Bringing Experimentation to Wireless Live Networks

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Research topics in mobile networks

- Advanced services
- Quality of Service and Quality of Experience
- Energy Saving
- Protocol Stacks for 3G and LTE networks
- LTE for critical services
- Novel network architectures

Experimental facility (PerformLTE)

- LTE Pico Cell Lab
- LTE Core Network
- LTE Conformance Testing Equipment
- Power Analyzer
- Networks Tools (TestelDroid, Fleximon)
- SDR Equipment
Recent projects and partners

- **Protocols stacks** for eNB emulators (AT4 wireless, formerly CETECOM)
- Migration from GSM-R to **LTE for railway** signalling (Alcatel-Lucent, AT4 wireless, ADIF, MetroMadrid)
- Configuration tools for **LTE testing equipments** (Keysight Technologies)
- Integrating **PerfomLTE** into FP7 Fed4Fire (coordinated by iMinds)
- Integrating **PerformLTE** into FP7 FLEX (coordinated by UTH)
- New H2020 projects starting the next year and evolving PerformLTE towards 5G communications
PerformLTE Initial Testbed Philosophy

- Instrumented LTE devices
- LTE network emulation
- Proprietary LTE deployment
- Commercial LTE deployments (orange, yoigo, vodafone)

Post-processing tools: Correlated results
LTE Emulator T2010A
- RRC and NAS signaling
- KPIs from all the stack
- Conformance testing and design verification
- FLEX extensions to provide S1 interface

Athena Wireless Pico Cells
- Release 8 compliant
- Band 7, configurable EARFCN and bandwidth
- Transmission power 2W

Agilent DC power analyzer N6705B
- Power consumption
- Battery emulation
PerformLTE resources (II)

Commercial LTE devices Monitored using TestelDroid
- Samsung Galaxy S4
- HTC One
- Samsung Galaxy Tab

Micro-core own implementation
- Supports basic procedures and end to end connectivity

Drive testing tools
- Provides information from the stack of commercial devices (Qualcomm chipsets)

Open Source Stacks and SDR
- OpenAirInterface working on ExpressMimo2
Commercial Core Network
- On demand network scenarios definition
- Complex scenarios (multiple PLMN, roaming, etc) and negative testing
- FLEX Extensions to support dynamic creation of networks
- Monitoring of all the interfaces in the network
PerfomLTE FLEX Evolution
Towards Interconnection of Testbeds

Fleximon Tool (release soon)
- Tool for remote monitorization of communication interfaces and interoperability testing

S1 extensions to the conformance testing equipment
- To operate with other FLEX and Fed4fire testbeds, ongoing core network topology design using jFed.

Upcoming programmable attenuation scenarios

Layer 2 connectivity
- To operate with other FLEX and Fed4fire testbeds, ongoing core network topology design using jFed.
User Experiences: TECRAIL Pilot

TECRAIL Project Concept

- Evaluation of LTE as replacement of GSM-R.
- Partners: final users, research centres and vendors.
- Final objective: Provision of pilot evaluating the technology.
User Experiences: Innovative SMEs
SAFE Project

Fed4Fire Experiment

- Evaluation of a head mounted real time video streaming for mission critical services.
- Work in laboratory with commercial base stations
- Final users interested in testing on field.
- OTT configuration of network QoS.
Proposal for pre-5G tech.

- Provide an architecture to support the provision of local services in a commercial node.
- Pilots to be produced during major events in Spain (Fallas in Valencia).
- Evaluate impact in non local services as well as QoE for blue light local services.
5G technologies demands experimentation on real networks

- Not only new radio access, new services, new architectures, etc.
- Very aggressive KPIs. Simulating macro behaviour won’t be enough
- Use (and mix) the already existing testbeds for SDN and Mobile net.
Experimentation on Live Networks
IoT Pilots

Upcoming IoT pilots

- H2020 ICT IoT-01-2016 demands high scale pilots.
- Communication of Things in smart cities is challenging.
- Evaluation of QoS/QoE in urban environments.
- Integration of CPS
- M2M Communications

Image from jdc.com
Major challenges

- Gap between researchers and commercial deployment.
- Not only equipment costs also deployment and operation.
- Spectrum is (a very) valuable resource. Access is forbidden to non operator organizations.
- Costs are very high
- Operators are reluctant to leasing equipment and even spectrum!
- Configuration inconsistencies can lead to outages
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First approaches

- Redirection of the data plane
- Full outdoor research deployment
- Dedicated sector for research
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Improving flexibility

- Roaming scenarios
- S1-FLEX
- Full C-RAN network
- Cognitive Radio
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Conclusions

Requirements
- Virtualization of wireless nodes
- Remote deployment of VMs
- Security layer
- Latency reduction
Thank you!

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## Experimentation scenario

**eNB emulator and instrumented devices**

<table>
<thead>
<tr>
<th>Cell Configuration</th>
<th>Duplex Mode, Frequency Band, DL and UL EARFCN, DL and UL Bandwidth, Cell Id, TDD Frame Conf., Cell Power, Simulated Path Loss, MCC and MNC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARQ</td>
<td>Maximum HARQ Rtx., TDD feedback mode and the redundancy version list.</td>
</tr>
<tr>
<td>RRC/NAS</td>
<td>Several RRC Timers (T300, T301, T310, T311, N310, N311) Access Point Name, IP version, IP address and Radio Link Failure Detection.</td>
</tr>
<tr>
<td>Channel Emulation</td>
<td>Fading Channel Emulation (Several profiles defined by the 3GPP: EPA5, EVA5, EVA70, ETU70, ETU300 and HST), Noise Generation.</td>
</tr>
</tbody>
</table>
### Experimentation scenario

**Monitoring LTE live deployments**

<table>
<thead>
<tr>
<th><strong>Radio measurements</strong></th>
<th>RAT, Cell ID, LAC, RSSI, PSC, cell changes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neighbouring cells</strong></td>
<td>PSC, RSSI, RSCP (Received Signal Code Power) RAT (Radio Access Technology)</td>
</tr>
<tr>
<td><strong>IP traffic capture</strong></td>
<td>Pcap file, Arrival timestamps, Promiscuous mode</td>
</tr>
<tr>
<td><strong>Traffic generation</strong></td>
<td>Ping, mobile-to-mobile TCP transfer</td>
</tr>
<tr>
<td><strong>Battery consumption</strong></td>
<td>Battery level, Temperature, Voltage, Current</td>
</tr>
<tr>
<td><strong>Geographical location</strong></td>
<td>Based on cell identifier and GPS</td>
</tr>
</tbody>
</table>

![Map diagram showing geographical locations and data points](image)
- Two different operators networks
- Testing from one network to another
- Integration of eNB from different vendors
- NAT of control interfaces to integrate non configurable nodes