GSM AIR INTERFACE AND PHYSICAL LAYER

LECTURE FOR
TSKS05 KOMMUNIKATIONSSYSTEM CDIO
2012-09-13

ANDREAS BERGSTRÖM
ERICSSON RESEARCH, LINKÖPING
AGENDA

› ABOUT ME
› GSM BASICS
  - GERAN NETWORK OVERVIEW
  - FREQUENCY BANDS
  - GSM LOGICAL CHANNELS
› RADIO NETWORK DEPLOYMENT
  - DIVIDING THE RESOURCES
  - FREQUENCY REUSE CONCEPTS
  - FREQUENCY REUSE PATTERNS
  - OTHER IMPORTANT ASPECTS
› GSM RADIO INTERFACE (UM)
  - RADIO INTERFACE STRUCTURE
  - TDMA FRAME STRUCTURE AND BURST TYPES
  - MAPPING OF LOGICAL TO PHYSICAL CHANNELS
  - RADIO INTERFACE EXAMPLE
› GPRS/EDGE – PACKET DATA IN GSM
  - MODULATION AND CODING SCHEMES
  - EGPRS LINK QUALITY CONTROL
  - GMSK AND 8PSK POWER
› GSM PHYSICAL LAYER
  - TRANSMISSION AND RECEPTION (TX/RX CHAIN)
  - CHANNEL CODING AND INTERLEAVING
  - MODULATION
  - DEMODULATION
  - AIR INTERFACE (UM)
  - DEINTERLEAVING
  - CHANNEL DECODING
› RECENT/FUTURE GSM DEVELOPMENT
  - EDGE EVOLUTION
  - VAMOS
  - OTHER 3GPP ACTIVITIES
› QUESTIONS? COMMENTS?
ABOUT ME
ANDREAS BERGSTRÖM

› Currently at Ericsson Research Linköping since Oct 2011:
  – LTE/LTE-Advanced and beyond…
  – HetNet SON (Self-Optimizing Networks)
  – Simulations, Simulator Development etc.
  – …

› Previously at GSM Systems department at Ericsson 2005-2011:
  – Research, Analysis, Simulations, Simulator development and Standardization.
  – Main topics: GSM Packet Data specifics: EGPRS/EDGE, EDGE Evolution, M2M, smartphone enhancements etc…

› Education:
  – Thesis work at E// Research HT04-VT05 (HSDPA Flow control)
  – …

› Personal:
  – From Sundsvall, now live in Västerlösa.
  – Married, 1 daughter Kerstin (2 years old) + another on the way…

› Hobbies
  – Triathlon - both full-distance Ironman (3.8km swim + 180km bike + 42km run) as well as shorter distances. Also done numerous “Svensk Klassiker”, marathons etc…
  – Also co-founder and president of the local triathlon club (“Linköpings Triathlonklubb”)

Ericsson Internal | 2012-09-09 | Page 3
GSM BASICS

GERAN NETWORK OVERVIEW
FREQUENCY BANDS
GSM LOGICAL CHANNELS
GERAN NETWORK OVERVIEW
(GERAN = GSM/EDGE RADIO ACCESS NETWORK)
GSM FREQUENCY BANDS

<table>
<thead>
<tr>
<th>System</th>
<th>Band</th>
<th>Uplink</th>
<th>Downlink</th>
<th>Channel Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM 400</td>
<td>450</td>
<td>450.4 - 457.6</td>
<td>460.4 - 467.6</td>
<td>259 - 293</td>
</tr>
<tr>
<td>GSM 400</td>
<td>480</td>
<td>478.8 - 486.0</td>
<td>488.8 - 496.0</td>
<td>306 - 340</td>
</tr>
<tr>
<td>GSM 850</td>
<td>850</td>
<td>824.2 - 849.0</td>
<td>869.2 - 894.0</td>
<td>128 - 251</td>
</tr>
<tr>
<td>GSM 900 (P-GSM)</td>
<td>900</td>
<td>890.0 - 915.0</td>
<td>935.0 - 960.0</td>
<td>1 - 124</td>
</tr>
<tr>
<td>GSM 900 (E-GSM)</td>
<td>900</td>
<td>880.0 - 915.0</td>
<td>925.0 - 960.0</td>
<td>0 - 124, 975 - 1023</td>
</tr>
<tr>
<td>GSM-R (R-GSM)</td>
<td>900</td>
<td>876.0 - 880.0</td>
<td>921.0 - 925.0</td>
<td>955 - 973</td>
</tr>
<tr>
<td>DCS 1800</td>
<td>1800</td>
<td>1,710.0 - 1,785.0</td>
<td>1,805.0 - 1,880.0</td>
<td>512 - 885</td>
</tr>
<tr>
<td>PCS 1900</td>
<td>1900</td>
<td>1,850.2 - 1,910.0</td>
<td>1,930.2 - 1,990.0</td>
<td>512 - 810</td>
</tr>
</tbody>
</table>
GSM LOGICAL CHANNELS
- DIVIDING THE RESOURCES
- FREQUENCY REUSE CONCEPTS
- FREQUENCY REUSE PATTERNS
- OTHER IMPORTANT ASPECTS
DIVIDING THE RESOURCES

› Among operators
  – Done by dividing the spectrum.

› Duplex communication
  – Half/Full Duplex, TDD/FDD

› Multiple access
  – FDMA, TDMA, CDMA, SDMA, …

› Cellular planning
  – Neighbouring cells can not use the same resources. Or can they? 😊
**Frequency Reuse Concepts**

**Frequency reuse** = Using same frequencies in different cells separated by “sufficient” distance to cause minimal interference with each other. The frequency reuse possible is dependent on many factors such as real world propagation environment, technology etc.

**Frequency plan** = Assignment of radio frequencies to radio transmission sites (cell sites) that are located within a defined geographic area. The frequency plan may use ratios that are different dependent on the number of transmitting sites to the number of antennas (sectors) on each site.
In GSM typically $k = 3, 7$ or $12$. 
FREQUENCY REUSE PATTERNS (2/3)

› In the GSM 900-band (2x25MHz wide), we can have 124 carriers á 200kHz.
› Diving these into groups of 12 frequencies gives 10 such groups where one cell can thus be covered by 10 carriers where each carrier can have 8 TDMA timeslots. Hence in total 80 Timeslots = e.g. 80 FR CS calls.
› These resources need to be shared between operators on this band.

4/12 reuse pattern

• Four base stations.
• Each base station has three antennas and serve three cells.
• In total 12 frequencies.
• Note: the base station is located in the intersection of three hexagons.
FREQUENCY REUSE PATTERNS (3/3)

<Cluster Size> x <Sectors per Site>

Loose (4x3) Frequency Reuse Pattern for BCCH (giving less interference and capacity)

Tighter (3x3) Frequency Reuse Pattern for TCH (giving more interference and capacity)
OTHER IMPORTANT ASPECTS

› Frequency Hopping

› Power Control
GSM RADIO INTERFACE (UM)

RADIO INTERFACE STRUCTURE
TDMA FRAME STRUCTURE AND BURST TYPES
MAPPING OF LOGICAL TO PHYSICAL CHANNELS
RADIO INTERFACE EXAMPLE
Radio Interface Structure

Multiple Access: TDMA+FDMA  Duplex: FDD (+TDD)

Time

Frequency

- TDMA frame
- 200 kHz carrier

Downlink

Uplink

960
925
915
880
TDMA FRAME STRUCTURE AND BURST TYPES

1 hyperframe = 2048 superframes = 2715 648 TDMA frames (3 h 28 min 53 s 700 ms)

1 superframe = 1 326 TDMA frames (6.12 s)

1 (25-frame) multiframe = 25 TDMA frames (130 ms)

1 (51-frame) multiframe = 51 TDMA frames (3060/13 ms)

1 TDMA frame = 8 time slots (13208 s or 4.615 ms)

1 time slot = 156.25 symbol durations (15.26 or 0.577 ms)

(TB: Tail bits - GP: Guard period)

Normal burst (NB)

<table>
<thead>
<tr>
<th>TE</th>
<th>Encrypted bits</th>
<th>Training sequence</th>
<th>Encrypted bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>53</td>
<td>26</td>
<td>56</td>
</tr>
</tbody>
</table>

Frequency correction burst (FB)

<table>
<thead>
<tr>
<th>TE</th>
<th>Fixed bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>142</td>
</tr>
</tbody>
</table>

Synchronization burst (SB)

<table>
<thead>
<tr>
<th>TE</th>
<th>Encrypted bits</th>
<th>Synchronization sequence</th>
<th>Encrypted bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>39</td>
<td>64</td>
<td>39</td>
</tr>
</tbody>
</table>

Access burst (AB)

<table>
<thead>
<tr>
<th>TB</th>
<th>Synchronization sequence</th>
<th>Encrypted bits</th>
<th>TE</th>
<th>GP</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>41</td>
<td>38</td>
<td>3</td>
<td>66.25</td>
</tr>
</tbody>
</table>

Ericsson Internal | 2012-09-09 | Page 17
MAPPING OF LOGICAL TO PHYSICAL CHANNELS

26-TDMA Multiframe Example (TCH+SACCH)

51-TDMA Multiframe Example (CCCH)
RADIO INTERFACE EXAMPLE (1/4)
SPEECH CHANNEL (NOTE TDD STRUCTURE)

TDMA frame

200 kHz carrier

Time

Frequency
RADIO INTERFACE EXAMPLE (3/4)
PACKET DATA CHANNEL (2+3)

<table>
<thead>
<tr>
<th>Time</th>
<th>Frequency</th>
<th>TDMA frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>880</td>
<td>915</td>
<td>925</td>
</tr>
<tr>
<td>960</td>
<td>200 kHz carrier</td>
<td></td>
</tr>
</tbody>
</table>

200 kHz carrier
Radio interface example (4/4)
Packet data channel (8+8)

Time

Frequency

TDMA frame

200 kHz carrier

Uplink

Downlink
(E)GPRS/EDGE
PACKET DATA IN GSM

MODULATION AND CODING SCHEMES
EGPRS LINK QUALITY CONTROL
GMSK AND 8PSK POWER
MODULATION AND CODING SCHEMES

› The radio block is the basic unit of transmission
› Channel coding/interleaving over one radio block
› Nine modulation/coding schemes (MCS) defined

<table>
<thead>
<tr>
<th>GPRS Coding scheme</th>
<th>Speed (kbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS-1</td>
<td>8.0</td>
</tr>
<tr>
<td>CS-2</td>
<td>12.0</td>
</tr>
<tr>
<td>CS-3</td>
<td>14.4</td>
</tr>
<tr>
<td>CS-4</td>
<td>20.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EDGE Coding and modulation scheme (MCS)</th>
<th>Bit Rate (kbit/s/slot)</th>
<th>Modulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCS-1</td>
<td>8.00</td>
<td>GM8K</td>
</tr>
<tr>
<td>MCS-2</td>
<td>11.2</td>
<td>GM8K</td>
</tr>
<tr>
<td>MCS-3</td>
<td>14.8</td>
<td>GM8K</td>
</tr>
<tr>
<td>MCS-4</td>
<td>17.6</td>
<td>GM8K</td>
</tr>
<tr>
<td>MCS-5</td>
<td>22.4</td>
<td>8-PSK</td>
</tr>
<tr>
<td>MCS-6</td>
<td>29.6</td>
<td>8-PSK</td>
</tr>
<tr>
<td>MCS-7</td>
<td>43.8</td>
<td>8-PSK</td>
</tr>
<tr>
<td>MCS-8</td>
<td>54.4</td>
<td>8-PSK</td>
</tr>
<tr>
<td>MCS-9</td>
<td>59.2</td>
<td>8-PSK</td>
</tr>
</tbody>
</table>
EGPRS LINK QUALITY CONTROL

› Link Adaptation (LA)
  – Extensive set of modulation and coding schemes
› Incremental Redundancy (IR)
  – Code combining of transmission attempts
› LA and IR can be combined
GMSK AND 8PSK POWER

Average power reduction:
- 0 dB
- -2 dB
- -3.3 dB
- -4 dB
- -6 dB

GMSK:
- P0
- P1
- P2
- P3

8PSK:
- P0, P1
- P2
- P3

Peaks up to 3.3 dB higher
GSM PHYSICAL LAYER

TRANSMISSION AND RECEPTION (TX/RX CHAIN)
CHANNEL CODING AND INTERLEAVING
 MODULATION
 DEMODULATION
 DEINTERLEAVING
 CHANNEL DECODING
TRANSMISSION AND RECEPTION (TX/RX CHAIN)

From Higher Protocols

Binary data for Transmission

Channel Encoder

Interleaver Data+Header

Modulator Burst Mapping Insertion of TS

Tx pulse shaping

Radio transmitter

Radio channel

digital analog

RF

To Higher Protocols

Received Binary data

Channel Decoder

De-Interleaver

Eq./Demod

Rx filter

Radio receiver

Ch. Est

0 1 0 ...

20.34, 9.54, ...

20.34, -15.65, -34.32, ...

20.34, 9.54, ...

0 1 0 ...

0 > 0 0 > 0

0 0 1 1 0 0 ...

0 1 1 0 ...

0 0 1 1 0 0..

0 1 1 0..

0 0 1 1 0 0..

0 1 1 0..
Uncoded bits are coded in the channel encoder.
In EGPRS a 1/3 convolutional code is used (EGPRS2 DL uses a Turbo Encoder).

To reach the desired code rate of the MCS used, the code word is punctured

The punctured code word is interleaved to avoid bursty errors at the receiver.
The modulation consists of
- Modulating the bits onto symbols
- Modulating the symbols onto a transmit pulse

Possible modulations:
- For GSM/GPRS: GMSK
- For EGPRS/EDGE: GMSK and 8PSK
- For EGPRS2: GMSK, QPSK, 8PSK, 16QAM, 32QAM (see later slide)

\[
\begin{align*}
s_1 &= I_1 + Q_1 j \\
s_2 &= I_2 + Q_2 j \\
s_3 &= I_3 + Q_3 j
\end{align*}
\]
Pulse modulation

- To transmit the information over the air interface and keep it within the carrier spectrum mask, a transmit pulse is needed.
See earlier slides.... 😊
The demodulation consist of two major tasks:
1. Channel estimation
2. Signal demodulation

The channel estimator uses the known training sequence code (TSC) to estimate the channel.

The demodulator returns soft bit values. The larger absolute value, the larger confident from the demodulator.
The deinterleaver performs the reverse operation of the interleaver.

The quality of the code word is spread out.

<table>
<thead>
<tr>
<th>Bin</th>
<th>Soft value sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>+</td>
</tr>
</tbody>
</table>

\[ \text{mod}(3k,9)^{-1} \]

The quality of the code word is spread out.
The soft bits are depunctured with the same puncturing scheme used in the transmitter.

A Viterbi decoder is used in the decoding.

0s (= no confidence on whether it's a 0 or 1) is inserted in the punctured bit positions as soft value.

In case Incremental Redundancy, IR, is used, the soft values are combined before Viterbi decoding.
RECENT/FUTURE GSM DEVELOPMENT

- EDGE EVOLUTION
- VAMOS
- OTHER 3GPP ACTIVITIES
EDGE EVOLUTION (1/7)

Dual-antenna terminals

10 ms TTI

Fast Ack/Nack

3 - 8 dB link improvement

80 ms e2e latency

16/32-QAM & Turbo codes DL

&

100 kbps per timeslot

80 kbps per timeslot

100 kbps per timeslot

+20% bitrate per carrier/timeslot

Higher symbol rate UL/DL

Dual carrier DL

1.0 Mbps

with 32QAM & 10 TS

16-QAM UL

32-QAM UL

EGPRS 2 (Next Slides...)

16-QAM UL

&

80 kbps per timeslot

32-QAM UL

&
**EDGE EVOLUTION (2/7)**
**EGPRS2 CODING SCHEMES UPLINK**

- **Level A:** Adding 16QAM
- **Level B:** Adding 16QAM+32QAM+Higher symbol rate

### Uplink Level A

<table>
<thead>
<tr>
<th>MCS</th>
<th>Modulation</th>
<th>Bitrate (kbps)</th>
<th>Symbol Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAS-11</td>
<td>16QAM</td>
<td>76.8</td>
<td>NSR</td>
</tr>
<tr>
<td>UAS-10</td>
<td>16QAM</td>
<td>67.2</td>
<td></td>
</tr>
<tr>
<td>UAS-9</td>
<td>16QAM</td>
<td>59.2</td>
<td></td>
</tr>
<tr>
<td>UAS-8</td>
<td>16QAM</td>
<td>51.2</td>
<td></td>
</tr>
<tr>
<td>UAS-7</td>
<td>16QAM</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>MCS-6</td>
<td>8PSK</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>MCS-5</td>
<td>8PSK</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>MCS-4</td>
<td>GMSK</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td>MCS-3</td>
<td>GMSK</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>MCS-2</td>
<td>GMSK</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>MCS-1</td>
<td>GMSK</td>
<td>8.8</td>
<td></td>
</tr>
</tbody>
</table>

### Uplink Level B

<table>
<thead>
<tr>
<th>MCS</th>
<th>Modulation</th>
<th>Bitrate (kbps)</th>
<th>Symbol Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBS-12</td>
<td>32QAM</td>
<td>118.4</td>
<td>NSR</td>
</tr>
<tr>
<td>UBS-11</td>
<td>32QAM</td>
<td>108.8</td>
<td></td>
</tr>
<tr>
<td>UBS-10</td>
<td>32QAM</td>
<td>88.8</td>
<td></td>
</tr>
<tr>
<td>UBS-9</td>
<td>16QAM</td>
<td>67.2</td>
<td>HSR</td>
</tr>
<tr>
<td>UBS-8</td>
<td>16QAM</td>
<td>59.2</td>
<td></td>
</tr>
<tr>
<td>UBS-7</td>
<td>16QAM</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>UBS-6</td>
<td>QPSK</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>UBS-5</td>
<td>QPSK</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>MCS-4</td>
<td>GMSK</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td>MCS-3</td>
<td>GMSK</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>MCS-2</td>
<td>GMSK</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>MCS-1</td>
<td>GMSK</td>
<td>8.8</td>
<td></td>
</tr>
</tbody>
</table>
**EDGE EVOLUTION (3/7)**

**EGPRS2 CODING SCHEMES DOWNLINK**

**Level A:** Adding 16QAM+32QAM+turbo codes

**Level B:** Adding QPSK+16QAM+32QAM+turbo codes+Higher symbol rate

---

### Downlink Level A

<table>
<thead>
<tr>
<th>MCS</th>
<th>Modulation</th>
<th>Bitrate (kbps)</th>
<th>Symbol Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAS-12</td>
<td>32QAM</td>
<td>98.4</td>
<td></td>
</tr>
<tr>
<td>DAS-11</td>
<td>32QAM</td>
<td>81.6</td>
<td></td>
</tr>
<tr>
<td>DAS-10</td>
<td>32QAM</td>
<td>65.6</td>
<td></td>
</tr>
<tr>
<td>DAS-9</td>
<td>16QAM</td>
<td>54.4</td>
<td></td>
</tr>
<tr>
<td>DAS-8</td>
<td>16QAM</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>DAS-7</td>
<td>8PSK</td>
<td>32.8</td>
<td></td>
</tr>
<tr>
<td>DAS-6</td>
<td>8PSK</td>
<td>27.2</td>
<td></td>
</tr>
<tr>
<td>DAS-5</td>
<td>8PSK</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>MCS-4</td>
<td>GMSK</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td>MCS-3</td>
<td>GMSK</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>MCS-2</td>
<td>GMSK</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>MCS-1</td>
<td>GMSK</td>
<td>8.8</td>
<td></td>
</tr>
</tbody>
</table>

### Downlink Level B

<table>
<thead>
<tr>
<th>MCS</th>
<th>Modulation</th>
<th>Bitrate (kbps)</th>
<th>Symbol Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBS-12</td>
<td>32QAM</td>
<td>118.4</td>
<td></td>
</tr>
<tr>
<td>DBS-11</td>
<td>32QAM</td>
<td>108.8</td>
<td></td>
</tr>
<tr>
<td>DBS-10</td>
<td>32QAM</td>
<td>88.8</td>
<td></td>
</tr>
<tr>
<td>DBS-9</td>
<td>16QAM</td>
<td>67.2</td>
<td></td>
</tr>
<tr>
<td>DBS-8</td>
<td>16QAM</td>
<td>59.2</td>
<td></td>
</tr>
<tr>
<td>DBS-7</td>
<td>16QAM</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>DBS-6</td>
<td>QPSK</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>DBS-5</td>
<td>QPSK</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>MCS-4</td>
<td>GMSK</td>
<td>17.6</td>
<td></td>
</tr>
<tr>
<td>MCS-3</td>
<td>GMSK</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>MCS-2</td>
<td>GMSK</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>MCS-1</td>
<td>GMSK</td>
<td>8.8</td>
<td></td>
</tr>
</tbody>
</table>
EDGE EVOLUTION (4/7) EGPRS2 LINK PERFORMANCE

DOWNLINK THROUGHPUT PER TIMESLOT (NO IRC/MSRD)  

Downlink, no IRC

Radio Link Bitrate (kbps)

C/I

EGPRS
EGPRS2-A
EGPRS2-B

egfrsmInternal | 2012-09-09 | Page 40
Detta är fyra figurer som man vill jämföra, tror du inte det blir bättre att ha dem i en 2x2 ruta?
EDGE EVOLUTION (5/7)

EGPRS2 LINK PERFORMANCE

DOWNLINK THROUGHPUT PER TIMESLOT (WITH IRC/MSRD)

Downlink, with IRC

Radio Link Bitrate (kbps)

C/I

EGPRS
EGPRS2-A
EGPRS2-B
EGPRS2 Link Performance

Uplink Throughput per Timeslot (No IRC)

Uplink, no IRC

Radio Link Bitrate (kbps)

C/I

EGPRS
EGPRS2-A
EGPRS2-B
EDGE EVOLUTION (7/7)

EGPRS2 LINK PERFORMANCE

UPLINK THROUGHPUT PER TIMESLOT (WITH IRC)

Uplink with IRC

Radio Link Bitrate (kbps)

C/I

EGPRS
EGPRS2-A
EGPRS2-B
VAMOS (VOICE SERVICES OVER ADAPTIVE MULTI-USER CHANNELS ON ONE SLOT)

Full rate (FR), half rate (HR), VAMOS FR (VFR) and VAMOS HR (VHR) allocations on a single time slot.

VAMOS downlink air interface. The RBS is transmitting a single AQPSK modulated signal to a pair of VAMOS mobiles.

VAMOS uplink air interface. Two mobiles simultaneously transmit GMSK modulated signals on the same carrier frequency.

Two examples of the AQPSK constellation. The subchannel power distribution is illustrated by the length of the colored vectors.

Cell capacity as a function of the number of TCH TRXs.
OTHER 3GPP ACTIVITIES
(AFFECTING THE GSM UM)

› M2M/Smartphone improvements:
  – Handle more users with smaller transactions per user.
› Introduction of OFDM in GSM
  – A.k.a SPEED – Single Precoded Enhanced EGPRS Downlink
› Multi-Carrier Downlink
  – Up to 4 carriers in DL to one UE
› MIMO for GSM
› …
QUESTIONS?
COMMENTS?