Mobile Communication Technologies
Technical Capabilities and Time-to-Market

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Sammendrag/Abstract:

This document provides an overview of some the most promising mobile communication technologies — both existing technologies and technologies to come. It also provides information about when the upcoming products are planned and estimated to become commercially available on the market.

The first part of the document describes the **basic concepts and technologies** underlying most modern wireless telecommunication. Among others it gives short explanations to the cell concept and abbreviations like TDMA and FDMA.

The descriptions of the different wireless network technologies are divided into three groups. The first group is labeled **mobile telecommunication systems.** Examples of these kind of systems are GSM, GPRS and UMTS. A second group is labeled **systems based upon a LAN idea.** Examples here are wireless LAN (e.g., WaveLan, Breezecom) and wireless-home systems such as homeRF. The final group concerns **direct link or ad-hoc networks**, where IrDA and Bluetooth are described.

The document also describes key factors in the market, as well as and when the different technologies are expected to be **commercially available**. The expected **coverage** for the different years (2000-03) is also commented upon where applicable.

Note to the reader: sections 1-3 in this document are largely reused from two sections in a previous NR document [1]. Here, that text has been updated and refined to accord with the latest and most accurate information available.

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1. 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.

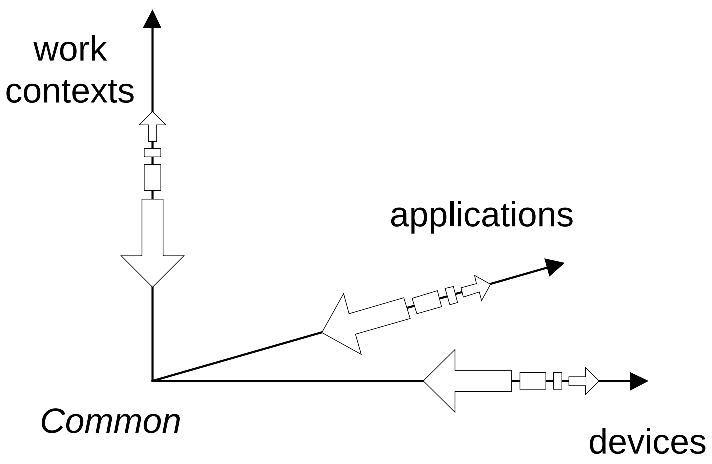

Figure 1: Evolutional and productification trends in the 80’s

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.

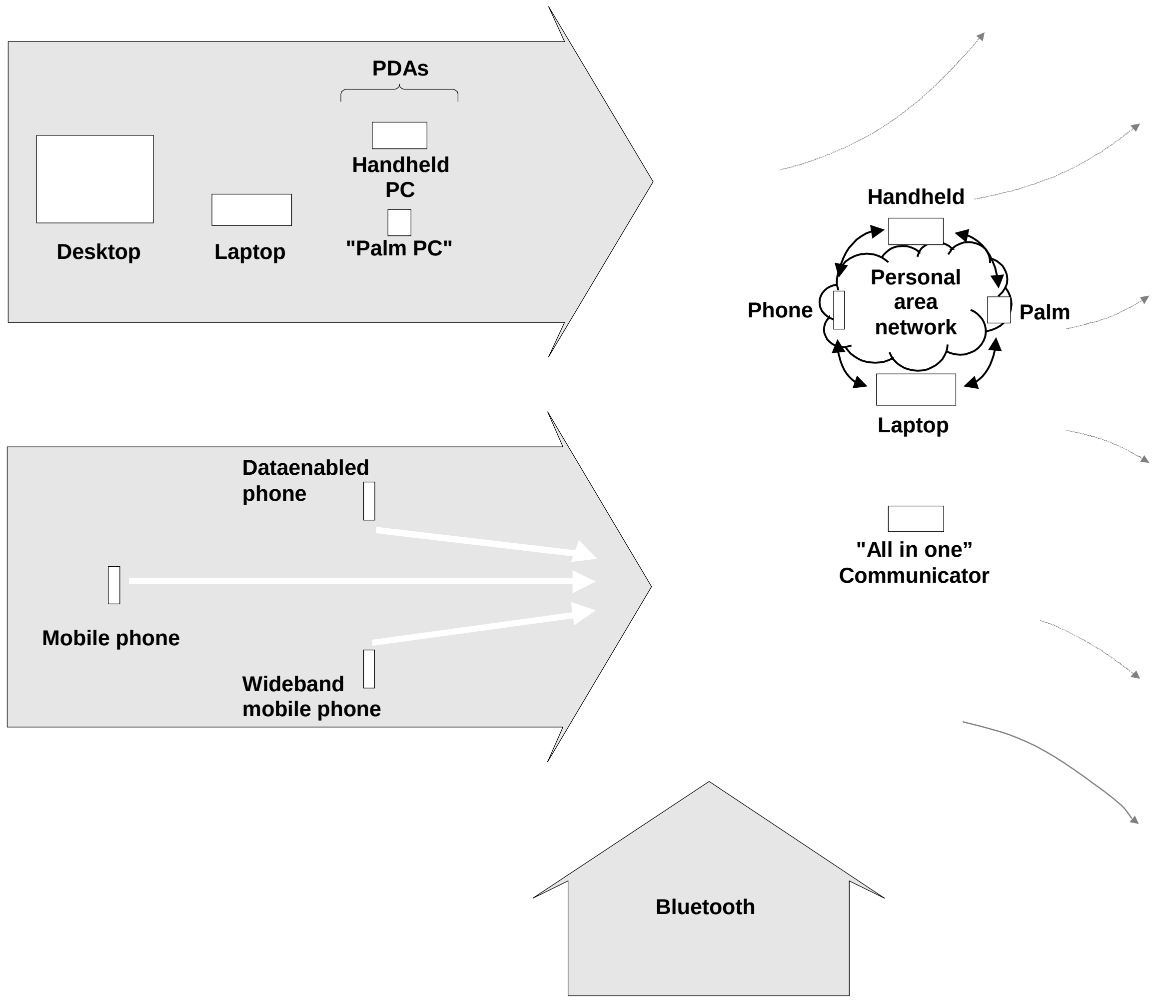

Figure 2: New mobile technologies and device evolution: status per 2000

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 → CDMA), data enabled phones with built in modem, WAP etc.
- Telecom and data convergence: the area of convergence in which new, small computers

and mobile phones 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.

The rest of this study can be roughly divided into three parts:

1. Chapter 2 contains an overview of some basic technologies and principles in modern radio based telecommunication. If you are familiar with such things as the concept of cells, and abbreviations such as TDMA, CDMA, etc. you can skim this chapter and start reading on chapter3.
2. Chapters 3 to 6 explain some existing and coming communication technologies. Chapter 3 gives a brief categorization and describes some general subjects. Chapter 4 describes mobile telecommunication systems including 2G+ and 3G systems. Chapter 5 describes wireless LAN systems while chapter 6 describes direct link and ad-doc network technologies.
3. Chapter 7 concludes with an overview of different communication technologies and indicates what kind of basic services that are suited for the different technologies.

2. Basic technology 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 purposes. The most applicable 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. These two methods are discussed in the two following sections: “The cell concept” and “Sharing ‘the air’”.

2.1 The cell concept

In traditional radio communication one major goal has been to install antennas at high points on the land and use large 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 blocks other possible traffic on that frequency, over a very large geographical 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 a cell *c* where frequency *f* is used, neighboring and other nearby cells employ other frequencies. Only cells which are adequately distant from cell *c* may reuse frequency *f*. 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. Smaller cells allows for smaller 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 one cell to another (i.e., from the coverage area 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 complicate the system. With smaller cell sizes, more handsets can be served, but at the cost of more handoffs and other call administration.

2.2 Sharing "the air"

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

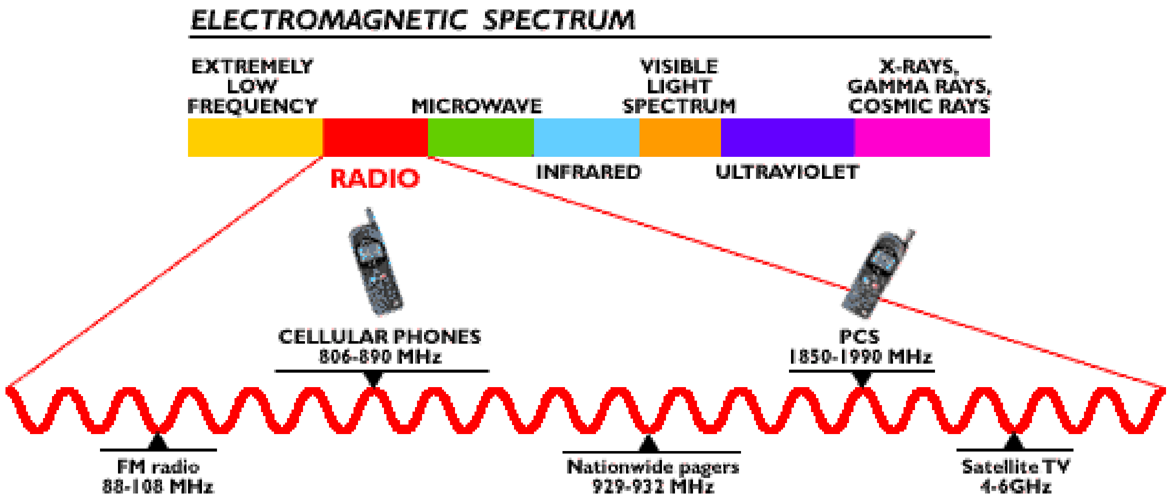

Figure 3: Transceiver spectrum[1]

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

The introduction to the "air-sharing" techniques below is motivated by two factors. First, the abbreviations are used a lot in telecommunication literature. Having basic knowledge about these techniques can be useful in different contexts. Second, the different technologies have implications upon the capabilities of the system as experienced by the user.

2.2.1 FDMA

FDMA stands for Frequency Division Multiple Access. This is the basic method of employing different frequencies in order to allow simultaneous transmission of different communication channels. This technique is used in standard broadcast. A radio station may be 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 tuned frequency is let through, and is then demodulated or "decoded". To allow many stations in the same band each station should occupy as narrow a part of the frequency spectrum as possible.

2.2.2 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 time-slot to each connection. This scheme is used in GSM, for example, 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

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

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 is able to use. If all timeslots on all frequencies are busy, no more terminals can connect to the same radio base station.

2.2.3 (W)CDMA

In opposition to FDMA and TDMA, a Code Division Multiple Access (CDMA) scheme lets each transmitter spread its signal over a wide frequency band. 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 and assemble 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.

2.2.4 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 with CDMA is that all transmitters have the same spreading code. This means that the transmitters cannot 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 specially designed for infrared transceivers.

3. Three classes of systems

The description of the different transceiver systems is here 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. The systems are classified according to where they appear to have their main focus. The three categories are:

1) **Mobile telecommunication systems.** These 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 devices and small ad-hoc network where no additional infrastructure is used or needed.

The three different categories of systems are described in the three following chapters.

4. Mobile telecommunication systems

The following is an overview over 2 G+ and 3 G systems (Second Generation "Plus" and Third Generation). The overview in this chapter will cover:

1. **Key factors in the market.**
2. **Estimated time schedule**
3. **Theoretical vs. Practical bandwidth.**
4. **GSM, the baseline.**
5. **2G+ systems**

   GSM / HSCSD

   GSM / GPRS

   GSM / EDGE
6. **3G systems**

   UMTS phase 1

   UMTS phase 2

4.1 Key factors in the market

Market key drivers in the cellular sector are development of technologies, regulatory environment (licenses and competition policies) and economic growth in the sector (market demand for cellular products and services). These key drivers are relevant for market strategies. They are also relevant when analyzing how fast the communication technology will develop.

In the cellular sector the standardization process has been a success. Internet proves the success of a non-standardization philosophy and GSM the opposite. The reason could be that the cellular sector needs to harmonize use of frequencies to obtain global solutions including interoperability between networks. GSM, the second generation of mobile phones, has been a tremendous success, and a success also outside Europe. IMT / UMTS, the third generation, is foreseen to be even more successful. The standardization process has been a global process, with strong participation from market leaders in the sector. The IMT family will most likely be a more global solution than today's second generations' family. This overview is limited to 2G+ and 3G families. Both are or will be worldwide-standardized solutions with an enormous market potential. Non-standardized solutions based on frequency bands not allocated in international frequency plans, will offer only limited market opportunities.

The Telecom sector has been through a liberalization process in Europe and also most countries in the world the last decade. In general the sector has full competition, regulated by some sector specific regulations and also general competition laws. For different reasons, the cellular/mobile communication sector is more heavily regulated. Mobile network operators need licenses from governmental organizations to operate in the market. Frequencies for most network types are limited resources, which limit the number of licenses available. License conditions and rights and obligations for cellular operators, defined in the license or other regulations, give essential information for both economical and technological market analyses.

The networks will coexist; to a large extent, they will also provide interoperability between networks. National regulations will influence the degree of interoperability, roaming possibilities and "real coexistence", etc. It is judged, however, that the main trend will be in line with regulations which enforce coexistence between 2G and 3G networks.

The market possibilities for the sector in general are considered to be very promising. The auction of UMTS licenses in the United Kingdom resulted in a total equivalent to 314 Billion NKr for the Government. Ovum predicts 1.2 Billion customers of UMTS in 2010, compared to 154 Millions GSM customers in Western Europe in 1999.

4.2 Estimated Time Schedule

The estimate provided here for UMTS is based on UMTS phase 1, and commercial delivery of the service in high-density areas / towns in key cities in Europe. (An earlier launch is estimated in Japan / East Asia). Please note that this table represents rough estimates with a high degree of uncertainty. The estimates are mainly based on figures from Ericsson and Telenor Mobil.

Note: these estimates regarding UMTS are optimistic in the sense that they are based on expectations from telecom operators and equipment manufacturers. They do not take into account unexpected problems with the technology etc.

Table: Estimated launch time and life expectancy of different technologies in the market place in Europe.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
HSCSD	X	X	?								
GPRS	X	X	X	X	X	?	?	?			
EDGE		X	X	X	X	X	X	?	?		
UMTS-Phase1		X	X	X	X	X	?	?	?		
UMTS-Phase2				X	X	X	X	X	X	X	

4.3 Maximum throughput vs. experienced throughput

There can be large differences between the throughput that is marketed as the maximum throughput for a specific technology and the throughput as experienced by the user. There can be several reasons for this:

- More than one user must share the same resources
- There is packet loss during transmission due to harsh radio conditions, long distances to base stations, reflections and absorption by buildings etc. To provide high speed radio access to highly mobile users is quite difficult.

An example of the first, and probably most important consideration, can be easily illustrated with the GPRS system. In today's GSM, eight users can share the same frequency within the same cell. This is done through a TDMA scheme with eight slots. Each user can take one timeslot getting 9,6 Kbps. With GPRS this is handled somewhat differently, and there can be up to 64 simultaneous data users. Each of these will only get one 64^{th} part of the expected maximum capacity of 115 Kbps. This rate is in fact significantly lower than with today's GSM.

This is not as bad as it seems at first glance. Many applications can make good use of a very narrow bandwidth as long as the user stays connected. The other, more important point is that the worst-case scenario will happen quite seldom. With 8 users, which is the maximum number of users in today's system), all GPRS users will have approximately 50% more bandwidth than with today's GSM system. With fewer users, bandwidth will increase, and with more users bandwidth will be lower. In a competitive market, there is probably little room for providers which do not scale their system in such a way that acceptable bandwidth is provided for users.

4.4 GSM, the baseline

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. Still, 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 time-slot where it sends digital voice packages. It listens for packages on another frequency and in another time-slot.

The GSM system is optimized for transmission of voice, and among others its *circuit switching* properties limit the amount of bandwidth available to the user. This is a problem when sending large amounts of data. A single terminal can achieve approximately 13000 bps, 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, as well as other *packet-based* network protocols such as IP.

4.5 2G+

The 2G+ denote systems that are based on GSM but extend the basic capabilities of the GSM system. The extension goes in two directions, "more bandwidth" and "packet switching".

4.5.1 HSCSD – High Speed Circuit Switched Data

HSCSD is a GSM service that combines two or more time-slots in the GSM radio channel to deliver circuit switched data services up to 64 Kbps or more (9,6 Kbps * 8 time-slots = 76.8

Kbps). HSCSD is already on the market in Europe. Telenor has HSCSD possibilities for subscribers giving up to 4 time-slots (38400 Kbps). The cost for this service is twice the cost of normal GSM.

4.5.2 GPRS - General Packet Radio Service

The design goal of GPRS is to reuse 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 100 Kbps, but it seems like most manufacturers will limit this to the standard of 56.8 Kbps. If more that one person is using the same frequency they will have to share the 100 Kbps. 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 contrast to GSM, no specific call set-up is necessary to use GPRS for data transport. Packets from the subscriber unit are routed from the phone to a gateway at the operator. From this gateway they are routed through the Internet to their 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 first to the gateway, and then to the subscriber. No call set-up, modems, etc. are necessary, resulting in much shorter delays when connecting. It is also possible to take normal phone calls while still receiving data packets. Services which employ small amounts of information over long periods of time become much more manageable when using GPRS.

GPRS implementations are foreseen in the market place (telecom-operators) in 2000/2001. Ericsson will deliver new GPRS products (equipment) in Q4-2000 (Products from Ericsson: Serving GPRS Support Node, Gateway GPRS Support Node and Packet control unit).

It is reasonable to believe that NOT all telecom operators will chose to implement GPRS, due to license obligations and rights and following competition strategies. Telecom operators granted both GSM and UMTS licenses could have a strategy to implement either GPRS or EDGE.

4.5.3 EDGE - Enhanced Data Rates over GSM Evolution

EDGE is the next development step after GPRS, and is a major improvement of phase 2+. EDGE is expected to be on the market in 2001 / 2002 (Ericsson will have products in Q3-2001). EDGE gives increased throughput due to a new modulation technique. Throughput will be up to 384 Kbps (48 Kbps * 8 time-slots). EDGE can be used to improve both circuit switching (HSCSD) and packet switching (GPRS). EDGE has a throughput that makes it possible for EDGE-solutions to co-exist with UMTS, in order to provide high-speed services for wide area coverage (rural areas), while UMTS will first appear in urban and highly populated areas.

4.6 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 up to 384 Kbps for fast moving subscriber units, and up to 1 Mbps for slow moving subscriber units. The system will be based on a CDMA scheme in contrast to GSM, which 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 last few years, in mobile phone systems in the US. The major disadvantage is that this system requires a new and very costly infrastructure. Use of this system will likely be limited to city and metropolitan areas only. When travelling out of the UMTS coverage area, a handoff to GSM/GPRS will be necessary, at the cost of a much lower bit rate.

The UMTS cell system is based on different cell sizes. Smaller cells provides higher bandwidth, but at the cost of many base stations and frequent handoffs.

Cell type UMTS	**Radius (meter)**	**Square km**	**Throughput**
Macro	700 – 8000	covers 1.2 – 165 sq. km	144 Kbps (384 Kbps)
Micro	75 –700	approx. 1-70 pr sq. km	384 Kbps
Pico	20 – 75	approx. 70- 350 pr sq. km	384 Kbps (2 Mbps)

There is a high degree of uncertainty as to whether 2 Mbps is a rate that is achievable other than under very ideal circumstances. A more realistic expectation for inner-city coverage seems to be 364 Kbps.

4.6.1 UMTS Licenses and timing

Policy documents (white papers) for Norway, Denmark and Sweden and UMTS-forum's regulatory report indicate that the number of licenses and their commercial launch in the Nordic countries.

Country	**Type (national/ Regional)**	**License Award**	**Commercial Launch**
Denmark	Probably 4 National	Q4 2001	2002
Finland	4 national awarded	Q3 1999	Jan 2002
Norway	Probably 4 National	Q4 2000	2002
Sweden	4-5 National (some maybe Regional)	Nov 2000	2002

4.6.2 UMTS Phase 1

UMTS Phase 1 is based on "Agreed" Standards called the 1999 version, or the 1999 standard packet. Phase 1 is the version of UMTS that will be/is the product-basis for the services from telecom operators in the marketplace in 2001 in Japan, and 2002 / 2003 in Europe. Ericsson predicts some time between Q4-2001 and Q1-2002 for commercial presence of UMTS equipment in Europe.

Characteristics for Phase 1 are that the core network to a large extent will be similar to GSM/DCS 1800 network. It will not be possible to utilize the full flexibility in the UMTS concept (e.g. the service providers opportunities to develop value-added services will be approximately the same as today using the GSM / DCS1800 systems).

For Europe, Ericsson will deliver terminals Q1 or Q2 2000 with the following characteristics:

- Support for HSCSD and GPRS
- 384 Kbps Downlink packet
- 128 Kbps Uplink packet
- 64 Kbps Circuit Switched data both up/down

The same terminals are also expected to contain WAP, Bluetooth, color display and built-in PIM (Personal Information Manager), with e.g. calendar, contacts, to-do-list.

4.6.3 UMTS Phase 2 +

UMTS Phase 2 is the 2000 Standardization package while *UMTS Phase 2+* is the 2000 package and "all new" versions that will come after the 1999 package. UMTS Phase 2 will be a full IP-version with all the possibilities this will include.

One characteristic will be that the service provider will be provided with a platform for developing own services — services that can be ported between networks. From a commercial point of view, this will offer new possibilities to service providers, and a clearer distinction between telecom operators and service providers is expected to arise.

It has not been possible to obtain precise information as to when the 2000 standard package will be finished.

4.6.4 UMTS – more than evolution from 2 generation systems

Some elements that separate UMTS from 2G+ systems are:

- UMTS will give the customers the possibility to combine mobility with multimedia, resulting in a higher demand for bandwidth and creating a significant shift towards new data services. A key driver for UMTS is the increasing demand for multimedia services. Demand is also increasing for access to multiple types of media, often used in various combinations. Thus UMTS will provide both narrow and wideband services (e.g. voice, data, graphics, pictures and video), in combination, on demand and on-the-move.
- UMTS will cater for different kinds of mobility:
    - ***Terminal mobility***, which means that a terminal can be used while on the move.
    - ***Personal mobility***, where a user is *not* restricted to a special terminal when wanting to access his or her services. Roaming based on a common smart card technology and the provision of the Virtual Home Environment (VHE) are major aspects in this context. *VHE means that the user will have the same interface and service environment regardless of location.* Another issue here is the capability for a user to register for different services on different terminals.
    - ***Service mobility***, which means that a user can access his or her personalized services independently of the terminal and serving network.
- *Transparent services*, i.e. the possibility to access the same services in different networks (e.g. fixed, mobile or satellite networks), are mainly seen from the user's point of view.

Transparency must be secured also in the pre-UMTS networks that are interconnected to UMTS.

4.6.5 National regulations and implications

EU and national Governments will secure and promote the introduction of UMTS in Europe, but the policy (regulations) for UMTS differ from the policy we know from GSM. The License conditions will have fewer or none conditions connected to coverage, detailed requirements for how fast the networks should be built etc. The general philosophy is to leave more to the competition.

How fast UMTS network will develop (with respect to coverage) will depend both on national regulations and market demands. Regulations that will influence conditions for new UMTS operators **and** "old" GSM operators are rights and obligations to get/give roaming, interconnection, access to virtual operator's etc.

Roaming obligations and rights will have significant influence of commercial situation for new players.

We believe that 2 G+ network will decrease in volume and 3 G will increase. How fast 3 G will evolve and 2 G be phased out is hard to predict. In general most people will resist being very specific to predict future market shares between new and old operators and technologies. To some extent the technologies will be in competition also for an operator with license for both the new and old system. Choice of Technology will be a cost question. If 2G+ systems to a large extent can be upgraded to match UMTS (for a lower cost) the two technologies can melt together completely or coexist permanent to give a variety to market demands.

4.6.6 Bottleneck - Equipment

The licensing process for the provision of third generation (3G) IMT-2000 networks has already begun, and the issue of as many as 100 license awards is anticipated over the next 16 -20 months.

The high number of new licenses owners / operators will give a challenge for the manufactories of equipment to deliver to all the new market players at the same time. The pressure for Europe will increase due to the fact that Japan and South Asia are very promising markets and will probably be prioritized.

4.6.7 Norwegian UMTS applications

In Norway there are seven applicants competing for a total of four UMTS licenses. The seven applicants are:

- Broadband Mobile ASA (Enitel ASA and Sonera Corporation)
- NetCom GSM AS
- Tele2 Norge AS
- Orange Norge AS (Orange plc and Bredband Mobil AB in cooperation with Schibsted ASA, Nera ASA, Bane Tele, Norsk Aller AS, Veidekke ASA and Four Seasons Venture III AS)
- Telenor AS

- BusinessNet AS (A consortium of Tele 1 Europe AS, Western Wireless International and Rix Telecom)
- A consortium of Orkla ASA, Dagbladet ASA, Hafslund ASA, Hakon Gruppen AS, NorgesGruppen ASA, OBOS/NBBL and Posten Norge BA

Many believe Telenor and NetCom to be guaranteed a license such that, in reality, the competition is among the other five applicants for the two last licenses.

The bandwidth promised in the applications ranges between approximately 100 kbps and 384kps, depending on population density of the area, the number of people sharing the resources and the year (2002-05).

Coverage is one of the major criteria by which the applicants are evaluated. The applications that promise the most extensive coverage are the ones from NetCom and Telenor. NetCom promises within three years to cover all localities with more than 8000 inhabitants, and to cover a total of 76% of the population. Telenor promises within the three first years to cover all localities with more than 2800 inhabitants. After five years they will cover all localities with more than 200 inhabitants, covering more than 84% of the population.

5. 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.

5.1 Wireless LAN

Wireless LAN is a technology that lets one extend or replace ones traditional wired LAN with a radio based one. It is typically a substitute or addition to an Ethernet LAN. On top of the radio interface, IP is normally used. Typical reasons for choosing a wireless LAN instead of a wired one include:

- the terminals should be mobile
- the location of the LAN is temporal and/or
- (re-)wiring the building is expensive or impractical.

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 2-10 Mbps, and most follow the IEEE 802.11b standard. Examples of products in this category are 3com’s Air Connect, Breezecom’s BreezeNet and Wavelan.

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 transceiver makes it necessary to have many base stations, in order to cover a larger area. One terminal is allowed to roam from one 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. Use of protocols such as the “mobile IP” protocol can solve these problems. Another problem is connected to security. A nice service for a company would be to offer guests with PCs and wireless LAN cards access to Internet, printers etc. In such a scenario, it would be necessary to put severe restrictions upon what the guest 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/

5.2 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 radio interface for HomeRF is called SWAP (Shared Wireless Access Protocol) which is very similar to the protocol in the Bluetooth initiative.

Version 1.0 of the specification was released in February ’99, and the first consumer devices are already on the market. The HomeRF group outline future applications in the areas of:

- automatic regulation of heating, lighting, burglar alarms, etc.
- cordless connection of peripherals
- carrying the mobile display pad in the garden for checking problems with plants, checking automobile parts from the garage, or reading stock quotes in the kitchen
- accessing information and sharing files between computers.

For more information see:

http://www.homerf.org

http://www.comdex.com

6. Direct link or ad-hoc networks

The technologies described in this section have their primary focus upon direct links between two devices, or small ad-hoc networks independent upon 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).

6.1 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. First, 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 beam.

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 speeds between 2400 bps and 4 Mbps. All IrDA devices are expected to handle 9600 bps. The typical maximum speed for chips in handheld devices is 115 Kbps, 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 simpler to use by application programmers, standards have been developed for special use cases. Two interesting use cases are the use of the IrDA device 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 here is that although one doesn't need to connect a cable to one's device to connect to the LAN, it provides only 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 seeing it as inaccurate and therefore difficult to implement.

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

6.2 Bluetooth

In 1994 Ericsson Mobile Communications started working on a radio interface to eliminate the need for cables between keyboards, PCs, Phones, Headsets, etc. The IrDA had limited range, it was directionally 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 1900 by July 2000. 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 directly from the start.

The Bluetooth technology can be seen both as a wireless cable (e.g., connecting a PC to a disk drive), and as an ad-hoc network (e.g., 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 worldwide and could cover both voice and data. The transceivers should be small, cheap and have 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 options exist. Two examples are a symmetric connection with 432 Kbps both ways, and an asymmetric link with 721 Kbps one way and 57 Kbps 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, or in one of several 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 eavesdropping. 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 2.4 GHz. 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 uses a 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 often called (in Bluetooth terms) a Piconet. One of these units is the master of the network. It is the master’s ID and clock which are used to select the frequencies used in the frequency hopping scheme explained above. The master polls the slaves, checking whether 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 attend 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 do not share the same 1 Mbps 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 speaker-phone, 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 market first half of year 2000.

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

7. Network and basic services

System	Bandwidth	Typical Connection latency	Typical Round Trip Time	Suitable	Less suitable
GSM	9600 bps	Maybe 30 sec.	Maybe 1/3 sec.	Important, few and relatively small pieces of information. User must be willing to spend much time and money. – Telephony – SMS – E-Mail , Fax – Calendar updates	Any large data transfer i.e. documents, programs, e-mail attachments, WWW, etc. Most entertainment. Short frequent messages such as WAP, stock exchange updates, etc (except SMS). *Too slow and too long connection latency for most use cases.*
HSCSD	14 to 36 Kbps	Maybe 30 sec.	Maybe 1/3 sec.)	Still relatively small pieces of information, but larger than for GSM. – Most office application documents. – Most WWW pages	As for GSM, except what is mentioned as suitable on HSCSD. User still pays for inactive time in interactive systems, such as reading time in a WWW and WAP session.

GPRS, Eight users on channel.	14 Kbps	Maybe a few seconds.	Assumed 1/10 sec.	As for GSM, but also including: – Short frequent messages: – WAP – Stock exchange updates – Instant messaging, – Talk and Chat similarities Able to connect and disconnect between information transfers.	Any large data transfer i.e. documents, programs, e-mail attachments, WWW, etc. Most entertainment.
GPRS, One user on channel.	Approx. 50 Kbps	Maybe a few seconds.	Assumed ¼ sec. Assumed 1/10 sec.	– Most WWW uses. – Most office application documents. – Simple interactive graphic based applications – Low quality video when necessary. – Less demanding screen transfer protocols. – Interactive client-server programs.	– Most client-server programs with interactive use. – ”CD quality” music transfer. – Video for entertainment purposes – Most program downloads – ”CD quality” music transfer. – Video for entertainment purposes – Most program downloads

EDGE / UMTS	364-2000 Kbps	Maybe a few seconds.	Assumed ¼ sec.	– Fairly good video (Similar to early VHS) – Most multi-media – Program and document transfer. – Screen transfer protocols, low interactivity – Client – Server application, low interactivity. – CD and production quality music.	– TV quality video – Studio quality sound (many tracks etc.) – Screen transfers with a huge amount of updates (Full screen video etc.)
			Assumed 1/10 sec.	Screen transfer protocols and use of most interactive programs (text editors etc.)	– TV quality video – Studio quality sound (many tracks etc.)

8. Sources / References

8.1 Reports

- EITO: “European Information Technology Observatory 2000”
- Umts- forum: “IMT-2000 Licensing Conditions & Status. A selected regional overview”
- Umts-forum: ”Regulatory Framework for UMTS”
- Umts-forum: ”The Path towards UMTS - Technologies for the Information Society”
- Umts-forum: ”Considerations of Licensing Conditions for UMTS Network Operations”
- (Umts-forum: ”The Future Mobile Market: Global trends and developments with a focus on Western Europe”)
- ”Etablering av et regulatorisk rammeverk for UMTS i Norge” http://www.npt.no/norsk/fagomraader/frekvensforvaltning/no_umts_rapport.html)
- ”Telestyrelsens UMTS-udredning” , National Telecom Agency, Denmark
- UMTS reports Sweden: http://www.pts.se/aktuellt/umts-rapporter.html

8.2 Organizations

- UMTS-forum: http://www.umts-forum.org/index.html
- Norwegian Post and Telecommunications Authority (NPT), www.npt.no
- National Post and Telecom Agency (PTS), www.pts.se (Sweden)
- National Telecom Agency, http://www.tst.dk/ (Denmark)
- Wireless LAN alliance: http://www.wlana.com
- HomeRF: http://www.homerf.org
- IrDA: http://www.irda.org
- Bluetooth: http://www.bluetooth.com
- See also at the end of the chapters describing different technologies.

8.3 Surveys

- Ericsson
- Telenor Mobil
- Telia
- Norwegian Post and Telecommunication Authority

8.4 Technical Notes

[1] Lunde, Thorstein; Taylor, Ian; Kluge, Anders; Larsen, Arve and Holmes, Peter: "Wireless communication, portable devices and use". Notat Nr. IMEDIA/08/99, December 1999.