Inclusion of "Self-x" Features in the SESAME-based Wireless Backhaul for Support of Higher Performance and Availability

Dr. Ioannis P. Chochliouros[1] and Philippos Georgantas

Hellenic Telecommunications Organization S.A. (OTE)

[1]Head of Research Programs Section, Fixed
SESAME Project Coordinator

The 5G Infrastructure Public Private Partnership

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Introductory Scope_(1)

➢ **The backhauling is a crucial component of the modern SESAME architecture.**

- **Backhauling infrastructure enables communications between the CESCs (Cloud-Enabled Small Cells) and the core network (CN)**, but also it **interconnects** CESCs **with each other and with managing system components** *(i.e., the CESC Manager (CESCM).*

- **Both signalling traffic** *to control and monitor the Physical Network Functions (PNFs) and Virtual Network Functions (VNFs) of CESCs*, **as well as the access traffic** *exchanged between User Equipments (UEs) and the core network*, **are carried over the backhaul**.

- Further, *the micro-servers forming the Light Data Centre (DC) are interconnected via the backhaul.*

➢ **In SESAME, this is necessary to offer features like Service Function Chaining (SFC),** *which enables chaining of different edge services running on separate machines.*

➢ **An *important candidate for 5G backhaul technologies* are *wireless radio communications*.**

In contrast to traditional wired backhauls relying on technologies like Ethernet over copper or fibre optics, **wireless backhauls do not require the deployment of an additional infrastructure.**

Instead, **each CESC is equipped with at least one wireless radio transceiver dedicated to backhauling.**

In the following slides, we present the main concept of *"how wireless backhauling is applied in SESAME"* in the context of backhaul network virtualisation and Self-x backhauling features.

We also provide a short introduction into which are the *wireless radio backhaul technologies that are considered for SESAME deployments*.

Inclusion of "Self-x" Backhauling Features_(1)
SON consideration

- **Self-Organising Networks (SON)** *denotes a set of features and capabilities for automating the operation of a network so that operating costs can be reduced and human errors can be minimised.*

- **This implicates for an enhanced network management.**

- **With the inclusion of SON features, standard manual planning, deployment, optimization and maintenance activities of the network can be effectively replaced -and/or supported- by more autonomous and automated processes,** *thus making network operations simpler and faster.*

SON functions, denoted in the context of SESAME as *"Self-x" functions*, are organised around three main categories: *self-planning, self-optimization and self-healing.*

Inclusion of "Self-x" Backhauling Features_(2)
SON consideration

The automation of the management processes in wireless networks **by means of "Self-x" functions is seen as a** key element **to deal with the** complexity and the stringent requirements **associated with future 5G networks.**

Whereas at the access radio SON features are applied by the NMS *(Network Management System)* or at the EMS *(Element Management System),* *in the wireless backhaul the SDN controller is the responsible* for applying self-planning, self-optimization and self-healing.

In the backhaul, *centralized* **and** *decentralized Self-x approaches* as introduced by *cSON (centralized SON)* and *dSON (decentralized SON)* solutions, as well as *hybrid solutions* are *possible*.
- *The* centralized part *of the Self-x functions is executed in the* SDN controller*.*
- *The* decentralized aspects *of SON are executed in the* CESCs*.*

Self-x functions are able to automatically tune global operational settings of a small cell (e.g., maximum transmit power, channel bandwidth, electrical antenna tilt) *as well as specific parameters corresponding to Radio Resource Management (RRM) functions* (e.g., admission control threshold, handover offsets, etc.).

Inclusion of "Self-x" Backhauling Features_(3) Self-planning

Self-planning implicates for *automatization of the process of deciding the need to roll out new network nodes in specific areas,*
by identifying the adequate configurations/settings of these nodes and/or
by proposing capacity extensions for already deployed nodes (e.g., by increasing channel bandwidths and/or adding new component carriers).

Specific self-planning functions can be the following:

Planning a new cell: *This process intends to automatically make the decision that a new small cell has to be deployed in a certain area, specifying as well as its geographical position.*

RF planning of a new cell: *This process intends to automatically select RF aspects, such as transmit powers and antenna parameters of the new small cell.*

Spectrum planning: *This should decide the type of spectrum that is needed (i.e. licensed, non-licensed, etc.), the required bandwidth and the assignment of this spectrum to the different available small cells.*

Inclusion of "Self-x" Backhauling Features_(4)
Self-planning

Aware of the available wireless interfaces and the links of the mesh network formed by the CESCs, the SDN controller can assign wireless channels to the interfaces to *assure an efficient spectrum sharing* and *reuse of the backhaul during the planning phase*.

Each active tenant is assigned a share (slice) of the backhaul network. However, due to the high dynamicity of the traffic occasioned by fluctuations in the number of users and varying traffic patterns,
it is likely that the slice for a tenant is modified during network operation, which is part of the self-optimization.

The self-planning applied in the wireless backhaul is mainly performed by the SDN controller that has a general network overview.
Thus, we can put declare the *self-planning* to be a *cSON feature*.

Inclusion of "Self-x" Backhauling Features_(5)
Self-optimization

Once the network is in operational state, **the self-optimization** includes the *set of processes intended to improve -or maintain- the network performance* *in terms of coverage, capacity and service quality* **by tuning the different network settings.**

Specific self-optimization functions can be the following:

Mobility Load Balancing (MLB): *This aims at* **coping with dynamic load variations by optimizing the network parameters**, *so that load from highly loaded cells can be shifted to low loaded cells.* *This is usually done by* *tuning handover* *and* *cell reselection thresholds*.

Mobility Robustness Optimisation (MRO): *This intends to* **optimize the handover parameters in order to minimize the handover failures and the inefficient utilization of network resources** *due to, e.g., ping-pong effects. In SESAME both handovers between small cells (SCs) and handovers from/to SCs and the rest of cells of the tenant can be considered.*

Automatic Neighbour Relations (ANR): *This function is* **responsible for automatically building the Neighbour Relation Table of each cell.**
The proper identification of the neighbour relations of a cell is fundamental for mobility purposes, because handovers can only be executed between neighbour cells.

Specific self-optimization functions can be the following:

Coverage and Capacity Optimization (CCO): *This functionality intends to **provide optimal coverage and capacity in the radio network (RN).** This is done by adjusting RF parameters of the small cells (i.e. transmit power, antenna tilt, antenna azimuth, etc.) in accordance with specific optimization targets and by trying to avoid coverage holes, weak coverage areas, pilot pollution, overshoot coverage and download (DL) / upload (UL) channel coverage mismatch.*

Optimization of admission control / congestion control / packet scheduling parameters: *This intends to **optimize the setting of different RRM parameters** such as the admission/congestion thresholds, the priorities of the quality of service (QoS) classes, etc.*

Inter-Cell Interference Coordination (ICIC): *This functionality intends to **configure the power, time and frequency resources in a coordinated way among different cells so that inter-cell interference can be minimized.** The adjustment is done at a relatively slow rate.*

Energy saving: *This use case **aims at reducing the energy consumption in the deployed network.** This is usually done by switching-off the cells that carry very little traffic at certain periods of the day (e.g. at night) and by making the necessary adjustments in the neighbour cells so that the existing traffic can be served through some other cell.*

Self-optimization

Basic concerns:

In SESAME, *the SDN controller gathers detailed information* about the state of the backhaul links and the ongoing control and data transmissions.

As a result, **the controller is capable of sharing the available wireless backhaul resources among the tenants** so that the requirements (SLAs) can be satisfied.

The actions of the SDN controller **not only limit to** *assigning different shares of the network topology and the physical bandwidth* (in terms of wireless link data rates) to the tenants,
but also *on rerouting traffic throughout the network,*
in a way that other network policies, like congestion avoidance or energy saving, can be satisfied.

Inclusion of "Self-x" Backhauling Features_(8)
Self-healing

Self-healing is *relevant to the automation of the processes related to fault management* (i.e.: fault detection, diagnosis, compensation and correction), *usually associated to hardware and/or software problems,* in order to keep the network operational, *while awaiting a more permanent solution to fix it and/or prevent disruptive problems from arising.*

Specific self-healing functions can be the following:

Cell Outage Detection (COD): *This consists in* **detecting poor performing cells, usually due to hardware or software faults** *(e.g. faults in the connectivity, in the radio boards, in the power supply, etc.).*

Cell Outage Compensation (COC): *This refers to the a***ctions to solve or alleviate the outage detected in one cell***, usually by acting on the neighbouring cells in order that they serve the traffic of the cell in outage.*

Inclusion of "Self-x" Backhauling Features_(9)
Self-healing

During network operation, it may be necessary to apply self-healing features in the wireless backhaul.

- *While wireless links are stable in general, under certain meteorological conditions or upon obstruction of the line of sight between wireless transceivers,* **one or several links may disappear (temporarily).**
- *Another incident could be the physical failure of a wireless interface, which would cause the loss of all wireless links associated to the interface.*

In any of these cases, **the controller needs to be able to react by redirecting traffic over alternative routes**, *taking into account how the new assignment of wireless backhaul resources will affect the overall network performance and whether the new state would be acceptable in terms of meeting SLA requirements.*

For this purpose algorithms are designed to assure robustness of the network *by, for example, calculating backup paths that are as disjoint as possible from main data paths in order to be able to provide alternative routes in case of failures.*

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Self-Healing can be applied both as cSON and dSON features.

- *In a **cSON approach**, failures detection and correction are responsibility of the **SDN controller**.*
- *In a **dSON approach**, the **CESCs** can react to failures on their own.*

Such features can include fast-rerouting without waiting for new instructions from the SDN controller.

Regarding the architectural models for implementing the Self-x functions, the following possibilities are distinguished:

Centralized SON (cSON): *This is a solution where the Self-x algorithms are executed at the NMS or at the EMS.*

Distributed SON (dSON): *This is a solution where the Self-x algorithms are executed at the Network Element level (i.e. autonomously within a single SC or in a distributed manner among several SCs).*

Hybrid SON: *It combines cSON and dSON, in such a way that*
- *part of the Self-x functionalities are distributed and reside at the SC*
- *while others are centralized and reside at the EMS and/or the NMS.*

Updating of the SESAME Architectural Framework_(2) – Distinction of possible options
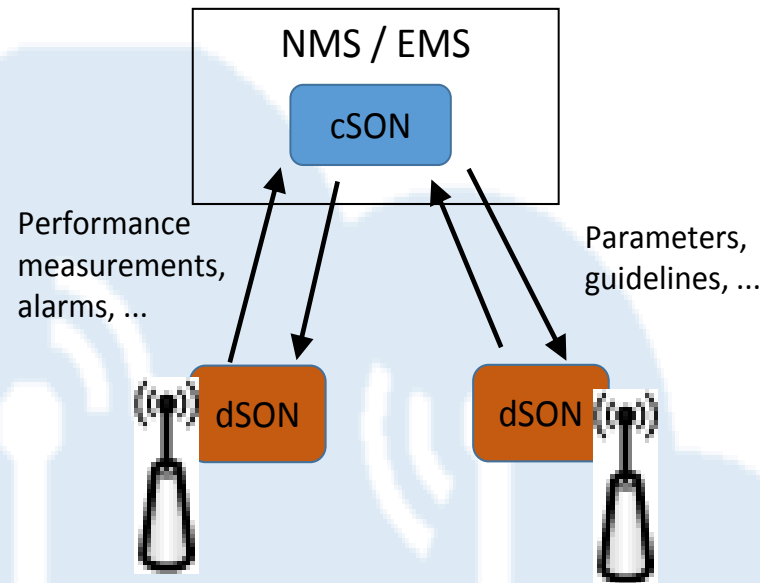
The figure depicts a *simplified view of the SESAME architecture,* *by focusing on the relationship with "Self-x functionalities":*

- *The* *PNF EMS and SC EMS* *include the* *cSON functions* *and the* *centralised components of the hybrid functions*.

- *The* *dSON functions* *-or the decentralised components of the hybrid functions- reside at the* *CESCs.*

Whatever "Self-x" function is considered be deployed in SESAME, it can be implemented as a PNF or it can be implemented as a VNF.

Implementation of "Self-x" properties as VNFs provides certain benefits:

➢ **Inherent flexibility** through *easy instantiation, modification and termination* procedures;

➢ An **inherent efficiency in hardware utilisation**, since *VNFs are executed on a pool of shared NFV* (Network Functions Virtualization) *infrastructure resources*;

➢ An **inherent capability to "add" new functionalities and/or extend/upgrade/evolve existing VNFs.** In SESAME, this can be applied to distributed "Self-x" functions that would run as SC-VNFs in the Light DC.

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Thank you for your attention!
Questions / Answers

Dr. Ioannis P. Chochliouros
Head of Research Programs Section, Fixed
Coordinator of the SESAME Project
Research and Development Dept., Fixed & Mobile
Technology Strategy & Core Network Division, Fixed & Mobile

Philippos Georgantas
Research Programs Section, Fixed

Research and Development Dept., Fixed & Mobile
Hellenic Telecommunications Organization S.A. (OTE)
1, Pelika & Spartis Street
15122 Maroussi-Athens,
Greece

http://www.sesame-h2020-5g-ppp.eu/

Tel.:   +30-210-6114651
Fax: +30-210-6114650
E-Mail: ichochliouros@oteresearch.gr ; ic152369@ote.gr

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