User demand, network capacity and network dimensioning

Jan Markendahl

March 9, 2015

GÖR DIREKT:
Räkna ut vilken datatakt det blir om du skulle sprida ut din dataanvändning (dina GB per månad) likformigt under månaden, Dvs under alla dagar, alla timmar och alla sekunder

Topics today

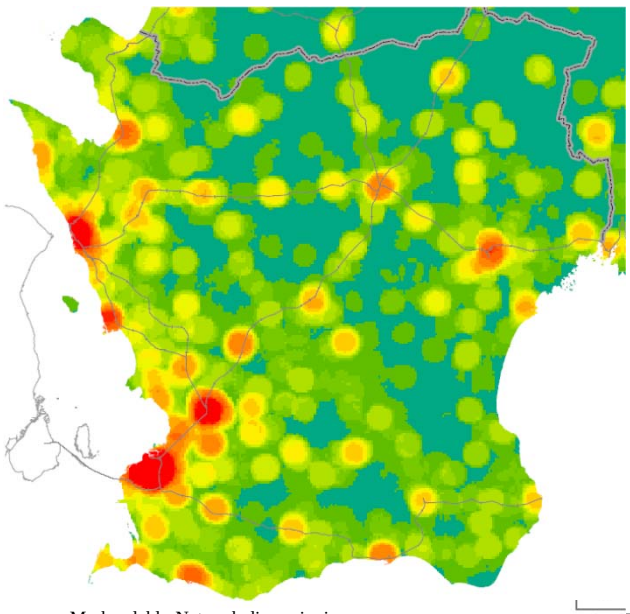
- How to estimate user demand
- Capacity of a base station
- Network dimensioning

- Q&A for your country case
- More about country markets and spectrum s

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

Population density in Skåne



Population density (persons per sqkm)

- Sweden average: 20

- Sweden rural araes: 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

Geografical data for Sweden

	Km²	Inabitants	Inh./km2	Share of area	Share of 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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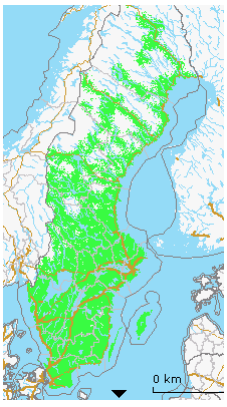
92% of the population is living at 6 % of the total area

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

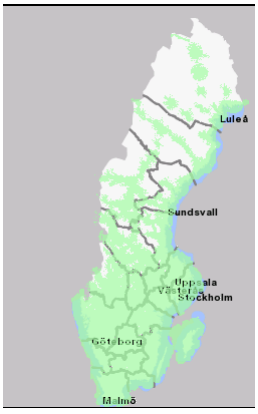
GSM coverage

Tele2



~70% covered area

Telenor Telia



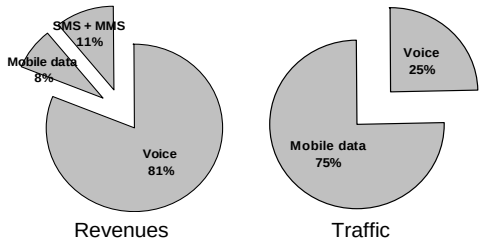
~65% Covered area

~90% covered area

Estimation of user demand

- The network dimensioning part of the course
- How to describe demand
  - Location of users
  - Number of users
  - Service mix
  - Traffic per user
- How to estimate demand for dimensioning

Traffic, prices and revenues



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

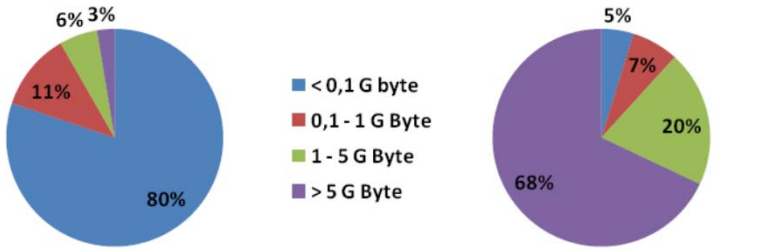
EUR per MB	2007	2008
Voice	1,46	1,36
SMS	439,5	351,6
Mobile data (laptop)	0,014	0,011

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

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

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

Distribution of mobile broadband usage and subscriptions in Sweden Q4 2099



Share of subscriptions

Share of data usage

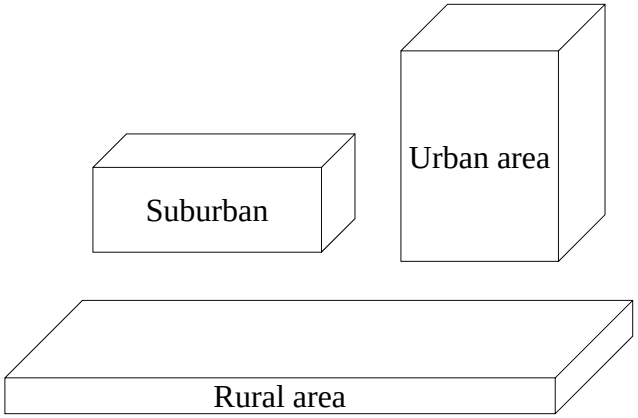
Demand estimates as input for dimensioning of network capacity

- 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

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

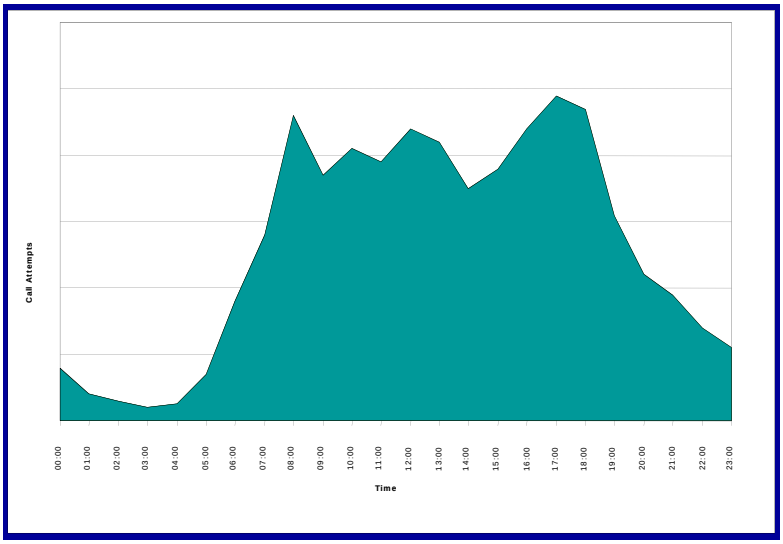
Traffic density



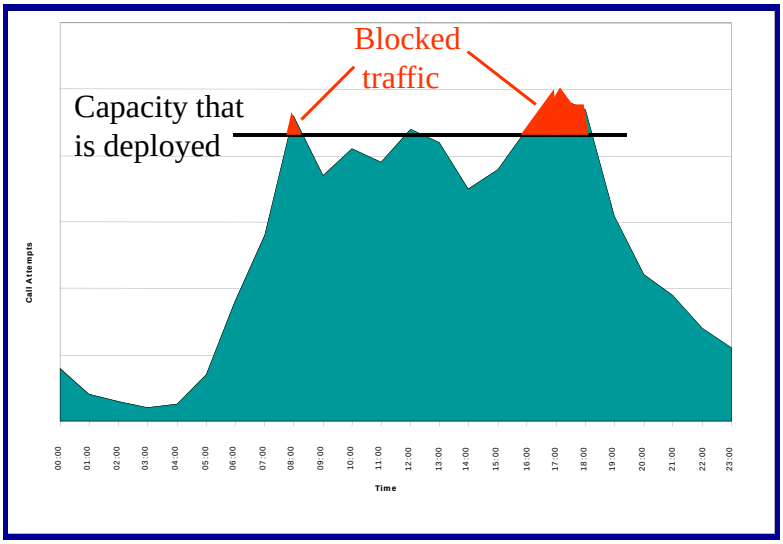
Dimensioning Real time services

- 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

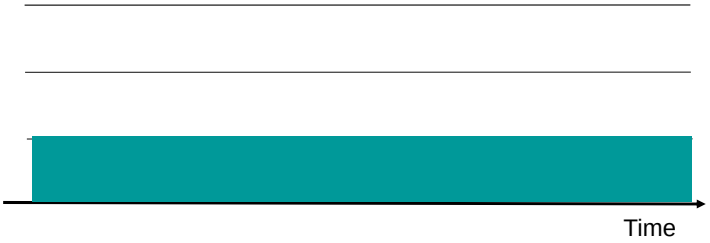


Capacity dimensioning – The busy hour



Capacity dimensioning – Mobile broadband

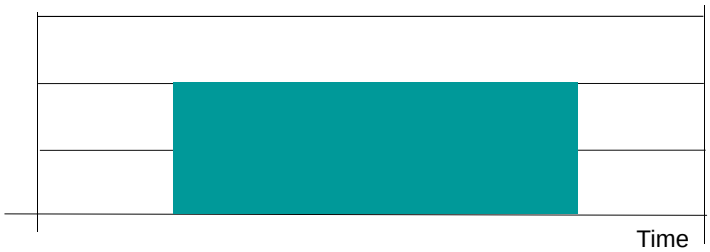
Montly demand of MBB spread out
- all days of the month
- all 24 hours of the day



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

Capacity dimensioning – Mobile broadband

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



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

Short exercise

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  - Assume data used during 4 hours per day

Example of User demand – Mbps per sqkm

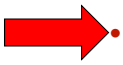
	Average data rate per user (Mbps)			
Number of active users per sqkm	0,01	0,1	1	10
10	0,1	1,0	10	100
100	1	10	100	1000

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

Topics today



- How to estimate user demand
- Capacity of a base station
- Network dimensioning

- Q&A for your country case
- More about country markets and spectrum s

The capacity needs to be increase at least 1000 times the coming years

Contributions

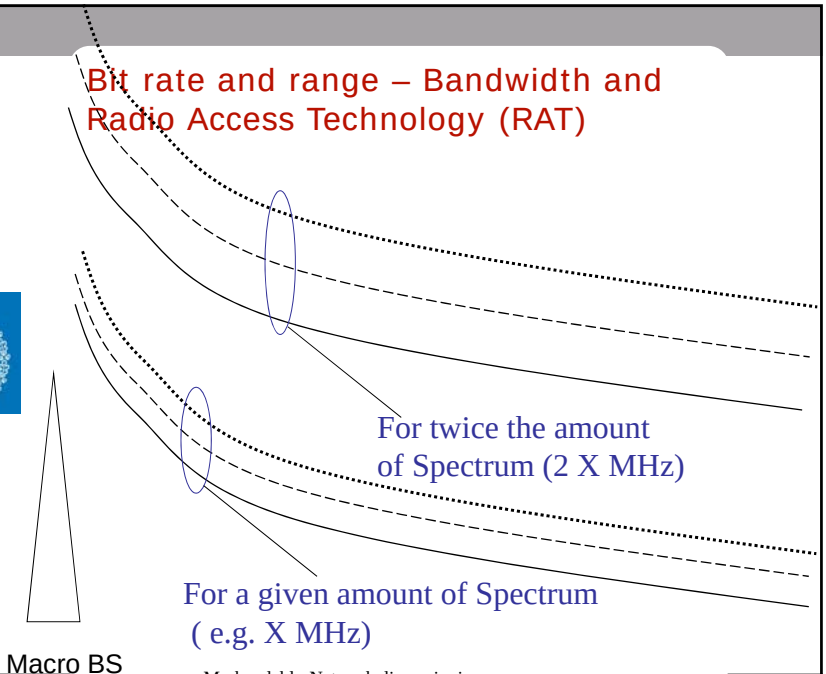
- One enabler is ”more spectrum”
- Another contribution comes from ”better technology” (improved spectral efficiency)
- A third contribution is from ”denser network”

3 minute discussion – discuss in groups

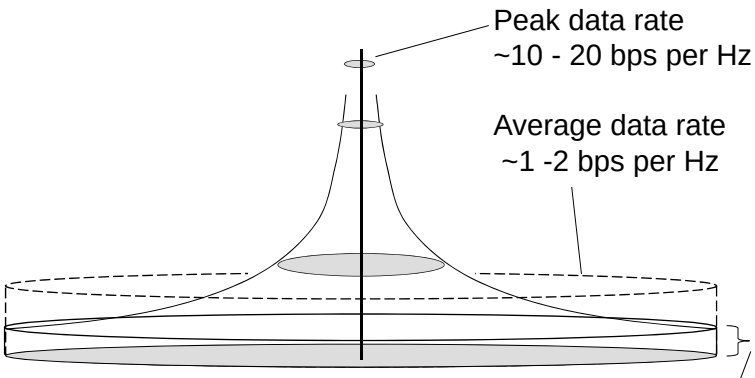
- How do you think the different aspects contribute?

(More spectrum)*(improved spectral eff.)*(denser network) = 1000

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

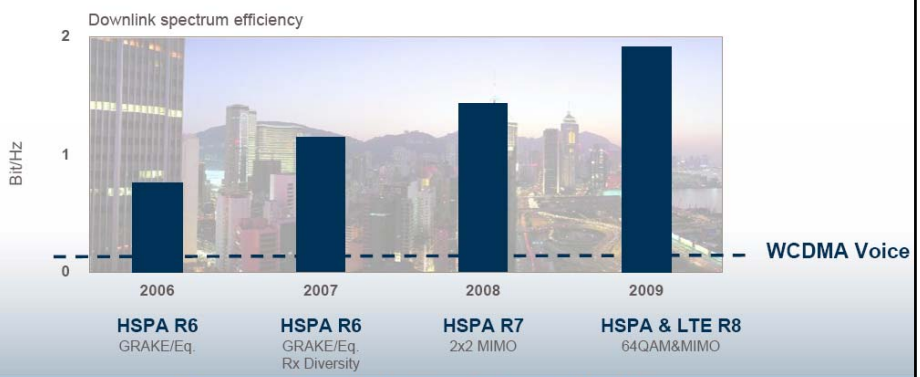


Spectral effiency



From Ericsson:
Capital markets day, May 2008

HSPA and LTE capacity evolution

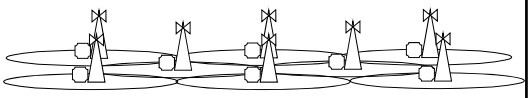


The capacity will double – but not 100 fold

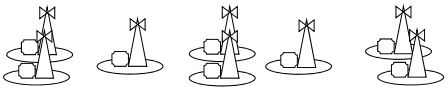
ERICSSON

Density of base station sites

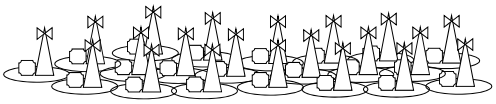
- Deployment for low or medium data rates



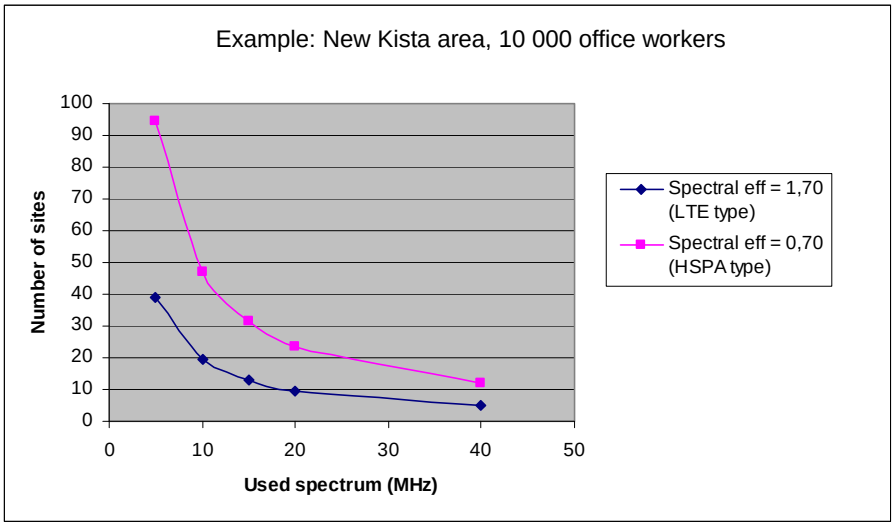
- Coverage for high data rates with existing sites



- Deployment needed for high data rates



Amount of spectrum and number of sites



Capacity of a base station?

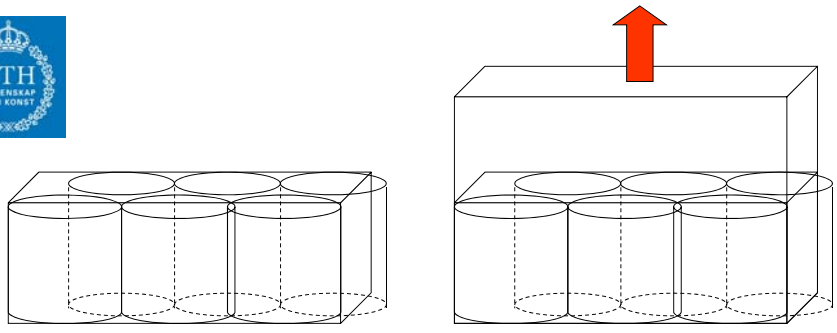
I. Bandwidth * spectral efficiency * No sectors/ spectrum reuse

II. Bandwidth * No sectors/(spectrum reuse *spectral efficiency)

III. Bandwidth * No sectors *spectrum reuse /spectral efficiency

IV. Bandwidth * No sectors * Spectral efficiency

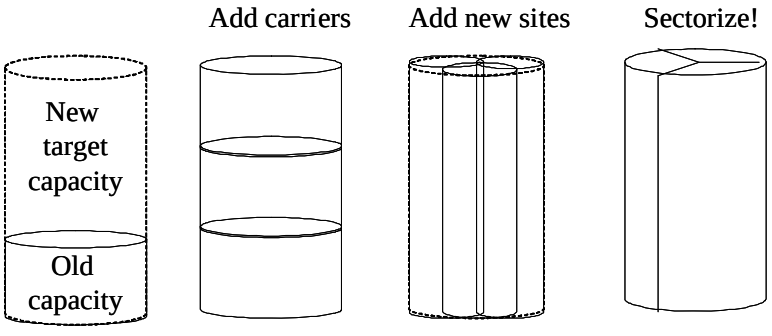
What to do when the demand increases?



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

What to do when the demand increases?



Capacity of a base station – type?

- Bandwidth * No sectors * Spectral efficiency

A. 5 MHz * 1 * 1 = 5 Mbps

B. 10 MHz * 3 * 1 = 30 Mbps

C. 20 MHz * 3 * 2 = 120 Mbps

D. 20 MHz * 1 * 10 = 200 Mbps

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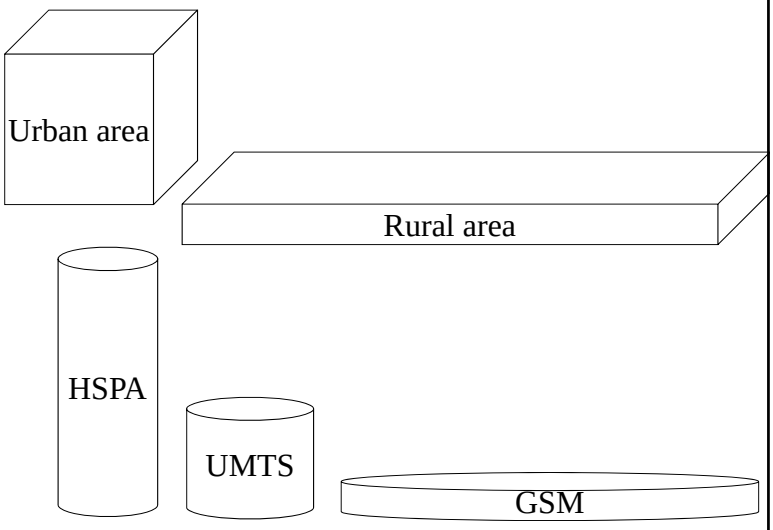
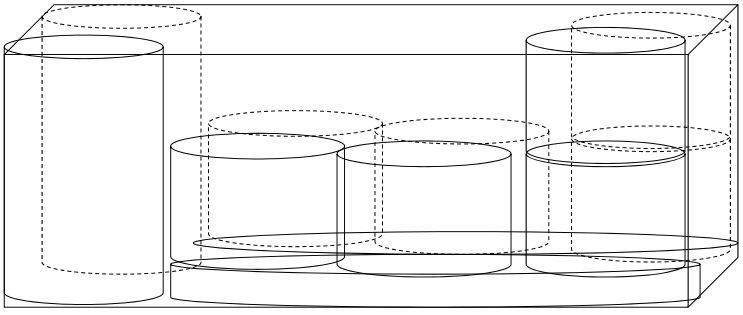
The dimensioning problem



The dimensioning problem

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



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

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

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

Analysis steps for dimensioning

- 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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Q&A for your country case

- More about country markets and spectrum

Case: Spectrum and network economics

Scope

•Analyze drivers, benefits and obstacles for operators to build and operate efficient mobile networks

•Each of you will get a country to analyze

Your tasks

1.Describe the overall situation and main challenges in your country for spectrum and mobile networks

2.Compare the network strategy, deployment status and offred services for two operators in your country

What to do in order to pass

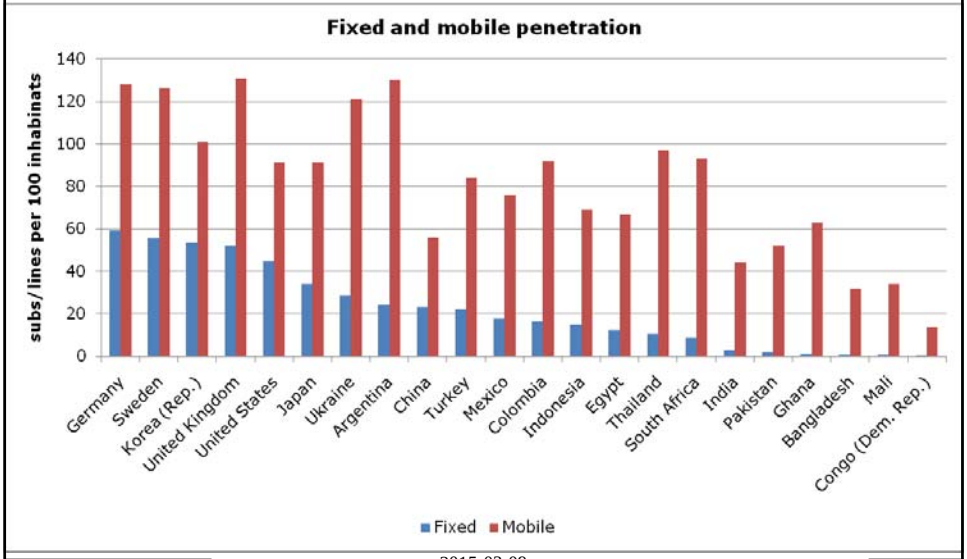
- Prepare a draft report and send for review
  Max 4 pages in total
- Review reports of others in the review group
- Present review comments in group session
- Make a oral presentation of results
  Max 6 minutes and 3 slides
- Attend the presentation seminar
- Revise report according to the review comments and submit a final version

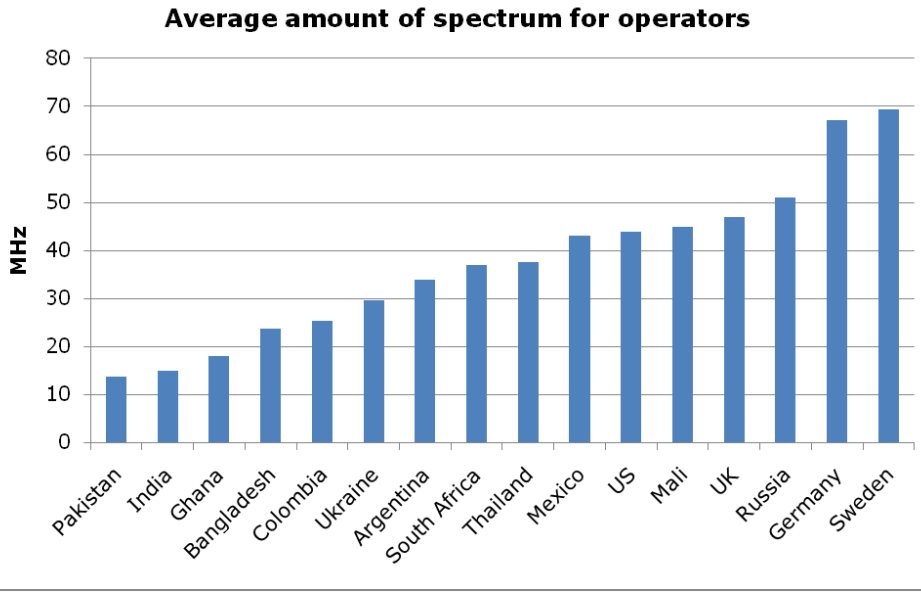
Schedule for the Case: Spectrum and network economics

- March 2,
  - Lecture: Introduction to tele-economic modelling and analysis and the student case to analyse
  - Each student gets individual asssigment
- March 9
  - Lectures on operator challenges and spectrum
  - Q&A session for your assignment
- March 18
  - Oral presentation of your case
- March 2- 20
  - You will work with your case, report and presentation and review work of others, see details next slide

Activity	Deadlines
Home work is assigned to each student	15-03-02 ; 12.00
Draft report sent to teacher & reviewers filename: "country"_v1.doc	15-03-10; 16.00
Review comments sent to teacher and authors filename: "country"_review_by"name"	15-03-12; 10:59
Review session and discussions in review groups (no teacher present)	Anytime before 15-03-13; 16:00
Do your presentation slides, put together all slides in the review group and send to teacher filename: "countryA, countryB, countryC".ppt	15-03-16; 11:59
Oral presentation, Each review group will present together	15-03-18; 09:00-12:00 Max 6 min per student
Send final report version to teacher filename: "country"_v2.doc	15-03-20; 11:59
Feedback and grading send to student	15-03-27; 12.00 latest

Countries in the world are different





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Lessons learned 2000 – 2010

What differences can we observe in Sweden

Jan Markendahl

Aspects to discuss

- Service mix and traffic mix
- Radio access technologies
- Coverage and capacity
- Investments
- Network sharing
- Spectrum
- Cost of radio equipment
- Number of sites

Service and traffic mix

- 2000
  - Voice and sms
  - > 99% of the traffic is voice
- 2010
  - Voice, SMS and MMS + mobile data
  - Mobile services for enterprizes, craftmen
  - > 90% of the traffic is data

"Mobile organizations – The enterprise market for mobile services"

Construction company NCC saved half a million SEK per person

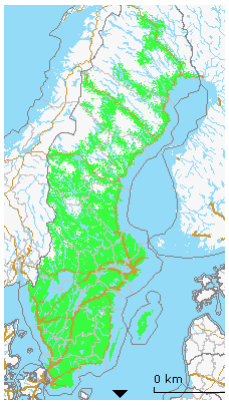
The project leaders of Kista Science Tower accessed the company intranet using portable computers

To share blue prints, action points and report and track changes

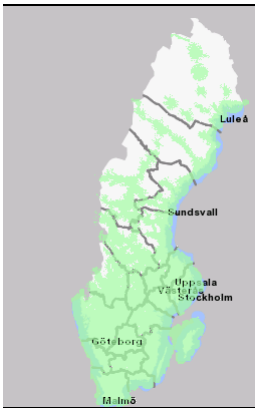
The result: Each person saved up ½ to 1 hour per day, according to NCC the time saving ~ 0,5 MSEK!

Compare voice ARPU and the potential to increase revenues

GSM coverage
Tele2 - Telenor - Telia



~70% covered area

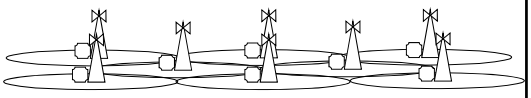


~65% covered area

~90% covered area

Density of base station sites

- Deployment for low or medium data rates



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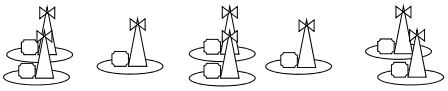

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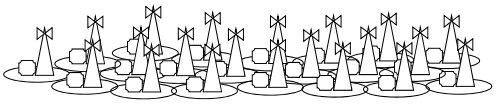
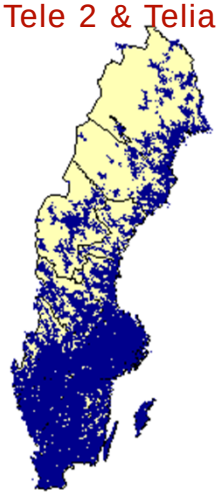


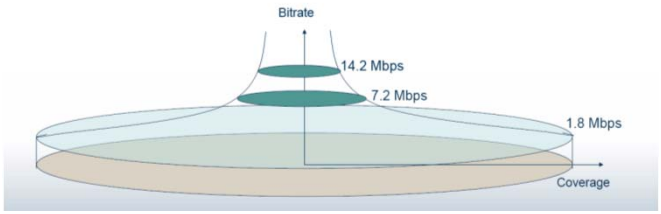
3G Coverage
Turbo 3G, Turbo 3G+ (HSPA)

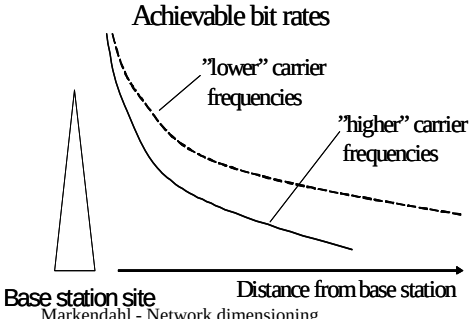
Tele 2 & Telia



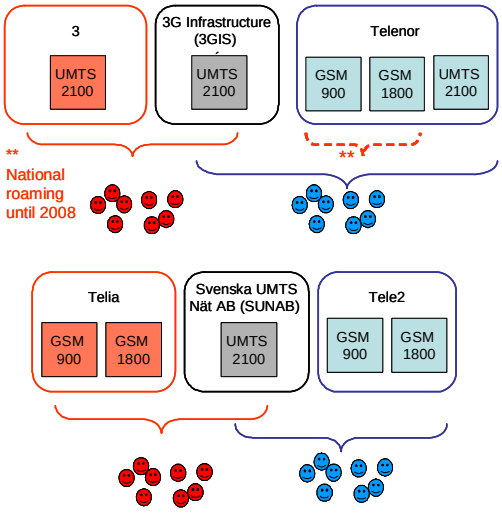
Telenor & Tre

Bit rates, coverage and carrier frequency

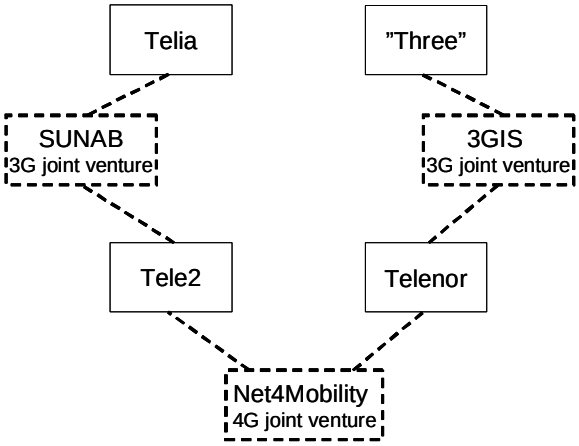




Network sharing in Sweden



Many partnerships and joint ventures



Network sharing - Why cooperation ?

- Drivers for network sharing
  - To reduce network costs
  - To get access to spectrum license
  - To get access to the competence and network of an established operator
  - Aggregated spectrum means that operators can "offer more", i.e. higher bit rates
- Anti-drivers for network sharing
  - Less independence
  - Decision making takes more time and effort

Investments in mobile networks in Sweden 2000-2009 (Million SEK)

Operator	Investments
Telia	10334
Tele2	4006
SUNAB	5797
Telenor	2945
Hi3G access	13384
3GIS	8786

Cost of radio equipment is decreasing rapidly

512 MSEK (50 MEuro)
~6 KEuro per base station

TELE2

telenor

~ 750 MSEK

Press release

Stockholm, 18th of December, 2009

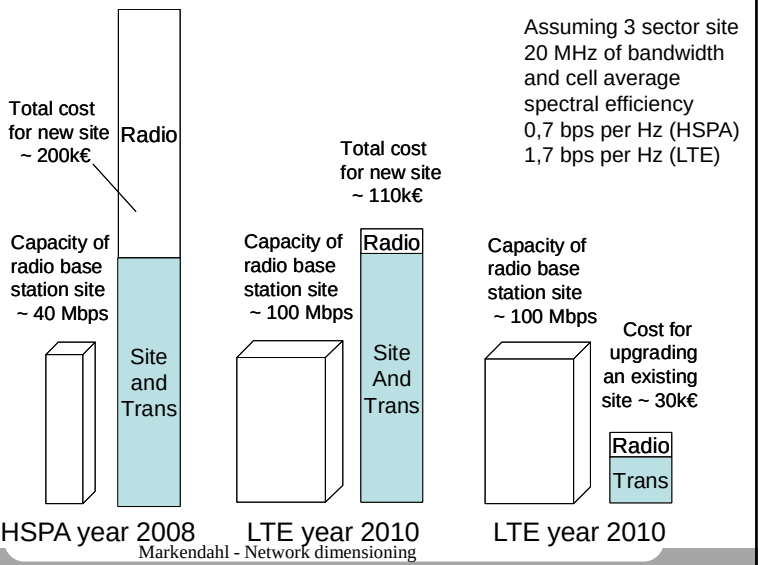
Tele2 and Telenor select Huawei to deploy 4G network

Net4Mobility, the joint venture by Tele2 and Telenor, today announced that Chinese telecom equipment vendor Huawei will supply infrastructure and modems for next generation mobile communications, 4G, in Sweden. The agreement with Huawei comprises the deployment of the first nationwide 4G network in Sweden and modem services for the new network.

By combining the procurement of a network- and modem vendor, the operators secure an effective deployment and a commercial launch of high-quality 4G services in 2010. For customers, 4G enables increased mobility and use of high capacity services, with up to ten times the current speed of turbo-3G initially.

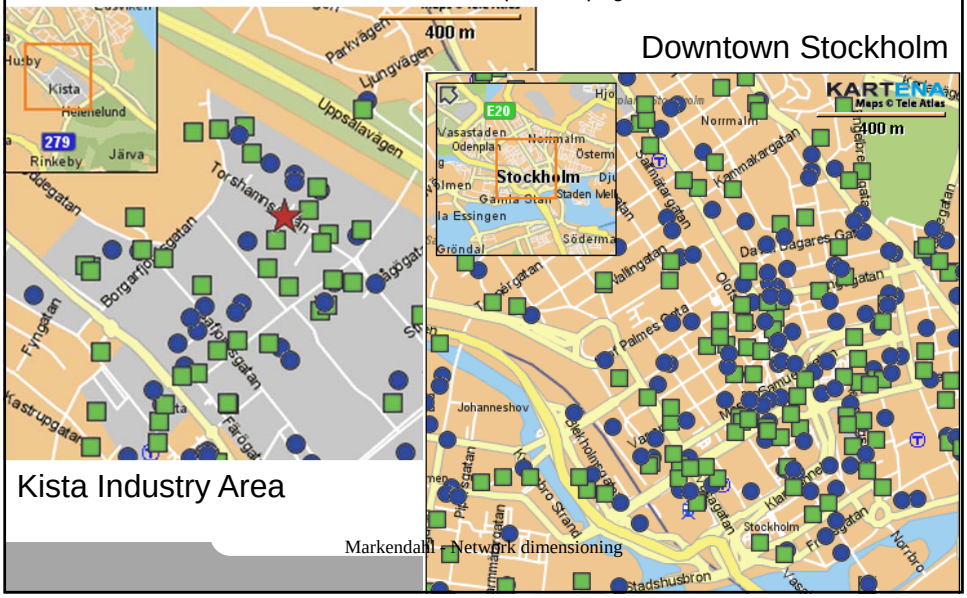
– Huawei provides high technology and cost efficiency, both vital components in our investments to build a nationwide 4G network. Tele2's customers will be able to access high-quality and affordable mobile services at speeds equivalent to some of today's fixed broadband connections, **said Niclas Palmstierna, CEO, Tele2 Sweden.**

Capacity, cost and cost structure



Base station site location in urban areas

from PTS "Transmitter map" web page, December 2009



Examples of Base station densities (Urban areas in Sweden)

Name and type of area	*Total density of sites*	*Typical densities for operators*
Residential area in Uppsala	~6 per km^2	1 3 per km^2
Residential area Akalla	~ 14 per km^2	3 5 per km^2
Central part of Uppsala	~ 20 per km^2	3 8 per km^2
Industry area Kista	~ 50 per km^2	7 20 per km^2
Central part of Stockholm	~ 130 per km^2	20 40 per km^2

Compare network sharing year 2000 and year 2010

- 2000
  - Many new base station sites were needed
  - Radio capacity relatively expensive
  - Capacity demand was relatively low
  - No shortage of spectrum
- 2010
  - Many base station sites exist
  - Cost of radio capacity has decrease dramatically
  - Capacity demand is increasing
  - Amount of spectrum is important