On 5G realistic outcomes 2020

EFFORTS, CHALLENGES & TRENDS

Valencia Workshop 20th November 2015 UPVC - Tweether
Agenda

• On 5G activity
• Spectrum
• Research of interest
  Architectures
  Networking improvements
  Spatial processing
  RAT in mm-wave
• Priorities
What you can hear on 5G! but...

- New access system & device to replace 4G with 10Gbps throughputs, 5ms latency...
- Thanks to:
  - MASSIVE MIMO
  - mm-Waves
  - Moors law

But what is true is that “5G” will certainly shape the future wireless communication
5G Unpreceeding worldwide activity

- Gov. Budgets EU 700M€ - ASIA: CHINA, JAPAN, COREA: 1B$ each
- Partners
  - Industries in telecom: all majors are investing + a lot of specialized companies in modems chip set, MMIC, antennas and software...
  - Operators: 21 on the board of NGMN for the requirements and lobby on the spectrum
  - Academics, through the EU programs, and massively in US and Asian universities
- Associations & Alliances
  - 3GPP & NGMN + joint ventures
- Normalisation: 5-GPPP - ETSI,IMT Vision- ITU-R...
Spectrum for wireless communications

<table>
<thead>
<tr>
<th>Bands</th>
<th>UFH</th>
<th>L</th>
<th>S</th>
<th>C</th>
<th>X</th>
<th>Ku</th>
<th>Ka</th>
<th>Q</th>
<th>V</th>
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<tbody>
<tr>
<td>λ</td>
<td>60cm</td>
<td>30cm</td>
<td>20cm</td>
<td>5cm</td>
<td>3cm</td>
<td>2cm</td>
<td>1cm</td>
<td>6mm</td>
<td>4mm</td>
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<td>WiFi</td>
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<td>Freq GHz</td>
<td>0,45</td>
<td>0,7-0,9</td>
<td>1,6-1,9</td>
<td>2,1-2,6</td>
<td>3,5</td>
<td>5-6</td>
<td>10</td>
<td>11-18</td>
<td>22-30</td>
<td>38-43</td>
<td>60</td>
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- **Every one loves it**
- **Satellite mitigation?**
- **μ RAT street**

**Legend:**
- LTE PMR
- Mobile
- Fix LTE Access
- 5G RAT

11/11/2015
Some key points on the spectrum

• Get more in UHF: 450 & 700MHz (digital dividends) for PMR security and Countryside coverage.
• Use the 3,5GHz for the digital divide
• Study C band solutions to avoid incoming saturation
• Enlarge Ku Band ITU-R rules for mitigation with satellite
• Exploit mm-wave spectrum for PmP fronthaul & backhaul
Research ongoing examples

• Architectures: Core, Fronthaul, Backhaul, Access
• SND & NVF
• INTEGRATION of Aggregation, MIMO, Interference management
• MIMO
• BEAMFORMING
• New RAT (Radio Access Technology) mm-Wave?
Architectures - 4 Tiers - Hetnets

- Research on core for PMR/LTE Security

- Efficient architecture for fronthaul and backhaul Distribution (split & collect) of capacity 1 to N
- Availability, Resiliency, Load Balancing, TCO

- Efficient & Supple architectures to deploy SDN & NVF principles

Note: Chain or loop of microwave links PtP would not fit above requirements
SDN – NFV – Aggregation

- SDN (Software Defined Network)
  - To configure the whole network to optimise the local needs
  - Load balancing
  - Regional Events
  - Resiliency

- NVF (Network Virtualisation Functions)
  - Proxy of functions and applications
  - Relevant proxy firmware at every node of the network (fronthaul, backhaul, BS)
  - And even on the terminal (1 terabyte on a chip for multimedia)

- Aggregation at access node to manage object information (IoT)
  - Collect and control

- Carrier Aggregation of several bands
Example of industrial development

LTE Advanced brings different dimensions of improvements

- **Leverage wider bandwidth**
  - Carrier aggregation across multiple carriers, multiple bands, and across licensed and unlicensed spectrum
  - Higher data rates (bps)

- **Leverage more antennas**
  - Downlink MIMO up to 8x8, enhanced Multi User MIMO and uplink MIMO up to 4x4
  - Higher spectral efficiency (bps/Hz)

- **Leverage HetNets**
  - With advanced interference management (FeICIC/IC)
  - Higher spectral efficiency per coverage area (bps/Hz/km²)

QUALCOM presentation on chip set functions
MIMO - conditions on channels

- Channels correlation
- $\rho_i = \frac{S_i}{N_i}$ strength/channel
- Channel parameters knowledge and stationarity

$Y = HX + N$

$C = \log\det[I + (\rho/m)HH'']$  
With no knowledge of channels

$C = \log\det[I + (\rho/m)VQV'']$  
With channels knowledge

MIMO ON CROSS POLAR COULD BE VERY EFFICIENT IFF HIGH POLAR DECOUPLING: IT MAKES 2 INDEPENDENT CHANNELS
MIMO- conditions on bearing & boresight

Cross polar MIMO boresight
Ex, 42GHz

MIMO efficiency depends on
- Antennas line / reflexions plan
- Terminal Orientation /Base station
Beamforming and beam steering

Distance of elements: 0.65λ 6cm for LTE 2.6GHz & 4mm in Q band
The higher in frequency the more elements and better diagrams

Interference cancellation with auxiliary antenna: BS neighbour
Beamforming: Multibeam

BS SHOULD HAVE SEVERALS BEAMS FOR:
- Continuous communication links in backhaul
- Density of users in access
New RAT cm-wave or mm-wave?

With frequency non stationarity increases signals get weaker >> difficult and rapid hand-over + sur-modulation would limit high data rate
A very complex and fast changing uneven field

- Frequent Hand over
- Channel evaluation
- Learning sequence...
- Low levels & high amplitude range, phase change...
- Then data rate is reduced
- The higher the frequency the more complex signal in mobility
- Hand set: mask of the head
Priorities, expectations, outcomes 2020

• **Everywhere**: Coverage with capacity: Small cells thus backhaul & fronthaul, multi-bands integration, spatial processing, cells cooperation.

• **Network efficiency** architectures from core to access: architectures, SDN, NVF, aggregation (bands & IoT)

• **Digital divide**: access with LTE LTE-A 3,5GHz +backhaul

• **Security PMR**: LTE solutions, integration of terminals, functions on overlay or independent core.

• **mm-wave** for spectrum and high capacity of fronthaul & backhaul

• **Conclusion**: Push all above research to foster LTE-A