1. Introduction to GPRS

Mobile Communication is revolutionizing our everyday life. More and more people are buying mobile phones, the number of subscribers has multiplied in the last years and will not cease increasing during the coming years. Using present statistics, the influence of higher data rates has not been completely considered. But it seems guaranteed, the boom will continue and the figures will rise higher and higher. The statistics displayed are only estimated forecasts of the subscriber development within the next few years.

![Subscriber development of mobile communication networks](source: EMC&GSM MoU Association)

Evolutionary concept of the GSM-Standard

The development of the Mobile Communication Standard GSM, Global System of Mobile Communication is subdivided into different phases: Phase 1, 2 und 2+. It started with phase 1 in the year 1991, in the year 1995, Phase 2 was specified and realized and since the year 1997 the specification of the GSM Phase 2+ has been available. An introduction of the features of the new Phase 2+ in existing networks is planned between the end of 2000 and middle of 2001. With Phase 2 no total rework is done any more. Instead of this, GSM is continually modified and enhanced by so called Annual Releases. One key decision at this phase was to keep GSM compatible to the existing development phases, we call this Downward Compatibility. There will be no GSM Phase 3, future standards will belong to the standards of the 3rd Generation, one of them is called UMTS, Universal Mobile Telecommunication Standard.
The realization of some features can be viewed together with the different evolutionary phases. The next picture gives a brief overview of the 3 development phases within GSM and outlines the position of GPRS within the different development steps.
The features of the different evolution steps are:

**GSM Phase 1:**
Introduced in the year 1991, phase 1 holds all central prerequisites for mobile transmission of speech and user data. Only a small number of supplementary services were defined at this state.

**GSM Phase 2:**
This phase was completed in 1995. It specifies a vast set of so called Supplementary Services which are integrated into the mobile communication standard GSM. Most of these features are comparable to ISDN features in the fixed network.

Examples of these Supplementary Services are:
- CLIP (Calling Line Identification Presentation): Displays the number of the calling person on the mobile phone.
- Call Waiting: To hold a call for establishing another call to a third party.
- Multiparty Communication: Conference call, switching between 2 established connections.
- Closed User group: Closed group of users, with restricted access possibilities.
- Advise of Charge: Display the actual amount of the charge.

**GSM Phase 2+:**
In the published Annual Releases, modifications and innovations of the mobile communication standard are specified. Comparing to the features specified in the Phase 1, we have to take into account more and more the growth of the demand of mobile data transfer. More and more data has to be transmitted faster and faster. Multiple forecasts predict that the proportion between speech and data will be changed even more. The amount of transmitted data will increase much faster in comparison to the rise of voice data. The innovations and modifications of the mobile communication standard are published.

![Development of the proportion between voice and data applications](Picture: Development of the proportion between voice and data applications)
There is a request for the introduction of data transfer methods and also of methods that allow a much higher transmission rate. The next picture shall put the 3 methods into a chronological order. The picture also gives one example of the chronological introduction of the 3 services.

**Picture: Prognosis of the chronological realisation of phase 2+ features**

**Phase 2+ - features for higher data rates:**

**HSCSD:**
High Speed Circuit Switched Data: This innovation of GSM is based on a multislot-solution, bundling of timeslots within one Frame. Today, each subscriber gets allocated a Timeslot within a TDMA Frame. The idea is now, in case of the request of higher data rates, to combine more Timeslots during one Frame and enhancing the data rate by this way. Per allocated Timeslot, the data rate of 14,4 Kbit/sec is available. Due to bundling, we get the theoretical data rate of max. 8x14,4 Kbit/sec = 115,2 Kbit/sec. In reality we expect data rates in the range of 4x14,4 Kbit/sec = 57,2 Kbit/sec, because the limited resources at the air interface are making it very unlikely, that one customer will ever get all the theoretically existing resources.

**GPRS:**
General Packet Radio Service: GPRS is also based on a multislot-solution, also in this service, Timeslots will be combined. In contrast to circuit switched communication, the data transfer here is realized in a packet oriented way. The transmission only takes place when there are some data packets to be transmitted. The network carries out a dynamic allocation of the transmission resources. Another feature of GPRS is the quality of the radio link. GPRS allows a dynamic adaption between user data and redundant data. By this way, GPRS allows the theoretical maximum value of up to 171,2 Kbit/sec.

**EDGE:**
Enhanced Data Rate for GSM Evolution: The latest evolution of the GSM-Standard uses another modulation technique, 8-PSK (8-Phase Shift Keying) which allows you to transfer more data symbols with each modulation symbol and therefore enhance the data rate. An inconvenience in real networks is that the better carrier/interference ratio is needed for 8-PSK. This leads to the fact, that 8-PSK-modulation can only be used with a good quality radio link. EDGE is not a stand-alone technique, rather it forms a hybrid system either with HSCSD or GPRS. Both methods are then called ECSD (Enhanced Circuit Switched Data) oder EGPRS (Enhanced General Packet Radio Services).
In the picture above you can see that deriving from GSM there are 2 separate paths of technology development. One way is formed by the circuit switched principle, the other way is formed by the packet switched principle. Both ways have to be considered independently of each other. Possible realisations can be done at the same time, one after the other or either or. In the lower part the american standard of mobile communication TDMA is indicated. In the future development of this standard it will appear in the EGPRS compact which will be compatible to the EGPRS classic standard.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Mode of Data Transfer</th>
<th>Modulation</th>
<th>Bundling of Timeslots</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM</td>
<td>Circuit Switched</td>
<td>GMSK</td>
<td>1 Timeslot</td>
</tr>
<tr>
<td>HSCSD</td>
<td>Circuit Switched</td>
<td>GMSK</td>
<td>Up to 8</td>
</tr>
<tr>
<td>GPRS</td>
<td>Packet Switched</td>
<td>GMSK</td>
<td>Up to 8</td>
</tr>
<tr>
<td>ECSD</td>
<td>Circuit Switched</td>
<td>GMSK + 8PSK</td>
<td>Up to 8</td>
</tr>
<tr>
<td>EGPRS</td>
<td>Packet Switched</td>
<td>GMSK + 8PSK</td>
<td>Up to 8</td>
</tr>
</tbody>
</table>

Picture: Characteristics of the generation 2.5 standards
New Services for GSM Phase 2+:

- **Enhanced Full Rate, EFR:**
  The Enhanced Full Rate Speech Codec is based on a new speech coding algorithm that offers a better speech quality. Please note that the voice data rate stays on the same level as the full rate speech codec used before. The EFR only uses new algorithms for the calculation of the reproduction of the analog voice signal into a digital bit sequence.

- **Advanced Speech Call Items, ASCI:**
  Introduces new features of voice connections: These are for example:
  - Voice Group Call Services VGCS, allowing group calls
  - Voice Broadcast Services VBS, a group call, on call is distributed point to multipoint.
  - Enhanced Multi-Level Precedence and Preemption eMLPP: For the allocation of priority and precedence parameters during the establishing of voice calls, used for a faster connection.

- **Customized Applications for Mobile Network Enhanced Logic, CAMEL:**
  This service allows the integration of intelligent network features into a mobile communication network. It should not be considered as a closed chapter, more as an open gate for different kind of services (some of them may not be known today) because we are just at the beginning of the research and development stage of this kind of features.
- **Expanded frequency bands GSM 450 and GSM 480:** The extension of the existing frequency band in the area of 450 MHz and 480 MHz.

**International development of Mobile Communication Standards**

The next picture gives an overview of the international development of mobile communication in the european, american and japanese arena. At the same time we can see the introduction of GPRS as an intermediate step of the introduction of the 3rd generation standards.

**Features of GPRS:**

As an introduction to GPRS the main features are listed and summarized. This shall verify the decision of many network operators and manufacturers to go for GPRS.

GPRS forms a direct link into the Internet:
Due to the integration of GPRS into GSM-Networks we get a direct link to packet oriented networks like IP or X.25. This link is direct and does not take the deviation way of an intermediate network. On the other side, GPRS combines the access to the internet with the features of a mobile communication network.

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**Picture: Evolution of international Mobile Communication Standards**

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Co-existence with circuit switched networks:
One of the main features of GPRS is the strict combination with existing circuit switched networks, there will not be a stand-alone-GPRS-network, this will always be an extension of GSM. Due to this reason, all the existing features will last for the foreseeable future and there will only be some new features.

Circuit switched data transfer:
Circuit switched data transfer in the case of GSM signifies that the transfer of user data, e.g. voice requires the allocation of a fixed and continuous physical ressource. For example the allocation of 1 Timeslot on 1 frequency channel for the complete duration of the communication. Another example is the closing of an electrical circuit between 2 points. Circuit switching means the assignment of a physical communication way for the whole time of the connection.

Packet switched data transfer:
The main difference with regard to the circuit switched way is the fact, that the data is transported in form of packets. The real physical ressource is only allocated for the temporary interval we need to transmit data. The radio link is only assigned for those times it is needed to transport these packets. A classic example for packet data transfer is the sending of letters and parcels via the normal post. Each message or letter has to be packed into a packet or envelope and will be conveyed individually. This transportation on the physical way only takes place, if there are some packets to be transmitted. Another problem of packet data transfer is also shown very clearly in this example: Addressing. Every packet can only be transported if it contains the destination address. This aspect requires the introduction of new switching elements to the existing GSM networks.
Higher data rates due to channel combining
GPRS uses the principle of bundled timeslots to enhance the data rates. There are up to 8 Timeslots which can be combined within 1 TDMA Frame.
Higher data rates due to channel coding:
Another strategy of GPRS to enhance the data rate is a flexible adapted comportion between user data and error correction. Due to the introduction of the so-called Coding Schemes CS-1 up to CS-4 the netto data rate can be extended. In comparison, the comportion between user data and error correction in GSM is constant.

<table>
<thead>
<tr>
<th>Traffic channel:</th>
<th>Information:</th>
<th>Error protection:</th>
<th>Total:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice (full-rate):</td>
<td>13.0 kbit/s</td>
<td>9.8 kbit/s</td>
<td>22.8 kbit/s</td>
</tr>
<tr>
<td>Data:</td>
<td>2.4 kbit/s</td>
<td>20.4 kbit/s</td>
<td></td>
</tr>
<tr>
<td>4.8 kbit/s</td>
<td>18.0 kbit/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.6 kbit/s</td>
<td>13.2 kbit/s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GSM-data rate

GPRS-data rate

21.4 kbit/s
9.05 kbit/s

Coding scheme 1
Coding scheme 4

Dynamic allocation of transmitting resources:
In contrast to HSCSD where we could find a higher data rate also based on the principle of multislot-solution, GPRS carries out the allocation of the physical ressource in a dynamic way. Multiple subscribers can share the existing physical channel. This allows the use of surplus capacities.

Picture: Traffic distribution of a radio cell. Example: Urban Cell, weekdays
**Chronological course of the introduction of GPRS:**

The introduction of GPRS in one GSM-Network has to be considered as an intermediate step towards the transition to the 3\textsuperscript{rd} generation, UMTS. GPRS comprises the introduction of a packet-oriented core network that will also be necessary in the 3\textsuperscript{rd} generation standard. Because of this, the introduction of UMTS can be realised in the future by exchanging the Radio Subsystem RSS and this can be done relatively easy.

The introduction of GPRS itself is divided into 2 phases:

**GPRS-Phase 1:**

- Point-to-point data transfer
- GPRS Identities, e.g. MS with IP-Adress
- GPRS-Security functions, authentication and ciphering
- Data transfer with different Coding Schemes for higher data rates
- Transmitting of SMS via GPRS-channels
- VoB, Volume oriented Billing, charging by the amount of transferred data
- TCP/IP or X.25 based bearer services

**GPRS Phase 2:**

- Point-to-multipoint data transfer
- Special PnP or PtM Service, e.g. group call or conference calls
- Support of further data transfer services and QoS-profiles