Universität Würzburg
Informatik III (Verteilte Systeme)
Prof. Dr. P. Tran-Gia

Chapter 8.2
GSM-Technology

Prof. P. Tran-Gia

www3.informatik.uni-wuerzburg.de

2006

Chapter 8 Mobile Communications Networks

Characteristics and Network Structure

▶ GSM : first version standardized 1991(GSM : Groupe Spéciale Mobile, later Globale System for Mobile Communication)

▶ Prevalent mobile network of the 2nd generation (2G)

	GSM 900	GSM 1800 (DCS)	GSM 1900 (PCS in USA)
Uplink	890 - 915 MHz	1710 – 1785 MHz	1850 – 1910 MHz
Downlink	935 - 960 MHz	1805 - 1880 MHz	1930 - 1990 MHz

(DSC :   Digital Cellular System)
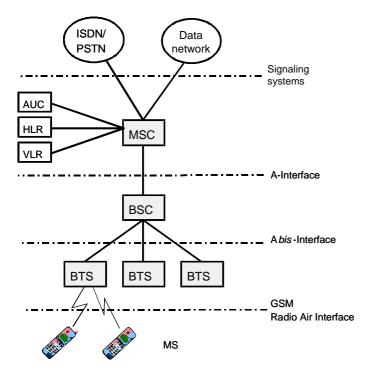
(PCS :   Personal Communications Service)

▶ E.g. System GSM 900:

  ▪ 124 frequencies/ frequency pairs,

  ▪ TDMA with 8 time slots with channel distance of 200 KHz each,

  ▪ physically maximal 124 wave bands usable

Universität Würzburg

Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

Architecture of a GSM Mobile Network

PSTN: Public Switched Telephone Network

AUC: AuthenticationCenter
HLR: Home Location Register
VLR: Visitor Location Register
MSC: Mobile SwitchingCenter

BSC: Base Station Controller

BTS: Base Transceiver Station

MS :   Mobile Station

Universität Würzburg

Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

System Components

▶ **Mobile Station (MS)**
- Cell phone, comprises hardware and software
- Stores all relevant information of a GSM subscriber

▶ **Base Transceiver Station (BTS)**
- Corresponds to a radio cell, can be realized with sectors
- Includes antenna, signal processing, amplifier
- Serves the Abis interface to the BSC (Abis has several 16kbps and 64kbps connections)
- Typical radius: 100m to 35km

▶ **Base Station Controller (BSC)**
- Controls several BTS
- Reservation of radio frequencies, supports handover between BTS
- Supports multiplexing of multiple connections prior to transmission to fixed network

Universität Würzburg
Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

5

System Components

▶ **Base Station Subsystem (BSS)**
- Corresponds to one site in the network of a mobile service provider

▶ **Mobile (Services) Switching Center (MSC)**
- Switching center, responsible for a number of BSS
- Supports control of connections to its BSCs and to other MSCs
- Mobility monitoring
  - Paging (calling of a mobile subscriber within a network)
  - Updating of subscriber locations

▶ **Home Location Register (HLR)**
- Database, stores information of subscribers registered or authorized in its area of administration
- Stores fundamental subscriber data (services, class, tariff, etc.)
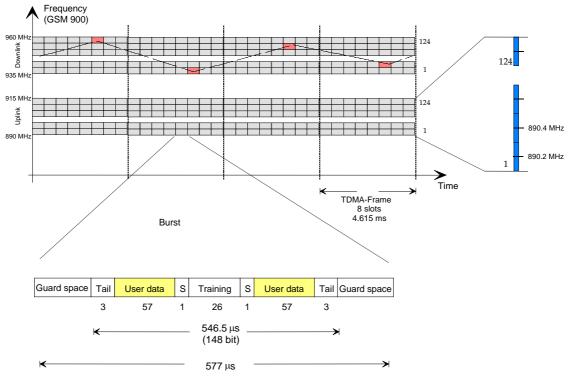
▶ **Visitor Location Register (VLR)**
- Associated with each MSC
- Database, stores information of subscribers temporarily visiting the MSC's area of administration

Universität Würzburg
Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

6

GSM: Multiple Access Scheme

Guard space	Tail	User data	S	Training	S	User data	Tail	Guard space
	3	57	1	26	1	57	3	

546.5 μs
(148 bit)

577 μs

Universität Würzburg
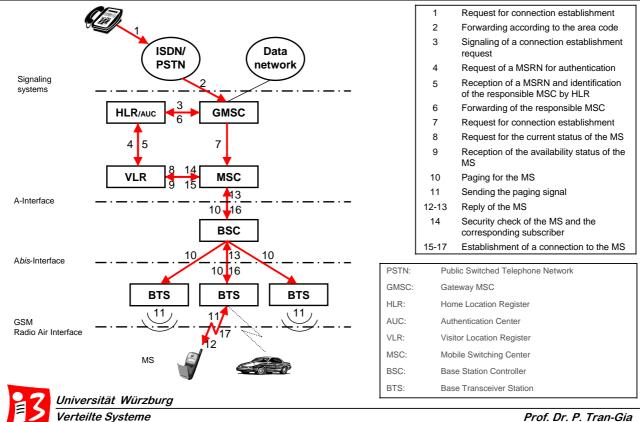**Verteilte Systeme**   *Prof. Dr. P. Tran-Gia*

7

GSM: Multiple Access Scheme

▶ Combination of FDMA, TDMA
(frequency bandwidth 200 kHz, time slot 577 μs)

▶ with „*slow frequency hopping*" : avoids frequency selective degradation of the radio link quality of one specific channel over a longer period of time

▶ Bit rates:
  ▪ Gross bit rate: $\dfrac{2 \times 57\,\text{bit}}{4.615\,\text{ms}} = 24.70\,\text{kbps}$

  ▪ Net bit rate per channel: $24.70\,\text{kbps} \cdot \text{code-efficiency}$
  ▪ Coding: combination of convolutional coding, parity check and fire-code
  ▪ Code efficiency depends on application and code
  ▪ Net bit rates between 12kbps and 13kbps for voice transmission

Universität Würzburg
Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

8

GSM: Example for a Connection Establishment

1	Request for connection establishment
2	Forwarding according to the area code
3	Signaling of a connection establishment request
4	Request of a MSRN for authentication
5	Reception of a MSRN and identification of the responsible MSC by HLR
6	Forwarding of the responsible MSC
7	Request for connection establishment
8	Request for the current status of the MS
9	Reception of the availability status of the MS
10	Paging for the MS
11	Sending the paging signal
12-13	Reply of the MS
14	Security check of the MS and the corresponding subscriber
15-17	Establishment of a connection to the MS

PSTN:	Public Switched Telephone Network
GMSC:	Gateway MSC
HLR:	Home Location Register
AUC:	Authentication Center
VLR:	Visitor Location Register
MSC:	Mobile Switching Center
BSC:	Base Station Controller
BTS:	Base Transceiver Station

Signaling systems

A-Interface

Abis-Interface

GSM Radio Air Interface

MS

Chapter 8 Mobile Communications Networks

8.1 Introduction
8.1.1 History of mobile communication
8.1.2 Fundamental concepts of mobile communication systems
8.1.3 Multiplexing schemes in mobile communication networks

8.2 GSM-Technology
8.2.1 Characteristics and network structure
8.2.2 Example for connection establishment
8.2.3 GPRS: General Packet Radio Service

8.3 3rd Generation Mobile Networks - UMTS
8.3.1 Characteristics of 3rd generation mobile networks
8.3.2 UMTS network architecture
8.3.3 Fundamentals of the (Wideband) CDMA-Technology
8.3.4 Important control mechanisms in UMTS
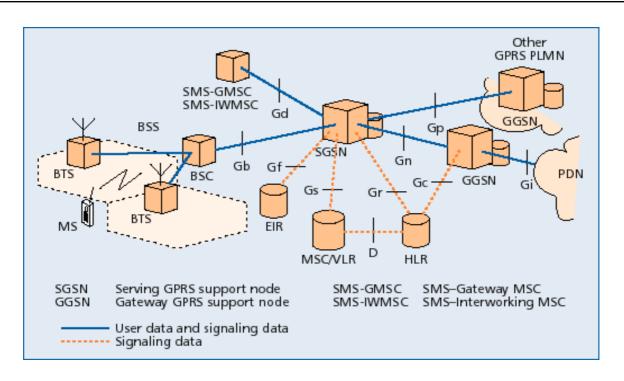8.3.5 Soft capacity and coverage area

General Packet Radio Service (GPRS)

▶ GPRS is the extension of GSM for the transmission of packet data traffic

▶ Instead of circuit switching like in GSM, packet switching is used (TCP/IP in GPRS fixed network)

▶ GPRS belongs to the mobile network generation 2+ or 2.5

▶ Channel allocation in GPRS

  ▪ Join utilization of one channel by several users

  ▪ Higher data rates by using several channels in parallel (PDCH=Packet Data Channel)

  ▪ In the starting phase utilization of the idle GSM channels (on-demand channel), later explicit reservation of channels for GPRS (dedicated channel)

▶ Few hardware changes required for GPRS, i.e. architecture of GSM with additional functional nodes: SGSN and GGSN

▶ Flexible utilization of the air interface resources

▶ Several data rates per channel with different coding schemes

GPRS System Architecture

SGSN: Serving GPRS Support Node

▶ Main functionality: authentication, billing, session management
▶ Session management
  ▪ Attach: registration at the SGSN
    – authentication
    – Copying the user profile from HLR to SGSN
    – Temporary ID (P-TMSI) is assigned to mobile
  ▪ Detach: counterpart of attach
  ▪ Management of PDP context (Packet Data Protocol context):
    – Temporary IP address of the mobile
    – Quality of service
    – Address of corresponding GGSN
    – PDP context stored in MS, SGSN, and GGSN
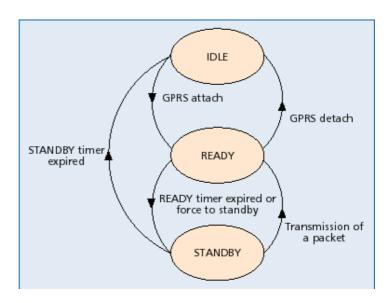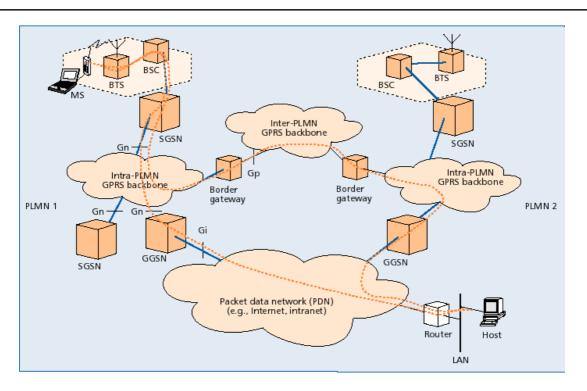

SGSN: *Serving GPRS Support Node*

▶ Location management:
  ▪ IDLE: MS not attached
  ▪ READY: MS informs SGSN about change of cell
  ▪ STANDBY: MS informs SGSN about change of routing area (routing area: cluster of several cells)

Connection to the Internet with GPRS

GPRS: Protocol Stack

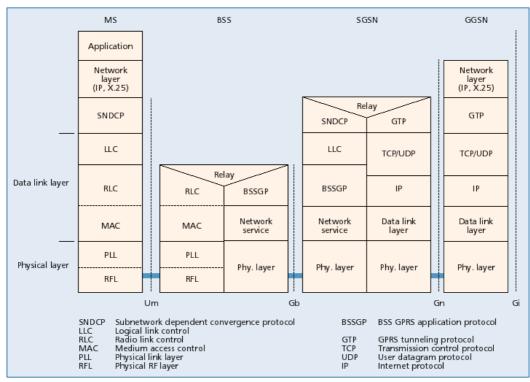|		
SNDCP	Subnetwork dependent convergence protocol	BSSGP BSS GPRS application protocol
LLC	Logical link control	
RLC	Radio link control	GTP GPRS tunneling protocol
MAC	Medium access control	TCP Transmission control protocol
PLL	Physical link layer	UDP User datagram protocol
RFL	Physical RF layer	IP Internet protocol

Data Transmission with GPRS

- ▶ Utilization of GSM channels, i.e. FDMA/TDMA with frequency hopping
- ▶ Data is segmented into RLC blocks (radio link control)
- ▶ RLC provides secure transmission with an ARQ mechanism (automatic repeat request)
- ▶ Size of RLC blocks depends on chosen coding scheme
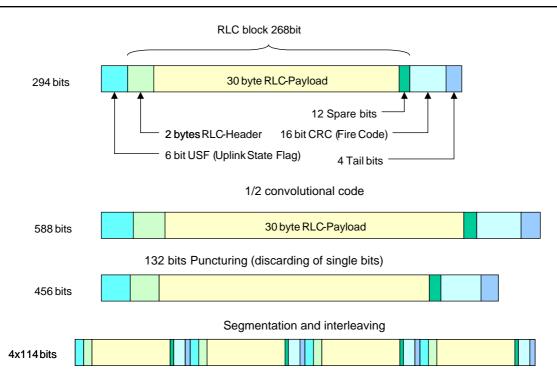- ▶ Data rate of a PDCH (Packet Data Channel) for different CS:

Coding scheme	Pre-cod. USF	Infobits without USF	Parity bits BC	Tail bits	Output conv encoder	Punctured bits	Code rate	Data rate kbit/s
CS-1	3	181	40	4	456	0	1/2	9.05
CS-2	6	268	16	4	588	132	~2/3	13.4
CS-3	6	312	16	4	676	220	~3/4	15.6
CS-4	12	428	16	0	456	0	1	21.4

Universität Würzburg
Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

17

Example: Coding Scheme 2

RLC block 268bit

294 bits
30 byte RLC-Payload

12 Spare bits

2 bytes RLC-Header
16 bit CRC (Fire Code)

6 bit USF (Uplink State Flag)
4 Tail bits

1/2 convolutional code

588 bits
30 byte RLC-Payload

132 bits Puncturing (discarding of single bits)

456 bits

Segmentation and interleaving

4x114 bits

Universität Würzburg
Verteilte Systeme   *Prof. Dr. P. Tran-Gia*

18

Multiplexing and Channel Allocation

- ▶ Task of the MAC layer (medium access control)
- ▶ Data transmission is realized in TBF (Temporary Block Flow)
- ▶ At most one TBF per up- and downlink for a mobile
- ▶ TBF between mobile and base station exists only during data transmissions
- ▶ TBF consists of:
    - ▪ TFI (Temporary Flow ID)
    - ▪ Number of PDCHs with associated USF (uplink state flag) for uplink TBF
- ▶ TBF can use several PDCHs (theoretically up to 8):
    - ▪ Currently mobiles with up to 4 neighbored PDCHs
    - ▪ In theory data rates up to 171.2kbps (CS 4, 8 PDCH),
    - ▪ Realistic data rates: 26.6kbps and 53.2kbps with CS 2 and 2/4 PDCH
- ▶ Several TBFs can share one PDCH, multiplexing with
    - ▪ TFI on the downlink
    - ▪ USF on the uplink, i.e. USF in the downlink RLC block specifies which TBF is to use the next RLC block on the uplink
    - ▪ All TBFs of one PDCH get the same bandwidth, i.e. RLC blocks are sent in a round robin fashion

---

Example for Multiplexing on the Uplink Using USF

- ▶ Three uplink TBFs on time slots (TS) 1-3:
    - ▪ A: USF 1 on TS 1, 2 and 3
    - ▪ B: USF 2 on TS 2, USF 3 on TS 3
    - ▪ C: USF 2 on TS 3

Scheduling at the base station:

TS 1 — MS A

TS 2 — MS A / MS B

TS 3 — MS A / MS C / MS B

Scheduling discipline: Round Robin on every PDCH

TDMA frame		1–4	5-8	9-13	14-17	18-21	22-25	26-29	30–33
TS 1	Downlink	USF 1	USF 1	USF 1	USF 1	USF 1	USF 1	USF 1	USF 1
	Uplink		A1	A4	A5	A7	A9	A11	A12
TS 2	Downlink	USF 1	USF 2	USF 1	USF 2	USF 1	USF 2	USF 1	USF 2
	Uplink		A2	B1	A6	B3	A10	B4	A13
TS 3	Downlink	USF 1	USF 3	USF 2	USF 1	USF 3	USF 2	USF 1	USF 3
	Uplink		A3	C1	B2	A8	C2	B5	A14