5G - SPECTRUM SHARING BELOW 6 GHZ VS. NEW SPECTRUM
ALLOCATION ABOVE 6 GHZ

WPMC 2014, Sydney

Matti Latva-aho
What is 5G?
5G Is Not Just Radio Technology

• **Technology** boost is a key enabler for
  – New **services**
  – New ways for **spectrum sharing policies** and using higher frequencies
  – Generating totally new **business models**
  – Emergence of **micro operators**?
10 Years Old Vision for 2010
by European WINNER project
The Vision for 2020+
Industry Views on 5G

Qualcomm

Nokia

Huawei

Ericsson

DoCoMo

Samsung
A Research Community View

By European FP7 project METIS

www.metis2020.com/

• **Five challenges**

  – Fundamental technical difficulties that should be addressed within the 5G mobile and wireless communications systems in 2020 and beyond

Possible futures 2020

- **Very high data rate**
- **Very low latency**
- **Further evolution**
- **Extension to new application fields**
- **Very low energy, cost, and a massive number of devices**
- **Very dense crowds of users**

Disruptive approach for traffic explosion

Mobility

3GPP Rel-14

3GPP Rel-13

3GPP Rel-12

Today
Timeframe for 5G

Most vendors

- Research and Technology Trials
- Standard
- Product R&D
- Deployment

WRC’12

WRC’15

SPECTRUM STUDIES – sharing VISION for "Beyond IMT-Advanced"

IMT.UPDATE (traffic, etc..)

System optimisation / standardisation/Trial

Implementation (Pre-commercial Trial)

Beyond 2020 system

European research community

Exploring new paradigms, fundamentals, system concepts

Further developments on fundamentals


WRC’12
IMT UPDATE (traffic, etc..)

WRC’15

SPECTRUM STUDIES – sharing VISION for "Beyond IMT-Advanced"

Rel-12

Rel-13

METIS

Centre for Wireless Communications
University of Oulu

© Department of Communications Engineering

3GPP
How Radical Innovations Can Be Afforded?
TOKYO, JAPAN, May 8, 2014 --- NTT DOCOMO, INC., a personalized mobile solutions provider for smarter living, announced today that it will conduct experimental trials of emerging 5G mobile communications technologies with six world-leading mobile technology vendors: Alcatel-Lucent, Ericsson, Fujitsu, NEC, Nokia and Samsung.

The parallel collaborations between DOCOMO and each of the six vendors will involve experimental trials to confirm the potential of 5G mobile technologies to exploit frequency bands above 6GHz and realize very high system capacity per unit area, and new radio technologies to support diverse types of applications including machine-to-machine (M2M) services. DOCOMO also expects to collaborate with other companies in its effort to test a wide range of 5G mobile technologies.
Nokia to build 5G test network in Oulu

Finnish mobile technology company Nokia plans to build a high-speed 5G data transfer test network. The company has already made a decision-in-principle on the matter and named two staffers to take forward construction of the network, with actual testing to begin early next year.

Nokia plans 5G test network, will share APIs via new partnership unit

September 1, 2014 | By Tammy Parker

Nokia (NYSE:NOK) is planning to build a 5G data transfer test network in Oulu, Finland, early next year, according to a Finnish news report. In addition, the company announced a sweeping partnership program that will, among other things, have Nokia's networks unit opening up certain internal application programming interfaces (APIs) to partners, and even competitors.
What Could 5G Be In More Technical Terms

By Samsung (@ http://www.eucnc.eu/?q=node/71)
RAN RESEARCH CHALLENGES

1. SPECTRUM
   ➔ SPECTRUM SHARING SCHEMES
   ➔ NEW SPECTRUM ALLOCATIONS

2. L1 & SPECTRUM EFFICIENCY
   ➔ MASSIVE NETWORK MIMO
   ➔ NEW MODULATION SCHEMES

3. NW ARCHITECTURES AND FUNCTIONS
   ➔ HETNETS, SMALLCELLS, D2D, M2M,...

4. NEW CHANNEL MODELS

Spectrum Sharing Schemes

**Individual Authorization (Licensed)**
- Exclusive Access
  - Cellular Networks, Broadcast, ...
- Co-Primary Shared Access
  - Shared use among OPs under agreed terms or under a new Collective License
- Light Licensing
  - e.g. US FCC regime at 3.55 – 3.6 GHz Licenses are given to limited # of users
- Licensed Shared Access (LSA)
  - Authorized use by an operator under an agreement with the incumbent (Vertical sharing)

**General Authorization (License Exempt = Unlicensed)**
- Unlicensed Shared Access
  - e.g. WLAN, Bluetooth, ... ISM bands @2.4GHz, 5.8GHz
- Secondary Horizontal Shared Access
- Unlicensed Primary Shared Access
  - TV White Spaces (US model), UNII band @ 5GHz, PMSE in TV bands...
- Unlicensed
- Co-Primary
- Shared Access
  - Licensed
  - Shared use among OPs under agreed terms or under a new Collective License

e.g. DECT @1900, PHS, ...
REPORT TO THE PRESIDENT
REALIZING THE FULL POTENTIAL
OF GOVERNMENT-HELD SPECTRUM
to spur economic growth

Executive Office of the President
President's Council of Advisors on
Science and Technology

JULY 2012

Federal Primary Access
Incumbent
Guaranteed Access
Must not exclude spectrum use if
spectrum isn't in current need

Secondary Access
Registers with database
Might be high power
Possible fee for spectrum use
Possible allowance because of public good

General Authorized Access
Low power
Sensing and/or database use to determine access availability
No fee to use spectrum
Licensed Shared Access

3.8 GHz

3.6 GHz

2.6 GHz

2.4 GHz

2.3 GHz

2.1 GHz

Licensed

ISM

Licensed

LSA

3550-3650 MHz NTIA Exclusion Zones

Citizens Broadband Radio Service (CBRS)
European Industry View on Spectrum
Attenuation vs. Frequency

Average atmospheric absorption of MMWs: (A) Sea Level: T = 20°C, P = 760mm, H₂O = 7.5 g/m³ (B) 4 km altitude: T = 0°C H₂O = 1 g/m³
Identified New Frequency Bands of Interest
by METIS project
LTE Evolution and Spectrum

- LTE evolution is a fact – let’s not reinvent the wheel.
- Plenty of spectrum potentially available below 6GHz – sort out those possibilities first.
- Spectrum sharing mechanisms in small cells domain is a very viable path – LSA, co-primary sharing.
- Solutions for 10+ GHz schemes are needed as well – channel modelling and transceiver implementation need to be solved.
- Some of the points above imply drastic changes to operator roles – business models may need to be adjusted.
LTE Evolution and Spectrum (2)

- Expansion to spatial and frequency domain processing in various different ways for spectrum efficiency optimization and interference co-ordination made LTE unique.

- Drawbacks of LTE: of 4G L1: huge overhead signaling, large latency (10ms over air; 50ms E2E), inflexibility to adapt to different frequencies and bandwidths.

- Huge set of use scenarios and spectrum allocations calls for more flexible design.

- **A key question**: how much can you really improve LTE style system in practice with real RF impairments in multiuser MIMO environment?
Coverage vs. capacity

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

by Jens Zander, KTH
Coverage vs. capacity

by Jens Zander, KTH

The coverage world

- Public operators
  - Access any-time, anywhere
  - "Insurance" – guaranteed access
  - Monthly fee

- Power/Site/Backhaul
- Exclusive spectrum licensing

The capacity world

- Facility owners
- Sanitary requirement / no charge
- User experience – high data rates

- Ultra dense deployment – Interference
- (Low power, no site cost, existing backhaul)
How Operator Roles May Change?

• **Wide coverage** area expensive to maintain
  – Insentives for operators? Emergence of public operators?

• Lot of traffic in densely placed **small cells**
  – Network maintanance difficult in indoors

• Spectrum **regulation** likely to go towards shared spectrum
  – Spectrum is no longer owned; operator business less regulated

• Content will be changing much faster and lot of content relevant only to the context will be there; users/machines generate lot of content
  – Dynamic **local caching** to be shared by any operator customer

• Access and content provisioning will finally be separated
  – YouTube and Netflix have already done that in practise!

• Emergence of **micro operators**?
How 5G Radio Might Evolve

**Frequency bands**
- e.g. < 10GHz
- e.g. 10-30GHz
- e.g. > 30GHz

**Bandwidth**
- e.g. < 100MHz
- e.g. 100-1000MHz
- e.g. >1000MHz

**Waveform**
- LTE based (or advanced multi-carrier waveforms)
- OFDM (new numerology)
- Single carrier

**LTE evolution; standard ready before 2020**
- Push MIMO to limits
- Multioperator spectrum sharing
- Small cells explosion
- NFV/SDN
- Dynamic content caching

**New air-interface for 5G; standard ready earliest by 2025**
- Massive MIMO
- New MC modulation
- mmWave solutions
- Novel RF solutions

**mmWave option for 5G; standard ready earliest by 2025**
1st International Conference on 5G for Ubiquitous Connectivity


**Scope:**

In order to meet the huge demand for increasing capacity in wireless networks several major leaps in technology development need to be made. Several research initiatives around the world on 5th generation mobile cellular systems have been launched recently. Also frequency regulation and standardization activities will be launched very soon targeting at the next generation standard. This conference targets at bringing together researchers and developers as well as regulators and policy makers in presenting their latest views on 5G, potential disruptive technologies enabling 5G, spectrum policies for 5G, future business