Wireless Communication, Portable Devices and Use

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Sammendrag/Abstract:

The current state of development in portable devices and wireless technology has brought us to the brink of new era. Given the present frame of technological possibilities and opportunities within the market, it is inevitable that the times ahead will bear witness to the production of small, highly-specialized devices for highly specified areas of application. Many of these will include components for proximal and/or global network connectivity. On the other end of the spectrum, the coming decade will also yield the development and productification of “all-in-one” wireless devices — devices hosting a *very* wide spectrum of functionalities — including applications related to communication and work/business support, as well as “on demand” entertainment.

The intention of this report is therefore to provide an impression of the current status in portable and wireless technologies, both networks and devices, and to sketch out some future directions of development and possible use.

The chapters within this document are written and organized such that they can be read as independent units, or as a whole. The subject matter addressed herein includes:

- Wireless Communication Technologies
- Platforms
- Today’s Devices, and
- Use Cases for Portable Technology.

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1. Introduction

The purpose of this document is to collect and present some of the results achieved in POW and POWFACE, two Internal Projects carried out at NR in during 1999. The two projects have had different, yet related foci. In POW, the focus was:

- to look into the new kinds of small, mobile devices emerging and expected within the market, particularly their feature-sets;
- to investigate both existing and future technologies for connectivity to such devices, with focus upon both wireless and broadband connectivity; and,
- to consider the ways in which these devices can be used in new, innovative ways in order to meet needs existing in both common and specialized areas of use.

The POWFACE project has had its focus in the area of user interface issues and themes, specifically in relation to the kinds of technology and use areas studied within POW.

The chapters within this document are written and organized such that they can be read as independent units, or as a whole. The subject matter addressed herein includes:

- Wireless Communication Technologies
- Platforms
- Today's Devices, and
- Use Cases for Portable Technology.

Closing the document is a summary, followed by a list of references to relevant material and links. Other relevant links can be found in section 5.4, as well as interspersed throughout the document.

2. Background

Trends serve to shape the field of information technology: sometimes trends come quickly and are quite immense, other times they appear slowly yet have long periods of influence; sometimes, the world is simply ”never the same again”. Perhaps this latter phrase best characterizes the situation we find ourselves in at present.

Consider Figure 1, for instance, which illustrates a certain perspective upon a widespread IT trend within the 1980’s and early 1990’s. The figure depicts three axes: work contexts, applications and devices. The perspective illustrated here is that during that period of time:

- commonplace applications and devices began being used in new work contexts;
- new applications began being devised for such work contexts; and
- certain new devices were conceived to host these new kinds of applications.

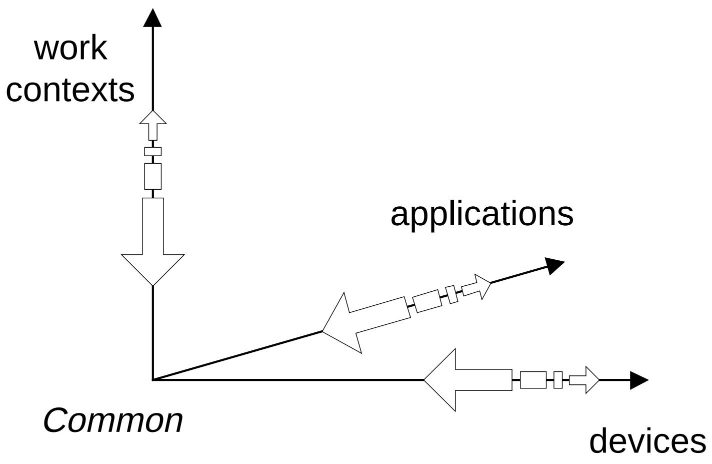

Figure 1: Evolutional and productification trends in the 80’s

In the 1980’s and early 1990’s, however, there was an overwhelming tendency in productification which could be likened some kind of effort towards generalization. As Figure 1 illustrates, this trend tended to bring everything which was *new* back to a common ground: *the desktop*. If a new application were devised, there was an effort to ensure that it would operate on as many kinds of platforms as possible, and that it could be used within as many work contexts as possible. Such generalization could often lead to the ”necessary” elimination of perhaps some of the most useful features and functionality within the new application.

The evolution of certain new devices also suffered from this same phenomenon. Rather than being productified as a niche device for specialized use, product development organizations saw to it that as many applications as possible were ported to the new device. Again, the result was a product which was less suitable for the specialized use contexts and applications from which its design was originally conceived.

In the latter half of the 1990’s this trend has perhaps lessened, though it is still somewhat prevalent. Currently, there is a general recognition by product development organizations that specialized devices, hosting specialized applications, for specialized areas of use, can be productified and sold for a justifiable level of profit.

This turn in the trend certainly has a number of causes, including the continual increases in processing power and memory capacity — within smaller and smaller components — at lower and lower costs. The customer base is also increasing in terms of sheer volume and diversity. Perhaps one of the primary causes, however, has been the need for product development organizations to yield to the forces and implications resulting from the enveloping, yet enabling convergence of tele- and data communication technologies.

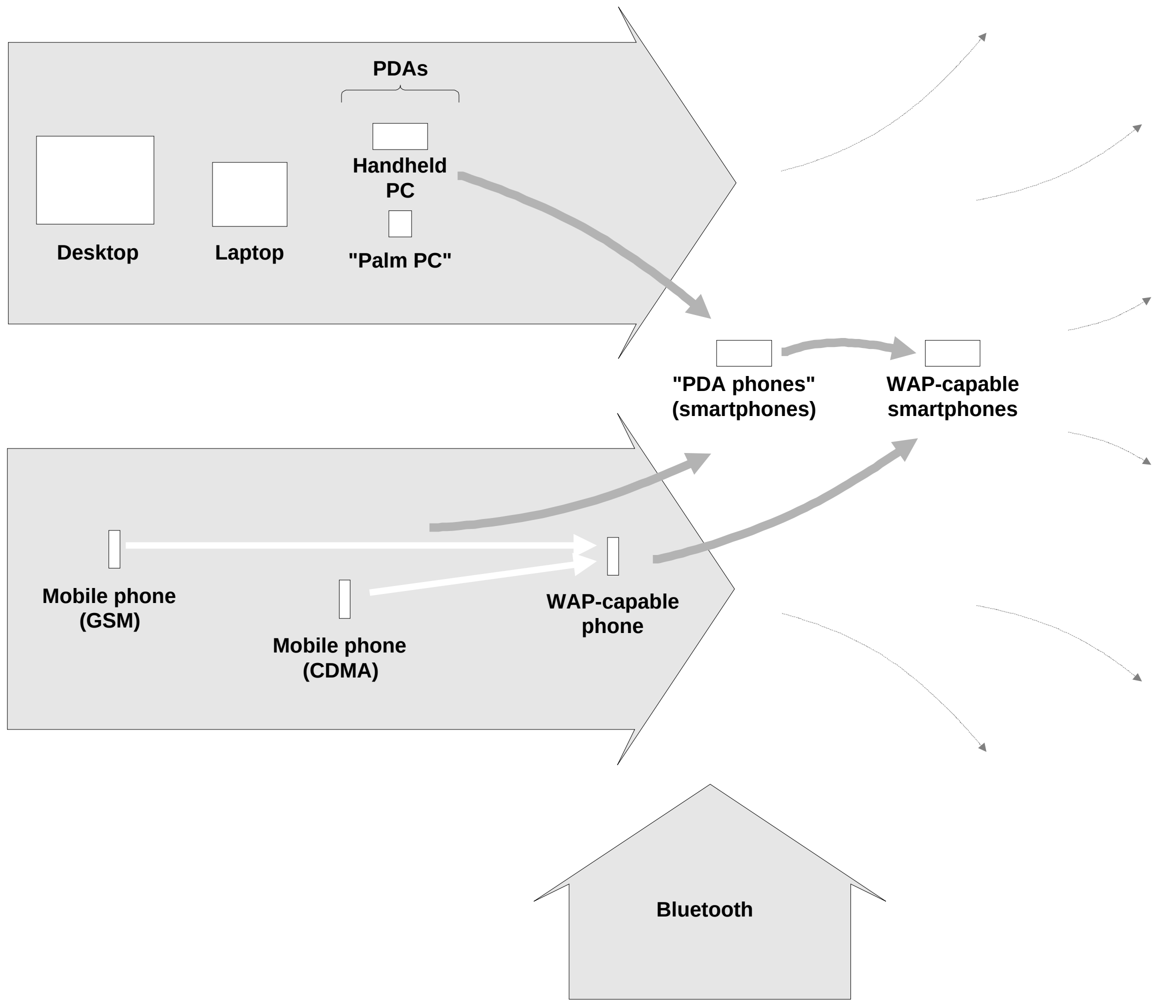

Figure 2: New mobile technologies and device evolution: status per 1999

Figure 2 intends to illustrate several things related to this turn in the product development trend; it employs a (non-linear) temporal axis, from left to right, which depicts:

- the evolution of data device technology: from larger desktop machines to smaller, handheld/palmtop devices;
- the evolution of telecommunication technologies: new, higher-bandwidth transmission technologies (e.g., GSM $\rightarrow$ CDMA), new phone-based interaction possibilities (e.g., WAP);

- telecom and data convergence: the area of convergence in which new, small computers and mobile devices for telephony (as well as common and/or WAP-based network access) are joined within the same platform; and
- the arrival of Bluetooth: a technology which enables secure, seamless detection and inter-connection of devices located within close proximity of one another.

The right-hand side of Figure 2 depicts an imminent explosion of new devices, enabling technology, and components. Given the current frame of technological possibilities and opportunities within the market, it is inevitable that the times ahead will bear witness to the production of small, highly-specialized devices for highly specified areas of application. Many of these will include components for proximal and/or global network connectivity. On the other end of the spectrum, the coming decade will also yield the development and productification of "all-in-one" wireless devices — devices hosting a *very* wide spectrum of functionalities — including applications related to communication and work/business support, as well as "on demand" entertainment.

3. Wireless Communication Technologies

This chapter describes some wireless communication technologies suitable for mobile devices such as PDAs, portable PCs and mobile phones. The different communication technologies have quite different capabilities when it comes to coverage, bandwidth and the degree of mobility they offer to the end terminal. The different end terminals are also connected in different manners, sometimes as a direct transmission and sometimes via intermediate systems using wireless transmitters or cable.

The first half of the chapter presents some basic technologies and concepts used in many wireless communications systems. The second half contains a summary and comparison of the different systems.

3.1 Basic technologies and concepts

One major problem of wireless communication is how to allow many users to communicate at the same time. Different segments of the electromagnetic spectrum have been dedicated to different user groups and uses, the most usable parts of this spectrum have become quite crowded. There are two general solutions applied to this problem; the first is to reduce the range of the each radio transmitter, the second is to use some kind of sharing scheme. I will discuss these two methods in the two following sections, “The cell concept” and “Sharing ‘the air’”.

3.1.1 The cell concept

In traditional radio communication one major goal has been to install antennas at high points on the land, or use tall antennas, and thereby allow stations further away from each other to communicate. The problem with this approach is that the frequency used by the two stations is blocked for other traffic over a large area. This is demonstrated by a mobile phone system made by Bell around 1970, it covered New York City, but could only handle 12 simultaneous calls.

The idea of a system built on many small cells was developed to cope with this problem. In such a system each radio base station is designed to cover a relatively small area using some assigned frequencies. In the neighboring cells other frequencies are used, but further away than the neighbor the same frequencies are used again. This frequency reuse allows many more handsets to be used at the same time within the same area. The result is seen in today’s modern cellular systems, which can handle hundreds or thousands of simultaneous calls from a city center. The cell system also has one other major advantage. The smaller the cells, the smaller the transmitters. Smaller transmitters consume much less power. This enables battery powered devices to work for a longer time before recharging.

The cell idea also has some disadvantages. When the user is mobile he may move from on cell to another i.e. from the coverage are of one base station to another. The call needs to be transferred from one base station to another. This process is called handoff. This and other similar processes complicates the system. With smaller cell sizes, more handsets can be served, but at the cost of more handoffs and other administration.

3.1.2 Sharing "the air"

A communication service is normally only allowed to use one or two blocks of the electromagnetic spectrum. Figure 3 illustrates this kind of partitioning.

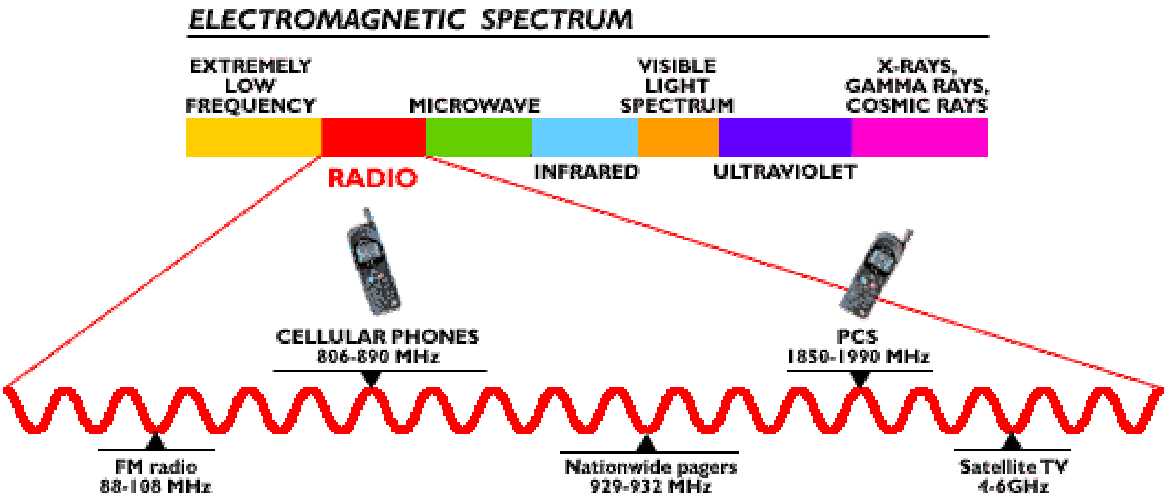

Figure 3: Transceiver spectrum (adapted from [5])

It is important to utilize this "space" as efficiently as possible. Many different schemes have been developed to accomplish this.

The introduction to the methods is motivated by two factors. Firstly, the abbreviations are used a lot in telecommunication literature. Having a basic knowledge can be useful when reading this literature. Second, the different technologies have implications on the capabilities of the system as experienced by the user.

3.1.2.1 FDMA

Before I start explaining the more complicated schemes I will say a few words on Frequency Division Multiple Access, FDMA. This is the basic method of letting different communication use different frequencies to let them access then same medium (the air) at the same time. This is used in standard broadcast. A radio station maybe placed at 100MHz and another at 102MHz. By tuning your radio receiver you decide which station to listen to, i.e. you tune your radio to suppress electromagnetic waves of other frequencies. Only the frequency let through is demodulated or "decoded". To allow many stations in the same band stations should occupy as narrow a part of the frequency spectrum as possible.

3.1.2.2 TDMA

In Time Division Multiple Access (TDMA) more that one radio sender is allowed to use the same frequency during the same period, but not at the exactly same time. This is often accomplished by assigning a timeslot to each connection. This scheme is for example used in GSM, where up to eight cellular phones can connect to a base station on each frequency. In GSM the eight terminals are sending in a round robin fashion, each of them in approximately 0.5ms each time. The TDMA scheme is normally applied together with a FDMA scheme. In GSM this means that the base station can handle eight phones at a time on each frequency it can use. If all timeslots on all frequencies are busy no more terminals can connect to the same radio base station.

3.1.2.3 (W)CDMA

In opposition to FDMA / TDMA a Code Division Multiple Access (CDMA) scheme lets each transmitter spread its signal over a wide frequency band. there A spreading code is assigned to each transmission or transmitter. This code is used in the transmitter to spread the signal, and in the receiver to collect the signal together again. Without the spreading code, it is impossible to receive and decode the signal. Other signals that are spread using a different spreading code are seen as noise. A CDMA scheme therefore has no hard limit on the numbers of users. Each new transmission just increases the noise, resulting in a decrease of the signal to noise ratio. When the signal is too weak in comparison to the noise, communication breaks down. Since all terminals share the same frequency area, a handoff does not imply a change of sending frequency and timeslot such as in GSM. Handoffs are simply handled by selecting the base station with the best signal. If a high bandwidth is used, this scheme is often called WCDMA.

3.1.2.4 DSSP and CSMA/CA

In Direct Sequencing Spread Spectrum, as in CDMA, a spreading code is used to spread the signal over a wide bandwidth. The difference to CDMA is that all transmitters have the same speeding code. This means that the transmitters can not transmit simultaneously. To avoid collision a scheme is used that looks much like the one used on Ethernet. This scheme is called Carrier Sense Multiple Access, Collision Avoidance (CSMA/CA). The basic idea is that each transceiver listens for a carrier. If no carrier is heard, the net is free for transmission. In wireless networks a "virtual carrier" is used, where the sender and receiver do a 4-way handshake using special packets. These are sent after a period of listening to the net without anyone sending. The IEEE 802.11 standard used CSMA/CA. The standard allows three different signal transportation method, one based on DSSP, one based on frequency hopping and one special designed for infrared transceivers.

3.2 Different types of systems

The description of the different transceiver systems is divided into three categories. The categories are not totally exclusive, and some of the systems can be placed in more than one of the categories. I have placed the systems where I find them to have their main focus. The three categories are:

1) **Mobile telecommunication systems.** There are systems run by the telecommunication companies enabling users to connect to and from any subscriber terminal. A typical example is today's mobile phone system and tomorrow's multi-media, multi-terminal version.

2) **Systems based upon a LAN idea.** These systems extend or substitute wired LANs in companies and organizations. The wireless part of the network is connected to the company's infrastructure, with services such as printers, archives, general Internet connections etc.

3) **Direct link or ad-hoc networks.** This category contains links directly between two participants and small ad-hoc network where no additional infrastructure is used or needed.

3.2.1 Mobile telecommunication systems

The mobile telecommunication systems are often divided into three generations. The first generation includes analogue systems, for example NMT450 and NMT900 (NMT - Nordic Mobile Telephone). The second generation includes digital systems, in Europe this is typically GSM (Global System for Mobile Communications). The third generation, not yet developed, is a system that provides high bandwidth to a large variety of terminals. These terminals that can have multimedia capabilities. An example of one such planned system is UMTS.

The description below starts by describing GSM, a typical second generation system. It then describes the GPRS system that will give GSM better characteristics for data transfer. It concludes by saying some words on UMTS, a third generation system.

3.2.1.1 GSM

GSM is the most common cellular phone system in Europe. Most countries in Europe have some GSM coverage, while many have an extensive coverage in both urban and rural areas. In Norway, the GSM system covers all urban areas and most roads. Although there is typically no coverage in mountain and backcountry areas except for a few of the most popular places. The main advantage of GSM as a carrier of data traffic is this wide coverage. For long distance mobile data transfer, GSM is often the only existing practical solution. The “radius” of a GSM cell can be up to a few kilometers.

The GSM system uses a combination of FDMA and TDMA. Each frequency used by the system within a cell gives space for eight subscriber units. Each subscriber unit gets a dedicated timeslot where it sends digital voice packages. It listens for packages on another frequency and in another timeslot.

The phone calls are routed from the subscriber unit via the radio interface to the radio base station. The radio base station is connected to the wired telephone system, which does the rest of the routing to the subscriber at the other end. This means that if a terminal has connection with any base station that is willing to serve it, then it can call any telephone service or subscriber. Calls going to a mobile subscriber use the telephone number to find a registry that contain information about which base station that has contact with the subscriber terminal at the moment. This information is then used to route the call to the proper base station. When a subscriber terminal moves from one radio base station to another the registry is updated. The GSM system is capable of carrying out handoffs while keeping the connections up. Handoffs are almost unnoticeable for the user. If a packet is lost, for example when roaming or driving through a spot width bad signal strength, the packet is substituted in the receiver end with a pleasant sound.

The GSM system is optimized for transmission of voice, and among others its *circuit switching* properties limit the amount of bandwidth that is available to the user. This is a problem when sending large amount of data. A single terminal can achieve approximately 13000bps, but in practice 9600 is chosen as the transfer rate.

When using GSM for data transport a standard connection is established between the subscriber unit and an Internet Service Provider (ISP) or other modem set-up. If the ISP is connected with ISDN or other fixed lines (e.g., wired telephone system), the packets are converted between the GSM part and the fixed line part. Over this link a PPP (Point to Point Protocol) is used and also other *packet-based* network protocols such as IP.

3.2.1.2 GPRS

The design goal of GPRS (General Packet Radio Service) is to use as much of the GSM infrastructure as possible (e.g., radio base stations, cell structure, etc.) but at the same time offer users better bandwidth. The central idea is to enable packet based switching in addition to the line based switching of GSM. The subscriber can get a higher data rate at need if there are free timeslots at the base station. The maximum data transfer rate is then approximately 100kbps, but it seems like most manufacturers will limit this to the standard of 56.8kbps. If more that one person is using the same frequency they will have to share the 100kbps. With eight users we are more or less back to GSM's 9600bps. A remedy to this is to make smaller cells so only a few users will be in each cell. The disadvantage is the cost of extra base stations and more frequent handoffs.

In opposition to GSM no specific call set-up is necessary to use GPRS to data transport. Packets from the subscriber unit are routed from the phone to a gateway at the operator. From this gateway it is routed through the Internet to its destination. Packets going to the subscriber unit are also routed via this gateway. This two step routing can typically be done using Virtual Private Network (VPN) protocols. The Internet user sends their package to the standard IP address. From there the packet is routed firstly to the gateway, and then to the subscriber. No call set-up, modems etc are necessary resulting in much shorter delay when connecting. It is also possible to take normal phone calls while still receiving data packets. Services that give a small amount of information over a long period of time becomes much more manageable when using GPRS. GPRS is expected to be available in Norway first half of 2001 for both Netcom and Telenor subscribers.

3.2.1.3 UMTS

UMTS (Universal Mobile Telecom System) or 3G is the name of the "next generation cellular system". This system will support advanced multi-media terminals. The bandwidth of the system is expected to be a few Mbps for fast moving subscriber units up to tens of Mbps for slow moving subscriber units. The system will be based on a CDMA scheme in contrast to GSM that is based on FDMA/TDMA. This has the advantages of better frequency utilization and less complicated handoff procedures. The scheme is also well suited to deliver high bandwidth data. Similar technology has already been used for many years within the military and for the latest few in mobile phone systems in the US. The major disadvantage is that this system requires a new and very costly infrastructure. This system will probably be a city and metropolitan coverage only system. When travelling out of the UMTS overage a handoff to GSM/GPRS has to be made, at the cost of much lower bit rate. UMTS is expected to be available in 2002.

3.2.2 Systems based upon a LAN idea

The "LAN category" naturally splits into two. The first group is the typical wireless LAN made for offices etc, while the second group are LANs made for the private home as a part of the "intelligent house" idea. The two groups are described in the following sub-sections.

3.2.2.1 Wireless LAN

Wireless LAN is a technology that lets you extend or replace your traditional wired LAN with a radio based one. It is typically a substitute or addition to Ethernet or a FDDI (Fiber Distributed Data Interface). On top of this IP is normally used. Typical reasons for choosing a wireless LAN instead of a wired one is that the terminals should be mobile, that the location of the LAN is temporal or that wiring the building is expensive or impractical. Examples of products in this category are 3com's Air Connect, Breezecom's BreezeNet and Wavelan.

The radio transceivers are often placed on a PCMCIA card for use with portable PCs. Cards also exist for stationary PCs and PDAs. A wireless transceiver typically supports bandwidth of 2-10Mbps, and most follows the IEEE 802.11b standard.

The typical range of a transceiver is between 30 and 100 meters. The range of each radio transmitter can be dramatically improved by using directional antennas etc. Although this can extend the range up to several kilometers it also immobilizes the terminal since the antennas have to beam exactly towards each other.

The short range of each transceivers makes it necessary to have many base stations to cover a larger area. One terminal is allowed to roam from radio base station to another base station on the same LAN. If the new base station is connected to another LAN problems arise. Packets routed to the old IP address are routed to the old LAN. Packets sent from the mobile client do not find the default gateway. Using mobile IP for example can solve these problems. Another problem is connected to security. It is unlikely that most corporations will allow unknown mobile terminal to connect to their intranet without severe restrictions on what the mobile terminal is allowed to do.

For more information see:

A class in wireless networks: http://www.csm.ohiou.edu/comt391w/

Breezecom: http://www.breezecom.com/

Wavelan: http://www.wavelan.com/

Wireless LAN Alliance: http://www.wlana.com/

3.2.2.2 HomeRF

The intelligent house is the idea of a house where the different consumer electronics, lights and other consumer devices work partly automatically and are controllable from a central point. To be able to do this, the devices need to be able to communicate with each other, this requires both a network and some protocols. The HomeRF working group aims to do this. Some core members of the group are Compaq, Ericsson, HP, IBM, Intel and Microsoft.

The group has developed an open royalty free standard supporting interoperability between the electronics in and around the home. Their vision is a home where all the different consumer electronic, such as phones, PCs, TVs, baby monitors, VCRs etc work together.

The HomeRF group outline applications such as:

- Automatic regulation of heat, light, burglar alarm etc.
- Connecting peripherals without cords.
- Carrying the mobile display pad in the garden for checking problems with plants or checking automobile parts from the garage or reading stock quotes in the kitchen.
- Accessing information and share files between computers.

Version 1.0 of the specification was released in February ’99, the first consumer devices were demonstrated at COMDEX in November ’99, and the first products are supposed to appear on the consumer marked in the first half of year 2000.

The radio interface for HomeRF is called SWAP (Shared Wireless Access Protocol), which supports both voice and data communication. The protocol can handle 6 voice channels, and 1-2 Mb/s of data support. It uses the international license free 2400 MHz band (same as Bluetooth) and the range is up to 50 meters. Emphasize has been put on the reliability and the security of the network. The SWAP protocol is very similar to the protocol in the Bluetooth initiative.

For more information see:

http://www.homerf.org

http://www.comdex.com

3.2.3 Direct link or ad-hoc networks

The technologies described in this section have its primary focus on direct links between two devices, or small ad-hoc networks using no external infrastructure. This does not imply that they cannot be used as a part of a wireless LAN for example, but only that this is seldom done, or that the technology is inferior to other technologies for those kinds of applications.

3.2.3.1 IrDA

An infrared gate is attached to many of today’s portable PCs, PDAs, printers, digital cameras etc. The small size and low cost of the device has made it almost ubiquitous in the world of portable equipment. The IrDA is mainly for connection between two terminals, but it offers some limited network control.

The IrDA gate has some special characteristics. Firstly, its limited range of approximately one meter for the standard version and 20cm for the low power version. A direct "line of sight" between the two IrDA devices is needed. The devices do not need to be perfectly aligned since the transmitter has a fairly wide spread.

The speed of the IrDA port is quite competitive compared to alternatives like a “com-cable” or Bluetooth. The IrDA specification version 1.3 and newer IrDA chips can handle speed between 2400bps and 4Mbps. All IrDA devices are expected to handle 9600bps. The typical maximum speed for chips in handheld devices is 115kbps, the same as the typical speed for the cable connection for the same devices. The IrDA connection is an open-air connection. This makes it vulnerable to inference from other electromagnetic wave sources. These can be sources such as radio transmitters, sunlight, light bulbs and strip lights.

To make the IrDA gate more simple to use by application programmers, standards have been developed for special use cases. Two interesting use cases are the use of the IrDA devise as a serial port and as a last link in a LAN. The IrCOMM standard makes the IrDA device behave like an ordinary serial port. This means that each user applications does not need to handle the IR port specifically. The IrLAN standard describes how to use the IrDA port as a connection point to the LAN. A disadvantage is that although you don't need to connect a cable to your device to get connected to the LAN, it gives very limited mobility for the user. The one-meter range combined with the need to "point" towards the receiver can be more limiting than a cable.

Some critique has been raised against the standard. On such is made by Donald Becker after implementing an IrDA stack for the Beowulf Linux Cluster Project (See link below). Becker states that the standard is incomplete and is a rather sloppy piece of work. He also questions their idea of defining their own higher level protocol, instead of for example defining PPP over IrDA and using standard IP protocols from there.

Becker states that the incompleteness of the link specification protocol in addition to the restrictive physical capabilities makes software that allows communication between more than two partners unlikely. His conclusion is that although IrDA ports are almost everywhere, often the required software is not available. He states it will stay this way until a better standard for using them is developed. Another hope for the standard is that IrCOMM will be widely accepted so that user programs do not need to handle the IrDA specifics.

For more information see:

- IrDA organization at http://www.irda.org
- HPs pages at http://www.semiconductor.agilent.com/ir/
- IrDA critique at http://cesdis.gsfc.nasa.gov/linux/misc/irda.html
- IrDA on Win CE at http://www.cewindows.net/wce/20/irda.htm

3.2.3.2 Bluetooth

In 1994 Ericsson Mobile Communications started working on a radio interface to eliminate the need for cables between keyboards, PCs, Phones, Headset etc. The IrDA had limited range, it was direction sensitive and it worked primarily for connecting only two devices. Ericsson aimed for a standard that could overcome these limitations. While working on this, Ericsson looked for partners so that the new standard could gain international support. They found Nokia, IBM, Toshiba and Intel, and together they started the development of the Bluetooth technology. The number of member organizations in the Bluetooth interest group was approximately 1200 by November '99. An interesting point is that the five starting companies have already made a wide variety of devices, for example both PCs and cellular phones. This selection of devices has allowed interesting services to be imaginable from the start.

The Bluetooth technology can be seen both as a wireless cable i.e. connecting a PC to a disk drive, and as an ad-hoc network, for example when connecting eight PCs in a meeting room. The description here will start by focussing on the radio link, mainly with the "wireless cable" perspective. The networking aspect will also be described.

A goal for the project was to develop a link technology that could be used world wide and could cover both voice and data. The transceivers should be small, cheap and have a low power consumption. The standard should be open. The Bluetooth radio link supports both synchronous and asynchronous traffic, the synchronous part is typically used for voice in different phone applications, the asynchronous mode is used for data transfer. Different packet size and symmetry option exists. Two examples are a symmetric connection with 432kbps both ways and an asymmetric link with 721kbps one way and 57kbps the other. Version two of the standard is supposed to double these rates.

The working range for a Bluetooth transceiver is approximately 10 meters. This can be expanded to around 100 meters by adding transmitter power. A problem with this is that it will consume more battery power. Another way of extending the range is to use larger antennas on any non-portable elements.

Connection establishment typically takes around six-seconds, with a maximum of 23 seconds. To enable faster connection different levels of participation on a link are enabled. A unit can be connected and ready, disconnected, and have different states in between. The closer a unit is to a full connection the faster it connects, but the more power it uses.

The Bluetooth standard contains some basic routines for security control. Every Bluetooth device has an ID, so you can restrict who is allowed to connect etc. A frequency-hopping scheme is used which gives some security from people who might be eaves dropping. If material sent is especially sensitive the standard recommends using other encryption in addition.

The Bluetooth transmitter works in an internationally available license free radio band at 2.4GHz. It shares this band with other consumer devices such as garage door openers and microwave ovens. To make the system less vulnerable to noise from such equipment it can also use the frequency-hopping scheme. For each packet, the system changes frequency before the next packet is sent. If one packet is lost due to noise on one frequency, the packet can be resent on another frequency later.

A Bluetooth link as described above can have more than two participants, and is then more fruitfully seen as a network. Each network can connect up to eight units, and is in Bluetooth terms often called a Piconet. One of these units is the master of the network. It is the masters ID and clock that is used to select the frequencies used in the frequency hopping scheme explained above. The master polls the slaves, checking if they have something to send, and in this way implements a TDMA scheme.

Other Piconets can of course be within the 10 meter range. The different IDs of the masters of the net make sure that the net does not use the same sequence of frequency hops. It is possible that they now and then try to send one packet at the same frequency at the same time. This is likely to destroy both packets. Simulations done by Ericsson indicate that ten Piconets in the same area will reduce the effective speed for each of them by approximately ten percent.

A device can on more than one Piconet at a time. This means it is possible to link Piconets together into something called Scatternet. Since each Piconet has a different master than the other nets, members of different Piconets does not share the same 1Mbps of bandwidth.

Different kinds of devices have different possibilities and needs, but are still expected to work together. The Bluetooth standard contains several usage models that are made to cover different information exchange as required by the different devices. A general PC should typically be able to do networking via a cellular phone, act as a speakerphone, exchange business cards and sync calendars. A cellular phone should support services like wireless hands-free, networking towards a PC, business card exchange and address book.

The specification was released in mid autumn ’99 while the first product release was at the COMDEX exhibition in November ’99. Large volumes of the chip are expected to be available on the marked first half of year 2000.

For more information see: http://www.bluetooth.com

3.3 Location and positioning

This section concerns location and positioning which, technically speaking, are not actually wireless communication technologies; instead, one can understand them as basic services which can be delivered via wireless communication. This topic is therefore included in this chapter.

There are basically two ways of establishing the position of a user terminal. The first possibility is to use radio communication to calculate where the device is sending from. The other possibility is to have a position detection device on the terminal.

In the first case, using the radio system, has traditionally been done by calculating bearings from two or more radio receivers, and comparing these to calculate a position. With three or more stations bearing the sender a fairly accurate position can be given. In today’s cellular system, an easier and often more precise method is simply for the system to let the user application ask which cell the device is in. If the cells are small, the position can be accurate enough for some applications.

Using a positioning device is the other possibility. Today, this is done by placing a Global Positioning System (GPS) receiver on the terminal. This device uses signals from a net of satellites to decide its position. This position can then be used at the terminal, or sent by the radio link to some application. GPS currently has a precision of 100m horizontally and 150m vertically. For special needs additional information can be used making the position precise down to a meter.

4. Platforms

Today's mobile devices are concentrated around four major platforms. The Symbian licensees target the EPOC platform. Microsoft's partners target the Windows platform, with both Windows CE and Windows 95/NT etc appearing on mobile devices. 3Com offers its PalmOS platform. The announced cross-licensing agreement between 3Com/Palm and Symbian partners may prove an interesting development within this area, possibly providing the Palm interface on an EPOC platform.

We have chosen to describe these platforms according to the following attributes:

Current target devices: Today's mobile devices come in several different forms and sizes. We have chosen to describe these as handheld (like Psion 5, HP Jornada 690), palm size (like PalmPilot, Casio E-105), mobile phones (like Nokia 9110, Ericsson R380) and notebooks (like Sony Vaio).

Future trends: Several companies have announced plans for future developments of their platform. We have tried to summarize these future trends.

Development Environment: An essential part of mobile devices is the ability to develop software for them. We have made a brief summary of the available environments.

Java Support: The variety of development environments may make cross-platform development difficult. Java support on these platforms may alleviate this.

Software Philosophy: We have noticed a difference in software philosophy between the different platforms. This may be due to the development environments offered, but also to the market segments of each platform.

Direct Mobile Connectivity: Most devices provide some sort of connectivity. We have summarized existing and emerging offerings.

Middleware: New applications and systems enable by direct mobile connectivity may benefit from additional middleware services.

Involved Companies: The companies investing in a specific platform may have a significant impact on the targeted user groups and market segments.

The below table summarizes the main attributes of the four major platforms.

	EPOC	WindowsCE	Windows	PalmOS
Current Target[1]	H/MP[2]	H[3]/P/A	Small NB and upwards	P
Future Trends	Great investments in MP	Consumer devices, difficulty in finding partners for MP	-weight/size +power	Connectivity
Development Environments	Free C++ toolkit (emulator and real device support), specific design for mobile devices	Retail Visual Studio (C++, Visual Basic) - very similar to other Windows development.	Many	Several free ones (mainly GNU based)
Java Support	Planned (Beta)	Possibly (J++)	Yes	At least partial
Software Philosophy		Largely Money Based	Mixed	Mostly Free
Direct Mobile Connectivity	Mobile phone, Bluetooth(?), IrDA	IrDA, possibly mobile phone, Bluetooth(?)	IrDA, Bluetooth(?)	IrDA, wireless packet
Middleware	Possibly Jini	Possibly Universal PnP[4]	Several	-
Companies (Existing/Future Products)	*Licensees:* Psion, Motorola, Nokia, Ericsson, Philips, Matsushita *Other partners:* Sun, 3Com/Palm, Lernout & Hauspie	HP, Sharp, Casio ++[5]	Many	3Com, Handspring

[1] H=Hand, P=Palm, A=Auto/Car, MP=Mobile Phone, NB=Notebook

[2] Philips Ilium Mobile Phone + Synergy Clip On, Ericsson R380

[3] Also Handheld Pro, with machine sizes close to small Windows based portables.

[4] http://www.microsoft.com/hwdev/homenet/upnp.htm

[5] Some manufacturers, like Philips and Everex have discontinued their CE offerings.

5. Today’s Devices

5.1 Introduction

There have been many advances since devices such as the Psion Organiser 1 (1984) (http://www.org2.com/psion1/), now that people seem to have busier schedules, there has been a demand for functions and applications such as:

- file-o-fax (contacts, diary etc.)
- phone
- Short message service
- emails
- internet access
- Microsoft office

5.2 Types of devices

Every month, new portable communication devices are becoming available, each with an assortment of the above functions and in a different size and shape. Each of these devices may be placed in one of the following categories:

- Pagers (numeric, alphanumeric and 2-way)
- Handheld PDA’s (stylus only and with both a stylus and mini keyboard)
- Mobile phones
- Notebooks

5.2.1 Pagers

Pagers are still commonly used though the technology has advanced since the days of numeric pagers (Figure 4), where the remote worker would be alerted with a telephone number and then have to find a phone and call the number to find out the message. However, these pagers are still available.

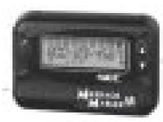

Figure 4: A numeric pager

Alpha-numeric pagers are available, these save the user having to find a telephone since a short message can be sent. The sender can read a message to an operator who types and sends the message, or they can use a code that refers to a specific message. For example, by dialing 14 may send the message “come to the office ASAP”.

More recently, 2-way pagers have become available. Users can also send messages either using a 2-way pager with a small keyboard (Figure 5) or a pre-programmed menu system, this system will have similar functionality to the current SMS (Short Message Service) available on GSM mobile phones.

Figure 5: A 2-way pager

5.2.2 Handheld PDA's (Personal Digital Assistants)

Data entry to PDA's such as the Palm5 (Figure 6) is by use of a pen/stylus, which may be used as a pointing device (similar to a mouse). If character input is required, either the character recognition software can be used (where around to 30 letters per minute can be entered) or the 'on screen keyboard' can be used which has a greater input rate. Color displays are available and as processing power increases, displaying video is possible on newer models. Separate keyboards are available for some of these devices, though they are often large and impractical.

Figure 6: 3Com's Palm5 PDA.

If users require a PDA with a keyboard, then models such as the Psion Revo (Figure 7) are available. PDA's with a keyboard also include a pen/stylus. Again, Color displays are available in most new models, particularly ones running Windows CE. The latest version of EPOC (release 5) also supports color, so EPOC devices will include color in the near future.

Figure 7: Psion Revo PDA

5.2.3 Mobile phones

Mobile phones are very practical for many people, both at home and at work. They can store hundreds of numbers, have answering services for when the phone is switched off, and many have SMS (Short Message Service) with which they can send text messages to fellow SMS mobile phone users. Prices are decreasing as connectivity is becoming easier which makes mobile phones ever more popular. Some mobile phones such as the Ericsson SH-888 (Figure 8) combine an infrared port for connectivity with compatible devices.

Figure 8: The Ericsson SH-888 mobile phone.

WAP (Wireless Application Protocol) mobile phones are new to the market (Figure 9). They look similar to conventional mobile phones and have the same functionality, but they also have capabilities for accessing the Internet. Although they have a great potential for mobile communication, their full potential is still to be unveiled when new services become available, for example, booking or rescheduling plane flights via text and menus rather than voice. It is the responsibility of independent companies to create these services, though since it is a new technology, with relatively few users, it may take some time before the full functionality of these devices is commonly known and available.

Figure 9: The Alcatel 'One Touch Pocket' WAP mobile phone.

As the technologies converge, new products become available. The combination of a mobile phone and a PDA is now available (Figure 10). This convergence saves users having several devices and thus leads to easier operation.

Figure 10: The Nokia 9110 communicator.

As time passes, the size of these new devices continues to decrease, wearable mobile phones are already being introduced to the market. One example is Samsung's Watch Phone (Figure 11). The product weights only 50 grams including the battery. It offers 90 minutes continuous talk time and 60 hours of standby time. In addition, the phone comes with voice-activated dialing, a phone directory, ear and vibration alert. This device is one of the first of its kind which realizes features of the "*Dick Tracy* watch", a watch phone first introduced in a Jan. 13, 1946 *Dick Tracy* comic strip[6]. That watch is illustrated on the front cover of this document, while related information can be found at: http://www.maloka.org/english/ciencia/fisica/0112.htm

Figure 11: The Samsung Watch phone

[6] The *Dick Tracy* comic, illustrations, etc. are protected by copyright: © 1999 Tribune Media Services, Inc. All Rights Reserved.

5.2.4 Notebooks

Powerful mini-notebooks are available, marketing has targeted business executives due to the slightly higher price. For example, the Toshiba Libretto (Figure 12) measures 210x132x35 and weighs only 1.1Kg. (see http://www.csd.toshiba.com/cgi-bin/WebObjects/Toshiba). Mini-notebooks obviously have a slightly smaller screen than regular notebooks, though if users of this type of device ever need to use it to show a presentation they would connect it to a projector as with normal notebooks. Most companies seem to be concentrating on developing regular notebooks so there are far fewer mini-notebooks on the market to choose from, due to this, the ones available are likely to be older and slower.

Figure 12: The Toshiba Libretto.

The Mitsubishi Pedion (Figure 13) has the power of a 266 MHz Mobile Pentium® II and a 12.1 inch color LCD screen. The Pedion comes standard with 96 MB RAM, 4.3 GB hard disk drive, 2 Type II PC Card slots, SoundBlaster® PRO hardware, 4 Mbit infrared port, Universal Serial Bus (USB) port and Microsoft® Windows® 98. Advantages of regular sized notebooks compared to mini-notebooks are that they are faster, have larger screens, hard disks, keyboards etc and are therefore more comparable to a regular desktop PC.

Figure 13: The Mitsubishi Pedion notebook.

5.3 Typical sizes and weights

Size and weight is also becoming increasingly significant in affecting consumers choice of products, see Table 1. Price also affects user's choice of devices and the 'price/performance' ratio is constantly being reduced as new technologies are introduced to the market.

Table 1: Some typical sizes and weights

	Type	Example Model	Screen	Dimensions (mm)	Weight
Pagers	1-way alpha numeric	Motorola CP1250	Up to 8 lines, 26 characters/line	70x50x15	42g
	2-way + keyboard	Motorola Pagewriter 2000	Up to 9 lines, 27 characters/line	95x72x30	190g
Handhelds	+ keyboard	Psion 5	B+W 133x55mm	170x90x23	354g
	''	Psion Revo	B+W 480 x 160 pixel	157x79x18	200g
	''	HP 620	Color	178x104x36	586g
	''	HP Jornada 680	Color 167mm	189x95x34	510g
	''	HP Jornada 820	Color 210mm	246x178x33	1.1Kg
	+ stylus	3COM Palm IIIx	B+W	106x83x18	190g
	''	Philips nino 500	Color	133x87x19	227
	''	3COM Palm 5	B+W	114x78x10	113g
	''	3COM PalmVII	B+W	133x83x19	190g
	''	HP Jornada 420	Color	130x82x23	250g
Notebooks	Mini	Toshiba Libretto	180mm	210x132x35	1.1Kg
	''	Mitsubishi Amity CN3	210mm	235x170x36	1.18Kg
	Standard	Mitsubishi Pedion EM	307mm	297x218x23	1.7Kg
	''	HP Omnibook XE2	330mm	311x249x40	3Kg
		Dell Inspiron 7000	381mm	327x266x63	4Kg (inc.CD drive)
Smart Phones	all in one	Nokia 9110 Communicator	2 screens, phone + PDA	158x56x27	253g

5.4 WWW Links

Pagers

http://www.mot.com/MIMS/MSPG/cgi-bin/prodcat.cgi

http://www.nec.com/communications/pagers/products/index.html

http://www.glenayre.com/products/devices/default.asp

http://www.uniden.com/docs/product/prlist.cfm?prodcat=Pagers

http://www.motorola.com/MIMS/MSPG/SmartPagers/pw2k/pw2000.html

Handhelds

Stylus-operated

http://www.mitsubishi-mobile.com/mitsubishi-mobile/products/products_main_frames.htm

http://nino.philips.com/

http://www.palm.com/products/palmv/index.html

http://www.palm.com/products/palmiiix/index.html

http://www.palm.com/products/family.html

Keyboard- and stylus-operated

http://www.hp.com/jornada/

http://www.compaq.co.uk/products/handheld/aero/

http://www.compaq.co.uk/products/handheld/c-series/

http://www.psion.com/series5/s5spec.html

http://www.psion.com/computers/s3mxindex.html

http://www.casio.com/hpc/

Notebooks

Mini

http://www.mitsubishi-mobile.com/mitsubishi-mobile/products/products_main_frames.htm

http://www.csd.toshiba.com/cgi-bin/WebObjects/Toshiba

Standard

http://www.hp.com/omnibook/

http://www.dell.com/

http://www.compaq.co.uk/products/portables/portables.html

http://www.mitsubishi-mobile.com/mitsubishi-mobile/products/products_main_frames.htm

Mobile phones

http://samsungelectronics.com/

http://www.nokia.com/phones/

http://www.mot.com/GSS/CSG/Europe/English/Products/products.html

http://mobile.ericsson.com/

WAP and Smart phones

http://www.mot.com/LMPS/iDEN//

http://www.nokia.com/phones/7110/index.html

http://www.nokia.com/phones/9110/index.html

http://www.alcatel.com/telecom/mbd/products/products/detailed/gsm/product.htm

6. Use Cases for Portable Technology

6.1 Mobile devices and usability

Mobile devices — suited for the palm of your hand — have obvious limitations compared to your desktop computer, when it comes to interaction style and usability. The main differences being:

- The screen is limited in size and quality, from 3-6 lines of characters on a mobile phone, to 1/4 of a VGA screen on a PDA[7]. The output of multimedia material is obviously also limited, due to low processing power, memory limitations, and screen quality (see section 5.3).
- The input possibilities are either numerical (typical for mobile phones[8]), small alpha-numerical (e.g. Psion), and/or based on a touch sensitive screen, pen and various types of character recognition. (see section 5.3).

These limitations in input and output possibilities are changing as the technology evolves towards more processing power and new memory technology; screen size may become irrelevant if projections can be made directly onto your retina. On a more basic and persistent level are the problems arising from specific mobile use situations. For example:

- In a typical use situation, users will be on the move outside the normal working environment. Applications must be designed with this in mind.
- In a number of mobile situations, use of the device cannot demand the user's undivided attention. The user must be able to share her attention between the mobile device (e.g. taking (voice-)notes of something she sees) and other factors in her immediate environment (e.g. traffic).

The last point is described as 'having tasks outside the computer' [9] to explain the use situation where the outside world needs attention, as opposed to the office setting where you can concentrate solely on using the computer, and the task is 'inside the computer'.

In the following sections, different scenarios for future use of portable technology will be described.

6.2 Tram Schedules on Mobile Devices

One can imagine positioning functionality included[9] (see section 3.3) in mobiles phones and PDAs. This opens for a range of possibly useful applications. Information on maps (with a permanent 'you are here' mark), information about shops and where to find them when entering a shopping center, or to make your call go to the nearest police station or policeman when you need one.

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[7] The new Psion Revo has 480x160 pixel screen resolution, and is approaching the limits to be suitable for 'the palm of your hand'

[8] Most mobile phones also allow the possiblility for alphanumeric input through use of the numeric keypad. On some phones, for instance, the '2' key also allows for the possibility of "typing" the characters 'a', 'b' and 'c', where 'a' is typed by pressing '2' twice, etc.

[9] The mobile phones have implicit an positioning system in the GSM network, but this is only at around 200 meters accuracy. With GPS included in the phone or PDA, the accuracy improved considerably to the scale of some meters

Another application idea is to have tram information available, based upon your location at a given point in time. Your web/WAP-enabled device will be able to know which tram station you are currently at or near, and provide you with the appropriate schedules. 'Trafikanten' (Oslo and Akershus Traffic Service AS) [10] has already implemented a service to give information about how to get from one given station to any other given station (by combinations of bus, tram, and local train) in the Oslo area. One could also include information about where the trams and buses are at a given point in time, to get information in compliance with the real world situation.

A service of this kind could work as follows: You arrive at the station to catch the tram. There are now trams in sight and you select the Trafikanten-service from your telephone register, and call it up. Trafikanten will then give you a list of the trams leaving from this station (your GPS-system on the telephone has informed the service on which station you are at), and you select the one you are interested in. The operation does not give you the timetable, but an estimation of how many minutes it will take for the next tram to get to your station. The time provided is 14 minutes, and confirms your suspicion that you've just missed your tram. Then you punch in your destination, and ask for alternatives to your regular tram. The services suggests that you take a bus to another station, (the bus will be there in 2 minutes) change to a tram at that station and get to your destination about 6 minutes earlier than with your regular tram. Trafikanten currently has this information implemented in their present web-service, included estimated walking distances between stations. It is then up to you to decide what to do, or ask for other alternatives. If it is raining, you will probably get on the bus, if you see a neighbor you want to talk to, you will maybe stay. The point is you will be able to make a well-informed choice, based on real world information.

This could also be implemented as a kiosk service at the stations, with a better screen and interaction possibilities, but it would imply high cost and could also lead to problems with accessibility when another person is using it, and you are in a hurry.

6.3 The 'unwired' hotel room

The future hotel room might be equipped with a wireless LAN, Bluetooth or other available wireless networks (see section 3). The following description will be based on Bluetooth technology.

Bluetooth is expected to be cheap, small and easily integrated with a lot of different equipment, like mobile phones, PDAs and laptops, as well as any other equipment you can imagine which sends or receives signals or data.

One can imagine that your laptop and mobile phone include Bluetooth communication devices. The hotel you stay in might have Bluetooth for specifically selected (higher-priced) rooms. Their service will include Internet access and information and services from the hotel.

When you arrive at your room and turn on the laptop, it connects to the hotel LAN via Bluetooth. Through your GSM-phone (or more precisely, the smart card inside the phone) confirmation of your identity, with regard to the hotel, your home server and your bank is performed. This all happens through wireless connections: you only turn the laptop and GSM-phone on[10].

[10] In this scenario, turning the phone on requires a simple password or PIN code, in order that the smart card can

You read your email and decide to change a document that you need for a meeting the next day. You fetch the document from your home server, then perform some editing. Thereafter, you send the document to the hotel printer, and order some copies[11]. You also send a copy by email to some of your colleagues, with some comments. Then you place the new version back onto your home server. You also send it to a colleague that you know is travelling to present some related material (knowing she will be connected at her hotel), and recommend that she perform some changes in her presentation, according to the information you have just modified.

Later, you look up hotels in the city to which you re travelling the next day, and make a reservation. Again your smart card — which also serves as authentication for your payment method — is used. To decide where to eat you check the hotel information which includes today's menu and prices. After reviewing some information on local entertainment you also decide to pay your hotel bill, thereby escaping the queue at the reception desk in the morning.

All this is done without worrying about cabling, compatibility problems with plugs or the like, and also without security and confidentiality risks.

6.4 Stream and sync

One can foresee progress towards a more interactive technology when it comes to television, inspired from Internet services and technology. One can also expect a service overlap between the Internet and broadcasting. One possible service in this scenario is to have 'clickable' web-addresses available to *personal* PDAs (or other devices) as they are shown in relation to a television (or "in-house"[12]) broadcast. When watching, you can use the links available on the personal screen to 'leave' the broadcast, in order to investigate information which is of special interest to *you*; this operation doesn't affect the flow of the broadcast, thereby avoiding conflicts-of-interest which could arise when multiple users are simultaneously employing the service. Should you tire of your own browsing, or see something in the ongoing broadcast which triggers your interest, you can easily "go back to the program": the new links are continually cached locally upon your personal device, and are available through a single button press.

This service requires that users have some kind of computer of their own (e.g., PDA, laptop or desktop), equipped with wireless technology (see section 3). It also requires that users have Internet access through some kind of wireless connection. Two different scenarios based on this technology are presented below.

One setting for this service is at the airport: Having nothing better to do, many people are sitting around and watching one of the airport's televisions. It is currently running a commercial for travel guide books. Links related to the books are being broadcast within the local vicinity of the television (e.g., via Bluetooth). The links point to WWW sites where there is extensive information about the books. Being interested in a book on southern Spain (that is where you are heading), you are no longer interested in the television, but would rather focus on the guidebooks. You turn on your PDA, "tune in"

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authenticate the user.

[11] Many professionals entrust hotels with the transmission and reception of business faxes. This same kind of trust could likely be expanded to include the prnting of business documents.

[12] One context for in-house broadcasts are airports.

to the television’s Bluetooth channel, and the most recent links from the commercial (e.g., perhaps the links broadcast within the last couple of minutes) are now downloaded, cached and viewable upon your PDA. Through wireless connections, Internet access is provided and you follow one of the links to a site for the guidebook about Spain. You preview the contents of the guidebook, and decide to buy it. You go further to get information on where in Seville you can by it, (or a bookstore which can deliver it to your hotel then next day) and you reserve (or order) the book.

Another application area for this technology is net-based learning. One scenario is a class watching a film of, for example, large cities. Links related to the film are broadcast to the students, who all are equipped with PCs or other computers. They can follow links individually and try to develop their own perspective on how the large cities are developed, the particular problems of pollution, town planning, crime, over-population, ghettos and so on. Later the different information and perspectives can be discussed, and the different information on the net, combined with the information in the film can be evaluated by the students as a common discussion.

6.5 Mobile surveyor

A lot of time is wasted these days simply by the fact that some workers are mobile, perhaps too mobile. Often much of the ’mobility’ is involved in carrying information from remote locations back to the office. The following example is primarily based on the capabilities of Bluetooth technology, though other wireless technologies may also be capable.

Imagine the case of a surveyor, who has to check out possible locations for a major new building (for example, an opera house). Since it is likely that many companies will be involved in the decision, development, planning and building of the opera house, there may also be a rush for a decision to be made. On the day of a major meeting, representatives from the different companies agree to be available “on demand” via audio-video teleconferencing; the surveyor has traveled to a proposed site early that same morning. There, he takes only three things: a digital video camera, a laptop and his mobile phone, all of which have compatible wireless connections (e.g., Bluetooth). He takes some short clips of the area from various angles to give a good impression of the site. He uploads these clips onto his laptop, and selects some suitable frames from the footage. The data is then passed through his mobile phone via the wireless connection, and forwarded over to the meeting via a standard GSM network. The images of the area help clarify his exact position to the company representatives, thereby initiating a discussion as to whether this is a suitable site for the new building. It is likely that there will be objections to the site and that someone may suggest another site. They simply call the surveyor and tell him to go to another site; when he has prepared and delivered the materials from the new site, a new teleconference is initiated and new discussion ensues. This use of technology rapidly increases the productivity of the site selection process, simply by cutting out the surveyor’s travel time between the office and the sites.

6.6 ”WAPmap”

Often people wish they had a map when trying to find a shop or a friend’s new house. Basically a map gives us directions, from point ”A” to point ”B”. When asked by a passerby ”Do you how to get to…?”, if you do know how to direct them to their destination, you are effectively cutting out their use of a street-map.

When people use a street map, they basically look to find out a route from where they are to where they want to be, e.g. ”first right, second left, pass the fountain, on the corner beside the traffic lights”. If there was a database of all street names, land marks and public transport routes in a city, then navigation could be done on a WAP telephone. You enter your start and destination points[13] and a list of landmarks (or major street corners) along the way appears on your phone. You could then check through the list to see whether you know your way to any of these. If you do, you could use the directions from that landmark to your final destination. If you have no familiarity with the area at all, however, you could follow the instructions from your current position to each landmark along the way. The directions provided are text-based (easier than the familiar tourist holding a standard map at all angles trying to work out where north is etc.). Systems having aspects of this functionality are already available for some public transport systems on the Internet [10] and could be expanded for access via WAP phones.

6.7 The field journalist

Journalists are often on the move: news comes fast, and becomes old news fast. In different situations, journalists may require different kinds of equipment in order to capture their story. Such equipment could include cameras or video equipment, audio recording devices, phone, (digital) notepads, etc.

For a number of journalists, it is probably quite rewarding to feel they have constructed their story in the structure and manner they wish it to be presented. For certain news distributors, this could also be a more efficient process by which to create their news spots and programs.

To capture the raw materials for a story — and to put stories together quickly — journalists could benefit from being able to put together and “tear down” the equipment they need as fast (and often as discreetly) as possible, preferably without any technical hassle. This kind of possibility can be realized through Bluetooth technology. Using digital equipment which includes Bluetooth components, journalists can rapidly have an interconnected set of tools at their disposition — tools which enable them to capture the story materials they need. On an interconnected portable computer with multimedia editing facilities, the materials can be shaped into a multimedia news item which, when ready, could be transmitted (e.g., via GSM) to the news editing desk for final check and release/distribution.

6.8 ”Print and Run”

When people go to meetings, conferences etc. these days, they often get new ideas for their reports, papers and presentations at the last moment. If already equipped with pre-prepared slides and/or copies of their material, including these last-minute changes would require re-printing the document. If they’ve already left their office, however, re-printing the materials might prove to be quite a problem. Not only is a printer needed — even with a printer available, there may be the need for new drivers, connection cables, etc.

[13] Your start point might be known, should your phone include positioning facilities (see section 3.3).

The idea behind the “Print and Run” service is that certain environments often encountered by the business traveler (e.g., airports, hotels etc.) could provide a wireless printing service. To achieve the service would require a wireless transmitter on both the user’s device and the printer-side system. This requirement shouldn’t be a major hurdle, however, since Bluetooth transmitters will likely be standard equipment in the near future. In addition, the *format* of the document/presentation to be printed would have to be compatible with the printer-side system; the document could be transferred in either a printable format, or its source format. Again, this shouldn’t be a major hurdle. In this case, the service providers would ensure that their platform included a very wide variety of drivers and/or transformation programs (e.g., Acrobat Distiller), as well as a very wide variety of application software (in order to accommodate documents transferred in source format).

7. Summary

The intention of this report has been to provide an impression of the current status in portable and wireless technologies, both networks and devices, and to sketch out some future directions of development. Across the last couple of decades, we have seen development towards a uniform technology platform (the PC), a common work context (the office), and a relatively standardized set of applications — development which has been dominated by a very few software companies. The development and dissemination of mobile technology and wireless networks are challenging this development. This trend necessitates a more diverse set of applications, suited for a wider range of areas and contexts, and the end of the PC as the dominating device for information and communication technology.

One major problem in wireless communication is to provide bandwidth to many units communicating at the same time over a limited frequency spectrum. Wireless communication technology can be described in three categories: mobile telecommunication systems, wireless LANs and direct link or ad-hoc networks. Global System for Mobile communication (GSM) is the most widely used network for mobile telecommunication. It has its limits when it comes to bandwidth (9600 bits pr. second) but has proven to be a popular and stable technology in the area of voice communication. To improve bandwidth and efficiency, General Packet Radio Service (GPRS), as a packet switched network within the GSM infrastructure, is being developed in order to bring increased flexibility and higher bandwidth to the system. It is expected to be available in Norway in 2001. Universal Mobile Telecom System (UMTS), often called 3G for 3rd generation) is a qualitatively different network, and is expected to deliver 2-10 Mbit bandwidth to the customer. The cost of UMTS deployment will be huge, and the system is expected to be primarily limited to densely populated areas and major motorways only.

Wireless LAN is available now. It delivers typically 2Mbit bandwidth over 30-100 meters. More light-weight technology for the home, for control of consumer electronics, is under development, e.g. Shared Wireless Access Protocol (SWAP). The main initiative in the ad-hoc network category is Bluetooth. A very strong consortium is behind this (e.g. Ericsson, Nokia, IBM, Intel, Microsoft, and about 1200 other companies in November 1999), and the focus is on short range, broadband ad-hoc networks for data and voice, with low-cost, small transceivers. Bluetooth ad-hoc networks (called piconets) are limited to eight devices at one time, but one device can be a member of more than one piconet. It is an open standard and was published in mid Autumn 1999. Bluetooth is expected to be widely available in the year 2000.

Wireless communication devices can most simply be categorized as pagers, handhelds, notebooks and phones; this categorization is primarily based upon the size and primary functionality of the device. Compared to networks, there is little information available about future devices; this lack of information is fundamentally due to industrial secrecy, in order to protect market shares and sector niches. Clearly, however, the trend is toward smaller devices with greater functionality and communication possibilities.

One can expect to see mobile computing extended to a wide variety of use situations in both private and professional life. The current screen size and quality of many small mobile devices is limited, however, and input possibilities can sometimes be cumbersome; it is likely that these aspects of the devices will change, through major efforts directed at improving device usability and efficiency. On a more persistent level, however, are problems due to the use context, which usually intrinsically implies movement and use within an uncontrollable environment. Emerging applications for mobile use will be based on broadband wireless communication, positioning information, local wireless networks, and will be highly information- and communication- intensive. A number of concrete use cases are described in the report.

8. References and Related Links

[1] Hummingbird Spread Spectrum Transceiver, see:
http://www.xetron.com/900xcvr.html

[2] BARWAN, see:
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[3] Qualcomm Inc., see:
http://www.qualcomm.com/

[4] CDMA basics, see:
http://www.qualcomm.com/cdma/phones/whatiscdma/basic.html

[5] Data transmission and PCS and Cellular Frequency Allocations, see:
http://www.qualcomm.com/cdma/phones/whatiscdma/freqs.html

[6] Qualcomm's Mobile Information Management System (Trucking and Freight), see:
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[7] Davis, J., Kanellos, M. "Microsoft touts home networking standard", CNET News.com, see:
http://www.news.com/News/Item/0%2C4%2C30678%2C00.html?dd.ne.tx.fs5.0108

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[9] Kristoffersen, S. and F. Ljungberg. (1999) Making Place to Make IT Work: Empirical Explorations of HCI for Mobile CSCW, in Proceedings of International Conference on Supporting Group Work (GROUP'99), ACM Press.

[10] Home page for 'Trafikanten'; see http://www.sol.no/trafikanten/