Multi-Layer LTE / Wi-Fi Access Network Selection - results from the SEMAFOUR project

Author: Thomas Kürner  Date: 2015-07-14

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<th>Name</th>
<th>Company</th>
<th>Address</th>
<th>Phone</th>
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<tbody>
<tr>
<td>Thomas Kürner</td>
<td>TU Braunschweig</td>
<td></td>
<td></td>
<td><a href="mailto:t.kuerner@tu-bs.de">t.kuerner@tu-bs.de</a></td>
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Outline

- What is the SEMAFOUR project?
- SEMAFOUR Vision
- Results achieved within SEMAFOUR‘s LTE/WLAN Traffic Steering use case
What is SEMFOUR?

- SEMAFOUR is a collaborative research project funded by the European Commission within its seventh framework programme.
- The goal of SEMAFOUR is to develop a Unified self-management system efficiently operating a heterogeneous mobile network comprising a multitude of radio access technologies and layers.
- SEMAFOUR mainly has concentrated on 3GPPP radio technologies, but has considered IEEE 802.11 as well.
SEMAFOUR Key Facts

- Website: www.fp7-semafour.eu
- Scheme: EU FP7 STREP (No. 316384)
- Duration: 09/2012 – 08/2015
- Effort: 500 Person Months
- Budget: 6.1 M€ (total), 3.8 M€ (funding)
- Coordinator: Dr. Colin Willcock (Nokia, Germany)
SEMAFOUR Vision

Network Operator

Service Provider

General Network-Oriented Objectives

Network Status related to General Network-Oriented Objectives

UNIFIED SELF-MANAGEMENT SYSTEM

Integrated SON Management

Policy-Based SON Management

Operational SON Coordination

Multi-RAT / Multi-layer SON

WLAN Mgmt.

2G / 3G SON

LTE SON

Physical Network Resources

Physical Network Resources

Physical Network Resources

HETEROGENEOUS NETWORK

Decision Support System
SON Functions for Multi RAT and Multi Layer Networks

SON Design Principles

Multi-layer LTE/Wi-Fi TS

Dynamic Spectrum Allocation and Interference Management

Active Antenna Systems

High Mobility

Submission Slide 7 Thomas Kürner (TU Braunschweig)
• In the remaining part of this presentation is on the Multi-layer LTE/Wi-Fi Traffic Steering use case, where the partners Ericsson, Nokia, iMinds and TNO have worked on.

• The following slides are an extented version from:
Multi-Layer LTE / Wi-Fi Access Network Selection

Yu Wang+, Daniela Laselva*, István Z. Kovács*, Per-Henrik Michaelsen*, Relja Djapicφ, Pieter Willemen^, Kathleen Spaeyx, Bart Sasx, Dries Naudts^, Andreas Bergström+

†Ericsson Research, Stockholm, Sweden; *Nokia, Aalborg, Denmark; φTNO, Delft, Netherlands; ^iMinds/Ghent University, Ghent, Belgium, x iMinds/University of Antwerp, Antwerp, Belgium
Why SON for LTE/WiFi Access Network Selection?

- **Operators are using Wi-Fi for offloading**
  - “Carrier grade Wi-Fi”

- **Great interests in integrating cellular and Wi-Fi networks**
  - WiFi Alliance: Hotspot 2.0 Release 1/2
  - 3GPP: IP session continuity, ANDSF, Radio interworking

- **One key technology component: access network selection**
  - Today behaviour: “Wi-Fi If Coverage”.

- **SON for access network selection**
  - SON: proved working in related areas, e.g. load balancing
  - A good candidate to address the LTE/Wi-Fi access network selection in dynamic radio and traffic environments
Objective (1/2)

- **Objective:**
  - Access network selection between multi-layer LTE and Wi-Fi in dense urban deployments to improve user experience and network efficiency

- **Implemented SON functions:**
  - Threshold based SON functions
    - SON for LTE load control
    - SON for Inter-RAT LTE/Wi-Fi load control
  - Throughput based SON functions
    - QoS-oriented access network selection, e.g. based on a per user throughput metric
Objective (2/2)

SON for LTE load control

SON for Inter-RAT LTE/Wi-Fi load control

Throughput based SON function
SON Function Design – Monitoring KPIs

• **LTE load**
  - Average raw percentage of physical resource blocks (PRBs) utilization
  - Average fraction of required PRBs in a cell to serve connected UEs with a certain minimum bit rate

• **Wi-Fi load**
  - Average percentage of channel busy time of a Wi-Fi AP
  - The channel is considered as busy if there is at least one active connection associated to the AP and the AP or a UE is transmitting

- How fast the SON functions can change configuration parameters which determine access network selection of UEs
  - **Observation & Adjustment period** (0.5 – 2 seconds)
  - **Control parameter step size** (0.5 – 5 dB)
SON Function Evaluation - Scenario

- Realistic dense urban environments
- Dense WiFi deployment
- Outdoor & Indoor

Outdoor Hot Zone

Traffic hot zone area

Deployment:
- LTE macro layer:
  - 20MHz@1.8GHz,
  - 46dBm
- LTE micro layer:
  - 20MHz@1.8GHz
  - 33dBm
  - 6dB range extension
- WiFi 802.11n:
  - 20MHz@2.4/5GHz,
  - 20dBm
Threshold based SON Functions
SON Function Design for the Access Network Selection

- Monitoring KPIs
  - LTE load and WiFi load monitoring

- LTE load is high
  - No
  - WiFi load is high
    - No
    - LTE load is low
      - Yes
      - WiFi load is low
        - Yes
        - Steer traffic to WiFi
          - Steer traffic to LTE
            - Steer traffic to WiFi
              - Steer traffic to WiFi

- SON for LTE load control
  - Steer traffic to WiFi

- SON for Inter-RAT load control
  - Steer traffic to LTE

* When both LTE and WiFi load is high or low, no action will be taken
SON Function Design – Control Parameters

WiFi RSS Threshold

LTE RSRP High & RSRP Low Thresholds

To steer more traffic to WiFi

- Decrease WiFi RSS Threshold
- Decrease RSRP High Threshold
  Increase RSRP Low Threshold
### SON Function Evaluation - Overview

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<th>Objective</th>
<th>LTE Load Control</th>
<th>Inter-RAT Load Control</th>
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<tr>
<td>Control Parameter</td>
<td>RSS Threshold</td>
<td>RSRP Thresholds</td>
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<tr>
<td>Environment</td>
<td>Indoor</td>
<td>Outdoor</td>
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<td>Mobility</td>
<td>Static Users</td>
<td>Mobile Users</td>
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- **Presented in this presentation:**
  - LTE Load Control + RSRP Thresholds + Outdoor + Static Users
  - Inter-RAT Load Control + RSS Threshold + Outdoor + Static Users
SON Function Evaluation – LTE Load Control

• RSRP Threshold Low (macros) and RSRP Threshold High (micros) are properly adjusted to meet the objective, i.e. keep LTE cell load within target range (60-80%)
SON Function Evaluation – LTE Load Control cont’

- The SON configuration results in 50% offload to Wi-Fi while good Wi-Fi throughput is achieved, i.e. 5th-ile throughput of 2.6 Mbps
- Overall good performance is achieved, avg UE throughput=19.1 Mbps
  – vs. Baseline “Wi-Fi if coverage” with mean UE throughput = 10.5 Mbps
- Micro performance lower than macro due to presence of cell-edge UEs

Outdoor Hot Zone scenario without UE mobility
SON Function Evaluation – Inter-RAT Load Control

- RSS Thresholds are properly adjusted to meet the objective, i.e. balance the load between LTE and Wi-Fi

Fixed Threshold = -65 dBm
Throughput-based SON Functions
**Principle of Throughput based Traffic Steering**

- Throughput based Traffic Steering between LTE and Wi-Fi is based on predicted/measured user throughput in LTE and Wi-Fi.
- A user session is served by the RAT (LTE or Wi-Fi) which provides the highest throughput (plus a hysteresis to minimize IRAT handovers).
- The algorithm runs @Call Setup and During a Call (if enabled).
Results from Throughput based SON functions

- Throughput based SON function outperforms the threshold based functions
  - Gains of 25%-240% for the 5th percentile user throughput depending on scenarios
  - More balanced user throughput among the network layers
SON Function Implementation

- The proposed SON functions are intended to be implemented in a distributed manner
  - Control parameters are updated every few seconds

- Implementation of the access network selection rules
  - **Executed in terminals assisted by the network**: Control parameter thresholds are sent to terminals via broadcasted or dedicated signalling channels being standardized in 3GPP (RAN2 R12)
  - **Controlled by the network**: Control parameters are monitored at a network node and the node controls the access network selection

- Information exchange between LTE and WiFi
  - Standardization of such an interface is being discussed in 3GPP (Release 13 work item RP151114 “LTE-WLAN Radio Level Integration and Interworking Enhancement” covers the LTE-WLAN exchange (between the LTE eNB and the WT (WLAN Termination function)) and the UE reporting of WLAN measurements required for implementing the presented schemes
  - Proprietary interfaces
  - Terminals as relays
Summary

- SON functions for LTE and WI-Fi traffic steering have been designed, evaluated and demonstrated in realistic dense urban scenarios.

- The effectiveness of the SON functions was proved with controlled load levels and improved user throughput.

- We found the performance of the SON functions were most sensitive to the control parameter updating pace, i.e. the step size and period.

- Throughput-based SON outperforms threshold-based SON in user throughput and improved manageability at the cost of further complexity (throughput prediction).

- Among other findings, the study unveiled the importance of information exchange between LTE and Wi-Fi.