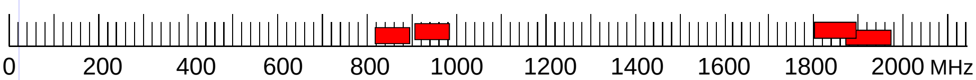
# Dimensioning, configuration and deployment of Radio Access Networks.

## Lecture 2.1: Voice in GSM

## GSM

- Specified by ETSI
- Frequency Division Duplex
- TDMA system
- Originally at 900MHz, but today also at 800, 1800, 1900 and some other bands world wide



## Basic Frame Structure

•Symbol rate 271 kbps 

•8 time slots / channel


•1 time slot / cell used for signaling (BCCH)

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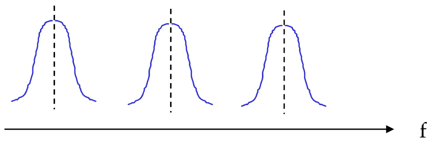
## RF Parameters

- Radio Channels with 200 kHz radio bandwidth
- Note that the channel is allways overlapping the adjacent one

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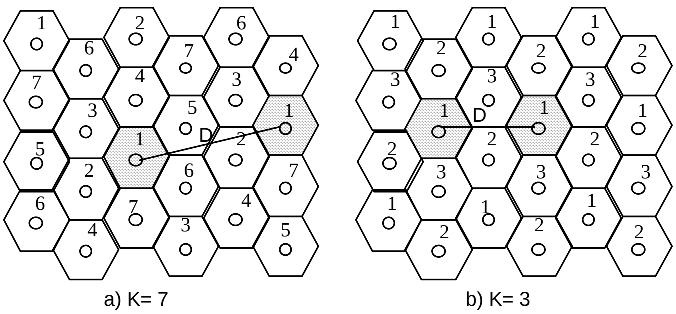
# Cell planning

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# Traffic

An *Erlang* is a unit of telecommunications traffic measurement. Strictly speaking, an Erlang represents the continuous use of one voice path. In practice, it is used to describe the total traffic volume of one hour.

Example, if a group of user made 30 calls in one hour, and each call had an average call duration of 5 minutes, then the number of Erlangs this represents is worked out as follows:

Minutes of traffic in the hour = number of calls x duration

Minutes of traffic in the hour = 30 x 5 = 150

Hours of traffic in the hour = 150 / 60 = 2.5

**Traffic figure= 2.5 Erlangs**

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## Trunking

Erlang traffic measurements are made in order to help telecommunications network designers understand traffic patterns within their voice networks. This is essential if they are to successfully design their network topology and establish the necessary trunk group sizes. The more efficient the existing lines are used the higher the Trunking Efficiency is of the network

## Erlang B

Several traffic models exist which share their name with the Erlang unit of traffic. They are formulae which can be used to estimate the number of lines required in a network, or to a central office (PSTN exchange lines).

Erlang B is the most commonly used traffic model, and is used to work out how many lines are required if the traffic figure (in Erlangs) during the busiest hour and the number of blocked calls are known. The model assumes that all blocked calls are immediately cleared.

http://www.erlang.com/calculator/erlb/

# Erlang B Table

## Erlang B Traffic Table

Maximum Offered Load Versus B and N
B is in %

| N/B | 0.01 | 0.05 | 0.1 | 0.5 | 1.0 | 2 | 5 | 10 | 15 | 20 | 30 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .0001 | .0005 | .0010 | .0050 | .0101 | .0204 | .0526 | .1111 | .1765 | .2500 | .4286 | .6667 |
| 2 | .0142 | .0321 | .0458 | .1054 | .1526 | .2235 | .3813 | .5954 | .7962 | 1.000 | 1.449 | 2.000 |
| 3 | .0868 | .1517 | .1938 | .3490 | .4555 | .6022 | .8994 | 1.271 | 1.603 | 1.930 | 2.633 | 3.480 |
| 4 | .2347 | .3624 | .4393 | .7012 | .8694 | 1.092 | 1.525 | 2.045 | 2.501 | 2.945 | 3.891 | 5.021 |
| 5 | .4520 | .6486 | .7621 | 1.132 | 1.361 | 1.657 | 2.219 | 2.881 | 3.454 | 4.010 | 5.189 | 6.596 |
| 6 | .7282 | .9957 | 1.146 | 1.622 | 1.909 | 2.276 | 2.960 | 3.758 | 4.445 | 5.109 | 6.514 | 8.191 |
| 7 | 1.054 | 1.392 | 1.579 | 2.158 | 2.501 | 2.935 | 3.738 | 4.666 | 5.461 | 6.230 | 7.856 | 9.800 |
| 8 | 1.422 | 1.830 | 2.051 | 2.730 | 3.128 | 3.627 | 4.543 | 5.597 | 6.498 | 7.369 | 9.213 | 11.42 |
| 9 | 1.826 | 2.302 | 2.558 | 3.333 | 3.783 | 4.345 | 5.370 | 6.546 | 7.551 | 8.522 | 10.58 | 13.05 |
| 10 | 2.260 | 2.803 | 3.092 | 3.961 | 4.461 | 5.084 | 6.216 | 7.511 | 8.616 | 9.685 | 11.95 | 14.68 |
| 11 | 2.722 | 3.329 | 3.651 | 4.610 | 5.160 | 5.842 | 7.076 | 8.487 | 9.691 | 10.86 | 13.33 | 16.31 |
| 12 | 3.207 | 3.878 | 4.231 | 5.279 | 5.876 | 6.615 | 7.950 | 9.474 | 10.78 | 12.04 | 14.72 | 17.95 |

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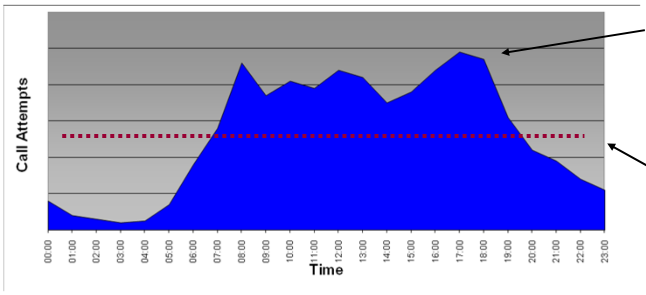
# Network Traffic Load




**Network Capital requirements are a function of peak demand**

**Service Revenues are a function of average demand**

30mErlang is the statistical traffic per subscriber in busy hour.
Minutes of use is the sum of all traffic, i.e the blue area

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## Blocking in Celular systems

- Typically we plan the voice capacity of our mobile phone systems for 2% blocking rate (98% availability)
- This is far worse than the typical 99.999% availability we plan our fixed line networks for.
- For data there is no QoS measure.

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## GSM Capacity

(static channel Allocation)

If we now look at a very simple GSM network with static channel allocation 5MHz of spectrum we find that:

- 5MHz divided over 200kHz per radio channel may gives us 25 carriers.
- With a reuse factor of 3 and if we make a simple approximation and neglect control channels we get:
  - 25 carriers /site => 8,33 carriers /sector => 8 carriers/sector

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# GSM Capacity

(static channel allocation)

What is then the total capacity per sector?

- 8 carriers per sector
- 8*8-1=63 traffic channels per sector/cell
- 2% blocking
- 52 Erlangs/sector (cell)

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# Exercise 1

In the year 2000 the American operator AT&T decided to swap its IS-136 TDMA system for GSM. The reason for this was twofold: the benefits of scale using GSM handsets and the need for additional capacity.

At the time AT&T had 10MHz of spectrum in the 800-band. IS-136 was a TDMA system using radio channels 30 kHz wide with 3 time slots each. The system used a cell plan with a reuse of 7.

- Approximately, how many base stations would AT&T have needed in order cover the capacity need in NY City if the regulator FCC would have allowed a maximum blocking rate of 2%?
- Approximately, how many base stations would they have needed if they had used GSM instead with a reuse of 3?

NY city is approximately 116 km2 and the population around 8 million. AT&T had in the year 2000 around 10% penetration. Each user is supposed to load the system with ~25mErl in the peak hour

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