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Communication Networks in the Early 1980s and the Portfolio of GSM Services

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1.1 Station-to-station Morse Telegraphy, the Origin of All Modern Technical Text Communication

Morse telegraphy, via wires and also wireless, which existed as far back as the nineteenth century, is the origin of all modern technical text communication. It is important to emphasize that text communication over radio is not at all new. It was there when GSM was first defined, it was there many years before and indeed it has always been there for a very long time already. The first radio systems, the Morse systems, were created in the infancy of radio technology, and they were still in use in the 1980s when GSM was defined.

It was actually forbidden to send larger ships across the sea without having equipment and skilled people to handle these systems. Therefore, the importance of radio text communication was fully understood among communications engineers. How to integrate text communication into the new pan-European system was part of the general discussion among land mobile telecom engineers in those days.

These radio services were station-to-station services without any support from any type of ‘network’.

1.2 Network-based Communication Services in the Early 1980s

In contrast to station-based communication between two radio stations, network-based communication means that the users communicate with network nodes and pass their information.
via one or several connected nodes to the recipients. This method enables the communication to be supported by, for example, automatic routing, etc.

1.2.1 Telephony

The most widely used fixed-network service was, of course, telephony. The service was fully automated, and practically every household had a telephone. But the fixed networks made progress, and a range of new non-voice services was created. Therefore, it was important to consider these for the conception and standardisation of the new GSM system, which began at the end of 1982.

The first fully automatic mobile communication networks went into operation in the early 1980s. Back then, the number of mobile users was very small compared with the number of fixed users. Mobile communication was seen as an extension of the fixed networks, and hence an objective was that the mobile networks should support the services of the fixed networks, and of telephony above all. Therefore, the scope of the analogue mobile networks existing at that time was primarily telephony.\(^1\) This meant that users could make national and international calls. For calls to mobile users, the callers did not need to know where the mobile was at the time of calling. The mobile network provided an automatic routing of the call. Subscriber numbers were still very small compared with the fixed networks, which was caused by high price levels on equipment, subscription and traffic. People referred to the mobile phone as the ‘rich man’s toy’. Mobile stations were mounted in cars, with high equipment and service costs. Hence, only professional users could afford them. The situation improved in the mid- and late 1980s. But still the penetration of the population was small.

1.2.2 Telex, the Forefather of Modern Text Communication\(^2\)

The forefather of modern text communication was Telex (= Teleprinter Exchange). It was a public, worldwide text communication service. It allowed dialogue between two ‘teleprinters’. This was enabled by the development of suitable terminals with a keyboard and printer function, progress in switching and transmission systems and standardisation of the service. It was first implemented in the 1930s. In 1979 the Telex service was used by 1 100 000 users in 155 countries. It was used heavily for international connections. The 106 000 German Telex users\(^3\) sent 35% of their traffic to foreign destinations in 1976, which accounted for 58% of the revenue.\(^4\) There were extensions of the Telex service via shortwave radio and

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\(^1\) The first-generation systems were also used for fax and remote control, both entirely based on implementations in the terminals.


\(^3\) This compares to about 25 000 mobile telephony users.

satellite services, which allowed text messaging to and from and between ships as well as aircraft (Maritex is an excellent Telex service to ships using the shortwave radio band).

The service was standardised comprehensively, so that it was unnecessary for agreement to be reached between two users before communication (as later in data communication). Instead, the message could simply be sent to any other Telex user by dialling his directory number and thus setting up a connection.

The service had limited possibilities. The bit rate used was just 50 bit/s, which was due to the speed limitations of the partly electromechanical equipment. The text was encoded according to International Alphabet No. 2. This used 5 bits per character and enabled 32 different possibilities to be represented. These were used for 26 letters, without differentiation of lower and upper case, and some control signals (such as carriage return and line feed, space and switching between letters and numbers).

Telex was very successful in spite of the limitation of its service features. It was the backbone of international business communication for many decades. Telex no longer exists as a public service. It is remarkable that it worked globally, was interoperable between equipment of all manufacturers involved and was easy to use. These properties made Telex a great example for the conception and standardisation of OSI (Open System Interconnection) in data communication. Telex was popular with users owing to its simplicity, speed and reliability. Also, Telex messages were considered to be legal documents, very much like letters. It was loved by network operators because it was highly profitable. All this can likewise be said of SMS today.

### 1.2.3 The Advent of Many Faster Transport Techniques for Text and Data

Telex traffic had been carried on specific 50 bit/s switching and transmission systems. The need to realise higher data rates for more comfortable text communication or for data communication led to new developments:

The public switched telephone network was equipped with modems that could offer speeds ranging from 300 to 9600 bit/s in the early 1980s.

New Telex switches and transmission systems with advanced features were developed. This led to a family of circuit-switched data services using the CCITT X.21 interface working at speeds of 600, 2400, 4800, 9600 and 48 000 bit/s.

Packet switching services were standardised and developed. The key interface was X.25, offering data rates of 2400, 4800, 9600 and 48 000 bit/s with synchronous transmission. Terminals with asynchronous transmission used a packet assembly/disassembly unit. Possible speeds were 300, 600 and 1200 bit/s.

Progress of technology allowed the building of digital circuit-switched telephone exchanges and digital transmission equipment that was cheaper than the existing analogue

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5There seem still to be company internal applications in aircraft and ship communications.


7See previous footnote.
equipment. Therefore, the analogue telephone network was converted in steps into a digital telephone network. The analogue speech signals were converted into 64 kbit/s digital signal streams. By adding a digital subscriber line, the ISDN (Integrated Services Digital Network) was created. It offered to users two 64 kbit/s channels for telephony and a 16 kbit/s channel for signalling. This resulted in a total rate of 144 kbit/s. The rate of 64 kbit/s for a voice channel was established long before ISDN in the development of digital transmission systems. The state of the art required such a high bit rate in order to achieve at least the same quality as in good analogue connections.

1.2.4 Creation of New, Fully Standardised Text Communication Services

Facsimile technology was developed early in the twentieth century but did not find a wide use. In 1976 the CCITT approved technical specifications for powerful fax machines (groups 2 and 3 with up to 9.6 kbit/s transmission rates) working in the telephone network. This led to the introduction of public fax services by PTTs in the late 1970s. These fax machines were fully interoperable. Users could simply dial a connection to another fax machine, the telephone number of which could be found in the public directory, and be sure that the message was received and printed correctly. The standardisation of facsimile led to a strong acceptance in the market. Fax was first adopted on a large scale in Japan, as it allowed Japanese characters to be transmitted. This led to a volume production of fax machines. The price of these machines fell, and a breakthrough in the world market was achieved. A large number of communication partners were available. This again drove the usage and penetration of fax machines even to private users.

This success led to the standardisation of group 4 machines intended for ISDN with a 64 kbit/s data rate. However, the machines were expensive, so no high penetration was achieved. Another unattractive element was the interworking with the large base of group 2 and 3 machines. For such connections the speed of the fast machines was reduced and users had no advantage. The use of a server that could store and forward the fax messages and would allow the fast machine to send rapidly was not considered in standardisation. Once again, the lesson was: a wide user base and a low cost make services attractive even if the performance is limited.

Fax was very widely used in the 1980s and early 1990s, but it was superseded by the advent of personal computers and word processing programs such as Word. Received fax messages could not be further processed by a PC. Some people referred to fax messages as ‘dead documents’. Therefore, users preferred to exchange text messages as Word documents via data communication or email. Fax is still widely used in many countries. It still fulfils a service need that even email cannot fulfil: the simple ‘remote copy’ of documents to be sent end to end in real time. A large number of hotels still use fax for reservation purposes.

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8 Based on information in: Wolfgang Mache (1980), Lexikon der Text- und Datenkommunikation. Oldenbourg Verlag, Munich, Germany, ISBN 3-486-24361-6, p. 267
Teletex had been standardised to overcome the limitations of Telex. The initial idea was to convert every office typewriter into a communication terminal. The full character set of typewriters was used. The Teletex messages were formatted as A4 pages, so that a correct representation of letters could be achieved. This was a wonderful idea that needed global standardisation in order to achieve a wide acceptance and volumes of traffic and technical equipment.

A very great effort was made by many network operators and manufacturers in the late 1970s to standardise this new service. As interworking between the different emerging new transport technologies was not possible at the time at reasonable cost, an agreement was needed on a single transport technique. There were fervent advocates of using X.21 circuit-switched digital networks with 2400 bit/s. Then there were other fervent advocates of X.25 packet switching technology and fervent advocates of the telephony network with modems to avoid the cost of a data network. Later the ISDN faction also urged for ISDN offering 64 kbit/s channels for fax transmission. But none of the fighting parties was able to win, and there was no will for a compromise, so they were unable to agree on a single transport technique. Hence, this unresolved dispute led to a segmentation of the market and communication islands that could not communicate between themselves. Several systems became operational in 1981, but they were all switched off during the 1980s.

Then there was an overregulation of the service. A conservative faction requested that, in order to guarantee quality of service, every Teletex terminal be operational for 24 hours 7 days a week. This was possible if a company had one Telex machine in a separate room, but, in instances where all typewriters had been converted into Teletex stations, this requirement was opposed by the people responsible for fire protection. The idea of using a server to store messages to unreachable terminals and to transmit the messages as soon as the terminals became reachable was addressed too late. Such a server was, however, already inherent in the first SMS concept.

In view of all these factors, for which the Teletex designers themselves were responsible, the wonderful service idea of Teletex did not fly in the market. The demand for text communication was later covered by email.

1.2.5 Creation of Value-added Text Communication Services Based on Servers

Interactive Videotex was based on the idea of using a TV set as the user terminal and of offering a dial-in service to a server where information could be accessed. The server stored a lot of information for users and offered access to the remote computers of information suppliers. The users dialled via the telephone network with a low-cost 1200/75 bit/s modem into the server of the Interactive Videotex service. This service found a wide acceptance. However, owing to its restrictions (formats, screen resolution, data speeds, etc.), Interactive Videotex was uncompetitive in the time of wide availability of PCs and was replaced by Internet browsing.
Short Message Service (SMS)

Message Handling Systems (MHSs) were systems where a server supported the generation of the message by a dumb terminal. The MHS stored the message and forwarded it to the target MHS. The recipient could then look into his mailbox and retrieve the message. The MHS could be accessed by a wide range of services: the telephone network with a modem, packet switching networks, etc. Such systems had been standardised since the late 1970s (X.400 series), and the first systems appeared in the market in the early 1980s, providing a service that was similar to email. They were not a great success as a public service, as the cost of access via the telephone network was too high. The generation of a message by a dumb terminal lasted quite some time. Consequently, no operator worked on a low-cost access, e.g. by dial-in ports in every local exchange. Another important reason for X.400 fading into oblivion was definitely the horrendous addressing format of the standard. However MHSs were fairly successful for closed company internal communications. Most computer systems offered such features to their users.

1.2.6 The Development of Private Mobile Radio Networks

According to Wikipedia:9

Mobitex is an OSI-based, open, standard, national, public access, wireless, packet-switched data network. Mobitex places great emphasis on safety and reliability with its use by military, police, firefighters and ambulance services. Mobitex was developed at the beginning of the 1980s by the Swedish Televerket Radio.10

Mobile text and data networks for private mobile radio applications in the USA and Canada offered in the late 1970s voice and text/data transmission in a single integrated network.

Research work was done well before the standardisation and development phase of such networks and services.

1.2.7 Internet, Web Browsing and Email as the Winners in Communication in Fixed Networks

As a result of the fragmented development in telecommunications, a lack of innovation and a lack of fundamental agreement in telecommunication standardisation in several areas, the Internet has become the present dominant transport network. Fixed text communication has migrated to email, and Interactive Videotex services have been replaced by web browsing. The future is looming already in the shape of social networking (Facebook, etc.) and Twitter.

10 This was confirmed by Thomas Haug, who was involved in Mobitex.
1.3 Services Portfolio of GSM

1.3.1 Way of Working in GSM Standardisation

As this book may be read by people with other professional backgrounds and possibly by students, a short tutorial on how the GSM standardisation machinery worked is offered here. Most people believe that a group of people gather together and start to fight over which of a number of already developed solutions to a specific problem is the best. In the end, and after much blood has been spilt, a winner is announced, and that is the standard. People are unaware of the tremendous amount of advanced technical development work that is involved in the standards body itself. This may even be unique to the mobile business, and to GSM in particular.

According to Wikipedia:¹¹

Standardisation is the process of developing and agreeing upon technical standards. A standard is a document that establishes uniform engineering or technical specifications, criteria, methods, processes or practices. Some standards are mandatory while others are voluntary. Voluntary standards are available if one chooses to use them.¹²

For mobile communication systems – intended for a global or pan-European usage – a comprehensive standardisation is needed to achieve the necessary functioning: every SIM card must work in every terminal; every terminal must function in every network; interworking of all networks for message/call routing and for the support of international roaming must be possible.

The standard must enable attractive and economic services and equipment. For this, innovations and inventions are needed. However, for standardisation, not every contribution has to be novel. Often it is sufficient to choose between several well-known solutions and agree on just one, but the end result must be attractive to users, operators and manufacturers.

GSM standardisation work starts with an agreement about strategic targets. A work programme containing several work items is then developed. The work for each work item follows a structured methodology:

- stage 1: service requirements;
- stage 2: architecture and message flows;
- stage 3: interfaces and protocols.

In the early years (up to 1987), decisions required unanimity. They have since been made by consensus. Only in selected cases are votes taken. This open process allows every

¹² ETSI, the European Telecommunications Standards Institute, has very elaborate directives (199 pp.) with many defined terms. However, there is no definition of ‘standardisation’ or ‘standard’. ‘The objective of the Institute is to produce and perform the maintenance of the technical standards and other deliverables which are required by its members. “STANDARD” shall mean any standard adopted by ETSI’ (see ETSI Statutes).
participant to make contributions to all aspects. The process can be described as a joint development process.

To judge the value of work in a standardisation context, it is necessary not just to look at the creation of an idea. For successful standardisation it is necessary to write a contribution paper, to seek support, to submit it to the appropriate standardisation working group, to present it and to make sure that it is accepted and incorporated in an emerging standard’s document. In many cases a good solution needs contributions from several parties. Other activities to ensure acceptance are to become an editor of a specification, to monitor the issue over a long period and ensure that it is not removed and to improve it over time. Becoming a chairman and organising the work so that the ideas can flourish is also a possible way of contributing to a successful outcome.

The agreement on a standard is a necessary but not sufficient condition for success in the mobile communication market. There are so many standards that are not used, as they are normally voluntary. Mandatory standards are made obligatory by law. This covers only very restricted areas such as user and network safety. In GSM standardisation, the GSM MoU Group made the GSM standards mandatory for their members. For market success it is important that a high quality standard is actually implemented and widely used. Hence, efforts to seek the agreement of commercial actors to use a standard are very worthwhile if success is to be achieved in the market.

1.3.2 Service Philosophy of GSM Developed from 1982 to 1984

The GSM committee was founded at the end of 1982, and it was given the task of standardising a future pan-European mobile communication service and system using the 900 MHz band. The GSM committee agreed upon the following as basic targets for the service:

- The focus was to be upon mobile telephony, but it was expected that non-voice services would also be required.
- Mobile stations were to be used in all participating countries, including support of handheld mobile stations.
- All services that existed in the fixed networks were to be made available to mobile stations.

The existing analogue mobile telephony networks had nearly no non-voice services. Neither could they offer SMS-like services. Packet radio networks had supported text communication since 1978. Also, private mobile radio systems (e.g. Mobitex) had supported text messaging since about 1980. Therefore, a need existed to offer attractive non-voice services in the GSM system, the next generation of mobile networks.

The ‘coexistence between vehicle-borne and handheld mobile stations’ led to a long discussion. No existing European mobile system supported handhelds. In Central Europe there was very limited spectrum available for public mobile services, as much of the spectrum was used during the cold war for military purposes in many countries. Therefore,
delegates feared that insufficient capacity would remain for stations onboard cars, trucks, railways and ships where a radio connection was indispensable. However, all delegates saw that the support of handheld stations would be attractive to customers. Therefore, it was concluded that the GSM standard should allow handhelds to be introduced at the discretion of the network operator. This meant that the GSM standard should allow small cells to be implemented and should specify special functions to enable cheap handhelds.\textsuperscript{13}

1.3.3 GSM’s Fixed-network-service Companions

1.3.3.1 Reference Model

A reference configuration was agreed for all services that were defined as companions of the fixed-network services (Figure 1.1).

The reference configuration envisaged the same specification for the terminals (TE in the diagram) in the fixed and mobile networks. Other unstandardised terminals could be adapted by using a terminal adapter function (TA). Within the mobile network, specific functions are needed to ensure a sufficient quality of service. This includes a special channel coding and, in some service, specialised error correction protocols. These functions could not be understood by the fixed networks. Therefore, an interworking unit (IWU) was needed between the mobile and fixed network. The special functionalities would be handled by the TE or TA on the one side and the IWU on the other. This made it possible, in an elegant way, to concentrate the additional functions needed for non-voice services in defined units and to

![Figure 1.1](image.png)

\textsuperscript{13} GSM provides the following functions which help handhelds: power control and discontinuous transmission and reception to save battery consumption, and slow frequency hopping to enhance the speech quality in a fading environment.

install these according to demand without creating additional cost for the basic telephony service.

1.3.3.2 Teleservices

Teleservices were defined at the time as: ‘A type of telecommunication service that provides the complete capability, including terminal equipment functions, for communication between users according to protocols established by agreements between administrations’.¹⁵

A wide range of teleservices was envisaged:

- short message transmission;
- access to message handling service;
- interactive videotex;
- Teletex;
- Telex;
- fax;
- teleaction service (alarm service, telemetry service, etc.);
- picture transmission.

The Short Message Service, as a very special type of messaging implemented as an integral part of the signalling systems, was proposed in GSM as the only new service that did not already exist in public networks (Figure 1.2).

Efforts were made to interest the people responsible for ISDN in standardising it jointly so that a seamless service would exist. But there was no interest on the fixed side.¹⁷ The reason for this was probably that the ISDN representatives saw mobile services as a small brother proposing a service with severe restrictions for customers (message length) that they did not want to impose on their customers, as they planned rich text services such as Teletex. But they did not understand that there was a mass market for a simple service usable on every ISDN telephone.

In the family of envisaged SMS services, only the point-to-point services were really commercially successful. The point-to-multipoint services, later called cell broadcast, were

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¹⁷ I had talks in the late 1980s at a time when we were seeking a harmonisation of supplementary services. I undertook a second imitative when I was ETSI TC SMG chairman in the debate about fixed-mobile convergence in ETSI in the late 1990s.
not successful, as no attractive applications were found and no reasonable business model could be developed.

Hence, the SMS point-to-point services remained the only new services that had no companion in the fixed networks. It became a very successful GSM service. This book will explain how and why.

Substantial work was put into the standardisation of an access to message handling systems, especially by the Nordic operators. A full technical report was developed in standardisation. The service required a dumb terminal, all intelligence was in the MHS server and hence lengthy dialogues took place on the circuit-switched GSM bearer services used for access to the MHS. This was too expensive, and consequently it was not accepted by the market.

The standardisation of a mobile Teletex version was completed, but it was not implemented, as the service died in the fixed networks. Mobile Telex was seen as too old and was therefore not standardised.

The mobile fax version was standardised, but it was not successful in the market because it required clumsy fax machines connected to mobile stations and because the fax service was superseded in fixed networks during the first half of the 1990s when the GSM systems were launched.

The teleaction and picture transmission services were discussed at the time in the fixed network standardisation. However, the standards were not completed, and the services were not implemented in fixed networks and hence not further considered in GSM.

1.3.3.3 Bearer Services

Bearer services were defined at the time as: ‘A type of telecommunication service that provides the capability for the transmission of signals between user–network interfaces’.\(^\text{18}\)

A wide range of bearer services was envisaged:

- Telephony.
- 3.1 kHz audio band signals.
- Circuit-switched data services:
  - unrestricted digital (i.e. raw channel of about 13 kbit/s);
  - 300 bit/s duplex asynchronous;
  - 1200 bit/s duplex asynchronous;
  - 1200/75 bit/s duplex asynchronous;
  - 2400 bit/s duplex synchronous;
  - 4800 bit/s duplex synchronous;
  - 9600 bit/s duplex synchronous;
  - several half-duplex versions.

Mobile telephony became the most successful service of GSM. The 3.1 kHz audio band signals bearer service did not find much market interest. All the circuit-switched data services (except half-duplex) were standardised and implemented by most networks. Many had high hopes for CS-based mobile data, and were very enthusiastic when 14.4 kbit/s and High-Speed CSD came around. However, this range was not very successful in the market, for many reasons:

- The call set-up time was way too long.
- Even high-speed data were not fast enough for Internet browsing.
- Reliability was a problem. There were dropped calls all the time, caused by the poor radio coverage early on.
- In the early years, laptops were pretty clumsy and heavy.
- Moreover, the charges per session were pretty high because most IT applications required a dialogue between terminal and host computer, where transactions took place only from time to time. The channel was therefore not used most of the time, but the charging counters counted the entire connection time. The network operators could have applied some sort of volume charging, as the function of DTX (Discontinuous Transmission) did make sure that radio resources were only used when data were sent.

Around the year 2000, the GPRS (General Packet Radio Service) in GSM took these applications over.

1.4 GSM Mobile Telephony and SMS – the Most Successful Telecommunication Services

GSM/UMTS reached 3552 million users worldwide at the end of 2008\(^\text{19}\) (Figure 1.3).

![Figure 1.3](image)

**Figure 1.3** Number of GSM and UMTS users worldwide\(^\text{20}\)

\(^{19}\) GSMA wireless intelligence. *Quarterly World Review*, Q4 2008.

\(^{20}\) Data from www.gsm.org, own graphic.
GSM/UMTS was preferred by 89.5% of all mobile users at the end of 2008. Therefore, it is the dominant standard for mobile communication.

By 2002, mobile telephony had already overtaken fixed telephony in the number of subscribers worldwide (Figure 1.4).

The number of GSM subscribers is greater than the number of Internet users (Figure 1.5): 3552 million versus 1542 million in 2004. Hence, more people can use SMS than email.

It is estimated that the world market saw about 3–4 trillion short messages and a revenue of the order of $80–100 billion in 2008. A substantial growth in the number of messages can be expected in the coming years. The growth in revenue will be slower. More details can be found in Chapter 8, Section 8.4.

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21 Source www.gsacom.com