



Is there a thing called 5G ?

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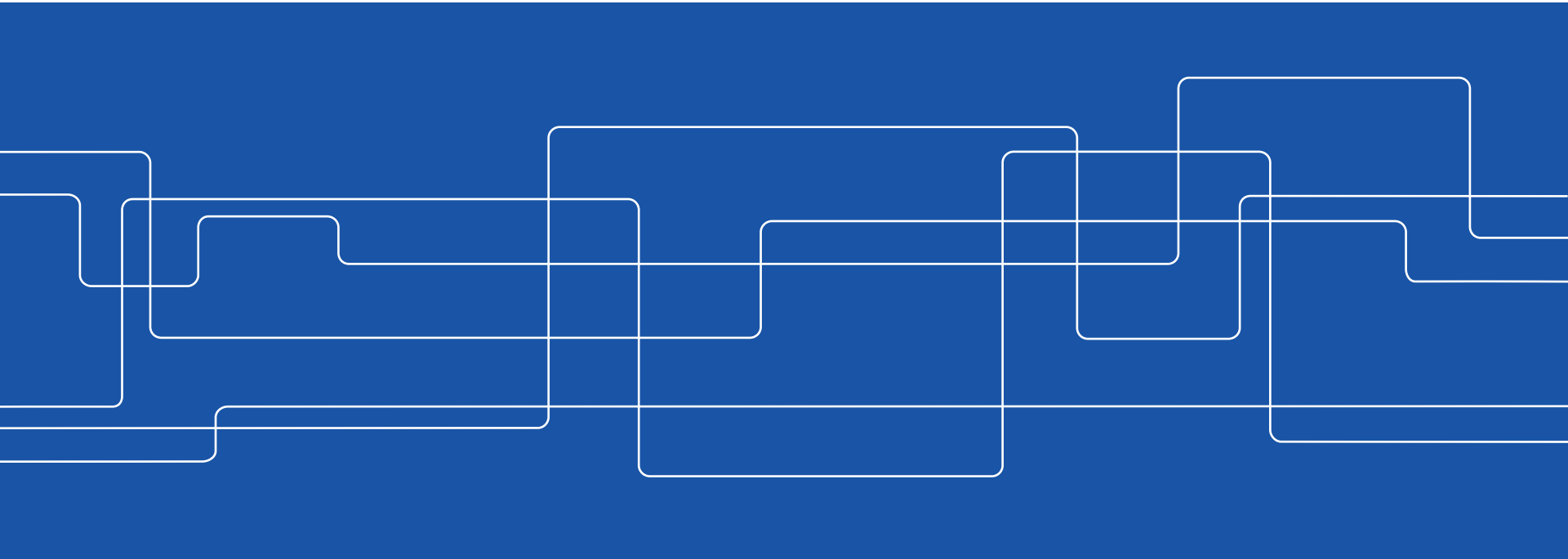
Outline

The 5G drivers

- Much more of the same
 - Scalability of IP-based services - the "1000x challenge"
- Something different
 - Things that do not scale in 4G
 - The Internet of Things and Senses



Much More of the Same



A lessons from History - Dominant designs



- From infrastructures driven by "killer apps" and "one-trick ponies"
→ general IP-based access infrastructures
- **Internet access** = dominant design for ALL services (fixed & mobile)
- Marginalizes other technical solutions – e.g. Wireless P2P, Mesh, ...
- Story sounds familiar ...?

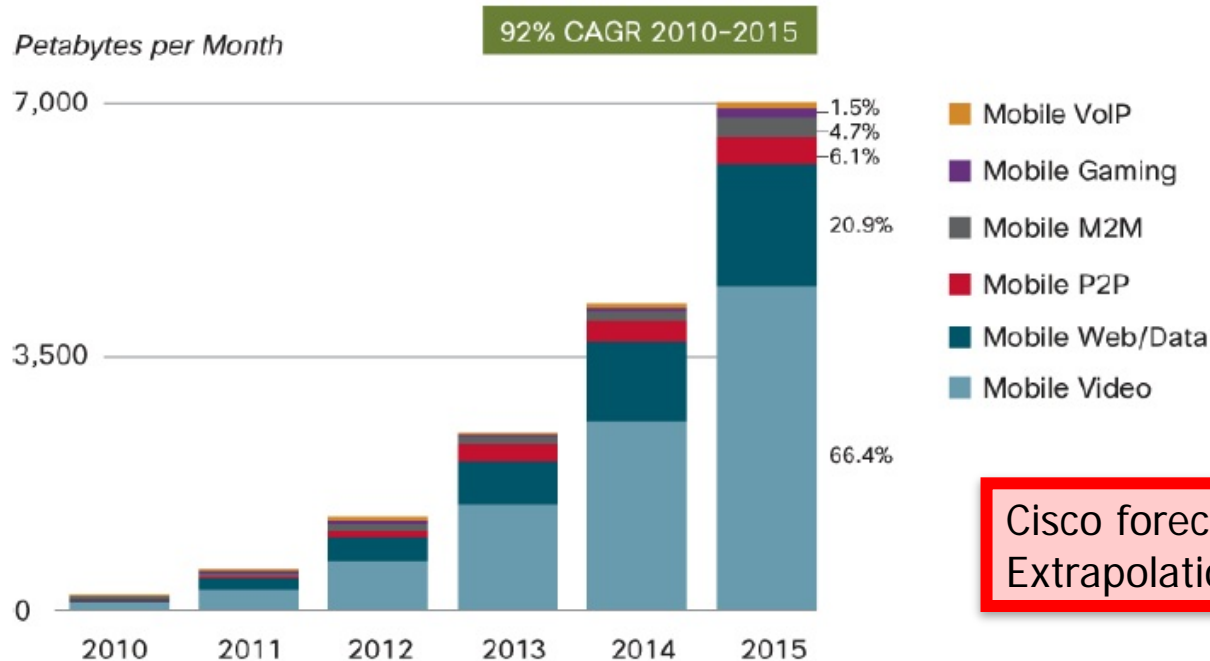
"IP is the answer - now, what was the question ?"

G Q Maguire



Transparency eats efficiency for breakfast

The price tag for transparency – the Wireless Data avalanche



Cisco forecast: 2015 – 26x
Extrapolation: 2020 - 1000x

VoIP traffic forecasted to be 0.4% of all mobile data traffic in 2015.

Source: Cisco VNI Mobile, 2011

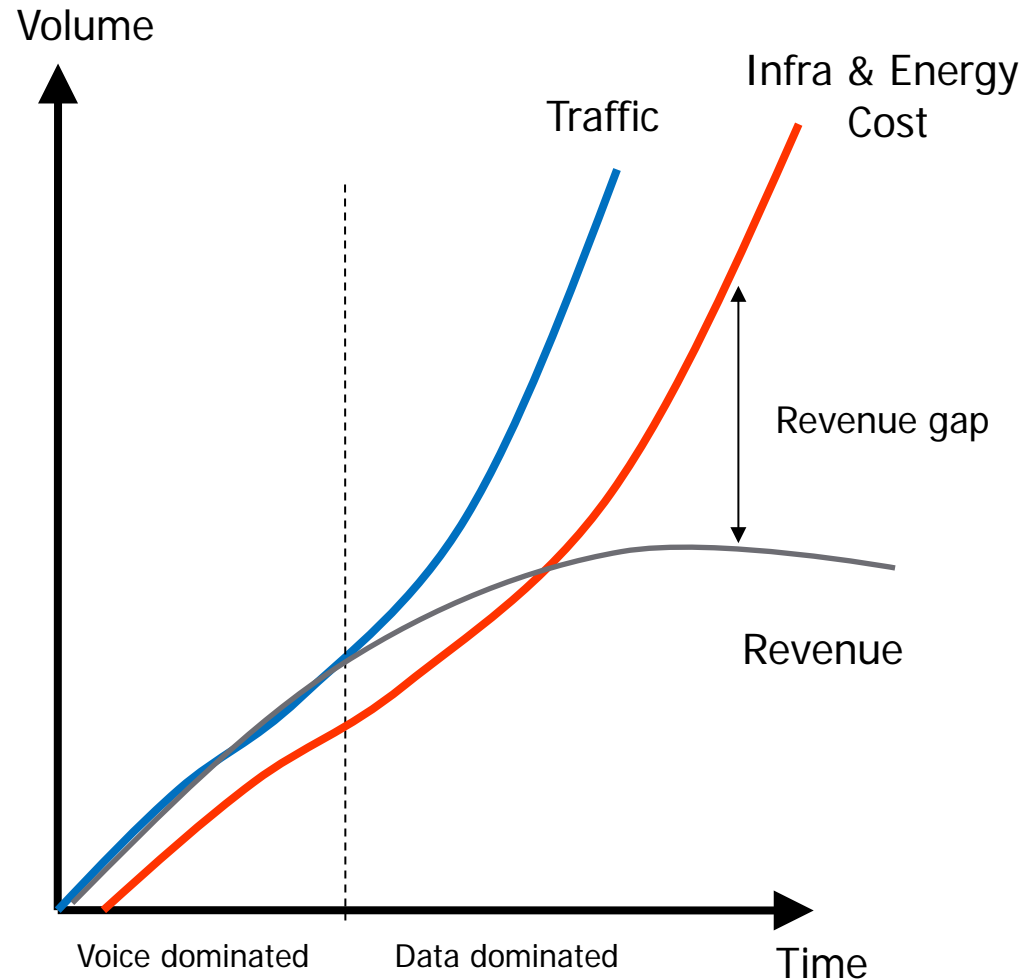
Exponential growth (now slowing down somewhat)
Assumes **zero marginal cost** for access
How long can this be sustained ?

Operator dilemma: More for less money

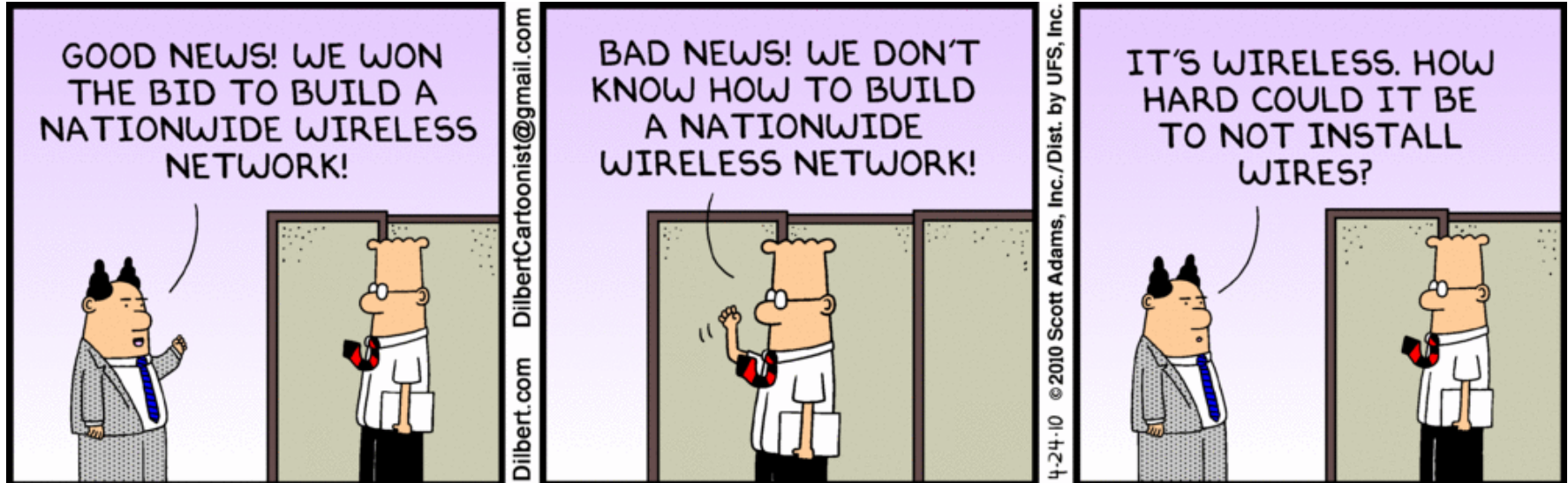
- Spending capability of user increases with GNP growth (<10% annually)
- Capacity requirements increase by 80-100% annually

$$C_{SYS} = c_{BS} N_{BS}$$

Challenge:
1000x lower cost/bit



How difficult can it be ?

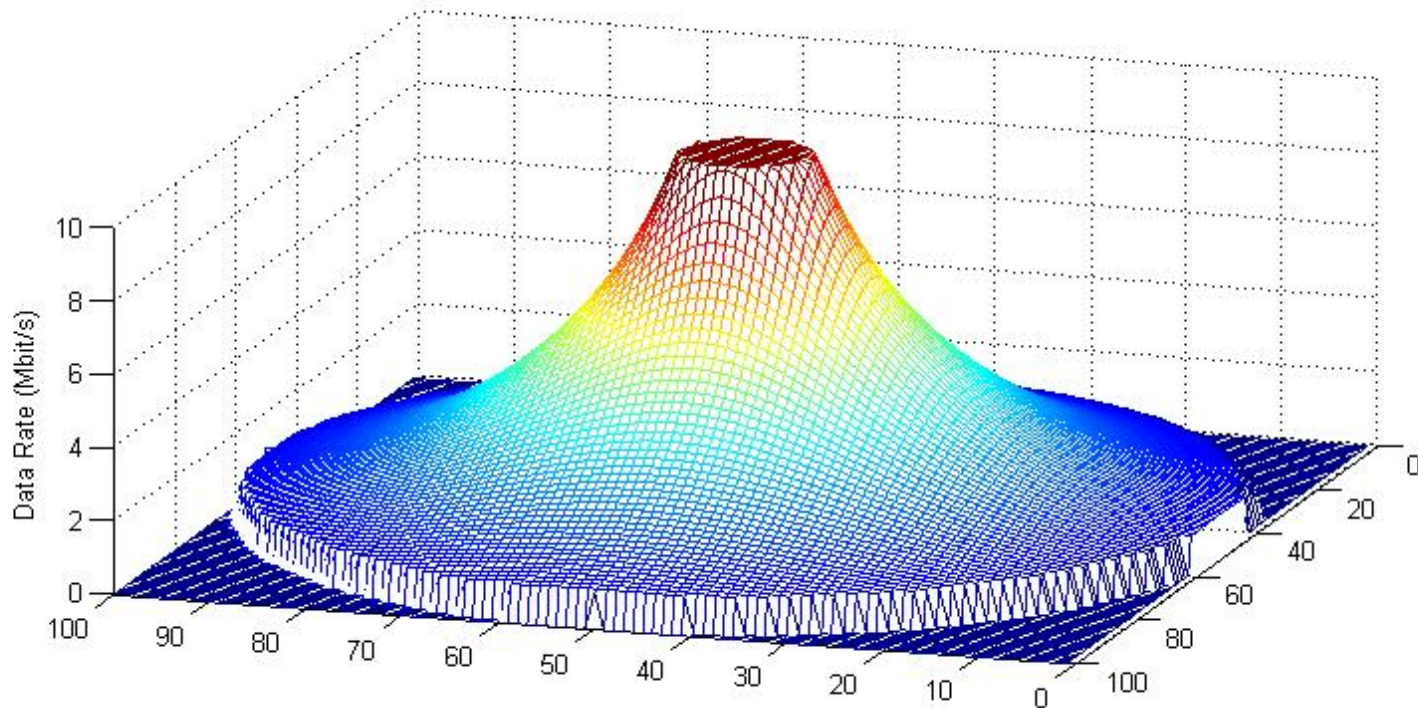


How to increase capacity ?

$$R_{tot} \approx \frac{\eta}{A} N_{BS} W_{sys} \quad C_{SYS} = c_{BS} N_{BS} + c_{sp} W_{sys}$$

- Increase η , spectral efficiency (signal processing)
 - Close to theoretical limits
- More base stations, N_{BS}
 - Expensive
- More spectrum, W_{SYS}
 - Shortage ?

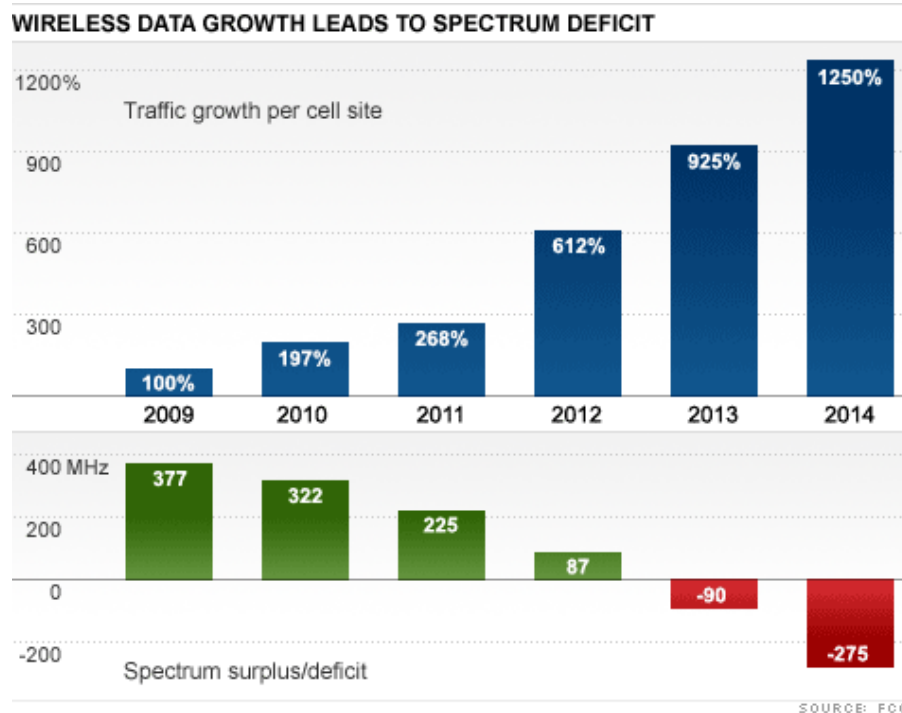
Moore's Law will not bail us out this time



Capacity \neq Peak Rate

Moore's law not applicable to concrete and steel

Solving "all" problems with more spectrum - the FCC – Spectrum deficit



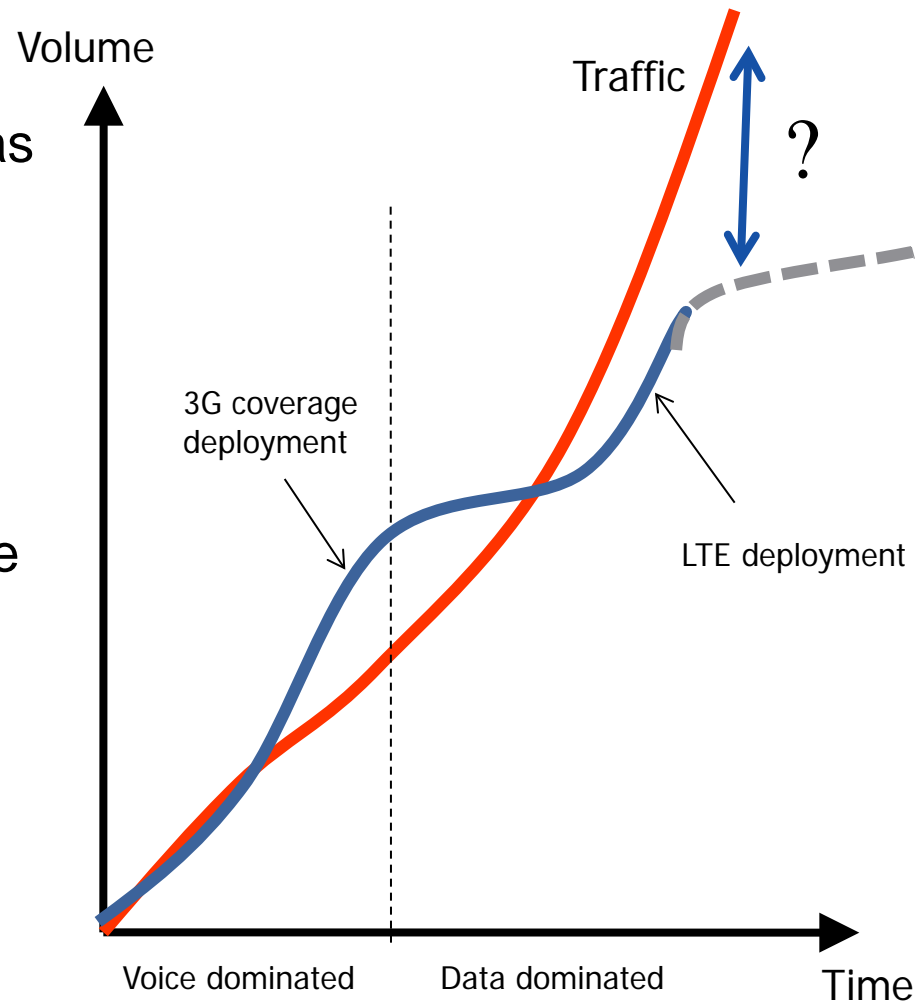
Key assumptions

Reasonable extrapolation of

- current deployment strategies (=moderate increase in base stations)
- transmission technologies.

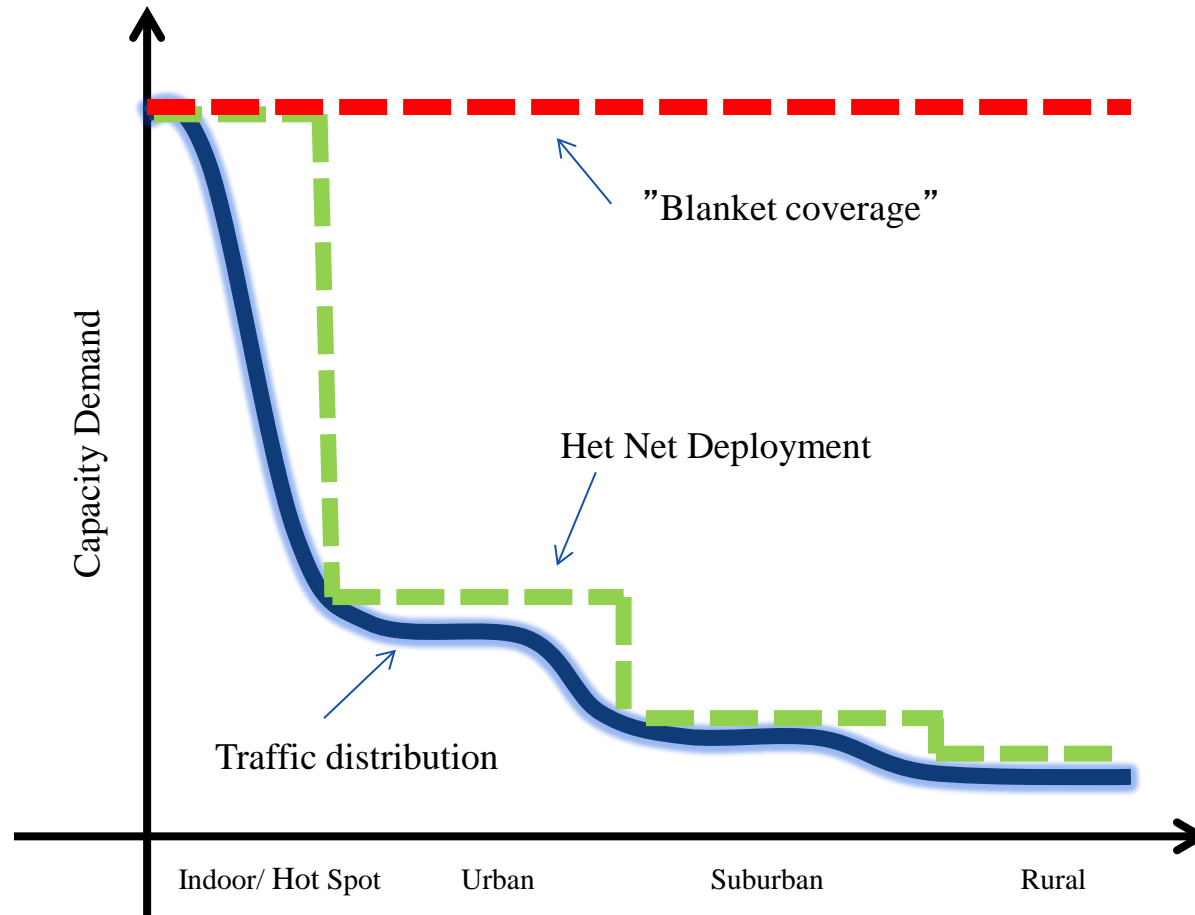
So what if cellular system can't keep up ?

- Excess capacity when 3G was deployed to meet coverage constraints
- Rapid LTE Deployment – medium term solution
- Traffic growth in cellular systems now decreasing (due to limited "bucket" sizes)



How to lower the cost:

"HET NET"s – deploy according to demand



The Light Analogy : HET NETs

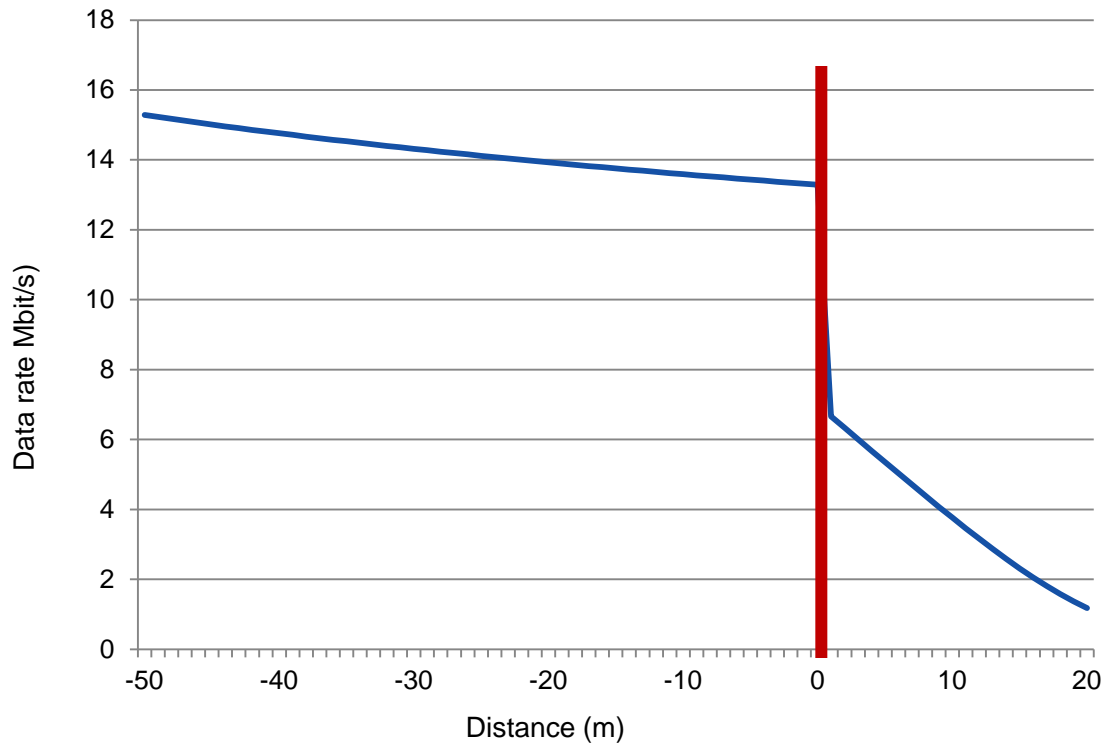


Outdoor – Wide Area

- Indoor – Short Range



Hitting the (brick) wall



- "Wireless Friendly" buildings: metalized windows & reinforced concrete
- 20 dB loss (at window) 30- 40 dB loss 10-20m into building

A World Divided

The coverage world



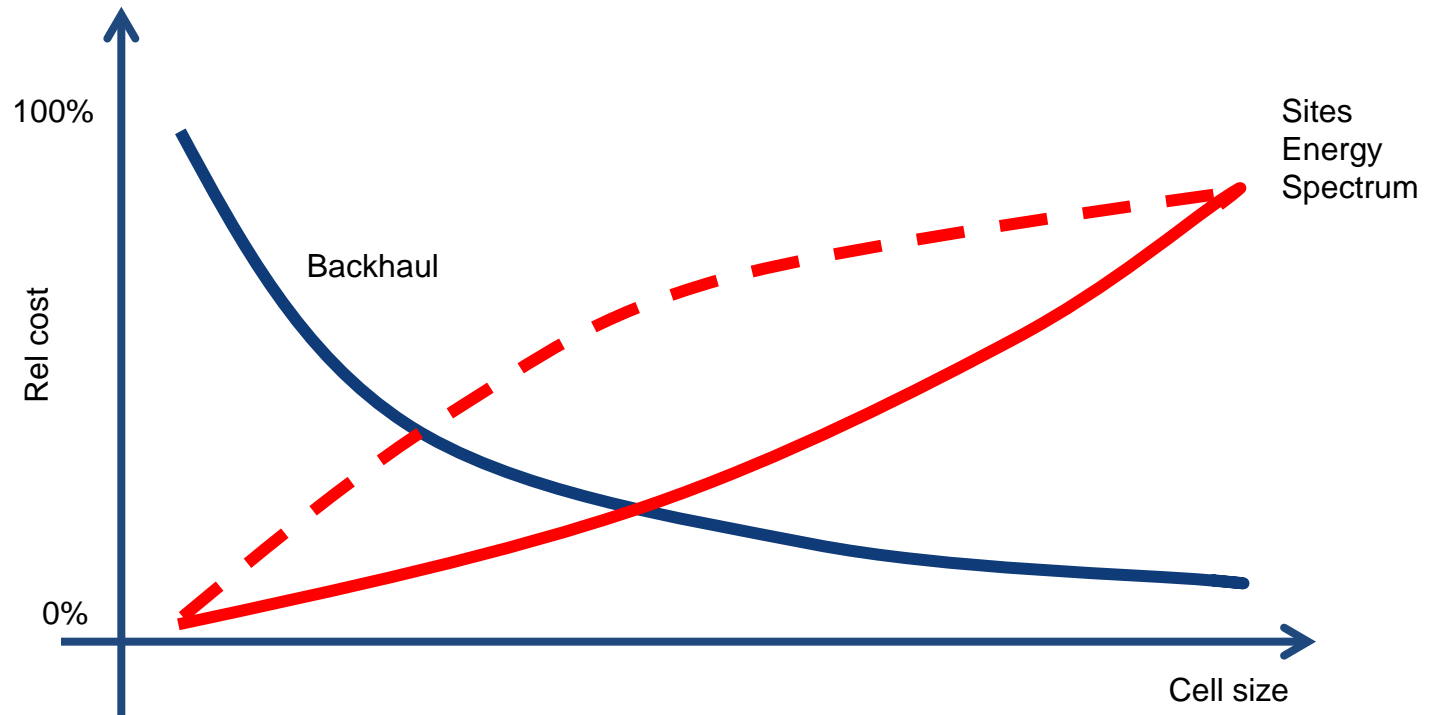
Industry grade equipment
High power/Wide area
24-7 availability
High **system** complexity

The capacity world

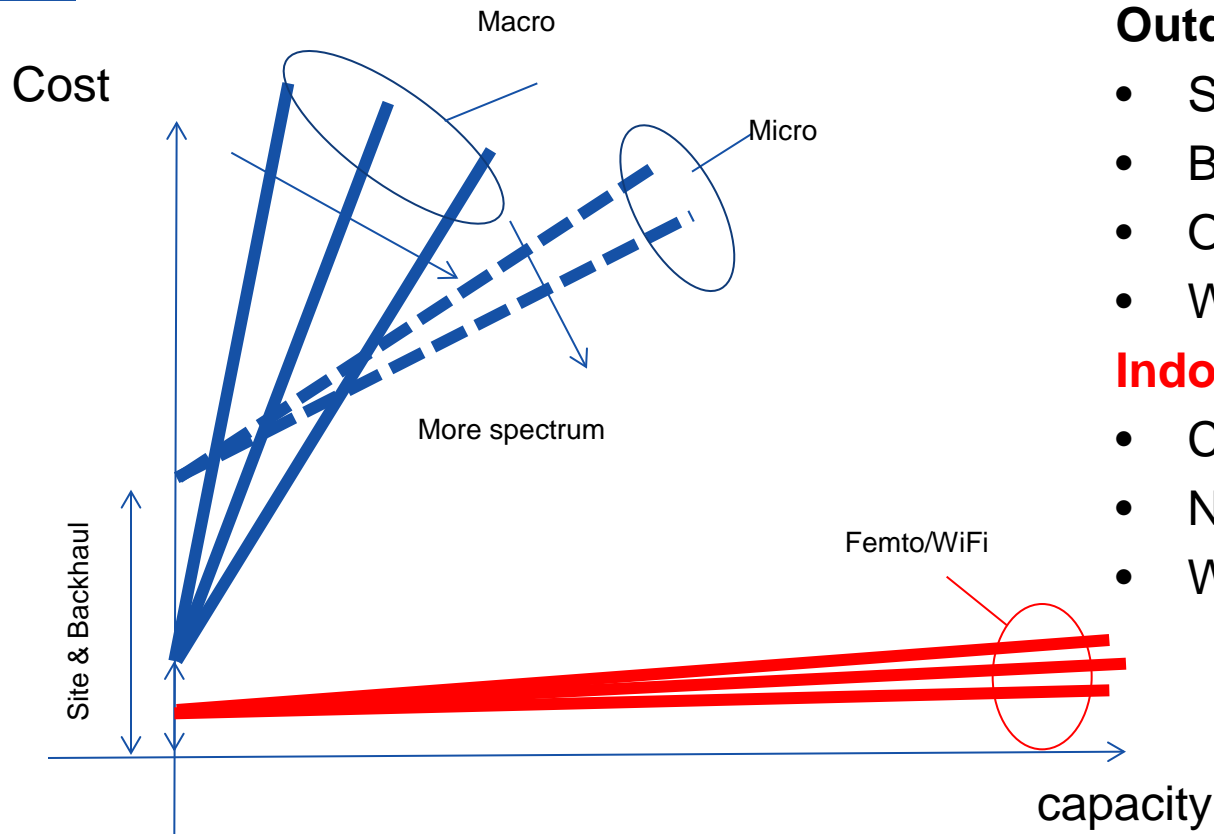
Consumer grade equipment
Low power/Short range
Reliability through redundancy
Deploy where backhaul available
Low **system** complexity



Cost factors



The cost for capacity



Outdoor Macro/Micro

- Site aquisition
- Backhaul
- Outdoor equipment
- Wall penetration loss

Indoor Femto/WiFi

- Cheap equipment
- No dedicated backhaul
- Wall loss = benefit!

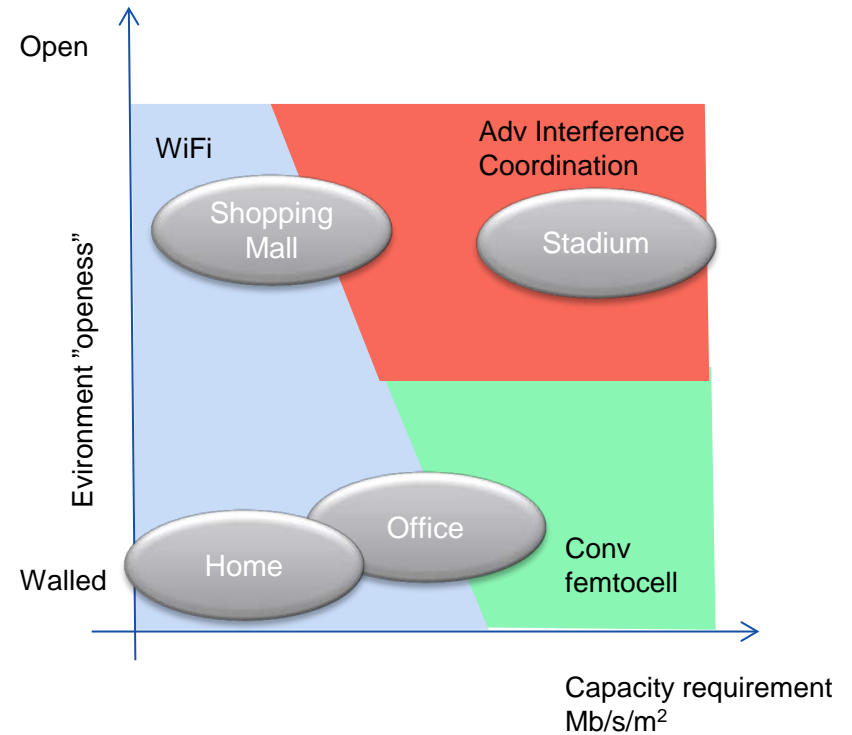
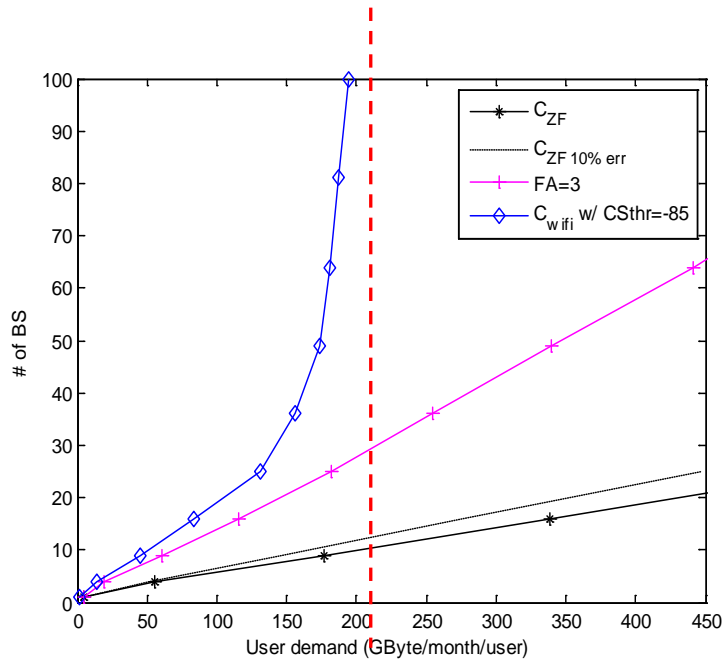
Capacity (were needed) is "cheap" - coverage is expensive

Is there enough capacity ?

	Outdoor		Indoor capacity			
	Macro	Micro	Macro	Micro	WiFi conservative	WiFi ideal *
Inter base distance (m)	300	100	300	100	30	10
Density BS/Sqkm	11	100	11	100	1 111	10 000
Avg Spectral eff (bit/s/Hz)	2	2	2	2	2	4
Available spectrum (MHz)	500	500	500	500	1 000	2 000
Aggregate max rate (Gbit/s)	1	1	1	1	2	8
No Sectors	3	3	3	3	1	1
"Effective" Reuse factor	3	3	3	3	3	1
Capacity/BS (Gbit/s)	1	1	1	1	0,67	8
Effective Wall penetration loss(dB)	-	-	10-30	10-30	0 - 10	-
Capacity/sqkm	11	100	1 -3	10 - 30	250 -750	80 000

* 1 AP/room, High wall penetration loss, 1 GHz extra shared spectrum < 6 GHz)

Capacity and Economic feasibility



A World Divided – business aspects

The coverage world



Public operators

- **Access any-time, anywhere**
- "Insurance" – guaranteed access at moderate data rates (1-2 Mbit/s)
- Monthly fee
- Power/Site/Backhaul
- Exclusive spectrum licensing – spectrum sharing

The capacity world

Facility owners

- Local access - "off-loading"
- Sanitary requirement / no charge
- User experiences – high data rates
- Ultra dense deployment – Interference
- (Low power, no site cost, existing backhaul)
- Post-code licensing – infrastructure sharing



A World Divided – Technologies challenges

The coverage world



- Power/Energy
- Site cost
- Backhauling
- Spectrum licensing
- Scalability (for IoT)

LTE -A



The capacity world

- Low cost, rapid deployment using existing backhaul
- Ultra dense deployment
- Interference management

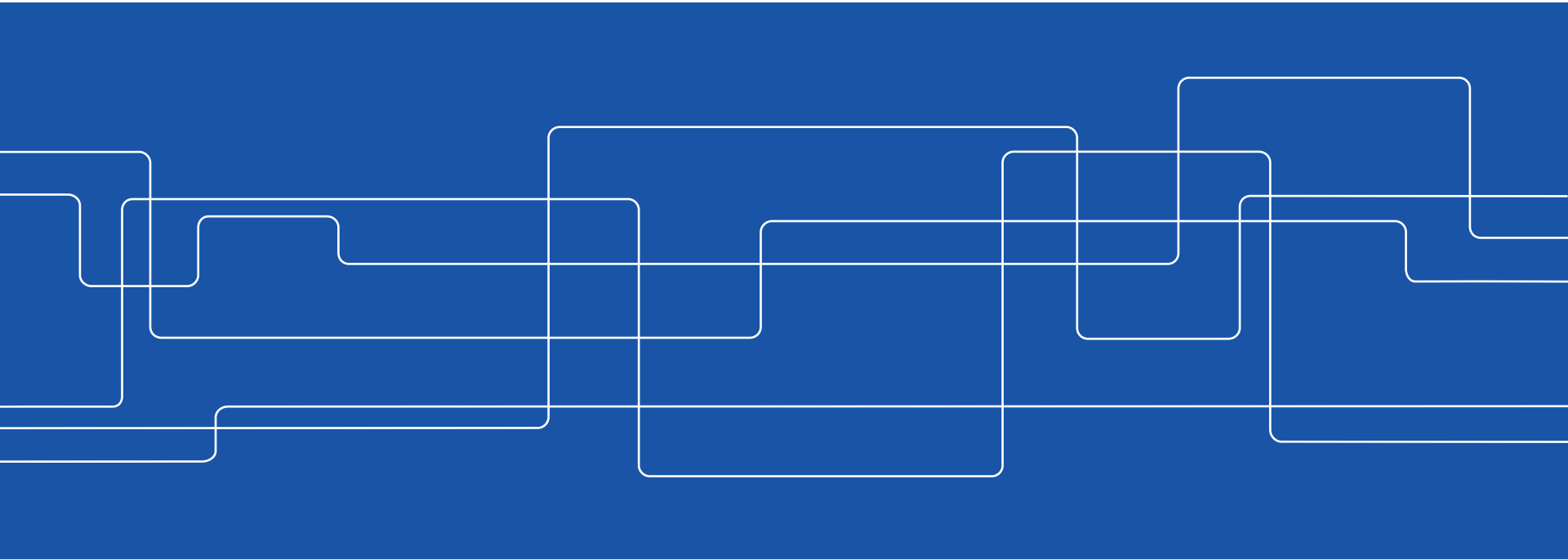
IEEE 802.11 HEW





Something different

Things that do not work or scale in 4G



Not only capacity ...



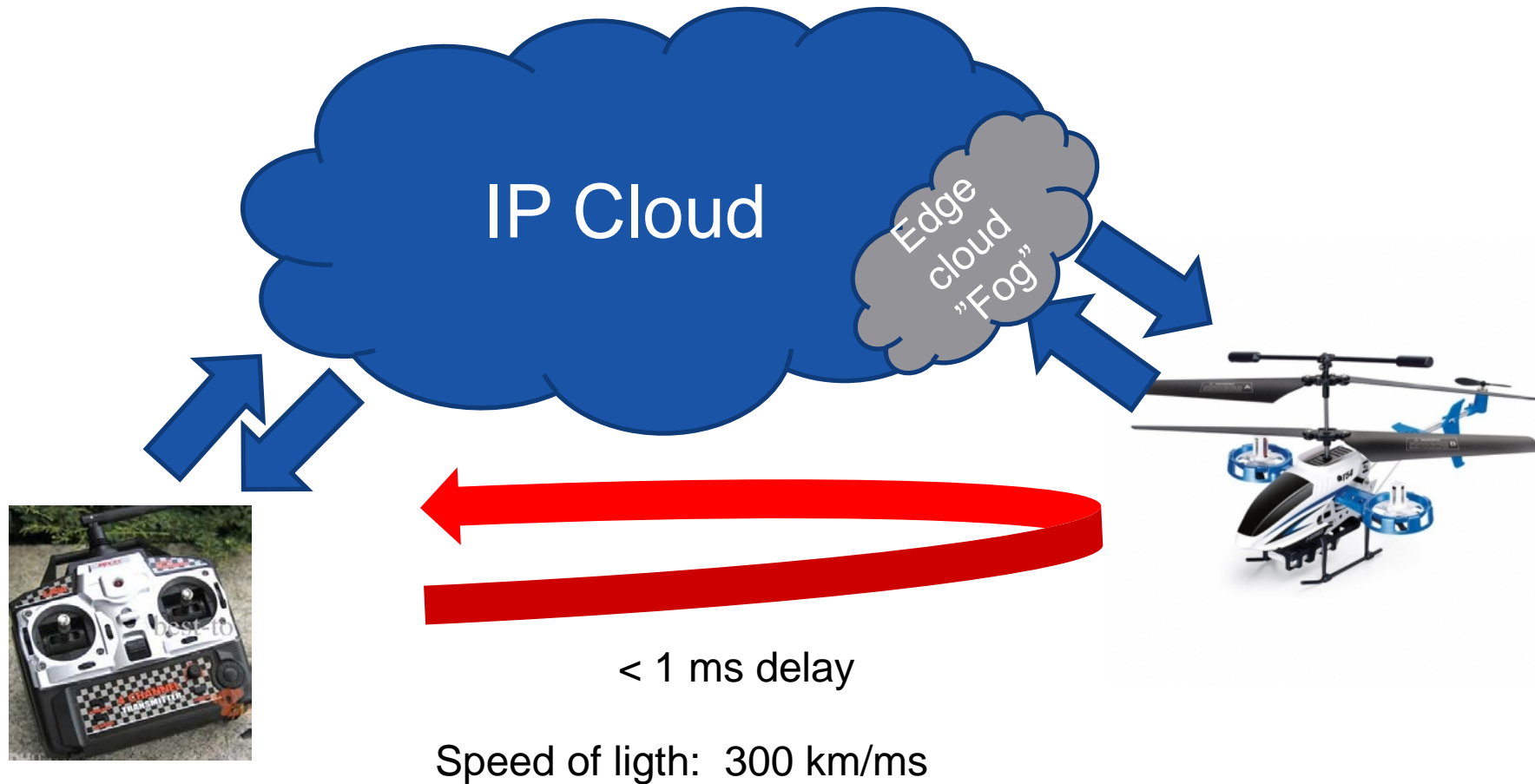
Internet of Things

- Billions of devices
- Low power
- Low cost
- High reliability
- Low delay

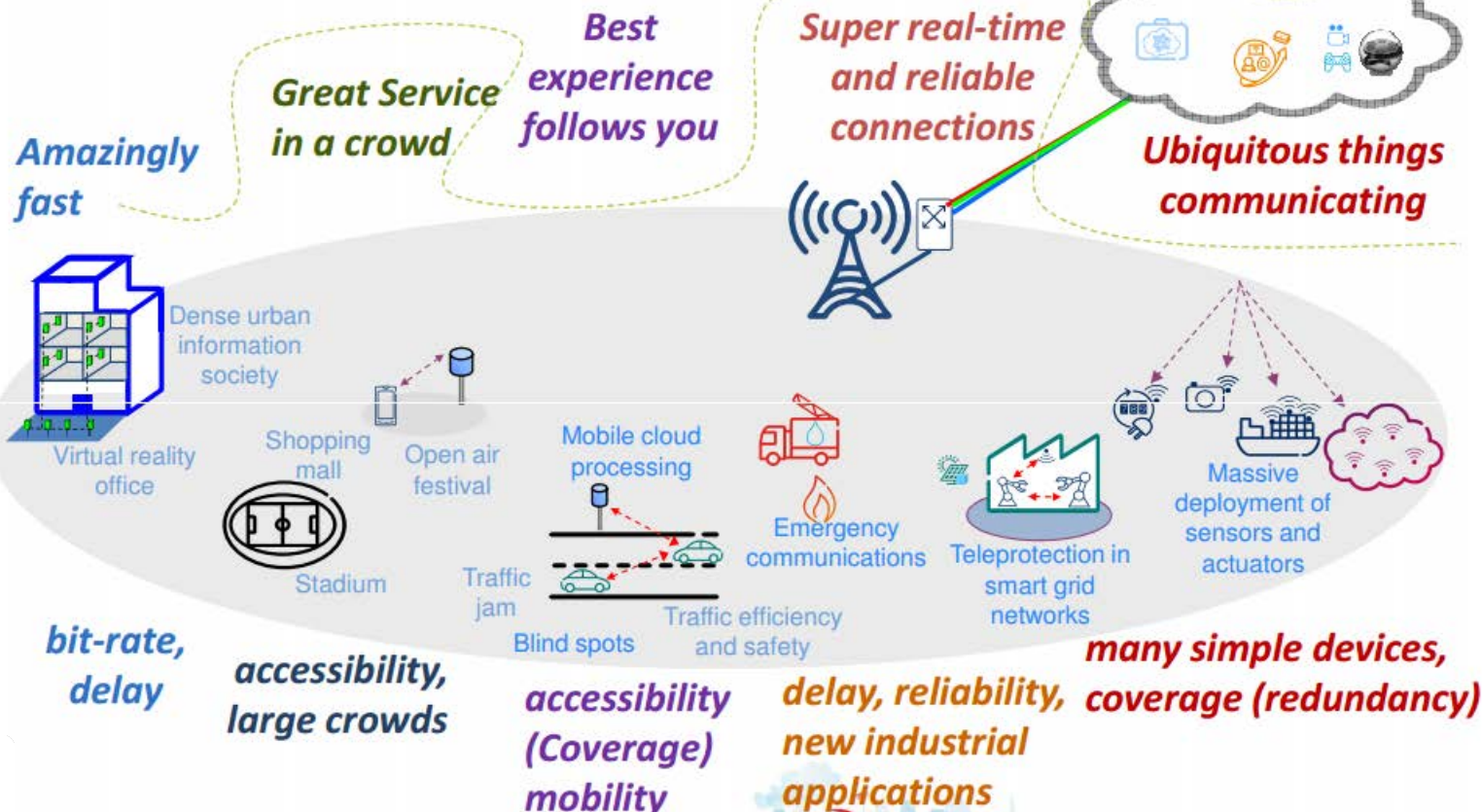
4G works – but not a scalable solution

(SIM-cards in every device ?)

"The internet of Senses" (the "Tactile internet")



METIS 5G Scenarios



In summary ...

Future wireless systems

Provide IP Access – not services

Wide-area infrastructure – “public” actors

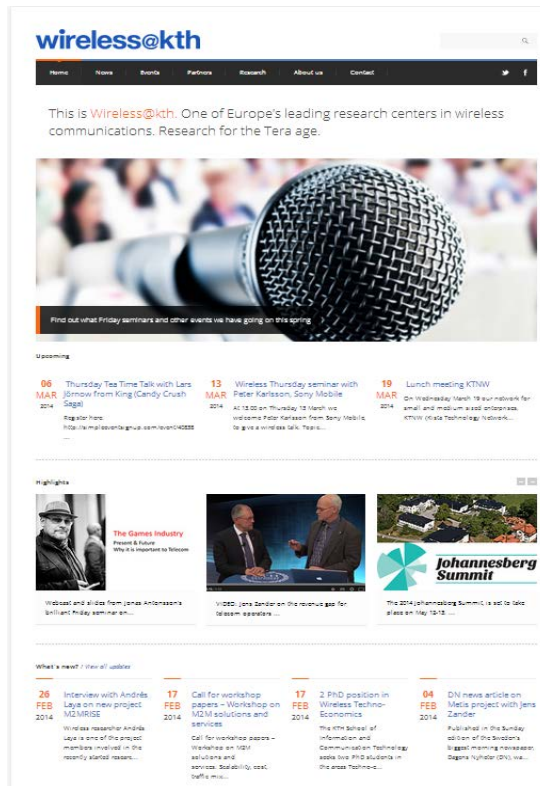
- Provides coverage
- Cost dominated by physical infrastructure, energy, backhaul
- Long time-horizon investment in radio equipment

Short range infrastructure – facility owners

- Provides capacity
- Cost dominated by fixed backhaul (long-term investment independent of wireless system)
- Short time-horizon investment in radio equipment

Infrastructure Sharing (offloading) necessary





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Upcoming

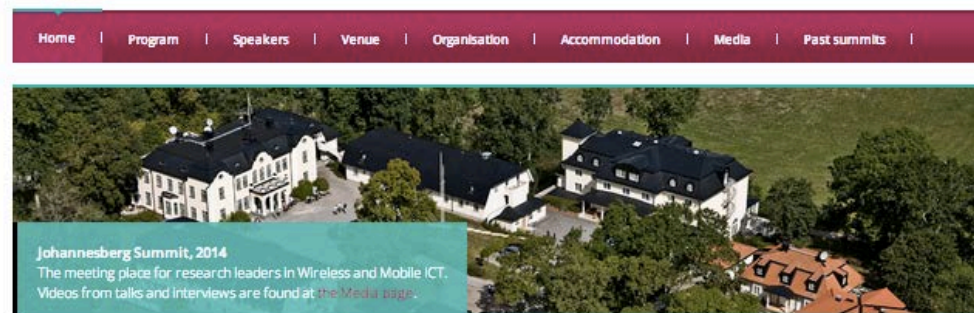
- 06 MAR 2014** Thursday Tea Time Talk with Lars Simon from King's College London
- 13 MAR 2014** Wireless Thursday seminar with Peter Karlsson, Sony Mobile
- 19 MAR 2014** Lunch meeting KTNW

Highlights

- The Games Industry** Press & Future why it's important to Telecom
- V2X** Jens Zander on the revenue gap for Spectrum operators
- The 2014 Johannesberg Summit** is set to take place on May 19-20


What's new? View all updates

- 26 FEB 2014** Interview with André Lay on new project MOBIWIDE
- 17 FEB 2014** Call for workshop papers - Workshop on 4G/LTE solutions and services
- 17 FEB 2014** 2 PhD positions in Wireless Technology Economics
- 04 FEB 2014** DN news article on Media project with Jens Zander

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Johannesberg Summit, 2014
The meeting place for research leaders in Wireless and Mobile ICT. Videos from talks and interviews are found at the [Media](#) page.



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Technology Neutral Spectrum Assignment – a nice concept but is it realistic ?
Posted on September 19, 2011 by Jens Zander

We learn from Economics theory that, if you want to trade goods effectively, these shall be as general as possible, usable by anyone as preferably for many purposes. In this way we attract a large crowd of willing buyers and the market becomes an effective instrument to share these goods. However, if the goods are very specific (like left lady's high-heels shoes in pink, size 40) the demand is very limited and few buyers will show up to facilitate effective trading.

This exactly the concept behind technology neutral spectrum licensing – instead of prescribing in detail when, where and how to use the spectrum, the new policy (e.g. "LITE") is to provide a "block edge mask", restricting what emission is allowed outside the allocated band. Any system conformant with these rules will be allowed and the market for licenses is now large.

What's the catch ? Well, its what in the business is called "Legacy Equipment", i.e. anything that is out there before these new regulations are put into place. We have already numerous examples of interference problems. Airport radars, GSM-R (railway) systems, TV-receivers are facing interference from new LTE/LMDS systems that are put into operation in neighboring bands. Is something wrong with these systems ? No. Are they violating the spectrum mask rules ? Not likely. Would the problems go away with perfect new equipment ? Unfortunately not.

You see, most of this equipment was not designed to have a LTE or LMDS base station next door. The wire designed with the implicit assumption that the neighboring band was empty or used in a very specific way. In this way receiver designers could cut some corners and save a few bucks in production cost. So it's clear where to put the blame. But will the airport-radar uses, the television set manufacturers or railways modify their systems ? Not likely. There seems to be "squatters rights" in the spectrum domain – the guys that where there first (and have significant investments made) are protected and the new users have to modify their equipment, restrict their use or even pay for the modification of legacy equipment. In Sweden a recent study show that using LMDS in the 900 MHz band is OK as long as you stay a kilometer away from the nearest railroad (i.e. where the highest population density are likely to be). If a different system is used LTE, GSM there may be different restrictions. Instead of having a technology neutral spectrum, specific rules apply for each technology and exact how close to the band edge the spectrum chunk is located. Will the bidders in a spectrum auction need to take this into account – yes of course, with a significantly lower valuation as consequence.

So Tech Neutrality is a nice concept but difficult in practice. It again exposes the shortcomings of our current paradigm of transmitter licensing. Here (and in many similar cases) its the receivers that cause the problems. The concept of [Spectrum Usage Rights](#) is a step in the right direction, but not a solution to these problems.

Posted in [Spectrum-Systems](#) | 2 Comments | [View 1 Picture](#)

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- Technology Neutral Spectrum Assignment – a nice concept but is it realistic ?
- Chescon 2011: Some rules
- USFC General Assembly 2011, Politics and Spectrum usage
- LightSquared – even more money down the drain?
- "Big Brother" says streaming more than 10 times is illegal

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Comments

Recent Comments

Jander Absolutely, I think this is one of the problematic areas for secondary spectrum use ("cognitive radio") in densely populated areas. There is plenty of spectrum in many places on paper, but when you...

Syed Faraz Yousaf H, if I am not wrong, Spectrum Sensing Cognitive Radio also work almost on the same spectrum neutral principles isn't it? Do you think their usage will also be limited by