

Network dimensioning and cost structure analysis + Introduction to HW3



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November 24, 2014

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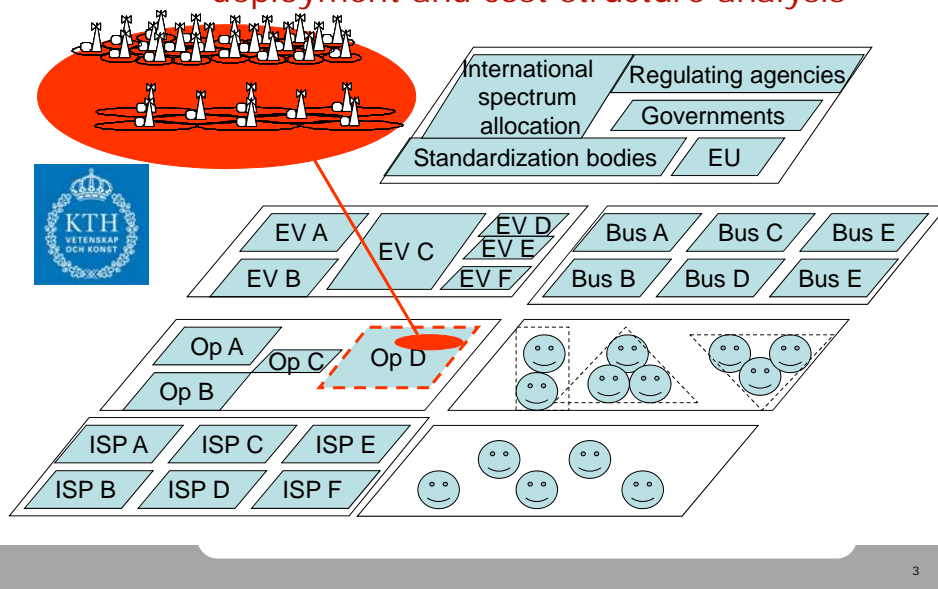
Topics today

- The network dimensioning part of the course
- How to estimate user demand
- Network dimensioning
- Cost structure analysis
- About HW3



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About network dimensioning, deployment and cost structure analysis



About network dimensioning, deployment and cost structure analysis

- Economics of wireless infrastructure, scalability cost-capacity trade-offs, spectrum allocation
- Network dimensioning, deployment and configuration strategies, impact of user demand
- Cost structure modeling & analysis of network, to calculate CAPEX, OPEX, Net present value
- Homework 3: Dimensioning and high level design of a wireless network incl. cost structure analysis



Homework 3

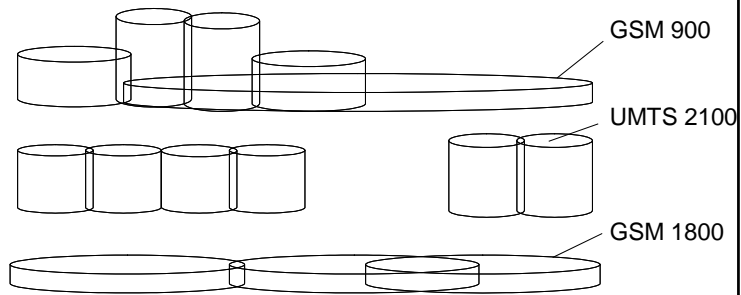
- For a specific user and traffic scenario you will
 - Make the dimensioning of a radio access network
 - Analyze the cost structure for different options



Transmission

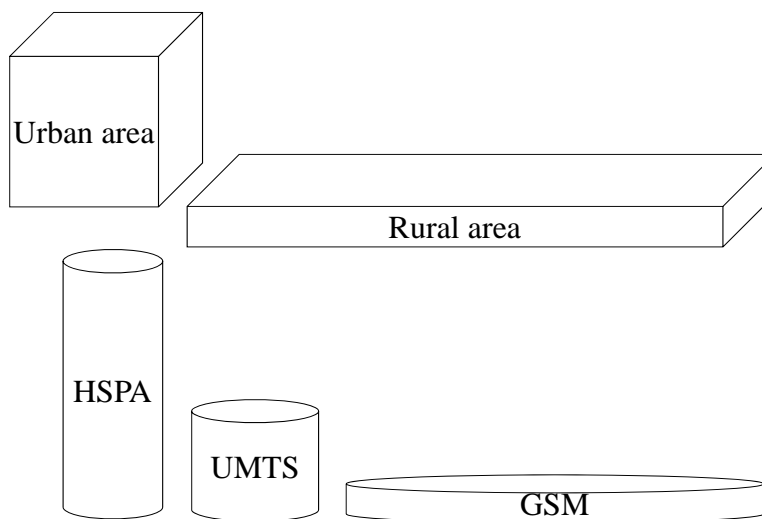
Buildout &
Site costs

Radio
Equipment



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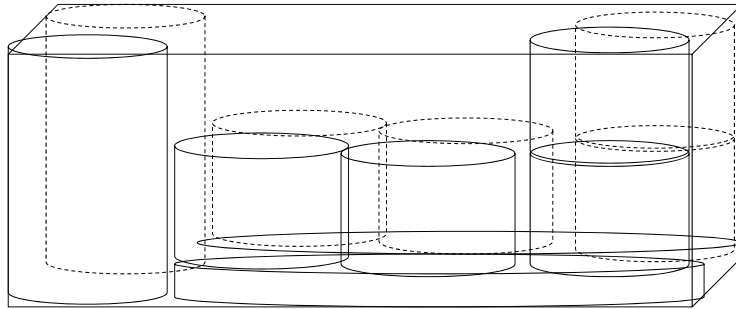
The dimensioning problem



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The dimensioning problem

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



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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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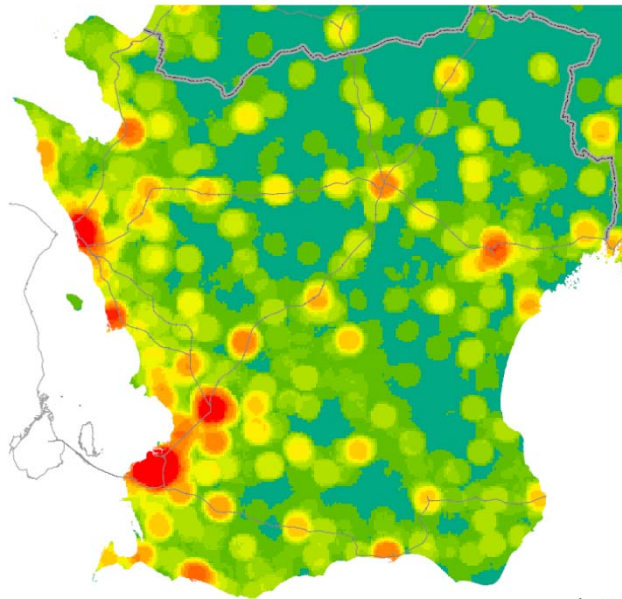
Estimation of user demand

- How to describe demand
 - Location of users
 - Number of users
 - Service mix
 - Traffic per user
- How to estimate demand for dimensioning



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Population density in Skåne



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Population density (persons per sqkm)



- Sweden average: 20
- Sweden rural areas: 1 – 10
- Sweden suburban areas: 100-1000
- Sweden urban areas: 1000 -10 000
- EU region rural areas: 100-200
- Malmö average: 2000
- Stockholm average: 4000
- Stockholm city: 25 000

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Geographical data for Sweden



	Km ²	Inabitants	Inh./km2	Share of area population	
Urban	2 109	5 197 620	2 464	0,5%	57%
Suburban	23 780	3 249 652	137	5,2%	35%
Rural	431 473	732 206	1,7	94,3%	8%
	457 362	9 179 478	20,1	100%	100%

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Geographical data for Sweden

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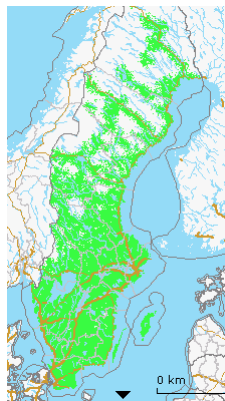
92% of the population is living at 6 % of the total area

8% of the population is living at 95% of the total area

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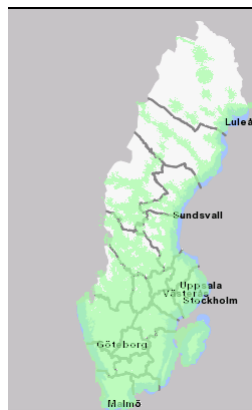
GSM coverage

Tele2



~70% covered area

Telenor Telia



~65% Covered area



~90% covered area

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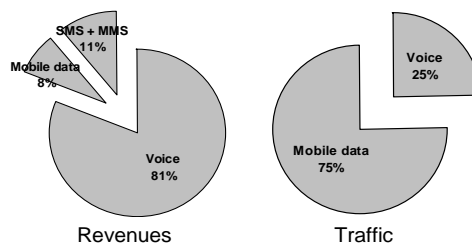
Estimation of user demand

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Traffic, prices and revenues



Traffic and revenue for different services at the Swedish market Q4 2008

EUR per MB	2007	2008
Voice	1,46	1,36
SMS	439,5	351,6
Mobile data (laptop)	0,014	0,011

Estimated price per MByte for voice, SMS and data for one Swedish operator

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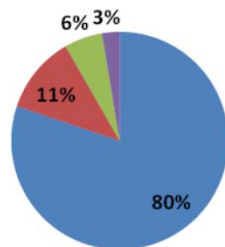
Amounts of data – orders of magnitude (GB per month and person, 2010 Northern Europe)



- Voice traffic 0,01-0,02 GB
- Smartphones 0,10-0,20 GB
- Laptop MBB as complement 1 – 5 GB
- Laptop MBB as substitute 2 – 20GB
- Fiber to the home (house hold) 100-200GB

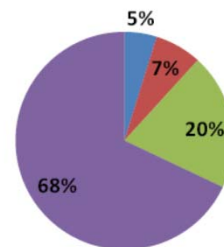
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Distribution of mobile broadband usage and subscriptions in Sweden Q4 2099



Share of subscriptions

- < 0,1 G byte
- 0,1 - 1 G Byte
- 1 - 5 G Byte
- > 5 G Byte



Share of data usage

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Estimation of user demand

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→ How to estimate demand for dimensioning

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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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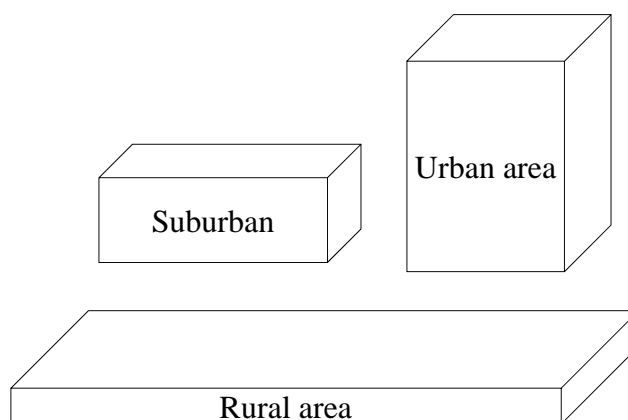
Demand estimates as input for dimensioning of network capacity



- 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

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Traffic density



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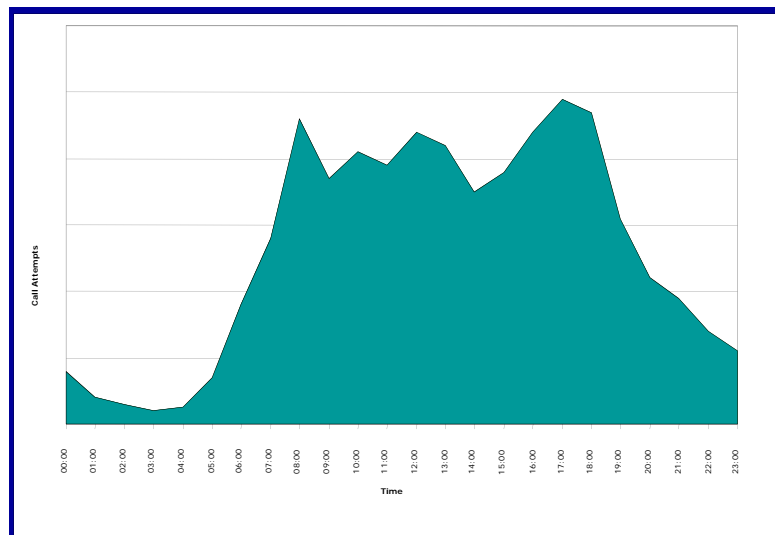
Dimensioning Real time services

- 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"



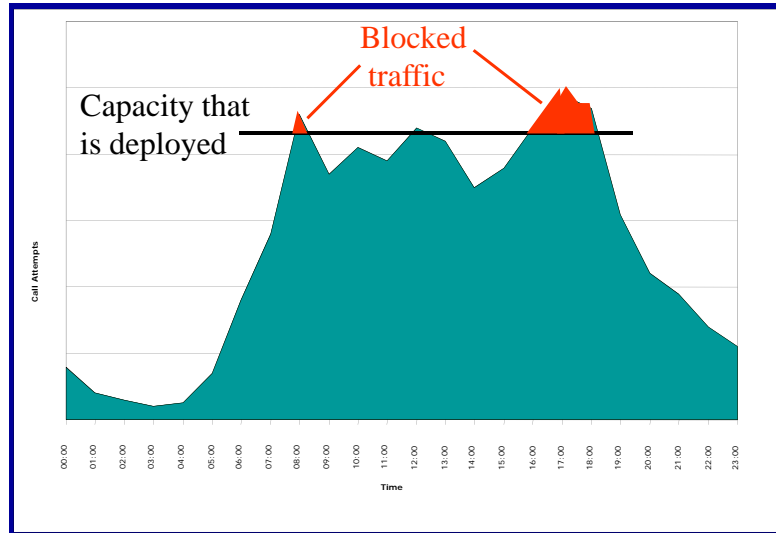
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Capacity dimensioning – The busy hour



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Capacity dimensioning – The busy hour



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Capacity dimensioning – Mobile broadband

- Monthly 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

Monthly demand of MBB spread out

- all days of the month
- 12 out of 24 hours of the day

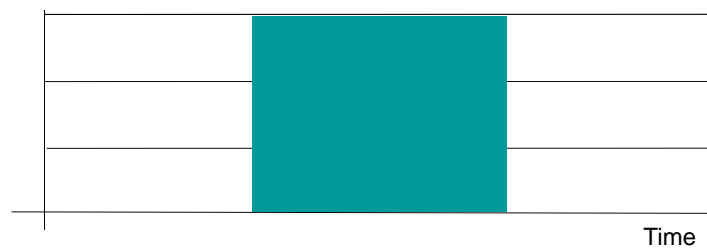


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Capacity dimensioning – Mobile broadband

Monthly demand of MBB spread out

- all days of the month
- 8 out of 24 hours of the day



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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

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Short exercise

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Example of User demand – Mbps per sqkm



Number of active users per sqkm	Average data rate per user (Mbps)			
	0,01	0,1	1	10
10	0,1	1,0	10	100
100	1	10	100	1000

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Are these numbers realistic?

- Population density
 - Stockholm average: 4000/ sqkm
 - Malmö average: 2000/ sqkm
 - Stockholm city: ~25 000/ sqkm
- Penetration of mobile dongles
 - 20 % 2010 (may be 50% in the future)
- Market share of operator ~ 40 %
 - Share of all users in an area: $0.2 * 0.4 = 8\%$
- Check Mbps per sqkm!! - With 8% of all users
 - In area with 25 000 / sqkm => 2000 / sqkm
 - In area with 2 500 / sqkm => 200 / sqkm
 - In area with 250 / sqkm => 20 / sqkm



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Implications for network deployment



- 1000 active users/sqkm, 50% market share
=> deploy capacity for 500 users /sqkm
- 5 GB usage per month per user
~ 15 kbps per user 24 hours all days for one month
~ 50 kbps per user during "daytime" for one month
- Capacity estimates for 500 users
 - 5 GB users: ~ 25 Mbps/sqkm
- Compare with throughput for one "cell"
 - "3G" using 5 MHz ~ 3,5 Mbps
 - "4G" using 20 MHz ~ 35 Mbps

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Agenda items

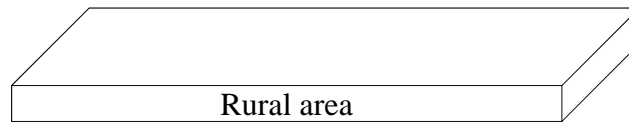
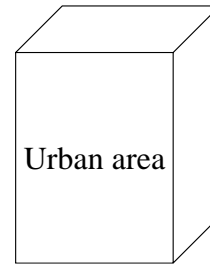
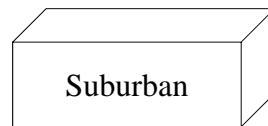
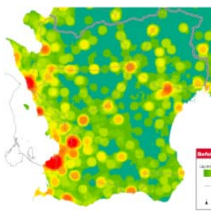


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Traffic density

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



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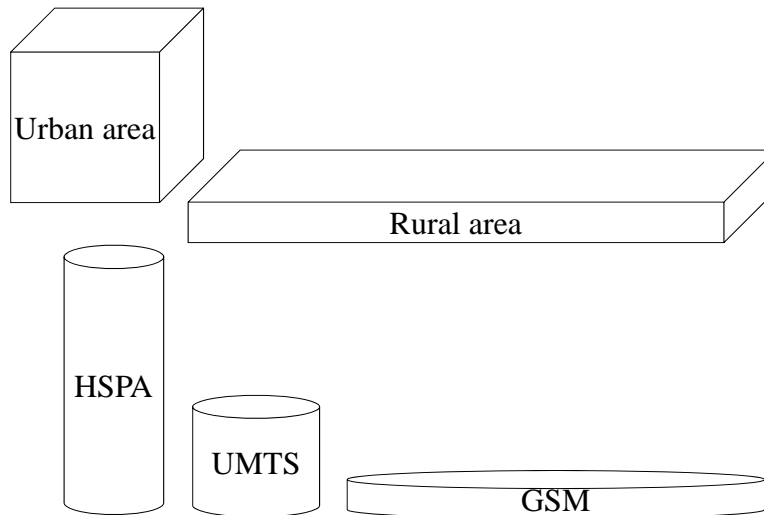
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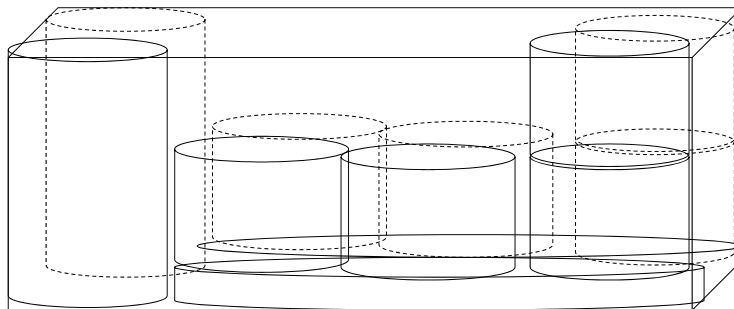
The dimensioning problem



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The dimensioning problem

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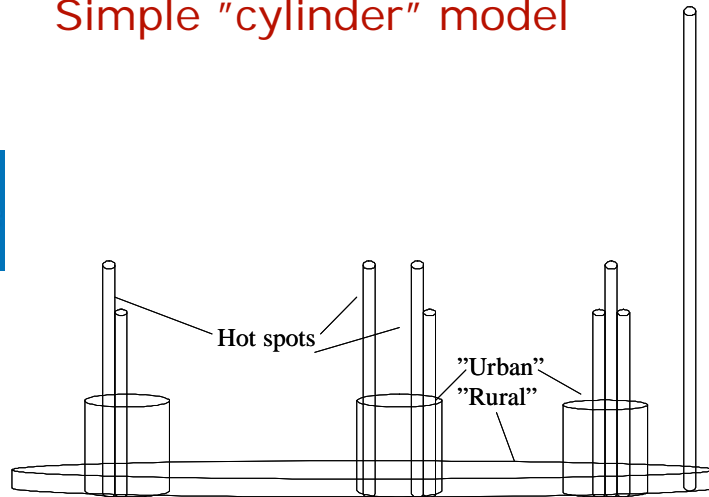
Capacity of a base station?

- I. Bandwidth * spectral efficiency * No sectors/ spectrum reuse
- II. Bandwidth * No sectors/(spectrum reuse *spectral efficiency)
- III. Bandwidth * No sectors *spectrum reuse /spectral efficiency
- IV. Bandwidth * No sectors * Spectral efficiency



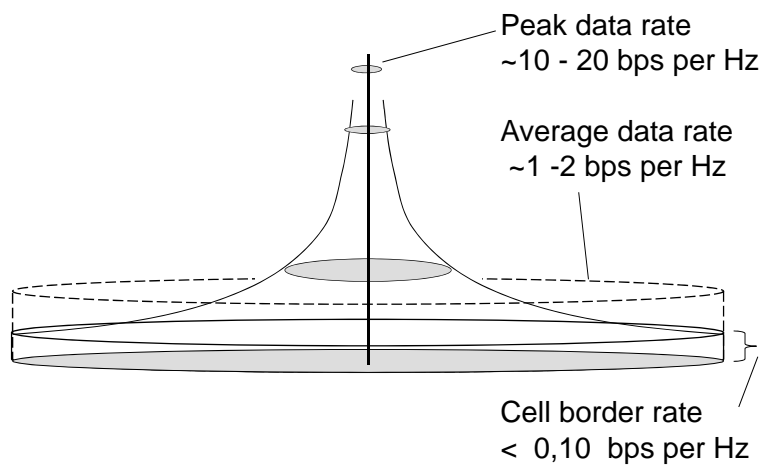
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Simple "cylinder" model



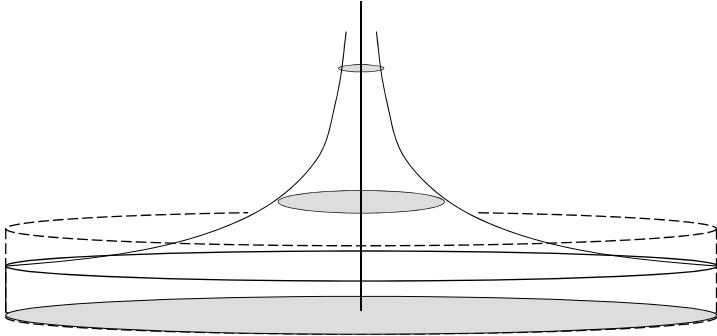
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Spectral efficiency

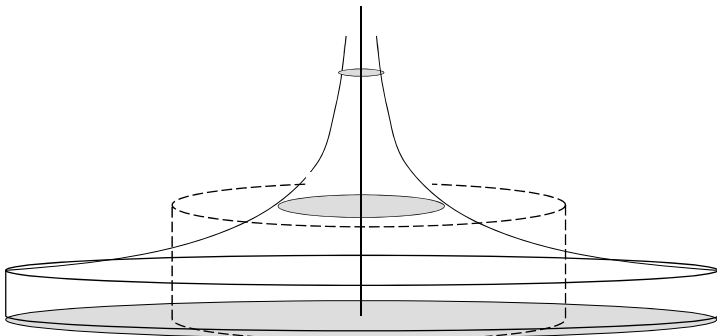


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Spectral efficiency and cylinder model



Spectral efficiency and cylinder model



From Ericsson:
Capital markets day, May 2008

HSPA and LTE capacity evolution



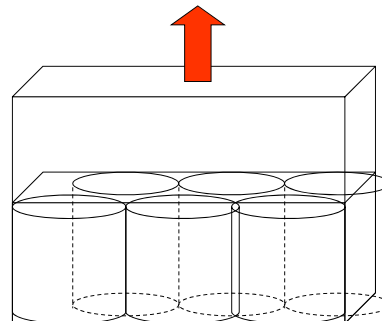
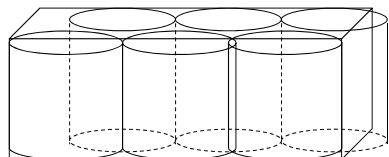
The capacity will double – but not 100 fold

B18_c

ERICSSON

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What to do when the demand increases?



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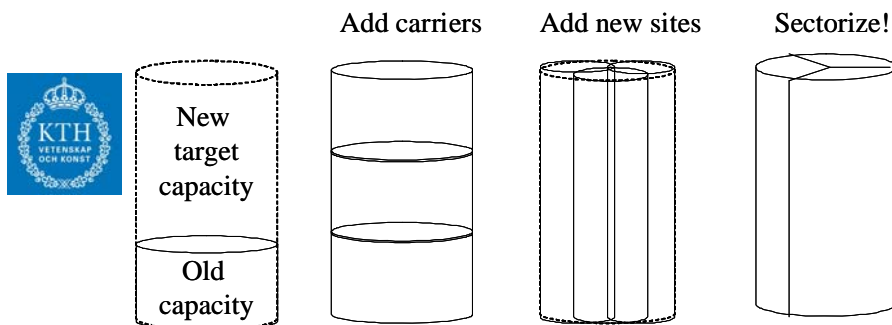
What to do when the demand increases?

- 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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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

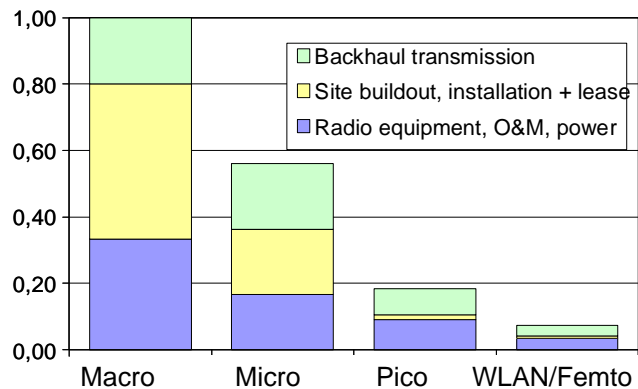
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Cost structure of radio access networks

- 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

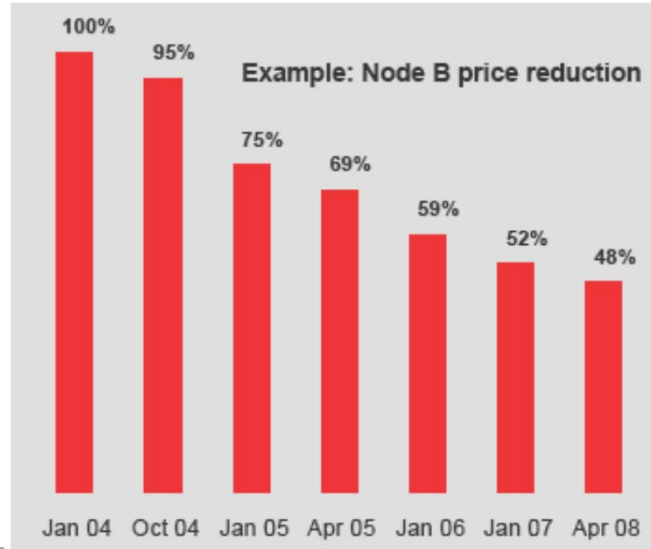


- All costs; equipment, leases, labour etc have an associated "cost trend"
- One example is Moore law for electronics
 - The performance/cost ratio is doubled every 18th month
- For price erosion 5 % you get

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

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From Vodafone, March 2008



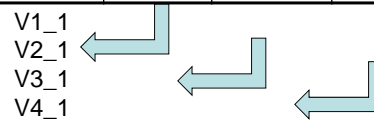
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NPV calculation

- 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



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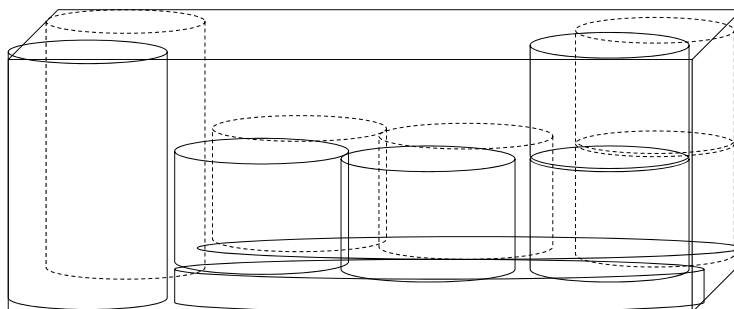
Good luck with HW3



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The dimensioning problem

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