Sector Members may have to remind Member States of this resolution at the forthcoming WTSA in 2004.

5.3.3 Enhancement of the Role of the Advisory Groups

Before this PP only the Telecommunication Standardization Advisory Group (TSAG) was allowed to act on behalf of the Assembly of the Sector. The WTSA may assign specific matters within its competence to the TSAG. The CEPT countries had submitted an ECP proposing that the mandates of the advisory groups of the R- and D-Sector should be aligned with that of TSAG. The PP agreed to the European proposal and the necessary amendments have been introduced in the CV.

This change implies that the advisory groups can be authorised by their relevant Sector assembly or conference to decide on certain matters in the interval between assemblies. In the T-Sector this provision has given TSAG the possibility to react rapidly to the changing needs of its constituents, since the advisory group meets once or twice per year compared to the four-year cycle of the WTSAs. It remains to be seen whether the membership wants to utilise the flexibility offered by these new provisions in the R- and D-Sectors.

5.4 Strategic Plan 2004 – 2007

An ITU strategic plan for the period 2004 – 2007 was adopted by the PP-02. It is contained in the annex to Resolution 71 (Marrakesh, 2002).

5.5 Financial Matters

5.5.1 Financial Plan 2004 – 2007

A number of Member States have dramatically reduced their financial contributions to the ITU and the Union is now facing a serious financial crisis with a significant imbalance between the expected income and the required expenditure. The PP struggled to find options for balancing the financial plan for the period 2004 to 2007 and resolved that a cost reduction programme should be elaborated by the Secretary-General. The PP approved the financial plan with a total expenditure of CHF 657 million, a negative balance of CHF 21 million resulting from the reduction in the number of contributory units chosen by Member States. A full wish list of activities would have required a financial plan totalling CHF 850 million. Serious concern was expressed over the future of the Union's finances and how to preserve the Union's ability to perform its core competencies over the coming

Eva Hildrum, Head of Norwegian delegation, and Einar Utvik, Telenor, at the Norwegian reception four-year period in the context of the current economic climate.

5.5.1.1 *Upper Limit of Member States' Contributory Unit*

As no consensus could be reached, the decision on the definite upper limit of the Member States' contributory unit was taken by a secret ballot based on a French compromise proposal. The conference set the upper limit at CHF 330,000 for the next four-year period, but for the first biennium (2004 – 2005) the upper limit should not exceed CHF 315,000.

The Council may exceed the limit of CHF 315,000 for the years 2004 – 2005 by up to 1 % in order to meet expenditure on unforeseen and urgent activities which are in the interests of the Union.

5.5.1.2 *Sector Members Contributory Unit*

Based on the principle that a Sector Member contributory unit is 1/5 of a contributory unit for Member States, the amount of a Sector Member's unit shall not exceed CHF 63,000 for 2004 and 2005, and for 2006 and 2007 the upper limit of a Sector Member contributory unit shall not exceed CHF 66,000.

5.5.2 Announcement of Class of Contributory Unit

5.5.2.1 *Announcement by Member States*

The new provisions regarding the announcement of choice of class of contribution for Member States were applied for the first time in Marrakesh. At this PP, the Member States had to announce before the end of the penultimate week of the conference their definitive choice of class of contribution based on a draft financial plan approved by the PP and a definitive upper limit of the amount of the contributory unit. Thus the conference could take into account the number of contributory units that Member States have committed themselves to pay for the next period of four years when finally deciding on the financial plan by the end of the PP.

The Conference noted the alarming reduction in the number of units pledged by Member States by the deadline set by the conference. Many Member States, particularly from Europe, announced a reduction in their contributions to the Union; UK and Italy (5 units each), the Netherlands and Sweden (3 units each), Denmark and Finland (1 unit each) and Australia (2 units). The total amount of contributory units from Member States was reduced by 22 units, resulting in a cut of around 6 % of the ITU general budget or a shortfall of more than CHF 21 million.

5.5.2.2 *Announcement of Class of Contributory Unit for Sector Members*

According to the new provisions, Sector Members shall announce their choice of class of contribution within three months after the closing date of the conference. This means that Sector Members must announce their choice of class of contribution by 18 January 2003. Sector Members who do not reply by this deadline will keep their previous class of contributory units.

5.5.3 Centralised/Decentralised Budget

5.5.3.1 *Review of the Union's Financial Management*

More than ten years ago the High Level Committee (HLC) recommended decentralisation of the ITU budgets and greater delegation of responsibility. For many years, Sector Members have argued that there should be specific Sector budgets both for expenditure and income to improve accountability and transparency and to obtain a more efficient use of funds. For a Sector Member it is difficult to understand why contributions from Sector Members cannot be earmarked to the sector of their choice rather than going into the overall budget of the Union.

The Working Group on Reform (WGR) recommended that a study should be conducted on the feasibility of replacing ITU's current centralised financial management system with a system of budgets managed by the Sectors, with the involvement of the Sector advisory groups. The CEPT countries submitted an ECP on sector budgets advocating greater management control for each Sector over its resources and the introduction of Sector specific budgets. The European proposal received support from the US, Australia and Brazil.

PP agreed on Decision COM6/1 "Review of the management of the Union" which instructs the Council to establish a Group of specialists, one from each administrative region, to undertake a review of the Union's financial management, and states i.a. that:

- there is an urgent need to seek innovative ways to rationalise internal costs, optimise resources and improve efficiency;
- a method for making more effective and efficient use of resources is to empower individuals to manage resources for the achievement of results by delegating to them authority for financial and human resources;
- the greater delegation of authority to managers will require appropriate accountability and control mechanisms;

- delegation of authority for the management of part of the Sector budgets to the Directors of the Bureaux will give them more effective control over the organisation of the work of their Sectors, and that therefore they will need to consult their Sector advisory groups in the application of this delegated authority;

- since significant benefits in terms of effectiveness and efficiency can be expected from carefully planned further decentralisation of the Union's resources, this decentralisation shall be implemented and reviewed by Council based on the work of a group of experts;

- in order to improve effectiveness and efficiency, the Secretary-General shall delegate authority to the Directors of the Bureaux for the management of their Sector budgets once the central mechanisms identified in the management review are in place.

A number of points in this decision are in support of ETNO positions concerning management of individual Sector budgets.

5.5.3.2 Review of Sector Members Payment to the Sectors

A number of countries tabled proposals aiming at increasing the payment from Sector Members in order to raise the income of the Union. These proposals received widespread support from African and Latin American countries as well as from Italy and Iran.

The Arab countries proposed to abandon the present system of free choice of class of contribution for Sector Members. Instead, the Arab proposal would give the task of determining the amount of the Sector Member contributory unit to the Council. Argentina wanted to discontinue the present arrangement of setting the Sector Member contribution at 1/5 of a Member State contribution. The objective of all these proposals was that Sector Members should pay more to the Union in light of – allegedly – increased rights given to them by previous Plenipotentiary Conferences.

There was much debate in Committee 6 on this issue, and whilst many developing countries supported the idea of changing the present system with the aim of gaining more income to the Union, many countries including countries from Asia and Africa spoke against any change in the system of payment at the present point of time, acknowledging that these proposals come at a critical time for both the industry and the ITU. There is a crisis of confidence in telecommunications and these are difficult times for suppliers, equipment manufacturers and operators alike.

Many European countries, supported i.a. by the Philippines, New-Zealand and others, argued that they feared a forced increase in payment might have an adverse effect and reminded that the participants from the private sector could easily opt for being members in a national delegation instead of becoming Sector Members. Europe shared the view that ITU must find ways to make itself more attractive to the private sector. The Sector Members contribute substantially to the technical work in the R- and T-Sectors and are responsible for chairing a large number of Study Groups, especially in the T-Sector. At present, Sector Members do not have the right to vote on recommendations and they cannot actively participate in the work of the Council.

The conference concluded that the free choice of class of contribution for Sector Members and the calculation system for the private sector's contributions remain unchanged, but it resolved that Council should establish a WG of the Council to study the matter further based on the Resolution "Review of the contribution of Sector Members towards defraying the expenses of the International Telecommunication Union". The resolution recognizes the importance of retaining and attracting more Sector Members and Associates to the ITU. The group will report to Council 2005. The WG should be closely monitored by Sector Members and Associates to make sure that the size of the contributory unit reflects the resources spent by the private sector in the Study Groups and chairmanships.

5.6 Management of Internet Domain Names and Addresses

The Minneapolis Plenipotentiary in 1998 adopted Resolution 102 on the management of the Internet domain names and addresses. For the review of this resolution, the main point for the Sector Members was that the future development of the Internet must be private sector driven.

Even though there was a perception that some Member States would have liked to get more involved with and have more control over the Internet development, the discussions in the drafting group went rather smoothly, and it was fairly easy to obtain a compromise that is quite balanced and fully acceptable for the private sector.

The revised resolution underlines that the development of the Internet is essentially market-led and that the private sector is playing a very important role in the expansion and development of the Internet, for example through investments in infrastructures and services. It also acknowledges that Member States represent the interests of the population of the country or territory for which a country code top-level domain (ccTLD) has been delegated and that Member States have an active role to play in coordinating the resolution of management and administrative constraints arising with respect to their ccTLDs. Recognising that ITU can play a positive role by offering a platform for encouraging discussions and for the dissemination of information, it instructs the Secretary-General to take a significant role in international discussions and initiatives on the management domain names and addresses. It further instructs the Director of the Telecommunication Standardization Bureau to continue to liaise and cooperate with appropriate entities on relevant Internet domain name and address management issues, such as the transition to IPv6, ENUM and internationalised domain names.

5.7 International Telecommunication Regulations (ITRs)

The ITRs were adopted by ITU's World Administrative Telegraph and Telephone Conference (WATTC) in Melbourne, 1988. It represented at the time a very tight compromise between the countries that had just started on market liberalisation on the one hand and the developing countries on the other. The most important articles of the ITRs concern "Charging and accounting" (of international telecommunications), the "International network" and "International services".

Already at the Minneapolis PP in 1998, there was wide recognition that the ITRs were out of date. The liberalisation of the telecommunications market in many of the Member states as well as the rapid technological development had made most of the provisions obsolete and of little or no use to administrations for the purpose of regulating international telecommunications. The Minneapolis PP therefore decided to establish a group of experts to study the ITRs and come up with proposals on how to tackle this problem.

The group of experts was unable to find a consensus and instead proposed four different options:

1 Termination of the existing ITRs by transferring relevant provisions to the Constitution/Convention and other to ITU recommendations;

2 Modification of the ITRs by a competent conference (WCIT = World Conference on International Telecommunications) thus keeping them as a treaty-level text;

3 To defer any decision on whether to review and modify the ITRs;

4 Proposals for new areas of regulation to allow further development and determination of which areas are really appropriate for an intergovernmental treaty-level regulatory agreement.

At Marrakesh there were two main groupings facing each other. One group that would have preferred to terminate the ITRs, but that was prepared to accept a deferral of any decision on the grounds that the existence of the ITRs, even though obsolete, had not hampered the development of international telecommunications. This point of view was put forward by many Member States with liberalised markets and it was strongly supported by European operators that would even have preferred to abrogate the ITRs without compensatory measures. For this group, the WTO "Agreement on basic telecommunications", which had been adopted many years after the ITRs, was considered a more adequate way of regulating international telecommunications.

The other group, mainly consisting of developing countries, was strongly in favour of updating the present ITRs and keeping them as a treaty-level instrument, and some even wanted to include new areas of regulation (e.g. e-commerce, IMT-2000, convergence, privacy, crime prevention and IPR). It was perceived that many developing countries wanted enlarged and updated ITRs in order to give them a stronger basis for commercial negotiations, particularly with the big international operators.

The decision of the Marrakesh PP was a hard fought compromise giving both sides the chance to claim they had got what they wanted. In resolution COM5/7 it is resolved that the Union should continue a process of reviewing the ITRs and that a world conference on international telecommunications (WCIT) be convened at the seat of the Union in 2007 or 2008. However, the convening of this conference should be made "on *the basis of the recommendations arising from this process of review*". The text that has been underlined implies that the PP-06 would have the possibility of not convening the WCIT if this is not considered necessary. A working group of the Council, open to all Member States, will be established "to study the ITRs and prepare recommendations on which provisions, if any, should be terminated, retained in the ITRs, transferred to the Constitution or Convention, or embodied in ITU Recommendations".

The group will prepare a final report, at the latest by the 2005 session of the Council, for transmission to the PP-06. The Council, after having considered this report, will make any comments it considers appropriate and transmit them with the report to the Member States and to the PP-06, including recommendations on any appropriate treaty changes, and *whether there is a need to convene a WCIT*.

5.8 Processing Charges for Satellite Network Filings

A huge backlog exists in ITU's processing of requests for satellite network filings as well as a lengthy timeframe (up to 2.5 years) for handling satellite applications. This has increased the pressure on ITU to address this issue.

Already in 1998 at the Minneapolis PP, a policy decision (Resolution 88) had been made to introduce processing charges for network filings with the aim of decreasing the processing delay within the Radiocommunication Bureau (BR). The Council followed up this decision at its 1999 session (Decision 482) by agreeing on the methodology and fee schedules. In addition, the World Radiocommunication Conference in 2000 (WRC-2000) adopted a regulatory provision on the possible cancellation of a filing in case of non-payment. However, this provision could only enter into force at a date to be decided by the Marrakesh PP.

PP-02 had long and sharp discussions on this issue. A compromise resolution was finally agreed, resolving

- that cost recovery for satellite network filings shall be implemented as soon as possible consistent with the general principles for cost recovery adopted in Resolution 91 (Minneapolis, 1998) of the PP;
- that all filings in accordance with Council Decision 482, as modified, received by BR after 7 November 1998, shall be subject to the application of cost recovery;
- that the entry into force of the provisions of the Radio Regulations referred to above shall be 1 August 2003.

The Council was also instructed to establish a group, open to all Member States and Sector Members, in order to make recommendations to the 2003 session of the Council on i.a. a possible extension of the implementation of processing charges for satellite filings to include identifiable and auditable costs incurred directly in the processing of satellite network filings.

5.9 World and Regional Telecommunication Exhibitions and Forums (TELECOM) Events

Concern was raised regarding the apparent decreasing interest among the private sector for participating in the TELECOM exhibitions. A number of Members voiced criticism against the way the budget and the selection of venues of the TELECOM exhibitions were managed. The membership advocated a larger degree of transparency and openness in the decision-making process based on objective criteria regarding the venues both for world and regional TELECOMs.

A number of countries were in favour of full cost recovery for the TELECOM events, as these are purely commercial activities and should not be covered by financial means from the general budget of the Union. The developing countries went against this idea arguing that full cost recovery would generate less surplus income and this would reduce the transfer of surplus from TELECOM events to development projects in the D-Sector. Unfortunately, the principle of full cost recovery was not adopted.

The PP resolved the issue by passing a resolution reflecting the wish of increased transparency in the decision-making process to select the venues of world and regional telecom events. The Council will have a stronger oversight role in the financial affairs of future ITU Telecoms activities, including the review and approval of the telecom accounts after examining the report of the internal and external auditors of the Union.

5.10 WTPF – World Telecommunication Policy Forum

The WTPF has been convened three times since it was established in Kyoto in 1994 as a forum for policy-makers to discuss and exchange views and information in order to create a shared vision on major policy issues. The PP resolved to maintain the forum to discuss and exchange views and information on telecommunication policy and regulatory matters, especially on global and cross-sectoral issues. It recommends that it should not be held during the present cycle 2004 – 2007.

5.11 Stable Election Procedures

So far each PP has had the sovereign right to establish and adopt procedures to be followed for the election of elected officials, members of the Council and members of the RRB, including the right to decide on the deadline for the deposit

Einar Utvik at the Norwegian reception of candidatures for the elected posts, the Council and the RRB, and to decide when the actual elections should take place. This has always caused a lot of debate and has consumed valuable time from the conference.

The PP-98 in Minneapolis decided that the ITU Council should develop draft stable procedures for the election of Member States to the Council, elected officials and members of the RRB. A Council Working Group developed draft stable election procedures which were submitted to the PP-02 for consideration. In addition, the CEPT countries had tabled an ECP proposing that the deadline for the announcement of candidatures should be at least two months prior to the opening date of the conference, and that all the elections should be held in the first week of the conference.

There was no disagreement that a stable election procedure is needed for ITU in order to increase the time available for delegates to deal with the substantive issues of the Union. The PP-02 agreed on stable election procedures which will form a separate chapter (Chapter III Election procedures) in "General rules of conferences, assemblies and meetings of the Union". The new agreed provisions lay down that submission of candidatures must reach the Secretary-General within 28 days prior to the conference, and that elections shall start on the ninth day of the conference. These new procedures will be applied for the first time at the next PP in 2006.

5.12 Observers

Provisions on observer status are dispersed in the ITU instruments and the conditions under which observers are admitted and their rights and obligations are far from clear and sometimes seem to be in contradiction. Furthermore, the WGR (Council Working Group on Reform) recommended that Sector Members be given observer status in meetings of the Council and that the advisory groups should develop criteria for the selection of Sector Member representatives.

The CEPT countries had submitted an ECP recommending the establishment of a Council WG to study the matter with a view to consolidating all provisions related to observers in order to get a clear understanding of their rights and obligations. The ETNO members supported the ECP and underlined that all provisions regarding observers should be studied, including those relating to payment for observers. However, today the provisions regarding the detailed rules for observer payment are laid down in the Financial Regulations which are approved by Council (i.e. by the Member States only)!

The PP adopted a resolution (Res COM5/2) recommending that Council set up a working group to study the possible consolidation of all provisions relating to observers. This Council WG will report to Council 2004. The Resolution also instructs the Council that Member States observers at the Council should be allowed to submit contributions to the Council and that they should be allowed, on a provisional basis, to address the meeting when invited by the Chairman of the Council. Many European countries were against this idea, as they feared it might complicate discussions among Council Members.

The Resolution instructs the Council to implement on a provisional basis the recommendations from the Council WG regarding the admission of Sector Members as observers at meetings of the Council.

5.13 Sector Member's Payment as Observers

Sector Members may also be observers at a Plenipotentiary Conference without the authorisation from their administration. For observers at the PP-02 , new provisions lay down that a Sector Member being observer at the PP would have to share in defraying the expenses of the Union.

The system for arriving at the cost of participation of Sector Members being observers at the PP is laid down in the Financial Regulations adopted by Council. The cost is arrived at by dividing the budget of the PP by the number of Member States contributory units. The price of attending as observer at the PP-02 was CHF 14,000. No wonder that only six Sector Members worldwide chose to be present as an observer! It should also be noted that in the Secretary-General's invitation letter to the Sector Members to attend the PP-02 as observers, no reference is made to the actual payment of the observers. This was later disclosed in PP-doc No 50!

5.14 World Summit on the Information Society (WSIS)

The WSIS was launched by Resolution 73 of the Minneapolis PP, 1998. The UN General Assembly endorsed this resolution and described the purpose of the Summit as being the "development of a common vision and understanding of the information society and the adoption of a declaration and plan of action for implementation by governments, international institutions and all sectors of civil society". It has been decided that the Summit would be held under the patronage of the UN Secretary-General, with ITU taking the lead role in preparations. The WSIS is to be held in two sessions, the first in December 2003 in Geneva and the second one in Tunisia in 2005.

Long discussions took place on what should be the input of ITU to the WSIS Declaration of Principles and Plan of Action. The results of these discussions can be found in Decision PLEN/1, "ITU input to the declaration of principles and plan of action of the WSIS and the information document on ITU activities related to the Summit" and in Resolution PLEN/7 entitled "World Summit on the Information Society".

The important parts of Decision PLEN/1 are found in the two annexes. Annex 1, which is to be forwarded to the WSIS Working Group of the ITU Council, contains a framework that should serve as a guideline for further elaboration of ITU's substantive input to the WSIS declaration and plan of action. In this framework, three broad objectives have been identified:

- Providing access to information and communication technologies (ICTs) for all;
- ICTs as a tool for economic and social development – and meeting the Millennium Development Goals (of the UN);
- Confidence and security in the use of ICTs.

These objectives were selected having regard to the core competencies of ITU and represent areas were ITU could play an important role in efforts aimed at overcoming the digital divide and creating digital opportunities, especially for developing countries.

Annex 2 contains an information document giving an overview of ITU and its role in the information society. This is to be submitted to the second meeting of the WSIS PrepCom.

Resolution PLEN/7 instructs the Secretary-General i.a. to make every effort to perform the leading managerial role of ITU, to strengthen cooperation with other UN organisations as well as UN projects in the WSIS preparatory process and to ensure effective allocation of the financial resources for the preparations for the Summit. All this should be done "within available financial resources".

The Marrakesh Conference did not fix any amount of financial contribution from the ITU, and so far the financial resources available are far from adequate. The estimated cost of the WSIS is in the order of 11–12 mill. CHF, while so far only around 1 mill. has been pledged. With the first session only one year ahead, one of the biggest challenges for the organising committee is therefore to mobilise the necessary financial resources for the Summit.

For the private sector it is also not obvious what is in it for us. The WSIS is a high-level political event, and it could certainly contribute to a global awareness of the challenges we are facing in the creation of the information society. However, there is probably a very long way to go from the declaration of principles to the creation of commercial opportunities that may engage the private sector in projects and joint ventures that can help bridging the digital divide and create digital opportunities for all.

5.15 Strengthening ITU's Regional Presence

For many years there have been discussions within the ITU about the strengthening of ITU's regional presence. This means that the ITU's field offices in Latin America, Africa, Asia and Eastern Europe must be expanded and run more efficiently, but also that closer ties should be developed with regional and subregional organisations.

There was a clear majority in favour of enhancing ITU's presence in the regions, so it was easy to obtain agreement on the revision of Resolution 25 from Minneapolis, 1998 (which was itself a revision of Resolution 25 from Kyoto, 1994).

In the revised resolution, it was again affirmed that a strong regional presence is important in order to enable the ITU to work as closely as possible with its Member States and Sector Members, improve the dissemination of information on its activities and develop close ties with regional organisations. It was resolved i.a. that a better balance of work should be achieved between headquarters and the regional offices and that the latter should be provided with greater autonomy in terms of both decision-making and addressing the crucial needs of Member States in the region. The regional offices should, in coordination with ITU headquarters, take measures with a view to supporting pilot projects for the implementation of e-services/applications, analysing and disseminating their results and managing their further adaptation and development within the region. They should also develop a suitable and sustainable business model that will result in private-sector participation and assist in the determination of an appropriate technology to meet the needs and requirements of rural populations.

Although both the Secretary-General and the BDT Director (in close collaboration with the Directors of the two other sectors) were instructed to take the necessary measures for further strengthening the regional presence, no concrete figures can be found in the resolution, e.g. in terms of increasing the staff in the regional offices. Committee 6 did consider the need for an equivalent of 12 P3 staff (4 for the Africa Region and two for each of the other Regions) to cover professional and support staff requirement in the Financial Plan for 2004–2007, but this was for budget evaluation purposes only, and when we consider all the reductions (also in number of staff) necessary for balancing the final Financial Plan, it may seem difficult for ITU-D to carry through the measures needed for expanding and empowering the regional and area offices, at least in the coming four-year period.

5.16 Radio Regulations Board (RRB)

The RRB consists of 12 elected members that fulfil the requirements of their positions on a part-time basis. The Board's main task is to approve Rules of Procedure, which include technical criteria, in accordance with the Radio Regulations and with any decision which may be taken by competent radiocommunication conferences. The Rules of Procedure shall be used by the Director and the Radiocommunication Bureau (BR) in the application of the Radio Regulations to register frequency assignments made by Member States.

PP-02 added a new task to those already performed by the RRB. At the request of one or more of the interested Administrations, it shall, independently of the BR, consider appeals against decisions made by the BR regarding frequency assignments.

There was a long debate whether the RRB members should continue to work on a part-time basis, and whether they should be granted the same privileges and immunities as the elected officials. PP-02 finally decided that RRB members shall, while in the exercise of their duties for the Union, or while on mission for the Union, enjoy functional privileges and immunities equivalent to those granted to ITU's elected officials. They shall continue to perform their duties on a part-time basis.

Several RRB members have complained that they lack adequate logistical support for the performance of their duties. PP-02 therefore urged each Member State nominating a member of the RRB to provide the necessary logistical support, such as computer hardware and software, to the member of the RRB it has nominated, except that, in the case of developing countries where such logistical support is not available from Member States, it shall be provided by the Union. Further, all Member States were called upon to provide all necessary assistance and support to the members of the RRB individually, and the Board as a whole, in carrying out their functions, and the Secretary-General was instructed to make available the necessary facilities and resources for the members of the RRB in conducting their meetings.

Ingunn Yssen, Senior Gender Adviser, BDT

5.17 Gender Mainstreaming in ITU

The initiative to introduce gender perspective as a new element in activities of the ITU, was taken by the Development Sector (ITU-D) at the World Telecommunication Development Conference (WTDC) in Valletta, 1998. PP-98 (Minneapolis) followed up this initiative by resolving to establish a task force on gender issues (TFGI). PP-98 also decided to incorporate a gender perspective in the implementation of all programmes and plans of ITU. WTDC-02 (Istanbul) decided to convert the TFGI into a permanent Working Group on Gender Issues, still in the ITU-D.

PP-02, in endorsing WTDC-02 Resolution 44 on mainstreaming gender in ITU-D programmes, decided that this should be done with regard to all ITU activities. It was further resolved to continue the work being done in BDT to mainstream and advance the gender perspective through ICT programmes that improve the socio-economic conditions for women, particularly in developing countries. High priority shall be given to the incorporation of gender policies in the management, staffing and operation of ITU and a gender perspective shall be incorporated in the implementation of the ITU strategic and financial plan for 2004–2007 as well as in the operational plans of the three Sectors and the General Secretariat.

Norway had taken an initiative early in 2002 to provide a Senior Gender Adviser to the BDT in an effort to assist ITU in carrying out its mandate for gender mainstreaming in ITU-D. Ms Ingunn Yssen, ex-director of the Norwegian centre for gender equality, was appointed to this post and started working for BDT on 1 September 2002. In addition, it was proposed that a gender unit should be created in the General Secretariat with senior full-time professional gender expertise and full-time administrative support. Although most delegations were favourable in principle to the establishment of such a unit, many were of the opinion that close consideration had to be given to the state of the Union's finances before a unit was created. The agreed text in the final version of the relevant resolution is "to consider creating, within the available financial resources, a gender unit in the ITU General Secretariat". Keeping in mind the reductions that had to be made to balance the budget, there is probably no chance that such a unit will be established in the coming four-year period.

PP-02 also encouraged all Member States and Sector Members to facilitate the employment of women and men equally in the telecommunication field including at senior levels of responsibility in the telecommunication administrations, government and regulatory bodies and intergovernmental organisations and in the private sector. Administrations were invited to give equal opportunities to male and female candidatures for elected official posts and for membership of the RRB.

During the PP a special session on Gender Issues was organized under the chairmanship of Ms Eva Hildrum, Norway. The event was addressed by HE Mr. Nasr Hajji, Morocco, Chairman of the conference, who showed a particular interest for these issues. Other panellists were Ms Iris-Marie Struiken-Wijdenbosch of Surinam and Ms Ingunn Yssen, the newly appointed BDT Senior Gender Adviser.

5.18 Special Measures Concerning Alternative Calling Procedures on International Telecommunication Networks

This issue was on the agenda already at the PP-94 in Kyoto, and the discussions resulted in Resolution 21 which was revised and re-issued by PP-98, Minneapolis, and which urged Member States to cooperate among themselves to resolve difficulties in order to ensure that national laws and regulations of ITU Member States are respected.

The reason for this issue being still on the agenda of the PP, is that many developing countries fear that the use of alternative calling procedures (including call-back and refile) may adversely affect their economies and may seriously hamper the efforts they make to ensure the sound development of their telecommunication networks and services. Consequently, as at October 2002, 106 Member States had notified the Telecommunication Standardization Bureau (TSB) that call-back is prohibited on their territory. ITU-T SG 2 has also concluded that certain alternative calling procedures such as constant calling (or bombardment or polling) and answer suppression seriously degrade the quality and the performance of the PSTN.

On the other hand, it is acknowledged that, in some cases, the use of alternative calling procedures may contribute to competition in the interest of consumers.

The result of the discussions at PP-02 was a revised Resolution 21 which resolved to encourage administrations and international telecommunications operators to implement the relevant ITU-T Recommendations in order to limit the negative effects that, in some cases, alternative calling procedures have on developing countries. Further, administrations and international operators which permit the use of alternative calling procedures on their territory in accordance with their national regulations, are requested to pay due regard to the decisions of other administrations and international operators whose regulations do not permit such services

5.19 Support for Regional Initiatives

Through two resolutions PP-02 expressed its wholehearted support for two regional initiatives

- the New Partnership for Africa's Development (NEPAD); and
- the Agenda for Connectivity in the Americas and Quito Action Plan.

5.19.1 NEPAD

NEPAD is a new African initiative where African leaders make a commitment to eradicate poverty in the continent and to place African countries, both individually and collectively, on a path of sustainable growth and to accelerate the integration of the African continent into the global economy. NEPAD is a comprehensive integrated development plan that addresses key social, economic and political priorities in a coherent and balanced manner. It has been endorsed widely by global and regional organisations, including the United Nations, the World Bank and the European Union.

In the infrastructure area, one of the goals of NEPAD is to bridge the digital divide through heavy investments in ICTs. This has been endorsed by WTDC-02, Istanbul, which stressed the need to support regional ICTs for development initiatives, such as NEPAD and the Connectivity Agenda initiative of Latin America. PP-02 instructed the BDT Director to pay particular attention to implementation of the provisions of the ITU-D Action Plan relating to support for NEPAD, earmarking resources so that this can be permanently monitored. It further requested the Secretary-General to release appropriate financial resources for activities to support NEPAD, in particular from the surplus on ITU world telecommunication exhibitions and forums (TELECOM).

5.19.2 Agenda for Connectivity in the Americas

The "Agenda for Connectivity in the Americas and Quito Action Plan" was established by CITEL in accordance with a mandate handed down by the Heads of State and Government of the Americas. It has been developed in accordance with the following principles:

- Each country should develop a national vision and an agenda for connectivity;
- National connectivity agendas must be conceived and executed with the active and ongoing participation of government and civil society, including the private sector;
- National connectivity agendas should be developed around three fundamental components: infrastructure or access, applications for the use of infrastructure, and high-quality content to be delivered via the infrastructure;
- Recognition of the importance of promoting the development of national and regional content to promote countries' respective cultural identities; and
- Ongoing monitoring and performance measurement of elements of the connectivity agenda.

As for NEPAD, WTDC-02 had given full support to the "Agenda for Connectivity" and PP-02 followed up by instructing the Secretary-General to release appropriate financial resources to support and stimulate the implementation of projects relating to the "Agenda", particularly by mobilising the surplus income from TELECOM. The BDT Director was instructed to pay particular attention to implementation of the provisions of the Istanbul Action Plan relating to the initiatives under the framework of the "Agenda for Connectivity" and to provide appropriate support to the Member States in this regard through the ITU Regional Office for the Americas, and to help identify additional financial resources that could supplement those assigned by ITU for supporting the development of all related projects in the Americas region.

5.20 Assistance to Countries in Special Need

As usual at plenipotentiary conferences, also PP-02 decided on assistance to countries that have special needs in the telecommunications sector. This time the countries concerned were the Federal Republic of Yugoslavia, Afghanistan and Bosnia and Herzegovina.

For Yugoslavia the assistance will be provided to support the country in rebuilding its public broadcasting and telecommunication systems. This is in recognition of the fact that the public broadcasting facilities in the Federal Republic of Yugoslavia have been severely damaged and that under the present circumstances and in the foreseeable future the country will not be able to bring its public broadcasting system up to an acceptable level without help from the international community, provided bilaterally or through international organisations. PP-02 also calls upon all Member States to offer all possible assistance and to support the Government of the Federal Republic of Yugoslavia, either bilaterally or in coordination with, the special action of ITU.

As regards Afghanistan, PP-02 recognises that, as a result of the past 24 years of war in the country, the telecommunication system has been destroyed and needs urgent attention for its basic reconstruction. In the same way as Yugoslavia, Afghanistan, as a war-torn country, will not be able to rebuild its basic telecommunication infrastructure, which is vital for the social and economic reconstruction of the country, without the assistance and comprehensive support of the international community. It was therefore resolved to initiate special action within the framework of ITU-D, with specialised assistance from ITU-T, in order to provide appropriate assistance to the Government of Afghanistan in rebuilding its telecommunication system. All Member States are called upon to offer all possible assistance and support to the country, either bilaterally or through the special action of the Union.

Special assistance to Bosnia and Herzegovina has already been provided by ITU for several years, based on resolutions from PP-94 (Kyoto) and PP-98 (Minneapolis), and considerable progress has been made in rebuilding the country's telecommunication sector. However, the telecommunication system is not yet at an acceptable level, and to achieve this, Bosnia and Herzegovina will still need help from the international community. PP-02 therefore resolved that the plan of action initiated after the Plenipotentiary Conferences of Kyoto (1994) and Minneapolis (1998) should be continued in order to provide appropriate assistance and support to Bosnia and Herzegovina in rebuilding its telecommunication network and to its Telecommunication Regulatory Authority. Member States are encouraged to offer all possible assistance and support to the country.

5.21 Assistance and Support to the Palestinian Authority

The question of special assistance to the Palestinian Authority has always been a delicate one, mainly because the question has been coupled with the sensitive issue of the political relations between the Palestinian Authority and the State of Israel. In Marrakesh, all conflicting issues were settled outside the meetings, and consequently it was easy to obtain consensus on a resolution which implies that the plan of action initiated after the PP-94 (Kyoto) shall be continued and enhanced.

PP-02 notes that ITU's policy of assistance to the Palestinian Authority for the development of its telecommunication sector has been efficient, but it has not yet fulfilled its goals, due to the prevailing situation. ITU will continue to provide assistance and support to the Palestinian Authority in rebuilding and developing its telecommunication infrastructure, re-establishing institutions for the sector, developing telecommunication legislation and a regulatory framework, including a numbering plan, spectrum management, tariff and human resources as well as all other forms of assistance. Member States are called upon to facilitate the establishment by the Palestinian Authority, at the earliest date, of its own international gateway networks, including satellite earth stations, submarine cables, optical fibres and microwave systems and to assist it in recovering its entitlements accruing from incoming and outgoing international traffic. The ITU Council is invited to allocate the necessary funds within available resources for the implementation of this resolution.

5.22 Future Conferences and Meetings

The conference agreed on the following main conferences and assemblies of the Union to be held up to the next PP in 2006:

- World Telecommunication Standardization Assembly (WTSA-04), Brazil, October 2004;
- Regional Radiocommunication Conference, first part (RRC-04), Geneva, 10–28 May 2004;
- Regional Radiocommunication Conference, second part (RRC), Geneva, late 2005;
- World Telecommunication Development Conference (WTDC), early 2006;
- Plenipotentiary Conference (PP-06), second half of 2006;
- World Radiocommunication Conference (WRC-07), first half of 2007.

It was decided that the duration of the next PP in 2006 should be reduced by one week, and PP-06 will last for three weeks. It should be noted that the next WRC (following the WRC in 2003, Geneva) will be held in 2007. Venues and exact dates of the PP-06 and the WRC-07 will be decided by the Council at its 2004 session.

6 Entry into Force

The amendments to the Constitution and the Convention signed during the PP in Marrakesh will come into force on 1 January 2004 between Member States being at that time parties to the Constitution and the Convention of the ITU 1992 and having deposited before that date their instrument of ratification of the present amending instrument.

Acronyms

mP	micro-Processor
3GPP	Third Generation Partnership Project
API	Application Programming Interface
AVI	Automatic Vehicle Identification
AEI	Automatic Equipment Identification
ARIB	Association of Radio Industries and Businesses
ASR	Automatic Speech Recognition
BDT	Telecommunication Development Bureau
BR	Radiocommunication Bureau
CAD	Computer Aided Design
CALM	Continuous Air interfaces Long and Medium range
CcTLD	Country code Top Level Domain
CCTV	Command and Control Training Vehicle
CDLC	Connected Limited Device Configuration (Java 2 Micro Edition)
CEPT	Conférence européenne des Administrations des Postes et Télécommunications
CITEL	Inter-American Telecommunication Commission
CME	CALM Management Entity
CPA	Content Provider Access
CPU	Central Processing Unit
CRM	Customer Relationship Management
CS	(ITU) Constitution
CV	(ITU) Convention
DAB	Digital Audio Broadcast
DVB	Digital Video Broadcast
DVD	Digital Video Disc
ETNO	European Telecommunication Network Operators’ Association
ETSI	European Telecommunications Standards Institute
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
GUI	Graphical User Interface
HLC	High Level Committee
HTTP	Hyper Text Transport Protocol
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Engineering
IGO	Inter-Governmental Organisation
IN	Intelligent Networks
IP	Internet Protocol
IPv6	Internet Protocol Version 6
ISDN	Integrated Services Digital Network
ISP	Information Service Provider
IT	Information Technology
ITRs	International Telecommunication Regulations
ITU	International Telecommunication Union
ITU-D	Telecommunication Development Sector
ITU-R	Radiocommunication Sector
ITU-T	Telecommunication Standardization Sector
IVR	Interactive Voice Response
J2EE	JAVA 2 Enterprise Edition
J2ME	JAVA 2 Micro Edition
JARTIC	Japan Road Traffic Information Center
JWT	Java Wireless Toolkit
JXTA	Juxtapose
LAN	Local Area Network
LIM	Linear Induction Motor

MEMS	Micro-Electromechanical Systems
MMS	Multimedia Message Service
MIDP	Mobile Information Device Protocol (Profile)
MS	Member States
NEPAD	New Partnership for Africa’s Development
NITU	Nordic ITU Cooperation
OLT	Open Land Mobile Telephone Service
ORSE	Organisation for Road System Enhancement
PCS	Personal Communications System
PDA	Personal Digital Assistent
POI	Point Of Interest
PP	Plenipotentiary Conference
PPP	Public Private Partnership
PROM	Programmable Random Access Memory
PSTN	Public Switched Telephone Network
RAG	Radiocommunication Advisory Group
RDA	Remote Data Access
RF	Radio Frequency
RR	Radio Regulations
RRB	Radio Regulations Board
RRC	Regional Radiocommunication Conference
RTD	Real Time Driver
SAP	Service Access Point
SDK	Software Development Kit
SG	Study Group
SIM	Subscriber Identity Module
SM	Sector Members
SME	Small and Medium-sized Enterprises
SMR	Specialised Mobile Radio
SMS	Short Message Service
SOAP	Simple Object Access Protocol
TDAG	Telecommunication Development Advisory Group
TETRA	Terrestrial Trunked Radio
TFGI	Task Force on Gender Issues
TSAG	Telecommunication Standardization Advisory Group
TTP	Trusted Third Party
TTS	Text-To-Speech Synthesis
UDDI	Universal Description, Discovery And Integration
UML	Unified Modelling Language
UMTS	Universal Mobile Telecommunications System
UN	United Nations
URL	Universal Resource Locater
UTRA TDD	UMTS Radio Access Network Time Division Duplex
VAS	Value Added Services
VPN	Virtual Private Network
VSC	Vehicle Safety Consortium
W3C	World Wide Web Consortium
WAP	Wireless Access Protocol
WATTC	World Administrative Telegraph and Telephone Conference
WCIT	World Conference on International Telecommunications
WG Plen	Working Group of the Plenary
WLAN	Wireless LAN Access Network
WRC	World Radiocommunication Conference
WSDL	Web Services Description Language
WSIS	World Summit on the Information Society
WTDC	World Telecommunication Development Conference
WTO	World Trade Organization
WTSA	World Telecommunication Standardization Assembly
XDSL	X Digital Subscribe Line
XML	eXtensible Markup Language

Expressions

APM	Automatic People Mover	APM is an automatic solution to personal transportation. Modern trains are moving automatically and intelligently on rails with no need of an active driver. www.geocities.com
CEN	Comité Européen de Normalisation (French)	European committee for standardization. CEN's mission is to promote voluntary technical harmonization in Europe in conjunction with worldwide bodies and its partners in Europe. www.cenorm.be
DSRC	Dedicated Short Range Communications	A wireless communications channel used for close-proximity communications between vehicles and the immediate infrastructure. It can support location-specific communications for services such as toll collection, transit vehicle management, driver information, and automated commercial vehicle operations. http://www.itsa.org/
EFC	Electronic Fee Collection	Fee collection by electronic means, e.g. based on smart cards or electronic tags. (Road Transport Informatics Terminology)
ELVEG	An Electronic Road Map	ELVEG is an electronic roadmap that covers the Norwegian road infrastructure, and in particular designed for fleet management applications and route planning services.
ETC	Electronic Toll Collection	Toll collection by electronic means, e.g. based on smart-cards or electronic tags. (Road Transport Informatics Terminology)
GPS	Global Positioning System	The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters.
ISO	International Standardisation Organization	The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from more than 140 countries, one from each country. ISO is a non-governmental organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity. http://www.iso.org/
ITS	Intelligent Transport Systems	Intelligent Transport Systems and Services (ITS) describes any system or service that makes the movement of people or goods more efficient and economical, thus more "intelligent". www.ertico.com

LRT	Light Rail Transit	Light Rail Transit is lightweight passenger rail cars operating singly (or in short, usually two-car trains) on fixed rails in right-of-way that is not separated from other traffic for much of the way. Light rail vehicles are driven electrically with power being drawn from an overhead electric line via a trolley or a pantograph. Also known as "streetcar", "tramway", "trolley car". www.apta.com
MCP	Multimedia Car Platform	MCP provides the specification of an open multimedia car platform in a heterogeneous network and service environment. The MCP project is built on results and achievements of the two predecessor projects MEMO (Multimedia Environments for Mobiles) and MOTIVATE (Mobile Television and Innovative. MCP was launched in January 2000. MCP brings together a number of car and receiver manufacturers, network operators and research institutes. http://www.aramis-research.ch/e/7229.html
OBU	On-Board Units	Any electronic or other equipment intended to deliver ITS services situated on a vehicle; also called In-Vehicle Equipment (IVE) http://www.ivsource.net/
OEM	Original Equipment Manufacturer	Originally OEM was an adjective used to describe a company that produced hardware to be marketed under another company's brand. Mitsumi, for example, produced CD-ROM drives that dozens of companies would label as their own. It is often now used as a verb, as in this sentence: "This CD-ROM drive is OEM'd by Mitsumi." http://www.cnet.com
PRT	Personal Rapid Transit	PRT (– Personal Rapid Transit) is a known comprehensive solution to personal automatic intelligent transit. PRT is small, fully automated vehicles designed to carry 1–6 persons on a reserved guideway with off-line stations. The vehicles are available 24 hours a day for exclusive use by an individual or a small group travelling together by choice. The guideways can be located above ground, at ground level or underground and the vehicles are able to use all guideways and stations on a fully coupled PRT network. PRT is a direct origin to destination service, without the necessity to transfer or stop at intervening stations. The service is available on demand rather than on fixed schedules. http://faculty.washington.edu/~jbs/itrans/PRT/Background.html
RTTT	Road Transport and Traffic Telematics	A Technical Committee (CEN/TC 278) responsible for ITS study items under CEN. Standardization in the field of telematics to be applied to road traffic and transport, including those elements that need technical harmonization for intermodal operation in the case of other means of transport. It shall support: vehicle, container, swap body and goods wagon identification; communication between vehicles and road infrastructure; communication between vehicles; vehicle-man-machine interfacing as far as telematics is concerned; traffic and parking management; user fee collection; public transport management; user information. http://www.cenorm.be/standardization/tech_bodies/cen_bp/resources/a278.pdf

SPIDER	An Advanced Route Planning Tool	SPIDER was started as a development project between Telenor Mobile Communications and SINTEF for Applied Mathematics with support from the Norwegian Research Council in 1997 to find the shortest route between several destinations. SPIDER is a generic C++ class library, providing functionality for transport planning and optimisation. The main functionality of Spider Planner is to allocate orders to vehicles in such a way that the total cost is as small as possible. It is in use for route planning within a number of companies with goods transport fleets. A spin-off company of SINTEF, Green Trip AS (www.greentrip.no), has the distribution and further development of SPIDER as its business idea.
TGV	Train a Grande Vitesse (French)	The TGV high speed trains are owned and operated by the "Grandes Lignes" unit of SNCF (Société Nationale des Chemins de Fer Français), the French national railways. The tracks they run on are owned and operated by RFF (Réseau Ferré de France). It can refer to the trains, it can refer to the high speed lines, it can refer to the entire French high speed rail system. http://www.trainweb.org/tgvpages/faq.html
TICS	Transport Information and Control Systems	ISO/TC204 Standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the transport information and control systems (TICS) field. http://www.sae.org/technicalcommittees/tc204.htm
ULTRA	Urban Light Transit	A personal automatic taxi to provide on-demand driverless travel – using its own guideway network. A new solution for transport in cities, airports and special applications worldwide. First operation with paying passengers is projected for 2005. www.atsltd.co.uk
VICS	Vehicle Information and Communications System	A system that processes and edits information about traffic congestion, road control, and other dynamic traffic information, and transmits it in real time to travellers in words and graphics, to navigation devices installed in vehicles. http://www.vics.or.jp/eng/index.html
VMS	Variable Message Signs	VMS can be used to inform motorists of changing traffic conditions and other related information. These signs will enable drivers to make informed decisions as to which route(s) to take. www.azfms.com/About/vms.html