Is there a thing called 5G ?

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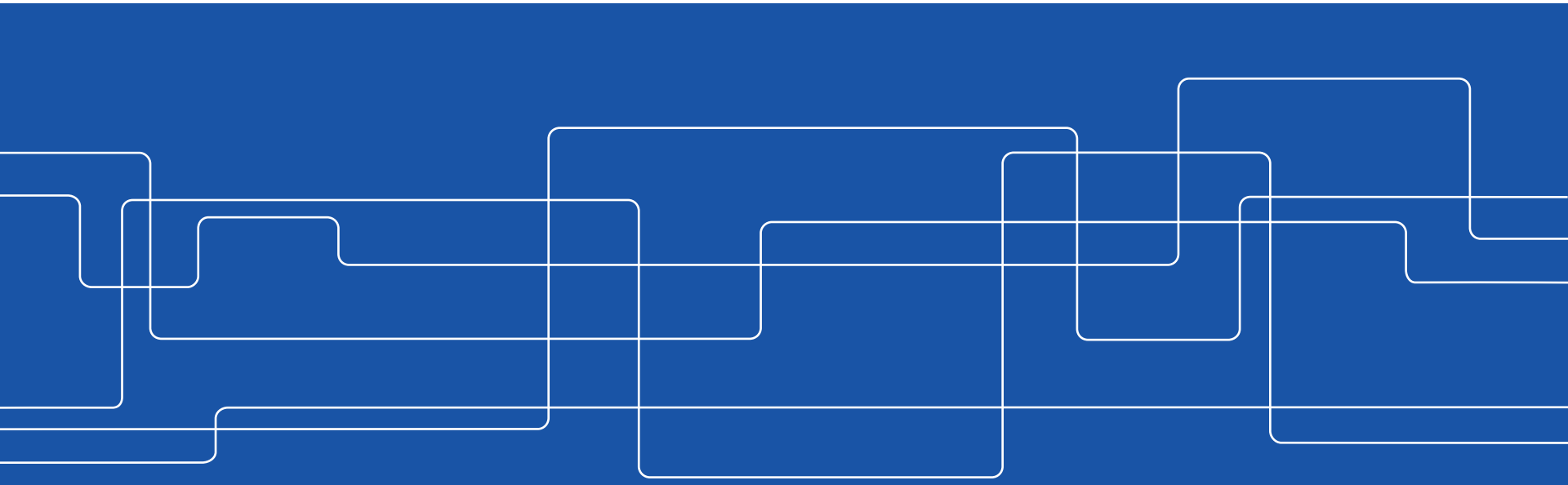
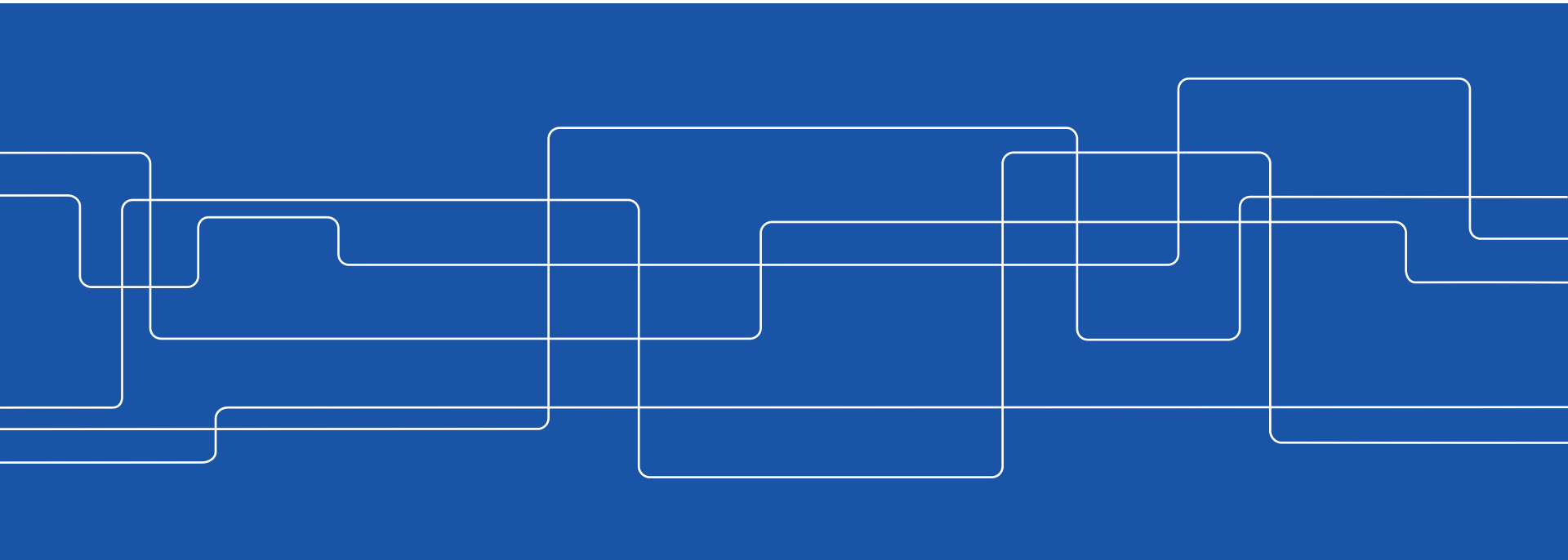


Outline

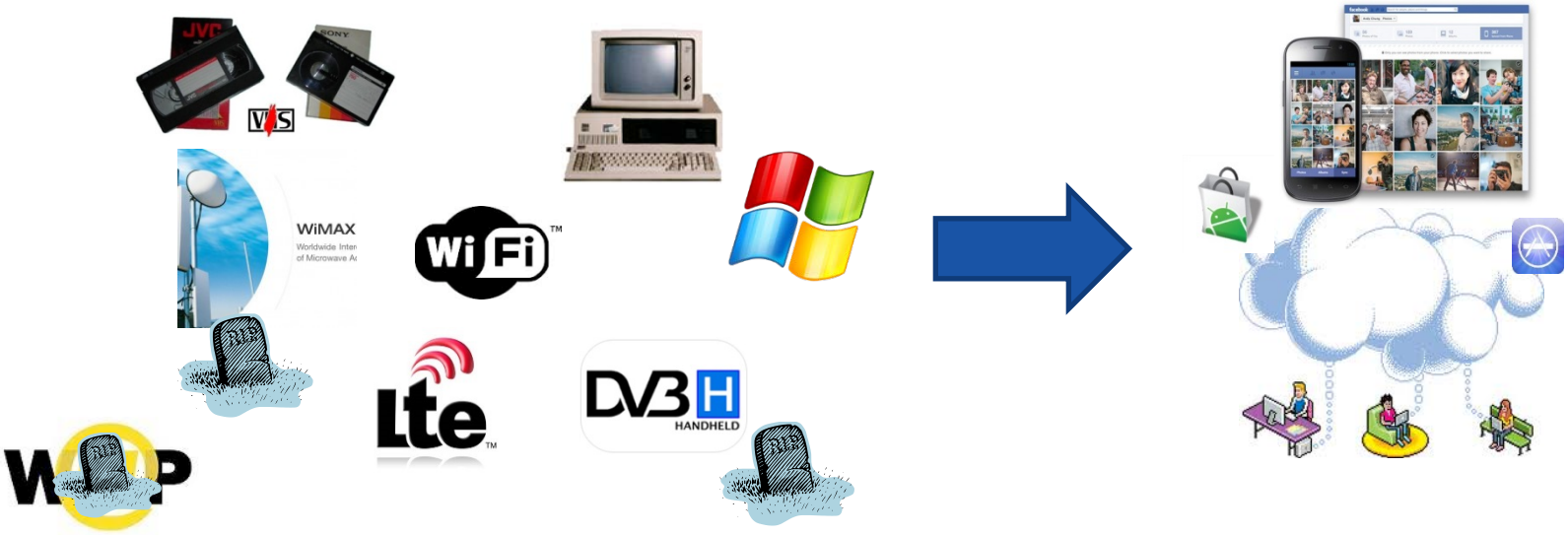
The 5G drivers

- 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

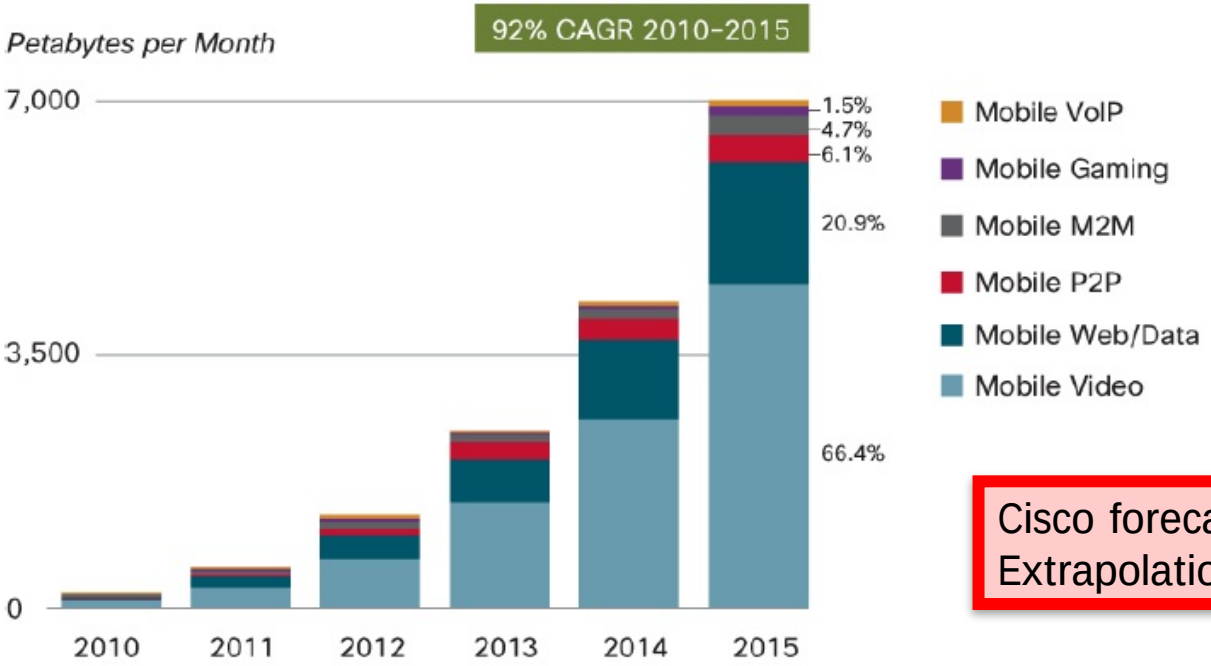


- From infrastructures driven by ”killer apps” and ”one-trick ponies”
  → general IP-based access infrastructures
- Internet access = dominant design for ALL services (fixed & mobile)
- Marginalizes other technical solutions – e.g. Wireless P2P, Mesh, ...
- Story sounds familiar ...?

> ”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



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

Source: Cisco VNI Mobile, 2011

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

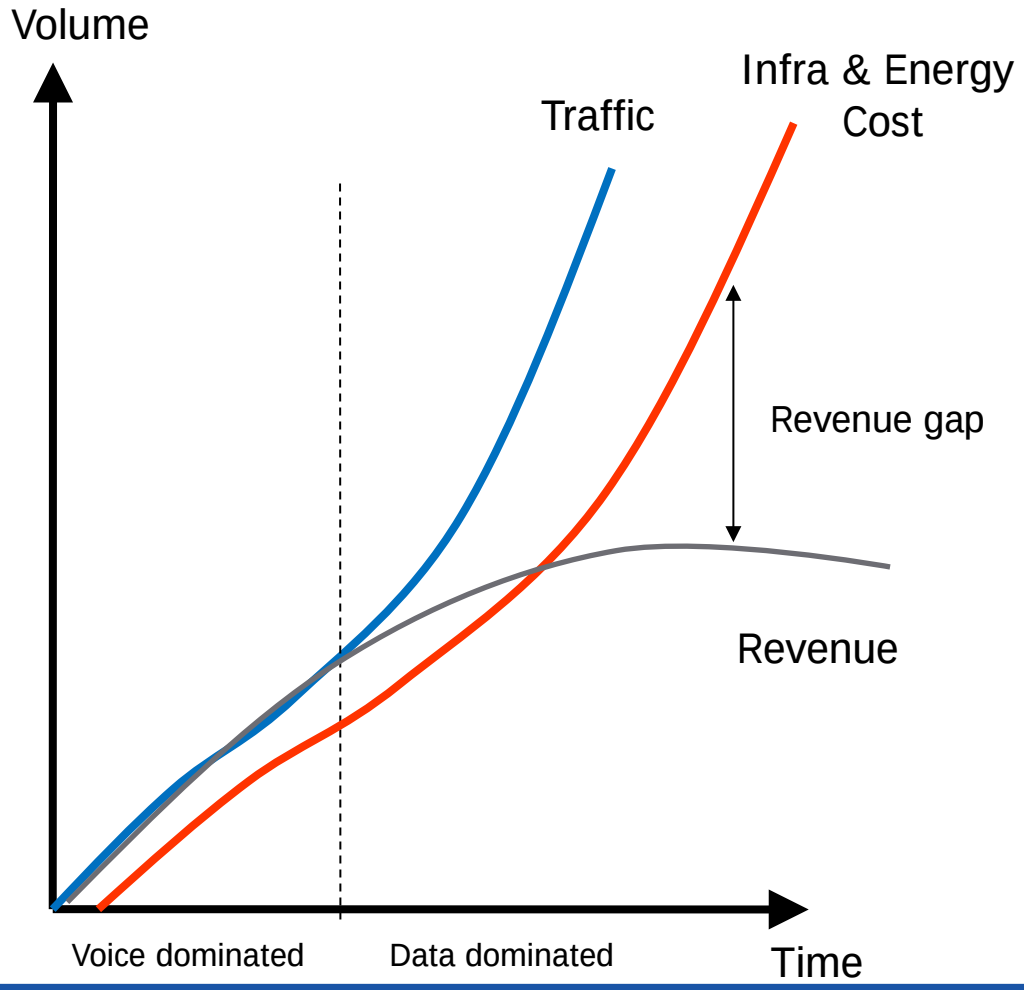
Exponential growth (now slowing down somewhat)
Assumes **zero marginal cost** for access
How long can this be sustained ?

Operator dilemma: More for less money

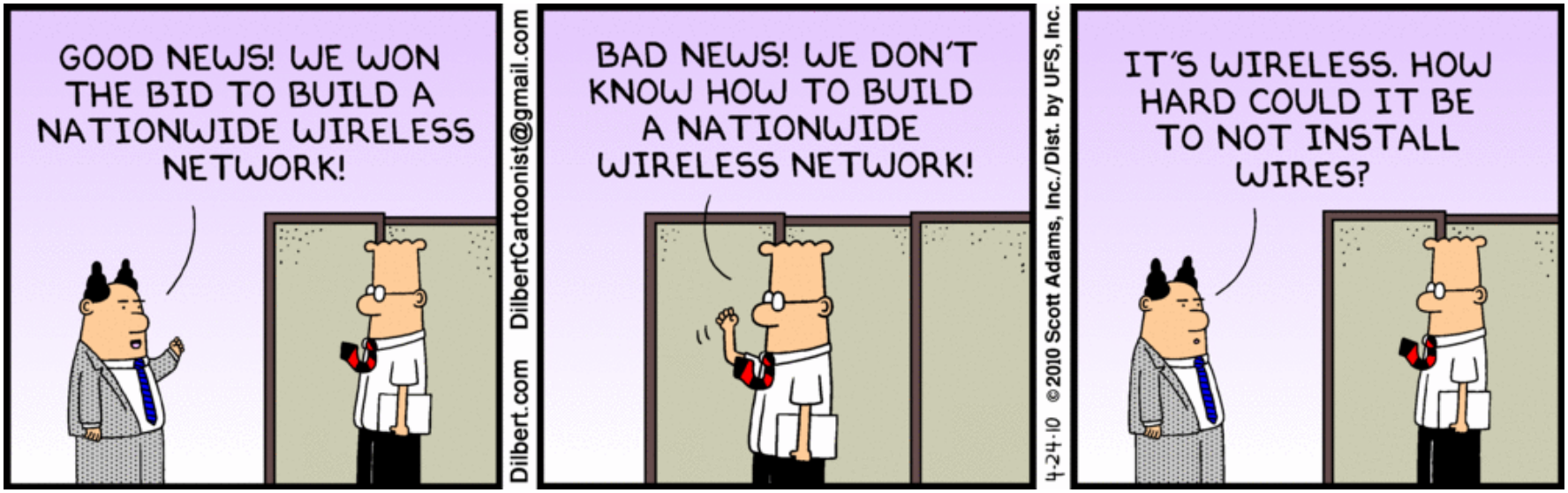
- Spending capability of user increases with GNP growth (<10% annually)
- Capacity requirements increase by 80-100% annually

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

Challenge:
1000x lower cost/bit



How difficult can it be ?

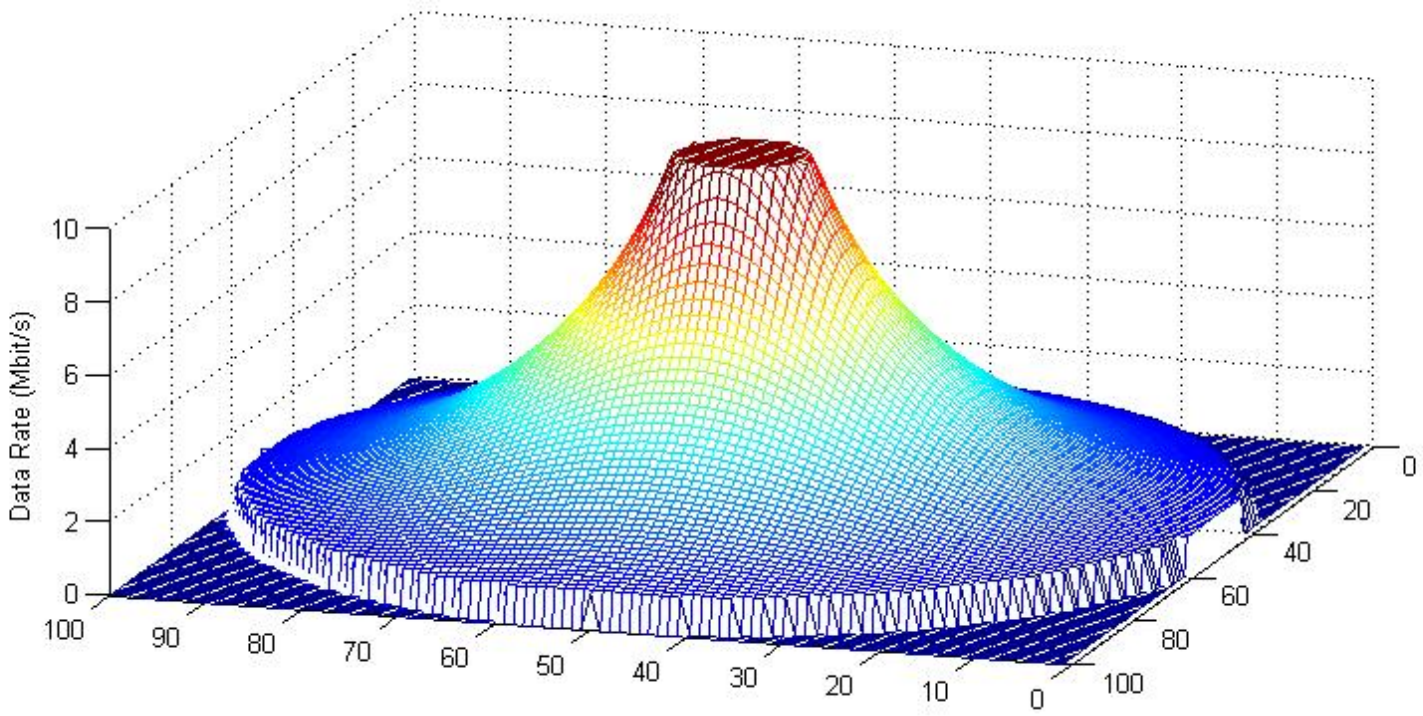


How to increase capacity ?

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

- 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 ≠ Peak Rate

Moore’s law not applicable to concrete and steel

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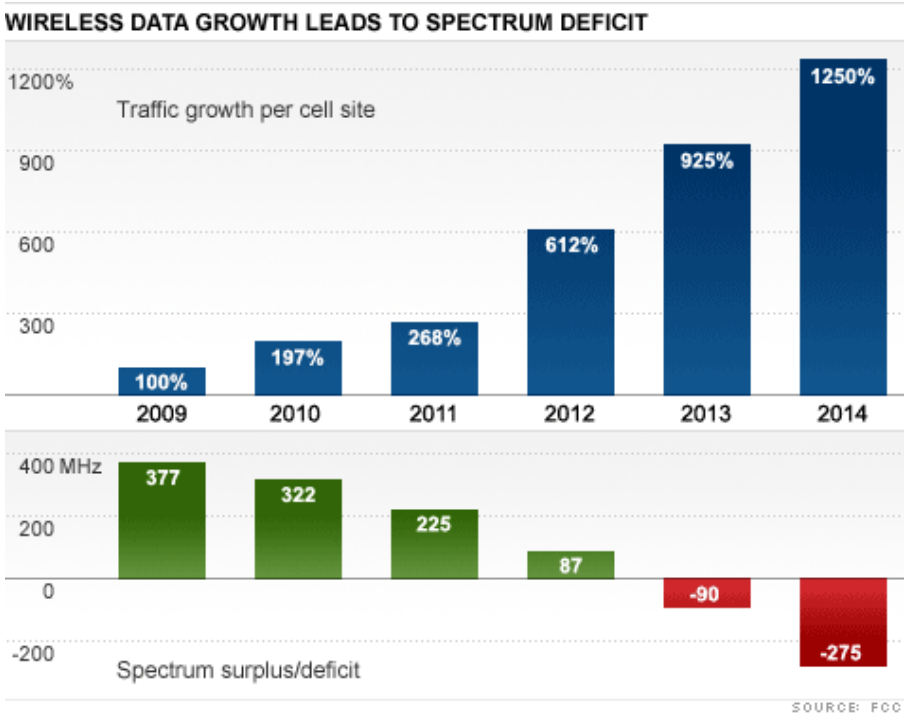
Solving ”all” problems with more spectrum - the FCC – Spectrum deficit



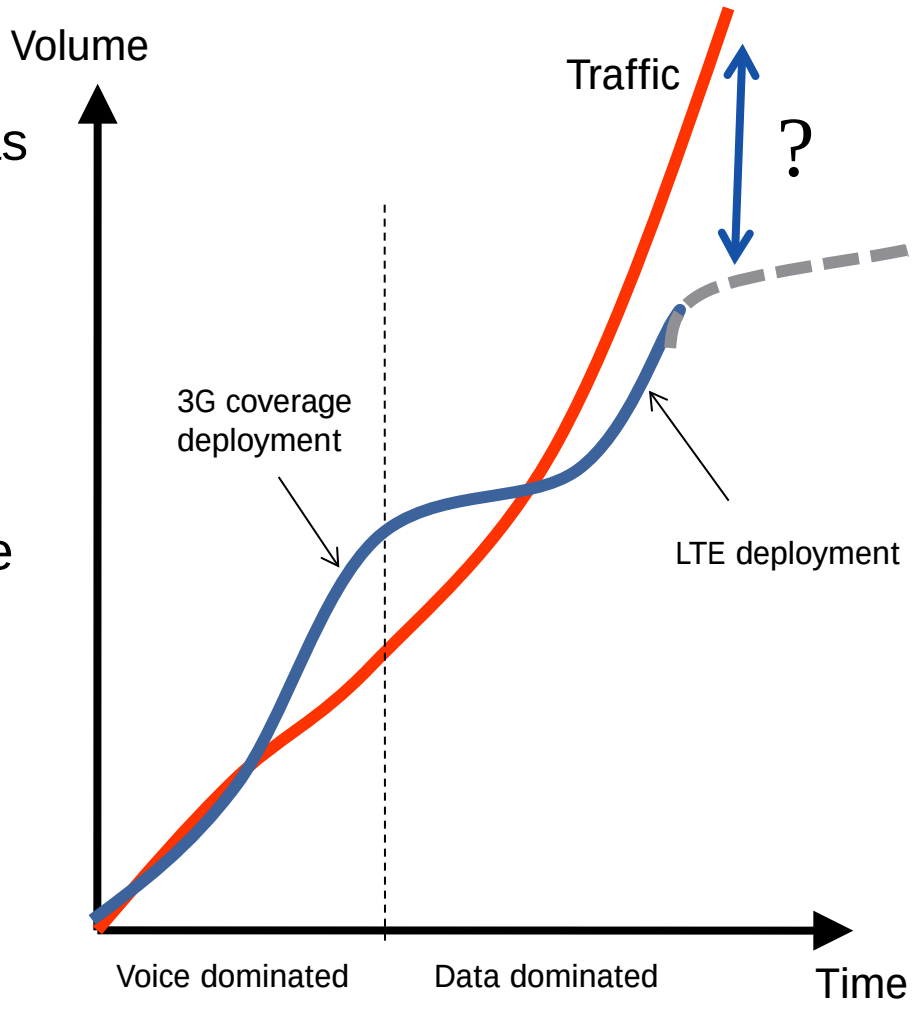
Key assumptions

Reasonable extrapolation of

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

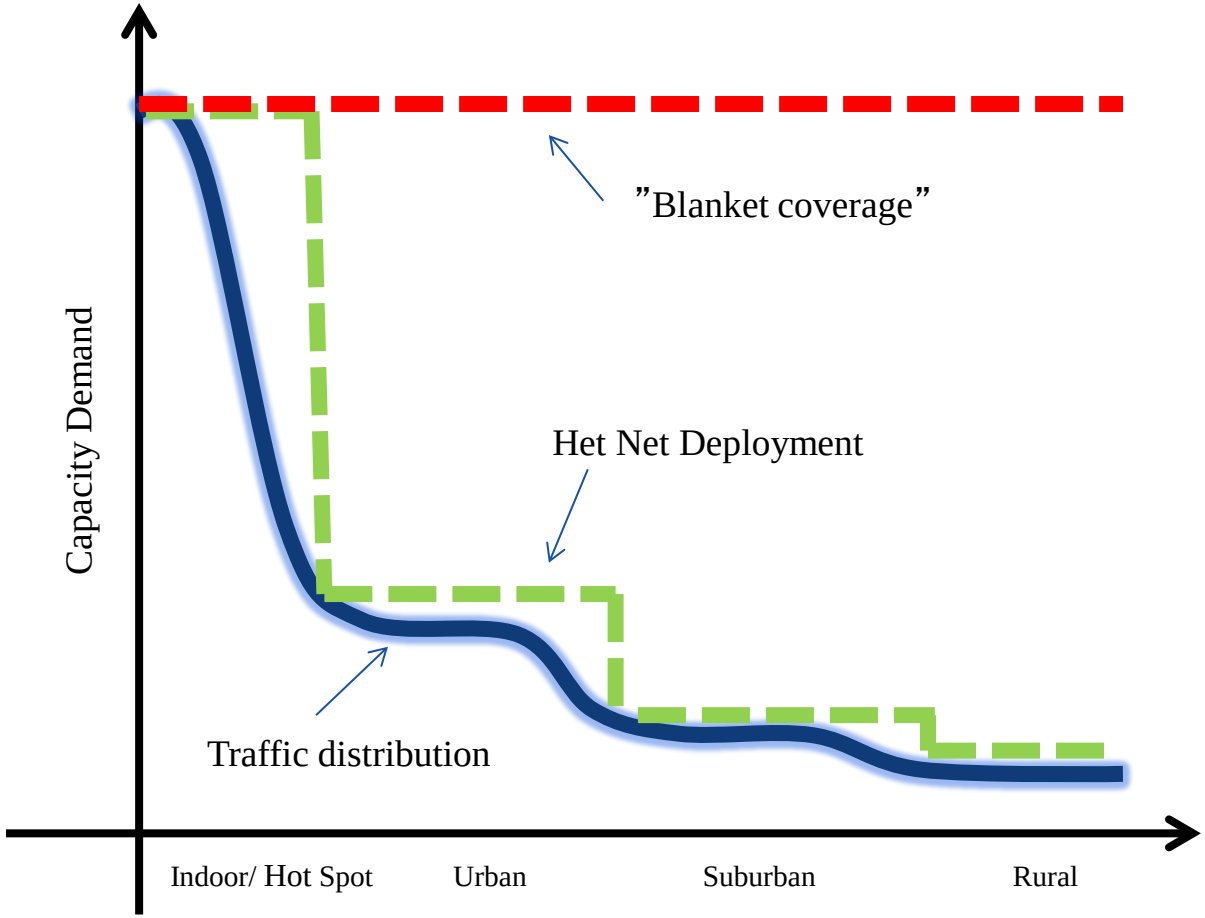
So what if cellular system can’t keep up ?

- 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

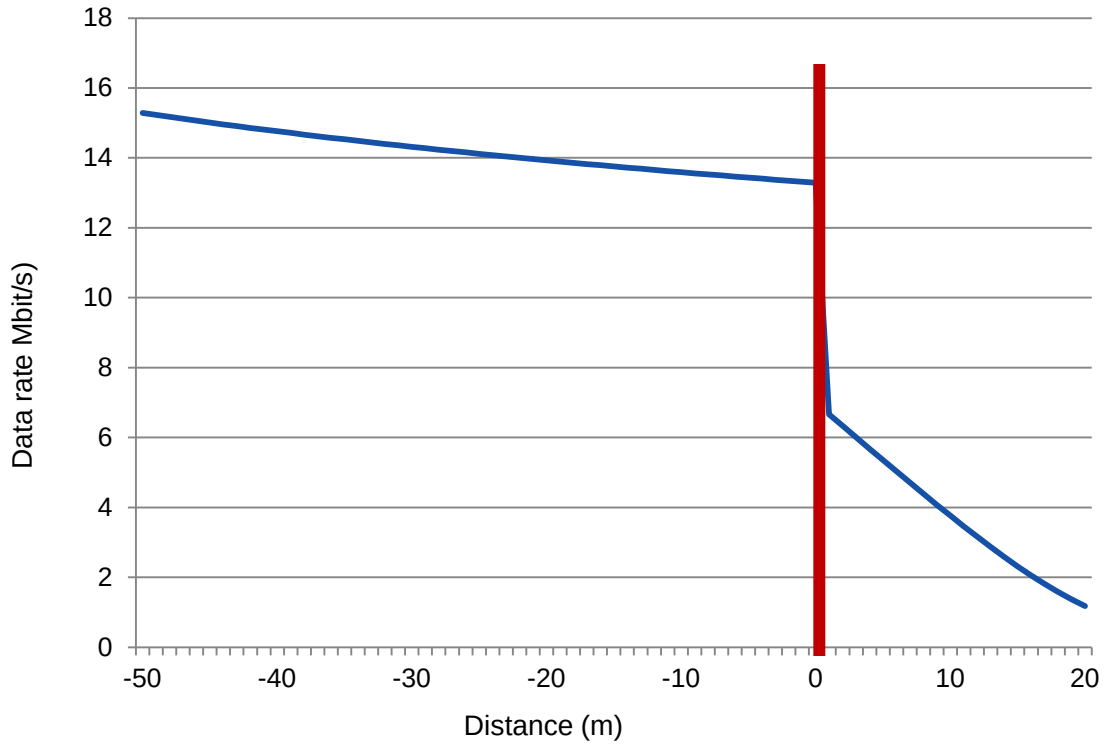


The Light Analogy : HET NETs

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

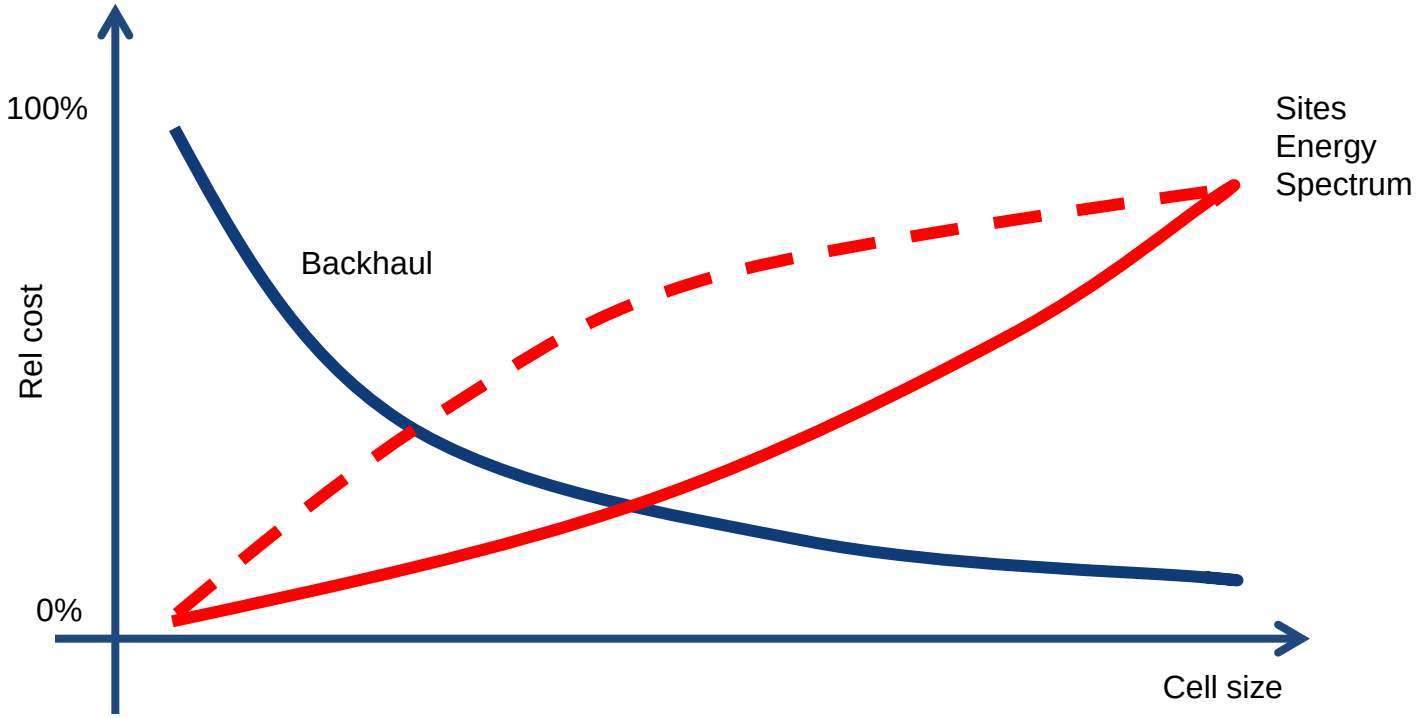
The coverage world

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

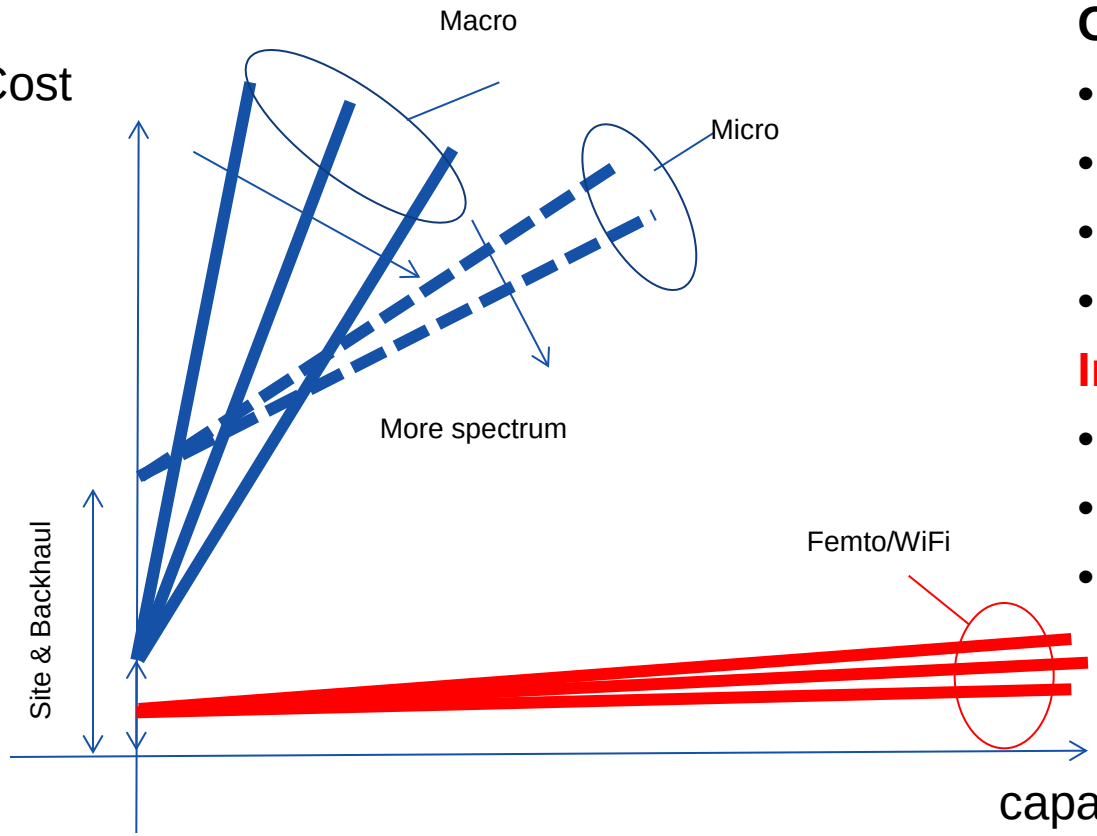
The capacity world

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!

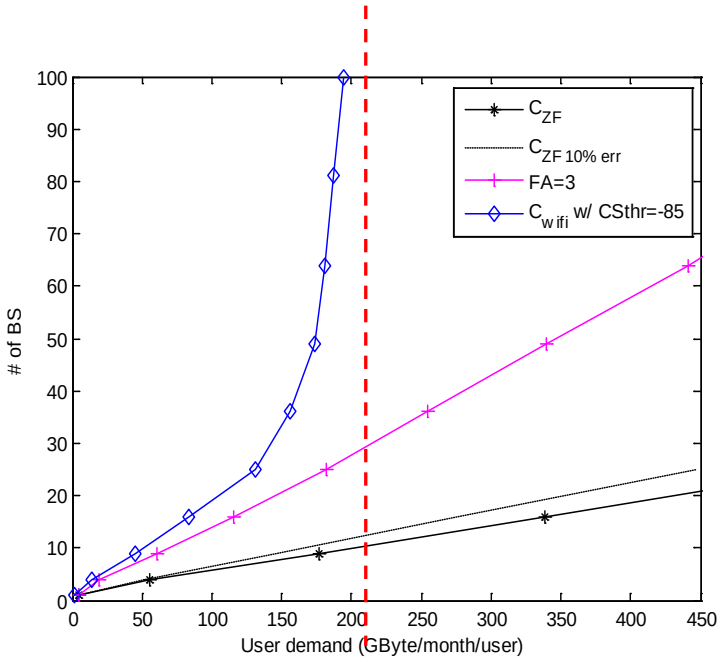
Capacity (were needed) is ”cheap” - coverage is expensive

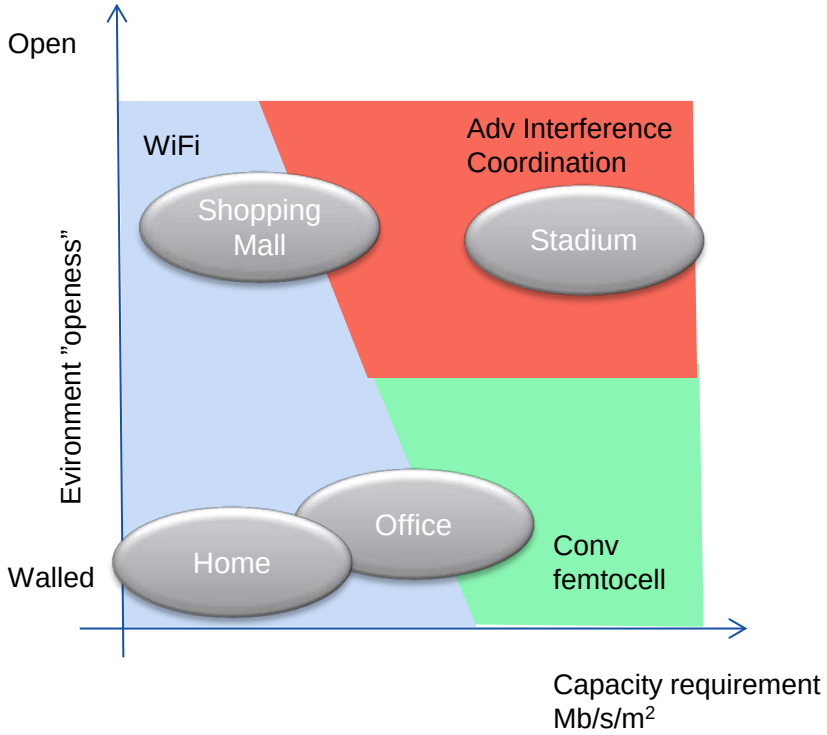
Is there enough capacity ?

	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)

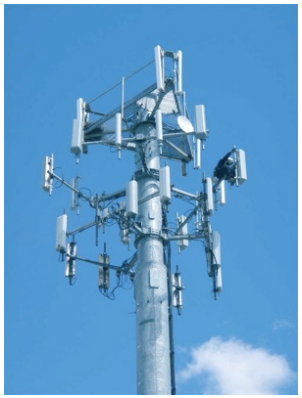
Capacity and Economic feasibility





A World Divided – business aspects

The coverage world



Public operators

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

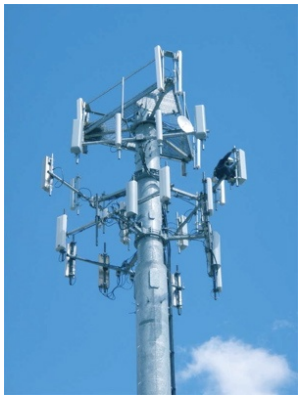
The capacity world

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

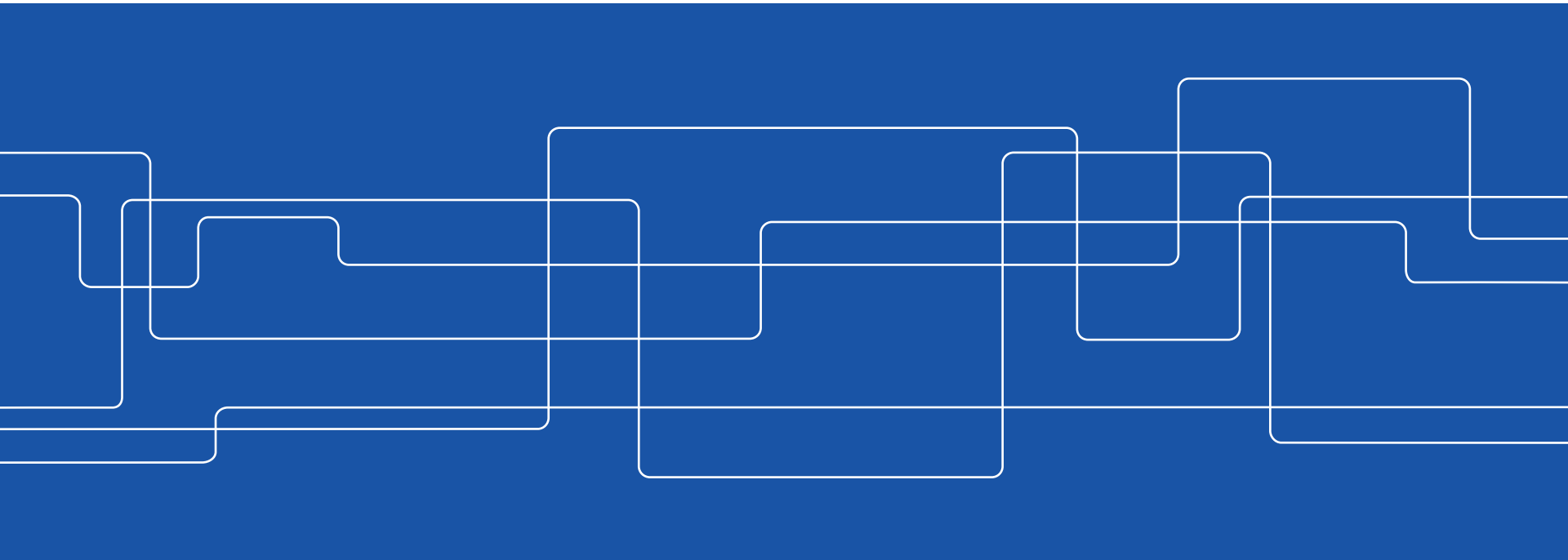
The capacity world

- 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 …

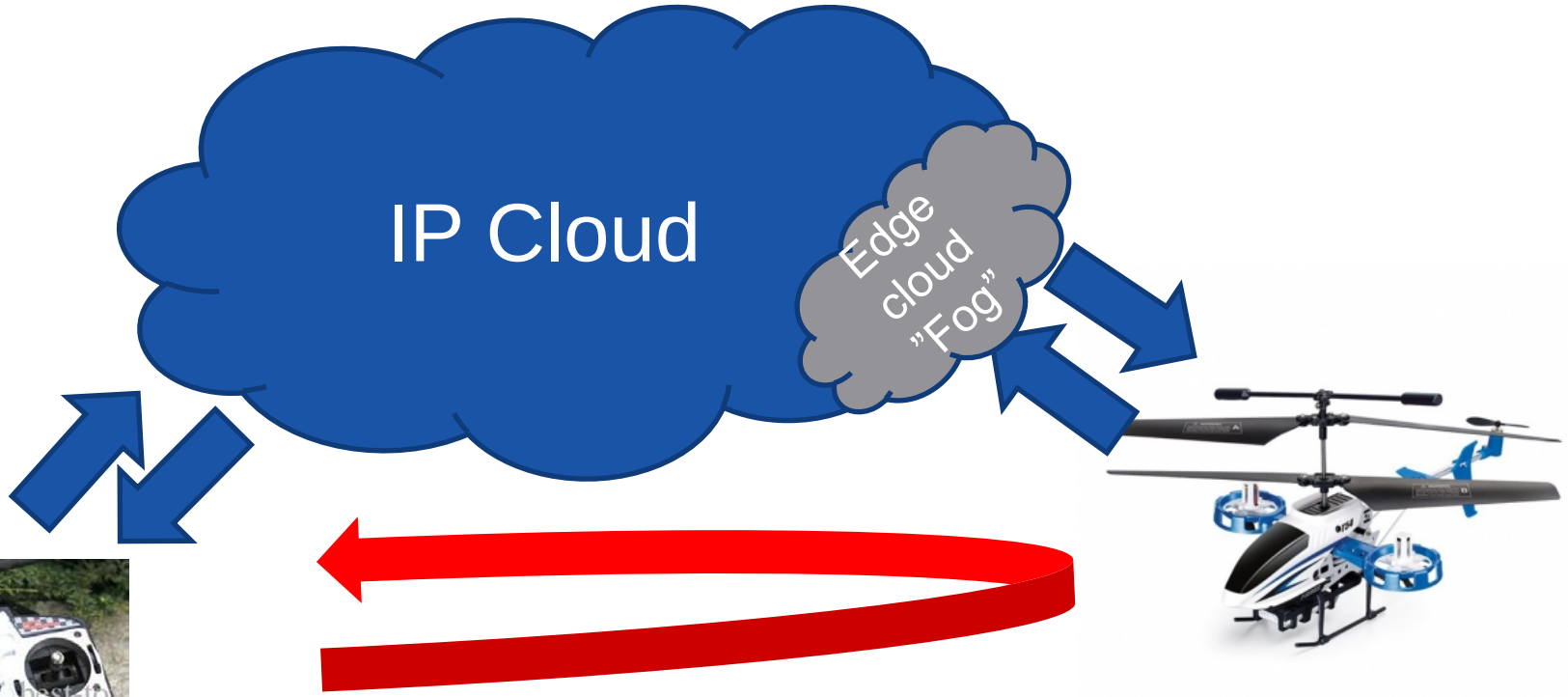
Internet of Things

- 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”)

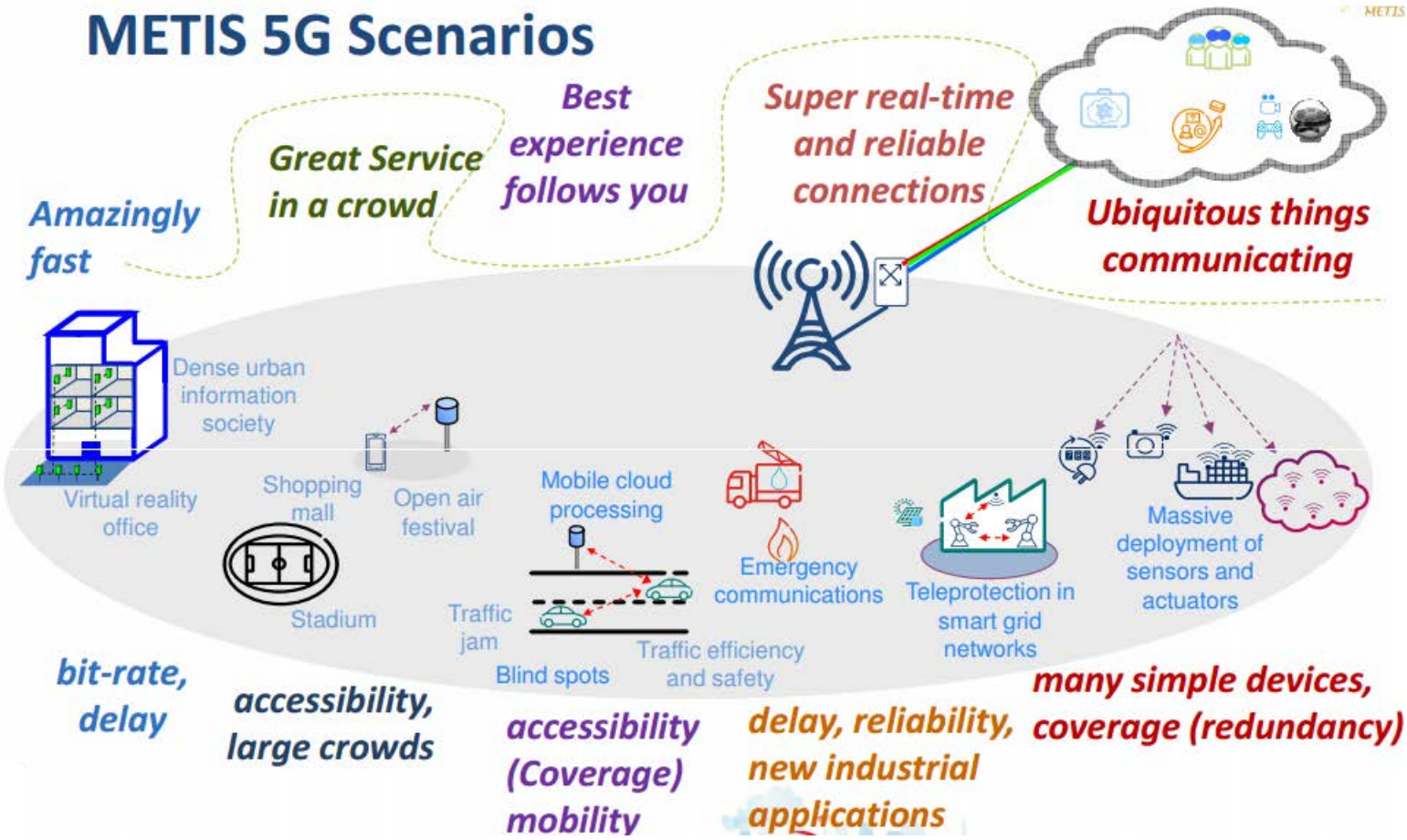


< 1 ms delay

Speed of ligth: 300 km/ms

www.metis2020.com

METIS 5G Scenarios



SEVENTH FRAMEWORK PROGRAMME

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In summary …

Future wireless systems

Provide IP Access – not services

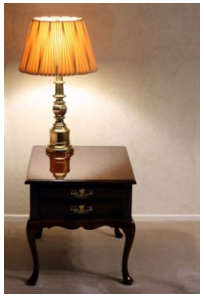
Wide-area infrastructure – ”public” actors

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

Short range infrastructure – facility owners

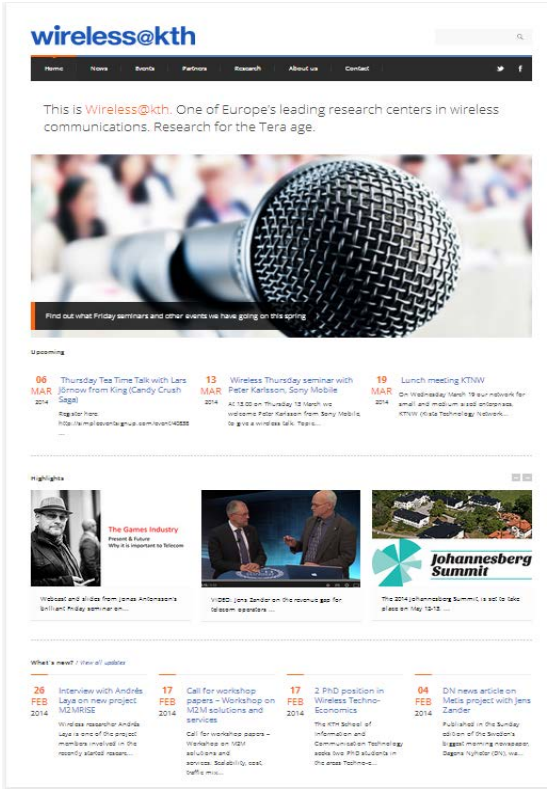
- Provides capacity
- Cost dominated by fixed backhaul (long-term investment independent of wireless system)
- Short time-horizon investment in radio equipment

Infrastructure Sharing (offloading) necessary

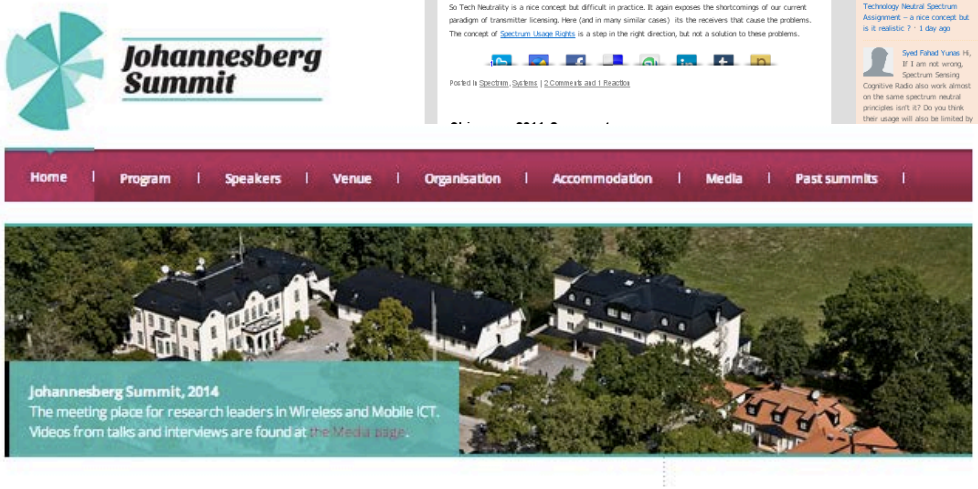


Read more !

wireless.kth.se



theunwiredpeople.com



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