Does Mobile Broadband Meet Users' Needs?

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This article concerns the roles that human issues and psychology play in technical development. An 'MBB (Mobile Broadband) staircase' model helps reveal different stages where users may have problems using MBB. It is emphasised that the users who are particularly unable to have their needs met with MBB are those that struggle with technology in general. Difficulties with MBB do not hit 'technology achievers' as hard, as they can usually make it work after some effort. However, a lot of what may be learned from studying 'technology strugglers' can benefit the 'technology achievers' also. Indeed, it is argued that all people, regardless of their aptitude with technology, are faced with problems at some levels of the 'MBB staircase'. This is because new technologies must adapt to the 'old brains' of users, because human evolution has not prepared us for using telecommunication services such as MBB.

It is possible to improve MBB by better understanding the behaviour and needs of users. By including a psychological perspective this article emphasises that users have both conscious and unconscious behaviours which need to be taken into account. We address elements concerned with usability (such as the user interface), technical parameters that need to be optimised (such as end-to-end delay) and how this can really be a help for those that are developing the services and technology for users.

1 Introduction

In 2004 UMTS (Universal Mobile Telecommunications System) was launched with what was then considered a fantastic theoretical downstream speed of 384 kbps (ie. from the network to the user) and 64-128 kbps upstream. Laptop PCs with PC cards were available for using UMTS. However, the users were disappointed with the speed. At that point in time, very few people thought that within the foreseeable future it would be possible to read email and browse Internet on a laptop almost everywhere. This is now possible in the Nordic countries where today MBB operators already have services with response times judged by users as typically being somewhere between 'acceptable' and 'very good'.

Running an MBB (Mobile Broadband) operation requires a lot of people with different technological skills. The implementations of the services made for end-users are dependent on an ability to understand what users need and how this can be achieved. Usually, the important priority is to make MBB work. MBB is a very complicated system. To have it work is a huge achievement and it is understandable that user aspects may have had a lower priority.

This article is about users who try to use services with different levels of success because their needs have not yet been fully understood and catered for by service design. Human behaviour is complex and involves the interplay of both conscious and unconscious factors. Humans have evolved to interact socially with each other and to succeed in a physical environment. Interacting with complex systems like MBB and with other people through MBB is not so familiar to us. There can be many mismatches between what we expect both consciously and unconsciously and what interface design and system behaviour provides.

For example, when watching TV news people may not consciously detect an asynchrony between the video and audio but may judge the newsreader more negatively than when the video and audio are synchronous. When lip-asynchrony is detected from time to time the TV companies often receive many complaints from viewers. As another example, people are more likely to be stressed in a videoconference situation when the framerate drops from 25 fps (frames per second) to 5 fps even though they may be too occupied to consciously detect the drop in frame-rate.

In this article we especially talk about the mature Nordic market, although we expect that other less-mature markets will also have these problems later on unless user-centred interventions are made.

2 The Problem Description

A reoccurring problem with information and communication technology is the difficulty of knowing enough about the users of the products and services. Guessing how users will experience a service is very unreliable. Different people may react differently due to different abilities or preferences. Even within

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a user group such as 'business users' there may be great variations in how people think and behave.

The large range, complexity and speed of evolution of communication services make it difficult to apply theories of user behaviour. Therefore, it is usually necessary to be empirical rather than theoretical, by trying out designs and products with intended users. User tests provide results for making evidence-based product and service design decisions.

Early user tests with MBB lead us to conclude that currently many users do not succeed with MBB and many potential users are lost as customers.

2.1 User Experience is Worse than Business Leaders Believe

A survey of senior business leaders has found that 80% think their organisation delivers great user experiences, whereas only 8% of their customers agree (Bain & Company 2007).

2.2 Churn is Not Good for Business

> *"Enterprises and network providers that provide superior QoE [Quality of Experience], enjoy a significant competitive advantage, whilst companies that ignore the importance of QoE may suffer unnecessary costs, lost revenue and diminished market perception"* (Soldani et al. 2006, p.xiv)

The concept of QoE is relatively new and extends beyond usability (Hestnes et al., 2009; Brooks and Hestnes, in press).

Soldani et al. also report that for customer churn:

- 82% of customers churn due to frustration over the product or service;
- 90% of customers do not complain before churning;
- 1 frustrated customer tells 13 others about the bad experience;
- For each that calls with a problem, 29 never call.

Therefore, there may be a negative chain-reaction and a supplier cannot rely on customer feedback in order to correct mistakes – it will probably be too late. Thus, user test data before going to market and good user experience after purchase is critical for customer retention and having a good image for gaining new customers.

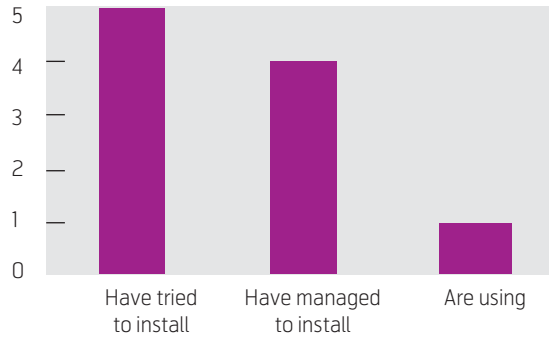

Figure 1 The 5:4:1-tendency

2.3 People are Not Using the Services that They Say They Need

MBB aims to provide asymmetric communication everywhere, anytime with higher and higher speed where coverage exists. Typical applications are Mobile-TV, surfing, and email reading. First generation, HSPA (High Speed Packet Access), is not really built for interactive symmetric services. For example, real-time person-to-person communication, like telephony, audio-conferencing and videoconferencing will not really be the ideal services for that technology.

But new applications and services are offered and, although market studies show that users have a need for them, they are not being used to the extent predicted. We have found that a lot of users do not install (or configure) their terminal for the services that are available. Some of those that try to install an MBB service do not succeed. Also, of those people that do successfully install, just a low percentage use it (Figure 1). From internal surveys, we see that there is often a 5-4-1 ratio between those that:

- Try to install and do not succeed (5 times those that use),
- Are able to install and do not use (4 times those that use).

Why this is the case is not yet understood.

3 Who are the Users?

Many users have a poor notion of exactly what MBB is. It could be the WLAN (Wireless Local Area Network) they are using at home, at an airport or hotel. It could also be HSPA like first generation of HSDPA 3.6 (High Speed Downlink Packet Access with theoretical maximum downstream speed of 3.6 Mbps), HSDPA 7.2 (HSDPA with theoretical maximum downstream speed of 7.2 Mbps) or HSUPA (High Speed Uplink Packet Access). For most users, MBB is a means to access Internet wirelessly. In this article, we are more focused on the mobile technologies (HSPA and its successors (HSPA+ and LTE (Long Term Evolution))). WLAN technology is not our main focus as they are nomadic technologies.

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3.1 What do Users Need?

The typical Norwegian MBB users (Ipsos 2009) are:

- Males between 30-50 years of age,
- Married/cohabitant,
- Paying the bill themselves,
- With fixed broadband at home.

They typically use MBB one hour each day for:

- Business related work,
- Reading email,
- Net-banking,
- Social media (eg. Facebook).

From our work in Denmark we have found the most important needs to be:

- Coverage,
- Stability,
- Speed,
- Predictable pricing.

3.2 Where are the Users?

The users mainly have a nomadic use of MBB and very often at places where there are alternative networks (such as fixed broadband, LAN or WLAN). The main locations are:

- Home,
- School/university,
- Office.

From an internal survey made by the Danish mobile operator TDC in 2009 (Analyse 2009), 36% out of 1266 respondents said they wanted to use MBB in their holiday home, which is mostly summer houses. According to Telenor Norway there is a high usage of MBB in winter sports areas and other holiday home areas. In addition:

- MBB is also used on travels, such as at hotels and airports.

- We have also found that people on the move use MBB in their parked cars (such as craftsmen, salesmen and people in service businesses).

- When it comes to real mobile usage we see a recent change in behaviour on trains. There is an increasing tendency to use laptop MBB among daily commuters on medium distance trains.

3.3 Users See the Network Through Their Terminal

For a typical user, MBB is a means to access Internet, and services are associated with the applications on the terminal. Users therefore see their services through their terminals and everything in addition (like MBB) is typically not very well understood by them.

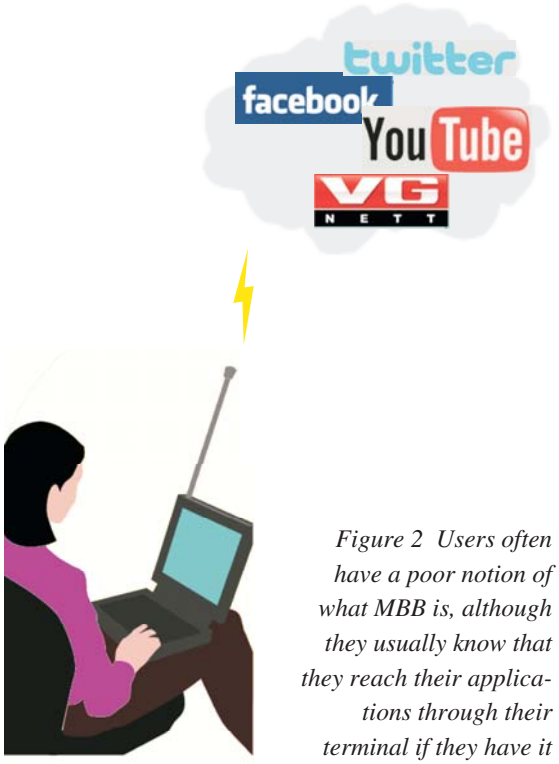

Figure 2 Users often have a poor notion of what MBB is, although they usually know that they reach their applications through their terminal if they have it

For MBB a terminal is commonly categorised by screen size:

- *None* – when there is M2M (machine-to-machine) communication,

- *Small* – when the terminal is a handset (mobile phone),

- *Large* – when the terminal is a PC (for example a laptop),

- *HD* – when the terminal is a very large screen, for example an HD-TV.

This way of categorising terminals is done to understand the typical network load from each category. There are also sub categories of each type, and the list is changing over time. The Apple iPad was launched at the time of writing this article, and is an example of something that may introduce a new category.

3.4 The MBB User Experience Staircase

For MBB we have developed the user experience staircase based on an analysis of usage problems. The staircase may also provide a checklist for those providing MBB services. In order to achieve good user satisfaction each step should be confirmed as positive, starting from the bottom and arriving at the top.

1 *Terminal not working* – If the terminal does not work because something is broken, a driver is missing or the connection manager is wrongly

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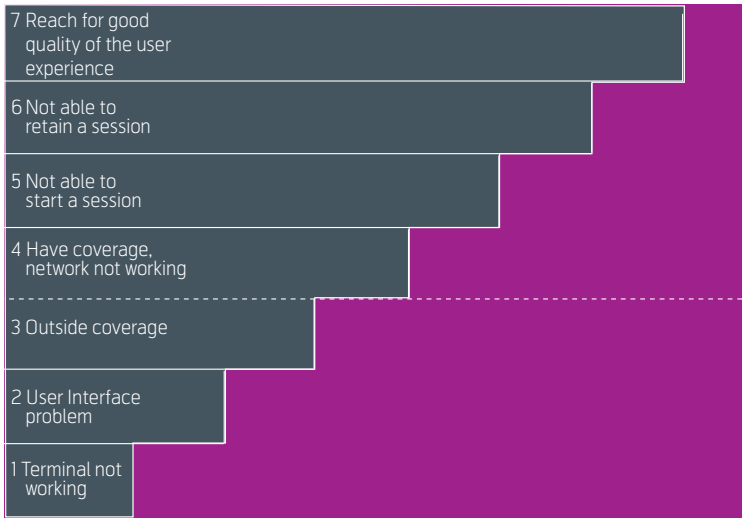

Figure 3 The MBB user experience staircase

installed, this has to be fixed before next steps have any meaning.

2 *User Interface problem* – When the terminal is working, the user needs to be able to use it, find the service, activate it and execute the needed function with an acceptable quality. For example, if the user does not know that the connection manager needs to be activated and connected to the network, it will not work. Another example is that a user may be asked to type in an Internet address but is not able to do this on a handset.

3 *Outside coverage* – The terminal is working and the user needs to be at a location where there is good enough coverage. Being at the cell edge may imply that there is too low bit-rate to be recognised as having access. Through drive-tests on a network with a median of 2 Mbps, areas have been found where there is less than 50 kbps and which give very long response times (typically more than 1 minute). Users can interpret such situations as being outside coverage.

4 *Has coverage, network not working* – If the coverage is acceptable, the network has to work to help users meet their needs. This step is the least likely to go wrong because MBB networks typically have an uptime of more than 99%.

Figure 4 A segmentation model of users on the basis of their level of success with using technology

5 *Not able to start a session* – Sometimes users must try several times to start a session and there could be many reasons for this: The server being accessed may deny the request because of overload, the information may be timed out in the network, or there may be too much packet loss.

6 *Not able to retain a session* – Even after a session has started, it can unexpectedly stop.

7 *Reach for good quality of the user experience* – When the session is up and running, it is important that the service quality is at the right level – good enough, but not unnecessarily high quality which turns out to be too expensive. Because this is assessed from a user perspective it is called QoE (Quality of Experience). The quality aspect includes both media quality (audio quality, screen resolution and distortion) and service experience (does it create enjoyment, surprise, frustration, resignation or desperation?). How to measure QoE, including what kind of scales could be used, is described in (Hestnes, Brooks, Heiestad, 2009A) and (Hestnes, Brooks, Heiestad, 2009B).

A lot of unknown problems are hidden in the three first steps (steps 1-3). There is little research in these situations, but as described in section 1, there are many usage issues for which we do not have empirical data. For example, without user tests we cannot know if people are not connecting to a service because they are struggling with their user interface or if there are other reasons. From steps 4 to 6 there is a lot of knowledge – how many times users have tried to set up a service, how long each session lasts and whether they were able to retain the whole session. At the top step there is also a lot of information for some older services and usage situations although less for newer services and usage situations. In this article we therefore concentrate on topics concerning steps 1-3 and step 7.

3.5 Types of Users

Figure 4 shows our simple segmentation model. It contrasts people who are predominantly successful with using technology and those who predominantly struggle when trying to use technology.

3.5.1 A Story from one of the 'Technology Strugglers'

Let us consider an anecdote about one of the possible 30% of people who struggle with technology based on an article in the Norwegian newspaper *Aftenposten*. A letter to the editor was highlighted because it concerned 30% of the population (Hansen, 2010). An active lady of 70+ revealed her problems with all new devices that didn't do what she would

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like them to do. Before retiring she had been the managing director of the cinemas in Oslo and she is now the chairlady for the Senior citizens network in Norway.

Mrs Hansen has a problem with most of her devices that are intended to offer a 'great step forward': Espresso machine, the car's dashboard, DAB radio, flat screen TV, mobile phone, PC, etc. She describes that she gets user manuals that should help her configure the device and get started, but they are not understandable. She writes that she gets warnings that Java is not working and does not understand at all what this means or how to get round it. When she calls the helpline or goes to a help desk, she cannot understand the technical language they are using because it is too complicated and advanced.

Related to this description are the 'friendly' pop-up windows that arrive via the Internet with no information about who sent it. The only message is to press the 'update' button. But the user does not know if this is an unfriendly virus, an aggressive sales campaign or a helpful update.

What is important here is that Mrs Hansen does feel that she needs these new devices. However, she would like to have more success with their use.

Another important point is that we believe that Mrs Hansen's descriptions are not restricted to the senior citizen population. Such stories of negative experiences could also be found in the business, male, and youth segments and even with established users. They may not be evenly spread across all segments, but they are a large group that should be taken seriously.

One reason why even 'technology achievers' would benefit from solutions for 'technology strugglers' is that many problems with using MBB will be common to us all as humans with certain expectations and limitations when using technology. This is the topic of the next section.

4 'Old Brains' and New Services

As humans, during our lifetimes there are behaviours that we automate as we learn better: We learn to read and walk without thinking; we learn to drive a car with less conscious effort. We deliberately practice behaviours so that we get better at them. For example, when playing sport or music we learn to play in a way that the physical skills are automatic so that we can concentrate on game strategy, musical style and responding to the play of others around us. These automatic behaviours become unconscious and it is normal and desirable that we make many behaviours unconscious so that we can direct our conscious attention elsewhere.

Just as individuals make behaviours unconscious, humans have evolved over time to automate much behaviour. These automatic, unconscious behaviours result from a brain that is 'hard wired' from many thousands of years of interacting with the social and physical world. For longer than the 200,000 years that *Homo sapiens* has been a species, our evolution has been based on absolute truths (Reeves & Nass, 1996) where, for instance, if something behaved socially it really was another human and if something looked liked it was moving towards us it really was. Surviving in our world encouraged automatic responses and therefore most of our social and natural responses are unconscious.

For example, we are not usually aware of our human reliance on the normal frequency and duration of head nods and speakers' lip-shape information when communicating. Artificial modification of the frequency and duration of head nods can disrupt abilities to communicate (Birdwhistle, 1970). Without lip-shape information listeners cannot tolerate as much noise interference (Summerfield, 1992) because humans automatically blend lip-shape information with heard speech in order to understand what is said (McGurk and McDonald, 1976). Therefore, technical parameters like delay, audio-video asynchrony, frame-rate and long response times can be expected to affect user experience. For example, even when people do not notice audio-video asynchrony in a TV-program, their ratings of the speaker can be negatively affected (Reeves and Nass, 1996). Although people may not notice a fluctuation between 25 fps to 5 fps in a videoconference, a physiological measure has shown that people are more stressed with 5 fps (Wilson and Sasse, 2000).

This is because brain anatomy appears to have been fixed millennia ago. Let us consider a book of human history that might be written with a proportionate space given to each human development stage. It would be a book of 201 pages in which humans are nomadic hunter-gatherers for the first 200 pages. Only on the final page would humans live in a settled agrarian society (Gardner, 2008). Only the last sentence of these 201 pages would describe the second half of the 20th Century when people start interacting with media. Therefore "Modern media now engage old brains" (Reeves & Nass, 1996, p.12).

It is therefore important when designing telecommunications enabled through MBB to understand that human communication relies on automatic, unconscious behaviours. This has implications for how we

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design a user interface and how we should optimise the behaviour of a service (such as QoS parameters of delay, asynchrony and frame-rate). There are also implications for how we should design user tests and measure user experience.

One reason why people may not notice QoS differences that still affect their behaviour is that conscious attention is very limited. If we focus on one thing, we reduce our attention to others. This is the case both for visual and auditory information. For example, if we have different speech played into each ear using stereo headphones, in order to focus on one speech we will not be able to recall what is said by the other speech and will not even notice if the language changes. Our memory of the 'now' (known as short-term memory) lasts less than 20 seconds (Peterson and Peterson, 1959) and only has a capacity for about seven items of information (Miller, 1956). So it is natural to attend to the immediate problem and forget the rest.

As well as having implications for QoS optimisation, this has implications for the design of a user interface. In particular, designers should expect users to focus on particular aspects of a user interface and potentially exclude, and therefore miss, other parts. For example, in the MBB Connection Manager user interface shown on Figure 5 it can be expected that first-time users with experience of WLAN Internet access will focus their attention on the bar chart graphic. This is because they have already learned to use a similar graphic for confirmation of Internet connection and strength with WLAN. On getting affirmative feedback (because the bar-chart appears to confirm connection strength) we can expect users to be moved straight on to their main task, such as go to their email application or Internet browser. They would therefore probably miss the 'connect' icon

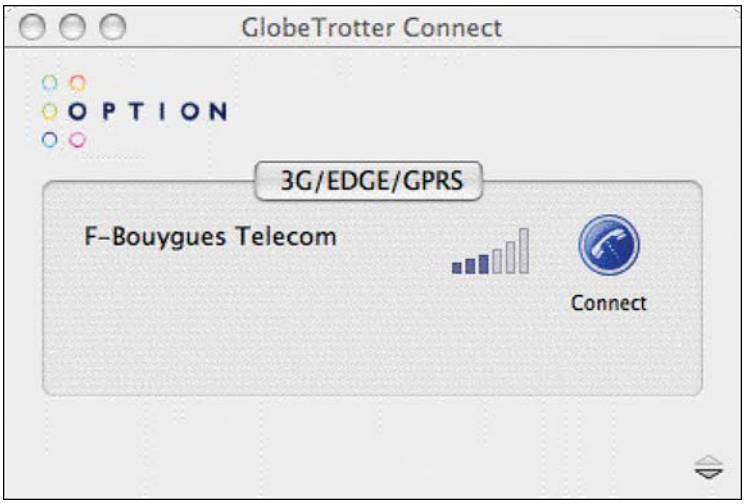

Figure 5 Example Connection Manager User Interface

because they are naturally keen to move on to their main task (eg. read email) and from their experience with WLAN they will not expect a second step for connection (ie. the need to push a 'connect' icon).

In the current example this lack of expectation to push a 'connect' icon would probably be increased because the 'connect' icon is ambiguous in colour and graphic. Indeed, the telephone position shown could actually be interpreted as showing that the 'line' is 'open' or 'off the hook'). The icon could be less ambiguous by:

- Making it more obvious that it is a button that should be pushed (eg. not just a status feedback symbol),

- Making the action achieved by pushing the button clearer, for example by using:
  - Colour coding, such as green for 'go' and red for 'stop',
  - Distinct system state representation, such as the telephone completely down for 'off-line' and completely up for 'on-line'.

5 The Difference Between Choosing to Use and Actual Usage

It is useful to distinguish two situations in which users will evaluate a product or service:
- The Choosing situation,
- The Usage situation.

An example of a choosing situation is when buying an MBB terminal for watching IP-TV. In the shop, people are faced with many terminals so that they can compare and choose based on sharpness, brightness, reflections, etc (Figure 6 left). The choosing situation is where the users' perception of a medium's quality is very appropriate.

Once a product has been bought or a service has been selected, various factors of user experience may emerge as more or less important. For example, when the IP-TV has been bought and the users are sitting in their living room watching a film, the situation becomes very different than in the shop (Figure 6 right). Now poor sound quality will be easier to detect because of a less noisy environment. Artefacts with the video may not be detected at all because of an engagement in the content of the film.

Because many of the user behaviours concerned with using a communication service are unconscious, subjective measures based on user opinion (such as user satisfaction) may give an incomplete, invalid or unreliable measure of user experience. As in other areas

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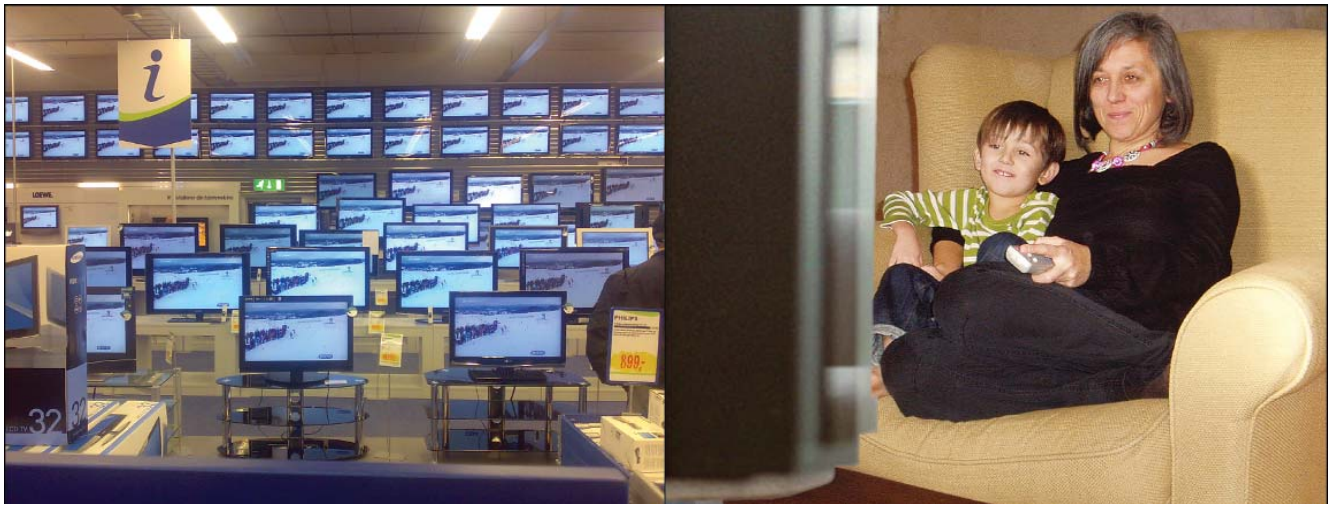

Figure 6 Left: A typical choosing situation, right: A typical usage situation

of psychological research, accepted good practice requires identifying and measuring objective behaviours, with subjective measures used mainly as a supplement. User measures can be objective if they record actual user performance, such as the number of errors done in a task and the time to complete the task (Brooks and Hestnes, in press).

To really understand the usage situations, user tests should be performed within a relevant context. For MBB the usage context concerns situations such as email reading and use of a web browser for Internet banking, news-reading and social networking. Therefore, at least user satisfaction, task efficiency and effectiveness should be measured in a task-oriented way.

6 Helping Those who Make Equipment and Services

A survey of 45 technologists within service providers, network operators and equipment manufacturers showed agreement for a need to better understand the users of their systems. Workshops and discussions with many more stakeholders (as many as 2000 over several years) indicate that the survey of 45 individuals is probably representative of most stakeholders. The respondents indicated a strong potential uptake of the results of work that provide information on user experience with technology. Of those asked, 80% said they were potential users of guidelines about user experience and 93% asked for a copy of available guidelines, see (ETSI 2006) and Table 1.

As can be seen in Table 2, there was the clear opinion that work on user-centred guidelines is necessary and that it is relevant that these guidelines map user experience test data to the technical performance of a system. For a scale ranging from 0 'not at all necessary' to 10 'extremely necessary' the mean rating for 'necessity' was 8 (out of 10) and the mean rating for 'relevance' was 7 (out of 10). A high agreement with these opinions was obtained as shown by the small standard deviation obtained for these ratings.

What these data indicate is that a lack of information about user behaviour with MBB does not reflect a lack of interest by stakeholders. Rather, our evidence is that stakeholders want this information but do not know how to obtain it in their busy work situation.

	Are you a potential guideline user?		Would you like to have the final report? (EG 202 534)	
	Absolute frequency	Relative frequency	Absolute frequency	Relative frequency
Yes	36	80%	25	93%
No	9	20%	2	7%
Total	45	100%	27	100%

Table 1 Responses to the question "Are you a potential guideline user?"

	How necessary is work on user-centred guidelines?	How relevant is the approach of the project to address the topic of user-centred technical guidelines?
Mean	8	7
Standard deviation	1	2
No. of respondents	45	32

Table 2 Responses on 11-point rating scales (0 = not at all necessary; 10 = extremely necessary)

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6.1 The Value of User Tests

As described already, it is important that technically skilled professionals also understand how difficult MBB can be for a great number of potential users that do have a need for this technology. The MBB user experience staircase shown in Figure 3 can be a checklist to help address usage problems. There are no quick solutions here because it is a complex problem and no one has all the answers. However, user tests show themselves to be a good way to identify where people struggle, who has most problems and in which situations. Controlled laboratory tests and more natural field studies are good solutions to reveal where users have difficulties and how they can be resolved.

6.2 Helping Technologists to Optimise for Users

Even when having climbed to the top of the MBB user experience staircase in Figure 3, there is currently little knowledge about how a certain set of technical parameters will be experienced by the end users. A particularly important situation is when trade-off decisions are required. Examples are packet loss versus delay for speech services, frame-rate versus resolution for audio-visual services and bit-rate versus latency for MBB services.

6.3 QoE expressed in QoS terms

It has been argued here that user-centred advice is required during the development process. In particular, there should be advice about how well users can be expected to use a system when the technical parameters have certain values. A methodology has been developed to help collect and combine user-based and technical information, and a database with over 350 guidelines has been gathered from laboratory studies and field trials documented in research reports. More information can be found on QoE expressed in QoS terms in (ETSI 2010A), (ETSI 2010B), (ETSI 2009), (Hestnes et al 2003A), (Hestnes et al 2003B).

6.4 Technologists are Expanding their Domain

One aim of this article is to encourage a multidisciplinary way of thinking. Whereas some technologists already have an economic dimension in their work, very few include a third – psychological – dimension. Applying theory and methods from psychology should enable us to understand why certain technologies will not work for user services. Psychological approaches can also help us determine how good a service needs to be to be 'good enough' for users. In this way we need not over-engineer and can better optimise technical solutions and their financial cost. For these reasons, work with technical, economic and psychological dimensions is where future development should focus.

7 Conclusions

Some may argue that MBB is only a network technology, that this alone is very difficult to get working properly and good user experience is of less priority. We argue that MBB should be designed to meet the needs of its users. This includes the terminals, the services and the user interfaces. Users should be able to do what they intended without negative consequences and with a good enough satisfaction or usage outcome. In this article, we emphasised that there is a sizeable group of 'technology strugglers' who should be taken seriously for business reasons. A simple segment model has been developed for this purpose to distinguish between those that usually achieve their goals with technology and those who do not or who do so only after a struggle. However, it has also been emphasised that all users should be expected to have difficulty with services if they do not take into

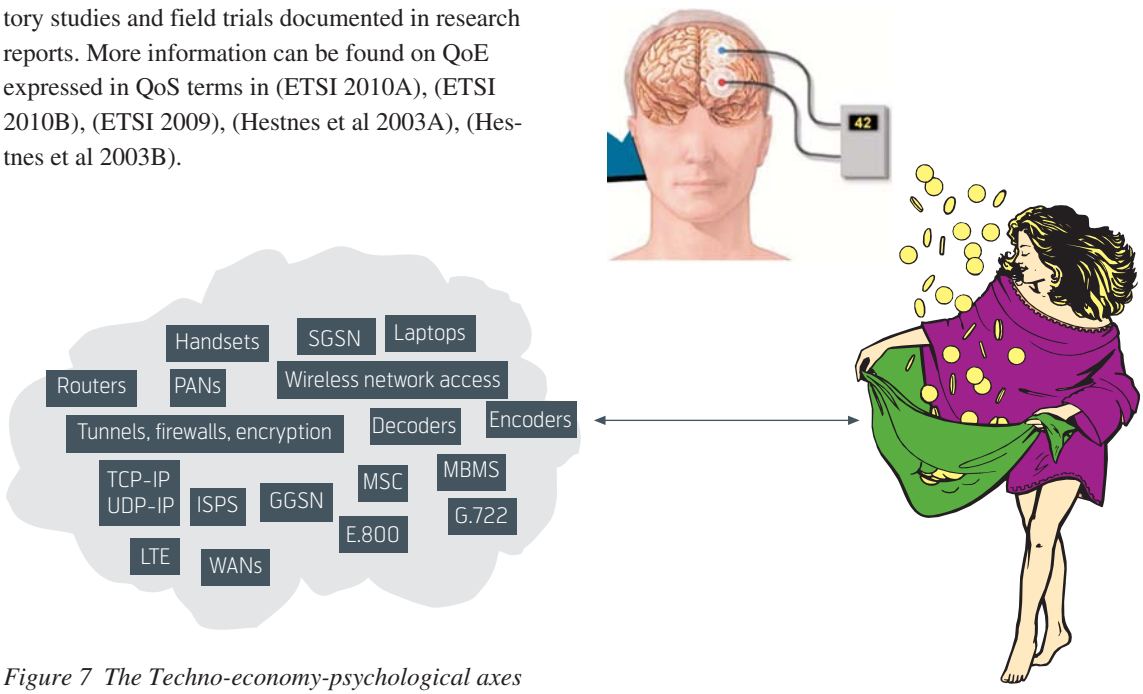

Figure 7 The Techno-economy-psychological axes

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account psychological factors such as automatic behaviour and limited attention abilities.

We argue that technologists who are making MBB solutions should have access to information about the user experience. Producing this information requires studies of usage situations that obtain data about usage outcomes for both conscious and unconscious user behaviours. User tests, such as laboratory experiments, field studies and usage observations, are the essential way that service providers can identify and meet the most important user needs.

Service providers state that they would like to have advice about user experience but lack time and knowledge of where to obtain it. Although we recommend that they look for studies that measure user experience related to technical parameters (such as QoS), we agree that this is not straightforward and there is a real need for work that makes more information available for service providers as accessible guidelines on QoE expressed in QoS terms.

From the MBB user experience staircase we can see that much can go wrong for users and potential users. The risk of difficulties is particularly high for people who are 'technology strugglers'. Although the 'technology achievers' are presented with the same problems, they have a more positive attitude to finding solutions and are more likely to find solutions faster. For the lower steps (Steps 1-3) there is little data because users are not connected and the MBB cannot monitor the traffic pattern and success rate. The top step (Step 7) is achievable only if the other steps are positive and it is at this step where the services can be adjusted to be more compatible with human performance.

This article encourages the development of MBB in a multidisciplinary way, with three key dimensions:

- Technological,
- Economic,
- Psychological.

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