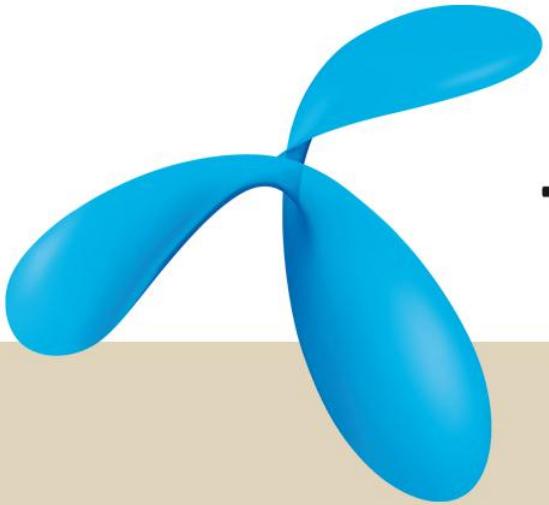

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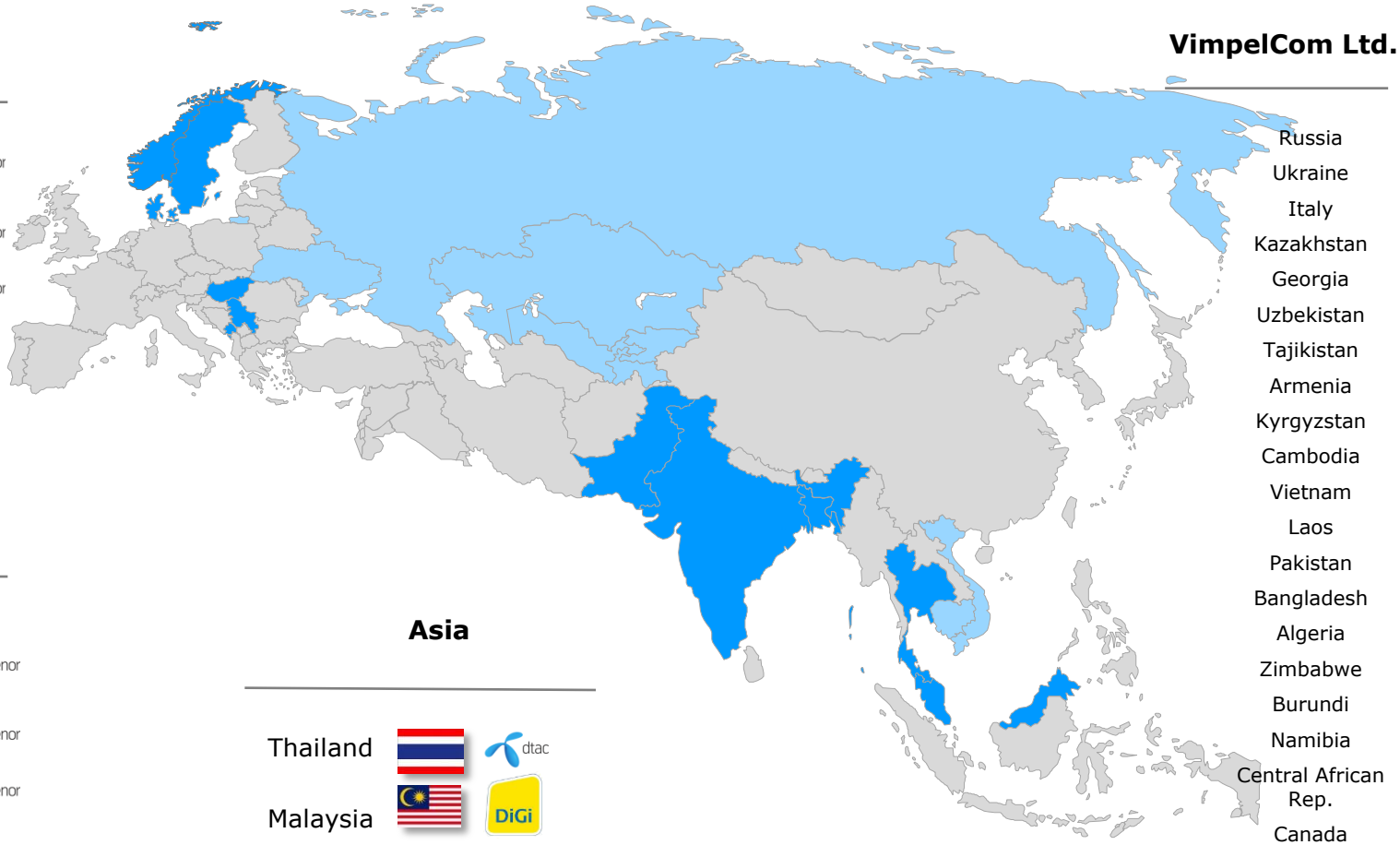
Refarming and other challenges for mobile communications

Guest lecture at UNIK4230 – Mobile communications

Rune Harald Rækken, Head Technical Vendor Development, Telenor Group

19th April 2012

Telenor Group mobile operations



Nordic

- Norway
- Sweden
- Denmark

Central and Eastern Europe

- Hungary
- Serbia
- Montenegro

Asia

- Thailand (dtac)
- Malaysia (DiGi)
- Bangladesh (grameenphone)
- Pakistan (telenor)
- India (uninor)

VimpelCom Ltd.

- Russia
- Ukraine
- Italy
- Kazakhstan
- Georgia
- Uzbekistan
- Tajikistan
- Armenia
- Kyrgyzstan
- Cambodia
- Vietnam
- Laos
- Pakistan
- Bangladesh
- Algeria
- Zimbabwe
- Burundi
- Namibia
- Central African Rep.
- Canada

Telenor Group holds 31,7% of the economic ownership in VimpelCom Ltd.

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Agenda

1	Background – Technology and frequency bands
2	Challenges for mobile operators
3	Heterogeneous networks
4	The concept of re-farming and its motivation
5	Planning the future – A portfolio of frequency spectrum

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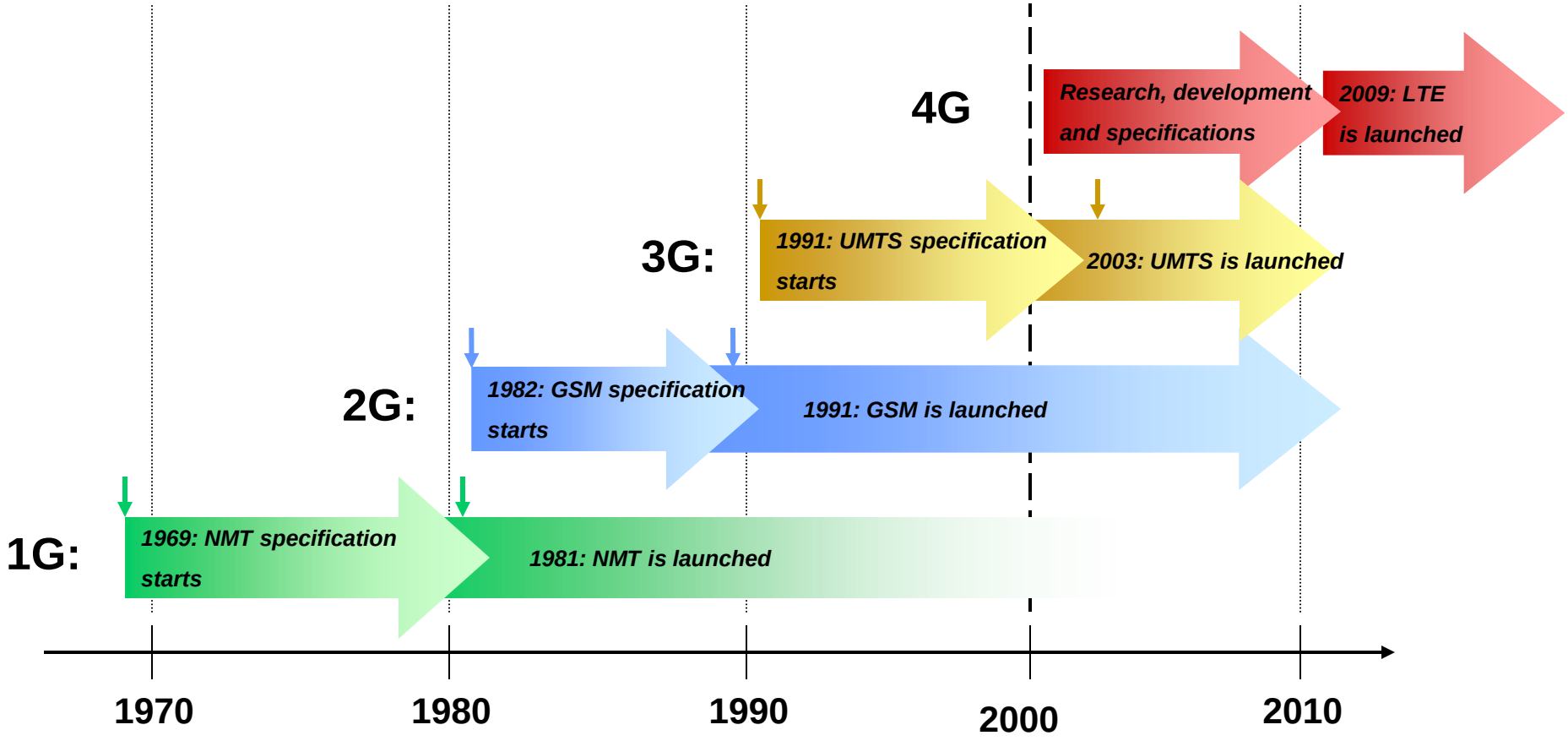
Mobile communications: ”The generation game"



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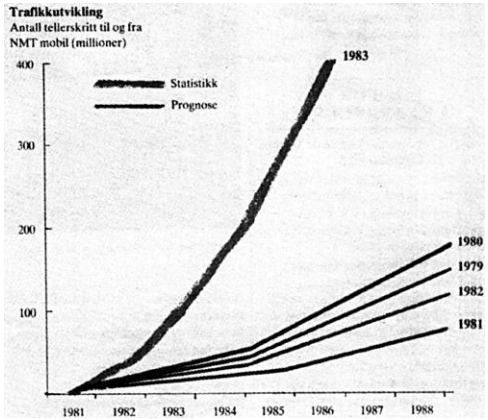
NMT – 1st generation

In 1986 approx. 87 000 subscribers i Norway

- Capacity problems

Closed down 2001

- Frequencies freed for other systems

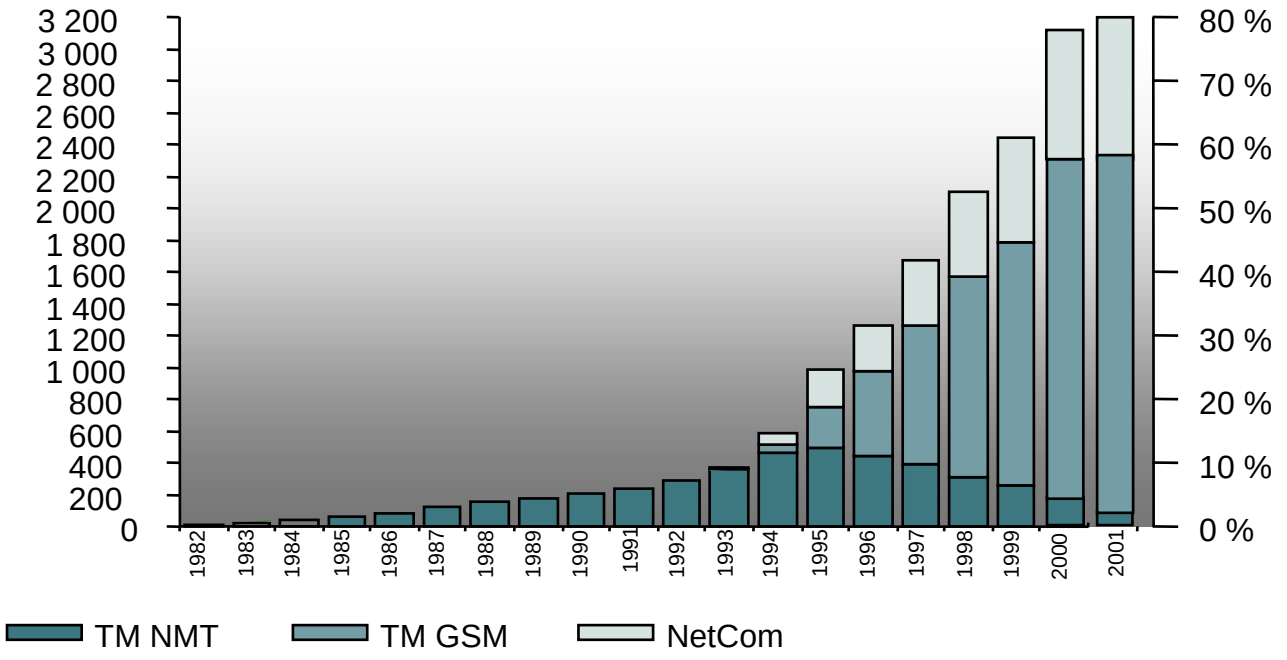


GSM – 2nd generation

1991: First operational GSM network in Finland: Radiolinja

1993: Tele-mobil (later: Telenor Mobil) and NetCom GSM open their networks in Norway

1998: GSM 1800 is deployed to increase capacity in cities and other densely populated areas



UMTS – 3rd generation

The first UMTS networks in Europe started in 2003 (Sweden, Italy, UK, Austria..). Norway: 2004

The most important differences from 2G were:

- Global standard (but with regional variations)
- Higher datarates (up to 2 Mbit/s defined, typically 384 kbps achieved in first phase)
- Improved multimedia support and security

Does not take over from 2G – supplements

Slow start – real breakthrough not until Mobile Broadband in 2006/2007

- High Speed Packet Access (HSPA) – ”Turbo 3G”

3G handset penetration in “Telenor countries” 30.08.2010:

Sweden	Norway	Den-mark	Malay-sia	Serbia	Hung-ary	Ukraine	Thai-land	Bangla-desh	Paki-stan
73%	**53%**	**42%**	**21%**	**16%**	**16%**	**10%**	**9%**	**4%**	**3%**

LTE – 4th generation

Data (IP) only

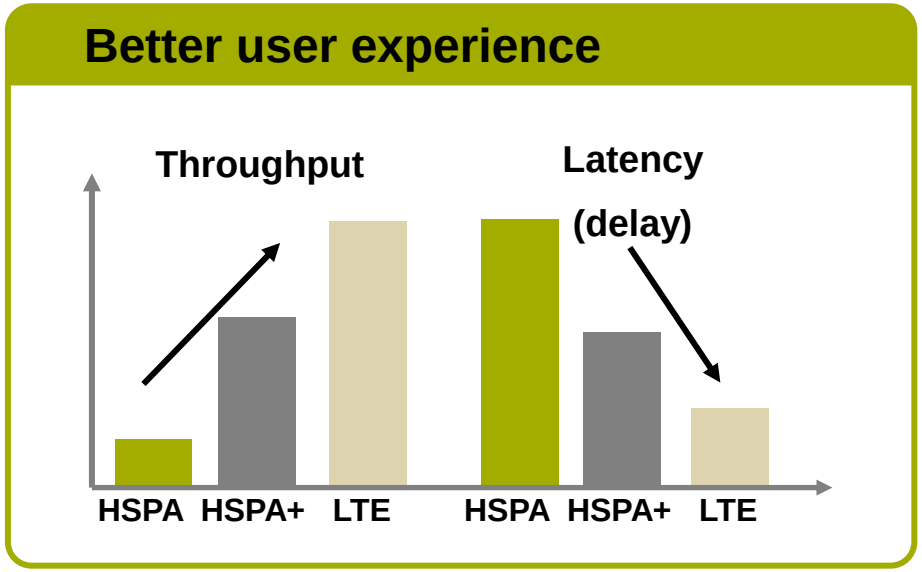
Laptop/PC support only in first phase

Mobility towards 2G/3G

Benefits from 2G and 3G ecosystem

First commercial launch:

- Sweden and Norway Dec 2009 (TeliaSonera)



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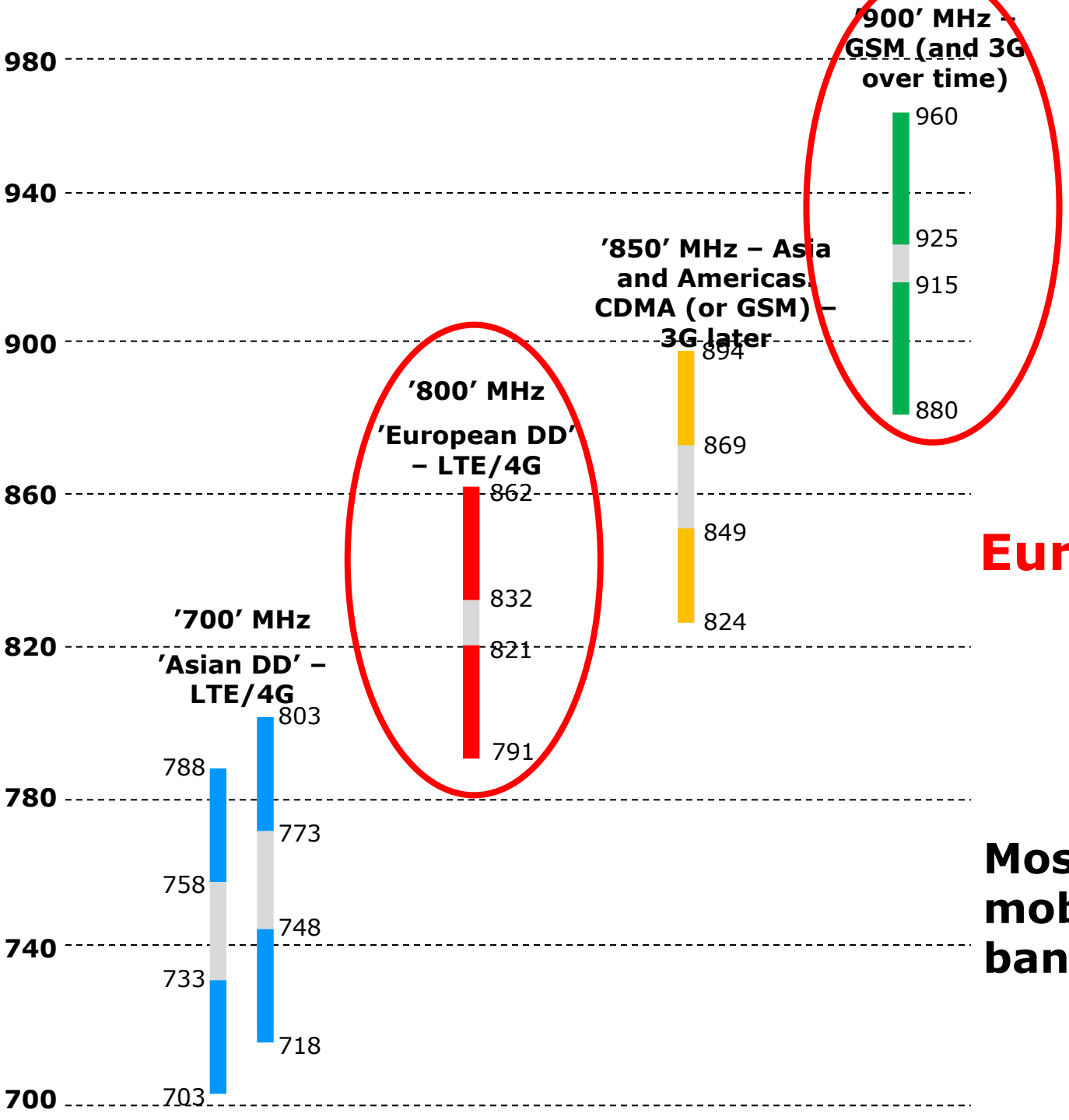

Europe

Most important mobile "Coverage bands"

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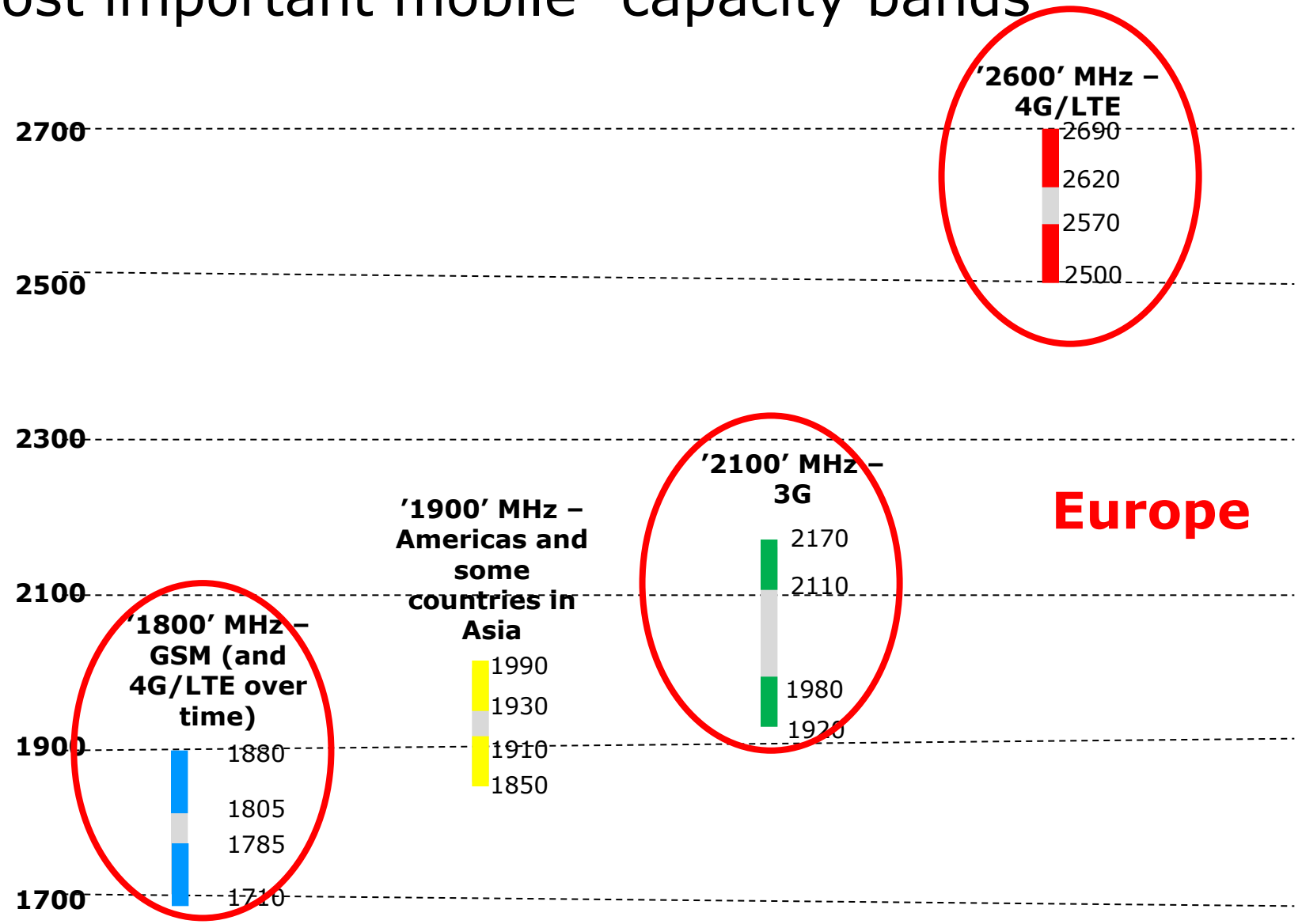
Most important mobile “capacity bands”



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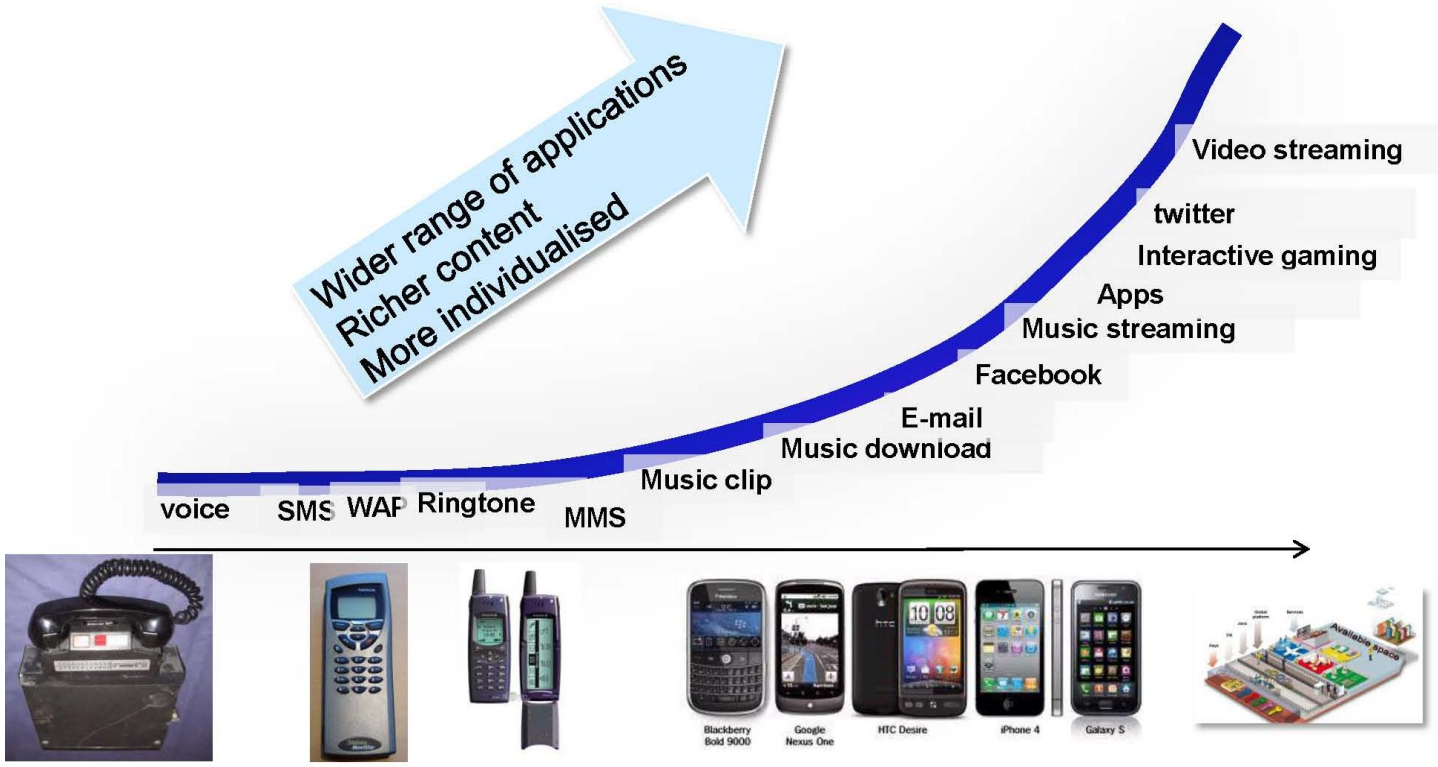
Challenge: Smartphones driving traffic explosion

Data and signalling



Handsets becoming more powerful and versatile

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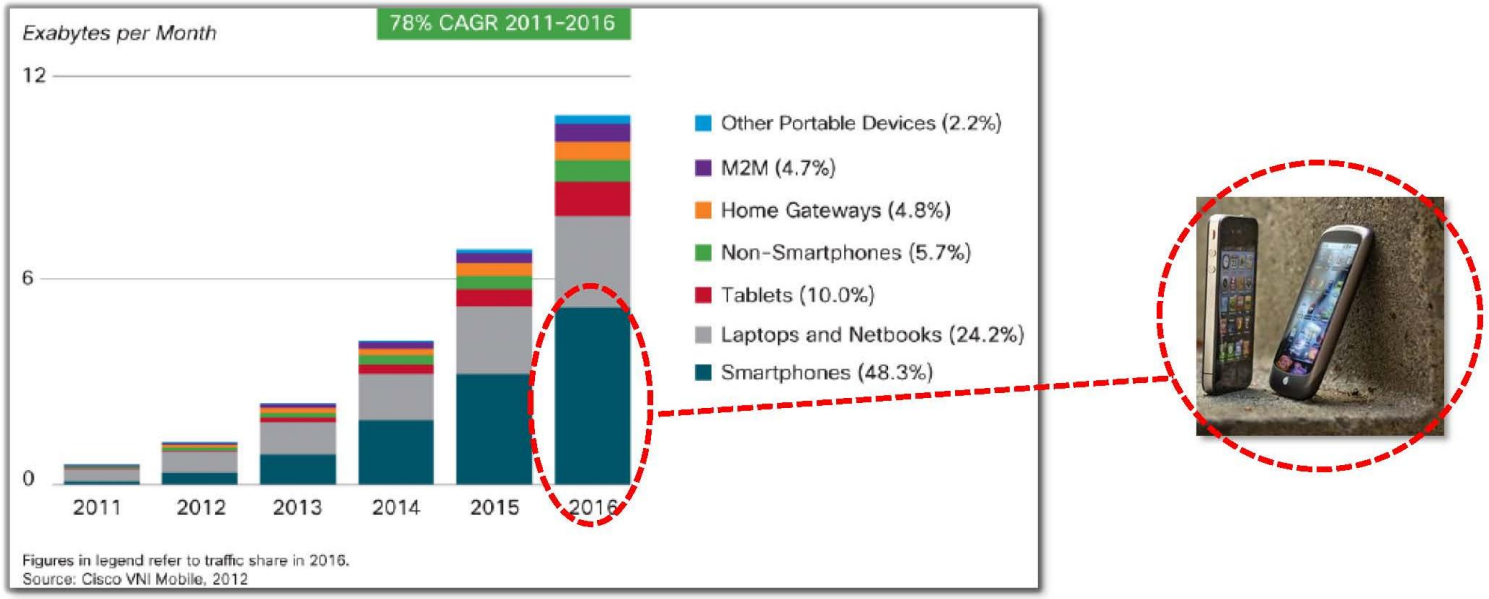
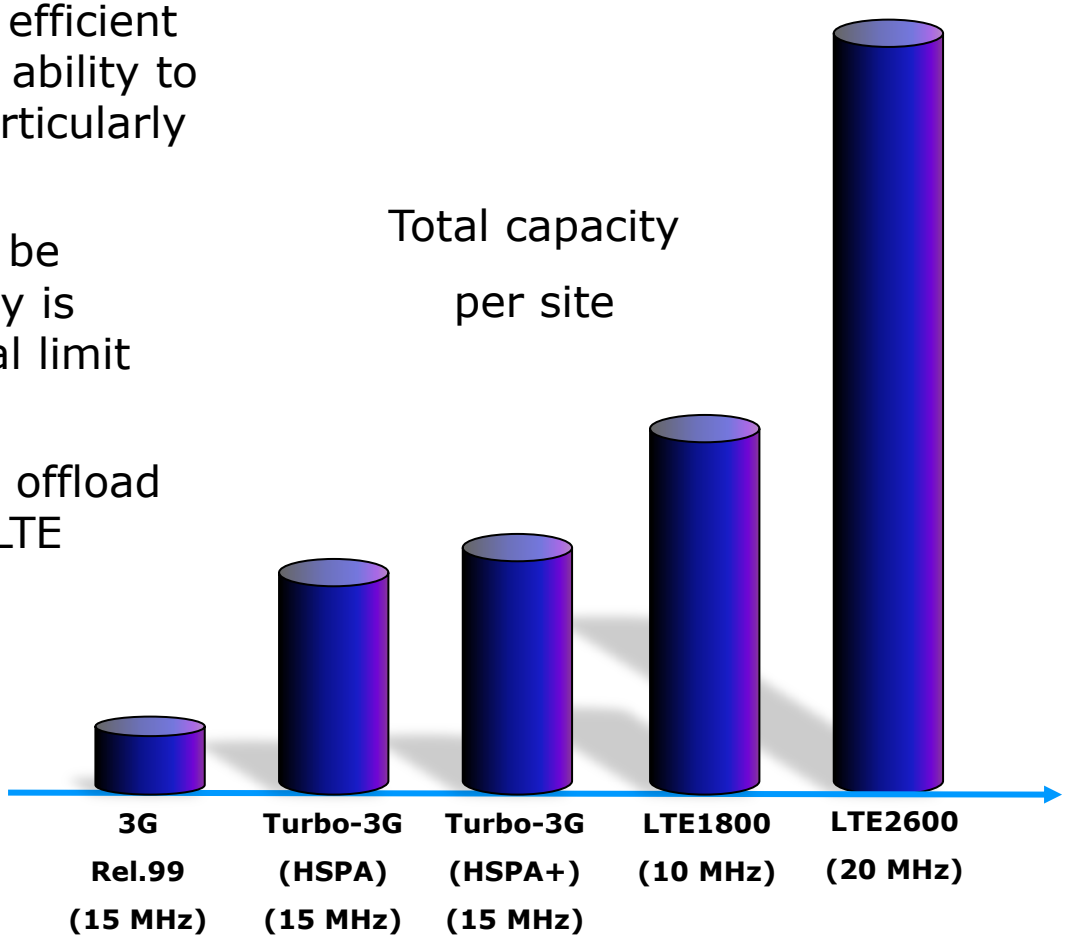
Challenge: Current network is not ready for the expected traffic growth



- Exponential growth in data traffic in mobile broadband
- Customer expectation is rising quickly
- Current mobile network is based on macro (large) sites
- Adding costly macro sites in certain geographical areas is challenging because of unsuccessful site acquisition
- The majority of mobile broadband users are indoors

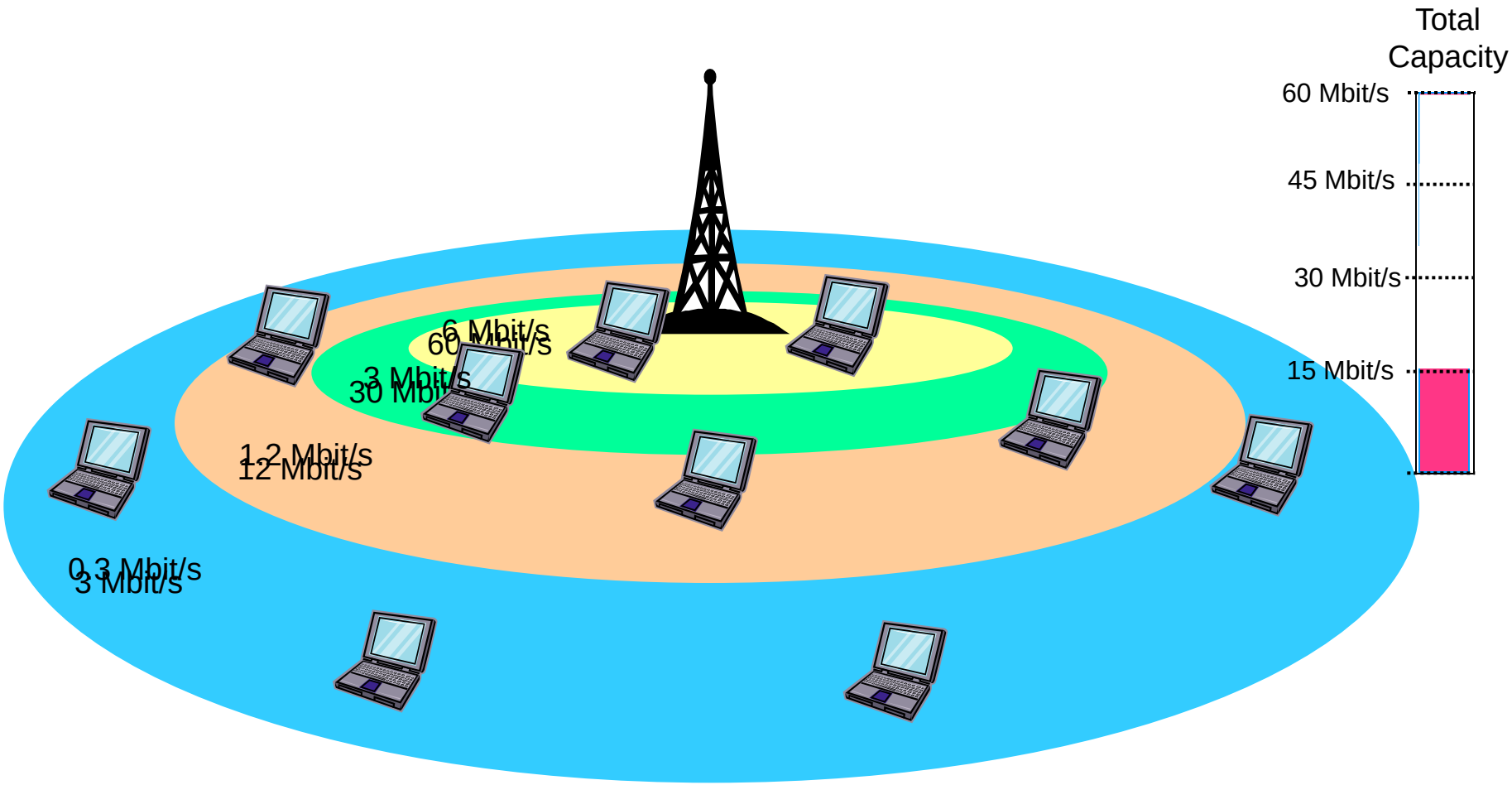
Challenge: Upgrading to LTE is not enough for managing data growth

- Despite being 50-100% more efficient than 3G, LTE will have limited ability to serve future MBB demand, particularly for indoor users.
- Future LTE improvements will be limited because the technology is already close to the theoretical limit for spectrum utilization.
- It will take time befor LTE can offload 3G due to low penetration of LTE terminals in market



Radio capacity to be shared amongst the active users

Download data rates depending on distance to base station as well as number of simultaneous users



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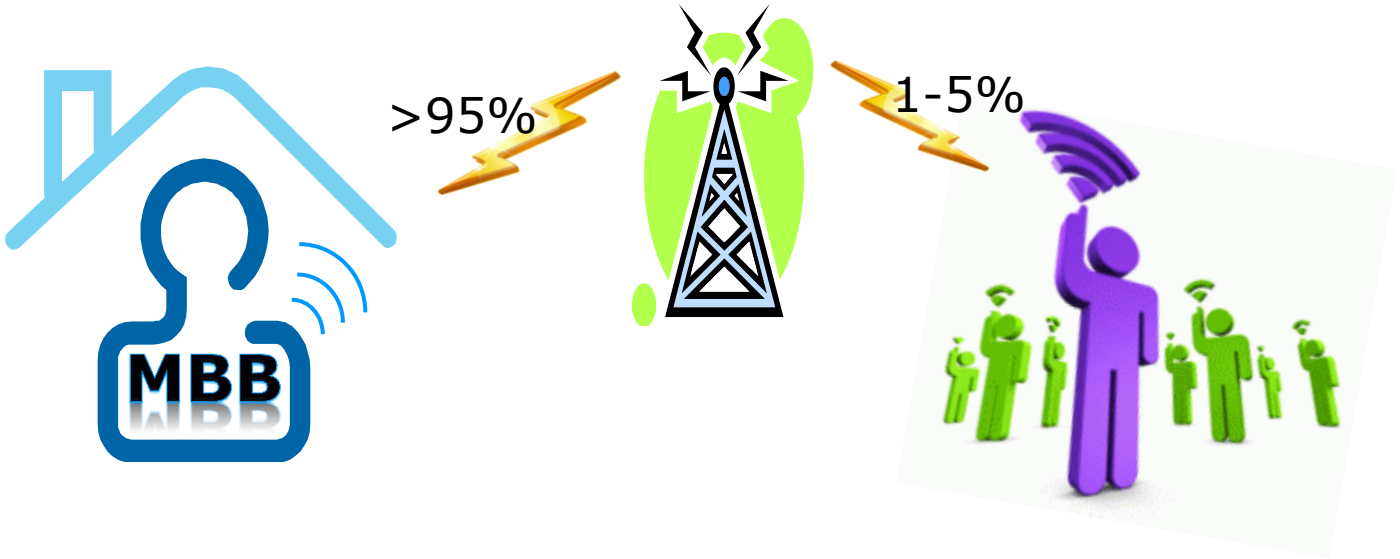
Challenge: Indoor users place additional strains on macro network resources



1. Analysis Mason: Nearly 90% of MBB users will be indoor
2. An indoor user occupies up to 10 times more macro cell capacity per consumed Byte => up to 10 times the cost

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Challenge: Operating multiple technology generations in parallel

	Technology	Typical Usage	Typical terminal	Handset penetration (Norway 2011)
2G	GSM/GPRS	Voice, messaging	Handsets	100%
3G	UMTS/HSPA/ HSPA+	Voice, handset data, mobile broadband	Handsets, dongles	60%
4G	LTE	Mobile broadband	Dongles, PC cards	0%

Operate 2G because:

- *Legacy handsets*: Long time till all handsets support 3G
- *Footprint*: Operators do not have the same coverage for 3G as 2G

Operate 3G because:

- *Efficiency*: More efficient than 2G
- *Mobile broadband*: Data rates and capacity
- *Terminals*: 4G not a handset technology (yet), long time till penetration reaches significant levels

Operate 4G because:

- *Efficiency*: More efficient technology
- *Cost*: Lower production cost

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Challenge: Coverage, capacity and spectrum (1)

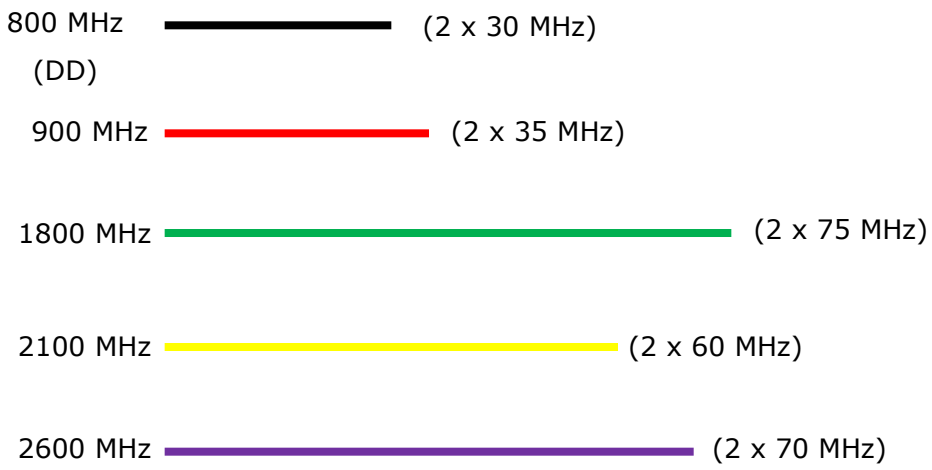
For each country and region there is a finite and predictable amount of frequency spectrum available

'Low frequencies' (<≈ 1000 MHz): Larger range – 'Coverage bands'

'High frequencies' (>≈ 1000 MHz): Larger bandwidth available – 'Capacity bands'

A mix of 'low' and 'high' frequencies will normally be desirable

European frequency bands:



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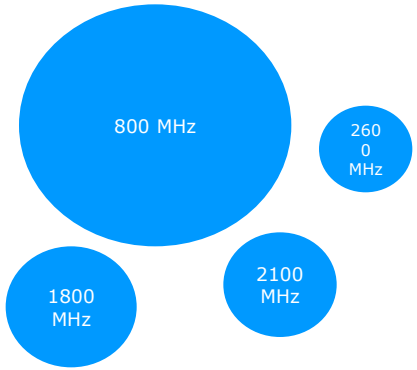
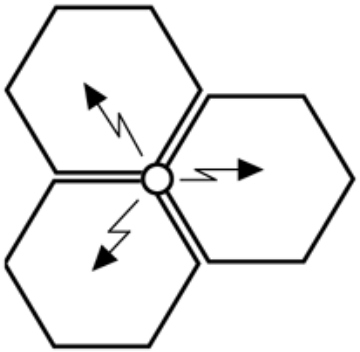
Challenge: Coverage, capacity and spectrum (2)





	DD	900 MHz	1800 MHz	2100 MHz	2600 MHz
DD	**1.00**	**0.80**	**0.22**	**0.17**	**0.11**
900 MHz	**1.24**	**1.00**	**0.28**	**0.21**	**0.14**
1800 MHz	**4.51**	**3.63**	**1.00**	**0.75**	**0.50**
2100 MHz	**6.01**	**4.83**	**1.33**	**1.00**	**0.67**
2600 MHz	**8.94**	**7.18**	**1.98**	**1,.49**	**1.00**

Based on COST-Hata model

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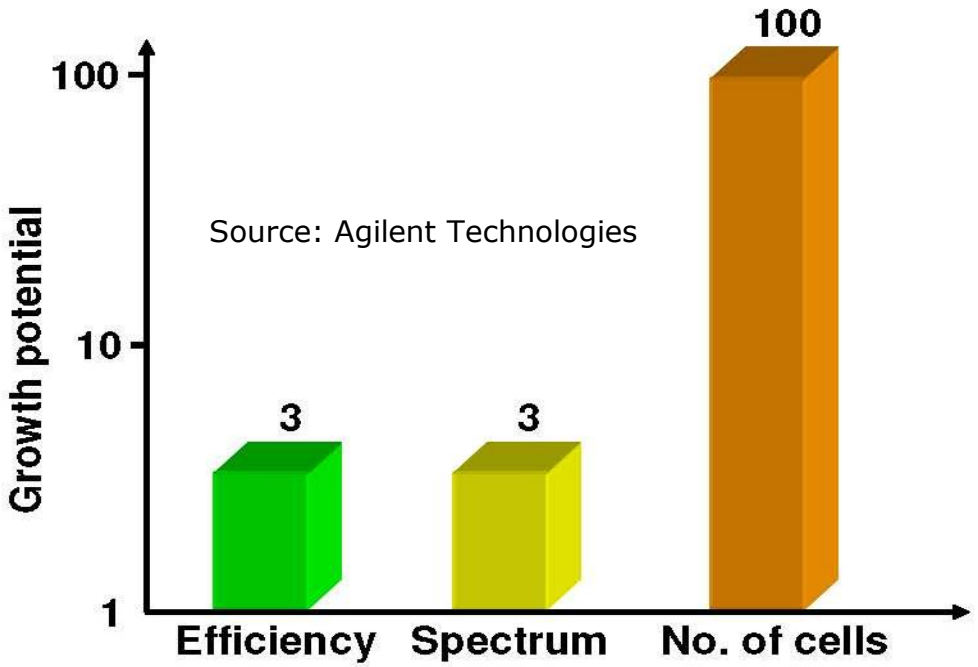
Out of the three ways to increase network capacity, adding new, smaller cells has by far the highest growth potential.



Source: Agilent Technologies

Spectrum and efficiency still matter but the future is all about small cells

For doubled spectrum size, required number of new cells can be halved

A Small cell provides similar capacity as a macro cell, but at a fraction of the cost

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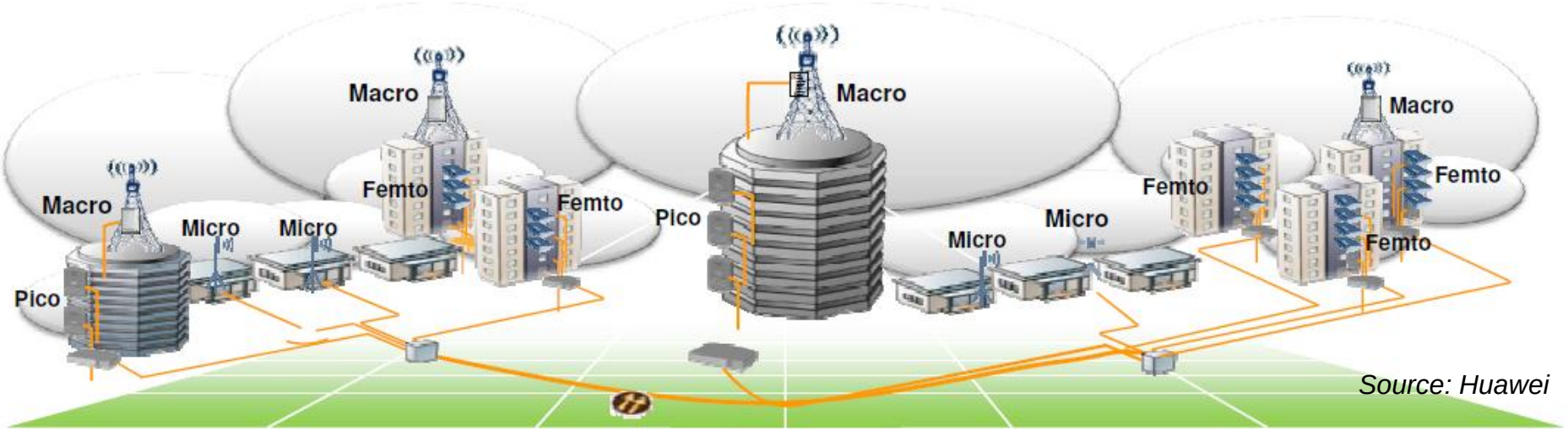
HetNet: Heterogeneous Network

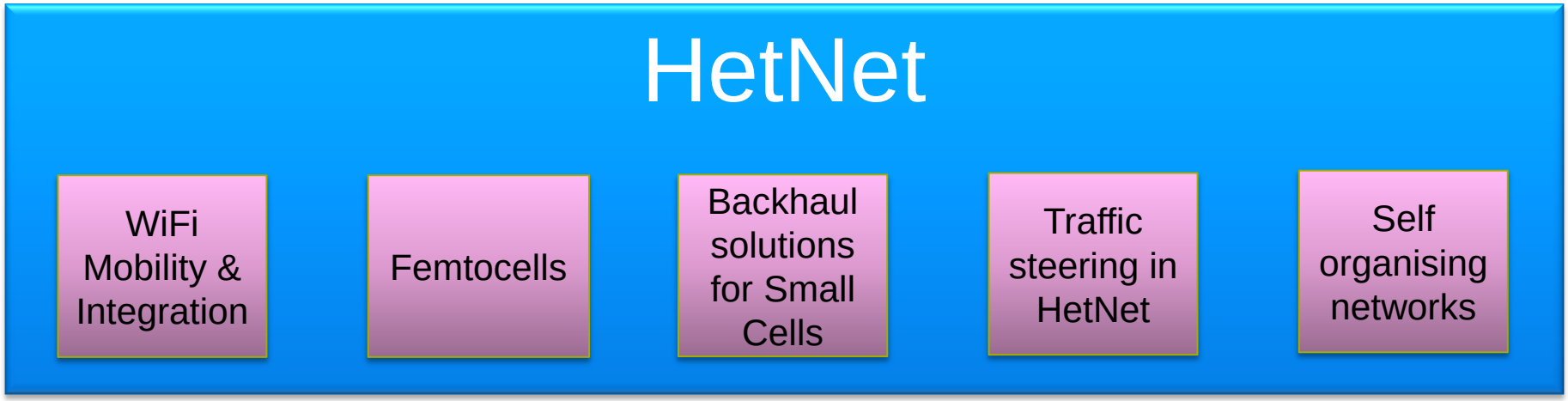
- A new term for mixed network architecture



- HetNet: Using a mix of large and small (outdoor and indoor) cells to secure customer experience the most cost-efficient way
- Possibly combining different access technologies
- Intelligent steering of traffic across different cell types to optimize user experience and traffic capacity

GSM macro cells and microcells can be considered as the first HetNet deployment, but without advanced traffic steering options

Heterogeneous Networks



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WiFi as part of HetNet

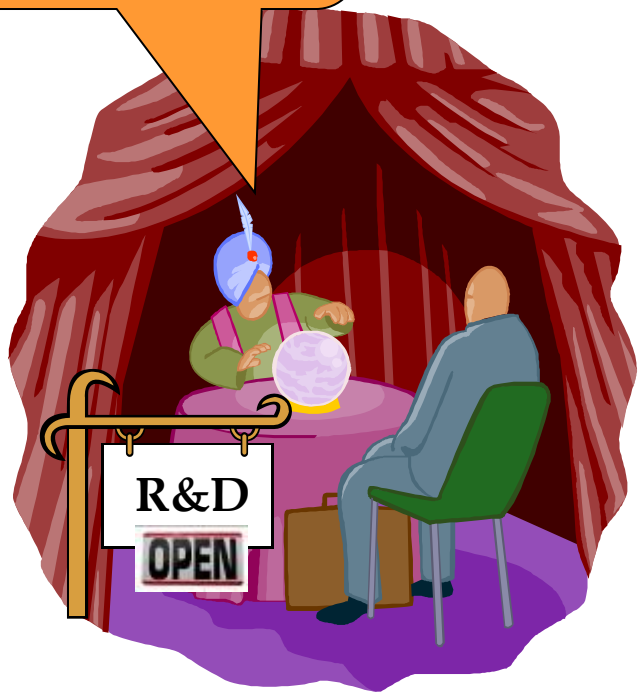
We can offer any kind of solution for WiFi integration

WiFi no more a tool just for data nerds

Security

Mobility

Discovery/Selection



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Femtocell

3G/HSPA/LTE micro base station

Works with standard handsets

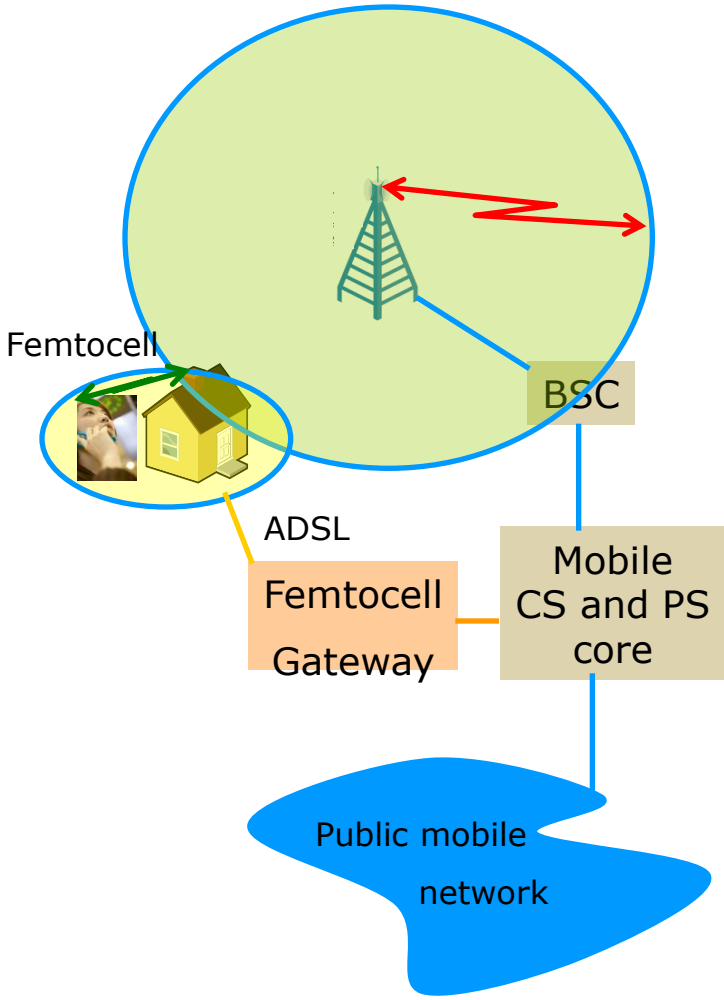
Zero touch, plug and forget

Improved indoor coverage and capacity.

Saves CAPEX in macro network

Target price < 100 US$.

Requires additional management system and femto gateway



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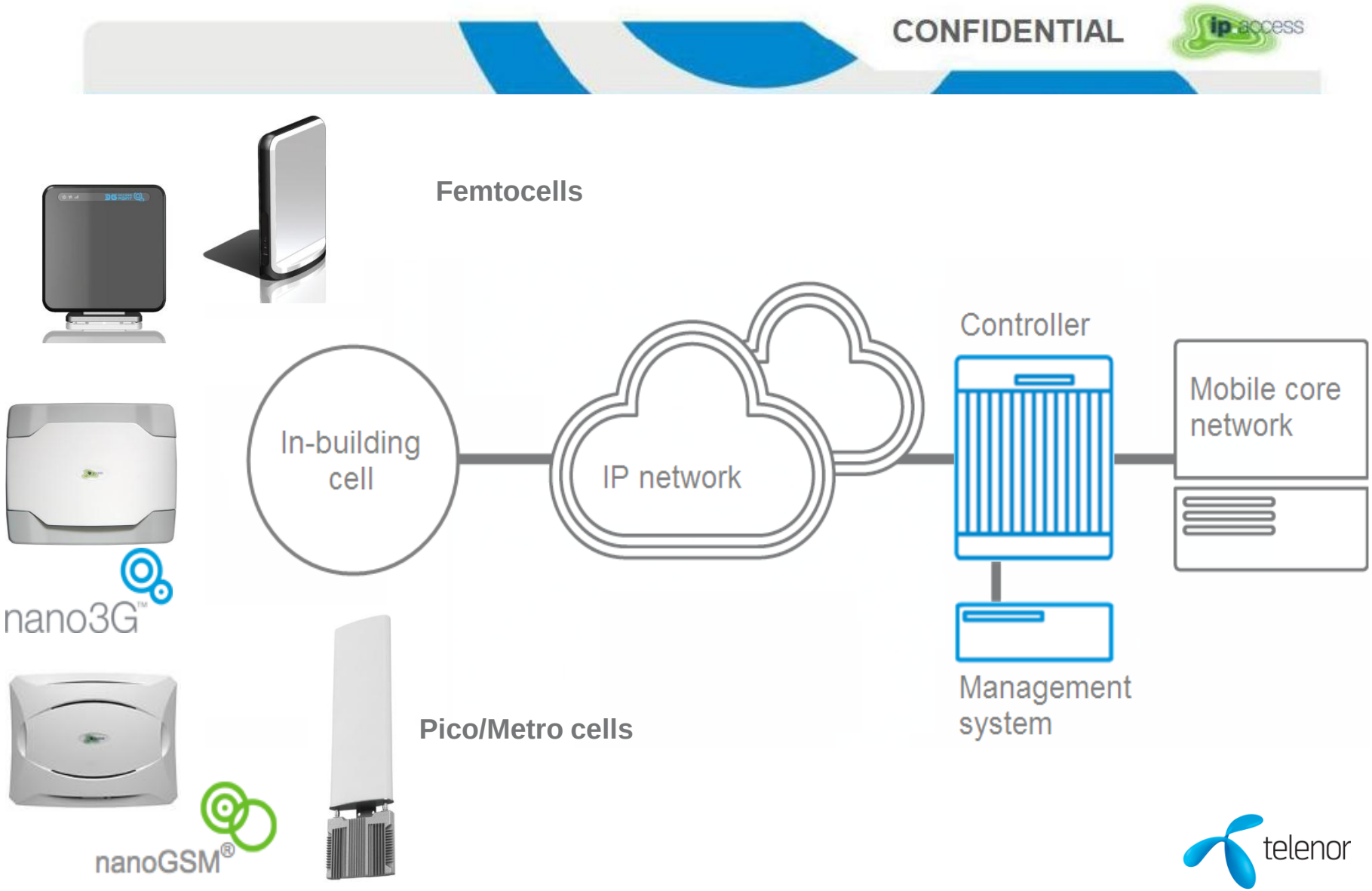
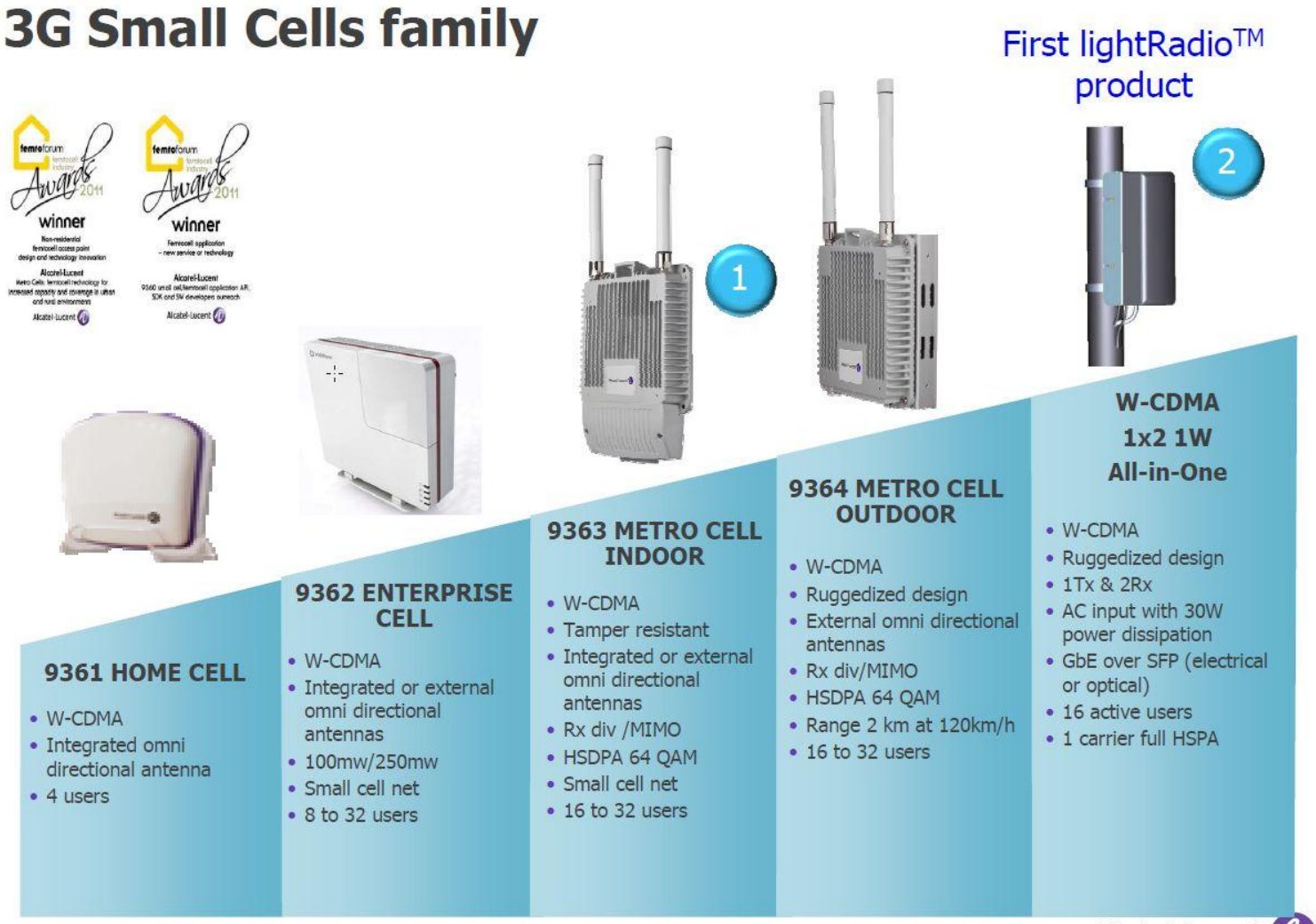
Example: Ip.access small cells



Example: Alcatel Lucent femtocells



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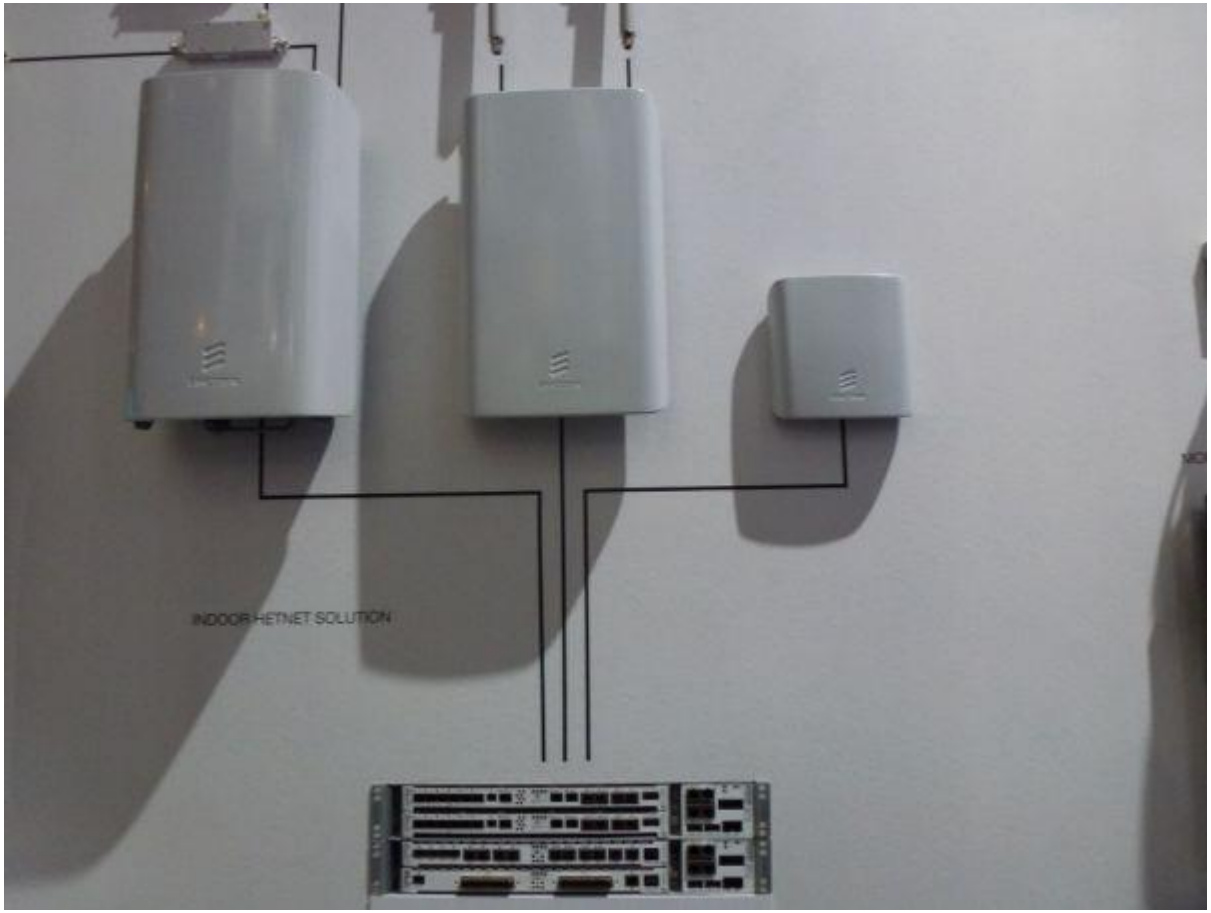
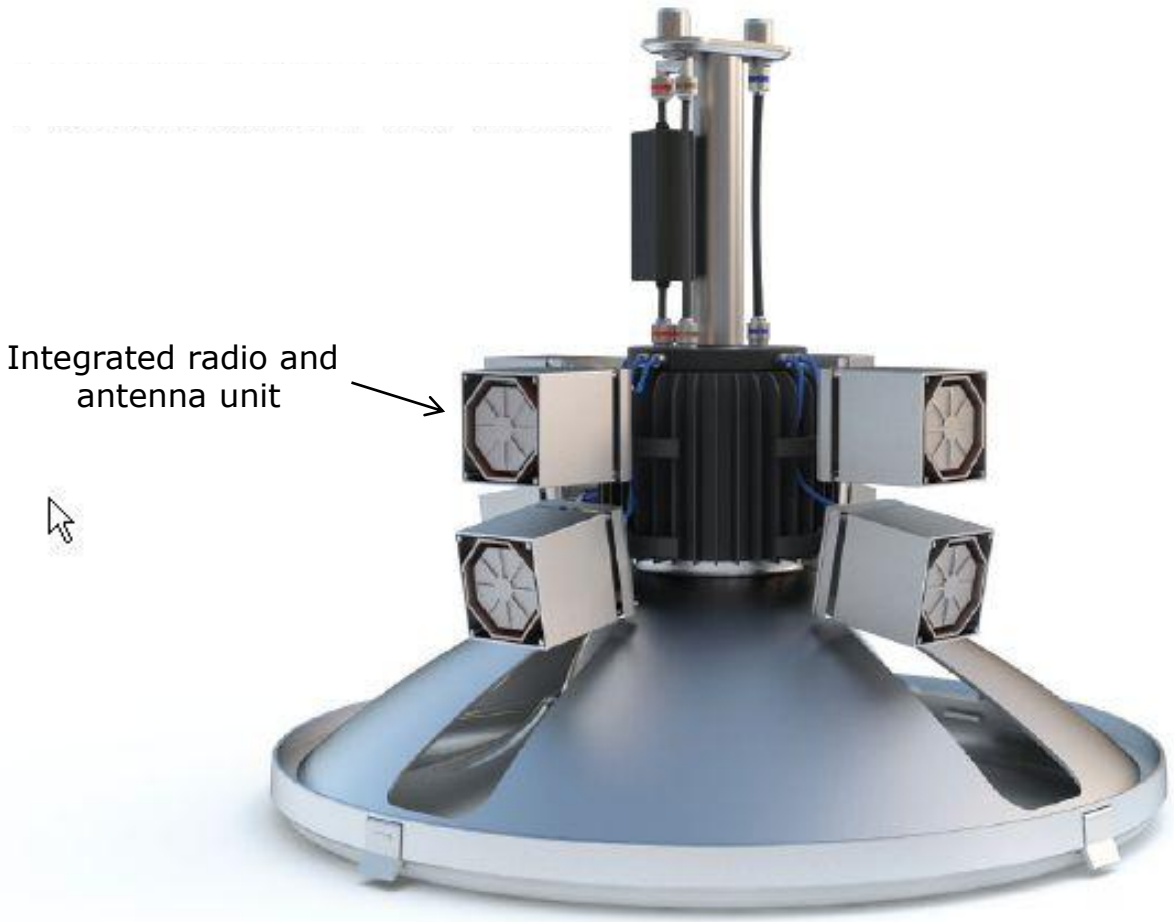
Ericsson’s Small Cell solution



Is this the new small cell? Mobile cells integrated in lamp posts

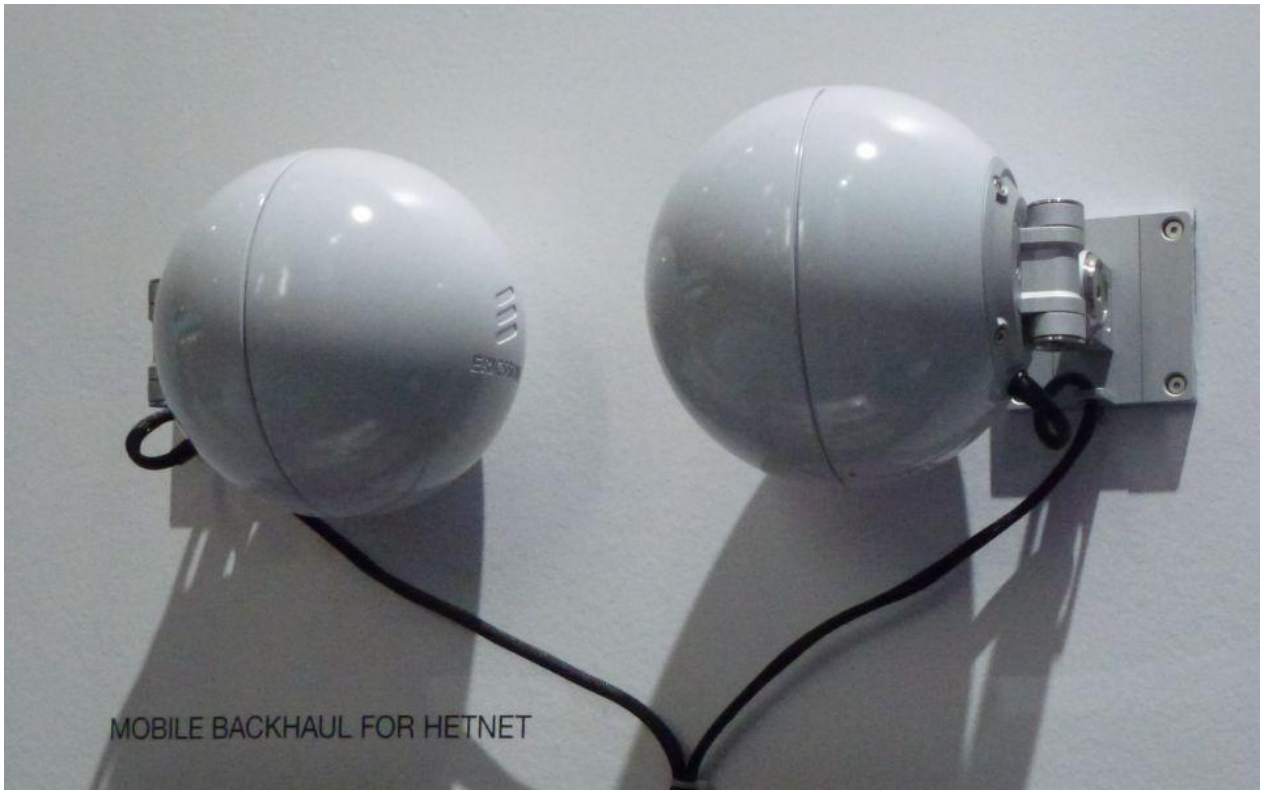


In 2015, all mercury light sources in outdoor lighting will be phased out in favour of more energy efficient alternatives, following the EU directive 245/2009

Source: Mobile antennas. Implementing new technlogies in public space. Master thesis at Aalborg University. A-S Voss, A Backe, T Rask Pedersen

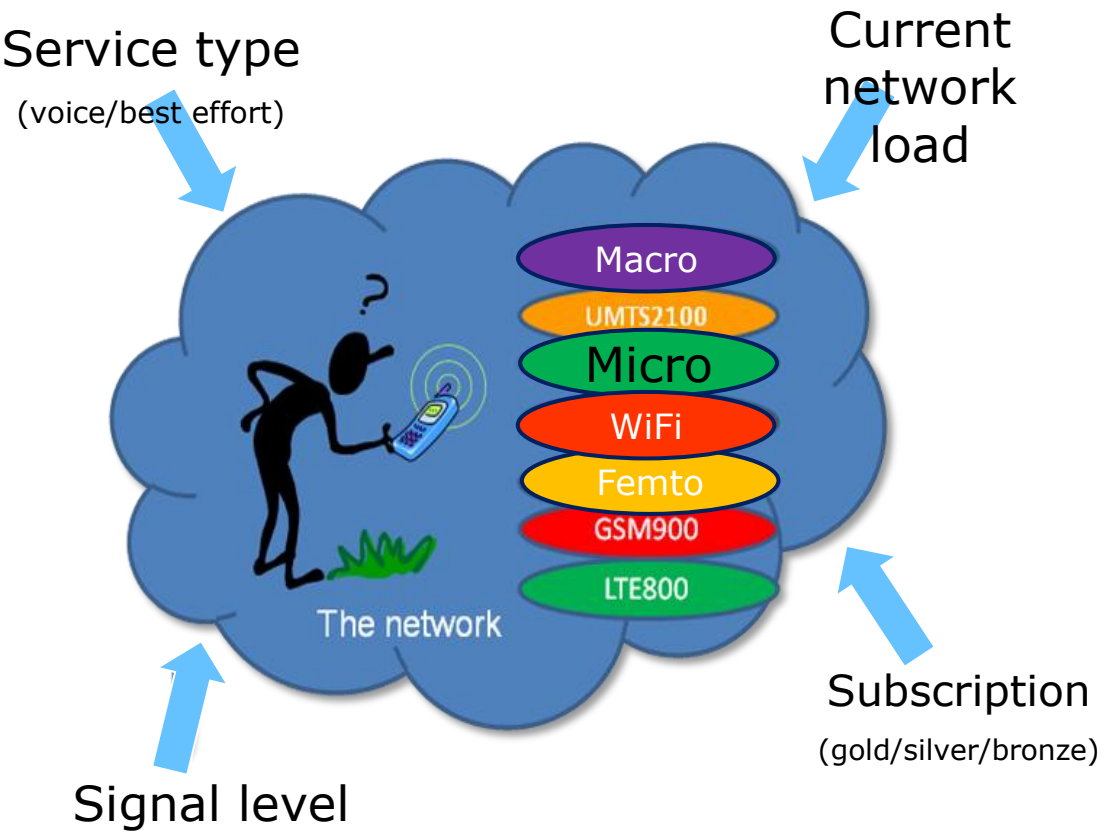
HetNet backhaul options

- xDSL
- Cable
- Fibre
- Microwave ⟶



Traffic steering in HetNet to improve user satisfaction and network efficiency

- Several parameters can be used to influence traffic steering
- Steering between macro – micro cells or between access technologies (even WiFi)
- Implementing traffic steering could reduce Capex for capacity and coverage



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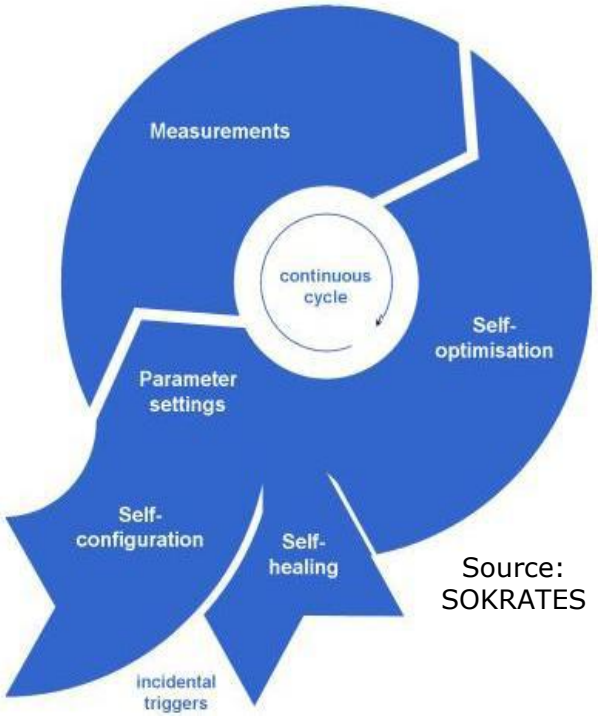
Self Organising Networks (SON) improves customer experience and network efficiency

SON is a growing family of functions for automating network configuration & operation. SON enables a much more dynamic network optimization than what would be possible by manual control.

- ***Self-configuration***
  Functions that allows newly deployed network elements to be automatically configured.
- ***Self-optimization***
  Functions for auto-tuning of the network to optimize given performance criteria.
- ***Self-healing***
  Functions for failure detection, diagnosing and healing.
- ***Self-planning***



Source: SOKRATES

For every new access network generation, number of network parameters increases 10-fold. HetNet deployment complicates this even further. Optimum processing and tuning of all these parameters can only happen with SON.

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What is ”refarming”

In agriculture: Switch from growing one type of product to another: E.g. from potato to carrot.

In mobile communications: Switch from one technology to another (in the same frequency band) – e.g. from GSM to GSM + UMTS

Requirements:

- Licenses are *technology neutral*
- (Often) Spectrum holding is *contiguous*
- Operators have a *minimum amount of spectrum each*

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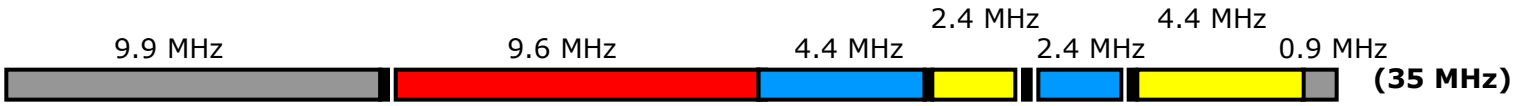
Refarming example 900 MHz

Before:



9.9 MHz + 0.9 MHz not allocated

Only red operator are able to refarm from GSM to GSM + UMTS (requires ~10 MHz and contiguous spectrum)

After

Government has:

- **Allocated the unassigned spectrum to the three operators**
- **Reshuffled the spectrum so that all operators have contiguous spectrum**
- **All operators can refarm from GSM to GSM + UMTS**

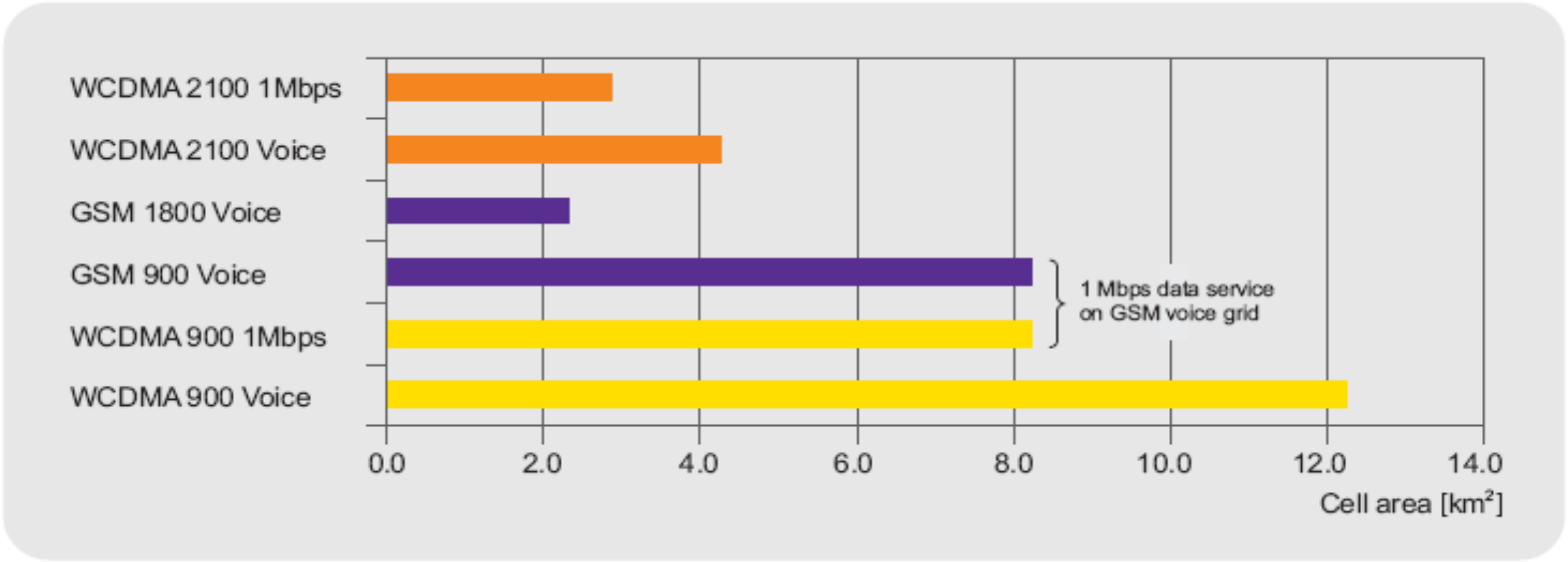
Legends: **Red operator** | **Blue operator** | **Yellow operator** | **Unassigned**

Why refarm from GSM to UMTS in 900 MHz?

(WCDMA = UMTS = 3G)

Larger UMTS cells: Less expensive deployment in areas with low population density

Better UMTS indoor coverage: Better quality in cities/urban areas



(Source: Nokia Siemens Networks & Elisa)

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Other refarming options

From GSM to GSM + LTE in 1800 MHz band

Recently large interest in LTE1800 among operators:

- Chipset and terminal support
- Infrastructure (base station) support

LTE1800 advantages (compared to LTE2600):

- (Approximately) twice the coverage
- Reuse of antennas and cell grid for operators which use GSM1800

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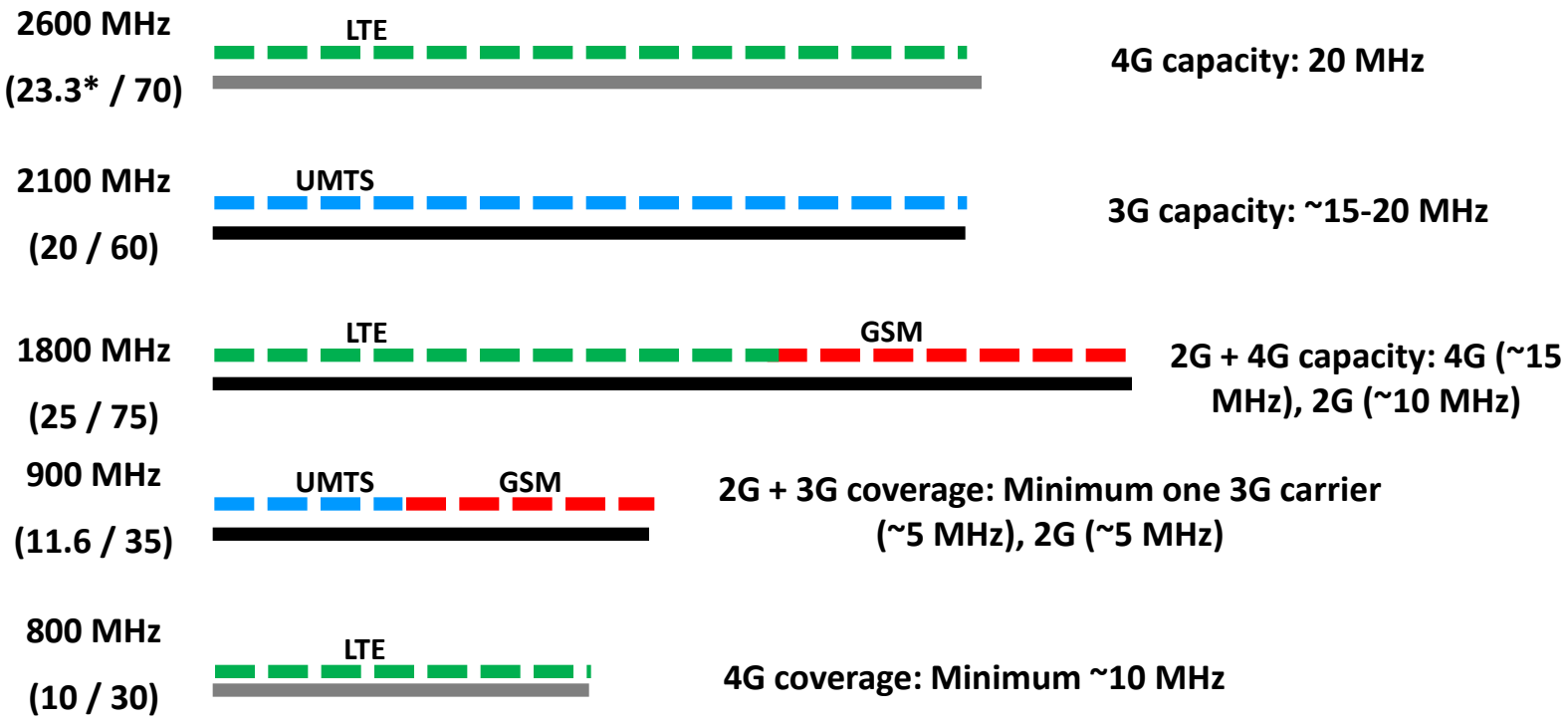
Planning a portfolio – The magical number three? (1/2)

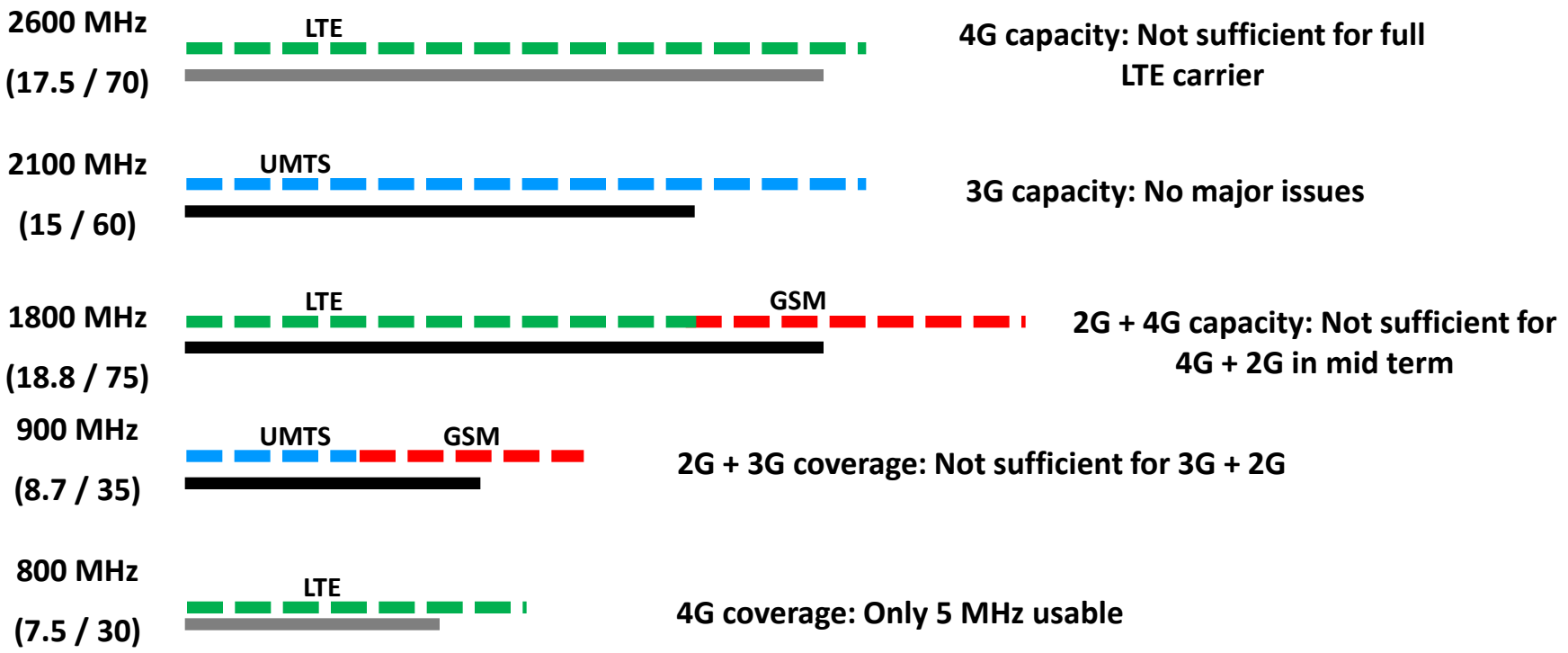
Imagine a situation where an operator has **one third of the maximum available spectrum** in the most important spectrum bands.

What would typically be the spectrum usage in mid term (2-5 years):



Planning a portfolio – The magical number three? (2/2)

Imagine a situation where an operator instead has **one fourth of the maximum available spectrum** in the most important spectrum bands:



Technology constraints one major reason for **consolidation** among mobile network operators in recent years, as well as the focus on **network sharing**

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Data support: Making the right choices

- For each category, which frequency / technology combination will be supported by more than e.g. 10 % of devices?
- Any investment decision is based on a forecast of device penetration and density and an assessment of how we can invest to influence penetration

UMTS 900	UMTS 2100	LTE 800	LTE 1800	LTE 2600
✓	✓	?	✓	✓
✓	✓	?	?	?
✓	✓	?	✓	✓
✓	✓	?	✓	✓
✓	✓	✗	✗	✗

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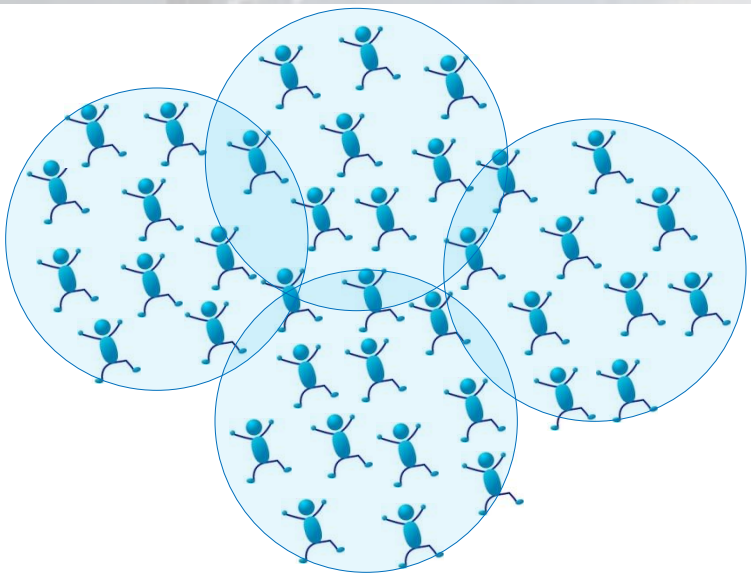
Building profitably across different area types

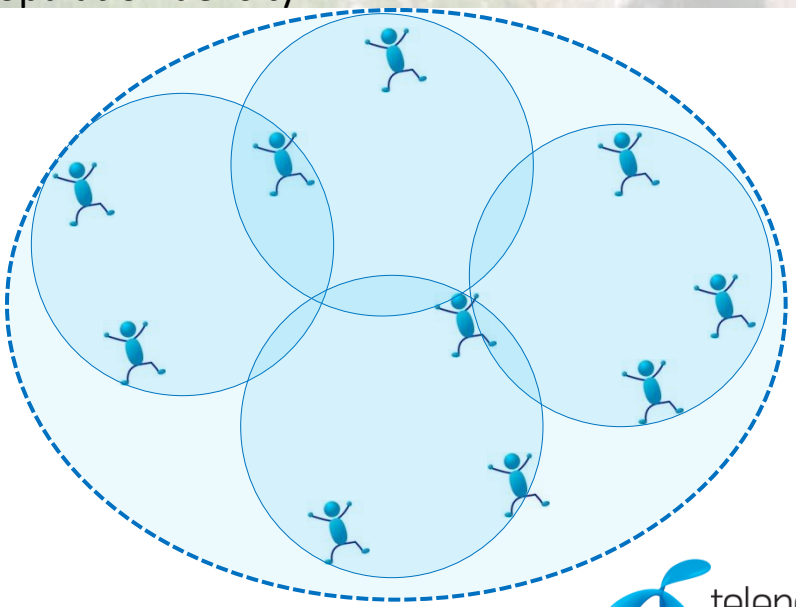
Urban area

- In this example, one must cover at least five customers in order for it to be commercially viable to set up a site
- In urban areas, the population density supports profitable rollout



Rural area

- Population density too low to support commercial rollout
- Larger coverage areas might ensure profitability
- Low market share ‘looks like’ low population density
- Low device penetration also ‘looks like’ low population density



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The value of an amount of spectrum

Case Example – Mobile Broadband in Oslo:

Urban part of Oslo:

Area: 135 km^2

Population: 560.000 people

Expected penetration: 40%

Average usage in peak hour: 100 kbit/s (downlink, mobile receive)

Case 1 – 2*10 MHz spectrum:

Traffic / site: 24 Mbit/s

Number of sites needed: 930

Case 2 – 2*20 MHz spectrum:

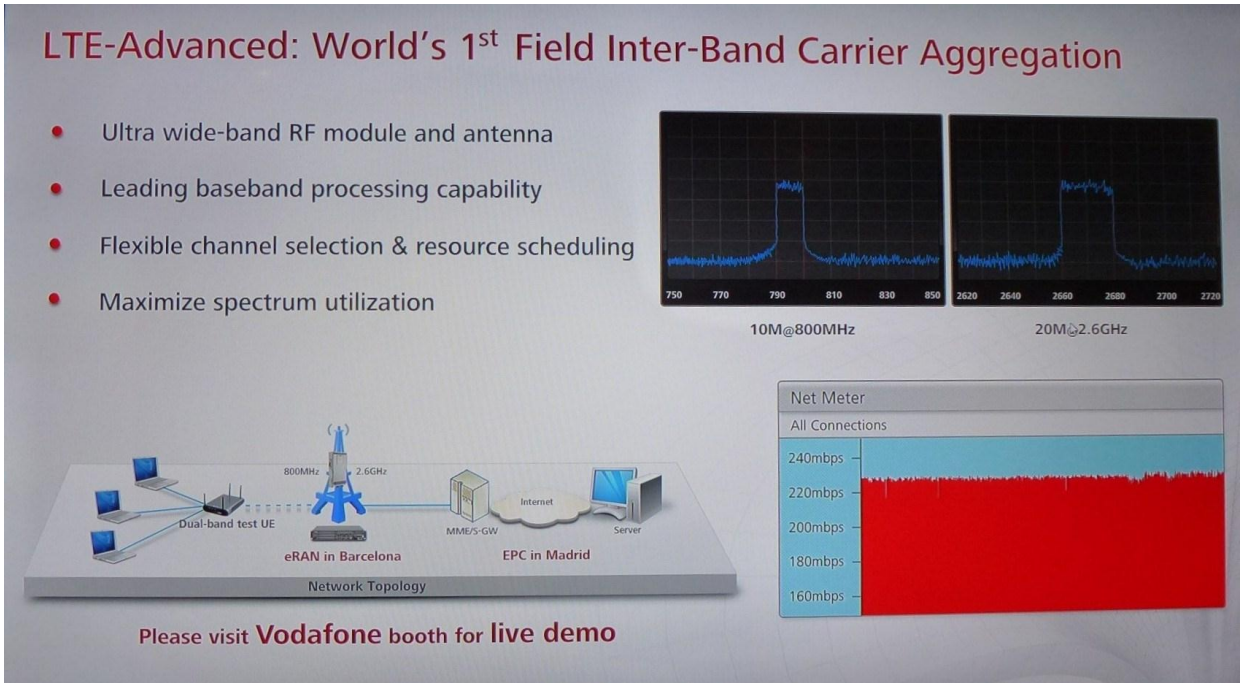
Traffic / site: 48 Mbit/s

Number of sites needed: 465

Conclusion:

(Provided Case 1 is profitable) The value of the additional 2*10 MHz spectrum in this example is equal to the cost of 465 sites (930 – 465).

Next step: Spectrum aggreagtion
From MWC 2012



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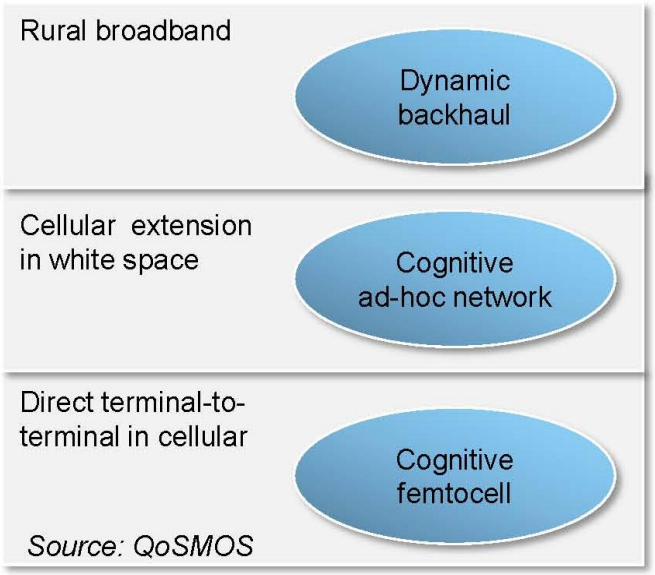
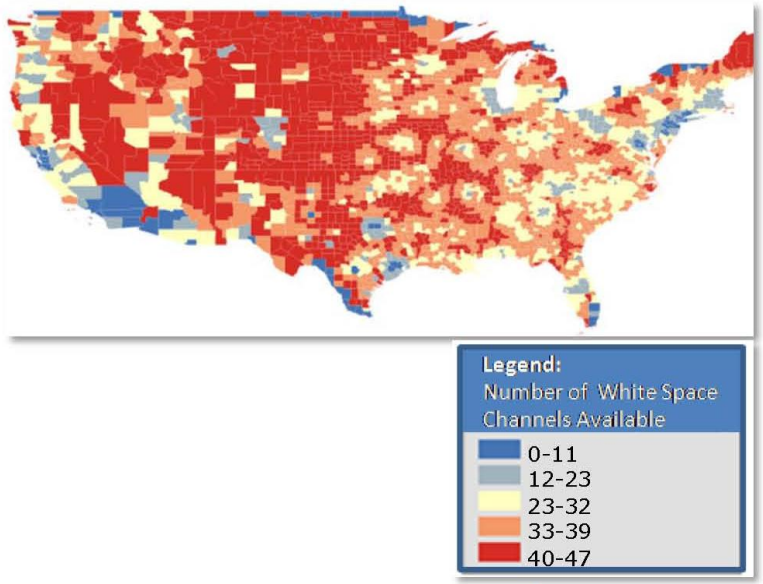
Future: Cognitive radio and dynamic spectrum management

- Generally lower utilization of several frequency bands (and different allocation principles)
- Standardization and improving technical capabilities
- Threat or opportunity – depending on use case





Driving more dynamics in utilization of frequency spectrum

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Thank you for listening!

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