





Requirements & Challenges

- in Wireless/Mobile Communications 2020

Jens Zander
Scientific Director, Wireless@KTH
KTH – The Royal Institute of Technology,
Stockholm, Sweden


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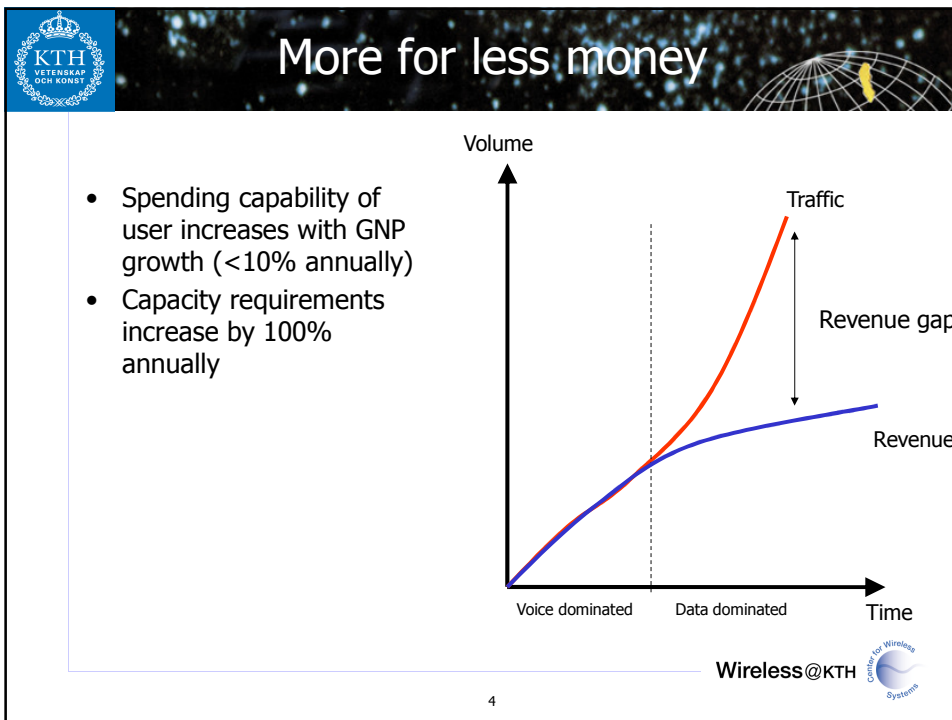
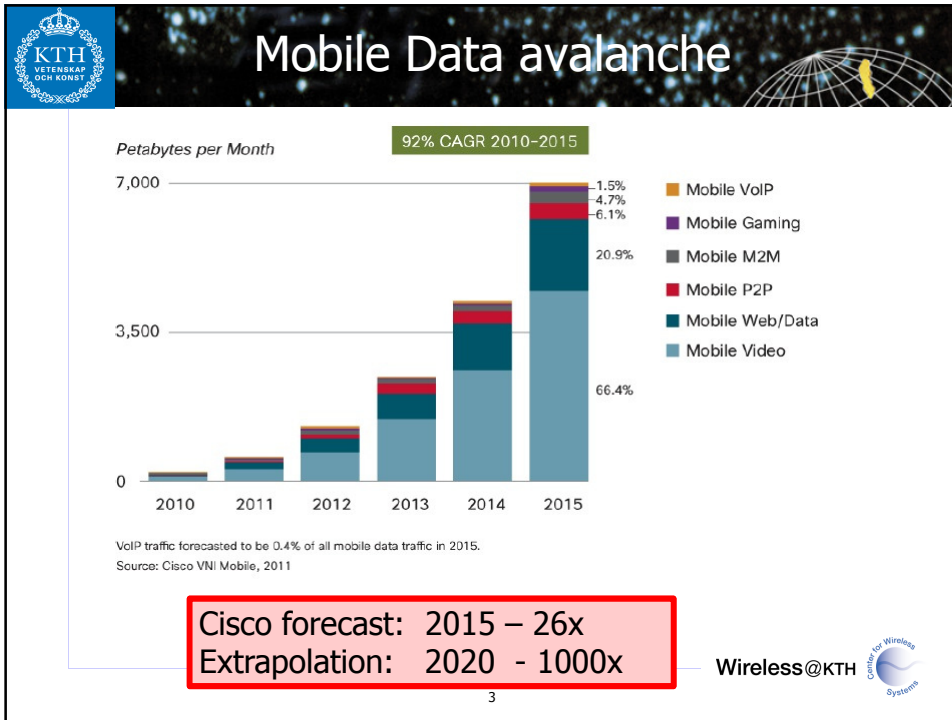


Outline

- Techno-economic issues in 4G and beyond
- Research Challenges 2020
- Potential solutions & Spectrum options

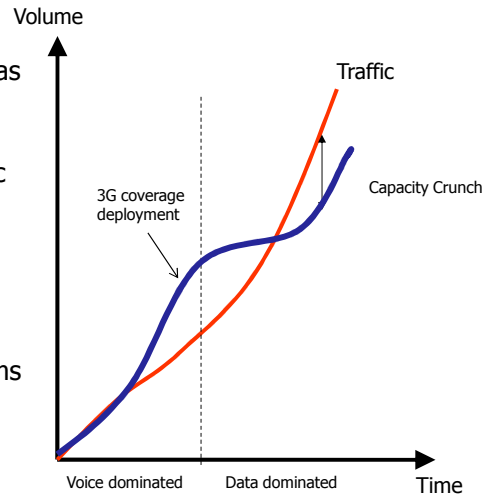
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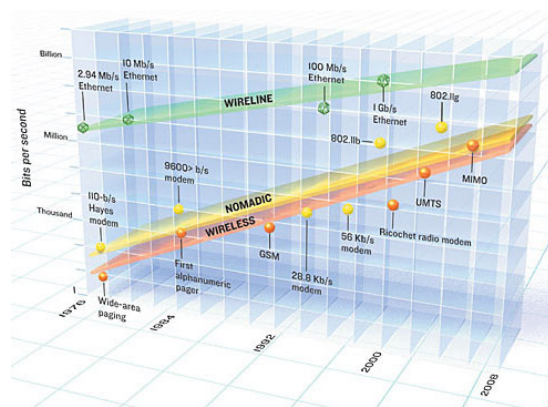


- but will operators keep up ?

- Excess capacity when 3G was deployed to meet coverage constraints
- "Hidden traffic" – A2A traffic ("App-App") causes severe problems ("Control plane overload")
- AT&T hit first ("iMess") but now most operators are experiencing similar problems



Can it be solved by more & cheaper electronics ?



“Edholms law”

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... Coverage/capacity are not simply related

Capacity \neq Peak Rate
 Moore's law not applicable to concrete and steel

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Peak vs Edge Rates

$$\frac{C_{system}}{N_{user}} \propto B_{user} A_{service}$$

- Edge rates dominate
- High peak rates make sense only in dense deployment
- Cost/Tech drivers:
 - Peak rates: Replace base station equipment
 - Edge rate: More Base stations sites


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Challenge 2020:

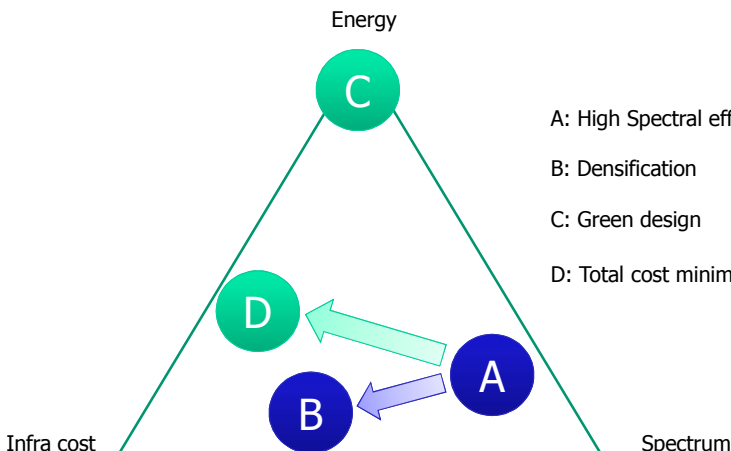
1000 times more capacity at todays cost & energy

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Key Design Constraints



- A: High Spectral efficiency
- B: Densification
- C: Green design
- D: Total cost minimization

$$C_{tot} = C_{spectrum} + C_{infra} + C_{energy}$$

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In search for 5 G
1000 times more capacity ..but how ?

What does the "market" think ?

Company	Spectrum	Spectral efficiency	Densification	Total capacity increase
Nokia Siemens	10x	10x	10x	1000x
Huawei	3x	3.3x	10x	100x
NTT Docomo	2.8x	24x	15x	1000x

What does capacity mean ?

$$R_{tot} = N_{user} R_{user}$$

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Increased Spectral Efficiency ?

- (Yet) Another air-interface
- Complex PHY-layer schemes (relaying, cooperation)
- Smart(er) antenna systems

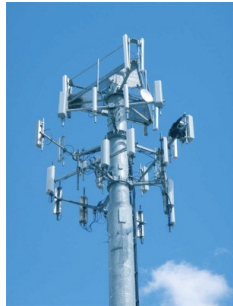
Increased complexity, energy consumption

Potential: 2-3 times improvement (?)

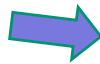
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Densification: Technology shift



- Industry grade eq
- High power
- 24-7 availability
- High **system** complexity
- **COST = equipment, site, spectrum, energy**



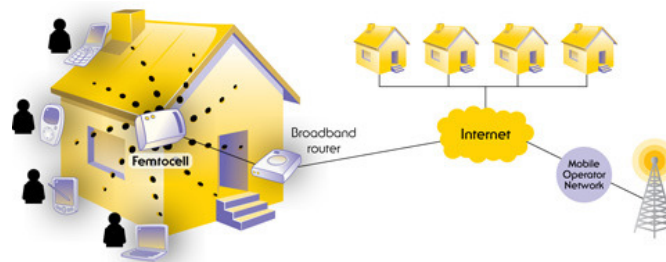
- Consumer grade eq
- Low power/Short range
- Low **system** complexity (P&P, SON)
- Massive deployment – mainly indoor
- Reliability through redundancy
- Deploy where backhaul available
- **COST = Deployment**



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Sharing infrastructure: A new ways to low-cost capacity




- Technology: Not an issue !
- Business model: Cooperation !

"HET NETs"

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Why do we need more spectrum?

- More data rate / Capacity ?
 - For very high data rates (>100 Mbit/s user rate)
- Lower deployment cost (fewer base stations)
- Lower energy consumption (lower spectral efficiency)

- Which frequency bands ?
 - Range – Bandwidth trade-off


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Spectrum options ?

	Exclusive <6 GHz	Shared < 6 GHz	Secondary <6 GHz	Exclusive > 10 GHz
Availability	Very Low	Low (100 MHz)	Good (>1 GHz) for <u>indoor use</u>	Very good
Advantages	<ul style="list-style-type: none"> • Guaranteed QoS • Long-term investments 	<ul style="list-style-type: none"> • Spectrum available • Low cost equipment/deployment 	<ul style="list-style-type: none"> • Spectrum available • Low cost equipment/deployment 	<ul style="list-style-type: none"> • Very high capacity • Low interference
Disadvantages	High deployment cost	<ul style="list-style-type: none"> • No QoS guarantees • Low availability 	<ul style="list-style-type: none"> • Limited QoS guarantees • Regulatory uncertainty 	LOS propagation, antennas Dedicated Deployment


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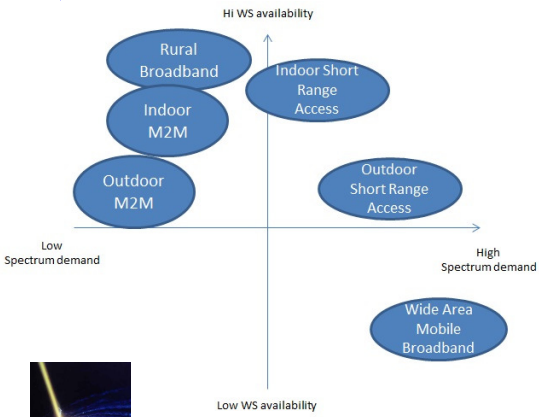
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Commercial Feasibility of Secondary Spectrum Use (FP7 QUASAR)






- Plenty of spectrum for secondary use, in particular short range indoor
- Availability very scenario & location specific
- Sensing useless in many popular scenarios – yields very low utilization
- Key challenges in business scalability:
 - Assessing impact of multiple interferers
 - Strong Coupling to infrastructure lifetime




SEVENTH FRAMEWORK PROGRAMME

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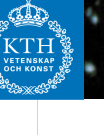


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Some conclusions




- Denser infrastructure – key to higher capacity
 - Infrastructure sharing – “disruptive” business model
 - Cost dominated by deployment & fixed infrastructure – not equipment, spectrum
- More spectrum → lower cost, lower energy consumption
- Spectrum options
 - Lower frequency bands preferable in short/medium term perspective due to lower deployment cost
 - Higher frequencies (mm-waves) for extreme data rates, low mobility



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Read more & Interact !



wireless.kth.se

The screenshot shows the homepage of wireless.kth.se. At the top, there is a search bar and navigation links for Home, News, Research, Seminars, Publications, and About. Below this, there are several featured articles with images and titles, such as 'Coming up: KTH, NTHU, DTU and Green: The State of the Art...', 'Wireless systems of tomorrow', 'Research strategy', 'Mobile Payment', 'Energy and our efficient 5G', 'Secondary spectrum', 'From our Community', and 'Technology Neutral Spectrum assignment - a nice concept but is it realistic?'. There is also a 'Subscribe to our updates' section with a 'Subscribe' button.

theunwiredpeople.com

The screenshot shows a blog post on theunwiredpeople.com. The article title is 'Technology Neutral Spectrum Assignment - a nice concept but is it realistic?'. The author is 'The Unwired People'. The article text discusses spectrum management, mentioning concepts like 'technology neutral spectrum' and 'interference protection'. It also includes a 'Comments' section with one comment from 'Jonas Kvarnström' and a 'Recent Posts' sidebar with links to other articles like 'Wireless@KTH - a nice concept but is it realistic?' and 'Character 2015 Game night'.

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