Cellular Access Multi-Tenancy through Small-Cell Virtualization and Common RF Front-End Sharing

Jose Mendes, XianJun Jiao, Andres Garcia-Saavedra,
Felipe Huici, Ingrid Moerman
NEC Laboratories Europe, Ghent University - imec, IDLab
Two types of base station

Super cell

Small cell

How to help multi-operators cover same small cell efficiently by “sharing the base station” as if they have “physical base station” there?
SDR small cell base station platform

- Mini PC (Inte NUC, etc...)
  - High flexibility
    - SW upgradable
  - Cost not so high
  - Readiness
    - Open Air Interface
    - srsLTE
    - Open LTE

Problem:
Only support one BS instance.

How to run multiple BS instances for multiple operators?
SDR small cell base station platform

Direct solution: multiple USRPs

Run multiple BS SW instances in bare metal to connect multiple USRPs
- Isolation of different operator is not good. (security, CPU resources)
- Number of USRP = number of BS instance!

Can we do better?
SDR small cell base station platform

- Each operator uses their own spectrum
- Total isolation from spectrum to network
- Transparency
SDR small cell base station platform

![Diagram of SDR small cell base station platform](image)

**SNR threshold to achieve 1% BLER**

<table>
<thead>
<tr>
<th>LTE MCS index</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without</strong> adjacent channel interference</td>
<td>4.4 dB</td>
<td>8 dB</td>
<td>9 dB</td>
<td>13.5 dB</td>
<td>17 dB</td>
<td>22 dB</td>
<td>28.6 dB</td>
</tr>
<tr>
<td><strong>With</strong> adjacent channel interference</td>
<td>8 dB</td>
<td>10 dB</td>
<td>11.3 dB</td>
<td>13.5 dB</td>
<td>17.8 dB</td>
<td>24.7 dB</td>
<td>29.5 dB</td>
</tr>
</tbody>
</table>
Preliminary experiments

Very preliminary experiments to pre-evaluate the feasibility of eNB virtualization with commodity software:

- PHY and simple MAC layer from srsLTE
- SISO setup (no MIMO)
- 1 server with 4x cores @ 3.7GHz maximum to run VeNBs
- Additional servers for Ues (srsUE)
- Memory is not a problem
Single 10-MHz VeNB experiment

CPU consumption

Throughput at receiver
Single 10-MHz VeNB experiment

**Downlink**

- BM, 3.7GHz
- BM, 2.7GHz
- BM, 2.0GHz
- VeNB, 3.7GHz
- VeNB, 2.0GHz
- VeNB, 2.7GHz

VeNB @1.2GHz ➔ BM @ 1.2GHz ➔ VeNB @ 2GHz

**Uplink**

- BM, 3.7GHz
- BM, 1.2GHz
- BM, 2.7GHz
- BM, 2.0GHz
- vUE, 3.7GHz
- vUE, 1.2GHz
- vUE, 2.0GHz
- vUE, 2.7GHz

- All BM configurations work well except @ 1.2GHz
- VeNB only works well @ 3.7 GHz
Multiple VeNB and IQ switch experiment

Maximum 20MHz bandwidth achieved in total.
With maximum 3 eNBs in it:
• 10+10MHz, 5+5+10MHz: 72Mbps
• 5+5+5MHz: 54Mbps
Conclusion

• Main take-away:
  • ~1.25x CPUs @ 3.7 GHz per veNB over a common low-cost SDR frontend seems feasible!

• Lots of future work:
  • Fully-fledged LTE stack (RRC, RLC, PDCP)
  • MIMO should be tested
  • There is room for a lot of optimization in both software-eNB and IQ switch!
Thanks!

Welcome to our demo!
SRH (Shared Radio Head): USRP

mux/demux (IQ switch)

KVM Hypervisor

operator 0

operator 1

operator n

eNB0 (VM)
eNB1 (VM)
eNB2 (VM)
eNBn (VM)

x86 server