MOBILE MULTIMEDIA — CHALLENGES AND OPPORTUNITIES INVITED PAPER

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ABSTRACT

Today, we observe the creation of an increasing number of multimedia consumer devices for mobile and home use. This includes set-top-boxes, game consoles, Personal Digital Assistants (PDA), e-books, but also mobile phones. Although these devices have many things in common with desktop PCs – above all Internet access - it is widely accepted that they will serve a different purpose. Many committees and companies are currently trying to define the open application platform for tomorrow's consumer terminals for home use, among others the so-called Multimedia Home Platform (MHP) of the European Digital Video Broadcasting (DVB) project. Meanwhile, on the cellular end of the multimedia business, portable appliances like cellular phones, e-books and PDAs are evolving to multimedia terminals, starting from narrow band Internet services like the Wireless Application Protocol (WAP) and slowly adopting video technologies. One of the main obstacles to overcome is bandwidth limitation - even for 3G mobile systems - and broadcast technology is considered to be a serious candidate to fill this gap, both for TV and data services. A special challenge is to provide multimedia services in vehicles, where, due to the static environment relative to the driver, some requirements for mobile and static terminals apply at the same time. This paper shall summarize some trends and opportunities of mobile multimedia - especially in the DVB and GSM (Global System for Mobile communications) domain, while outlining the different requirements for mobile, home, and car use of multimedia services.

Keywords: Digital Video Broadcast Terrestrial (DVB-T), mobile multimedia, MHP, Car Multimedia

1. CONVERGENCE VERSUS DIVERSIFICATION

Digital convergence is a key term, when talking about information technology and multimedia. Convergence mainly results from digital transmission and Internet technology: Digital transmission provides an abstraction between service and service delivery, i.e. the same network can deliver different service types and different networks may compete while carrying the same services. Internet technology, especially the World Wide Web finally constitutes a common platform for content addressing and interpretation (rendering). As consumers, we observe convergence through service integration and increasing independence of services and terminals. Today, we may surf the web using our TV set, while we may watch TV services in the Internet browser of our PC.

On the contrary, we observe a large diversification of user terminals. This observation is exactly addressed with what we call post-computer age or pervasive computing: Computational intelligence will go in all kinds of daily used appliances like pens, vending machines, microwave ovens, watches, toys and serve individual people exactly where they are and when they need it.

Many of the services offered will be communication services or at least based on connectivity - and thus communication - to other devices. With IPv6 (Internet Protocol version 6), the next generation Internet Protocol, there will be enough address space to uniquely address every single device on earth. Eventually, using existing connectivity and service discovery techniques, every device may carry and export its services and user interface to other devices like cellular phones, PDAs or car computers.

2. OPORTUNITIES AND CHALLENGES IN MOBILE MULTIMEDIA

This development offers lots of new opportunities but also challenges and risks. On the one hand, all kinds of new services become possible creating demand for new types of end user terminals. While a few years ago, the maximum penetration of computers was estimated to about 40-50% of all households, we are now facing a development where every person may own several computing consumer devices. Moreover, digital technologies made it possible to separate content, service, network and terminal provisioning into independent businesses. As a result we observe the development of competitive horizontal markets, however, not as fast and consequently as we could wish.

The mobile phone, with more than 600 million pieces being produced in year 2000, will become the most important "personal trusted" device. Already today, people use mobile phones as personal address books and calendars, and payment systems for mobile phones are currently deployed. Consequently, the mobile phone with its ubiquitous access becomes a preferred platform for service providers.

Contributed Paper

Original manuscript received June 19, 2000

Revised manuscript received September 28, 2000

It is difficult to predict, in how far mobile phones will integrate the functionality of today's PDAs, e-books, etc. And if this is the case, will the other devices disappear? What has been learned from the past is that many if not all of these terminal types will survive, same as the computer will not kill the TV and the phone will not make the computer obsolete. As a palm-size device, the mobile phone has some obvious limitations to render many types of services. Portable reception of TV services, for example, is definitely an attractive service that needs higher resolution and decent sound.

Car computing platforms are also considered a decent business, at least on long term. Firstly, the requirements for cars differ significantly from those of other terminals and thus call for dedicated devices. Second, with about 500 million cars on the road worldwide and about 9% new cars every year, the expectations of equipment manufacturers are rather high.

On the other hand, with increasing diversification in devices and software platforms, it will get increasingly difficult to guarantee interoperability of devices and services on all levels. A well known example for this are Internet enabled TV sets: Even though TV Internet browsing is possible today, it is not yet a popular service, since rendering and navigation of arbitrary web content on TV sets (using simple remote controls) is still a widely unsolved problem. Still worse, there is no common application platform today, neither for home nor for mobile devices. Needless to say, that interoperability of different vendor's equipment is a big problem as well. This altogether constitutes a major obstacle for content and service providers and consumers to invest in this fragmented and constantly changing market.

Last not least, all mobile communication devices share the same radio frequency bandwidth, which is a limited, scarce resource. Some relief is expected from 3rd Generation (3G) mobile systems like UMTS (Universal Mobile Telecommunication Services) and enhancements of existing systems, like EDGE (Enhanced Data rates for GSM Evolution) and GPRS (General Packet Radio System). However, there are serious doubts that 3G systems will allow attractive, reliable and cost efficient multimedia services in the future due to still existing bandwidth limitation per user and cell. This problem is currently attacked by several means:

- Data Broadcast is consuming less bandwidth per user and shall complement personal communications.
- Short-range radio links like HomeRF and Bluetooth for Point-of-Interest services.
- Hybrid, asymmetric networks, which use the scarce bandwidth of cellular systems to request information and download the information through broadcast networks like DVB-T.
- Load balancing of data traffic over networks and time. For example, during daytime more personal communication bandwidth is provided and less bandwidth for radio and TV services.

3. THE MULTIMEDIA HOME

As distinct to desktop PCs, Consumer type terminals will support a simpler user interface model and will be optimized for infotainment and e-commerce applications. The catalyst of multimedia services in the home will be digital TV, offering a broadband data pipe into the home. Digital TV is a success, even though in Europe it falls behind expectations raised some years ago. Some of the problems encountered are due to the failure of successfully introducing open standards for common application- and conditional access systems. The result is a rather fragmented European market where proprietary and incompatible systems compete against each other in vertical markets.

In Europe, the DVB project [1][2] tries to push open specifications and standards for application platforms - both for the home and for mobile services. The TAM (Technical Aspects of the Multimedia Home Platform) group in DVB is one of these bodies. TAM focuses on the specification of a Java based application platform called "Multimedia Home Platform" (MHP [1]).

MHP's concept builds on Java applications that are downloaded via the broadcast stream or an interaction channel (e.g. PSTN). These applications have controlled access to the system resources through dedicated Java APIs (Application Programmers Interface) (see figure 1). These include: graphics, tuner, MPEG-demultiplexer, service selection, service information, smart card, conditional access, persistent storage, etc. A security model distinguishes between trusted (signed) and distrusted applications, where the latter have only access to a limited set of resources. Multiple "cooperative" applications may run at a time, e.g. if they come from the same source.

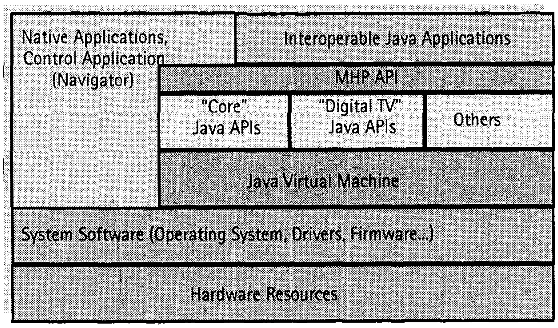

Figure 1: Software architecture of the Multimedia Home Platform

All in all, MHP defines three profiles, where the higher profiles contain additions to the lower profiles:

- Enhanced Broadcasting: Downloading of Java applications through the broadcast channel. Typical applications would be an electronic program guide, display of program associated data, news ticker, selection of views in sports events, etc.
- Interactive Broadcasting: An interaction channel is added (e.g. via modem) and Internet connectivity is used as a communication channel for the applications. An HTML profile will be added in a later version of the standard, defining the HTML features supported by the interactive broadcast profile.
- Internet Access: This is basically the interactive broadcast profile plus "a real web browser" that shall render most of the existing web pages. This profile is not yet defined.

First MHP terminals and applications have been demonstrated on Internationale Funkausstellung 1999, including games, electronic program guide and news ticker. It is worth noting that the application model in the MHP is very much tailored for TV use. That is to say, the applications and their lifecycle are tightly associated with the currently selected TV services: Every TV service may have a list of applications associated with it. These applications will be terminated as soon as the user selects another TV service, which references different applications.

A different approach is taken by the "Advanced Television Enhancement Forum (ATVEF)" [3], where the software platform merely consists of an Internet browser, which receives HTML/JavaScript content being cached in memory. This content is then timely synchronized with TV broadcast by so called "triggers". These messages are also transmitted in the broadcast. This platform has the advantage, that web content can be rendered, thus bridging the gap between Internet and broadcast. However, it is not obvious that the typical HTML "point-and-click" user interface is suited as a self-contained home platform. Consumer devices are usually controlled via remote controls rather than keyboards and pointers. Moreover, browsers typically do not give total control over the graphical service rendering. Eventually, it is not surprising that the integration of ATVEF and MHP is seriously considered within DVB.

As DVB also defines the terrestrial transmission of digital TV (DVB-T), mobile reception of digital TV and MHP applications will become possible. But also 3G mobile system providers claim to deliver multimedia services including video to next generation mobile terminals. The next chapter outlines and compares the main features of broadband and cellular networks.

4. CANDIDATE MOBILE COMMUNICATION SYSTEMS

A key element to enable mobile multimedia services is a wireless broadband communication channel. Most multimedia services demand for highly asymmetric channels. Hence data broadcast technology will probably be the enabler for many multimedia applications like browsing a pre-selected Internet content or downloading a video clip.

Beside TV and audio broadcast, digital TV standards offer high data rates for data broadcasting. The following standards are or will be in use in several parts of the world:

- DVB-T mainly in Europe but also in Australia and several Asian countries
- ISDB-T (Terrestrial Integrated Services Digital Broadcasting) mainly in Japan
- ATSC (Advanced Television Systems Committee) mainly in the USA

DVB-T [1][2] is the terrestrial variant of the DVB standard for digital TV, radio, and data broadcast services. It was developed to replace the analog TV system. The key features are high bandwidth efficiency, undisturbed reception, better picture quality compared to analog TV, and the capability to broadcast data services.

DVB-T uses Orthogonal Frequency Division Multiplexing (OFDM) for robust mobile transmission of MPEG2 transport streams. The available data rate in mobile reception is 15 Mb/s per UHF/VHF channel. OFDM is used in Digital Audio Broadcasting (DAB) as well, but with a 10 times lower bandwidth (1.5 Mb/s). It is ideal for a multi-path environment with changing channel conditions like in mobile environment (see figure 2).

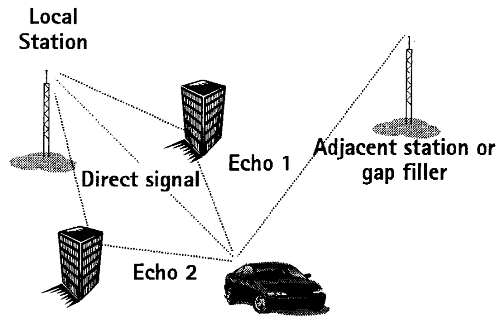

Figure 2: Example for multi path reception

Due to the fact that DVB-T can handle long echoes it is possible to use it in single frequency networks, where every transmitter transmits a certain transport stream on the same frequency. This reduces the number of frequencies needed to provide a wide area with the same TV/data services.

DVB-T operates extremely robust even under very unfavorable conditions. Undisturbed TV reception has been demonstrated - even with consumer type equipment - while driving 300km/h and in areas with long and strong echoes.

An in-car DVB-T receiver solution (see figure 3) and a handheld DVB-T demonstrator (see figure 7 [4]) have been presented on Internationale Funkausstellung 1999 in Berlin. TV, radio and data broadcast services were successfully demonstrated.

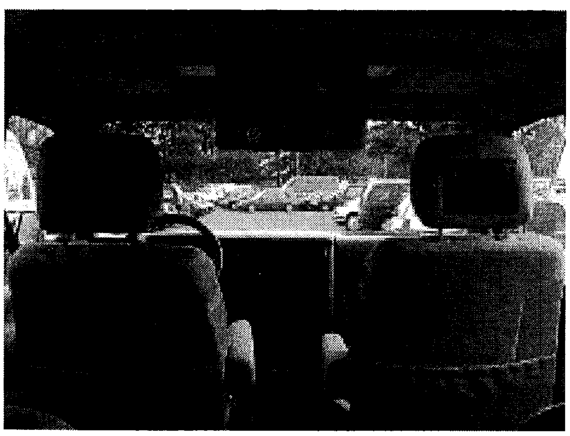

Figure 3: Mobile DVB-T/GSM Demonstrator Car

While other solutions for broadband mobile data reception exist, DVB-T is the solution selected for Europe and many other DVB-T adopters all over the world. For interactive services, existing and emerging cellular phone techniques (GSM, GPRS, UMTS, etc) will complement DVB-T. First experiences with hybrid web access have been made in the Memo EU project [5], using DVB-T or DAB downstream and GSM upstream (see figure 4). To increase the communication efficiency packet-switched systems (GPRS, UMTS) are preferable for back channel purposes.

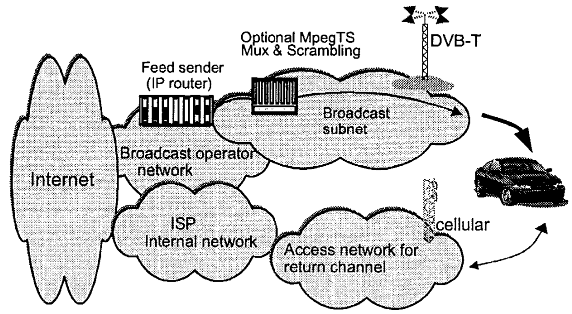

Figure 4: Hybrid network access

While DVB-T pilot projects currently run all over the world, DVB-T is in commercial operation in U.K, Sweden and soon in Spain.

ISDB-T [12] is the Japanese digital TV standard and is based on OFDM as well. Compared to DVB-T slightly different modulation schemes are used (DQPSK (Differential Quadrature Phase Shift Keying) instead of QPSK (Quadrature Phase Shift Keying)), which results in a better bandwidth efficiency and slightly better mobile performance for low data rates, but worse performance for mobile reception of high data rates.

The US standard **ATSC** [11] has been optimized for stationary reception. It uses a single side band system, Trellis coded 8-Level Vestigial Side-Band (8-VSB), instead of OFDM. The ATSC standard cannot be used for mobile reception at all. It has high bandwidth efficiency, hence it is well suited for High Definition Television (HDTV) distribution, although DVB-T and ISDB-T are capable of transmitting HDTV in stationary mode as well.

Enhanced second-generation cellular phone technologies (e.g. **GPRS**) and third-generation (3G) technology (**UMTS** [14][16]) will offer packet-switched data services with quite high data rates compared to 2G cellular systems. GPRS increases the data rate for packet-switched services up to 160kb/s [13]. UMTS supports both packet-switched and circuit-switched data services and asymmetric channels as well. On packet-switched connections it will offer up to 2Mb/s for stationary use. For pedestrians the data rate will be up to 384kb/s and for in vehicle use it drops to a maximum of 144kb/s. It should be noted, that - unlike with data broadcast - these maximum bit rates drop dramatically once the number of users per cell increases. Hence GPRS and UMTS can not replace the digital TV systems for broadband data broadcast, but will be the ideal complement to enable interactive services.

5. DRIVERS OF MOBILE MULTIMEDIA

In fact, there is more about mobile multimedia than simply creating a wireless home terminal. There are several interest groups, which drive mobile multimedia, not always for the same reason.

Some **national broadcasters** are forced by law to provide nationwide TV coverage through terrestrial transmission. They are interested in digital TV, because, firstly, it strongly reduces their transmission costs per channel by up to 60% and, secondly, they improve the attractiveness of terrestrial reception which decreased strongly since the introduction of cable and satellite services.

The **network operators** want to increase the sales of network bandwidth, by enabling new types of services with new network technologies. In many countries a close cooperation between the broadcast and cellular network operators has been established to be able to offer hybrid network capacity.

Service and content providers see the opportunity to advertise and sell their services to people everywhere and anytime, thus increasing the total usage of their services. Furthermore, mobility also calls for new type of services (and thus revenues).

Car manufacturers want to improve the cars' Man-Machine Interface (MMI) by using enhanced input/output devices. An open application platform would allow upgrading of multimedia equipment during the lifecycle of a car, which is much longer than the lifetime of computing equipment. Safety equipment for automated emergency- and breakdown calls brings in positioning hardware into the car and thus enabling other location aware services. But carmakers also seek an after-market relationship to their customers: Once having cars connected, they can offer car-specific services, including navigation and maintenance support.

Mobile terminal manufacturers serve individual persons instead of households. Since there are more individuals than households the market is naturally bigger then the home terminal market. Furthermore, there is a large potential for use- and fashion-based diversification and innovation of terminals.

Car terminal manufacturers currently suffer from vertical markets due to high customization efforts for OEM products. An open application platform would help them to reduce development time and costs. It is also a key driver for after market products. A wide range of services will increase the number of terminals sold.

People, finally, spend more than 10% of their lifetime traveling, either for business or leisure, while they want to stay connected in every respect. This desire is more than proven by the current sales figures for mobile phones and the emerging standards for mobile narrow-band data services like the Wireless Application Protocol (WAP). For car drivers, security and travel assistance are important aspects as well. They probably want to use the same services in the car they are used to at home and in the office. This is only possible with an open application platform.

Technology drives mobile multimedia with new means to communicate, cache, process, and display multimedia content:

- *Connectivity:* New means to communicate enable new services.
- *Memory and persistent storage:* Evolving memory technology allows caching of more content and offline processing, thus creating the illusion of instant access to interactive remote content. For example, audio/video content and whole web-sites may be downloaded in background and consumed offline. This is particularly important for data broadcast services [15], which are transmitted in carousel fashion.
- *Processing:* More processing resources with less power consumption allow rendering of more complex multimedia content.
- *Display:* Visualizing multimedia content demands for cheap high-resolution displays that comply to "mobile" requirements (ruggedness, temperature, etc.).

6. NEW SERVICES AND OPORTUNITIES

Mobile communication technology opens up new business and service opportunities. The first idea is to **deliver existing services to the mobile user**. The extended time window, in which mobile services are available to customers, relaxes to some degree the struggle of service providers for the limited time budget of customers. Finally, even existing services may create a new user experience, if consumed in a new environment. This may e.g. apply for following a car race on a portable TV while being physically at the race.

Secondly, the mobile environment as such adds a new dimension to the information channel and that is **location**, e.g. services and information can adapt to the location of the consumer. Among other things, such services benefit from the fact, that mobile users seek new forms of *information related to traveling*. These "location aware" services provide information being adapted to the current location of the user.

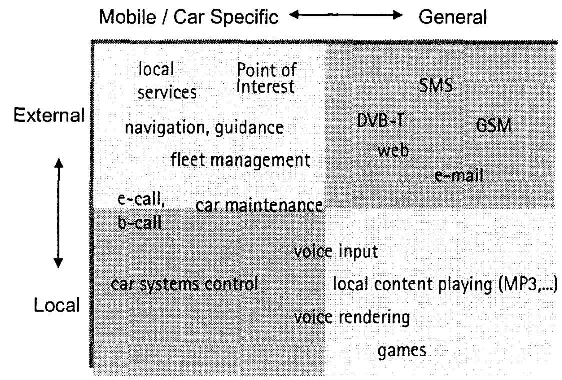

Figure 5: service partitioning of general- and mobile services

Finally, mobile handheld devices, like mobile phones, are in most cases *personal* and *trusted* devices suited for **personalized services**. These services range from personalized information to so-called mobile-commerce ("m-commerce") applications that require proper authentication and authorization features for secure transactions.

Figure 5 shows a partitioning into general services and services being designed for mobile use, which either act locally (upper part) or need a network connection (lower part). Voice control/rendering is here considered as an "local adaptation service".

In the following, some emerging service types will be discussed, focussing on car systems.

Location-aware services: Thanks to several satellite-based positioning systems like the Global Positioning System (GPS) or - less precise - cellular based positioning techniques, mobile terminals will be able to determine their current position. For car terminals, this may even be required by future legislation (e.g. the E911 guideline in the US). Professional services like *fleet tracking* and *fleet management* are examples of such services, which are realized by sending periodically the car's position to a service center, using a cellular data link or Short Message Service (SMS).

Some service providers already today offer *local traffic information*, *route guidance* and *off-board navigation*. Route guidance means that the driver is informed selectively about relevant traffic jams around the current position of the car. Similarly, the driver may be informed about the traffic situation along a specified route. With *off-board navigation*, the service provider guides the driver to the destination by sending him turn-by-turn driving instructions through the mobile communication network. This is possible, if the service provider is constantly informed about the current position. As distinct to on-board navigation, off-board navigation uses up-to-date information concerning new roads, road construction, traffic, weather conditions, but also local tourist information, like e.g. point of interest (POI), the nearest gas station, hotels, restaurants, etc..

It should be taken into consideration that although most of the above mentioned services seem to belong first of all to the car environment, location aware services will also be available with handheld devices and portables. First GPS equipped phones are even commercially available. Of course, there are specific telematics services like the car safety and security related services, which only make sense in the car environment.

Safety and security related services are going to be one of the key drivers for the telematics market. These are not necessarily multimedia services, but they require positioning and thus enable richer location aware services. These services require the highest level of reliability for the terminals to guarantee the functionality of the terminal even in case of accidents or breakdown. This is achieved by means of very reliable and also redundant communication modules.

In case of emergency, the in-car system initiates automatically a SOS call and sends the current position of the car to the service provider. The SOS call can also be initiated manually, in case of less fatal accidents or breakdown events. It is desired to include data indicating the status of the car electronics and sensors and send them to the service provider for remote car diagnosis and preparation of repair. This feature could be extended for anti-theft. In case of theft, the car could be located using a remote car-tracking system.

Another purpose of car terminals is to provide **in-car services**, i.e. to provide a common user interface (UI) to all units and functions inside the car (see figure 6). Up to now, the car includes several units and devices like e.g. radio, air-conditioner, electronically adjustable outside mirrors, etc, which have their own knobs, controls and displays. Since most of these devices are produced by different companies with even different UI styles, there is usually no consistent UI style and policy in the car. Besides, the area around the driver is very limited and must be totally restyled, if a new additional device is installed in the car. A multimedia terminal could act as a common user interface for all in-car electronics. This would make it possible to keep the UI style of all the different units consistent and scaleable. Integration of new devices could easily be carried out by updating the UI related software of the terminal and connecting the new device into the car-bus system. Several industry consortiums are currently trying to define open platforms based on car-bus systems (see chapter 9).

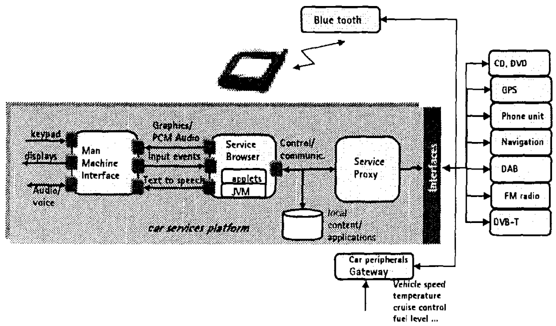

Figure 6: Conceptual diagram of a multimedia car system

In addition, car multimedia terminals have to provide car drivers with appropriate **user interface extensions** for a secure interaction with the system while driving. As mentioned before, most of the mobile multimedia services are already available for home terminals. But the integration of these services into mobile terminals is not only a matter of simply substituting the landline link to the service provider with a wireless one. Many of the requirements for home terminals apply to mobile terminals as well, like the limited number of keys, easy and safe use, lower resolution of the displays etc.. But car-terminals have to meet additional important requirements: Any interaction with the car system should not distract the driver. For security reasons and legislation, visual presentation of information to the driver should be very limited or even avoided. One might think that only passengers will really benefit from mobile multimedia services under this constraint. However, passengers are not the main customer group for in-car services. Investigations have shown that the average car only carries 0.4 passengers. Therefore, the Man-Machine interface has to be adapted to the driver's needs. A common solution for this is to integrate speech recognition (SR) and text-to-speech (TTS) systems. Thus, the information could be presented to the driver by means of TTS and the driver can operate the system safely while driving using speech recognition systems. Other techniques like finger-writing pads are considered as well [17].

It is worth mentioning the two main challenges for in-car voice IO. First, speech recognition in ambient noise is very difficult. Reliable results have only been achieved either with speaker dependant recognition, or with speaker independent methods using very small and fixed vocabulary (e.g. limited number of commands). Please note that speaker dependant methods require training, which is not suitable for rental cars.

The latest standardization activities for **wireless applications** like WAP (wireless application protocol) [8] will provide ubiquitous access to Internet information servers.

WAP has been designed taking into account

- the bandwidth constraints in mobile networks
- the technical limitations in the terminal's: processing power, memory and User Interface (display and keyboard)

WAP is intended to be an open, network independent platform. Even though it is also device independent the initial focus is on mobile phones. WAP services are coded in WML (Wireless Markup Language), which is defined in terms of XML (eXtended Markup Language). Client side scripting is possible through WML script. WML and WML-script are similar to HTML and Java Script, but have fewer features. WAP servers can be implemented by means of HTTP (Hypertext Transport Protocol) servers plus a WAP gateway, transcoding the content. Typical applications include *text based query services (flight schedules), e-commerce, banking etc.* WAP content formats do not yet include audio and video, but may do so in future since networks and devices are further developing

Bluetooth (BT) [9] is an industry standard for short range (<=10m) wireless communication and networking with bit rates up to 720kbit/. BT is a rather generic and cost efficient (<10$/device) technology and can be integrated in virtually any electronic device. Some forecasts say that in a few years time BT will not only be part of every PC and mobile phone, but also integrated into cameras, vending machines, household appliances etc.

Among others, BT will be used to integrate the functionality and services of handheld devices and smart phones in the car or office environment without any mechanical installation effort. In the well-defined car environment, where the distance between the appliances never exceeds 10 meters, Bluetooth is an ideal means for wireless in-car communication. The driver's smart phone, for example, located in his pocket and equipped with BT module can log itself into the in-car BT host server and offer its functionality including telephony and personal address book to the in-car multimedia system.

Due to the connectivity of home, office, portable, and in-car terminals true **multi-modal services** will emerge. The term multi-modal here has a twofold meaning:

1. Different terminals can communicate and synchronize information seamlessly. The content can be transferred between a large range of terminals, no matter if it is the office PC, a mobile phone or an in-car terminal.
2. Several input and output modalities (audio, video and tactile) can be used to deliver a similar content (= unified messaging). As an example an email text message can be displayed on a BT-screen, read to the user by a BT-text-to-speech system or sent as a voice mail to a mailbox.

Especially the combination of ad hoc networking and multi-modality opens up new visions for multimedia services. One could imagine, for example, that the in-car terminal could log into the BT host server of a gas station and download some *point-of-interest information* of the local area around the station while the driver is refilling the tank. Another possibility is to download special offers of a supermarket while the driver is looking for a parking space in market's car park.

Similarly, any BT device can *export its user interface* to a BT enabled mobile phone (e.g. using WML) and allow the user to interact with this device. Thus, cellular phones will be used to control household- and consumer equipment, vending machines, money dispensers and other devices.

It has to be mentioned that the success of the mobile multimedia business depends strongly on the cooperation of all service chain members. The end-user can only benefit from the new services, if the needed harmonized infrastructure of the network, content, service, and terminal providers are available.

7. TERMINAL TYPES AND THEIR REQUIREMENTS COMPARED

Both mobile and home terminals move towards multimedia, even though they come from different directions. As already mentioned, multimedia home terminals will evolve from TVs while **car terminals**, for example, evolve from car phones and navigation systems. Another constraint is that mobile wide band communication systems do not yet exist and Europe wide coverage for DVB-T is expected not before 2003-2005. This explains why many car manufacturers like to see multimedia to develop in the following steps:

1. Narrow band security, telematics and interactive services (e.g. WAP) will complement mobile car phones and navigation, enhanced by voice technology.
2. Car computers will provide a unified and consistent user interface to all electronic car equipment, also including local multimedia services like the Digital Versatile Disc (DVD). These appliances will be controlled via a high-speed optical bus, like MOST (Media Oriented Systems Transport) [7]. Due to the diversity of car peripherals and their interfaces, this needs a high degree of standardization currently under way in the AMI-C (Automotive Multimedia Interface Collaboration) [6] and IDB (Intelligent transportation systems Data Bus) [10] consortiums
3. Once reasonable coverage of mobile data and audio/video broadcast gets available, digital television, interactive services and Internet will make their way into the car.

Compared to home and portable devices, car terminals have some very special requirements:

- Voice recognition and text-to-speech are needed as user interface extensions, if the platform shall be used while driving. Finger writing is considered as well. This is even enforced by legislation.
- Telematics, navigation and security services need access to a positioning system.
- Unlike portable devices being restricted by size and power consumption, car multimedia systems may utilize high-resolution displays and high-end audio systems. This enables rich applications, like 3D computer games, at least for passengers.

The last point suggests that there are some commonalties in the home and car environment. In both cases TV and radio broadcast services can be decently delivered because of the audio/video equipment and the possible reception of broadcast streams. Both environments impose limitation on the user-input device, even though there are less compelling reasons to use voice I/O in the home.

However, MHP and other home platforms have to be re-assessed with respect to car requirements. First, there shall be support for application lifecycles that do not depend on the currently selected TV service. TV may not even be available for some terminals. Second, the car is a very dynamic environment, and the car platform shall be able to consistently handle external events like incoming calls, navigation prompts, car system alerts, passing of toll stations etc. That is to say, control has to be passed between applications without user interaction. Third, the platform shall support simultaneous execution of multiple applications from different sources. You may wish to use entertainment and navigation services at same time and it is unlikely, that these come from the same service provider. Finally, some APIs for GPS access, Voice IO etc. have to be added, which is quite easy in a Java platform.

With regard to portable terminals, we believe that there will be both the **handheld** "personal trusted device", designed as a small, permanent companion and **portable** devices with higher resolution screens and improved audio capabilities (see figure 7). Both will render multimedia services but within different applications. Due to their small displays and the limited bandwidth of cellular networks, mobile phones will rather be used to render short clips, e.g. the goal of the day, to enrich information services. There is already a service provider specializing in sports clip services for mobile phones [18].

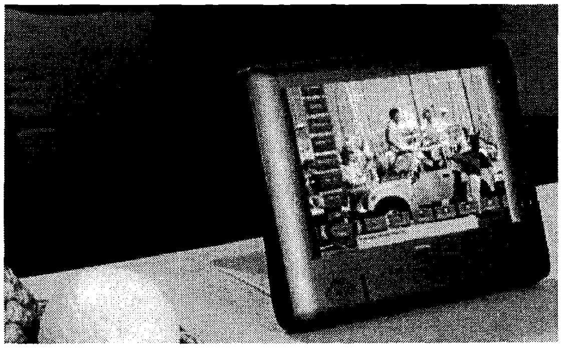

Figure 7: Mobile DVB-T / GSM Terminal Demonstrator

With larger screens, better sound, and maybe even equipped with mass storage, portable devices are more suited for real entertainment and even true Web access. For this purpose these devices will be equipped with a digital TV and cellular receiver. It is rather likely, that these devices will support the same application platform as digital TV receivers. A prototype of such a receiver has been presented on Internationale Funkausstellung 1999 in Berlin. As with mobile phones, power consumption, battery lifetime and weight are the technical challenges to improve consumers' acceptance. These points will be discussed in chapter 8.

Today, service providers usually cope with a single type of terminal per service. The World Wide Web is the fastest growing service market and is currently almost entirely dedicated to Personal Computers. As mentioned before, there will be more devices connecting to the Internet, which have been equipped with different types of user interfaces depending on their concrete usage and operational environment. This calls for **device-independent services**. Mobile phones have small displays, no loudspeaker and limited keyboard input. Car terminals may have improved resolution (VGA-SVGA) but shall employ text-to-speech systems for service rendering and speech input for content selection. TVs finally have a medium resolution interlaced display that may flicker with certain type of content. There are several options for the service provider to cope with this problem:

- Create content that renders well on all platforms using style sheets. In theory, style sheets can control the rendering from high-resolution displays down to voice rendering (so-called "aural style sheets"). This approach looks appealing at first sight. However, style sheets are not consistently supported across browsers. Secondly, this approach still puts some limitations on the high-end version of the content
- Create several versions of the same content for the particular devices. This is most commonly practiced today, but is very expensive both in terms of development and maintenance costs
- The raw content resides in databases and is converted "on the fly" for the respective terminal. This is a robust approach, but imposes some limitations on the artistic appearance of the content.
- Use gateways to convert arbitrary content into a format that renders well on the particular platform. Unfortunately, the development of such gateways is very difficult and conversion of arbitrary WebPages for mobile phone may even be impossible.

8. IMPLEMENTATION CONSIDERATIONS ON MOBILE TERMINALS

One of the most critical factors of wireless terminal design is the energy management. A wireless terminal needs, in addition to wireless communication technology, a "virtually" wireless energy source. True mobility of the terminal is limited if one has to attach the terminal constantly to a charger. There are two fundamental ways to increase the operating time of wireless terminals: reduction of power consumption or increasing energy density of the battery.

Typically, mobile wireless terminals have four functional blocks: display, processing module, communication module, and power management block. The three first ones are power consumers of the device and the last one is the energy source.

Multimedia devices are purposed for content- and media rich services. This kind of device needs a graphical display of relatively high resolution, preferably color. Selection of the display is critical with respect to power consumption. The power consumption of displays can vary from the mWatt range (passive matrix reflective LCD (Liquid Crystal Display)) to several Watts (active matrix LCD with backlight).

For TV applications, VGA resolution is almost sufficient. Most of today's Web content is however made for SVGA and higher resolution. Therefore SVGA resolution screens with fast display (video requirement) are the natural choice for multimedia terminals. There are several possible display technologies for this purpose. Field emission displays (FED), Active Matrix LCDs (AMLCD) (reflective or with backlight) or head mount displays (HMD's which are usually implemented using AMLCD technology). FED is an interesting candidate due to its scalability on power consumption depending on the content. White text on black background content consumes less electricity than "white Christmas". Power consumption can vary from the sub Watt to the 5..6 Watts range on 12.1" FEDs. However, despite of many promising ventures, FED have not been capable of migrating into the mobile terminal market.

Power consumption of AMLCD light modulating elements as such is not large. About 2/3 of the power is consumed by the backlight. Reflective colors AMLCDs are coming from several vendors. Of course, front light is needed in this case, but in daylight conditions, reflective LCD's are a good choice. HMDs bring a new dimension into the game of power consumption of displays. Power consumption is lower compared to any other alternative.

Intelligent mobile devices need calculation power for content decoding and applications. Depending on the architecture, the processor and the peripheral components consume from 100mW range to 10W range. Lowest power consumption figures today are observed on ARM based architecture solutions. Upper range solutions are typically x86-based. Since almost all leading Internet browsers run well on x86 platforms the usage of x86 architecture is appealing for web capable devices. One interesting approach on lowering the power consumption of x86 architectures is a processor using a code morphing software layer between applications and x86 core [19]. This kind of approach provides x86 platform for applications with power consumption of 1..2 Watts or less.

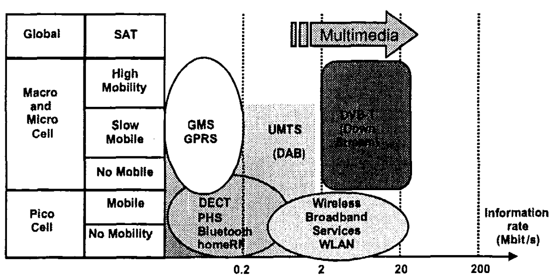

Figure 8: Segmentation of mobile wireless communication devices

There are three parameters, which can be used when segmenting wireless communication devices. These are cell size, mobility factor and communication speed. For example, current cellular phones operate on macro and micro cells with high mobility. Data speeds are from 9.6kb..128kb/s. Wireless Local Area Network (WLAN) falls in the category of mobile Pico cell equipment with high communication speed. DVB-T brings into this picture a system for high communication speed, full mobility and scalability from micro cells to macro cells (see figure 8).

The power requirements of the communication methods considered differ considerably. GPRS is generally a very low power block. This is mainly due to system design issues: the interface is ON only when needed. When a communication interface like DVB-T is used for reception of continues signals (case TV) it typically uses 1..2 Watts. If DVB-T communication interfaces are used to receive scheduled data packets power consumption can be naturally reduced.

The battery energy density is normally expressed either on volume metric energy density or gravity metric energy density. Figure 9 shows typical volume metric and gravity metric energy densities.

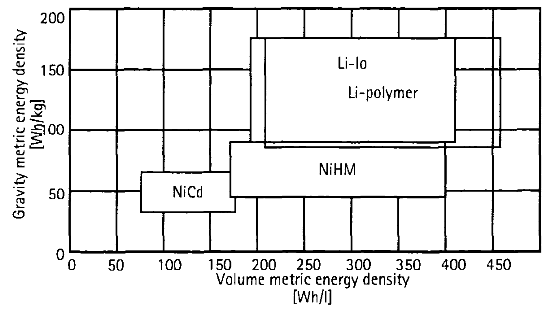

Figure 9: Battery energy densities

Lithium polymer batteries are a new interesting group of lithium-ion batteries. They are based on the same chemical principal than "traditional" lithium-ion batteries. The difference is on composition of electrolytes. New polymer structures use jelly like materials instead of liquid. This gives the possibility to implement batteries in virtually any form factor. Batteries can be shaped for example in size of 10.4" displays with a thickness of some millimeters.

As discussed in previous chapters, the technology for implementing a mobile multimedia terminal exists today. These kind of terminals have been also demonstrated (see figure 6) in tradeshows. We believe that the dissemination of terrestrial broadcast networks with wide coverage is an important precondition for the cost efficient delivery of rich, emotional multimedia content.

9. SOME ACTIVITIES AND PLAYERS IN MOBILE MULTIMEDIA

There are several activities trying to establish standards for multimedia appliances.

The standardization bodies for **car multimedia systems** recognized the need for a multimedia distribution channel in the car. To meet the demands of compatibility for the appliances from different manufacturers, a common open API is needed. Several manufacturers have already demonstrated some multimedia solutions for the car, but they are all based on proprietary platforms.

The *IDB forum* [10] specifies a low speed and a high speed bus system for vehicles. The IDB specification is open and uses existing standards if possible.

The *MOST consortium* [7] specifies the networking of car appliances over an optical bus from physical to application layer. It allows up to 22Mb/s bus transfer rate and allows to connect different devices which meet the MOST standard to work together.

AMI-C [6] is a cross industry consortium consisting of car manufacturers. AMI-C's goal is to develop specifications for a multimedia interface to motor vehicle electronic systems in order to control electronic devices in the car.

Both **Motivate** (Mobile Television and Innovative Receivers) and **Memo** (Multimedia Environment for Mobiles) have been EU projects [5]. While Motivate dealt with mobile reception of DVB-T signals, Memo's target was to provide network structures for hybrid mobile network access, using DAB and DVB-T.

MCP (Multimedia Car Platform) is a new EU project from the 5th Framework Program IST just started. MCP will define an open application platform for mobile multimedia applications and services. The MCP consortium consists of CE manufacturers, carmakers, service providers and Network operators. To avoid the creation of "just another standard", MCP will re-use as many existing standards as possible. The MCP project emphasizes on the openness of the platform to enable horizontal markets.

The **Bluetooth** [9] Special Interest Group is specifying and promoting the Bluetooth standard. This consortium, originally consisting of Ericsson, IBM, Intel, Nokia and Toshiba, has now been joined by almost 1200 Companies. The Bluetooth standard is available for free [9].

The **WAP** [8] standard, is an open standard defined by the WAP forum, offers an efficient way to interact via a markup and scripting language over a cellular network connection to enable new kinds of services.

There are **DVB-T** trials for mobile reception ongoing in several countries (e.g. Germany, Singapore, Finland, Sweden, USA). Their main target is to test and demonstrate mobile broadband data services via a broadcast medium. In Germany the largest trial takes place in Northern Germany and includes the main cities and highways in that area.

10. CONCLUSIONS

Next generation mobile phones will be the ubiquitous companion of the mobile information society. However, there will be the need for specialized terminals, like multimedia terminals for the car and portable entertainment devices. This diversification in terminals and the increasing number of terminals competing for bandwidth impose some key challenges:

- Compatibility of application platforms,
- Creation of services that render well on these different platforms,
- Efficient usage of bandwidth.

The first two points are a matter of careful standardization of scalable content and application environments. As regards the third point, it is felt that data broadcast and digital TV are important factors to efficiently deliver broadband services and rich and emotional content.

At the same time new service opportunities open up that really differ from existing services just being consumed in a mobile environment. For the car, many applications and services can make the task of "getting somewhere" much easier and voice I/O delivers these services even to the driver. In general, location awareness adds a new dimension to all kinds of existing services.

The technology for mobile services and mobile consumer devices is available today. The success of these services will finally depend on convincing business models and the harmonization and interoperability of services and devices.

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BIOGRAPHIES

Stephan Hartwig received his M.S. degree in Electrical Engineering from the University of Bochum in 1990 and a Ph.D. degree from the University of Dortmund, Germany in 1995. Since 1994 he is with the R&D dept. of Nokia Multimedia. He has been working as SW designer and project manager in projects related to digital TV systems, mobile multimedia and recently bluetooth solutions. Other research activities and publications include adaptive filters, image compression and image formats conversion. Mr. Hartwig is Member of IEEE, VDE and the image coding experts group of the ITG.

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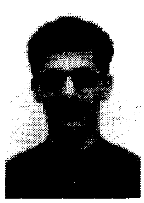
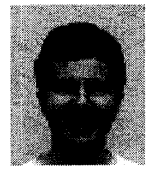


Reza Serafat was born in Sari, Iran on March 21, 1964. He received the diploma in Electrical engineering from University of Applied Science of Bochum, Germany, in 1990; the M.S. degree in Electrical Engineering from the Ruhr University of Bochum, Germany, in 1993 and the Ph.D. degree from the Christian Albrecht University of Kiel, Germany, in 1998. In March 1998 he joined R&D department of Nokia Mobile Phones, Smart Traffic Products, where he currently works as project leader for multimedia car platform. Mr. Serafat´s past research activities and publications include adaptive filters, array processing and speech processing.



Wolfgang Theimer was born in Bochum, Germany on February 25, 1965. He studied at the Ruhr-Universität Bochum and Purdue University, West Lafayette (USA). He received his M.S. degree in electrical engineering in 1990 and a Ph.D. degree in 1995, both from the Ruhr-Universität Bochum. His past research activities have concentrated on audio and image processing as well as pattern recognition. In October 1995 he joined the Nokia Mobile Phones R&D center in Bochum as software and system design engineer, later as project manager for advanced development projects. He is currently involved in design and development of intelligent user interfaces for in-car telematics terminals. Mr. Theimer is member of the IEEE.