

GSM

Backgrounds regarding data transmission in GSM and UMTS mobile networks
for **Sunny WebBox / Sunny Boy Control**



Contents

In addition to telephony, services for digital fax and data transmission were already defined back when GSM standards were first created. Apart from pure voice transmission, GSM specifications, for example, provide a broad diversified spectrum of fax and data services.

The first data services in GSM networks were circuit-switched, asynchronous data services (CSD, Circuit Switched Data), as those long used for remote data transmission in analog telephone networks. Only specific, international, standardized communication protocols are used for dial-up and transmitting data. Therefore, data can be exchanged with all conventional receivers, provided that the devices used comply with these international applicable standards.

Additional data services, which can achieve higher bit rates, have been introduced into cell phone networks since 2000. This includes HSCSD (High Speed Circuit Switched Data) with up to 38.4 kbit/s, and packet-switched data transmission GPRS (General Packet Radio Service) with up to 53.6 kbit/s.

At the beginning of 2004, Vodafone D2 and other cellular network operators launched commercial UMTS network services, which reached 384 kbit/s, and thus, considerably raised the bar for possible bit rates. The faster data transmission in the UMTS network is based on GPRS; however, the conventional circuit-switched data services are also available in the Vodafone D2 UMTS network.

1 Basics

The history of data transmission in GSM and UMTS cellular networks. With the friendly support of Vodafone D2 and Markus Weidel Sales System Consultant.

1.1 Circuit and Packet-Switched Data Transmission

Up until GPRS was launched, only circuit-switched data transmission was employed in cellular networks (CSD, Circuit Switched Data). In this case, one or more radio channels are occupied, just like telephony, during the entire duration of the connection, regardless of whether data is transmitted or not.

GPRS employs packet-switched data transmission. Here, the data to be transferred is broken down into small data packets, and transmitted through one or more available channels between the mobile end device and a packet-switched data network (e.g. the Internet). In the process, the radio channels are only temporarily occupied for the transmission and then immediately freed up again so that several end devices virtually have simultaneous access to the available radio channels. The recipient address contained in the data packet ensures that the data packets reach the desired receiver.

GPRS is also employed with fast data transmission in the UMTS network, which reaches up to 384 kbit/s.

1.2 The Analog and Digital Transmission Methods

Fax messages and data are always transmitted digitally within a GSM or UMTS cellular network. However, specific receivers, e.g. analog fax devices or analog landline modems, must obtain the data in analog form for circuit-switched connections.

Therefore, the GSM and UMTS standard offer two different transmission methods for circuit-switched data services: analog and digital.

Analog Transmission

The analog transmission (3.1 kHz audio) corresponds to analog modem operation. The required digital/analog conversion is automatically carried out at the cellular switching center.

Digital Transmission

In digital transmission (UDI, Unrestricted Digital Information), the data - unlike analog transmission - is digitally transmitted over the entire transmission network. The considerably faster dial-up poses an advantage over the connections with the receivers in the analog fixed line network. The bit rate adjustment is important for digital transmission. The bit rate must be adjusted, since data is transmitted at 64.000 bit/s in the ISDN network, for example, but it is transmitted at a maximum rate of 38.4 kbit/s (circuit-switched) in the cellular network. The adjustment is carried out according to the ITU-T standard V.110, which both receivers have to comply with.

1.3 Incoming Fax and Data Connections

Single Numbering

Your cellular phone number not only allows you to receive incoming voice calls, but also incoming circuit-switched fax and data calls from digital networks (single numbering). This provides you with the following advantages with mobile

fax and data reception:

- no additional telephone numbers
- no booking entry,
- and no additional basic price.

Requirements

Single numbering requires that the corresponding service identification is signaled to the cellular network when a fax or data call is made to your phone. This is the only way to inform your cellular phone that the call is a fax or data call.

The cellular phone can then switch the incoming connection through to the corresponding end device (e.g. PDA for a data connection).

The service identification signal is only transmitted if the call originates from a digital network (German cellular networks, ISDN). In addition, the following restrictions exist:

- Some analog fax devices do not signal a service identification.
- The service identification is not signaled in private branch exchange systems if the fax device has not been programmed as a fax device (e.g. with some multifunctional devices).
- The service identification is not always signaled for international connections.

Multi-Numbering

If you would like to receive incoming circuit-switched fax or data calls from all networks, then you require additional telephone numbers that are assigned to your existing SIM card (multi-numbering).

During this process, the cellular switching center in the cellular network, for example, know how they must prepare the data for the digital transmission for incoming data connections from an analog landline.

Note

The required information is automatically transmitted from your cellular phone to the cellular switching center for outgoing fax and data connections. If you only want to use your cellular phone for outgoing fax and data connections, you can always do this without ordering a fax or data number.

The direction in which the data is transmitted, whether it is an outgoing or incoming connection, is irrelevant. Thus, a connection that you establish using an online service or Internet provider is an outgoing connection, even if you receive data (e.g. WWW pages, e-mail).

Call forwarding and call blocking: You can also use the call forwarding and call blocking services for circuit-switched fax and data connections (both with single and multi-numbering). Using the corresponding basic service code, call forwarding or call blocking for fax and data connections can be switched on and off, regardless of the telephony settings.

2 CSD

2.1 Performance Features

CSD enables the circuit-switched data transmission in the cellular network using your cellular phone and suitable accessories. You can establish data connections to receivers in analog and digital landline and cellular networks, and transmit any data.

2.2 Bit Rates

CSD supports the following bit rates per radio channel:

- 2,400 bit/s
- 9,600 bit/s
- 14,400 bit/s*.

HSCSD allows higher bit rates to be achieved by consolidating several radio channels.

* The maximum bit rate in a radio channel in the Vodafone D2 network was increased from 9,600 bit/s to 14,400 bit/s by employing a new channel coding equipped with modified fault protection coding. This bit rate is only supported by newer cellular phones.

2.3 Data Compression

Many cellular networks support data compression according to the ITU-T standard V.42bis. As a result, the data quantity to be transmitted can be reduced in data connections and thus, the data throughput can be increased. This applies to sending and receiving uncompressed data, such as text and HTML files, or graphics.

2.4 Receivers

You can also reach analog and digital receivers using CSD (see also "Transmission Methods"). The receivers can be located in the following networks:

- in the cellular network,
- in the analog landline,
- in the digital ISDN landline,
- and in another cellular network.

In addition, numerous cellular providers offer mobile Internet access. Furthermore, there are special dial-in numbers in the Vodafone D2 network, for example, for many online services and Internet providers as well as the Datex-P Network.

3 HSCSD

3.1 Performance Features

HSCSD (High Speed Circuit Switched Data) offers the identical performance features as CSD; however, HSCSD allows significantly higher bit rates to be achieved. HSCSD is based on CSD, and is respectively also a circuit-switched, asynchronous data service that allows you to establish data connections between your cellular phone and receivers in an analog or digital landline or cellular network.

In a conventional circuit-switched data connection using CSD - also as with a GSM voice connection - a single radio channel is occupied on the transmission path.

However, instead of using only one channel, HSCSD exploits the transmission capacity of several channels, i.e. several channels are simultaneously occupied during a data connection. The data to be transmitted is divided into individual channels on the transmission path, and subsequently reassembled.

Note: HSCSD can also be used in GSM networks of numerous roaming partners.

3.2 Bit Rates

Depending on the number of combined channels and the channel coding used, there are different bit rates available in the cellular network. Note that a maximum of 4+1 channels can be combined using cellular phones that are currently available on the market, i.e. a maximum of four channels are combined for receiving data (downlink), and one additional channel remains for sending data (uplink). This asymmetrical channel assignment is, among other things, useful when you surf the Internet, since considerably more data is transmitted when downloading files from the Internet than sending the command to download.

You can define the maximum number of combined channels or the maximum bit rate for both transmission directions (up and downlink). The actual bit rate depends on the following factors:

- Availability of available channels: The flexible channel assignment (up/downgrading) of the cellular network allows the number of combined channels to fluctuate during the data connection:
 - Blocking: A voice connection is to be established in a radio cell, which, among other things, is completely occupied by HSCSD data connections. The data connection is reduced by one channel to create capacity for the voice connection. If the voice connection is terminated, the channel is reassigned to the data connection.
 - Handover: You change from one radio cell to another that does not contain sufficient available channels to maintain the data connection on all combined channels. Once sufficient channels are available, the number of the combined channels is increased again. Your HSCSD connection is always maintained in at least one radio channel.

- Error correction: In most cellular networks, HSCSD only enables a non-transparent data connection. An additional error protection protocol is used for the non-transparent data transmission. This protocol ensures that the data, which has been distorted on the transmission path, is requested again. As a result, the data rate for a non-transparent data transmission can fluctuate.

3.3 Applications

With higher bit rates, HSCSD ensures faster data transmission in the cellular network. Thus, for example, you can surf the Internet faster using the Internet service. All applications that up to now have been possible with CSD are also possible with HSCSD.

HSCSD is primarily aimed at customers who want to transmit large data quantities using a mobile device, and are only online for a short time. Typical applications for HSCSD include downloading large files from a company's intranet.¹

Number of combined channels	Maximum bit rates	
	at 9.6 kbit/s channel coding	at 14.4 kbit/s channel coding
1	9.6 kbit/s	14.4 kbit/s
2	19.2 kbit/s	28.8 kbit/s
3*	28.8 kbit/s	38.4 kbit/s** 43.2 kbit/s***
4*	38.4 kbit/s**	38.4 kbit/s** 57.6 kbit/s***

* Is not available nationwide in all cellular networks

** Only with connections to ISDN receivers that support the V.110 (UDI) standard

*** Theoretical value that is only achieved on the air interface in the cellular network.

4 GPRS

4.1 Performance Features

GPRS (General Packet Radio Service) makes mobile data transmission faster, more convenient, and more cost-effective:

- considerably higher bit rates for WAP, and mobile Internet access.
- on request, the user can remain permanently online through the packet-switched data transmission
- connection costs depend on the data quantity transferred
- the user is always available to take calls during the data transmission.

You profit from one of the aforementioned advantages of GPRS, especially with one of the following applications:

- WAP: for conveniently retrieving diverse information (news, stock market prices, etc.) directly on your cellular phone at low prices.
- E-mail: reading and writing e-mails using WAP or an e-mail program.
- Internet: surfing the Internet while en route using a PDA (e.g. iPAQ, Palm, etc.) or laptop - without an additional Internet provider. GPRS enables direct access to the Internet, and is particularly suitable for text-based Internet applications with low data volumes, and longer online times (e.g. chatting, instant messaging).

4.2 Bit Rates

Many cellular networks allow 8 radio channels to be combined, and can thus reach bit rates of up to 107.2 kbit/s. However, the GPRS cellular phones that are currently available on the market can only combine a maximum of 4+2 radio channels, i.e. max. 4 channels for receiving data, and 2 channels for sending data. This achieves a bit rate of up to 53.6 kbit/s in the reception direction.

Note:

- The specified bit rates are always maximum values. For example, the bit rates actually achieved during a GPRS data connection are influenced by the number of available radio channels.
- Voice connections generally have priority over data connections. If many radio channels are occupied by voice connections in one radio cell, than not so many radio channels can be combined for GPRS and HSCSD data services. The maximum bit rates are not achieved.

4.3 Always Online ("Always On")

If you choose a suitable tariff option, you can remain continuously online using GPRS, since only the transmitted data quantity is charged, and not the duration of the connection. Radio channels are only occupied if data is actually transmitted.

Example: Calling up an Internet page temporarily occupies several radio channels. While you read the pages (and no new data is requested), the radio channels are available to other participants. This takes place without requiring a prolonged dial-up each time, as with circuit-switched data services. You can still receive calls and text messages during a GPRS connection.

4.4 Availability during a GPRS Connection

You can receive telephone calls and text messages during a GPRS connection. If you receive a call, you can take the call, and you are immediately online again once the telephone call is terminated. Your connection is only occupied for the short time it takes to transmit data.

5 GPRS Compared to HSCSD

HSCSD is particularly suitable for accelerating the transmission of extensive data quantities. HSCSD is circuit-switched, i.e. it permanently occupies several combined radio channels. HSCSD is charged on a per minute basis. Therefore, HSCSD is ideal if large data quantities must be transmitted to a destination, and you are only online for a short time.

GPRS is more cost-effective for interactive applications, such as WAP, because it is packet-switched. The data is broken down into packets, and transmitted parallel on several radio channels. With GPRS, the data flows through the cellular network without permanently blocking the radio channels used in the process. If no data is being transmitted, for example, because you are reading an e-mail, the connection is suspended, and does not take up any more network capacity.

Bit rates: Most cellular networks allow you to achieve bit rates of up to 107.2 kbit/s using GPRS, while HSCSD allows you to achieve bit rates up to 38.4 kbit/s. However, the end devices that currently support bit rates of up to 53.6 kbit/s in the reception direction are the limiting factor for GPRS.