GSM, GPRS och EDGE

Ett halvt steg framåt

Mats Carlberg
matca@lysator.liu.se
mats.carlberg@ericsson.com

2003-12-09

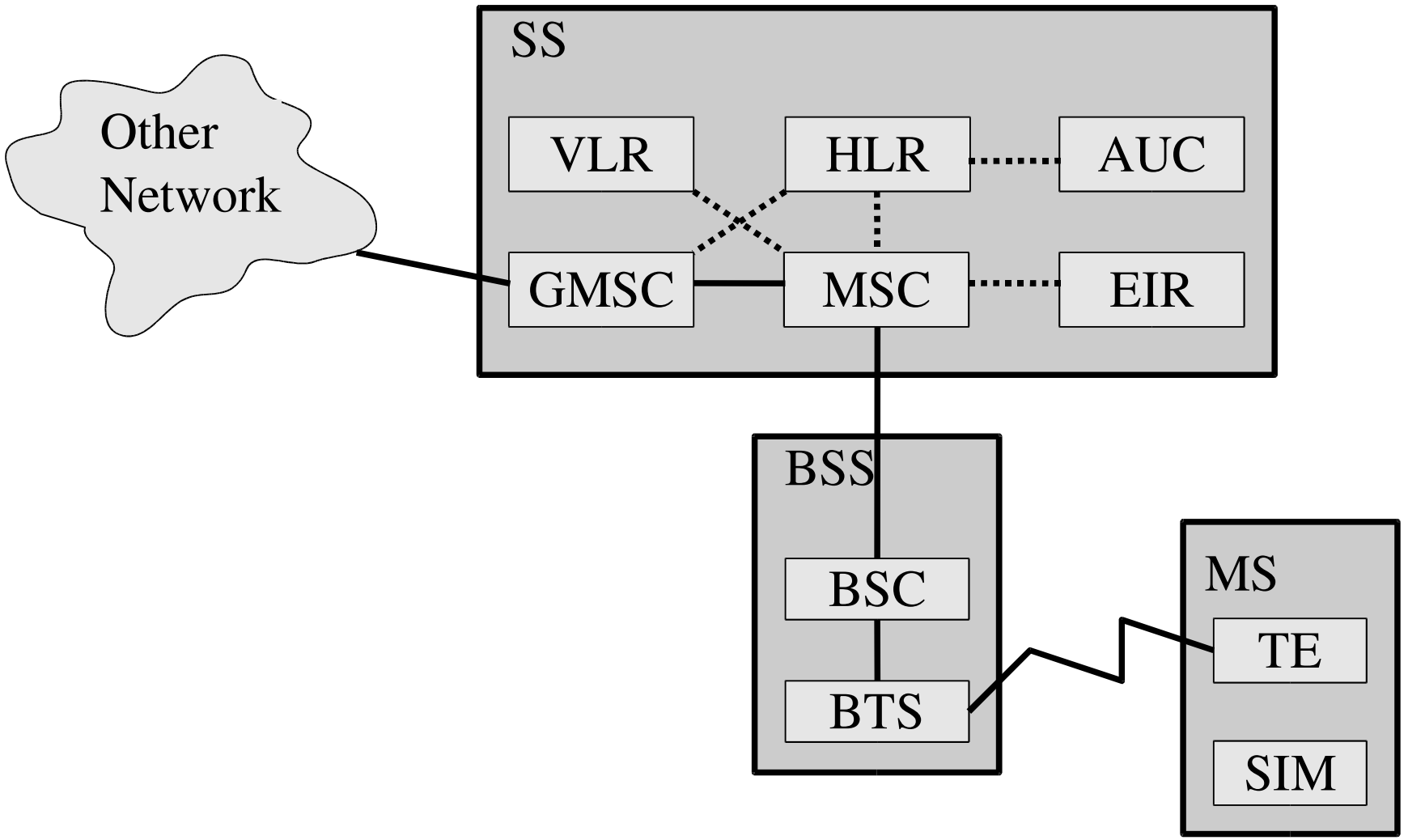
Översikt

- GSM-systemets delar och hur de hänger ihop.
- Paketdata i GSM.
- GPRS som utbyggnad av GSM.
- Paketdata i GPRS.
- Högre datahastigheter: EDGE.

Tre delar

- Mobile Station (MS)
- Base Station System (BSS)
- Switching System (SS)

GSM-systemet



Mobile Station (MS)

- Mobile Equipment (ME)
- Subscriber Identity Module (SIM)
  - Two types: ID-1 and Plug-in SIM
  - Three types of info stored in SIM:
    - Fixed; stored before sold.
    - Temporary network data.
    - Service data.

Fix data i SIM

- IMSI
- Authentication algorithm, A3.
- Subscriber authentication key, Ki.
- Ciphering key generation algorithm, A8.
- Ciphering key, Kc.
- Access control to data/functions.
- PIN, PUK, ...

BSS

- Base Tranceiver Station (BTS)
- Base Station Controller (BSC)

SS

- Mobile services Switching center (MSC)
- Gateway MSC (GMSC)
- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Authentication Center (AUC)
- Equipment Identity Register (EIR)

Area-hierarki i GSM

- GSM Service Area (many countries)
- PLMN Service Area (one per operator)
- MSC Service Area (one per MSC)
- Location Area (a group of cells)
- Cell (area covered by one antenna)

Uppgifter för MSC

- Switching and call routing.
- Charging.
- Service provisioning (e.g. SMS).
- Comminication with HLRs.
- Communication with the VLR.
- Communication with other MSCs.
- Control of BSCs.

Uppgifter för HLR

- Subscription database management.
- Communication with MSCs.
- Communication with GMSCs.
- Communication with AUCs.
- Communication with VLRs.

Uppgifter för VLR

- One per MSC.
- Keeps a copy of data from HLR.
- Keeps track of the LA.
- Keeps track of the status of the MS (e.g. idle).

Uppgifter för AUC

- Provide info to MSC/VLR for authentication, and establishing ciphering on the radio link. Triplet:
  - Non-predictable random number (RAND).
  - Signed RESponse (SRES).
  - Ciphering key (Kc).
- Stores IMSI and Ki (as do MS).

Uppgifter för EIR

- Stores three lists:
  - White list (all allocated equipment ids).
  - Black list (all barred equipment ids).
  - Gray list (faulty/non-approved eqs). (On operator level.)
- MSC asks EIR for access info.
- MSC decides how to use the info.

Frekvenser i GSM

- GSM 400: 460-468/488-496 MHz
- P-GSM 900: 890-915/935-960 MHz
- E-GSM 900: 880-915/925-960 MHz
- GSM 1800: 1710-1785/1805-1880 MHz
- GSM 1900: 1850-1910/1930-1990 MHz
- One carrier each 200 kHz.
  - 40, 125, 175, 375, and 300 radio channels.

Tidsmultiplicitet

- Time Division Multiple Access (TDMA).
- MS1 sends, then MS2, …
- Each time interval is called a Time Slot (TS).
- 8 TS makes one GSM frame.
- Info sent in TS is called a burst.
- 1 TS is 577 μs.

Kanalkodning i GSM

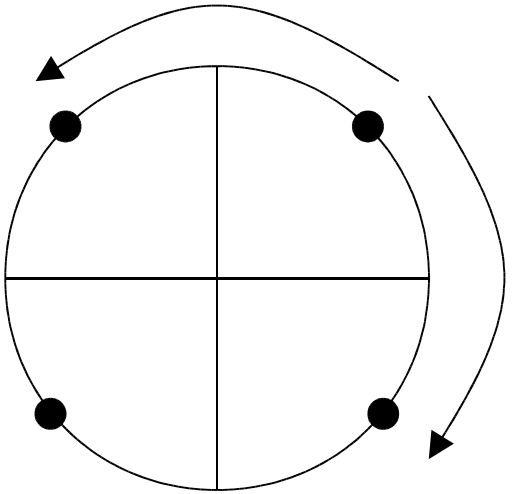
- Speech coder gives 260 bits/20 ms (13 kbit/s).
- Channel coding expands those to 456 bits.
- 260 bits split into 3 blocks:
  - 50 very important bits. Add 3 parity bits.
  - 132 important bits
  - 78 Not so important bits

Kanalkodning, forts.

- The 53 + 132 + 4 tail bits are convolutional coded (1:2) and gives 378 bits.
- Append the 78 ’non-important’: 456 bits.
- Interleaved in 8 blocks à 57 bits.
- Interleave over 2 bursts.
- Ciphering.
- Burst formatting: add tail bits, training sequence.

Modulation

- Gaussian Minimum Shift Keying (GMSK).
- Information in the phase change of the signal.
- $+\pi/2$ means same bit, $-\pi/2$ means other bit.



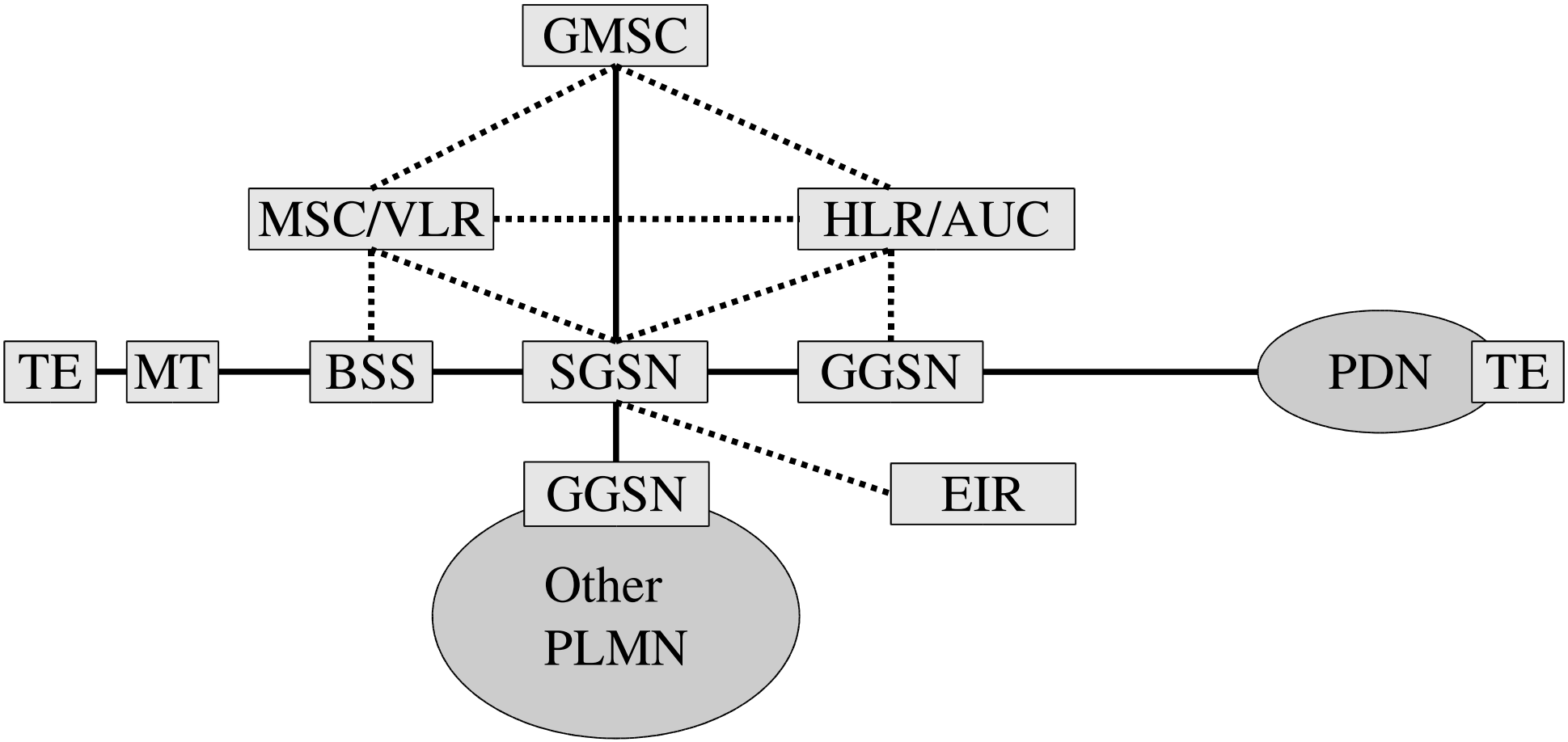
Paketdata i GSM

- High Speed Circuit Switched Data (HSCSD)
- Uses more resources per MS.
- Transparent mode (add error correction bits).
  - 9.6, 19.2, 28.8, 38.4, 48.0, and 57.6 kbit/s
- Non-transparent mode (no error correction bits).
  - 12, 24, 36, 48, 60 and 72 kbit/s

GPRS

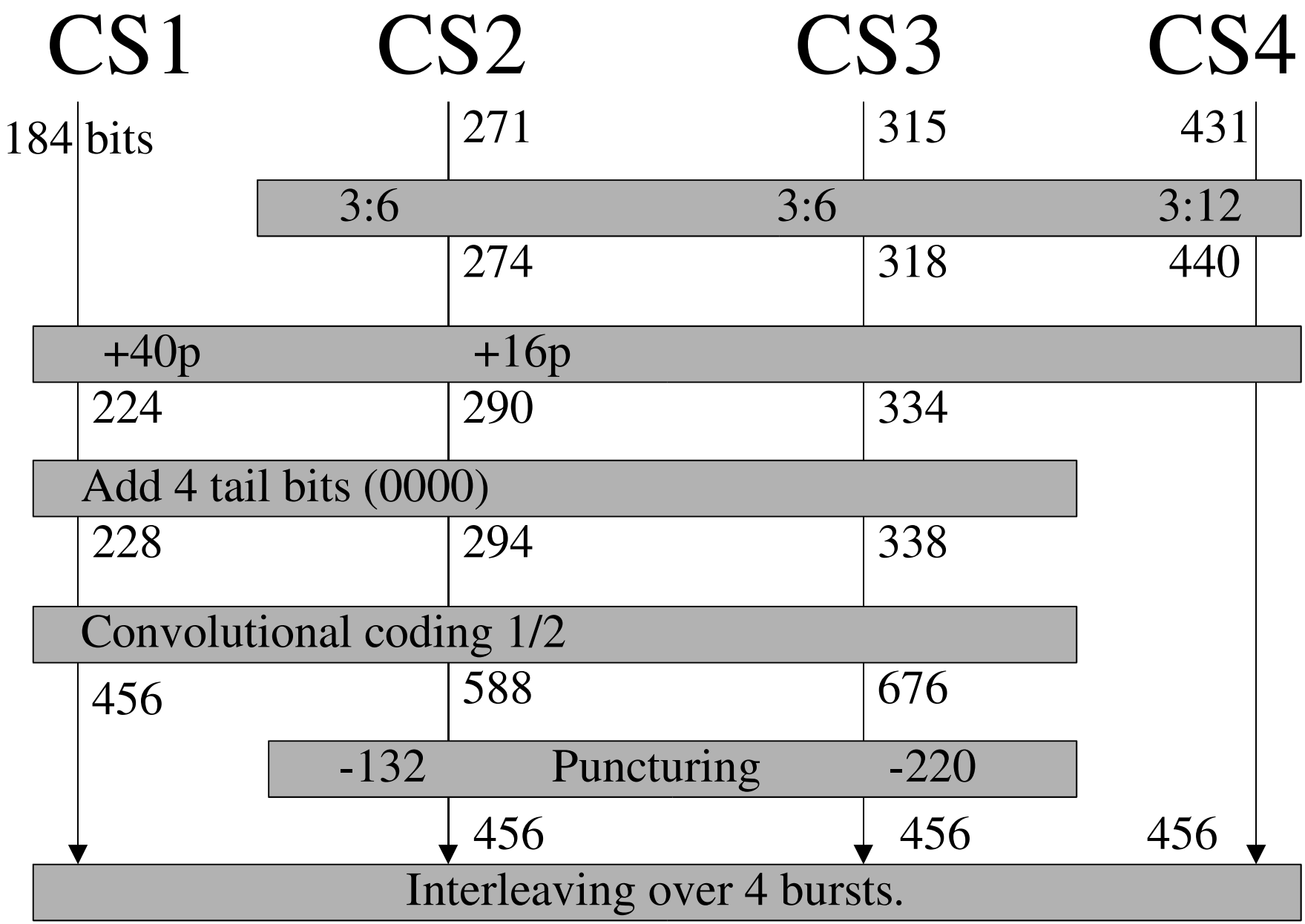
- General Packet Radio Services.
- Extension of GSM.
- New node in SS: GPRS Support Node (GSN).
- Shared TS.
- Other Channel Coding Schemes, CS1-CS4.
- Ciphering not only over the air interface.

GPRS-systemet



Kanalkodning i GPRS

	1 TS	4 TS	8 TS	Needed Channel/Interference
CS1	9.2 kbit/s	36.8	73.6	~ 6 dB
CS2	13.55	54.2	108.4	~ 9 dB
CS3	15.75	63	126	~ 12 dB
CS4	21.55	86.2	172.4	~ 17 dB

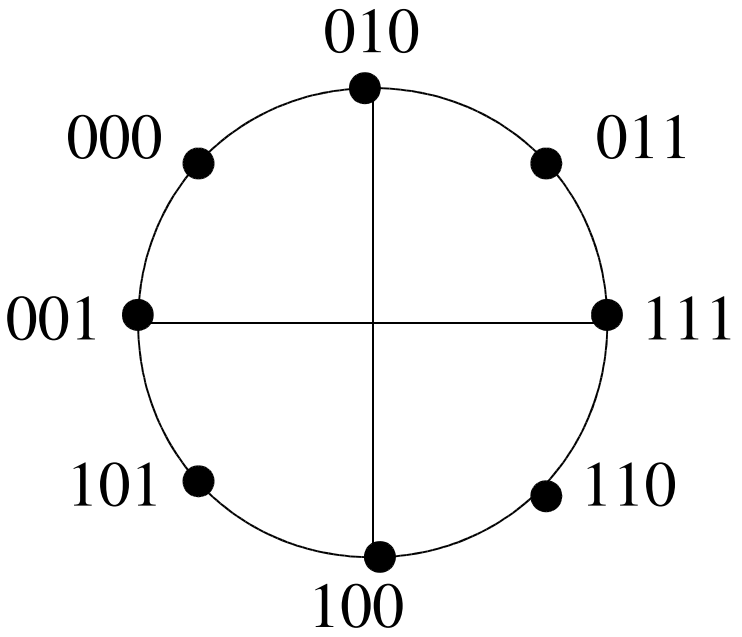

CS1
CS2
CS3
CS4
184 bits
271
315
431
3:6
3:6
3:12
274
318
440
+40p
+16p
224
290
334
Add 4 tail bits (0000)
228
294
338
Convolutional coding 1/2
456
588
676
-132
Puncturing
-220
456
456
456
Interleaving over 4 bursts.

EGPRS

- Enhanced Data rates for Global Evolution (EDGE).
- Other modulation, 8PSK.
- New CSs.
- Link Adaptation.
- Incremental redundancy (IR).

Modulering i EGPRS

- Eight Phase Shift Keying (8PSK)
- 8 points in phase diagram. 3 bits each.
- Rotate $3\pi/8$ between each symbol.



9 CS i EGPRS

- MSC1-MSC4 uses GMSK
- MSC5-MSC9 uses 8PSK.

CS	Mode	1TS	4TS	8TS
MSC1	GMSK	8.8 kbit/s	35.2	70.4
MSC4	GMSK	17.6	70.4	140.8
MSC5	8PSK	22.4	89.6	179.2
MSC9	8PSK	59.2	236.8	473.6

Länkkontroll

- Dynamic change of CS as needed.
- Incremental redundancy as needed.

Förkortningslista

- 8PSK 8 Phase Shift Keying
- A3 Authenication algorithm 3
- A8 Authentication algorithm 8
- AUC AUchentication Center
- BSC Base Station Controller
- BSS Base Station System
- BTS Base Tranceiver Station
- CS Coding Scheme, or Circuit Switched
- E-GSM European GSM
- EDGE Enhanced Data rates for GSM Evolution
- EIR Equipment Identity Register
- GGSN Gateway GSN
- GMSC Gateway MSC
- GMSK Gaussian Minimum Shift Keying
- GPRS General packet Radio Service
- GSM Global System for Mobile communication
- GSN GPRS Support Node

Förkortningslista, forts.

- HLR Home Location Register
- HSCSD High Speed Circuit Switched Data
- IMSI International Mobile Subscriber Identity
- IR Incremental Redundancy
- Kc Ciphering key
- Ki Subscriber authentication key
- LA Location Area
- ME Mobile Equipment
- MS Mobile Station
- MSC Mobile services Switching Center
- P-GSM Pasific GSM
- PDN Public Data Network
- PIN Personal Identity Number
- PLMN Public Land Mobile Network
- PUK PIN Unlock Key
- RAND Random Number

Förkortningslista, forts.

- SGSN Serving GSN
- SIM Subscriber Identity Module
- SMS Short Message Service
- SRES Signed RESponse
- SS Switching System
- TDMA Time Division Multiple Access
- TE Terminal Equipment
- TS Time Slot
- VLR Visitor Location Register