Research directions beyond 5G, and Vertical applications for 5G

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Service Oriented Radio and Cloud-Native Architecture

Service Oriented Radio (SOR)
5G Air Interface

5G Air Interface

Cloud-Native Architecture for E2E slicing

“5G-Beyond” with service awareness and sharing?
E.g. “Video” RAN Slice w/ cross layer?
E.g. Network/Spectrum Sharing?
Network/Spectrum Sharing for reasonable performance/cost tradeoff

Licensed spectrum
Exclusive use

Unlicensed spectrum
Shared use
Example: 2.4 GHz / 5 GHz / 60 GHz

Shared spectrum
New spectrum sharing paradigms
Example: 2.3 GHz Europe (LSA) / 3.5 GHz USA (CBRS¹)

¹: 3 tiers model of CBRS

Examp
le:
2.3
GHz
Europe
(LS
A)
/
3.5
GHz
USA
(CBRS)
Rethink “Spectrum Efficiency” with QoS constraint

Average UPT(Mbps)

Cell throughput(Mbps)

5% UPT(Mbps)

“Spectrum Efficiency” Changes with Bandwidth
- e.g. if 4Mbps 5% UPT required, 20MHz cell throughput is 4 times of 10MHz (i.e. SE is 2 times)

User Perceived Throughput normalized with used resource
Changes with Bandwidth
- 20MHz UPT/Hz is approximately 2 times of 10MHz (a.k.a Trunking gain)

Observations: “SE” gain ≈ UPT gain?
Rethink "Spectrum Efficiency " with Joint Pilot and Data

Control /Pilot/Data separately optimized

Self-contained transmission (short duration) for analog switching(mmWave)
/Interference agility (unlicensed spectrum) /URLLC

Self-contained transmission with overlaid data/pilot/control (Joint Optimization of data/pilot)

Experiments show better performance of “1/2” RS against “1/4 RS” for 1 bit data; but “1/4” RS is better than “1/2” RS for 2 bit data

Example: 1 bit with sequence modulation

How to achieve the best “Spectrum Efficiency” with joint Pilot and Data?
5G Use Cases Evaluation & Prioritization

Use Case Evaluation

<table>
<thead>
<tr>
<th>Use Case</th>
<th>5G Relevance/5G Essential</th>
<th>Business Impact/Operator Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 UHD/3D/Holo... Video</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>2 AR/VR</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>3 Connected Vehicle</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>4 Smart Manufacturing</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>5 Fixed Wireless Access</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>6 Delivery Drone</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Key relevant Use cases

Source: Huawei wireless X Labs