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D3.1

Demonstration scenarios

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Abstract: The overall objective of the SEMAFOUR project is to design and develop a unified self-management system for heterogeneous radio access networks, representing the complete environment as one single network towards the operator through a unified view. The objective of WP3 is to communicate the key project results and findings through demonstration activities. This first WP3 deliverable describes the high-level demonstration objectives and approach, and furthermore defines a set of specific demonstration scenarios based on a subset of the SEMAFOUR use cases as presented in deliverable D2.1.

Keywords: Multi-layer, Multi-RAT, Policy Management, Self-management, SON, SON Coordination, Demonstrations, Demonstration Scenarios, Decision Support System, Traffic Steering, Dynamic Spectrum Allocation, Interference Management.

Executive Summary

The objective of work package (WP) 3 of the SEMAFOUR project is to communicate the key project results and findings through demonstration activities. This WP3 deliverable D3.1 'Demonstration Scenarios' describes the high-level demonstration objectives and approach, and furthermore defines a set of specific demonstration scenarios based on a subset of the SEMAFOUR use cases as presented in SEMAFOUR deliverable D2.1. Each scenario description comprises a high-level description of the associated SEMAFOUR use case, a formulation of the demonstration objective, a storyline to indicate what the demonstration scenario would 'look like', a high-level description of relevant scenario aspects regarding e.g. network deployment, traffic/service/mobility aspects and relevant KPIs. Furthermore, as an input to the demonstrator development activities A3.2 and A3.3, key requirements imposed on the demonstration platform by each of the scenarios are outlined.

Chapter 1 of this document presents non-technical goals to consider for the demonstration activities with respect to e.g. the target audience, the desired length of individual demos, the intended effect, as well as the aim for attended and unattended modes of demonstration. The chapter furthermore provides a high-level technical overview of the targeted demonstration platform and some associated challenges. Chapter 2 of this document then presents the selected demonstration scenarios identified for use cases identified for development in WP4 ('SON for future networks'), while Chapter 3 presents the selected demonstration scenarios identified for development in WP5 ('Integrated SON management'), all as described in [1].

An updated version of this report (D3.4 'Demonstration scenarios (updated version)') will be delivered at the end of project month 30, i.e. February 2015.

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List of Acronyms and Abbreviations

CCO	Coverage and Capacity Optimisation
DSS	Decision Support System
DSS-NE	Decision Support System for Network Evolution
DSS-RCoQ	Decision Support System for determining the Resource Cost of QoS as input for SLA management
DSS-STM	Decision Support System for Spectrum and Technology Management
ES	Energy Saving
EU	European Union
FTT	File Transfer Time
ICIC	Inter-Cell Interference Coordination
KPI	Key Performance Indicator
KUI	Key Utilization Indicator
LTE	Long Term Evolution
MLB	Mobility Load Balancing
MRO	Mobility Robustness Optimisation
NOC	Network Operating Center
OMC	Operations and Maintenance Center
QCI	QoS Class Identifier
QoS	Quality of Service
RAT	Radio Access Technology
RLF	Radio Link Failure
SLA	Service Level Agreement
SON	Self-Organising Network
UE	User Equipment
WiFi	Any WLAN product based on the IEEE 802.11 standards
WP	Work Package

Table of Contents

1 Introduction

The overall objective of the SEMAFOUR project is to design and develop a unified self-management system for heterogeneous radio access networks, representing the complete environment as one single network towards the operator through a unified view. As described in [1], the project is divided into a number of work packages (WPs), including:

- WP2: "Requirements, Use Cases and Methodologies". In WP2, the self-management use cases for which technical solutions will be developed are defined, together with their requirements.
- WP3 "Demonstrator". The objective of WP3 is to communicate the key project results and findings through demonstration activities and to develop a demonstrator platform suitable for these purposes. The outcome of WP4 and WP5 will form the input to the demonstration activities in WP3.
- WP4: "SON for Future Networks". In WP4, SON functions for multi-layer LTE networks, for multi-RAT networks and for integrated multi-RAT and multi-layer networks will be developed.
- WP5: "Integrated SON Management". In WP5, concepts, methods and algorithms for an integrated SON management consisting of policy transformation and supervision, operational SON coordination, and monitoring, will be developed.

This WP3 deliverable D3.1 'Demonstration Scenarios' describes the high-level demonstration objectives and approach, and furthermore defines a set of specific demonstration scenarios based on a subset of the SEMAFOUR use cases as presented in SEMAFOUR deliverable D2.1. Each scenario description comprises a high-level description of the associated SEMAFOUR use case, a formulation of the demonstration objective, a storyline to indicate what the demonstration scenario would 'look like', a high-level description of relevant scenario aspects regarding e.g. network deployment, traffic/service/mobility aspects and relevant KPIs. Furthermore, as an input to the demonstrator development activities A3.2 and A3.3, key requirements imposed on the demonstration platform by each of the scenarios are outlined.

The outline of this report is as follows. In the remainder of Chapter 1 we present non-technical goals to consider for the demonstration activities with respect to e.g. the target audience, the desired length of individual demos, the intended effect, as well as the aim for attended and unattended modes of demonstration. We furthermore provide a high-level technical overview of the targeted demonstration platform and some associated challenges. Chapter 2 of this document then presents the selected demonstration scenarios identified for use cases identified for development in WP4 ('SON for future networks'), while Chapter 3 presents the selected demonstration scenarios identified for development in WP5 ('Integrated SON management'), all as described in [1].

At present, WP3 activities primarily focus on shaping the architecture, functionalities and interfaces of the targeted demonstration platform, while implementations are also starting. The next WP3 deliverable, due in project month 10 (June 2013), is the vision-oriented demonstrator (D3.2), i.e. an initial version of the targeted demonstrator, with limited features, that allows the presentation of the envisioned SEMAFOUR solutions and their expected impact on network operations and performance. Besides the actual development of the demonstrator a number of key challenges still need to be addressed, including e.g. how to exploit and make believable use of the option to have different simulation branches (see also below), further selecting among the described demonstration scenarios which scenarios will be considered for the vision-oriented (and later) demonstrations, preparing simulation traces for use in the vision-oriented demonstrations and tailoring demonstration scenarios for the distinct audiences and targeted demonstration 'depths' as described below.

An updated version of this report (D3.4 'Demonstration scenarios (updated version)') will be delivered at the end of project month 30, i.e. February 2015.

1.1 Non-technical Goals for Demonstration Activities

The demonstrations are meant to validate and draw attention to the project and its results. The demonstrations need to present the key achievements which are most relevant for the chosen target audiences (see below). The aim is to demonstrate in an accessible and impressive way, and support the recognition of the project as a whole.

This section describes the non-technical goals and guidelines for the demonstration activities. Among others, the target audience, the desired length of individual demos, the intended effect, as well as the aim for attended and unattended modes of demonstration are described.

Target Audience and Demonstration Scopes

Two types of audience with distinct needs shall be addressed.

1. *The **non-experts,** including Senior **Managers** and decision makers of the consortium members and Senior **EU representatives**:* This audience is familiar with mobile phone networks, knows about different generations (with more and more advanced capabilities), knows WiFi from home applications, and has a clear appreciation for service quality. We may not assume familiarity with network operations or management in general and SON in particular (not even the name).

   This audience shall learn from the demonstration *that we can improve network performance* with our technology and *why this is noteworthy*. This message shall be conveyed by employing easy to understand visualizations, ideally involving a mobile device and (simulated) streaming video (as a sample service), who's quality the attendee can experience by himself. We will, however, need to be clear that key benefits from our solutions are at the KPI level, not in the QoS of a specific communication session.

   A demonstration must be possible within a few minutes (ideally not more than **90-120 seconds)**, but exploring the demonstration for longer and (supervised, directed) "playing around" with it shall be supported and encouraged.

   The ambition is to prepare **3 demonstrations** of this type for this target audience, e.g. one scenario demonstrating the effects achieved by an advanced SON function developed in WP4, one scenario demonstrating self-management steered by high-level objectives, and one scenario demonstrating a developed Decision Support System (both WP5). This way, the three key solution development areas of the SEMAFOUR project can be representatively covered. The selection of actually demonstrated scenarios is based on available demonstration time and audience interest**.**

2. *The **technical expert,** including **EU Project Officers** and **EU external evaluators**:* This audience has a good understanding of multi-technology radio networks in general and a fair understanding of SON (i.e. is already familiar with the key concepts and has maybe even worked on single technology cases).

   This audience shall learn from the demonstration *how we can improve network performance*, what the *self-management framework* consists of, how an operator may control network behaviour through *policies*, and in which way some *selected SON functions* contribute to implementing a policy. This message shall be conveyed in a seemingly realistic setting relying on realistic network configurations, realistic environments and users' behaviour as well as realistic network control displays (OMC/NOC-like). The demonstration shall present typical KPIs and how KPIs react to enabling / disabling parts of our technology or changing its control input. The demonstration is primarily meant to be presented by experienced persons from the SEMAFOUR project, though some "playing around" shall also be supported.

   Two versions of demonstrations shall be possible:

   - **General overview:** This shall be presentable within 5 min as a strictly guided tour.

     The ambition is to prepare **3 demonstrations** of this type for this target audience, in line with the scenarios suggested above.

- **In-depth coverage of project highlights:** This shall be presentable within 15-30min depending on the available time and the amount of interaction with the audience. Depending on technical feasibility, the presentation itself would ideally allow some degree of interaction with the audience and potentially allow attendees to control some parts of the demonstration themselves.

  The ambition is to prepare **3 demonstrations** of this type for this target audience, e.g. the same three as mentioned above, but worked out more elaborately.

There is a clear preference for few highest quality demonstrations over more, but potentially mediocre ones.

Straightforward to Understand

All demonstrations should be well understandable (for the intended audience). What is shown and how it is shown should be informative. The control of the demonstrator, where applicable, should be self-explanatory. Wherever possible, the displays and the handling should connect to similar things already known to the audience. For example, the audience will have experience with the impact of congestion or poor radio connection on a demanding service.

Clear Message

Each demonstration should convey a small number of principal messages (about three). These messages need to be clearly visible from what is *shown* (e.g., using overlays and balloons with explanatory text) and should come across without any voice-over.

Interruption / Suspension

It shall be possible to interrupt/suspend a demonstration at any given instant. This shall support a closer analysis of individual phenomena and facilitate discussions. Preferably, the demonstration set-up still allows for actively accessing, displaying and filtering data in the network- and KPI-related windows in suspend mode in order to explain certain points. (Clearly, neither the network nor the KPI window receive updates related to the progression of time in suspend mode.)

Aim for Confidence in Results

The demonstration should support the impression that what is shown is real or, second best, realistic. Wherever reasonable, the set-up should look as little “fake” as possible, e.g., the aim should be a high resemblance of what is observable at OMCs/NOCs. The “story” of each individual demonstration therefore needs to be comprehensive in the sense of as few technical and logical gaps as possible.

Some simplifications as compared to reality will be unavoidable as, for example, that the network itself and the users will be simulated. These parts are apparent means to demonstrate the project’s achievements. But when it comes to the actual achievement, no gaps should be apparent (unless there are strong reasons). Simulations will be a central tool in building the demonstrations, but they are not the demonstrations in themselves.

What is shown shall be plausible. Among others, easy-to-grasp effects shall be demonstrated, where the effect is clearly related to (changing) some input. (Even in this setting, it is still however the effect that shall be easy to grasp, not necessarily how this is achieved.)

Some surprising effects that catch the attendees’ interest are desirable. A short and understandable explanation shall be available in those cases. For example, in a given demonstration scenario we may indicate that some sessions are actually worse off when we deploy the developed self-management solutions, as this may be an intended sacrifice in favour of other KPIs that is in line with performance trade-offs formulated in the high-level objectives.

Also, especially for the longer and more detailed demonstrations, a certain level of frankness / self-criticism is likely to increase the trustworthiness of the demonstration.

Underline Practical Relevance

The demonstrations should cover material that is tried and tested (and proven to work). In particular for those parts of the longer demonstrations, where technical material is presented, the audience should understand and gain confidence in which parts of the project's achievements are ready to be taken to the field.

Unattended Mode

Finally, at least one of the shorter demonstrations should be impressive as well as comprehensible if run in unattended mode. The goal is to attract the attention of by-passers, e.g., of people at conferences, fairs, or in lobbies. Even better would be if a seamless switch-over between unattended and attended mode (and reverse) is supported.

1.2 Some Technical Aspects of the Demonstration Platform

This section describes further a few technical aspects of the demonstrations, which are mentioned in one or more of the described scenarios in the subsequent chapters. The intention with this section is to ease the understanding of the subsequent scenario descriptions.

Architectural Overview

Although at present the discussion regarding the architecture, functionalities and interfaces is still on-going, it seems useful for understanding of the remainder of this document to provide here a draft and high-level overview of the architecture of the targeted demonstration platform. Figure 1 depicts the elaborate version of the demonstrator, allowing display of the various elements on different displays, involving e.g. tablets, laptops, LED screens, beamers and session terminals. The demonstration platform will also support a more portable 'single laptop version'. As shown in the figure, the demonstrator is developed with a client-server architecture, employing a single 'central server' and a number of clients:

- The *central server* is in charge of e.g. authorization and synchronization of clients, storage of configuration data, storage and playout of (potentially filtered/processed) simulation traces.
- Just like the central server, also the *demo client* is also invisible to the audience, relevant for setting up/loading demonstration scenarios.
- The *time client* controls the 'speed of time', i.e. it allows speeding up or slowing down of the demonstrations, jumping forward or backwards to e.g. bookmarked events. The time client also displays and allows (some degree) of (de)activation of different simulation branches (see below).
- The *operator client* enables the demonstration-giver to formulate high-level objectives and to (de)activate the different SON (Coordination) functions and Decision Support Systems.
- The *DSS client*, visible if the feature is activated via the operator client, displays the output generated by the different Decision Support System functionalities, including e.g. periodic performance reports and timely alerts and recommendations for network upgrades in case of anticipated performance issues.
- The *KPI client* shows the various KPIs/KUIs of interest for the demonstrations as diagrams, charts etc. Possibly filtered per UE category, node type, zoomed into a certain geographical area.
- The *network client* displays a map over the demonstrated network. This map may be overlaid with colours in order to indicate various performance metrics such as e.g. cell load,

interference levels, cell throughput, etc. It will also be used for selecting/indicating which users representing the actual session terminals.

- A proxy client/server to serve *session terminal client*s, i.e. actual handhelds used to display e.g. an emulated video streaming session corresponding with one of the UEs simulated on the network screen. See below for some more information on the involvement of handheld devices.

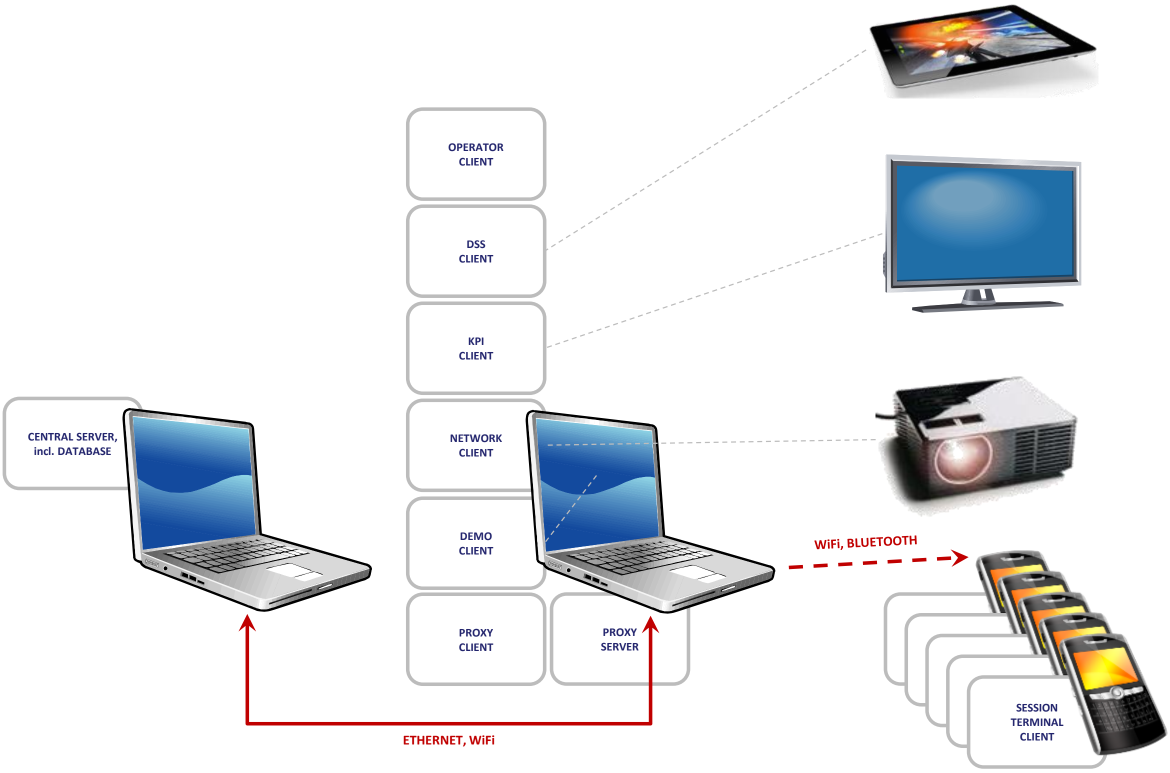

Figure 1: Overview of the targeted SEMAFOUR demonstrator.

Involvement of Handheld Devices

In several scenario descriptions, the involvement of handheld devices (session terminals) in the actual demonstration is mentioned. These devices could e.g. be a tablet, a smartphone or similar. The intention with this is to in a more hands-on way visualize the anticipated end-user experience in the given scenario, given the i.e. activation of certain SON functionality. In practice, this could mean e.g. playing out a video stream on the handheld device and/or showing one (or a few) selected KPIs to be shown on the screen of the handheld device. This illustrated end-user performance could be taken from either a specific selected user in the simulations or based on the n-th percentile of a relevant performance statistic. The latter option has the benefit of making the visualized results more representative to the general user population.

Note however that the flow of information will be one-directional in the sense that the video clip and/or KPIs are shown on the screen of the handheld device, but no control of the demonstration settings/playout etc. is possible via the handheld device.

Off-Line Simulations and Branching

As previously mentioned, the performed demonstrations are based on the input from simulations. During the demonstration, it shall be possible to modify the simulated network configuration by e.g. activating a particular SON function or perhaps adding a new network node.

Since the execution time of these simulations in almost every case is significantly slower than the desired playout speed of the demonstration, it will however not be possible to perform the simulations on-line, i.e. whilst the demonstration is running[1]. Instead these simulations will have to be done off-line, i.e. in advance before the demonstration is made. This makes it obviously not possible to, during the on-going demonstration, directly control the settings of the simulated network as described above. Instead this controllability will be provided by the possibility to manually (or automatically) switch between several so-called "branches", where each such branch is a pre-simulated trace representing a certain network state, e.g. with the given SON functionality on/off etc. or with a certain network deployment.

An illustration of this is given in Figure 2 below for a scenario with two possible SON algorithms (ALG1 and ALG2) inclusive of the possible choices w.r.t. activating/deactivating the SON algorithms -i.e. the switching between these branches, inclusive of the default actions. The vertical bar marked "Now" illustrated the current playout time in the demonstrator.

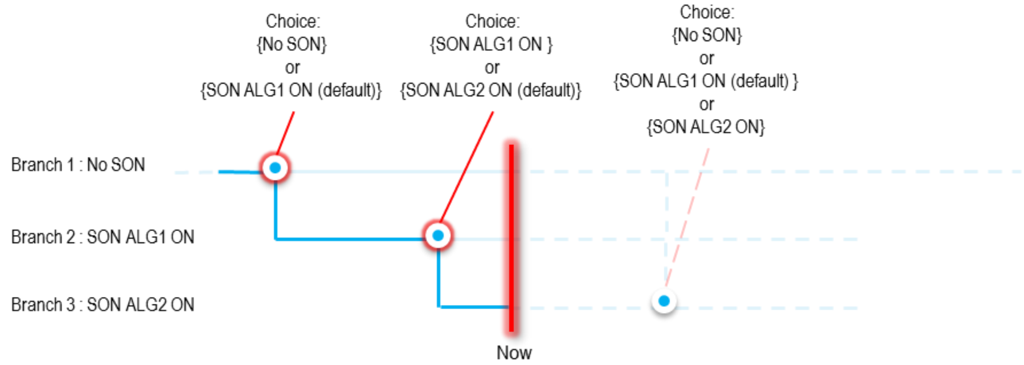

Figure 2: Illustration of the branching concept.

[1] We still keep open the possibility to actually support on-line simulations in the demonstrator, for instance in the form of running simulators that generate their trace information on-line and feed it to the different demonstrator clients via the central server. Although we anticipate that this approach would indeed be too slow to be very effective in live demonstrations, showing a minute or so of on-line simulations could help to establish some degree of trust with the audience that we are not 'faking things'.

2 Demonstration Scenarios for WP4 Use Cases

This chapter presents the demonstration scenarios for a subset of the use cases from WP4 "SON for Future Networks" as described in [1]. Note that this content is preliminary and the final details are dependent on the outcome of WP4. This will be reflected in the updated report (D3.4 'Demonstration scenarios (updated version)') which will be delivered at the end of project month 30, i.e. February 2015.

2.1 Dynamic Spectrum Allocation and Interference Management

The objective of the 'Dynamic Spectrum Allocation and Interference Management' use case is to develop and assess solutions to mitigate interference and to optimize the coverage, capacity and the quality of the network by autonomously assigning spectrum to individual cells, based on the current temporal and spatial usage and/or based on the predicted load, as extensively described in [1].

Demonstration objective

The goal of this demonstration is to show the effect of dynamic spectrum allocation and interference management. Advancements that the developed SON algorithm (ALG_1) can achieve over a reference scenario where no such algorithm is active, i.e. where the spectrum is statically assigned, are to be shown.

In particularly, the demonstration will show that:

- The end user experience has improved through session-level QoS statistics, e.g. user throughput or video streaming quality.
- Cellular network assets are more efficiently used, shown via resource utilization ratio (i.e. cell load vs. cell capacity) and without any overload situations (no "red" regions on the pixel map).

Demonstration storyline

Initialisation – We show an operational multi-layer multi-RAT network deployed in a dense urban environment, including a visualization on the KPI (session- and network-level statistics) and network screens. ALG_1 is inactive, i.e. with purely statically-assigned spectrum for each cell/RAT.

At some point in time the presenter enables the SON algorithm (ALG_1) via the network operator window. From then on a side-by-side demonstration is given, for the exact same scenario, of the effects of ALG_1 being off vs. on is shown both on the KPI and on the network screen.

As time progresses, the algorithm ALG_1 will detect several areas in the network where overload occurs at different times of the day. For these areas, the configuration will be affected by ALG_1 in order to improve the load situation. Later the settings could be switched back to the original setting, when for example the traffic situation has changed and the traffic load is low for this area.

Optionally I, the presenter can change some aspects of the demonstration at certain points during the demonstration, e.g. the traffic load, the spatial traffic load distribution, instances/parameterizations of ALG_1, the introduction of one or more new hot spots. The side-by-side demonstration of ALG_1 being on/off shall smoothly continue after such an effectuated change.

Optionally II, personal handhelds could be involved to show the improvements from ALG_1 in a "hands on" experiments. This could be done by showing a video stream on the screen of the handheld devioce which performs badly in the original network (ALG_1 turned off) and shows improvements when using ALG_1.

On scenario aspects

Refer to [1] for a detailed description of scenario aspects considered in the use case development work itself (WP4). The following considerations shall however be made:

- All RATs (GSM, UMTS, LTE) and layers (including femto cells) shall be included.
- Since dynamic spectrum allocation is important mainly in hot spot areas and applied mainly to small cells the impact may be limited to those areas where small cells are deployed.
- The scenario should consider outdoor and indoor deployments in urban areas with realistic user distributions.
- Terminal capabilities for different RATs need to be considered, however only one flow needs to be supported per UE.
- Highly dynamic users with realistic mobility models, outdoor and indoor, need to be considere+d. Also since the focus will be on small cells, indoor mobility needs to be used extensively. The simulation of 1,000 up to 10,000 UEs is targeted.

On KPIs

With regard to the demonstration (WP3), the following KPI/KUIs are deemed to be most relevant to be included in the targeted demonstrations:

- *Network-level statistics*
    - **Carried traffic per RAT**: the amount/percentage of traffic handled by the involved RATs. Shown as a line plot over time.
    - **Relative cell loads**: the fraction of the load that is handled by a given cell relative to its capacity, which will vary depending on the momentaneous spectrum allocation. The load could for instance be expressed in terms of an average utilization of the cell resources. Shown as a line plot over time and/or with a dial marked with low medium and high markings.
    - **Resource utilization ratio**: a pixel map representing the coverage area of the individual cells coloured with respective resource utilization ratio, e.g.: green – good ratio, blue – low traffic, red – overload situation.
- *Session-level statistics*
    - **User throughput**: the average of x-th percentile of the experienced user throughputs, determined over a certain time window. Shown as a line plot over time and/or a dial marked with low medium and high markings.

Demonstration platform requirements

In this section the scenario-specific requirements on the (different components of the) demonstration platform are formulated.

- *General requirements*
    - Regarding the demonstration timescale, the whole simulation time will be around one day and night (macroscopic timeframe), in which the network traffic varies in time and space. The dynamic spectrum allocation algorithm will react on this macroscopic traffic changes.
    - However, for interference management individual users need to be simulated in the order of 100 milliseconds or 1 second, if for example a video stream is shown (micro-timeframe). It will be based on an embedded simulation, which starts e.g. 1 minute before the induced change by the dynamic spectrum allocation algorithm and lasts for 2 to 5 minutes after the change. Thus, a “zoom into” the time scale can be achieved.
    - Regarding simulation branching, a side-by-side demonstration of two branches is foreseen: An initial demonstration of scenario A under reference session assignment where ALG_1 is disabled, and the same scenario where ALG_1 is enabled. Then

optionally, one or two scenario changes (scenarios B, C) may be introduced as well, which would then yield two or four additional branches.
- Terminal capabilities for different RATs need to be considered. Quantities will be shown as a pie chart, if relevant.

- *Network operator screen*
  - The network operator screen is used to enable and disable the dynamic spectrum allocation and interference management algorithm (ALG_1).
- *DSS screen*
  - No specific DSS screen requirements.
- *KPI screen*
  - A single KPI screen showing the above-mentioned KPIs.
- *Network screen*
  - A map will display the entire simulation area with its base stations of all considered RATs and layers.
  - Possibility to highlight each affected cell / base station by using e.g. different colours for different RATs and/or layers.
  - A pixel map representing the coverage area of the individual cells, coloured with respective resource utilization ratio, will be displayed in the background, indicating the load situation (e.g.: green – good ratio, blue – low traffic, red – overload situation).
- *Session terminal involvement*
  - In order to show the improvements on the individual user experience, caused by ALG_1, a session terminal will be used for showing a live video stream (achievable (peak) data rate). The selection of particular traces will be done by the demonstration operator.
  - What can be shown on the screen of the handheld device include:
    - Video Stream. Probably pre-recorded for the different scenarios.
    - Potentially, also connection parameters (e.g. current data rate, bit error rate) can be displayed

Related demonstration scenarios

The dewmonstration scenario ‘Decision Support System for Spectrum and Technology Management’ (DSS-STM) as described in Section 3.4.

2.2 Automatic Traffic Steering - Multi-layer LTE/WiFi traffic steering

The objective of the ‘Automatic Traffic Steering – Multi-layer LTE/WiFi traffic steering’ use case is to develop and assess advanced multi-layer LTE/WiFi traffic steering solutions, as extensively described in [1]. Multi-layer LTE/WiFi traffic steering studies the steering of traffic between LTE base stations and WiFi access points based on e.g. network loading, requested service, experienced/ required QoS, user profile (e.g. priority class) and user location. The eventual objective of the targeted traffic steering mechanism is to improve the end user experience and network performance via improved and more efficient utilization of both WiFi as well as of the cellular network assets, whilst minimizing additional network complexity. The use case will consider both macro cells and (low power) indoor/outdoor small cells in dense urban deployments covering multi-floor buildings, streets, etc.

Figure 3 visualises the ‘Automatic Traffic Steering – Multi-layer LTE/WiFi traffic steering’ use case, depicting a single LTE macro cell covering three WiFi hot spot cells. The figure includes two example scenarios where advanced load/QoS-based traffic steering may indeed outperform myopic (purely) coverage-based cell selection: *(i)* a scenario where a given user is barely covered by the WiFi access point and would be better served by the LTE macro cell; and *(ii)* a scenario where a given WiFi hot spot is so highly loaded that indeed also overall user-level performance may be improved by serving a subset of these session in the LTE network.

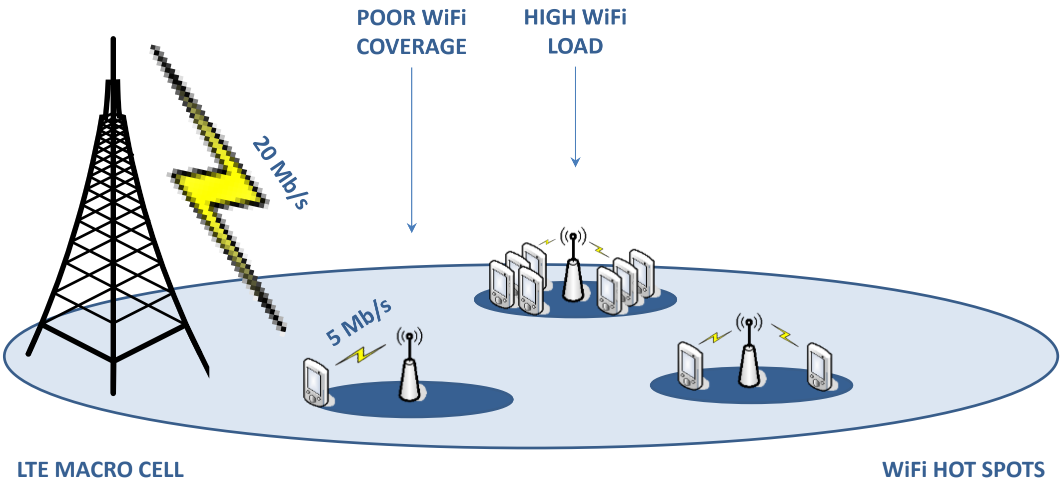

Figure 3: Example scenarios for the 'Automatic Traffic Steering – Multi-layer LTE/WiFi traffic steering' use case.

Demonstration objective

The goal of the demonstration is to show the advancements the developed traffic steering algorithm (ALG_1) can achieve over a reference scenario where straightforward coverage-based LTE offload to WiFi is applied, i.e. where WiFi network discovery, selection and access are determined purely by the availability/coverage of a WiFi hot spot (ALG_0).

In particularly, the demonstration will show that:

- The end user experience has improved through session-level QoS statistics, e.g. user throughput or video streaming quality.
- Cellular network assets are more efficiently used, shown via network-level statistics such as the spectral efficiency and signalling load.

Demonstration storyline

Initialisation – We show an operational multi-layer LTE/WiFi network deployed in a dense urban environment, including a visualization on the KPI (session- and network-level statistics) and network screens. ALG_0 is active in a purely coverage-based assignment of sessions to macro or small cells.

At some point in time the presenter enables the enhanced traffic steering algorithm (ALG_1) via the network operator window. From then on a side-by-side demonstration is given, for the exact same scenario, of the effects of reference algorithm ALG_0 and enhanced algorithm ALG_1, both on the KPI and on the network screen.

Optionally, but very much preffered, the presenter can change some aspects of the demonstration at certain points during the demonstration, e.g. the traffic load, the spatial traffic load distribution, instances/parameterizations of ALG_1, the introduction of one or more new hot spots. The side-by-side demonstration of ALG_0 and ALG_1 smoothly continue after such an effectuated change.

On scenario aspects

Refer to [1] for a detailed description of scenario aspects considered in the use case development work itself (WP4). For an effective and time-efficient demonstration (WP3), the scenario scope should be rather limited, where the following considerations may be made:

- Considering only a single (macro) LTE layer, rather than also micro, pico and/or femto cells. This will avoid the need to visualize and explain the effects of the traffic steering between the different layers and allow the demonstrator to focus on the most important part of the use case, i.e. traffic steering between the LTE macro layer and the WiFi hot spot layer.
- Consider LTE as the only cellular RAT to allow more transparent demonstration of the potential of the developed advanced traffic steering solutions.
- Considering UEs that are capable of doing only either seamless or non-seamless handovers between LTE and WiFi. The ability to do either seamless or non-seamless handover will have an impact on the decisions taken by the SON functionality. For instance, the SON functionality will less likely steer users that are not capable of doing a seamless handover while they are making a call. This will also change the results and the actions that are taken by the SON functionality.

On KPIs

With regard to the demonstration (WP3), the following KPI/KUIs are deemed to be most relevant to be include in the targeted demonstrations:

- *Network-level statistics*
    - **Carried traffic**: the amount/percentage of traffic handled by the LTE and WiFi network, respectively. Shown as a line plot over time.
    - **Relative cell loads**: the fraction of the load that is handled by an LTE cell or WiFi access point relative to its capacity. The load could for instance be expressed in terms of an average utilization of the cell resources. Shown as a line plot over time and/or with a dial marked with low medium and high markings.
    - **Network signaling**: the number of control messages that are exchanged between the different components of the core network and the different base stations and access points. Shown on a map between individual network components (e.g. cells).
- *Session-level statistics*
    - **User throughput**: the average of x-th percentile of the experienced user throughputs, determined over a certain time window. Shown as a line plot over time and/or a dial marked with low medium and high markings.
    - **UE latency**: the round-trip time experienced by a user, averaged over a certain time window. Shown as a line plot over time and/or a dial marked with low medium and high markings.
    - Besides their presentation on the KPI screen, the session-level metrics can also be shown on handheld devices as discussed in Section 1.2

Demonstration platform requirements

In this section the scenario-specific requirements on the (different components of the) demonstration platform are formulated.

- *General requirements*
    - Regarding the demonstration timescale, the algorithms that will be designed in the multi-layer LTE/WiFi traffic steering use case will operate with a granularity of several tens of seconds/minutes. This means that simulations will have to span a couple of hours (simulation time) to clearly see the effects of the proposed algorithms.
    - Regarding simulation branching, we foresee an initial demonstration of scenario A under reference session assignment algorithm ALG_0, while a some point ALG_1 is enabled, requiring side-by-side demonstration of these two branches. Then optionally, one or two scenario changes (scenarios B, C) may be effectuated, as exemplified above in Section 1.2, which would then yield two or four additional branches.
- *Network operator screen*

  - The network operator screen is used to enable and disable the advanced algorithm (ALG_1).
- *DSS screen*
  - No specific DSS screen requirements.
- *KPI screen*
  - A single KPI screen showing the above-mentioned KPIs. It would be beneficial if a) the KPIs could be hidden and shown again whenever this is deemed necessary, b) the ability was provided to scroll back in time and to zoom in on a certain time window and c) at a certain point in time, the currently shown value can be 'fixed' and that new values of KPI are, for instance, plotted as an additional line on the plot. This will be very useful when the SON functionality is switched on or off to have a reference for comparing the new KPI values to.
- *Network screen*
  - The network screen should show a map displaying the entire simulation area with its LTE base stations and WiFi access points. The network screen should also show the users as well as the base station(s) to which they are connected. In case users are simultaneously connected to both a LTE base stationand a WiFi access point, the ratio of the amount of traffic sent/received through the LTE base station and WiFi access point can be shown.
  - The network area map should also display which cells are overloaded and even show the intentions of the SON algorithm by using arrows pointing from one cell to another showing towards which cells traffic is steered.
- *Session terminal involvement*
  - Terminals representing individual sessions can be used in this use case. They can be used to display the QoS experienced by the represented user as well as which cell the user is connected such that actions of the traffic steering algorithm can be observed. The actions of the SON function can also be shown on the session terminal: whenever a user is 'steered' towards a certain cell or access point an indication can appear on the terminal giving the destination and possibly reason for the action.

Related demonstration scenarios

As the ‘Automatic Traffic Steering – Multi-layer LTE/WiFi traffic steering’ use case is closely related to the ‘Automatic Traffic Steering – High mobility’ use case, so are the corresponding demonstrations. This relation may allow for their integration in a single demonstration scenario. This use case is also a candidate for being used in the 'SON coordination and management through high-level goals' use case.

2.3 Automatic Traffic Steering - High mobility

The objective of the ‘Automatic Traffic Steering – High mobility’ use case is to improve the handover performance of users that have high mobility, as extensively described in [1]. High mobility occurs when the average amount of time that a user stays in a cell is low, i.e. the time-of-stay is short. Short time-of-stay can occur in two real-life situations:

a) When cell sizes are so small that even users with a low velocity perform frequent handovers.
b) When users move at a high velocity.

In both situations the time between entering the cell and leaving it again will be small and handovers will occur frequently. The goal of this use case is to develop a SON function that improves the QoS of the highly mobile users and reduces the signaling overhead in the core network by reducing the number of handovers and optimizing the handover timing of the users. This can be done by applying different handover policies to users depending on their mobility profile. For instance, it might be a good idea to steer highly mobile pedestrian users in a dense deployment of small cells to an overlaying macro cell to reduce their handover rate while keeping users which have low mobility connected to a micro/pico/femto cell for improved capacity and reducing the load in the macro cell. Another solution might be to not let the users handover to the strongest cell but instead let them skip cells along their path and hand them over to cells that are farther apart. A distinction between UE mobility state can for instance be made based on the mobility history of users; users that have experienced many handovers in the (recent) past are probably moving and will make more handovers in the (near) future while users that only made few or no handovers in the past are probably stationary and will probably experience only few handovers in the future.

Demonstration objective

The objective of the demonstration is to show the improvements from applying different handover policies to highly mobile users compared to less mobile users, as will be done by the developed algorithm (ALG_1) .

In particular, the demonstration will show that:

- The end user experience has improved through session-level QoS statistics, e.g. user throughput or video streaming quality.
- Cellular network assets are more efficiently used, shown via network-level statistics such as the spectral efficiency and signalling load.

Demonstration storyline

Initialisation – We show an operational multi-layer LTE/WiFi network deployed in a dense urban environment, including a visualization on the KPI (session- and network-level statistics) and network screens. The algorithm ALG_1 is inactive, i.e. no special handover configuration is done for the high mobility users.

At some point in time the presenter enables the algorithm (ALG_1) via the network operator window. From then on a side-by-side demonstration is given, for the exact same scenario, of the effects of reference algorithm (ALG_1 off) and the enhanced scenario (ALG_1 on), both on the KPI and on the network screen.

Optionally, the presenter can change some aspects of the demonstration at certain points during the demonstration, e.g. the traffic load, the spatial traffic load distribution, instances/parameterizations of ALG_1, the introduction of one or more new hot spots. The side-by-side demonstration of ALG_1 on vs. off shall smoothly continue after such an effectuated change.

On scenario aspects

The use case of WP2 can be limited to either of the two different cases in which problems might occur:

a) When cell sizes are so small that even users with a low velocity perform frequent handovers.
b) When users move at a high velocity.

The former situation will typically arise in a shopping street/mall where there are a lot of small cells. The latter situation might occur when for instance a highway or a high-speed railway crosses a number of macro cells.

Refer to [1] for a detailed description of scenario aspects considered in the use case development work itself (WP4). For an effective and time-efficient demonstration (WP3), the scenario scope should be rather limited, where the following considerations may be made:

- Consider evaluating only one of the cases a) or b) above, rather than both.
- Consider LTE as the only cellular RAT to allow more transparent demonstration of the potential of the developed advanced traffic steering solutions. Limiting the use case to a single layer will not be possible as the steering of users between different layers is at the core of this use case.

On KPIs

With regard to the demonstration (WP3), the following KPI/KUIs are deemed to be most relevant to be include in the targeted demonstrations

- *Network-level statistics*
  - **Signalling overhead**: the amount of signalling traffic that is sent through the packet core, expressed in (a multiple of) bit/s. Shown as a line plot over time and/or a dial marked with low medium and high markings.
- *Session-level statistics*
  - **Handover frequency**: the amount of handovers per second a user makes. Shown as a line plot over time and/or a dial marked with low medium and high markings.
  - **Radio link failures**: the number of radio link failures experienced. Shown as a line plot over time and/or a dial marked with low medium and high markings.
  - **Packet loss ratio:** the fraction of packets that are lost. Noticeable packet loss can be caused by data outage at the frequent handovers. Shown as a line plot over time and/or a dial marked with low medium and high markings.
  - Besides their presentation on the KPI screen, the session-level metrics can also be shown on actual session terminals involved in the demonstrations. These session-level metrics can all be aggregated per RAT, per layer, per cell/group-of-cells and/or per user/group-of-users.

Demonstration platform requirements

The demonstration platform requirements are in all essential aspects identical to those described for the 'Automatic Traffic Steering – Multi-layer LTE/WiFi traffic steering'demonstration scenario in Section 2.2.

Related demonstration scenarios

As the 'Automatic Traffic Steering – Multi-layer LTE/WiFi traffic steering' use case is closely related to the 'Automatic Traffic Steering – High mobility' use case, so are the corresponding demonstrations. This relation may allow for their integration in a single demonstration scenario.

3 Demonstration Scenarios for WP5 Use Cases

This chapter presents the demonstration scenarios for a subset of the use cases from WP5 "Integrated SON Management" as described in [1]. Note that this content is preliminary and the final details are dependent on the outcome of WP5. This will be reflected in the updated report (D3.4 'Demonstration scenarios (updated version)') which will be delivered at the end of project month 30, i.e. February 2015.

3.1 SON coordination and management through high-level goals

An extensive description of the 'SON coordination and management through high-level operator goals' use case is given in [1].

Demonstration objective

The objective of this demonstration scenario is to demonstrate the impact of:

- Coordinating simultaneously active SON functionalities in the network
- High-level operator goals acting on network performance and user-perceived QoS.

It is important to note that the high-level operator goals will be translated into rules/policies as an input to the SON coordinator, which then translates those rules/policies into SON-specific rules/policies. The change in behaviour of the involved SON functions as a result of these SON-specific rules/policies will impact the network performance and user-perceived QoS. In the demonstrator, the intermediate steps will not be visible, only the final impact on the network performance and the user-perceived QoS will be observed.

Demonstration storyline

The scene consists of screens displaying the network KPI performance and operator high-level goals (including the operator dashboard), with potentially user devices (tablets and/or smartphones) connected to the network (depending of the considered SON functions to be coordinated), which are engaged in some kind of application (streaming, web browsing).

- As a first step, the performance of the network is observed for the first (set of) operator high-level goal(s) without SON coordination. At this point, a notification/message from the SON coordinator to the operator, indicating the conflicts between the involved SON functionalities is observed. Then SON coordination is activated by the operator (via the operator dashboard). After a certain period of time, the effect of enabling SON coordination on the network performance screen and also on the connected devices can be observed.
- The second step consists of modifying the (set of) high-level objectives and seeing the effect of this on the network performance screen and on the connected user devices. For example, a robustness/resilience promoting strategy (less call drops, failures) can be visualized against a capacity promoting strategy (more users with high-data rate applications).

On scenario aspects

Refer to [1] for a more elaborate description of scenario aspects considered in the use case development work itself (WP5). For an effective and sufficiently exciting demonstration (WP3), the the following scenario considerations are proposed:

- As a first step, an outdoor multi-layer (macro and pico) LTE network with 20-40 macro cells is required. Possibly, this could be enhanced further depending of the considered SON functions to be coordinated.
- UEs need only be capable of a single service. For reasons of simplicity, we shall consider only one simultaneous service by all the users in the network, but not a mix of services. This

service could be either a real-time (streaming, voice), a non-real-time or a best effort (web browsing, file download) service.

- A non-homogeneous spatial traffic pattern with hotspot zones will be used. Temporal variations of this traffic pattern will include peak periods followed by low traffic periods.
- Stochastic mobility of users with different speed distributions will be assumed. Typical user speed will vary within the range defined by the mobility model.

Preferably, the simultaneously active SON functionalities in the network will be SON functionalities developed by SEMAFOUR WP4. Ideal candidates are automatic traffic steering and dynamic spectrum/interference management. As a fall-back option, a simple implementation of 3GPP SON functions (MRO, MLB, ICIC, CCO, ES) will be considered.

The following criteria will be taken into account in choosing the involved SON mechanisms:

- o SON temporal scales (Two cases can be considered: SON functions with temporal scales in the same order of magnitude to show a simple conflict situation and a second case with SON functions with different temporal scales in order to explain how these can be coordinated),
- o Conflict types (SON functions which have a high level of interaction will be considered),
- o Relation to high-level operator goals (SON functions which are expected to have a higher impact on the high-level operator goals will be considered),
- o Visibility of the effect in the demonstrator (although the aim is not to show the SON function behaviours in the demonstrator, we could envisage to show on the demonstrator SON functions whose behaviour are relatively easy to understand as a “bonus”).

The choice of high-level operator goals will be made in such a manner that switching from one goal to another will have the most "visible" impact on the end user experience and also on the network performance. For this, we can pre-define a list of “operator strategies”. Each operator strategy is a group of “high level operator goals”. The user/demonstrator should not be allowed to modify the goals inside each operator strategy but only to choose among different predefined strategies.

On KPIs

The KPIs that are of interest to show to the end user depend of the considered SON functions to be coordinated. Examples of KPIs are listed as follows:

- Blocked access attempts
- File Transfer Time (FTT) for non-real time or best effort data applications (file download, web browsing), latency for real-time applications (streaming, voice)
- Energy consumption
- Outage rate
- Throughput indicators (mean user, global, cell-edge average etc.)
- Radio Link Failures (RLF)
- Call/session drops
- Load distribution over RATs/layers/cells

Depending on the particular SON functions involved in the scenario, a different subset of those KPIs is expected to be impacted. For example, for traffic steering SONs, throughput indicators, load distributions, call drops and blocked access attempts are of utmost concern at the network level. As for user-perceived QoS, latency/FTT, call/session drops and blocked access attempts are most relevant. Another example is interference management SONs. For these SONs, throughput indicators, outage rates, call drops and blocked access attempts are of utmost concern at the network level. As for user-perceived QoS, again, latency/FTT, call/session drops and blocked access attempts are most relevant.

The network-level indicators can be monitored on a dashboard through curves and/or bar-charts, accompanied by a cartography-based visualization (indicators shown with a colour-scale on a map), if possible. For the user-perceived QoS, the effects can be directly visualized by running a specific service (YouTube, Skype, e-mail, file download, web browsing etc.) on a handheld device (smartphone or tablet).

Demonstration platform requirements

In this section the scenario-specific requirements on the (different components of the) demonstration platform are formulated.

- *General requirements*
  - Regarding the demonstration timescale, requirements from considered individual SON functions should be considered. As the management/coordination loop is slower than the loop of the individual SON fucntion, a longer time scale should be considered, at least the maximum observation time among the involved individual SON functions.
- *Network operator screen*
  - No additional requirements specific to SON coordination with respect to requirements considered for the coordinated SON functions
- *DSS screen*
  - No specific DSS screen requirements.
- *KPI screen*
  - The exact number of KPI screens depends on the considered sub-scenario. We can envisage at least two classes of KPIs to show: “High level objectives fulfilment” screen showing the progress of the KPIs corresponding to the operator objectives towards the targeted values of these KPIs, and a screen showing additional KPIs aggregating classical QoS indicators. This set of additional KPIs could be chosen in a way that shows the impact of the SON coordinator by comparing the results when evaluating the same scenario with and without coordination. The network-level indicators can be monitored on a dashboard through curves and/or bar-charts, accompanied by a cartography-based visualization (indicators shown with a colour-scale on a map).
- *Network screen*
  - No additional requirements specific to SON coordination with respect to requirements considered for the coordinated SON functions.
- *Session terminal involvement*
  - No specific session terminal requirements.

Related demonstration scenarios

The ‘SON coordination and management through high-level operator goals’ use case is directly related to the individual SON functions developed by SEMAFOUR WP4 (automatic traffic steering and dynamic spectrum/interference management) since those WP4 use cases are likely to be included in the coordination and management framework of this scenario.

3.2 Decision Support System for determining the Resource Cost of QoS as input for SLA management

The objective of the ‘Decision Support System for determining the Resource Cost of QoS as input for SLA management’ (DSS-RCoQ) use case is to support the network operator in (re)negotiations of SLAs with service providers, in particular w.r.t. determining QoS levels and associated prices. A typical question here is: what are the ‘resource costs’ if any (increased or reduced) amount of traffic is to be handled with any (increased or reduced) degree of experienced QoS for a given customer class of a given service provider? The objective of the demonstration scenario is to demonstrate the workings of the developed DSS-RCoQ. A more extensive description of the DSS-RCoQ use case is given in [1].

Demonstration objective

The objective of the demonstration scenario is to demonstrate the workings of the developed DSS-RCoQ. In particular, the demonstration will show how:

- The network operator can request the generation of a DSS-RCoQ report via a button on the network operator screen.
- The generated DSS-RCoQ report presents an analysis of the resource cost of QoS for SLA management purposes.

Demonstration storyline

Initialisation – We show an operational multi-RAT-layer network, including a default selection of KPI/KUIs visualised on network and KPI screens, visualising the general performance and loading of the network.

After some time, either as a consequence of an automated periodic trigger or upon specific request (given via a button on the network operator screen), a report is generated by the DSS-RCoQ and provided in the form of e.g. an automatically generated XLSX or PDF file. As an option, the results could also be presented via the KPI screen.

Consideration of different scenarios – Optionally, the demonstration can be repeated for different scenarios, e.g. to show how resource costs are different in capacity- versus coverage-driven network deployments, in low- or high-load scenarios, or with modest or ambitious QoS targets.

On scenario aspects

Refer to [1] for a more elaborate description of scenario aspects considered in the use case development work itself (WP5). For an effective and sufficiently exciting demonstration (WP3), the the following scenario considerations are proposed:

- Considering the involvement of different RATs/layers, we would intend to consider a realistically complex network scenario with multiple RATs and layers, in order to demonstrate the workings and output of the DSS-RCoQ in a realistic setting.
- Regarding service and mobility models, no specific requirements or recommendations are imposed at this point, although the DSS-RCoQ demonstration scenario is most exciting and realistic if a variety of service providers, services and customer classes, with varying performance guarantees are considered.
- Although in principle there is no need for SON (management) functions to be active in the demonstration scenarios, their involvement would certainly make the scenarios more complete and exciting.
- A realistic set of high-level performance objectives regarding e.g. coverage, accessability and service quality should be considered, which form an essential input for the DSS-RCoQ. These high-level performance objectives should match the performance agreements formulated in the different SLAs. The DSS-RCoQ primarily delivers analyses showing the relation between delivered (rather than guaranteed) performance and consumed resources. For a demonstration it would make sense that the delivered performance not only matches the high-level operator goals but also the performance agreements in the different SLAs. This requires an adequate translation of SLA into high-level operator goals.

On KPIs

In the current proposal, the DSS-RCoQ in no way affects the *KPI screen*, which addresses actual and current network performance and behaviour.

The *automatically produced report* comprises charts displaying for each customer class and each service provider, the experienced performance versus the amount of consumed resources (e.g. #PRBs × utilisation time, power/energy, etc) and the amount of carried traffic, thereby also indicating what percentage of the total network resources this corresponds to. Separate charts may be delivered for different times and/or areas. This is to be investigated in the WP5 work on the DSS-RCoQ use case.

Demonstration platform requirements

In this section the scenario-specific requirements on the (different components of the) demonstration platform are formulated.

- *General requirements*
  - Regarding the demonstration timescale, we note that periodic/requested DSS-RCoQ reports are likely to be generated on a timescale of days/weeks to monitor the balance between the delivered performance and consumed resources across the various customer classes and service providers. Potentially initiated (re)negotiations of new/existing SLAs is more likely to occur on a time scale of months.
  - Since no actions are taken that affect the network, no simulation branching applies.
- *Network operator screen*
  - The network operator screen should support operator requests for DSS-RCoQ reports.
- *DSS screen*
  - The DSS screen should support displaying the availability of DSS-RCoQ reports and allow viewing them.
- *KPI screen*
  - No specific KPI screen requirements.
- *Network screen*
  - No specific network screen requirements.
- *Session terminal involvement*
  - This demonstration scenario does not involve actual session terminals.

Related demonstration scenarios

The 'Decision Support System for determining the Resource Cost of QoS as input for SLA management' (DSS-RCoQ) use case is related to the other two DSS use cases:

- DSS-STM ('Decision Support System for Spectrum and Technology Management');
- DSS-NE ('Decision Support System for Network Evolution').

In case all three worked out demonstration scenarios will indeed make it to the final demonstration plan, it may be sensible to integrate them in a single demonstration scenario.

3.3 Decision Support System for Network Evolution

The objective of the 'Decision Support System for Network Evolution' (DSS-NE) use case is to support the network operator in selecting the most effective network evolution steps in response to changing demand or quality targets. This is done by continuous/periodic monitoring of network performance/ quality on the basis of measurements and/or planning data in reference to given targets, and analysing the available means (configuration changes, upgrade, new sectors/sites) to resolve identified short-comings. A more extensive description of the DSS-NE use case is given in [1].

Error! Reference source not found. Figure 4 below visualises the DSS-NE use case, depicting a region in an example multi-layer LTE network comprising both macro and pico cells. The figure includes two examples of identified problems and accompanying recommendations for network updates: *(i)* an area with a detected lack of coverage for which a pico cell placement is recommended; and *(ii)* an area where poor accessibility and performance due to a structural overload (lack of capacity) is observed, for which the addition of a sectorised macro site is recommended.

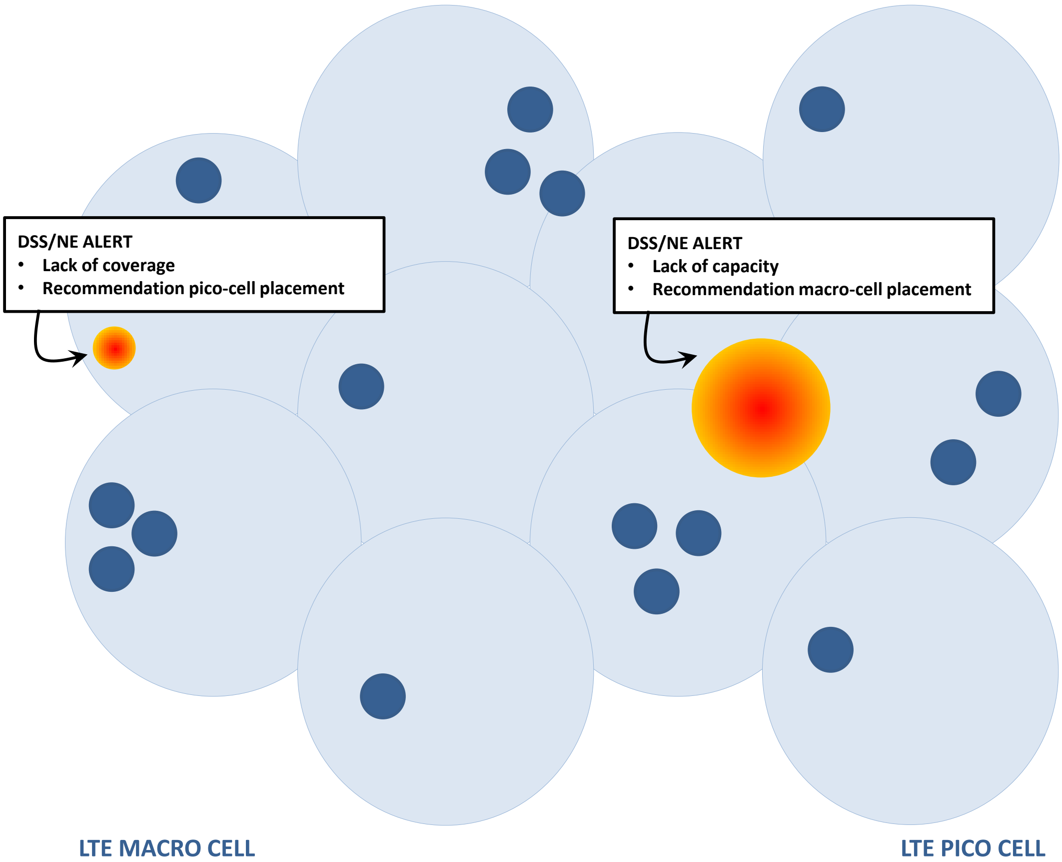

Figure 4: The 'Decision Support System for Network Evolution' use case, considering a network area comprising an LTE macro (light blue cells) and an LTE pico layer (dark blue cells).

Demonstration objective

The objective of the demonstration scenario is to demonstrate the workings of the developed DSS-NE. In particular, the demonstration will show how:

- The DSS-NE continuously observes some resource utilization KPI/KUIs and timely detects whether once one or more such KPI/KUIs are anticipated to structurally violate specified requirements.
- In such case the identified coverage, capacity or performance issue is shown on the network and KPI screens, while an 'alarm' message is displayed in the DSS window.
- Furthermore, the DSS-NE is demonstrated to recommend one ore more network update actions, both on the network screen and in the DSS window, along with an indication of the extent to which each proposed network update resolves the identied problem.

Demonstration storyline

Initialisation – We show an operational multi-RAT-layer network, including a default selection of KPI/KUIs visualised on network and KPI screens, visualising the general performance and loading of the network. If this feature is activated, continuously the 'worst-N' performance issues are noted. On a periodic basis, e.g. every 15 minutes, the DSS window (client) will output performance reports.

As time progresses, (the spatially heterogeneous) traffic loads grow, and hence with potentially different growth rates in different areas, and the different KPI/KUI visualizations evolve alongside, with the associated coloring (indicating the load levels) evolving from green via orange to, eventually, red. At some point in time, the DSS-NE timely identifies that in a specific area, e.g. a few cells in the center of the demonstration area, selected KPI/KUIs become ‘too orange’ and generates a message in the DSS window, e.g:

DSS-NE ALERT
‘KPI/KUI X is reaching a critical level, and predicted to fall beyond this critical level within Y weeks. One of more of the following network updates are recommended:

- *Update$_A$* *Estimated performance impact$_A$* *Deployment delay$_A$*
- *Update$_B$* *Estimated performance impact$_B$* *Deployment delay$_B$*
- *Update$_C$* *Estimated performance impact$_C$* *Deployment delay$_C$*
- …

The alert, the associated analysis and recommendations are also included in the periodic performance reports. Upon click on some kind of ‘show me’ button, the recommended network update(s) are visualized on the network screen, as well as their estimated impact on the critical KPIs, while the alert, the KPI and network screens then automatically zoom into the area of interest.

Multiple (e.g. 2 or 3) such alerts could be shown in the demonstration, considering different areas in the network, difference performance/resource issues and different proposed changes.

As part of the demonstration, it could also be shown what happens when an operator actually carries out one of more of the proposed network updates, e.g. place a new 3-sector macro site at suggested location (x,y). It can then be seen how the site appears in the network and how the local KPI/KUIs improve accordingly.

On scenario aspects

Refer to [1] for a more elaborate description of scenario aspects considered in the use case development work itself (WP5). For an effective and sufficiently exciting demonstration (WP3), the the following scenario considerations are proposed:

- Considering the involvement different RATs/layers, we would ideally consider a realistically complex network scenario with multiple RATs and layers, allowing a variety of network update options. This set of options then potentially includes macro and small cell placement, carrier additions, azimuth adaptations, and, if we would integrate this demonstration scenario with the DSS-STM (‘Decision Support System for Spectrum and Technology Management’) demonstration scenario, also site migrations to newer RATs and spectrum shifts between sites (RATs, layers).
- Regarding traffic and mobility models, no specific requirements or recommendations are imposed at this point. Both single service, no mobility or multiple service, full mobility scenarios may be sufficiently interesting.
- Although in principle there is no need for SON (management) functions to be active in the demonstration scenarios, their involvement would certainly make the scenarios more complete and exciting.
- A realistic set of high-level performance objectives regarding e.g. coverage, accessability and service quality should be considered, which form an essential input for the DSS-NE.

On KPIs

With regard to the demonstration (WP3), the following KPI/KUIs are deemed to be most relevant to be include in the targeted demonstrations:

- *Network-level statistics*
    - **Cell loads**: an indicator of the effective load handled by each cell, e.g. expressed in terms of an average utilization of the cell resources (PRB utilisation, average DL transmit power, average noise rise).

  - **Coverage probability**: the spatially defined probability that sufficient coverage exists to allow the establishment of a signalling connection and/or some minimum degree of service quality.
  - **Call success rate**: the fraction of calls that is admitted and successfully handled, i.e. without premature call termination and with a satisfactory service quality.
- *Session-level statistics*
  - **Video streaming quality**: a metric that expresses the user-experienced quality of a video stream, covering the effects of source bit rate, playout delays, hick-ups and visable packet errors.
  - **User data throughput**: the average of x-th percentile of the experienced user throughputs, determined over a certain time window. Shown as a line plot over time and/or a dial marked with low medium and high markings.

One or more selected KPI/KUIs can be visualised on the *KPI screen* in the form of line/bar/pie charts, while on the *network screen*, we can colour pixels, best server areas (if unambiguously identifiable) or cells/sites on a scale of green-orange-red to visualise a single selected KPI/KUI. In addition, the network screen shows the current level of the full set of KPI/KUIs in numerical form at each cell. Optionally, it should be possibly to request for only the 'worst N' coverage/performance problems to be displayed in the above-described green-orange-red colouring fashion.

The *timescale* of all the presented KPI/KUIs is chosen in line with the timescale at which the DSS-NE performs its analyses, which in turn is in line with the scale at which the high-level performance objectives are formulated, e.g. considering the 95th percentile of all cell edge performance measurements averaged over 15-minute intervals. Most likely, the DSS-NE will monitor (and trend) 5/15-minute KPI/KUI scores over longer periods of times and with a specified spatial granularity (e.g. cell level), identifying busy hours/days and concentrating on those when presenting the experienced performance.

Furthermore, we may want to indicate *key configuration parameters* of each cell on the network screen, i.e. those for which the DSS-NE may want to suggest changes.

Demonstration platform requirements

In this section the scenario-specific requirements on the (different components of the) demonstration platform are formulated.

- *General requirements*
  - The demonstration timescale is in the order of days/weeks/months to assess network performance/utilisation, derive network update proposals, and (potentially) effectuate one or more (simulation branches; see below) such proposals.
  - Regarding simulation branching, the basic demonstration scenario does not require any branching. In case the option of effectuating a recommended network update is considered, the demonstration could at the time of DSS-NE alert branch into separate subscenarios. Each such subscenario would then correspond with a different network update proposal that is operationally effectuated and, subsequently, assessed during a continued simulation playout of the scenario. An additional branch would then be applied to cover the reference case of doing no network updates. The different demonstrations run in parallel would then illustrate to what extent the performance issues are indeed resolved by the different possible network updates. As an alternative to branching with regards to to different network update options, we could potentially also observe the evolution of a given network update for different traffic evolution scenarios.

    A proposed effectation of branching the demonstration is illustrated in the figure below. We first run the default scenario until the time of DSS-NE alert #1. At that point we assume (about) three possible network updates. The evolution induced by the 'best' option (to be determined how 'best' is defined) is shown in the main window, while the evolution associated with the alternatives is shown in separate windows. One of the branches may likely be set up to show the reference case of ignoring all recommendations and leave the network deployment unchanged.

A little while later, in the evolution scenario associated with the network update that 'best' responded to DSS-NE alert #1, DSS-NE alert #2 occurs. Unrelated to DSS-NE alert #1, but proposed as another demonstration of the DSS-NE solutions, DSS-NE alert #2 is associated with a different region in the network, triggered by different performance issues and requiring different network updates. Again, three options exist, etc. Hence the demonstration scenario in this example requires storage of five distinct traces.

We assume that at the time of the DSS-NE alerts immediately a decision is made regarding the effectuated network update, which may or may not be effectuated after some update-dependent fixed delay. This way, we don't need to prepare separate traces for the cases when such a decision is made at e.g. 6:00 pm or 6:15 pm. That distinction is not relevant for the demonstration scenarios.

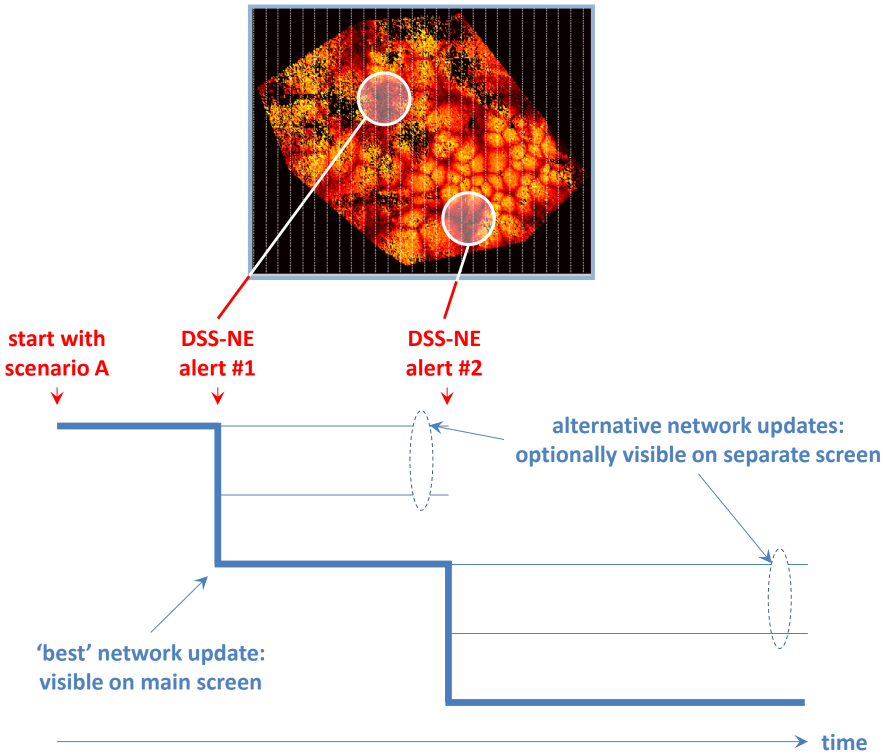

Figure 5: Branching in the 'Decision Support System for Network Evolution' demonstration scenario.

- *Network operator screen*
  - Via the network operator screen we may optionally likely like to activate the DSS(-NE) functionality, which will open the DSS screen.
- *DSS screen*
  - The DSS screen should support displaying the availability of periodic performance reports as well as the DSS-NE alert messages exemplified above.
  - Furthermore, the DSS screen should support selection of one or more recommended network updates. It is to be decided whether we will then further demonstrate only the selected update or the ignored alternatives as well, e.g. in a reduced screen.
- *KPI screen*
  - A single KPI screen suffices, showing the above-mentioned KPI/KUIs.

  - It should be possible to 'zoom into' such KPI/KUIs, i.e. to reduce the associated spatial scope to the regio of relevance, i.e. the region where performance issues are anticipated or observed. Such zooming should be synchronised between the KPI and network screens.
- *Network screen*
  - A single network screen should be sufficient showing a map that displays the entire simulation area with all its involved RATs and layers. The map should further show a pixel map of a selectable KPI/KUI, numerical values of all relevant KPIs/KUIs, key cell-specific configuration info.
  - At present there is no foreseen need to (un)select layers or RATs, but depending on the complexity of the network scenario, this may still be a desirable option.
  - The network screen should support zooming into areas that deserve attention (actual or anticipated coverage/performance issues). Such zooming should be synchronised with the KPI screen.
  - The presenter shall be able to click on a given site/cell to request cell-specific performance and configuration info.
  - The network screen should further support pop-up messages displaying the DSS-NE alerts, stating the anticipated/observed performance issues and the recommended network updates.
- *Session terminal involvement*
  - This demonstration scenario does not involve actual session terminals.

Related demonstration scenarios

The 'Decision Support System for Network Evolution' (DSS-NE) use case is related to the other two DSS use cases:

- DSS-STM ('Decision Support System for Spectrum and Technology Management');
- DSS-RCoP ('Decision Support System to determine the Resource Cost of Performance').

In case all three worked out demonstration scenarios will indeed make it to the final demonstration plan, it may be sensible to integrate them in a single demonstration scenario.

3.4 Decision Support System for Spectrum and Technology Management

The objective of the 'Decision Support System for Spectrum and Technology Management' (DSS-STM) use case is dealing with the conditions of the operational LTE network. Operators may swap their base stations to other technologies or frequency bands, if the performance or coverage requirements in the operational network cannot be met anymore or show bottlenecks in the network at a specific time and/or region, even though SON-mechanisms have already been applied.

High-level operator goals include identifying and showing bottlenecks in the network, providing possibilities to improve the network in the future by swapping or refarming base stations to other RATs and to prepare strategies in spectrum auctions in the future.
A more extensive description of the DSS-STM use case is given in [1].

Demonstration objective

The objective of the demonstration is to visualize made suggestions of the DSS-STM algorithm in order to achieve an optimal technology and the spectrum allocation for the base stations.

- The DSS-STM continuously observes performance readings, traffic variations, and UE population and anticipates, if and when situations occur that violate specified requirements.
- In such case the identified coverage, capacity or performance issue is visually shown on the network and KPI screens, while an 'alarm' message is displayed in the network operator window.

- The DSS-STM will then recommend one or more potential technology update(s) or frequency re-farming(s) to address this issue. This is to be shown on the network screen and in the network operator window (also in list form), along with an indication of the extent to which each proposed network update resolves the identified problem.

Demonstration storyline

Initialisation – We show an operational multi-RAT, multi-layer network, including a default selection of KPI/KUIs visualised on network and KPI screens, visualising the general performance and loading of the network.

As time progresses, (the spatially heterogeneous) several areas in the network will be detected where overload occurs on different times of the day. For these areas a list of settings could pop up with deployment/change recommendations to solve the problems in this area in the future.

On scenario aspects

Refer to [1] for a more elaborate description of scenario aspects considered in the use case development work itself (WP5). For an effective and sufficiently exciting demonstration (WP3), the following scenario considerations are proposed:

- Considering the involvement of different RATs/layers, all RATs (i.e. GSM, UMTS, LTE) and all layers (i.e. macro, micro, pico and femto cells) are of interest. Terminal capabilities for different RATs need to be considered to give plausible recommendations for the future.
- Regarding traffic and mobility models, one flow per UE with a spatially heterogeneous traffic distribution based on macroscopic user mobility is required.

On KPIs

With regard to the demonstration (WP3), the KPI/KUIs and other related aspects as described in the DSS-NE (‘Decision Support System for Network Evolution’) demonstration scenario are equally applicable to this scenario.

Demonstration platform requirements

The demonstration platform requirements are in all essential aspects identical to those described for the DSS-NE (‘Decision Support System for Network Evolution’) demonstration scenario.

Related demonstration scenarios

The ‘Decision Support System for Spectrum and Technology Management’ (DSS-STM) use case is related to the other two DSS use cases:

- DSS-NE (‘Decision Support System for Network Evolution’);
- DSS-RCoQ (‘Decision Support System to determine the Resource Cost of QoS as input for SLA management’).

In case all three worked out demonstration scenarios will indeed make it to the final demonstration plan, it may be sensible to integrate them in a single demonstration scenario.

References

[1] SEMAFOUR, 'Definition of self-management use cases', Deliverable D2.1, February 2013.