Conflict free coordination of SON functions in a Unified Management Framework

Demonstration of a proof of concept prototyping platform

N. Koutsouris, K. Tsagkaris, P. Demestichas
Dept. of Digital Systems
University of Piraeus
Piraeus, Greece
{nkouts, ktsagk , pdemest}@unipi.gr

Z. Altman, R. Combes
Orange Labs
Issy les Moulineaux, France
zwi.altman@orange.com

P. Peloso, L. Ciavaglia
Alcatel-Lucent Bell Labs
Nozay, France
pierre.peloso@alcatel-lucent.com

L. Mamatas, S. Clayman, A. Galis
Department of Electronic & Electrical Engineering,
University College London,
London, United Kingdom
a.galis@ucl.ac.uk

***Abstract*—This paper proposes the exploitation of a Unified Management Framework for coordinating (i.e. ensuring conflict-free and stable operation), multiple, autonomic control loops. The functionality is demonstrated through the instantiation to Self-Organizing Network (SON) coordination for managing LTE-Advanced Heterogeneous Network (HetNet) with relays.**

***Index Terms*—Unified Management Framework, Network Empowerment Mechanisms, SON, Coordination**

I. Introduction

The continuous growth of the user demand for sophisticated services is more and more often leading to complex wireless and wired network infrastructures, that struggle for delivering services with the required quality. This has motivated operators to adopt the use of autonomic management functions incorporating intelligence intended to tackle the challenges posed. However, although the approach has proven to bring performance and cost-effectiveness, it also lacks functionality to ensure the coordinated and conflict-free interworking of multiple autonomic functions that operate simultaneously in the same or interacting domains, especially the ones affecting the same parameters and/or KPIs.

Univerself [1] is an FP7 European research project that specifies a Unified Management Framework (UMF) in the form of functional blocks and interfaces, that will ensure the trustworthy integration, operation and interworking (conflict avoidance and knowledge sharing) of multiple autonomic control loops within the operator's environment. The core of UMF consists of three main blocks, namely Governance, Coordination and Knowledge, which are cooperating so as to ensure the smooth and efficient operation of autonomic mechanisms, such as the SON functions [2] in the radio access network segment. The UMF allows by means of policies to enforce operator business and operation objectives towards these autonomic functions. These are denoted as Network Empowerment Mechanisms (NEMs) when complying to the UMF specifications. Hence all NEMs are built on a reusable interface called "NEM skin" (see Fig.1) that is handling the communication with the UMF core blocks.

In this paper we demonstrate the usage of UMF and particularly its Coordination function as a whole for showcasing first the identification of possible conflicts and second the conflict-free, stable and converging operation of two SON functions in a LTE-Advanced HetNet with relays.

II. Description of the Demonstration

A SON coordination prototype using the UMF specifications in [5] has been developed in order to prove the merits of the proposed solution. Specifically in this demo, five UMF entities are involved: the three UMF core blocks, as well as two SON NEMs, the LB_NEM and the BRA_NEM (see Fig. 1.).

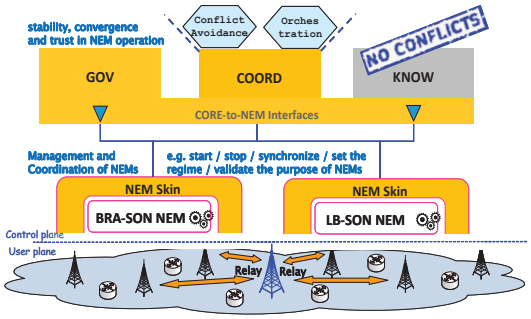

Fig. 1. UMF Deployment

The former NEM incorporates a Load Balancing (LB) SON functionality that adapts the coverage zone of the relay stations by adjusting their pilot powers. The latter includes a Backhaul Resource Allocation (BRA) SON functionality that adapts the portion of time allocated to a backhaul link in order to balance the relay load with its backhaul link load. In the use-case considered here, the two SONs, LB-SON and BRA-SON, operate at different time scales. The time scale of LB-

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SON is fixed according to operational constraints (i.e. avoiding too frequent handovers). BRA-SON uses bigger time-steps to guarantee convergence of the hierarchical system, and is seen as quasi static by the LB-SON [3] [4].

As stated, the implementation of the prototype has followed the UMF specifications [5] and it is mainly developed in Java. Nevertheless the implementation of the two SON functionalities was done in Matlab. The operator is constantly being informed about the NEMs that have registered with the system, their status and the status of the underlying infrastructure that they manage, through a powerfull Human to Network (H2N) graphical user interface (GUI), a screenshot of which is depicted in Fig. 2. This H2N tool includes functionalities that are able to visualize the problems that appear and the actions taken by the various UMF entities, as well as to guide the system's administrator when a human decision is necessary to be made.

The setup of the system is done on two machines, one for the UMF core and another one for the Matlab environment and the two SON NEMs. Both machines are connected to the same local area network. After the UMF system is initialized, the LB_NEM and the BRA_NEM are executed. During start-up, each NEM sends to the UMF core all the necessary information about its role, capabilities and settings, in a phased denoted as registration. Once registered, the conflict identification process (a function of Coordination) will take place in order to first determine whether the NEMs are conflicting (and if so, provide a conflict description), and second to choose and parameterize a conflict avoidance strategy avoiding the pre-identified conflicts. Then the Governance and the Coordination core blocks can send one or more control policies containing selected values that will ensure the desired behaviour, while all the procedures are supported by the Knowledge block.

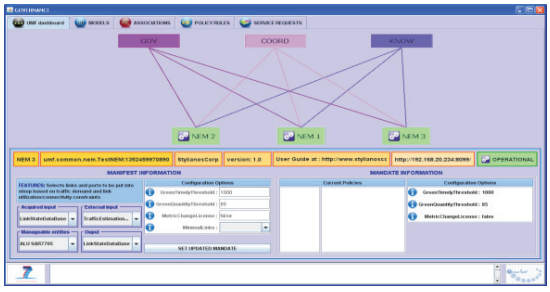

Fig. 2. Screenshot of the UMF H2N GUI

The interaction between the UMF core and the UMF NEMs is based on a RESTful API, namely several simple web services that have been implemented using the HTTP protocol and the principles of REST [6]. Therfore, every UMF entity incorporates a light web server called SIMPLE and a suitable client based on RESTY. This choice for implementation was done in order to facilitate the communication of all kinds of devices and equipment with the UMF system, even if this was not taken into account during their design.

The underlying wireless infrastructure of the LTE-Advanced HetNet comprises 4 base stations and 1 relay station. Through the demonstrator GUI the functionality related to NEMs coordination can be artificially halted. Thus it showcases the necessity of coordination and allows the assessment of coordination in a qualitative way. Fig. 3. shows that without the SON functionalities the eNB is highly congested (dashed red line line in the upper part of the image) while the backhaul has low load (continuous blue line in the lower part of the image). When the two SON functionalties are activated (see Fig. 3. in the middle), the worst direct and backhaul links are balanced and the maximum link usage is reduced to slightly below 60 percent. As a result, saturation of the macrocell is delayed, giving room to more traffic in the cell. The coordinated SONs successfully balance all the system loads by adapting both backhaul resources and relays' coverage, which on the average are increased.

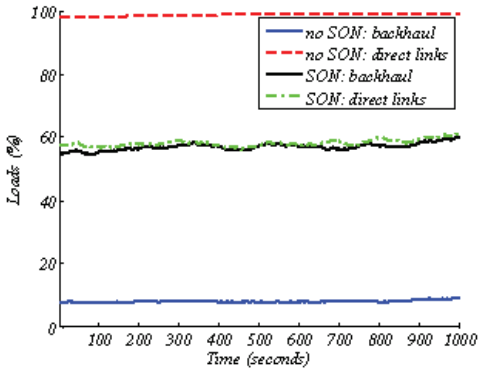

Fig. 3. Link usage for the worst direct (station to mobile) and backhaul links with (two middle curves) and without (top and bottom curves) SON.

III. Conclusions

This paper briefly presents the Unified Management Framework introduced by the FP7 EU project Univerself. It proposes the demonstration of two SON functionalities' coordination in order to ensure a conflict-free and stable operation, while minimizing the possibility of human errors.

Acknowledgment

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