Performance of SON for RSRP-based LTE/WLAN access network selection

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Outline

- Background & Objectives.

- RSRP-based LTE/WLAN access network selection.

- SON for LTE/WLAN access network selection.

- Evaluation scenario and main results.

- Conclusions and future work.
Today, in most of the cases, most of the time, the network selection between cellular and WLAN networks is manually controlled by the users, and typically set as “connect to WLAN when available”.

Current LTE/ WLAN access selection approaches:
- **IEEE**: 802.21 Media Independent Handover (MIH) based
  - Limited support in the networks and UEs.
- **Wi-Fi Alliance**: Hotspot 2.0
  - Easier 3GPP and WLAN network discovery and QoS control; supported in the newest UEs only.
- **3GPP**: Access Network Discovery and Traffic Steering Function (ANDSF)
  - Better support and industry traction; complex configurations possible; UE support is partially available.

Main limitations of current LTE/ WLAN access selection techniques:
- Relatively static configurations are possible only with periodic updates or location based mechanism.
- Difficult to integrate with other TS and SON functionalities in 3GPP networks.
- Requires very specific UE support.

**(Standardized 3GPP LTE/WLAN interworking solutions)**: addressed for Release 12 and work to be continued in Release 13.
Utilize (most of) the current 3GPP LTE/ WLAN interworking assumptions and proposed mechanisms.

Rely on standardized UE measurements and reports in order to be able to provide (a basic) access selection functionality to all UEs.

To be used in typical urban heterogeneous network deployment scenarios: LTE macro cells + outdoor LTE small cells + WLAN APs.
- The Operator deployed outdoor WLAN APs are (typically) co-located with the LTE small-cells.
- Possibly a large number of additional WLAN APs are operating under the macro cell radio coverage area.

A robust mechanism, which can be easily integrated into a SON function and ‘co-exist’ with existing traffic steering and load balancing SON functionalities.
- Network settings can be dynamically adjusted to achieve user QoS.
- No RAN-assistance (used as baseline).
- RAN-assisted without information exchange between LTE and WLAN.
- RAN-assisted with information exchange between LTE and WLAN.

In this presentation:

a) No RAN-Assistance (Baseline)

b) RAN-assisted – no information exchange

c) RAN-assisted - information exchange
Two RSRP threshold parameters $RSRP\_thr\_low$ and $RSRP\_thr\_high$ in combination with one RSS minimum connectivity threshold, $RSS\_min$, are used to determine where the UEs are connected, based on two rules.

Options for evaluating the rules:

A) At the beginning of the user data session
B) Periodically during the user data sessions

WHEN UE in the coverage area of a co-located LTE / WLAN cell:

IF $RSRP > RSRP\_thr\_high$ AND $RSS > RSS\_min$, THEN

UE served on WLAN

ELSE

UE served on LTE

WHEN UE in the coverage area of non-co-located LTE / WLAN cell:

IF $RSRP < RSRP\_thr\_low$ AND $RSS > RSS\_min$, THEN

UE served on WLAN

ELSE

UE served on LTE
Distributed SON function for the RSRP-based LTE/WLAN access network selection triggered by the estimated average LTE cell load.

The **Cell Load Thr_Low** and **Cell Load Thr_High** define the target operating range for all the LTE cells.

The **RSRP Thr_Low** and/or **RSRP Thr_High** are updated dynamically based on the estimated average LTE cell load.
A site-specific dense urban outdoor heterogenous network deployment is selected (downtown Hannover).
  - All signal propagation effects are modelled via ray-tracing.

An outdoor traffic 'hot zone' area is generated with increased offered traffic load compared to the other surrounding macro cells.
  - The outdoor small (micro) cells are deployed to cover the high traffic area.

Users are static, located outdoor, and generate simple downlink UDP-type traffic, characterized by a fixed call arrival rate and a file size.

The LTE network performance is evaluated based on standard RSRP measurements and SINR-to-Throughput mapping.

The WLAN performance is evaluated based on RSS measurements and a MAC throughput model extended for multi-link multi-AP scenarios.
- 24 LTE micro cells are co-sited with WLAN APs and located below roof-top at 5 m height along the streets
- 6 LTE macro cells (3-sector sites) are located above roof-top

Traffic hot zone area

**Deployment:**
- **LTE macro layer:**
  - 20MHz@1.8GHz, 2x2MIMO, 46dBm
- **LTE micro layer:**
  - 20MHz@1.8GHz, 2x2MIMO, 33dBm
  - 6dB range extension
- **WLAN 802.11n:**
  - 20MHz@2.4GHz, SISO, 20dBm
Evaluation steps

Step 1: Evaluate the proposed algorithm with manual settings for the
*RSRP Thr_Low* and *RSRP Thr_High* parameters.
- Global settings are used, the same for all macro or micro cells
- The *RSS_min* is kept fixed and the assumed value corresponds to a minimum signal level required for PHY connectivity.
- The results provide insight into the functionality, sensitivity and stability of the algorithm.
- Use the main results to set the baseline for the SON evaluation in Step 2.

Step 2: Evaluate the SON function by varying the *CellLoad_A_Thr_Low*,
*CellLoad A_Thr_High*, *RSRP A_Thr_High Step Size* configuration parameters.
- Different (global) values for the *RSRP A_Thr_Low* is are tested, while *RSRP A_Thr_High* is adjusted by the SON algorithm.
- Convergence of the algorithm is evaluated and characterized.
- Use the main results to set the baseline for the SON evaluation in dynamic UE conditions (future work).
The global settings which maximize the WLAN offloading rate do not maximize the user session throughputs (average or 5%-ile) and vice versa.

The WLAN access selection is maximized, up to 90%, when the RSRP thresholds are practically disabled (“connect to WLAN when available”).

The optimal RSRP threshold setting for the different cells may be different due to the different cell load/traffic conditions.

RSRP-based LTE/WLAN access network selection – Results (Step 1)
The correlation between the average $RSRP_{Thr\_High}$ value determined by the SON algorithm for a given micro cell and the experienced cell load can be observed.

Most of the micro cells have average load below the set $CellLoad\_Thr\_Low-High$ range, which indicates that, potentially, even higher offered traffic can be accommodated in the network.
The SON algorithm achieves the desired tuning, i.e. the values of the RSRP Thr_High are increased when the averaged cell load falls below CellLoad Thr_Low and it is decreased when the cell load exceeds CellLoad Thr_High.

Example of time-trace for highly loaded micro cell #17
Presented and evaluated a Self-Organizing Network (SON) solution for optimizing autonomously the access network selection between the Long Term Evolution (LTE) and WLAN systems.

Standard 3GPP LTE Received Reference Signal Power (RSRP) measurements available at the User Equipment (UE) and a set of simple rules based on network-provided RSRP thresholds are used.

The evaluation results show that with an optimal SON parameter configuration, gains in order of 50% and 150% can be achieved in the average and 5%-ile user session throughputs, compared to the “connect to WLAN when available” scenario.

For further improved performance in real-life mixed traffic scenarios a refined SON design is required. A combined evaluation including typical mobility and traffic steering mechanisms is planned.
Backup slides
1. Dynamic traffic steering and/or load balancing between LTE and WLAN networks in heterogenous network deployments
2. Robust access network selection mechanism which is network controlled and UE assisted
3. Include mechanism(s) to control end user quality of service

Example:
- **RSRP** thr = -90 dBm
- **RSSI** thr = -60 dBm

**AP** = Access Point
**RSSI** = Received signal strength indication (IEEE 802.11)
**RSRP** = Reference Signal Received Power (3GPP TS 36.133)
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**Simplified flow-chart for a typical network selection procedure**

1. **Evaluate strongest LTE cell and WLAN AP**
   - yes: **“Bad LTE”**
   - no: **“Good LTE”**

2. **“Bad LTE”**
   - yes: **“WLAN good”**
   - no: **“WLAN bad”**

3. **“WLAN good”**
   - yes: Connect to (stay in) WLAN
   - no: **“WLAN bad”**

4. **“WLAN bad”**
   - yes: RSRP of strongest LTE cell < RSRP thr
   - no: **Connect to (stay in LTE)**

5. **“Good LTE”**
   - yes: RSRP of strongest LTE cell < RSRP thr
   - no: Connect to (stay in LTE)**