Deliverable D4.11

Leaflet of the third prototype of a use-case

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SEVENTH FRAMEWORK PROGRAMME

FUTURE NETWORKS

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Foreword

Deliverable D4.11 accompanies deliverable D4.10 'Third Prototype of a Use-Case'. The role of D4.11 is to provide complementary material for UniverSelf Prototype 3 entitled "Conflict free coordination of SON functions in UMF", in terms of its context and implementation aspects, key results and findings. To this end, a leaflet document has been prepared and is incorporated in this document. D4.11 forms a key point in UniverSelf experimentation strategy proving the deployability, applicability and gain of the project solutions (UMF architectural components, NEMs, WP3 algorithms) in a real proof-of-concept prototype.

Proof of Concept

Conflict free coordination of SON functions in UMF

Abstract

This document describes UniverSelf Prototype 3 entitled ”Conflict free coordination of SON functions in UMF”, in terms of its context and implementation aspects, key results and findings. UniverSelf Prototype 3 is a subset of use case 4 entitled SON and SON collaboration according to operator policies. This prototype aims to demonstrate a twofold innovation based first on the automatic detection of conflicts while deploying SON functions and second on powerful coordination mechanisms allowing each of the SONs to seamlessly reach its objective, hence together and maximizing the overall network performances.

Date of release

31/03/2013

CONTENT

ABOUT UNIVERSELF

Four challenging objectives

UniverSelf is an FP7 IP project that addresses autonomic networks and the interoperability of their parts in a holistic manner, i.e. including both wireline and wireless parts of the network. This project is vital because the operational complexity in an operator's network is growing, because the cost structure of the current management model is not sustainable, and because the already existing management architecture is no longer adapted. Correspondingly, the four main objectives of UniverSelf are:

- Design a Unified Management Framework for the different existing and emerging architectures, that is cross-technology (i.e. wireless and wireline) and will serve as a common platform for both systems and services.
- Design the functions that will enable self-managing networks and embed these functions directly within the systems and elements that comprise the network infrastructure and support service delivery.
- Demonstrating the potential for deployment of autonomic solutions in carrier grade networks with an eye towards stimulating further research in Europe towards application and commercialization.
- Generate confidence in the viability and use of autonomic technologies in telecommunication networks by defining "certification" parameters for autonomic networking products.

These core objectives will be evaluated against three main, tangible targets.

- Target n°1: Reduction of the Operational Expense (OpEx)

  The target is to reduce by 30% the OpEx associated to the scenarios and use-cases which will be covered and studied during the life time of the UniverSelf project.
- Target n°2: Standardization of the Unified Management Framework (UMF)

  The target is to achieve the specifications of UMF components in Standard Development Organizations (SDO) to guarantee reference and interoperable autonomic systems.
- Target n°3: Industrial adoption ratio

  The target is to measure, based on a set of different quantifiable criteria, how much UniverSelf helped or contributed to the adoption of autonomic networking paradigms by the industry. The objective is also to quantify the project achievements to bring the autonomic networking topic from a research thematic to an industrial issue.

A pragmatic methodology

UniverSelf approaches the holistic network and service management challenges with three technical work packages:

- Unified Management Framework (WP2) that addresses the question how multiple management functionalities can successfully work together. The ultimate goal is a specification that provides a standard for the interfaces between a management functionality with the overall framework.
- Network Empowerment (WP3) with the goal to find appropriate algorithms and methods for the management problems.
- Deployment and Impact (WP4) that provides and assesses problems in a use-case style and approaches both the business impact and the question of trust and a corresponding certification process.

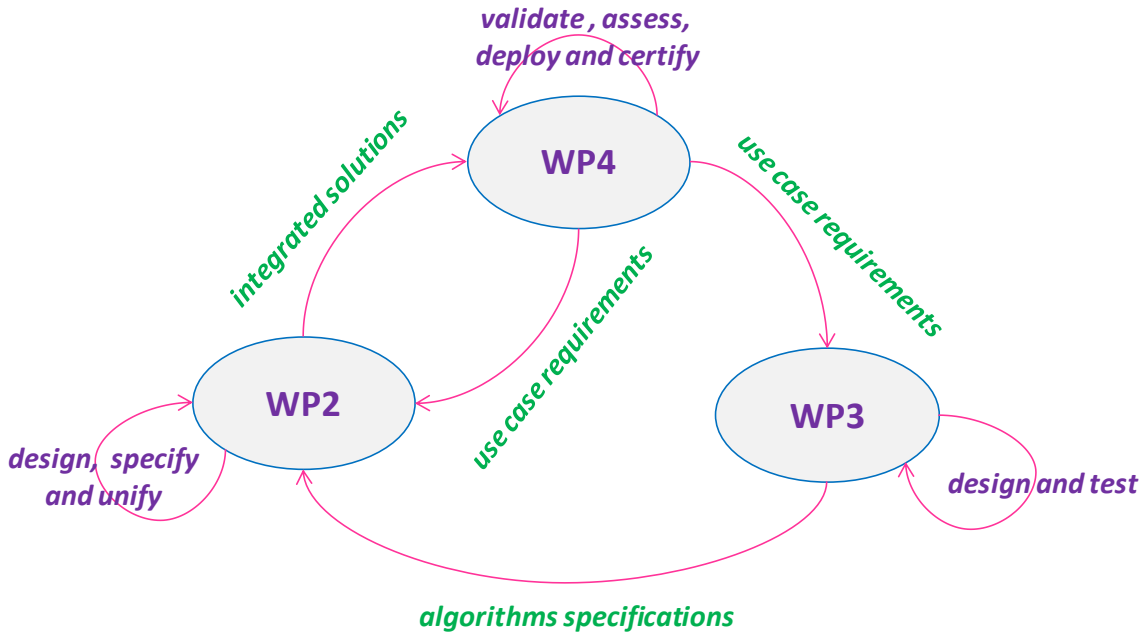


Figure 1 : High level view of UniverSelf methodology

Industry-focused and representative use cases

The following use cases are addressed in UniverSelf:

- Self-diagnosis and self-healing for IMS VoIP and VPN services
- Network stability and performance
- Dynamic virtualization and migration of contents and servers
- SON and SON collaboration according to operator policies
- Operator-governed end-to-end autonomic joint network and service management
- Network and services governance

In this document we focus on the fourth use case, i.e. “SON and SON collaboration according to operator policies”. This use case in principle bears the problem of the unsupervised operation of numerous Self Organizing Network (SON) functions in a radio access network, something that can lead to chaos, creating severe instabilities and drops in performance. Through the third prototype it is demonstrated a generic solution to automatically create coordination in-between independent SON functions. More specifically, two main aspects are shown, first the automatic detection of conflicts and second some coordination schemes tuned to the running SONs.

An impactful experimentation strategy

UniverSelf aims at demonstrating the feasibility and efficiency of the project solutions, mechanisms and algorithms in a proof-of-concept environment comprising simulation modules and prototyping activities, together with testing and assessment capabilities. The experiments will be driven, prioritized and refined by the project use cases and scenarios. UniverSelf will approach the refinement, assessment and validation of theoretical work through a framework for proof of concept, validation, simulation, experimentation and demonstration. This is our experimentation strategy and the corresponding timeline is highlighted in **Figure 2**.

The validation part of this activity will also address feasibility aspects, as well as assessment of key performance or stability, scalability etc. indicators and will work especially on the integration of the solutions in and via the Unified Management Framework (UMF).

Experimentation can be seen as a concrete methodology for the production of validation results close to real life scenarios. Experimentation and validation activities will focus on the collection and analysis of metrics related to the achieved performance and optimization benefits, QoS in service provisioning, the end-to-end

coherence of management actions, the system's stability and responsiveness, the realized compliance to the imposed policies and profiles, the CAPEX and OPEX gains etc… The main capabilities targeted for the federated framework for the experimental facilities, will be the computation resources, the incorporation of heterogeneous wired and wireless systems and network management operations (emphasis on the autonomic aspects). Moreover, issues related to the business sustainability and user acceptance and trust in autonomic solutions can be addressed.

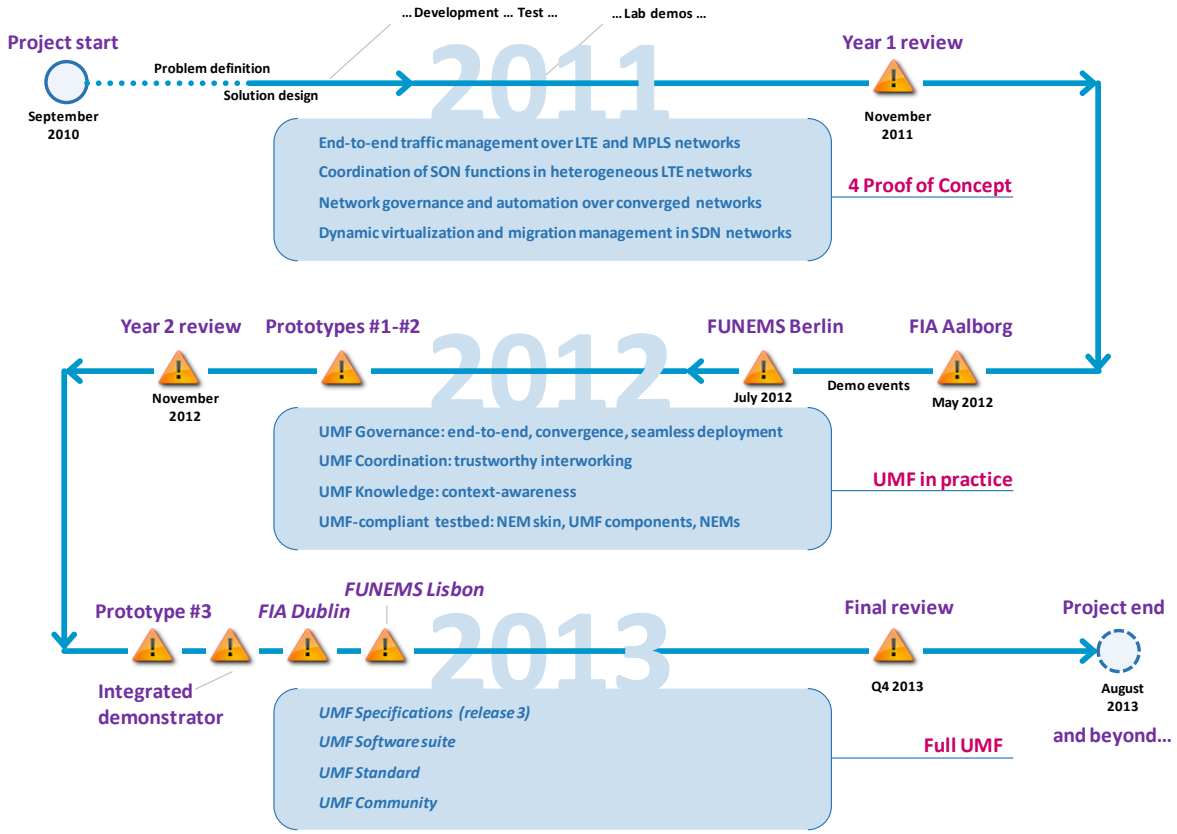


Figure 2 : UniverSelf experimentation timeline

In the context of the project, the criteria used for qualifying an experimentation as a "UNIVERSELF Prototype" are:

- Must be a prototype, not a simulation.
- Must solve a precise, problem (UC reference problems).
- Must contain one or more NEMs, which means a method solving a problem in a given specific technology/context.
- Must have a precise scenario (workflow/scripts).
- Must comply with the UMF specifications: details of certification should be considered.
- Must be evaluated/benchmarked (performance, functionality, UMF compliancy...)

An integrated portfolio

The aim of the project portfolio is to provide a comprehensive and consistent view about the solutions and technologies developed within the UniverSelf project, their constituting elements, their relationships and respective development levels. The portfolio presents an overall and integrated view about the solutions –i.e., the UniverSelf answer. The project portfolio is a tool useful to show the industry impact, feasibility, and relevance. The portfolio is currently structured around three dimensions: the capability levels (of a NEM or core mechanism), the development lifecycle, and the application domain(s).

Please note that the portfolio is currently still under construction at the time of edition of this leaflet.

The UniverSelf project produces two principal pieces of solutions tightly related: the Unified Management Framework (UMF) and the Network Empowerment Mechanisms (NEM). These elements constitute the base of the project portfolio. The various combinations (or packaging) of these elements (UMF core functions and mechanisms, NEMs) constitute the project integrated solutions. As example, UMF core functions, mechanisms and specific NEMs are combined together to provide an integrated solution to the use case 1 on self-diagnosis and self-healing for VoIP and VPN services. Similar examples exist for the other project use cases, and infinity of variations can be imagined to address the different problems and use cases.

By definition, the UniverSelf portfolio is limited to the project scope (set of use cases defined and technologies covered), however the approach taken in the project is to provide a unified and extensible technology that can adapt to other use cases (out of the initial scope of the project) and to other technologies with zero or minimal modification to the UMF and its specifications. The solutions developed are modular, composable, extensible, interoperable, and can interwork with legacy systems. The IT/telco environments where they can be deployed have been evaluated, tested, and benchmarked, Examples of interworking and deployment (options) are also described as part of the project portfolio documentation together with other elements (or views) related to the different solutions such are the applicable business reference use case(s), problems...

The UMF and the NEM concepts can be briefly described as follows:

A NEM achieves a self-management function (a closed control loop), with a specific purpose:

- an operational problem to be solved,
- a performance objective to be achieved,
- a network segment or service infrastructure to be targeted.

A NEM is therefore a kind of atomic component for autonomic network management. The parallel can be made with the usual design approach of using the relevant method to solve a concrete operational problem in a specific networking environment. Thus a NEM is defined by the combination of a method, an objective, and a context, such as for example, the use of Bayesian inference for fault diagnosis in FTTH environments, or the use of genetic algorithm for interference coordination in LTE networks.

Then, when a NEM is deployed or in use within an operator infrastructure, it has to deal with a set of actors: its environment: the operator, the network/service equipments, the legacy management systems and also the other NEMs. So, if we target a seamless deployment and trustworthy interworking of a large number of NEMs, we need more than just NEMs. Specifically, we need:

- Tools to deploy, drive and track progress of NEMs which highlight the need for Governance/Human-to-Network tools.
- Tools to avoid conflicts ensure stability and performance when several NEMs are concurrently working which highlight the need for Coordination/Orchestration mechanisms.
- Tools to make NEMs find, formulate and share relevant information to enable or improve their functioning which highlight the need for Knowledge management.
- Tools to Allow NEMs getting monitoring data and enforcing configuration actions at equipment level which highlight the need for specific adaptors.

Three challenging research topics are outlined above: Governance, Coordination and Knowledge management, which constitutes the core of the UMF.

PROOF OF CONCEPT

This section describes UniverSelf Prototype 3, in terms of its context and implementation aspects. UniverSelf Prototype 3 is a subset of Use Case UC4 SON and SON collaboration according to operator policies [1, 2]. The Use Case aims at demonstrating a generic solution that enables the automatic coordination between independent SON functions operating in a modern radio environment.

SONs pursuing individual goals can lead the network to crash down

SOLUTION DEMONSTRATED BY UC4:

Automatic conflicts discovery solution during SON deployment

Efficient coordination schemes in-between running SONs

Context

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 improve performance and bring 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.

UMF, through its core blocks, NEMs and interfaces, can ensure the trustworthy integration, operation and interworking (conflict avoidance and knowledge sharing) of multiple autonomic control loops within the operator's environment. By means of policies it allows to enforce operator business and operation objectives by means of these autonomic functions. UniverSelf prototype 3 has been developed following the UMF specifications in [4] in order to prove the merits of the proposed solution. Specifically in this demonstration, a LTE-Advanced heterogeneous network with in-band relay stations (using the same resources as the eNodeB) is considered. Five UMF entities are involved: the three UMF core blocks, as well as two SON NEMs, the LB_NEM and the BRA_NEM, as depicted in **Figure 3**. 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-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 [5][6]. The target is to coordinate the two SON functionalities in order to ensure a conflict-free and stable operation, while minimizing the possibility of human errors.

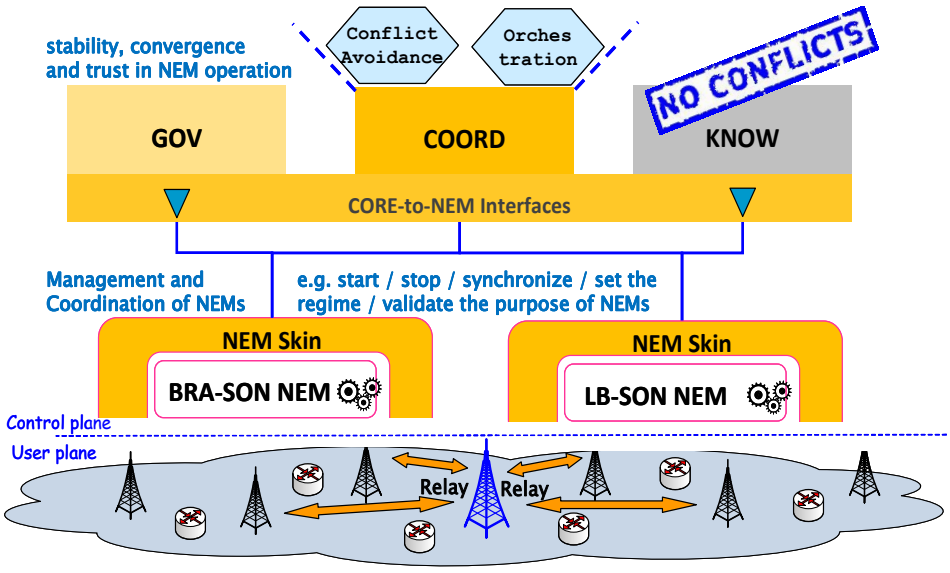


Figure 3: UMF deployment in UniverSelf prototype 3

A running implementation

As stated, the implementation of the prototype has followed the UMF specifications [4] 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 powerful Human to Network (H2N) graphical user interface (GUI), a screenshot of which is depicted in **Figure 4**. 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.

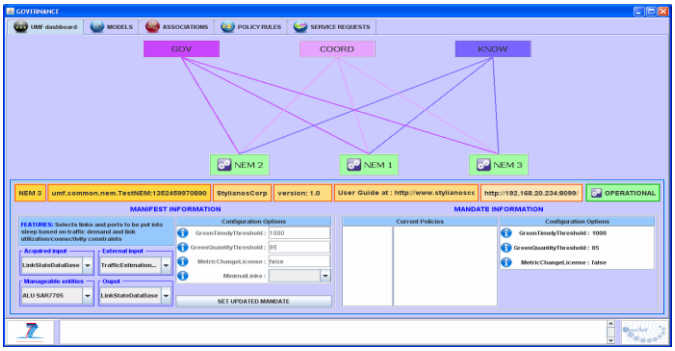


Figure 4: Screenshot of the UMF H2N GUI

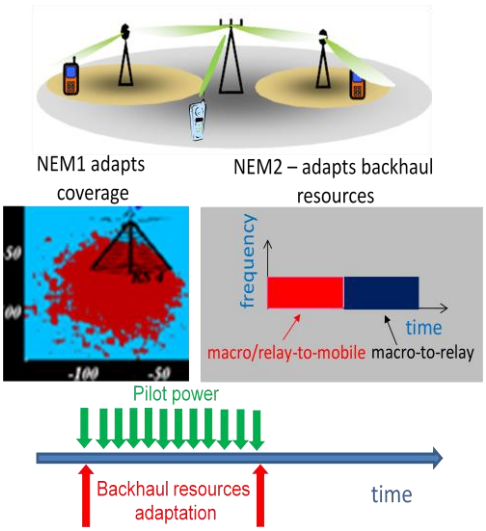
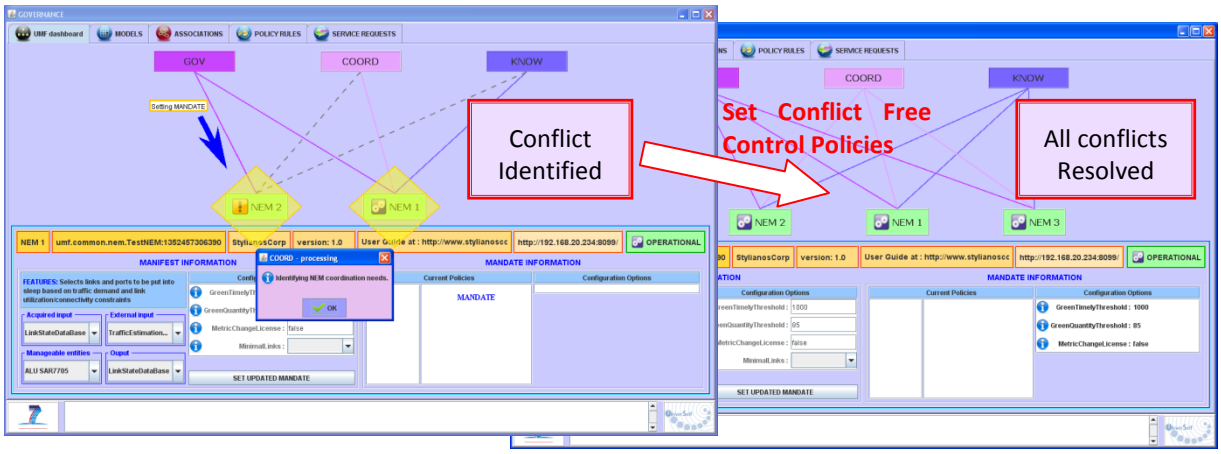


Figure 5: LTE-Advanced network with two NEMs

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. The underlying wireless infrastructure of the LTE-Advanced HetNet comprises 4 base stations and 1 relay station. 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.

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 [7]. Therefore, 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.



KEY RESULTS AND FINDINGS

Through the demonstrator GUI the functionality related to NEMs coordination can be artificially halted. In this way it is possible to showcase the necessity of coordination and moreover it enables the assessment of coordination in a qualitative way. In the following the downlink is considered with elastic traffic. Users arrive randomly according to a Poisson process of intensity λ, and receive a file size of 10 Mbytes. Upon download completion, they leave the network. **Figure 6** shows that without the SON functionalities the eNB is highly congested (green line in the upper part of the image) while the backhaul has low load (blue line in the lower part of the image). When the two SON functionalities are activated, as can be seen in **Figure 7**, 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 macro cell 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.

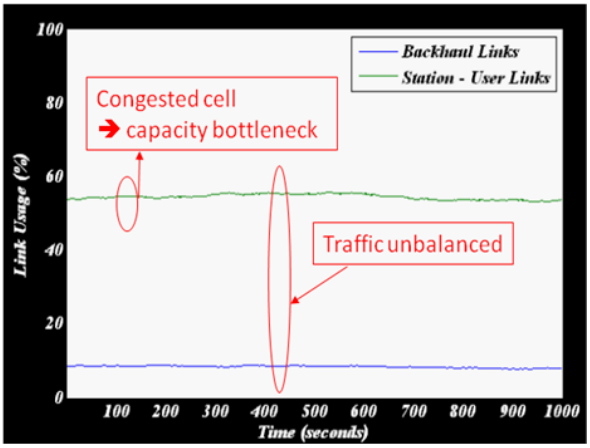


Figure 6: Without coordination

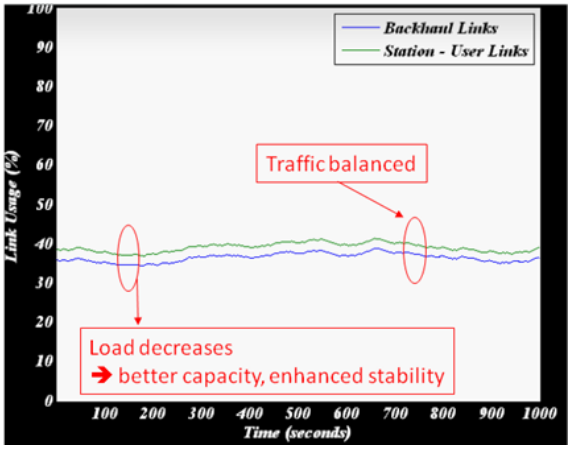


Figure 7: With coordination

Cell load impacts directly performance and QoS indicators (e.g. outage, blocked call rate, throughputs, file transfer time), and the load reduction seen in Figure 7 results in strong improvement in these indicators. As an example, Figure 7 shows the impact of the two coordinated SON functionalities on cell edge throughput [8]. Cell edge users are defined as those users with the 10 percent lower throughputs in the cell, and their average throughputs are depicted for the case with (dashed line) and without (continuous line) coordinated SONs. Triggering the coordinated SON considerably increases the average cell edge throughput from close to 0.5 Mbps to slightly above 2.1 Mbps.

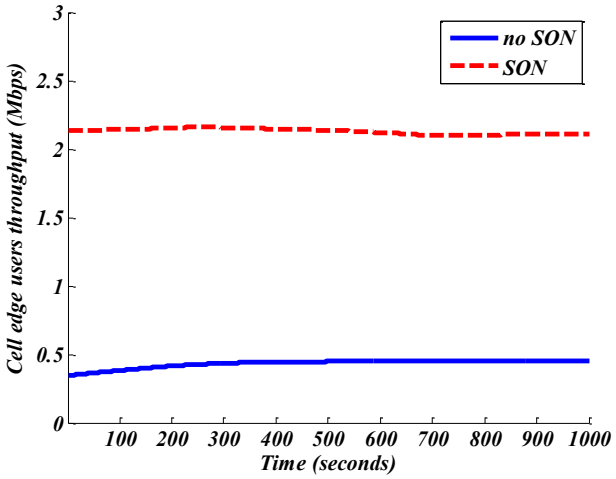


Figure 7: Impact of coordinated SONs on cell edge throughput

In summary, the key achievements that the UniverSelf prototype 3 implementation gets are the opportunity to validate the UMF in practice and the possibility to assess the behaviour and the impact of the various autonomic functionalities that are offered by the management system. Moreover, the proof that the UMF entities can interact and cooperate in a smooth way is also an important aspect to take away.

Thus, in general, the UMF COORDINATION solution

- **ensures desired and stable operation according to operator goals**
- **enables trustworthy operation**
- **facilitates large scale deployment of NEMs and reduces OPEX**

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