5G Architecture, Mobile Edge Computing and IoT

Professor Sasu Tarkoma, Head of Department
18 April 2017
50 Years of Excellence

- **Department of Computer Science**
  - Leading institution in Computer Science in Finland
    - #1 in Finland in QS Ranking 2017
    - #1 in Nordic Countries in Times Higher Education 2017

- **Core Computer Science and Data Science**
  - 17 professors and over 200 employees

**Industry Research Centers:**
- Nokia Center for Advanced Research (NCAR)
- Intel CRI-SC
5G Research
Architecture
Mobile Edge Computing
IoT
Current research topics include:
Digital services, IoT security and privacy, software-defined networks, Data Science, ...

Mobile Edge Computing
Data gathering, processing, and control at the edge
Data processing in the network (4G/5G Mobile Core)

Big Data Frameworks
Data processing in the computing cluster (cloud)

Batch processes
Starting point in 2014:
LTE RAN and EPC with SDN and Cloud

5G elements as services/applications running in virtualized environment

Virtualization aims for elasticity and runtime configuration support

Mobile Edge Computing
Multi-Access Mobile Edge Computing

Network Slicing and Network Service Chains

Local and centralized coordination of radio resources
5G Test Network Finland

- 5G Radio Network
- 5G Core Network
- Business and Regulation
- Internet of Things
- Network Functions Virtualization
- Network Management
- New Spectrum and Sharing Methods
- Quality of Service/Experience
- Software Defined Networking

EU
- 5G PPP / H2020, CELTIC+

ASIA
- NSFC-FINNISH ACADEMY, SINO-FINLAND ALLIANCE

USA
- WIFIUS PROGRAM

5gtnf.fi
Scaling Mobile Networks

5G is expected to support diverse use cases
Why current LTE networks cannot meet these demands?
   Telephony Centric – IP traffic an afterthought
   Convoluted Control and Data Plane
Solutions
   Move functionality to the Edge
   Move functionality to the Cloud (NFV)
   Network slicing

How do we modularize and refactor the network to meet the use case specific requirements?
Network Refactoring

Three steps:

1. Identifying the **roles** of the network functions
2. Splitting each network function into **modules**, creating one module for each role of the network function. For each module, we identify the requirements of a physical device instantiating that module.
3. Changing the **mapping** between physical devices and modules depending on the requirements (cost, latency, security, ...) from the network.

LTE control plane example:

- **Modularize** architecture
- Identify **state variables**
- Study **signals** between functions
- **Combine** modules
Refactoring: Thin Edge

Radio Access Network (RAN)

Storage
- HSS
- SPR

Control
- MME
- PCRF
- S-GW(C)
- P-GW(C)

GW
- S-GW(D)
- P-GW(D)

eNB(D)

eNB(C)
Refactoring: Intelligent Edge

Radio Access Network (RAN)

Control
- eNB\textsuperscript{(C)}
- MME
- PCRF
- S-GW\textsuperscript{(C)}
- P-GW\textsuperscript{(C)}

GW
- eNB\textsuperscript{(D)}
- S-GW\textsuperscript{(D)}
- P-GW\textsuperscript{(D)}

Storage
- SPR
- HSS
## Refactoring Approach for Optimizing Mobile Networks

<table>
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<th>Implementation</th>
<th>Initial Attach</th>
<th>Active to Idle</th>
<th>Idle to Active (UE)</th>
<th>Idle to Active (Net)</th>
<th>Handover (S1H)</th>
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<tr>
<td><strong>Thin Edge</strong></td>
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<td><strong>Intelligent Edge</strong></td>
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</table>

**Total number of signals per event**

Network in a Box
Create, scale, upgrade networks

Past Approaches

Proposed Approach

Features

Verticals / Use cases

Requirements
Coreless Mobile Networks
A state management perspective

Frans Ojala, 2016
Implications

In theory, if the data store is the bottleneck, our results indicate the following numbers for a simulation of 15 eNB with Apache Geode:

Current deployments are seeing a maximum of 1000 UE / eNB
UE per area increases depending on configuration: ~84 - 740 x

5G prospects for the control plane scalability: 100 - 1000 x
Off-the-Shelf Software-defined Wireless Networks

Open vSwitch (OVS) in base station
Use Wireless Isolation to force flows to OVS

Two approaches, Intelligent and Thin AP

Thin AP: Traffic is forced to flow through external host

Intelligent AP: OVS in base station

Seppo Hätönen, Petri Savolainen, Ashwin Rao, Hannu Flinck, and Sasu Tarkoma.
ACM SIGCOMM 2016 demo.

Instructions:
https://wiki.helsinki.fi/display/WiFiSDN/
Deployable on Off-the-Shelf Devices
Unified Mobile Edge for IoT Devices

Programmatically manage and compose IoT devices and services

IoT hub running at the edge as an SFC service
Intelligent AP, Philips Hue bridge and a light, Chromecast, connected curtain
Summary

**Network Refactoring** methodology for analysis and runtime network generation supported by network slicing

**Wireless SDN** for secure and stratified wireless networks

Wireless SDN and **multi-access edge computing** for IoT management and traffic offloading

**5G Test Network Finland**
Thank You!

www.cs.helsinki.fi
Additional slides
Securebox is a novel cloud-driven, low cost Security-as-a-Service solution that applies Software-Defined Networking (SDN) to improve network monitoring, security and management for smart IoT environment.
SoftOffload is an open-source software defined platform for achieving intelligent mobile traffic offloading.

It collects various traffic context from both end-users and network operators, and performs optimal mobile offloading to increase user-side throughput and reduce network congestion.

Code and demo:
www.cs.helsinki.fi/group/eitsdn/softoffload.html