Introduction to operator challenges and wireless infrastructure economics + Intro to HW2

Jan Markendahl, Associate Professor,
Wireless Infrastructure Deployment and Economics
Communication Systems , KTH
November 18, 2014

About home work 2 and 3

Homework 2 task:

- Compare business strategies of two mobile operators in ”your” country
- Find data on the business performance and operator strategy in order to be able to make a comparison

Homework 3 task:

- Dimensioning of a radio access network and analysis of the cost structure for different deployment options and types of used Radio Access Technologies (RATs).
- The analysis will be done for a specific scenario with a set of user and traffic data and different RAT´s with given capacity and cost figures

Home work 2 review groups 2014

- Group 1
  - Denmark: Dusan
  - Australia: Ahmad
  - Germany: Pehr
- Group 3
  - Mexico: Oscar
  - Austria: Mårten
  - France: Istiak
- Group 2
  - Finland: Ganapathy
  - Morocco: Menatalla
  - Portugal: Rachaen
- Group 4
  - Estonia: Sikandar
  - Ireland: Ali
  - UK: Athanasios

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HW2 Activities	Dates and deadlines
Home work is assigned to each student	14-11-18 ; 12.00
Draft report sent to teacher & reviewers filename: "country"_HW2_1.doc	14-11-21; 18.00
Review comments sent to teacher and authors filename: "country"_HW2review_by"name"	14-11-24; 10:59
Review session and discussions in review groups (room 303 available, no teacher present)	14-11-25; 10:00-12:00
Send slides for oral presentation to teacher filename: "country"_HW2.ppt	14-12-03; 09:59
Oral presentation of HW2 Each review group will present together	14-12-04 ; 10.00-12:00 Max 5 min per country
Send final report version to teacher filename: "country"_HW2_2.doc	14-12-05; 11:59
Feedback and HW grading send to student	14-12-12; 12.00 latest

TODAY

- 10-11:
  - Intro to operator challenges
  - Info about part 2 and HW2
- 11-12:
  - Operator strategis and cooperation
  - Some theory for HW2

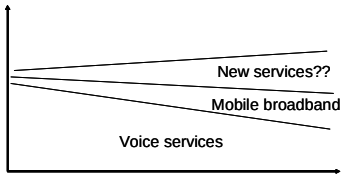
Two main parts

HW2 • First part is about overall picture, problems/ challenges related to operator busieness

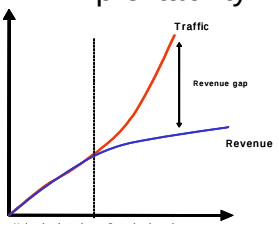
HW3 • Second part is about network challenges, relationships cost, capacity, performance, spectrum

Operator challenges – business related

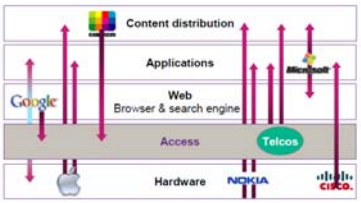
Revenue mix



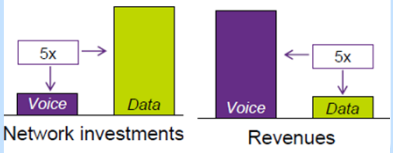
MBB profitability



The business landscape



Investments



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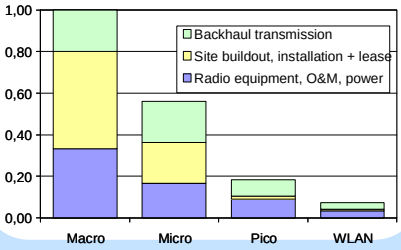
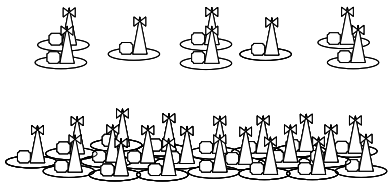
Operator challenges – network related

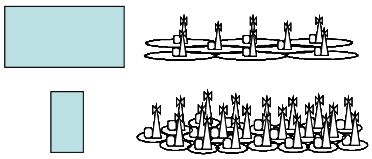
Cost structure



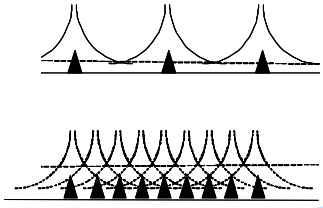
Scalability



Spectrum allocation



Data rate depends on range



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WHAT IS
Wireless Infrastructure Economics?

Costs, Prices, Revenues, Profits

Money related to capabilities and resources
Distribution of costs, cost structure models and analysis

Trade-offs between

Capacity
Performance

Network Costs
Amount of spectrum

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TODAY

- First part is about overall picture, problems and challenges
- **Where are the costs?**
- In the fixed/Broadband networks?
- In the Mobile Networks?
- In the Radio Access Network of the Mobile networks?
- In the Core Network of the Mobile Networks?
- For a Mobile Operator in general?
- **Where are the revenues? What kind of services?**
- Voice
- Messages
- Data
- Music
- Other services

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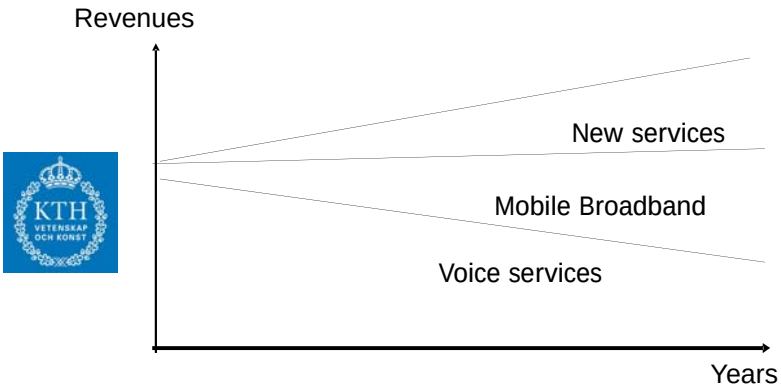
One motivation for our research
New services require new solutions



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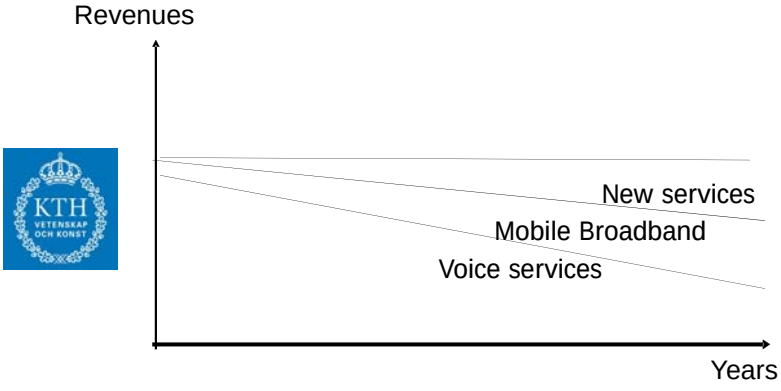
One motivation for our research
New services require new solutions



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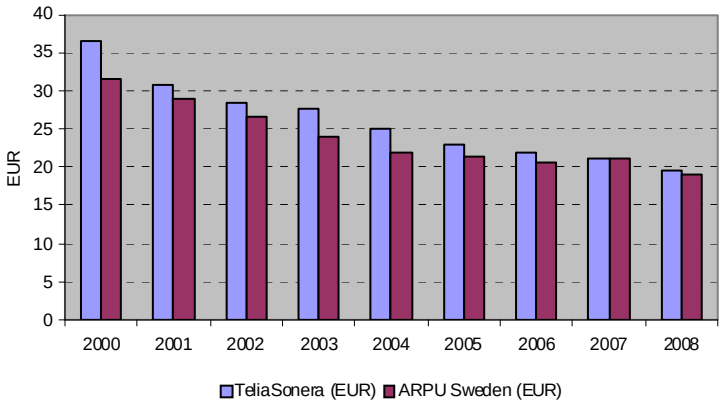
Revenues for mobile voice services in Sweden 2000-2008



From Mölleryd, Markendahl, Werding and Mäkitalo conference paper presented at CTTE 2010, May 2010

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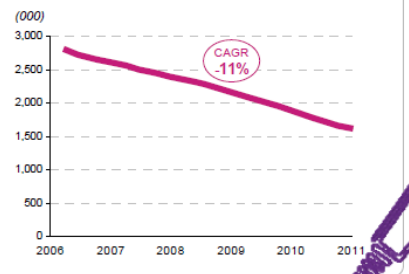
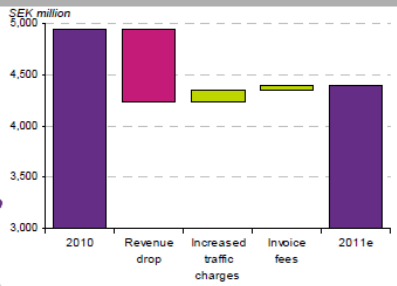
Controlled decline in consumer PSTN

Consumer PSTN development*



Initiatives to increase revenues*



* Example from Consumer segment Sweden

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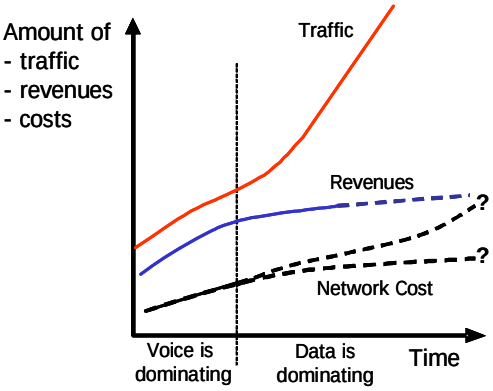
The revenue gap
”de-coupling” of traffic and revenues”

- Flat rate tariffs create large increase of data traffic
  - –Many GB per user per month
  - –Data traffic up >100 % per year
  - –Revenues do not follow



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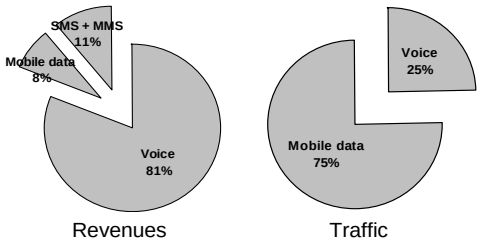
Traffic, prices and revenues



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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Traffic, prices and revenues

- Amount of voice data 10-20 MB per month
- Amount of mobile broadband data 1–20 GB per month
  - The number of mobile broad band bits are 100 – 1000 more than the number of voice bits
- But we pay more or less the same, i.e. the price per data bit is 100 – 1000 times lower => the cost per bit must be 100 – 1000 lower

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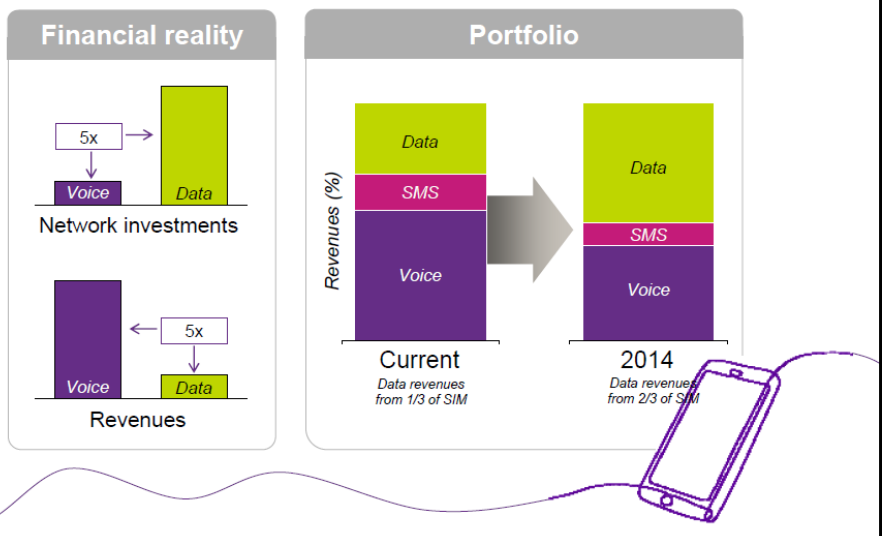
Rebalancing of pricing model needed



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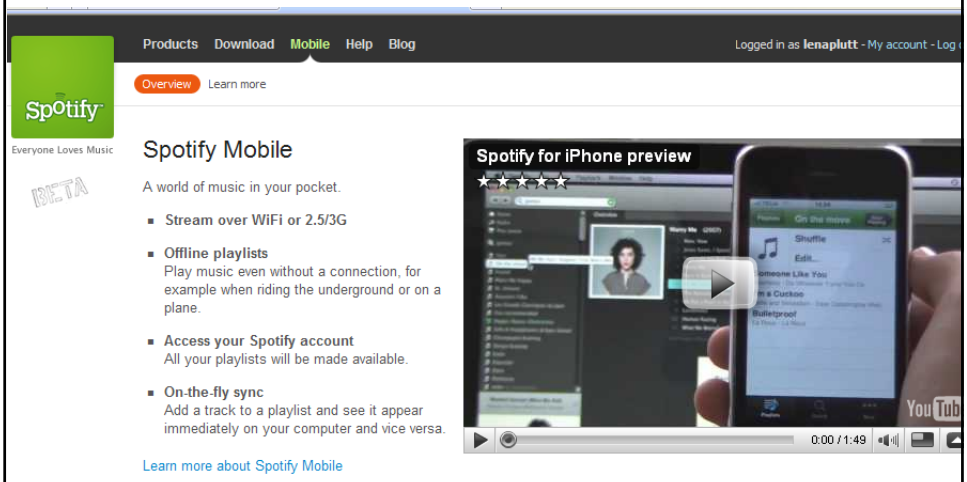
”New” services



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Source: IDATE

Revenue sharing for Apps?

Revenues from applications

	Previous	Now
Developer	20%	70%
Publisher	20%	0%
Aggregator	20%	0%
Operator	40%	0%
Handset supplier	0%	30%
	Type I-Mode	***Apple***

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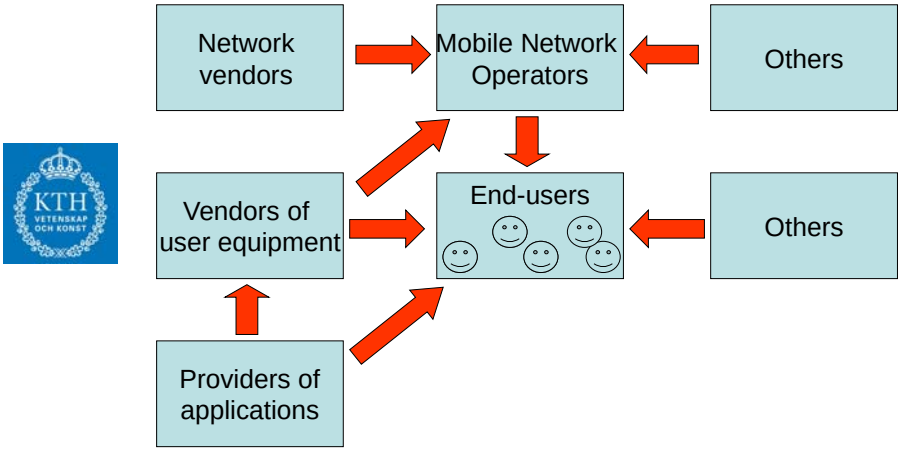
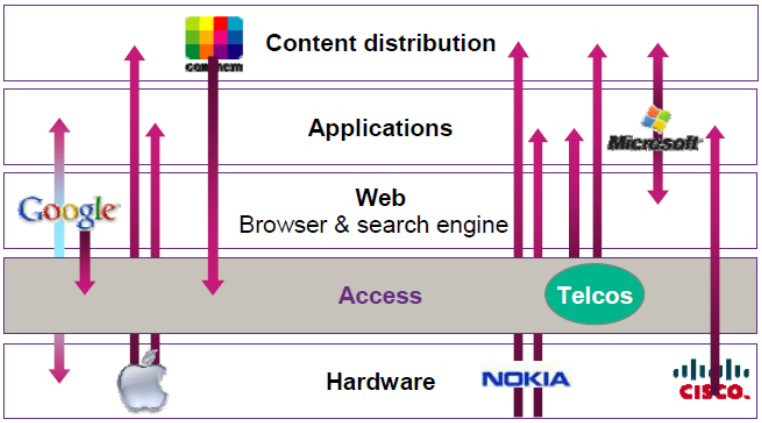
About actors and business

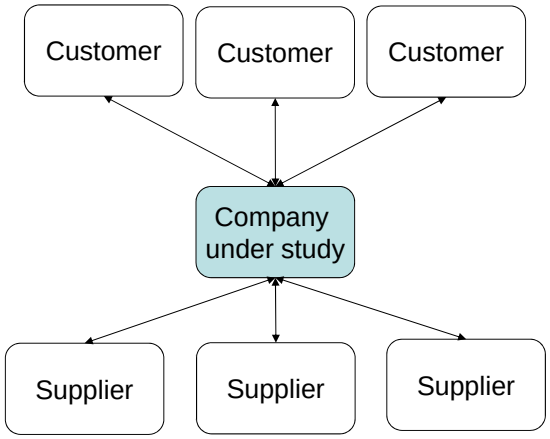


Changing competitive dynamics

Investor Day 2009



Cooperation:
Market Actors and Relations



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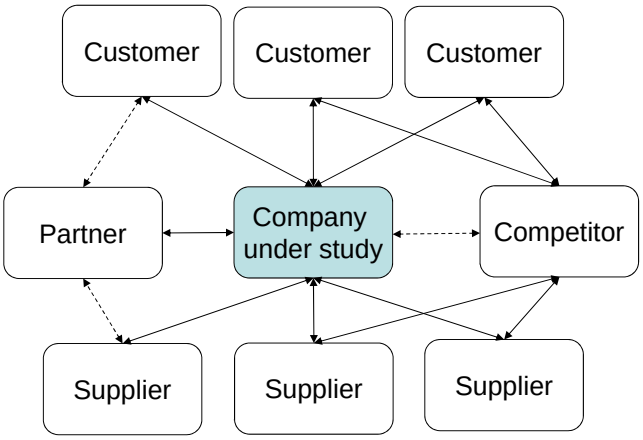

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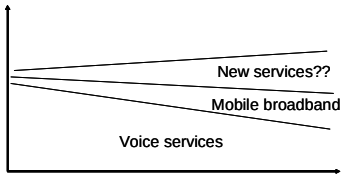
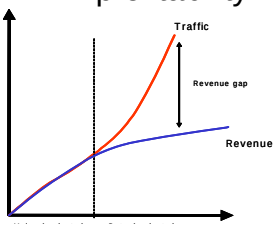
Operator challenges – business related

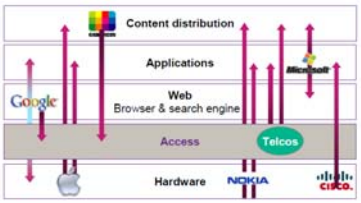
Revenue mix



MBB profitability



The business landscape



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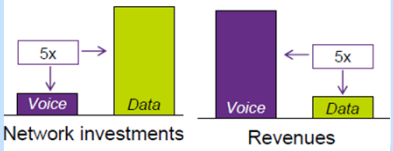

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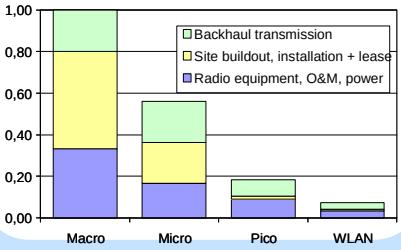
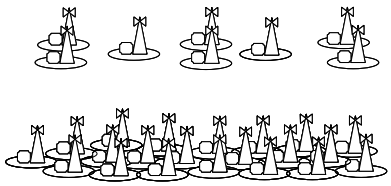
Operator challenges – network related

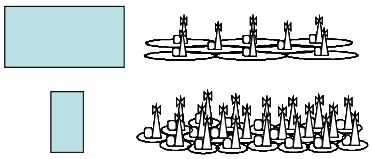
Cost structure



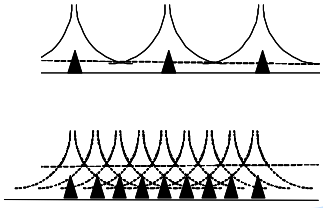
Scalability



Spectrum allocation



Data rate depends on range



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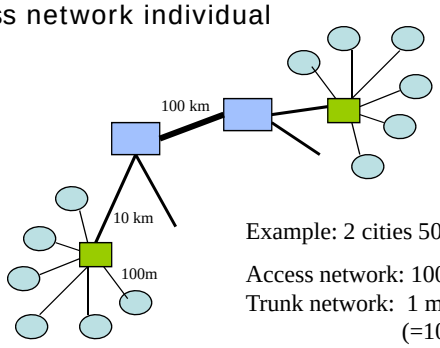
TODAY

- **Where are the costs?**
- In the fixed/Broadband networks?
- In the Mobile Networks?
- In the Radio Access Network of the Mobile networks?
- In the Core Network of the Mobile Networks?
- For a Mobile Operator in general?

The "last mile" problem: Most investments in Access Networks

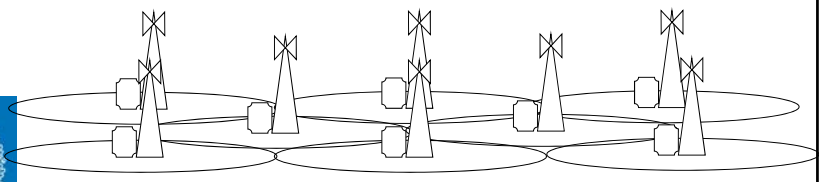
- Backbone network shared by many
- Access network individual



Example: 2 cities 50.000 user each

Access network: 100 m/user
Trunk network: 1 m/user
(=100 km/100.000 users)

Cellular networks in rural areas
– large coverage areas per base station
- few base stations per area unit

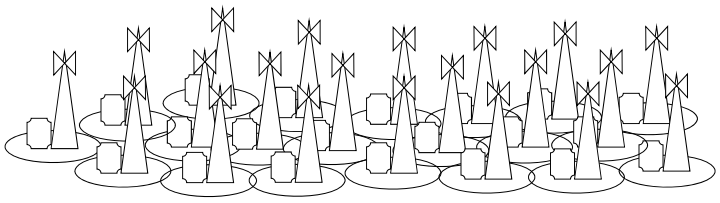


Range limitations

- Typical ranges (NLOS):
  - 10 kbit/s (GSM) 25+ km
  - 500 kbit/s (EDGE) 5-10 km
  - 2 Mbit/s (UMTS/) 2-3 km
  - 10 Mbit/s (HSPA) 500 m
  - 100 Mbit/s (LTE/WLAN) 50-150 m
- Coverage limited system

$$N_{BS} = \frac{A_{tot}}{A_{cell}} \propto \frac{1}{R^2}$$

Cellular networks in urban areas – many base stations per area unit



The infrastructure cost for capacity limited systems

- Spectrum limitation
  - B_{tot} available bandwidth
  - Spectral /reuse efficiency K

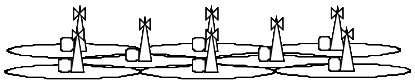
$$Cost \propto N_{BS} \propto \frac{N_{user} B_{user} K}{B_{tot}} A_{tot}$$

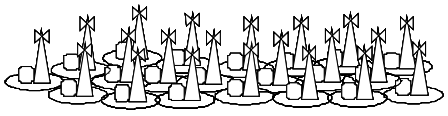
Cost structure

- Operator??
- Networks
- Radio access networks

Spectrum, capacity and cost

- High bandwidth means high capacity per site, i.e less number of base station sites

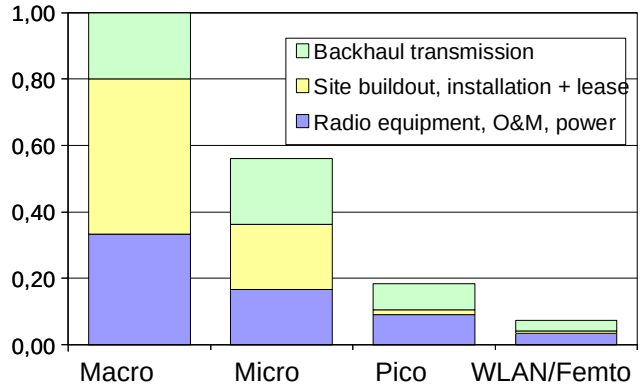




Cost structure of radio access networks

- 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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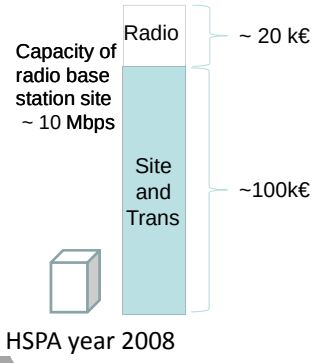
Cost structure, bandwidth and capacity



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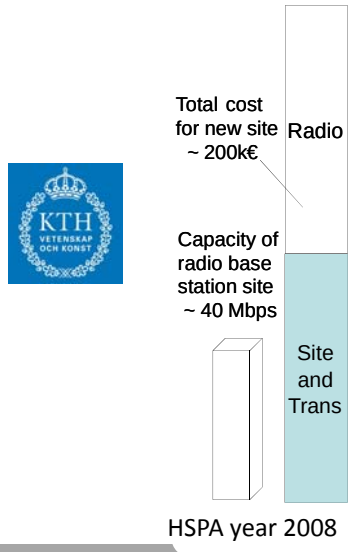
Cost structure, bandwidth and capacity



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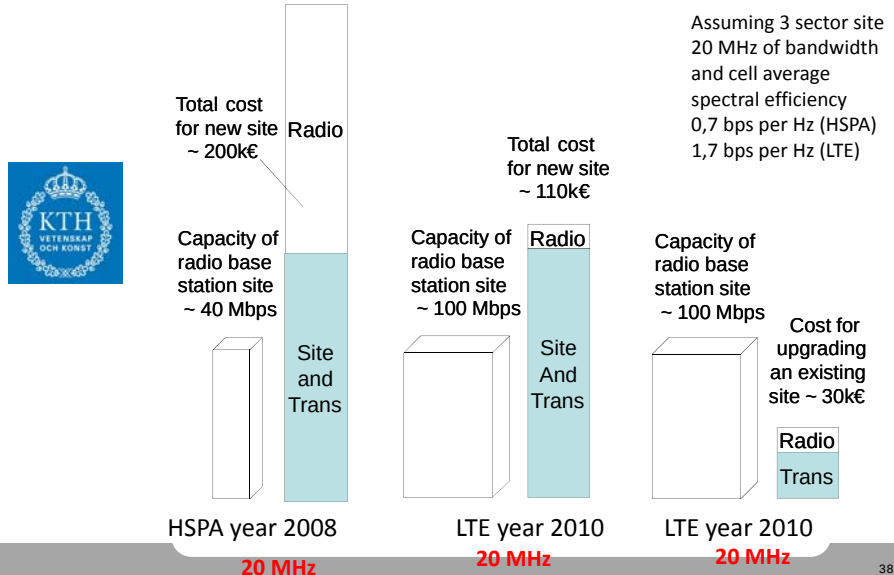
Cost structure, bandwidth and capacity



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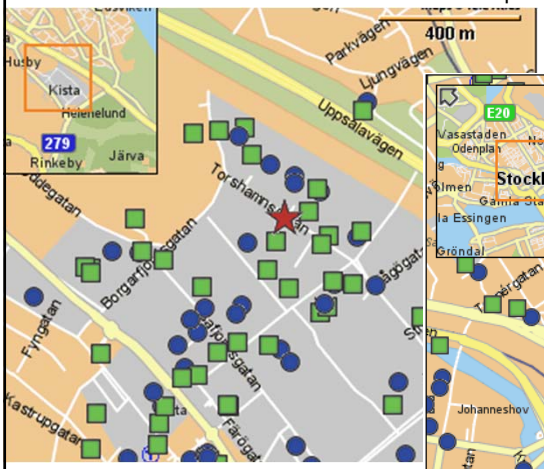
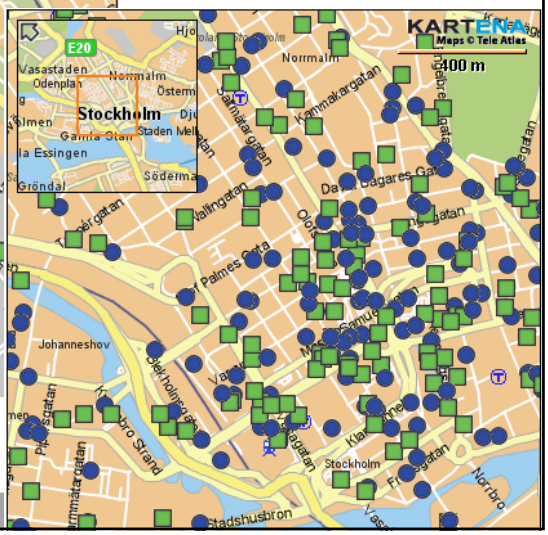
Base station site location in urban areas

from PTS "Transmitter map" web page, December 2009



Kista Industry Area

Downtown Stockholm



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

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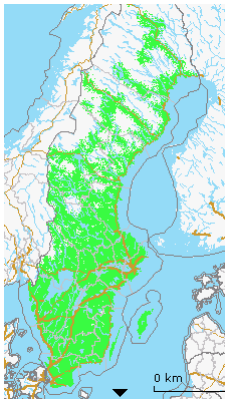
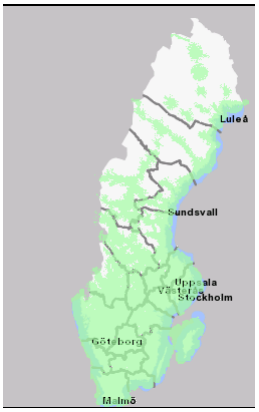
GSM Coverage

Tele2 - Telenor - Telia



~70% covered area



~65% covered area

~90% covered area

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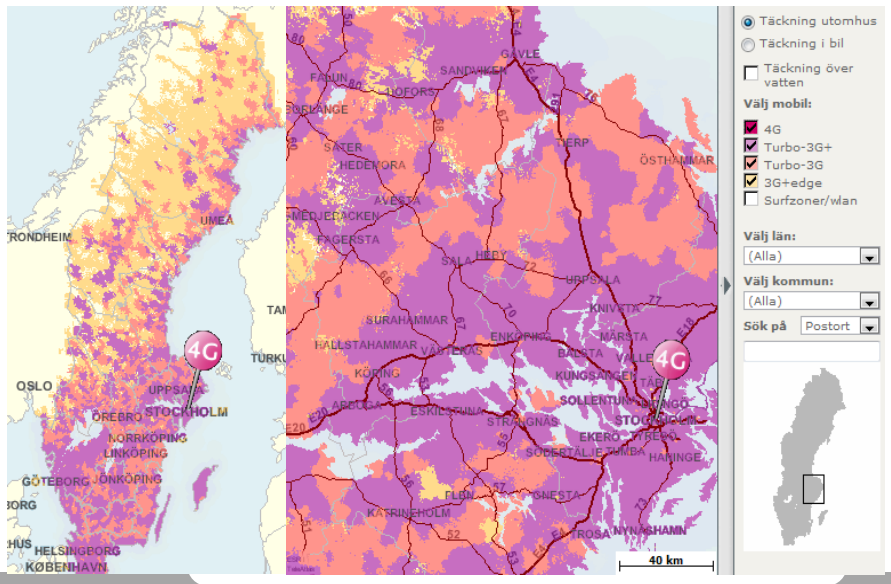
Coverage maps – Telia web page



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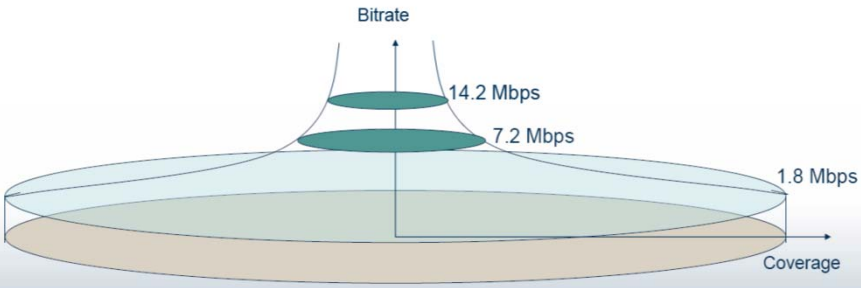
From Ericsson:
Capital markets day, May 2008

Coverage vs. bitrate



Double peak rate does not correspond to double capacity

ERICSSON

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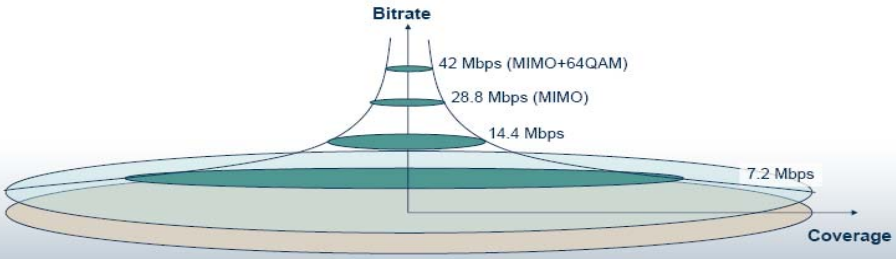
From Ericsson
Capital markets day
May 2009

Relation between Peak Rate & Coverage



Capacity does not scale with peak rate

ERICSSON

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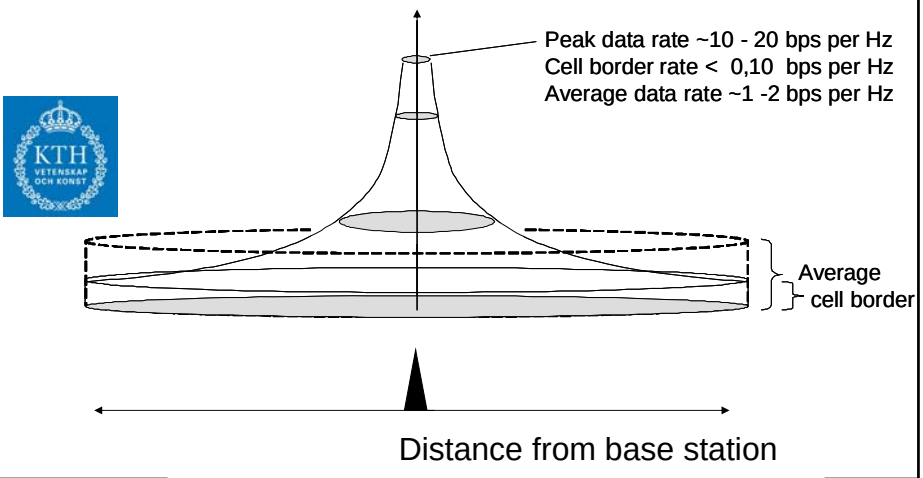
To improve the spectral efficiency
– i.e. more bits/second per Hz of spectrum



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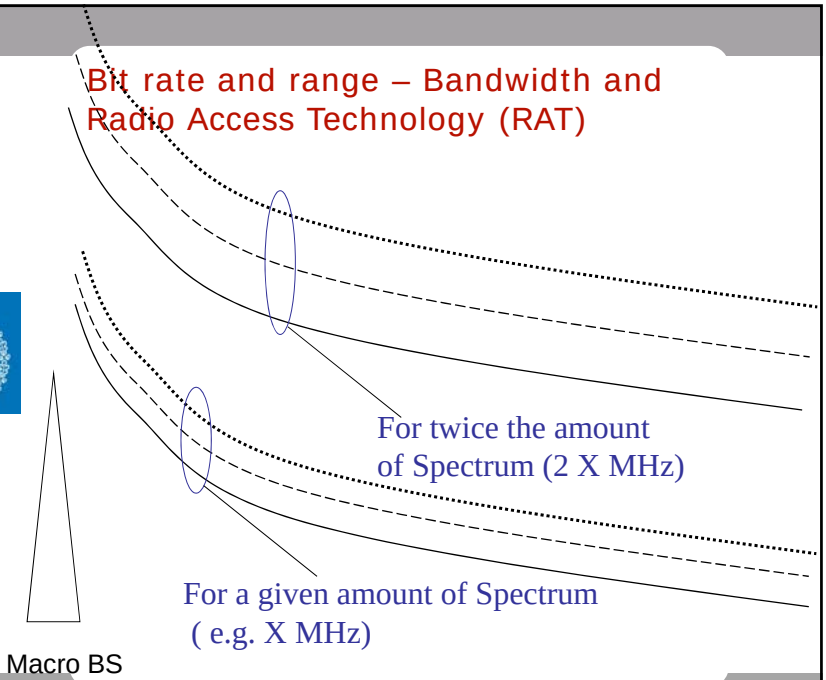
Bit rate and range – Bandwidth and Radio Access Technology (RAT)



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- Telenors löften helt orealistiska

KTH-professor dömer ut kampanj om nya mobilnätet
Av: Helen Ahlbom 93 kommentarer
Publicerad 20 maj 2009 00:00

Telenor lovar hastigheter på 150 megabit/s till nästan hela svenska folket i sin senaste reklamkampanj. Det är fullständigt orealistiskt om man inte bygger 100 000-tals nya basstationer, anser Jens Zander, professor i radioteknik på KTH.

"Leve Allemansrätten!" utropar Telenor i reklamfilmer och stora affischer över hela landet. "Nu bygger vi Sveriges modernaste mobilnät. Det ger mer än 99 procent av svenska folket 150 Mbps via luften", utlovar bolaget på reklamplats.

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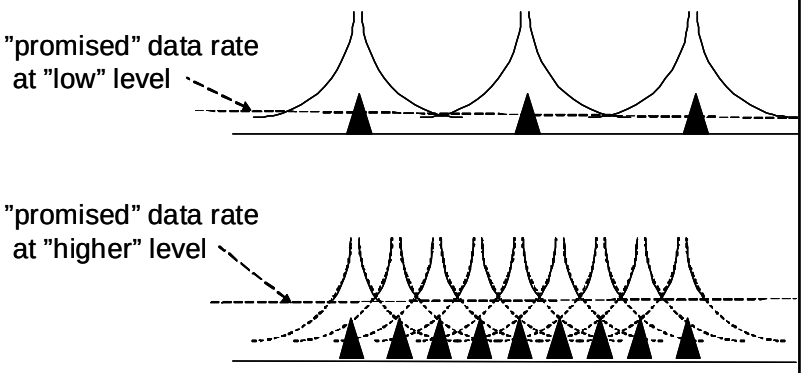
”Offered” bit rate vs coverage & load



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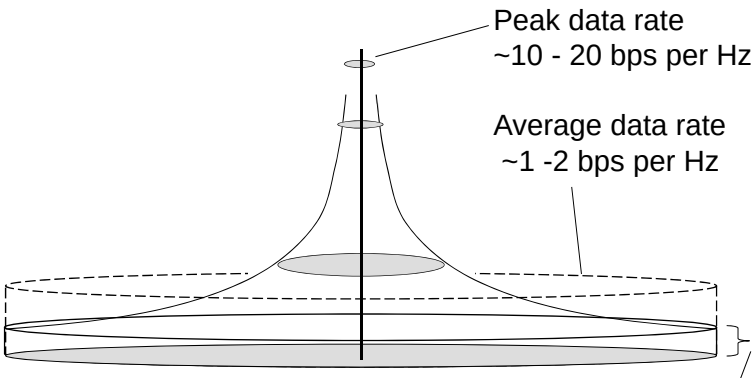
Spectral effiency



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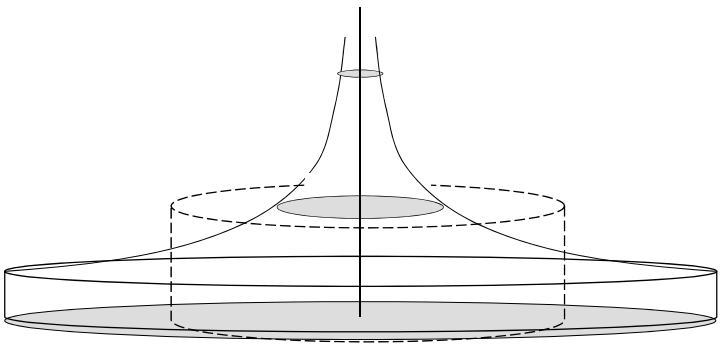
Spectral effiency and cylinder model



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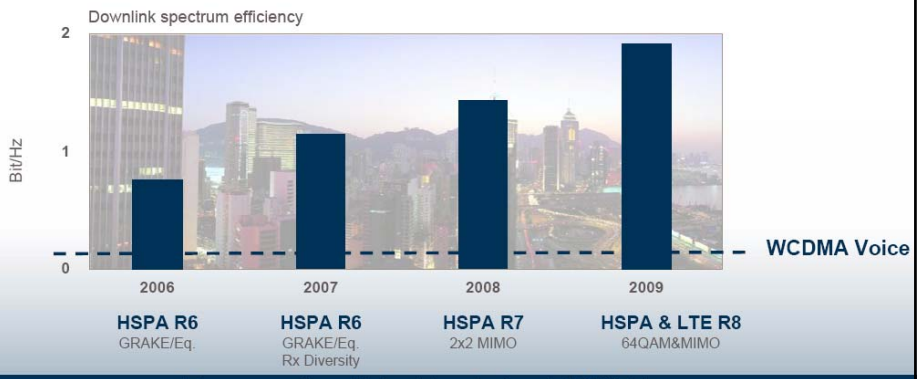
From Ericsson:
Capital markets day, May 2008

HSPA and LTE capacity evolution



The capacity will double – but not 100 fold

ERICSSON

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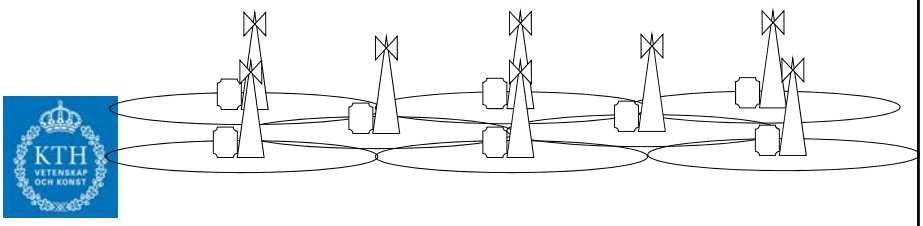

Cellular systems - low data rates

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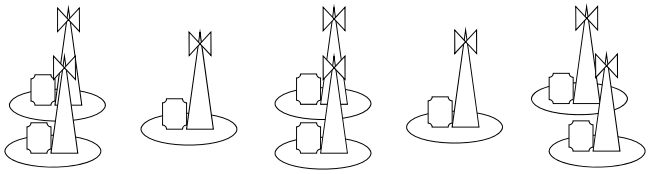
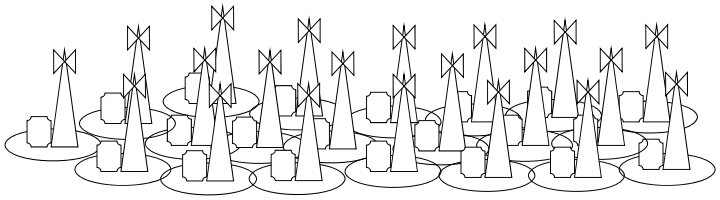


Cellular systems – higher data rates, the same sites

Zander formula

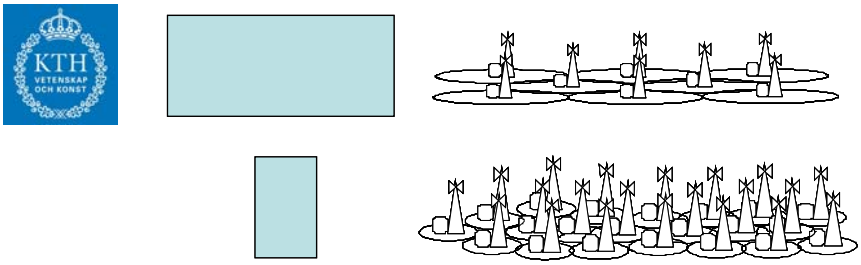


$$C_{system} \approx c_{AP} N_{AP} \approx c' N_{user} B_{user} A_{service} f(Q)$$

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.

Spectrum, capacity and cost

- High bandwidth means high capacity per site, i.e less number of base station sites



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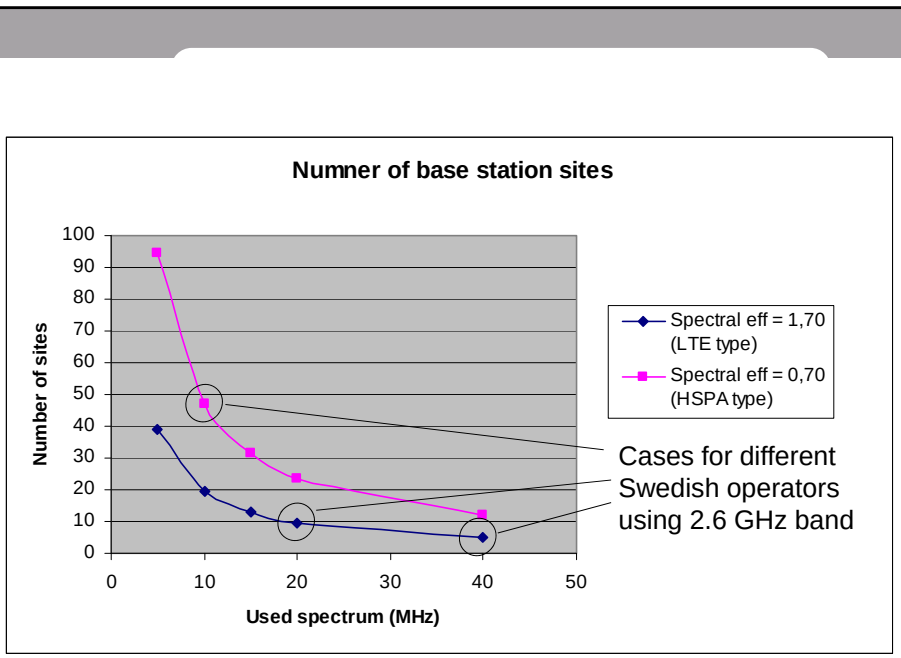

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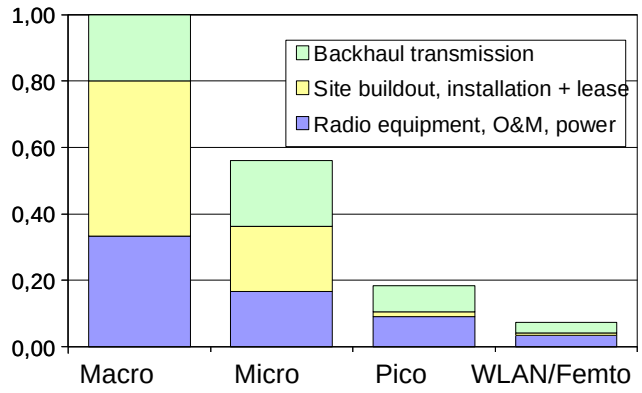
Cost structure of radio access networks

- 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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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

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Cooper´s law

- "the number of "conversations" that can theoretically be conducted over a given area in all of the useful spectrum is doubled every two-and-a-half years (www.arraycomm.com/technology/coopers-law)
  - The improvement in spectrum utilization has been over a trillion times in the last 90 years and a million times in the last 45 years.
- "Of the million times improvement in the last 45 years,
  - 25 times were the result of being able to use more spectrum
  - 5 times can be attributed to the ability to divide the radio spectrum into narrower slices
  - Modulation techniques like FM, SSB, time division multiplexing, another 5 times or so
  - The remaining **sixteen hundred times** improvement was the result of confining the area used for individual conversations to smaller areas, what we call spectrum re-use".

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To offload data traffic from the macrolayer

From Vodafone:
Investor relation info, March 2008

- Assessing the technical potential of 3G Femtocells to:
  - improve indoor coverage
  - reduce the cost of wide area network rollout
  - reduce need for capacity in macro network
- Trials
  - lab trials successfully completed
  - field trials now underway with two vendors in Spain
- Potential benefits
  - brings dedicated 3G coverage into the home
  - offloads heavy data users from the wide area network in dense urban areas resulting in reduction in RAN capex where deployed

Innovative products delivering low cost enhanced indoor customer experience

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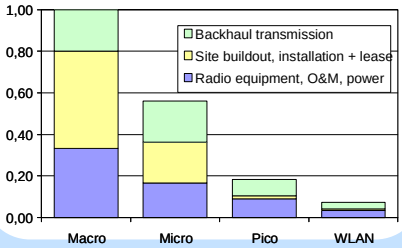
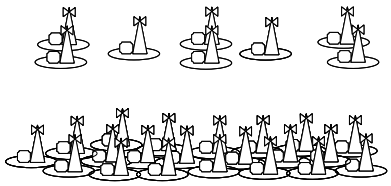
Operator challenges – network related

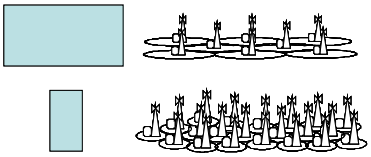
Cost structure



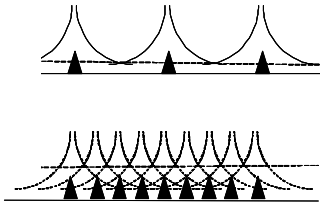
Scalability



Spectrum allocation



Data rate depends on range



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Thanks for your attention

- Link to my PhD Thesis, February 2011
  "Mobile Network operators and cooperation
  – A tele-economic study of infrastructure sharing
  and mobile payment services"
  http://www.impgroup.org/dissertations.php
- Link to Telia investor relation information
  http: //www.teliasonera.com/investors/reports-and-presentations/presentations/

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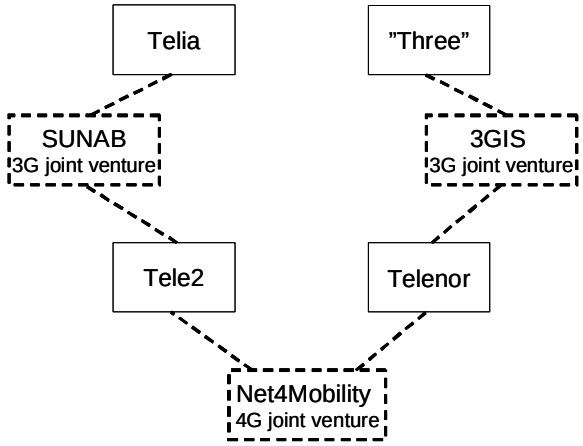
Network sharing in Sweden – joint ventures



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Industry focus

- Three main strategies to increase radio network capacity is described (Landström et al, 2011). ;
  - to improve the performance of the macro layer,
  - to build a denser macro layer (more base stations)
  - to add low power pico or femtocell base stations
- Current focus for R&D and standardization
  - To increase the peak data rate
  - To combine spectrum into larger chunks
  - To offload heavy data traffic from macro layer to local networks: picocells, femtocells or WiFI

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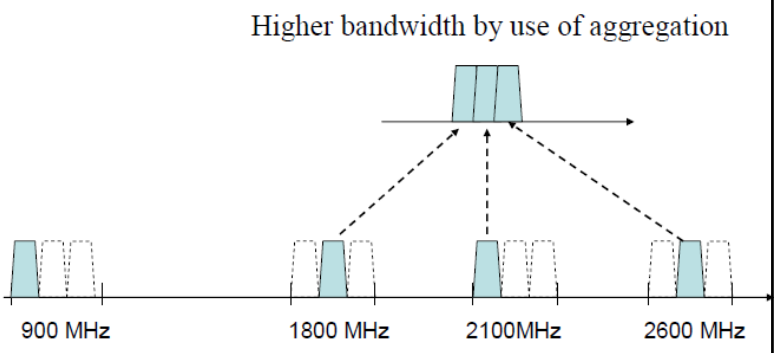
Data rate, bandwidth and aggregation of carriers or bands

- The higher bandwidth the higher the data rate



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Innovative products delivering low cost enhanced indoor customer experience

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To handle increasing user demand

- Two main development paths
  - Improve network performance and capacity
  - Add more spectrum
- Current focus for R&D and standardization
  - To increase the peak data rate
  - To combine spectrum into larger chunks
  - To offload heavy data traffic from macro layer to local networks: picocells, femtocells or WiFI

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BUT, there are two ”buts”

1. Spectrum alone is not the main issue
   - The traffic increases 1000 times the coming years
   - Only 2 – 5 times more spectrum is discussed
2. Regions and countries in the world are different
   - The world it is not like a ”Sweden XL”
   - In countries like Sweden and Germany :
     - There is a lot of fixed line infrastructure
     - Operators have ”quite a lot of” spectrum

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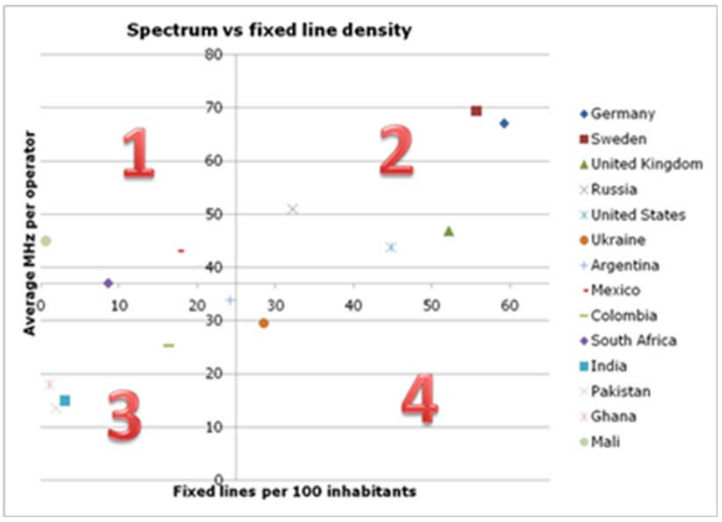
Differencies between countries



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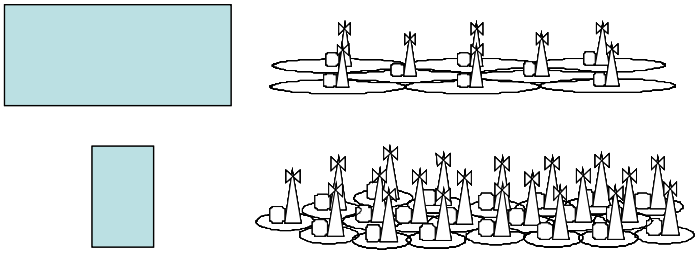

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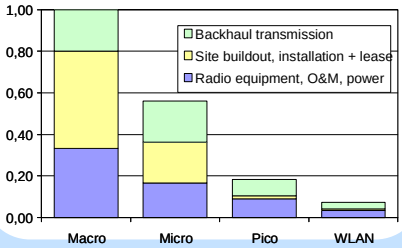
Operator challenges – network related

Cost structure



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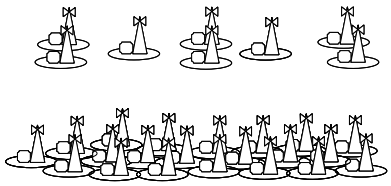

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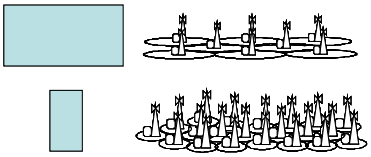

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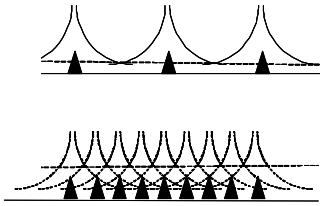
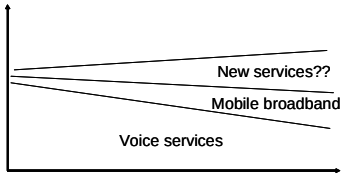
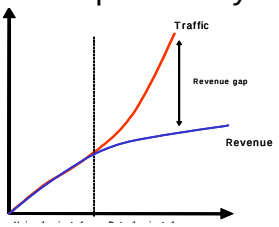


Operator challenges – business related

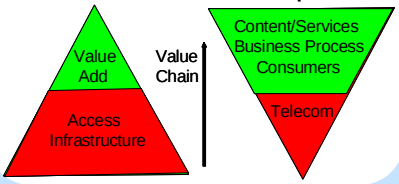
Revenue mix



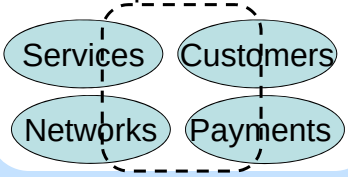
MBB profitability



Changing business landscape



What to handle for operators?



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

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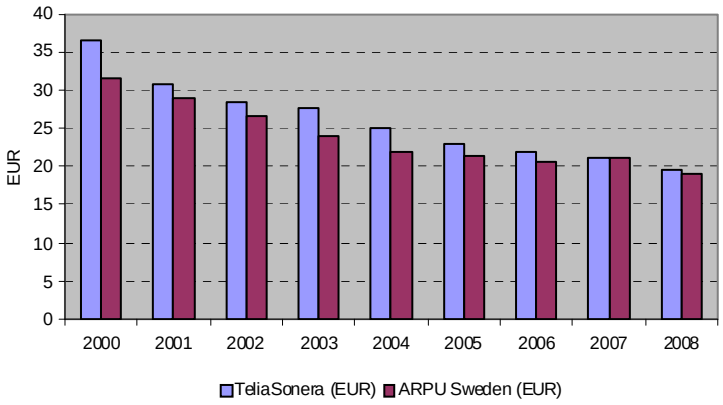
Revenues for mobile voice services in Sweden 2000-2008



From Mölleryd, Markendahl, Werding and Mäkitalo conference paper presented at CTTE 2010, May 2010

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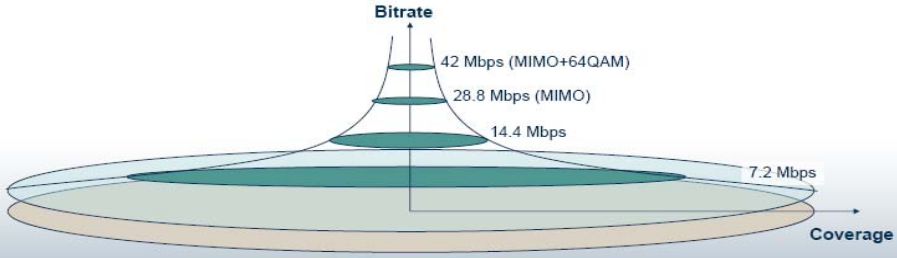
From Ericsson
Capital markets day
May 2009

Relation between Peak Rate & Coverage



Capacity does not scale with peak rate

ERICSSON

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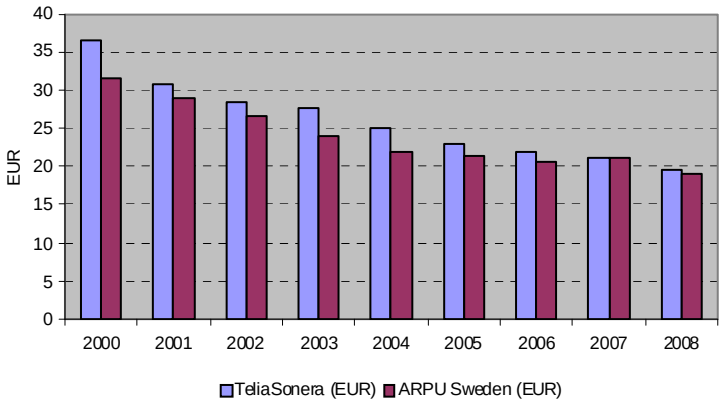
Revenues for mobile voice services in Sweden 2000-2008



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