Software defined radio networking: Opportunities and challenges

Putting more IT/SW to the network

Navid Nikaein
EURECOM, Mobile Communication Department
Trends and use cases

Drivers
User Requirements, Cost, Energy, and Sustainability

Global energy budget?
Massive Traffic Growth

Global network architecture?
Number of connected devices

Global network cost?
Divers use-cases

Enablers
Ubiquity, Mobility, and Wireless
Fundamental Challenges

Deep Impact of the network architecture

5G

- Very High Data Rate
- Very Low Latency
- Very Low Cost & Energy
- Mobility & Hostile Env.
- Mixed Traffic
- Dense & Massive & Hetreo
Mobility and Energy

- Mobility creates network dynamics
- Time-varying energy consumption

Diagram:
- Application
- User
- Context
- Mobility
- Protocol
- Channel
- Traffic
- Energy
Energy Environmental and Cost Aspect

- Worldwide energy consumed by ICT, currently, is 3%
  - 2% of total carbon emission, of which 0.2% represents wireless

- Energy Cost: 4 million BS
  - On the grid: 3000$/Year
  - Off the grid: 10x more → renewable source

Source: Z. Hasan et al.
Fundamental Trade-offs

- Interplay between energy and cost / bandwidth / rate / delay

- Trading for Energy
  - Increasing network cost for a given performance?
  - Expanding the bandwidth for a given rate requirement?
  - Reducing the transmission rate for a given bandwidth?
  - Delaying the service time without deviating a given QoS?
## Paradigm Shift to Maintain Profitability

<table>
<thead>
<tr>
<th>Current Network</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed power</td>
<td>Power Proportional</td>
</tr>
<tr>
<td>Full coverage</td>
<td>Coverage scaling</td>
</tr>
<tr>
<td>Full load</td>
<td>Load-aware</td>
</tr>
<tr>
<td>Max. spectral efficiency</td>
<td>Energy-aware</td>
</tr>
<tr>
<td>HTC traffic</td>
<td>Mixed HTC and MTC</td>
</tr>
<tr>
<td>...</td>
<td>Cyber-physical systems</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

- Mixed HTC and MTC: Cyber-physical systems
## Paradigm Shift to Maintain Profitability

<table>
<thead>
<tr>
<th>Current Network</th>
<th>Emerging Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Seen as different transport pipes</td>
<td>- SDN: Cost ↓</td>
</tr>
<tr>
<td>- Not flexible</td>
<td>- SON: &lt;40%</td>
</tr>
<tr>
<td>- Not scalable</td>
<td>- XaaS/NFV: Cost ↓</td>
</tr>
<tr>
<td>- Costly</td>
<td>- SDR: Cost &amp; Energy ↓</td>
</tr>
<tr>
<td>- Homogeneous</td>
<td>- Spectrum Sharing: &lt;50%</td>
</tr>
<tr>
<td>- ...</td>
<td>- Heterogeneous: &lt;60%</td>
</tr>
<tr>
<td></td>
<td>- Cooperation, ...</td>
</tr>
</tbody>
</table>
Switches can easily handle the state and bandwidth

Improves the scalability and flexibility

<table>
<thead>
<tr>
<th>Prio</th>
<th>Predicates</th>
<th>Service Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>provider = B</td>
<td>Firewall</td>
</tr>
<tr>
<td>2</td>
<td>provider != A</td>
<td>Drop</td>
</tr>
<tr>
<td>3</td>
<td>app = video AND plan = Silver</td>
<td>[Firewall, Transcoder]</td>
</tr>
<tr>
<td>4</td>
<td>app = VoIP</td>
<td>[Firewall, Echo-Cancel]</td>
</tr>
<tr>
<td>5</td>
<td>device type=M2M fleet</td>
<td>[HighPriority, Firewall]</td>
</tr>
</tbody>
</table>
Open the wireless infrastructure to provide users, applications, and carriers control over their state across all layers in an end to end manner?
Cloudification of Radio Network

MCN project

- On-Demand, Self-Service, Elasticity, Pay-as-you-Go, Remote Access
- Infrastructure- Platform- Software-as-a-Service (IaaS/PaaS/SaaS)
- CAPEX : # of equipment↓
- OPEX: centralization and energy saving

**Diagram:***

**From...**

- End user
- RAN
- Mobile Core
- Data Centre
- Cloud Computing - service enabler

**To...**

- RRH
- Service provider
- "as a service"

29/12/2013
### Full GPP BBU is not a myth: Local or in the Cloud

**eNB RX**

- **OFDM_demod time**: 202.992302 us (100 trials)
- **ULSCH demodulation time**: 347.516264 us (100 trials)
- **ULSCH Decoding time (39.23 Mbit/s, avg iter 2.000000)**: 1271.786873 us (100 trials)

**eNB Tx**

- **OFDM_mod time**: 176.144838 us (100 trials)
- **DLSCH modulation time**: 55.319101 us (100 trials)
- **DLSCH scrambling time**: 22.194255 us (100 trials)
- **DLSCH encoding time**: 79.016000 us (100 trials)

---

- **Summary (processing for 1ms subframe)**
  - RX: 1820 ms (< 2 cores)
  - TX: 330 ms (1/3 core)

- **On 3 GHz machine, < 2 cores for 20 MHz eNB**

- **On future AVX2 (256-bit SIMD), turbo decoding and FFT processing will be exactly twice as fast**
  - 1 core per eNB
Unified Software Interface

**Build a Complex Service as a software**

- Fine-grain control on how application, user, device, and/or operator are served?

![Diagram showing network components and services](image-url)
Conclusion

- Requirement for next generation mobile network are defined
- Need for a paradigm shift is there
  - Most of possible enabling technology ingredients are available
- Towards smarter wireless networks: **Unified cross technology wireless network OS and APIs**
  - Fine-grained network-wide measurement and control
  - End-to-end realtime network adaptation and optimization
- **Network function virtualization (NFV)**
  - Complex network function/service as software apps
- **Radio networking architecture depends on the deployment and scenario**
  - D-RAN vs C-RAN
  - Heterogeneity: Marco, micro, pico, femto
  - mW vs mmW
  - Licenses vs unlicensed bands
  - …