Radio Network Dimensioning for GSM/GPRS Supporting Circuit- and Packet-Switched Services

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Structure

- the problem
- coexisting circuit-switched traffic
- dimensioning rules for fixed PDCH configurations
- dimensioning rules for on-demand PDCH configurations
- configurations with fixed and on-demand PDCHs
Motivation

- radio network dimensioning demands the relationship between
  - offered traffic predicted by operator
  - QoS desired by operator for his clients
  - radio resources needed (number of PDCHs and TRX)
- analytical complexity caused by
  - radio channel attributes
  - bursty traffic (no Erlang-B-formula like in CS)
- system complexity – no test bench or field trials with complete protocol software and hardware components available
- solution: computer simulation of the system that models
  - system components and their protocols
  - traffic sources
  - radio channel
Capacity planning and radio network dimensioning

- relationship between
  - offered traffic
  - QoS desired
  - radio resources needed

Diagram:
- Traffic
  - Simulation model
  - Analytical model
- QoS
  - Capacity model
  - Erlang table
  - Erlang Formula
  - Radio network dimensioning
# Measures and methodology

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<th>term</th>
<th>circuit-switched</th>
<th>packet-switched</th>
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<td>traffic</td>
<td>offered traffic in Erlang</td>
<td>offered amount of data per time in kbit/s</td>
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<td>QoS parameter</td>
<td>blocking probability (GoS)</td>
<td>throughput, delay,...</td>
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<td>packet data channels</td>
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Simulation Environment (E)GPRSim
Dimensioning rules for fixed-PDCH scenarios (I)

**downlink IP throughput over offered traffic**

![Graph showing downlink IP throughput over offered traffic for different numbers of fixed PDCH.](image)

**Dimensioning Graph**

![Graph showing the dimensioning graph for different numbers of fixed PDCH.](image)
Dimensioning rules for fixed-PDCH scenarios (II)

- define the desired QoS
- estimate the number of users per cell
- estimate the offered traffic per user
- calculate the total offered traffic per cell
- determine the acceptable traffic per PDCH with the desired QoS from the dimensioning graph
- calculate the needed number of PDCHs
- PDCH = estimated offered traffic / acceptable traffic per PDCH
Example

- define the desired QoS
  - example value: 12.5 kbit/s is desired

- estimate the number of users per cell
  - example value: 10 users with 540 kbyte/h per user

- calculate the offered traffic per user and the offered traffic per cell
  - offered traffic per user = 540 kbyte/h = 1.2 kbit/s
  - total offered traffic per cell = 12 kbit/s

- take the acceptable traffic per PDCH from the reference graph
  - acceptable traffic per PDCH = 3.5 kbit/s/PDCH
  - PDCH = 3.4
  - 4 PDCHs have to be allocated for GPRS
Radio resource management

- on-demand assignment of PDCHs for GPRS
- voice connections are prioritized

Diagram:
- TCH release
- TCH shift
- Maximum number of on-demand PDCHs
- Maximum number of fixed PDCHs
- TCHs allocated for CS
- TCHs allocated for GPRS
- Transition
Circuit switched traffic

- radio network dimensioned for voice services with blocking probability of e.g. 1 % (blocking probability = Grade of Service (GoS))
- unutilized resources can be used for GPRS
GPRS performance with coexisting CS traffic (I)

**downlink IP throughput per user**

![Graph showing downlink IP throughput per user with different fixed PDCH configurations.](image1)

**downlink IP packet delay**

![Graph showing downlink IP packet delay with different fixed PDCH configurations.](image2)
GPRS performance with coexisting CS traffic (II)

**-downlink PDCHs assigned (average)**

**-downlink PDCH utilization**

- Downlink PDCHs assigned (average)
- Downlink PDCH utilization

- Offered IP traffic [kbit/s]
- Offered IP traffic offer [kbit/s]

- 0 fixed PDCH
- 1 fixed PDCH
- 2 fixed PDCH

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Dimensioning rules for on-demand-PDCH scenarios

- Simulation results show that the shared use of GSM physical channels both for CS and GPRS makes sense.
- Dimensioning rules for on-demand-PDCH scenarios are needed.
- The aim is to take an existing TRX scenario as the basis and find the acceptable CS traffic so that the desired GPRS performance can be achieved.
- If the predicted offered traffic is exceeded a new TRX module should be added to the base station.
- In the following an example is given for a 3 TRX scenario.
Example: 3 TRX scenario (I)

**Example values**

- offered CS traffic with 1.5 % GoS
- 10 GPRS users per cell
- 540 kbyte/h offered per user
- desired QoS of 12.5 kbit/s
Example: 3 TRX scenario (II)

- calculate the offered traffic per cell
  - total offered traffic per cell = 10 * 540 byte/h = 12 kbit/s

- regard the operating point $p$ defined by the desired user performance on the y-axis and the offered traffic per cell on the x-axis and choose the adequate GoS curve as the next that lies above the operating point
  - $p = (x = 12 \text{ kbit/s}, y = 12.5 \text{ kbit/s})$

- if the offered CS traffic corresponding to the GoS is predicted to be exceeded, a new TRX should be added
  - the operating point $p$ lies just below the 2% GoS curve
  - coexisting CS traffic up to 2% GoS is acceptable
  - since 1.5% GoS was assumed an additional TRX is not necessary in this cell
Mixed configurations

- to be able to guarantee the availability of GPRS, operators might provide fixed PDCHs and the rest as on-demand PDCHs
- in this case simple estimations can be done:
  - scenarios with 1, 2 or 3 fixed PDCHs: take pure on-demand configurations for dimensioning (probability that the first PDCHs are used by CS is low)
  - scenarios with more than 3 fixed PDCHs: take a pure fixed PDCH configuration for dimensioning (probability that the on-demand PDCHs are used by CS is high)
Conclusions

- fixed PDCH configurations can be dimensioned with one simple dimensioning graph
- on-demand PDCH configurations are recommended, since not all physical channels are highly utilized by CS
- dimensioning of on-demand PDCHs can be done by taking dimensioning graphs for the regarded TRX scenario as the basis
- for mixed scenarios with both fixed and on-demand PDCHs simple estimations can be done and pure fixed or pure on-demand dimensioning rules can be applied