Network dimensioning and cost structure analysis + Introduction to HW3

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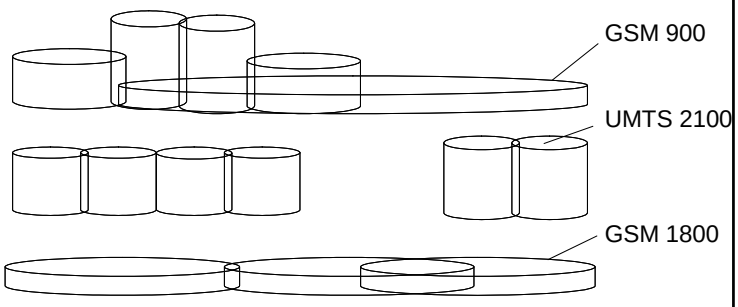
November 26, 2012

Homework 3

- For a specific user and traffic scenario you will
  - Make the dimensioning of a radio access network
  - Analyze the cost structure for different options

Transmission
Buildout & Site costs
Radio Equipment



Agenda items

- To estimate demand
- Dimensioning of radio access network
- Capacity, data rates and spectral efficiency of radio access technologies (RAT)
- Trade offs using
  - Number of base station sites
  - Spectrum
  - Cell structure
- What to do when the demand increases?
- Cost structure analysis

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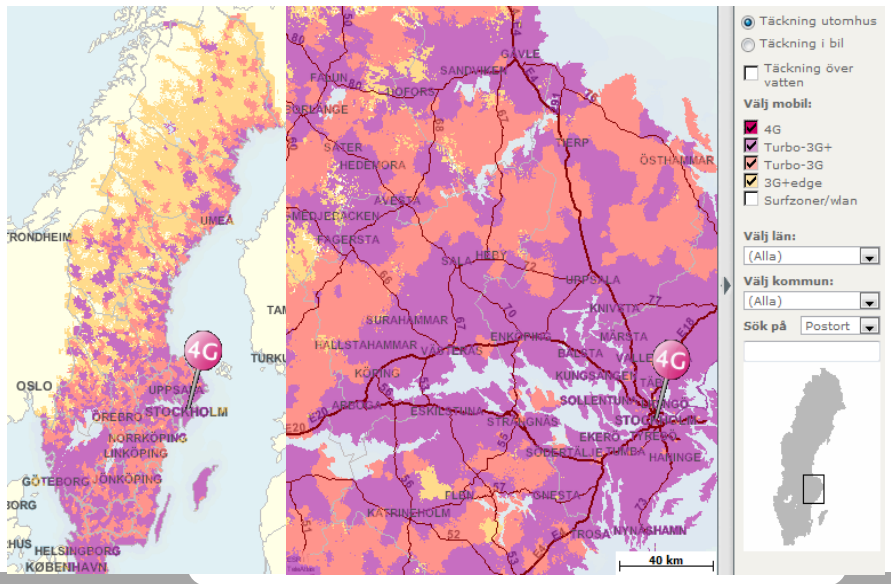

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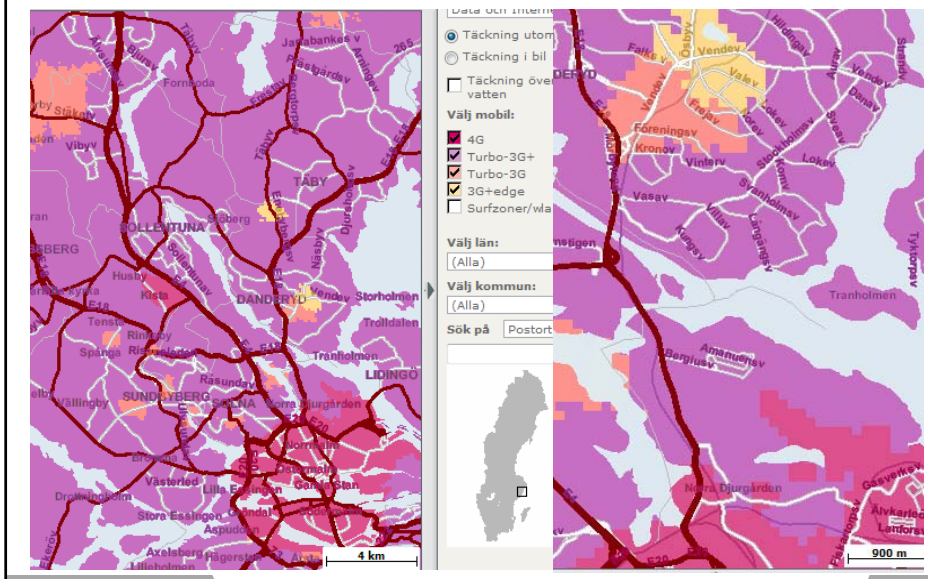
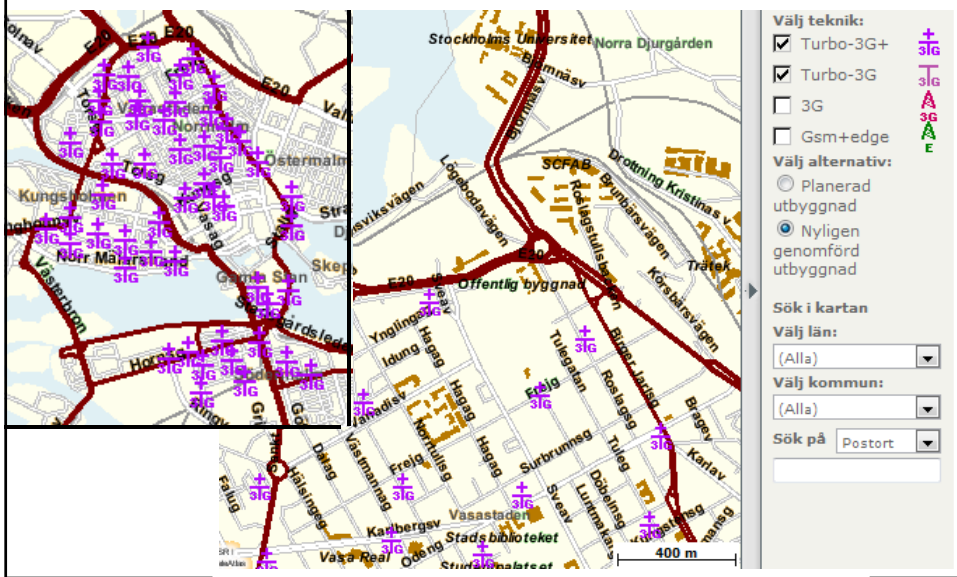


Deployment Dowmtown Stockholm



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Demand estimates as input for dimensioning of network capacity

- Amount of data
  - per user, per time unit, per area unit
- Usage:
  - Amount of data per user and time unit
  - Example 1: 100MB per day
  - Example 2: 5 GB per month
  - needs to be expressed as kbps/Mbps per user

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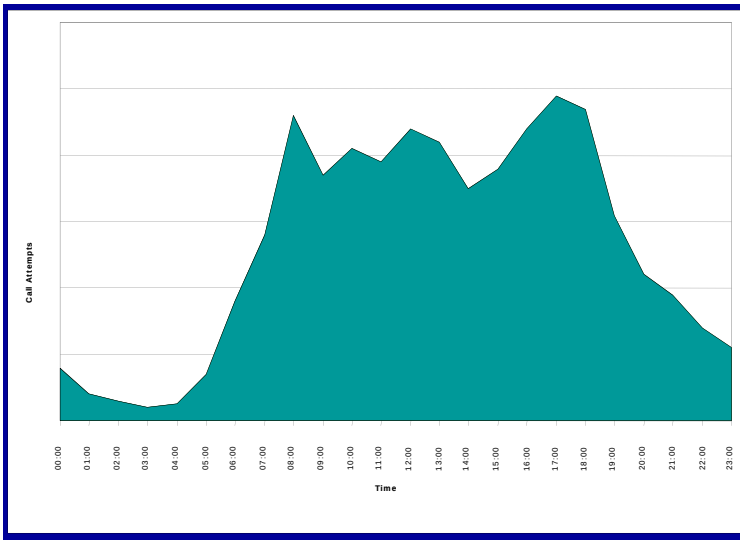
Demand estimates as input for dimensioning of network capacity

- Traffic
  - Amount of data per time unit per area unit
  - Depends on user density and usage per user
  - Example 1: 10 Mbps per sqkm
  - Example 2: 100 GB per day in a 2* 2 km area

Dimensioning Real time services

- For voice and RT data you need to estimate the maximum number of ongoing calls or session
  - Is based on the traffic during the ”busiest hour”

Capacity dimensioning – The busy hour



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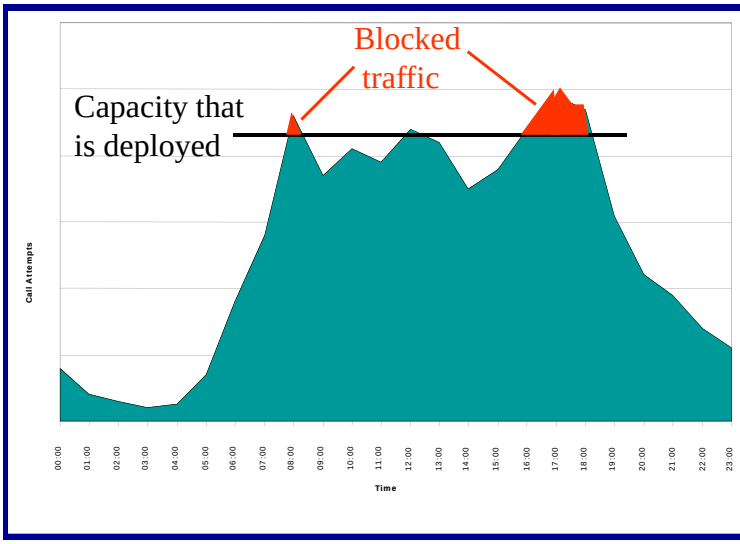
Capacity dimensioning – The busy hour



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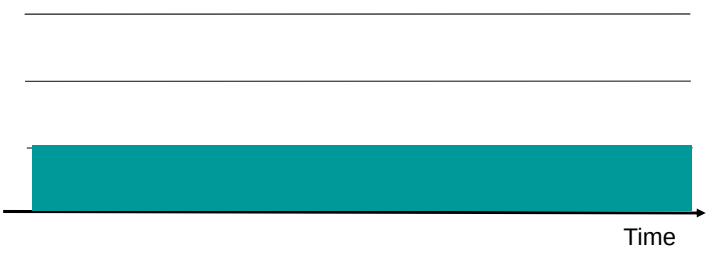
Capacity dimensioning – Mobile broadband

Montly demand of MBB spread out
- all days of the month
- all 24 hours of the day



For data NRT data traffic the approach with ”average data rate” per user can be used
X GB per user and month -> Y kbps per user

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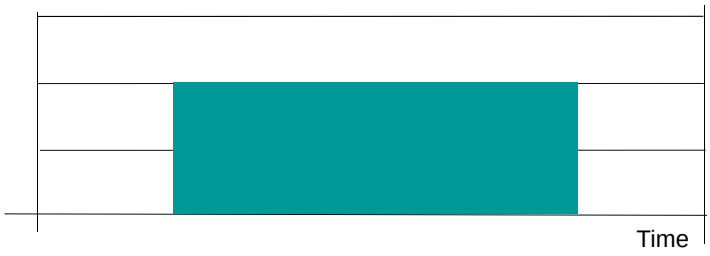
Capacity dimensioning – Mobile broadband

Montly demand of MBB spread out
- all days of the month
- 12 out of 24 hours of the day



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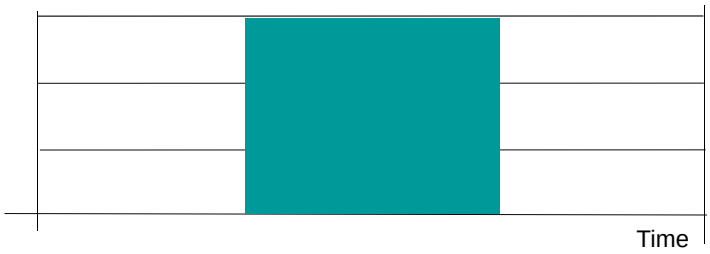
Capacity dimensioning – Mobile broadband

Montly demand of MBB spread out
- all days of the month
- 8 out of 24 hours of the day

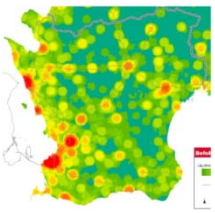


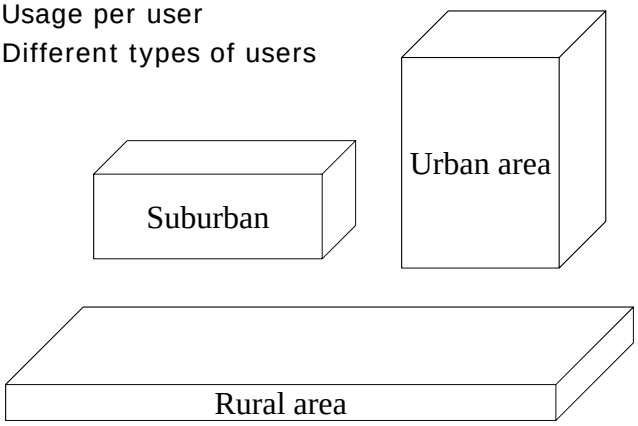
Short exercise

- What is the average data rate per user?
  - Example A.
    - Monthly usage 5.4 GB per user
    - Assume 30 days per month
    - Assume data used during 8 hours per day
  - Example B.
    - Monthly usage 14.4 GB per user
    - Assume 20 (office) days per month
    - Assume data used during 4 hours per day
- What is the average data consumption per month for these cases?
  - Example C.
    - The operator promises at least 1 Mbps
    - Assuming data usage 1 hour per day
  - Example D.
    - The operator promises at least 8 Mbps
    - Assuming data usage 4 hours per day

Traffic density

- Estimate the demand
  - Number of users per area unit
  - Usage per user
  - Different types of users





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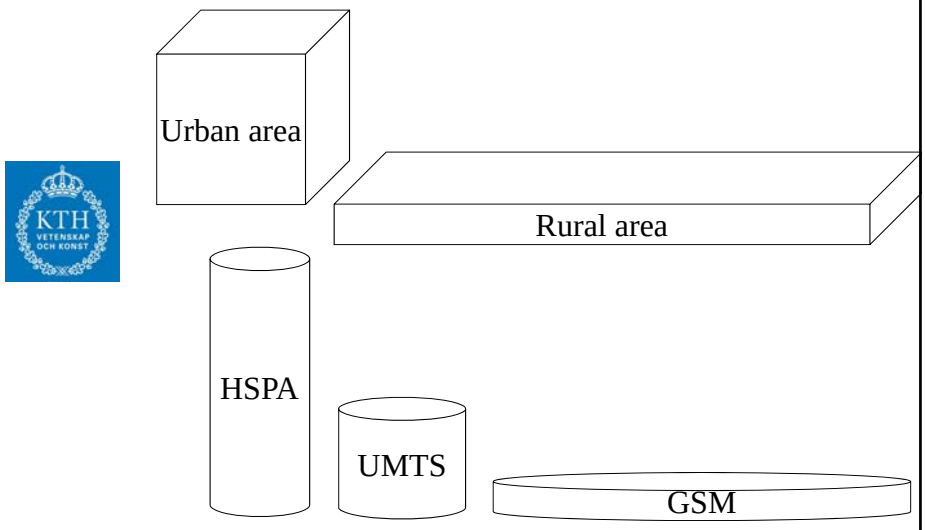
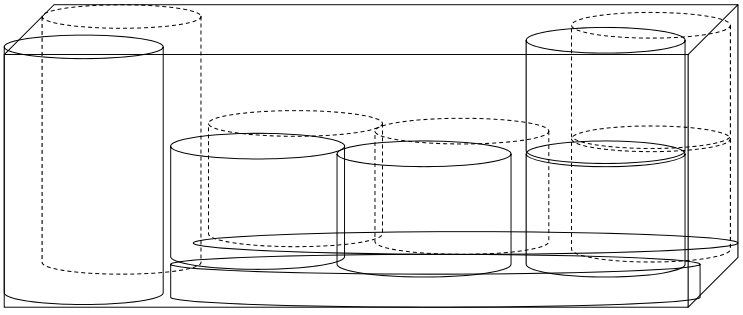
The dimensioning problem

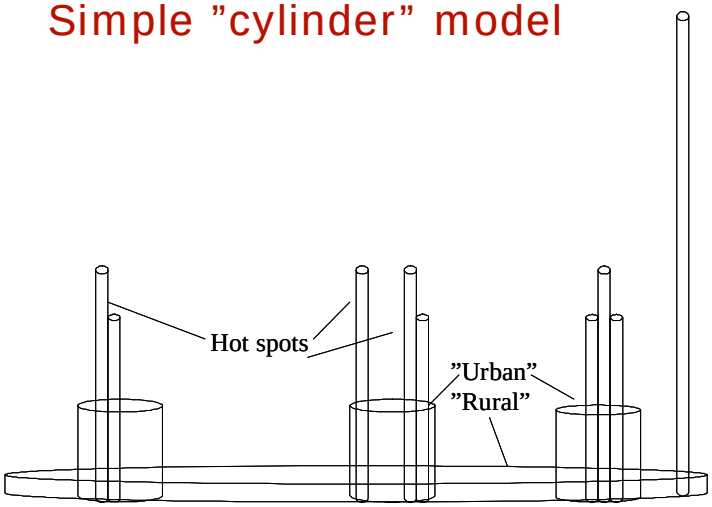


The dimensioning problem

- To satisfy the demand
  - To ”fill the demand box” with ”resource cylinders”



Simple ”cylinder” model



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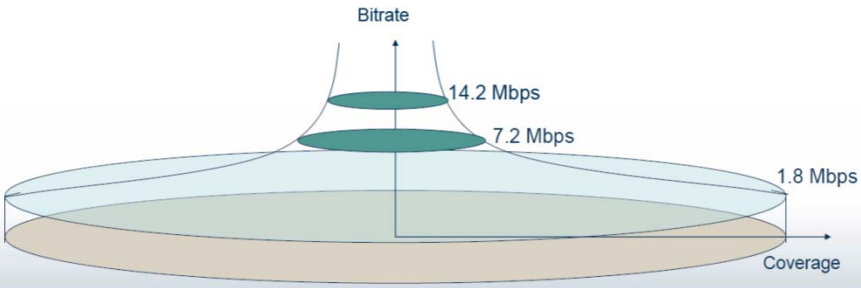
From Ericsson:
Capital markets day, May 2008

Coverage vs. bitrate



Double peak rate does not correspond to double capacity

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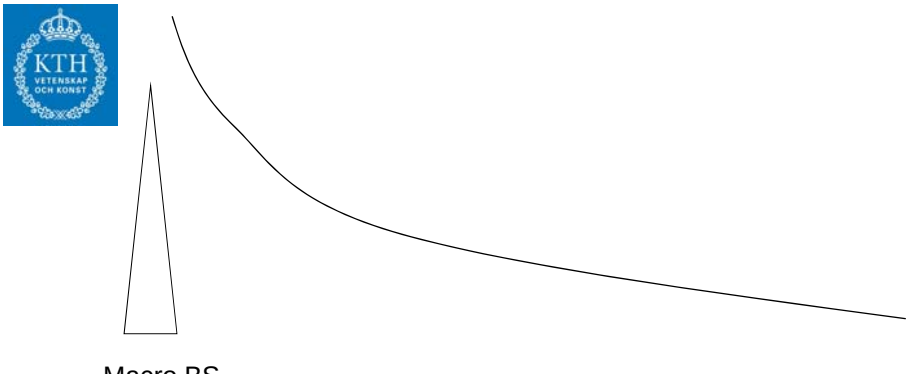
Bit rate and range – Bandwidth and Radio Access Technology (RAT)

RAT 1



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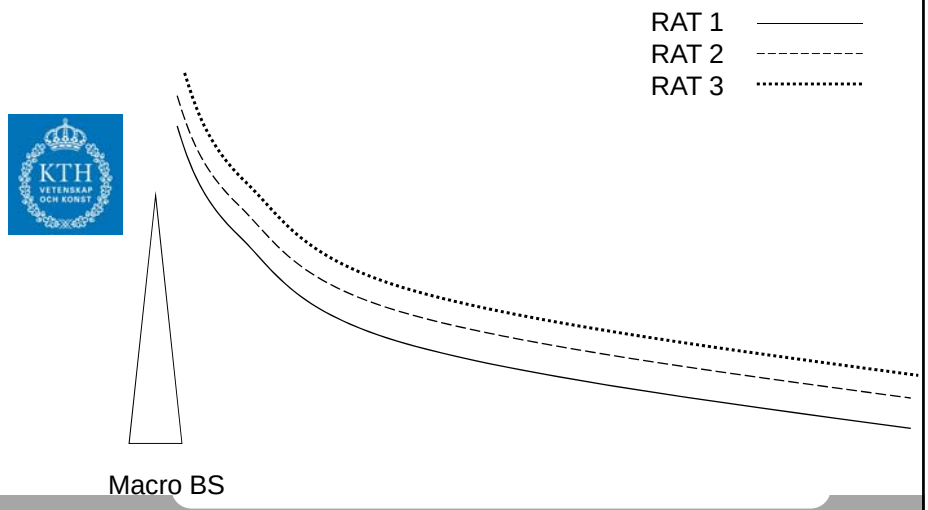
Bit rate and range – Bandwidth and Radio Access Technology (RAT)



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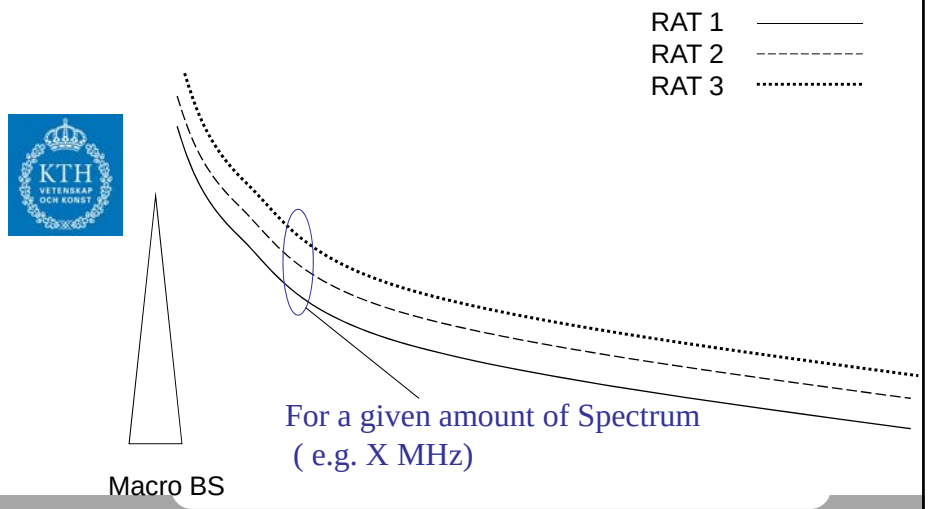

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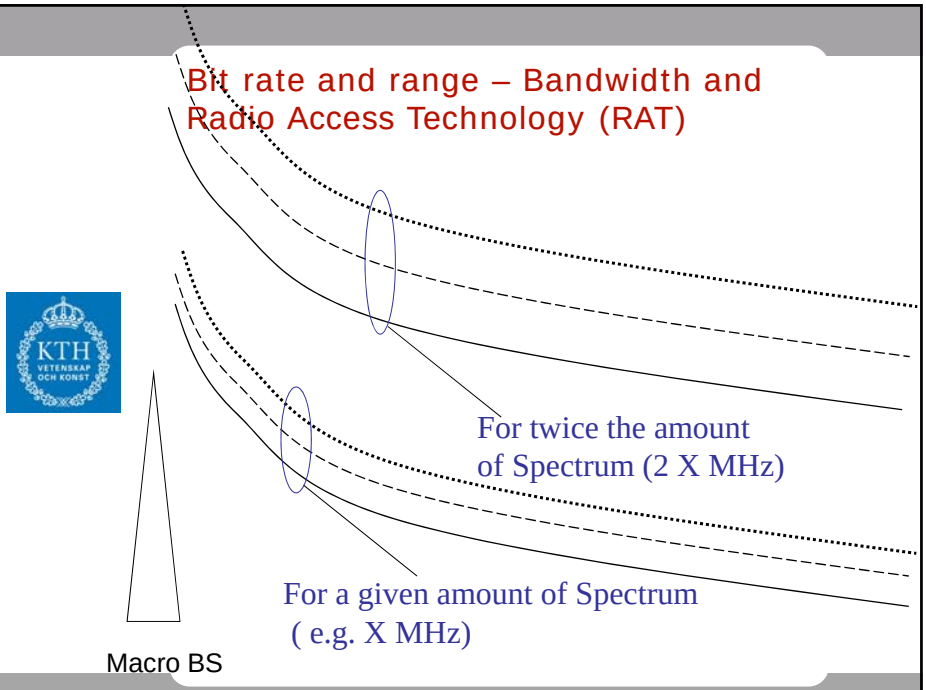
Bit rate and range – Bandwidth and Radio Access Technology (RAT)



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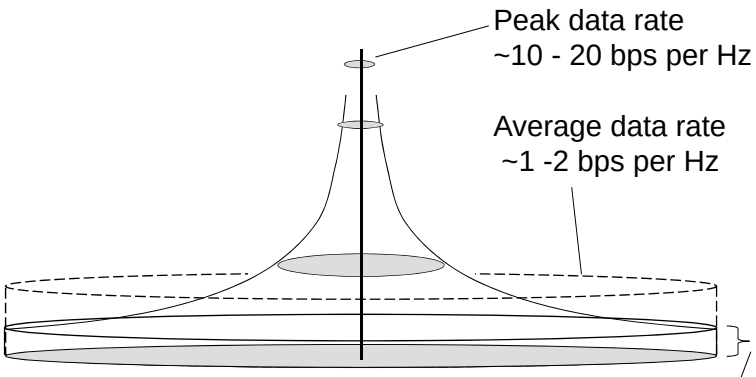
Spectral effiency



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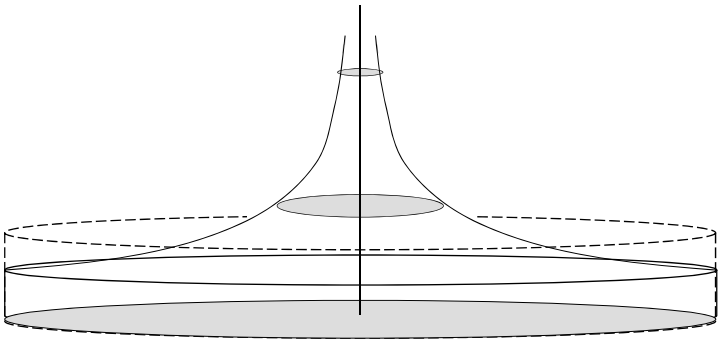
Spectral effiency and cylinder model



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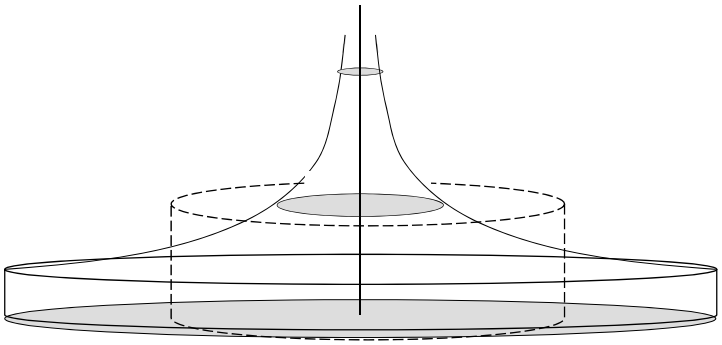
Spectral effiency and cylinder model



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From Ericsson:
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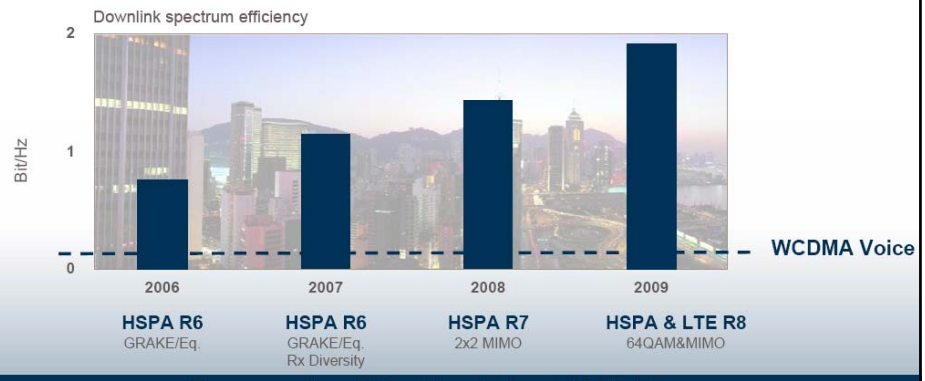
HSPA and LTE capacity evolution



The capacity will double – but not 100 fold

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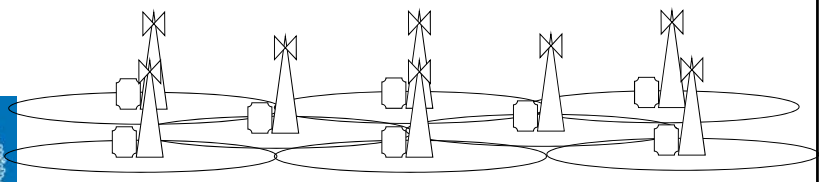

Cellular systems - low data rates

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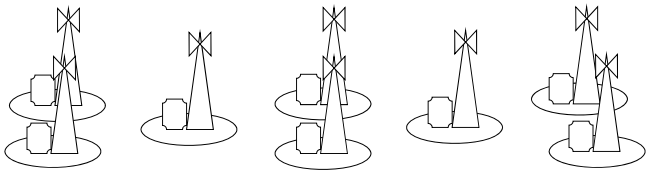

Cellular systems – higher data rates, the same sites

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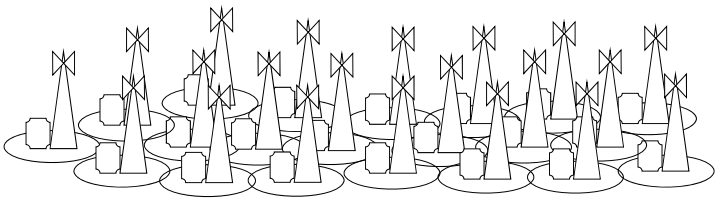
Zander formula



$$C_{system} \approx c_{AP} N_{AP} \approx c' N_{user} B_{user} A_{service} f(Q)$$

N_{AP} the number of access points (base stations)
N_{user} the number of users
B_{user} the average data rate of the users
$A_{service}$ the service area covered (volume indoors)
f(Q) is a function of the required Quality of Service.

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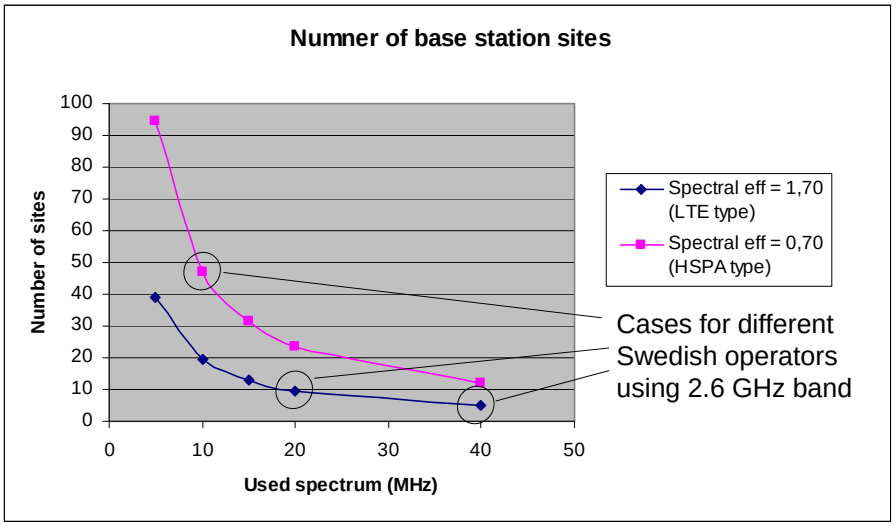

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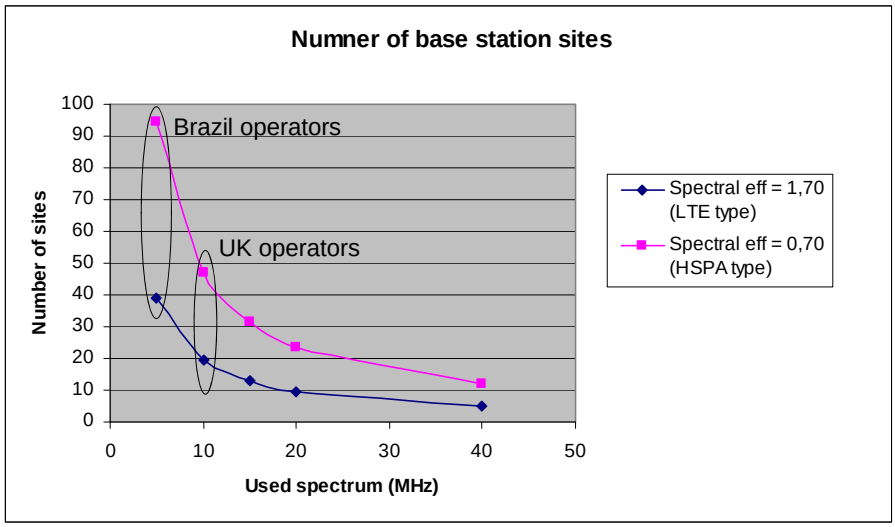

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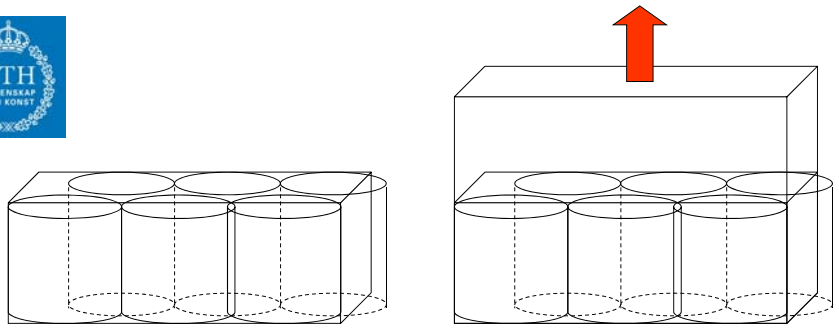
What to do when the demand increases?



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What to do when the demand increases?

- Deploy a denser network
  - Add more sites (number of AP´s)
- Increase the bandwidth
  - Add more carriers
- Add sectors at existing sites
  - Add antennas and radio equipment

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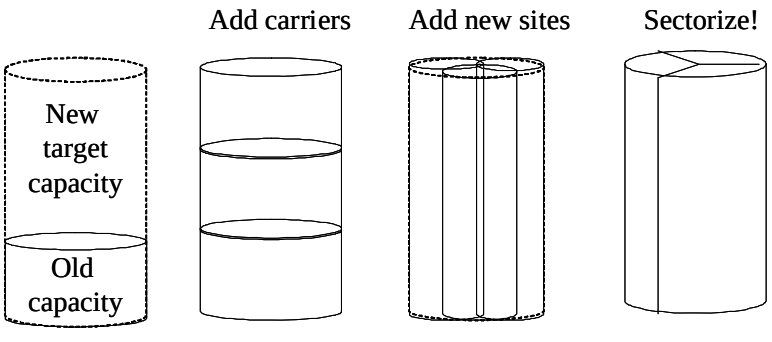
What to do when the demand increases?



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Capacity of a a cell as function of Spectral Efficiency and amount of spectrum

Spectral efficiency	5 MHz of Spectrum	10 MHz of Spectrum	20 MHz of Spectrum
0,7 bps/Hz	3,5 Mbps	7,0 Mbps	14 Mbps
2,0 bps/Hz	10 Mbps	20 Mbps	40 Mbps

- Using a base station site with 3 sectors (cells) will result in a site capacity 3 times higher
- Example:
  - With a radio access technology with spectral efficiency = 2 bps/Hz and 20 MHz of spectrum
  - the site capacity = 120 Mbps

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A short exercise: how many users can be served, - in a cell with capacities as below ?

Spectral efficiency	5 MHz of Spectrum	10 MHz of Spectrum	20 MHz of Spectrum
0,7 bps/Hz	3,5 Mbps	7,0 Mbps	14 Mbps
2,0 bps/Hz	10 Mbps	20 Mbps	40 Mbps

- Use the “user demand” A, B C or D from before

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→ Cost structure analysis

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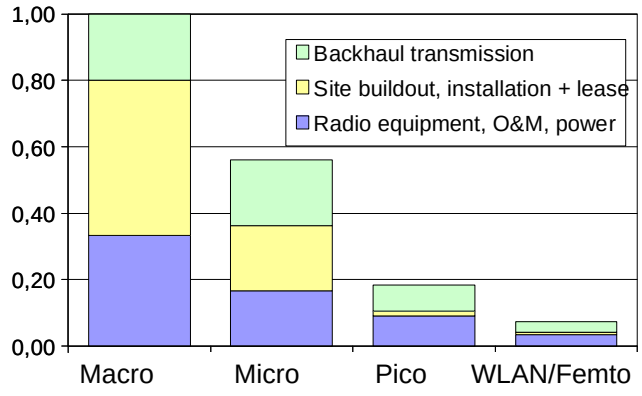
Cost structure of radio access networks

- It is not only costs for the base station equipment (the radio) but also for the transmission & sites

From
Klas Johansson
PhD thesis 2007



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Cost and capacity - examples

Equipment	Cost [kEuro]	Capacity [Mbps]
EDGE Macro BTS, 3 TDMA carriers	10	0,7
EDGE Macro BTS, additional sector	5	0,7
EDGE upgrade for existing GSM Macro	5	0,7
WLAN AP (1 AP per site)	1	10
UMTS Macro BTS, first cell at site	20	1
UMTS Macro BTS, additional cells (sectors or carriers)	10	1
UMTS Micro BTS, one cell only (i.e. no build out)	10	1
HSDPA Macro BTS, first cell at site	25	3
HSDPA Macro BTS, additional cells (sectors or carriers)	15	3
HSDPA Micro BTS, one cell only (i.e. no build out)	15	3

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Financial aspects

- Price erosion
- Discounted cost model
  - We need to consider the time and how the value of changes over time
  - Net Present Value calculation

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Price erosion

- All costs; equipment, leases, labour etc have an associated ”cost trend”
- One example is Moore law for electronics
  - The performance/cost ratio is doubled every 18th month
- For price erosion 5 % you get

100 95 90,25 85,7375 81,45063 77,37809 73,50919

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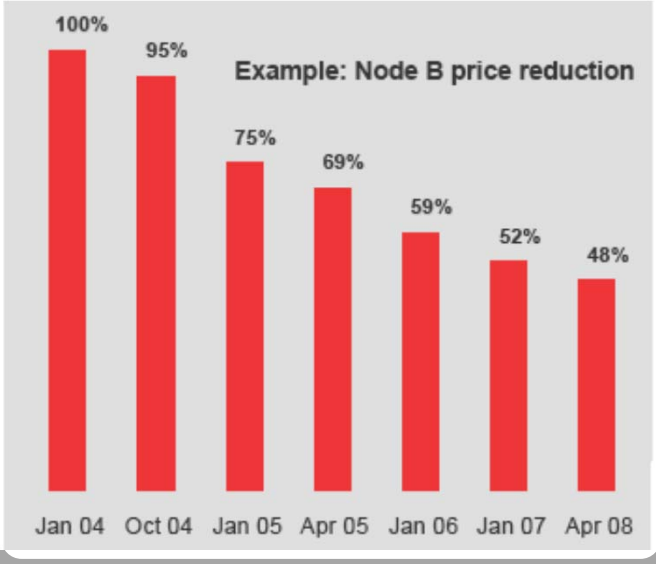
From Vodafone, March 2008



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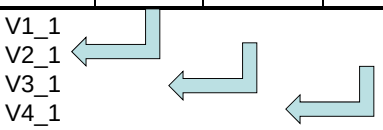
NPV calculation

- We need to consider the time and how the value of changes over time
- Net Present Value calculation (NPV in Excel)

Year	1	2	3	4
Value	V1	V2	V3	V4

V1_1
V2_1
V3_1
V4_1



Good luck with HW3