Proof of Concept

Governance and coordination of autonomic LTE wireless access and MPLS core network segments

Abstract

This leaflet presents the first prototype of a use case based on UMF release 2, which aims at proving the concepts introduced by UMF. The scenario centers on a network operator that wants to serve an additional traffic load in the managed network infrastructure. The operator uses the provided Human2Network graphical user interface to describe in a high level manner the characteristics of this load, as well as any other related business policies. Then a corresponding service request is issued and the system is acting autonomously in order to fulfil the entailed requirements, by making all the necessary configurations.

Date of release

17/10/2012

SEVENTH FRAMEWORK PROGRAMME

FUTURE NETWORKS

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.

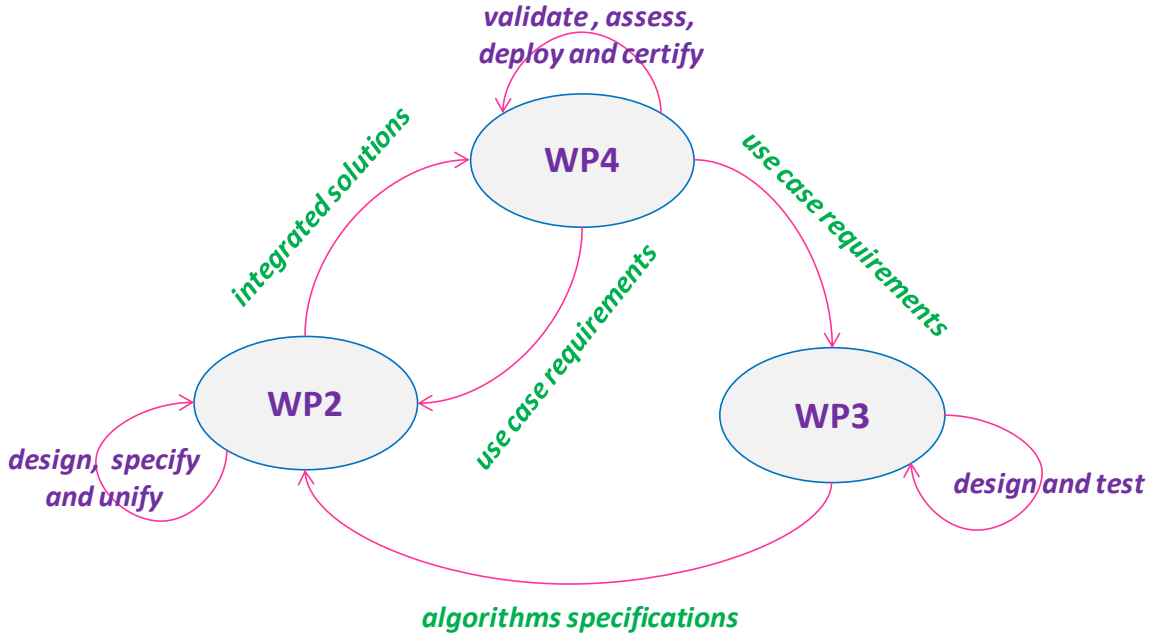


Figure 1 : High level view of UniverSelf methodology

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 fifth use case, i.e. “operator-governed end-to-end autonomic joint network and service management”. This use case in principle bears several problems, namely the enablement of operators to describe their goals and objectives in high-level terms (human to network interface), the analysis of business requests, the determination of candidate solutions, the invocation of the selected radio access networks and the request for an offer in terms of the quality which said network can provide, likewise the invocation of backhaul/core segments, and finally the resolution of possible incompatibilities between the offered QoS of radio access networks and backhaul/core segments, respectively. In this document we will focus on UC 7 Network and services governance.

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.

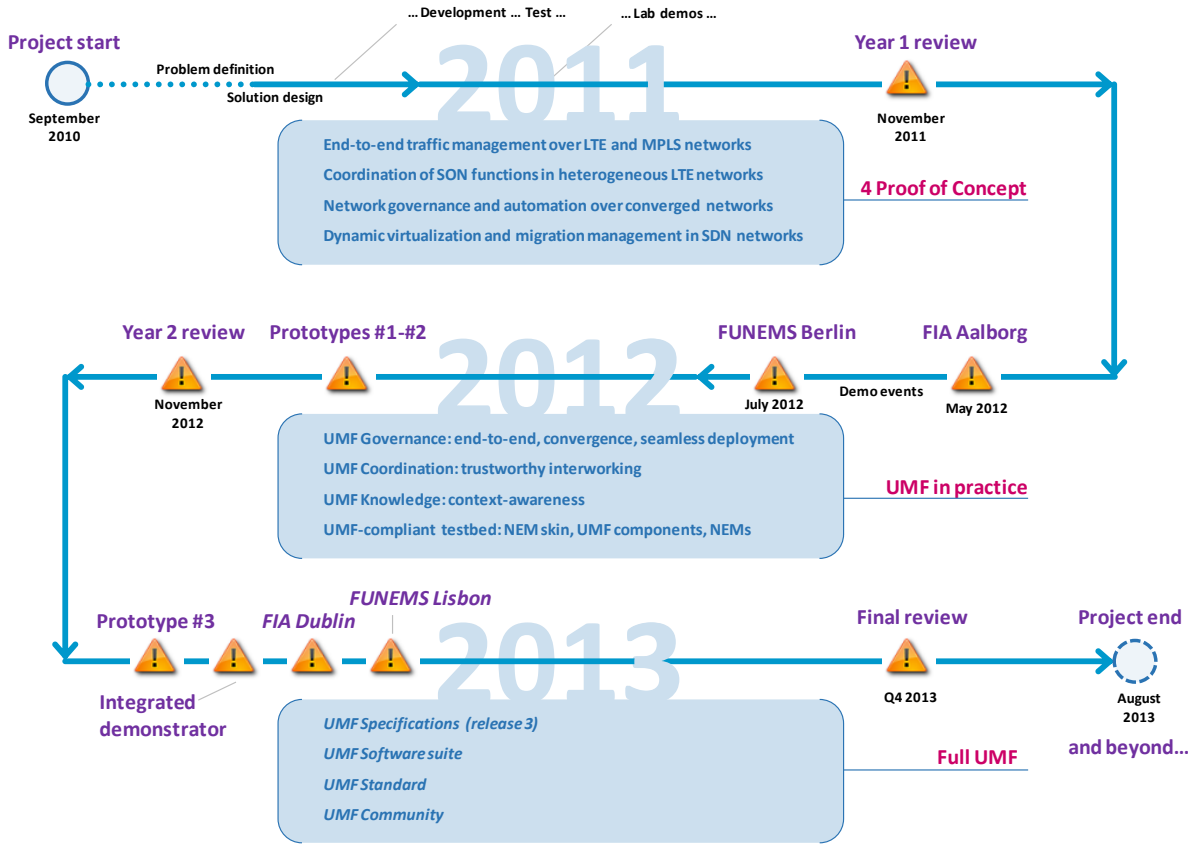


Figure 2 : UniverSelf experimentation timeline

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

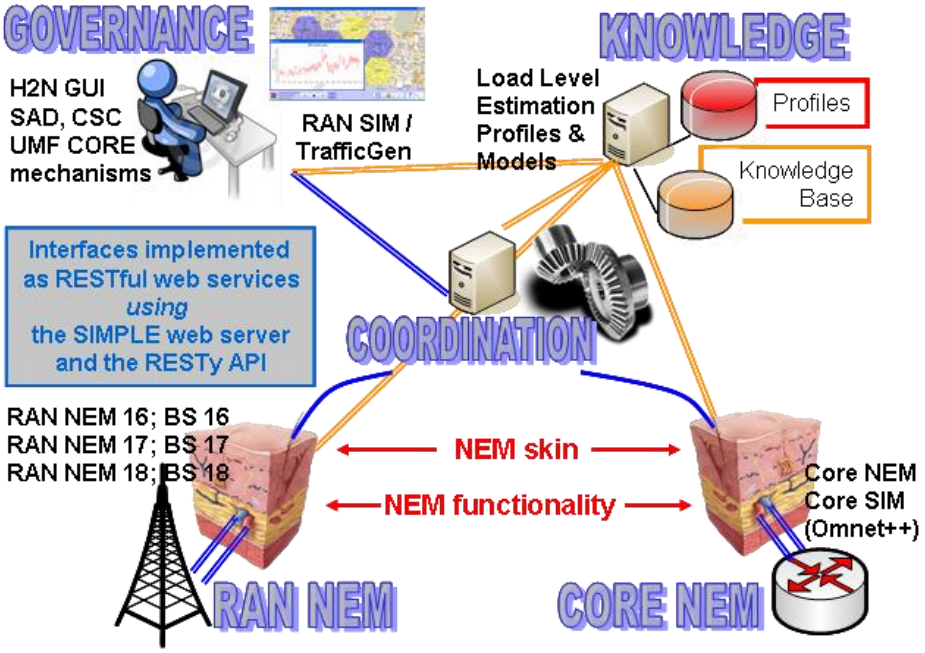
The problem and the solution

Today's telecommunication operators worldwide need to confront changes in both their business and operational environment. One of their main concerns is how to assure that a customer request for services and pertinent Quality of Service (QoS) will be satisfied in a fast, reliable and cost-efficient manner. The best solution can be provided by modernizing the supporting operations and management processes, so as to evolve from the cumbersome command and control mode to the so called "governance" mode. Governance aims at minimizing human intervention in the processes, at integrating and unifying disparate domains and technologies in the end-to-end service delivery path and at providing automated operations and decisions that are always aware of the dynamic context changes. Governance is materialized through a policy based framework [1] that provides the operator the means to set business level (technology agnostic) goals and objectives reflecting the highest level of a policies' hierarchy [2] and let them being automatically propagated to the network going through an arbitrary set of levels, where they are being transformed into lower level policies, until they finally reach the self-x capable element(s) in which they can be enforced in terms of lowest level, technology-specific commands.

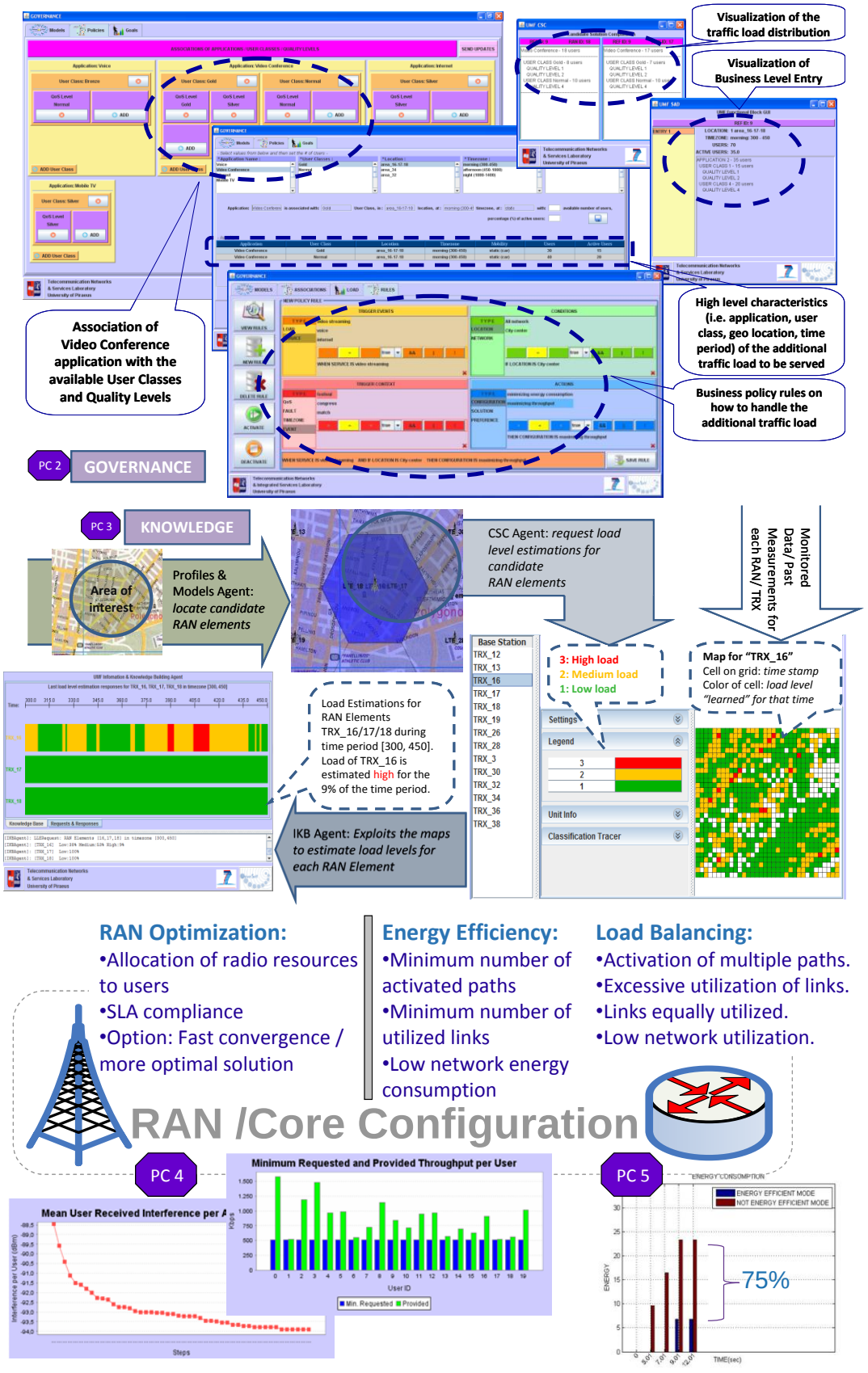
In Use Case 6 (“Operator-governed end-to-end autonomic joint network and service management”) it is assumed that a Mobile Network Operator (MNO) receives an urgent request for accommodating an additional traffic load, concerning a real time, video-based application (e.g. video-streaming of a programmed event), an associated set of user classes for the application, and a set of QoS levels for each user class of that application. In addition, the request can designate a specific location e.g. a conference centre of Piraeus region and a specific time period e.g. evening from 16:00 to 18:00, where the application will be delivered to an also (roughly) given number of conference attendants. The target is to ensure that the customer order will be satisfied in a fast, reliable and cost-efficient manner, by exploiting at the same time the technology advancement offered by network autonomicity at the maximum levels.

A running implementation

A prototype system has been implemented in order to prove the UMF concepts through the Use Case 6 scenario. All the necessary UMF Core mechanisms and several UMF NEMs have been developed and installed in a number of laptops connected through a LAN.



The specific UMF core mechanisms and NEMs that are involved are presented below, along with their functionality according to the Use Case 6 scenario.



KEY RESULTS AND FINDINGS

Use Case 6 implementation has proven that a very efficient management system can be built by following the UMF specifications. The concept of designing and deploying governance mechanisms provides the operators with the means to express their goals and govern (control) their possibly self-x capable network through a robust policy based framework. At the same time many other significant aims are achieved, like the end-to-end integration or the federation of wireless/wired access and core/backhaul network segments and their associated management systems, and all these under the "auspices" of operator policies. And one more worthy result, is the demonstration of a way to maintain and exploit always-up-to date inventories and knowledge (possibly derived through incorporated learning mechanisms) in all the aforementioned situations, thus increasing the reliability and adaptability of management decisions, and contributing to autonomicity.

More specifically, as regards to the knowledge mechanism, it addresses the problem of predicting long-term network traffic load for different areas or time-periods. The motivation behind is the ability to improve allocation, management and utilization of the available resources based on such knowledge, since the network traffic usually follows certain hourly-, daily-, and even weekly- patterns. These patterns derive from different characteristics of user behaviour and network usage habits, which in turn may vary from one area to another. For the online building of such knowledge, a machine learning algorithm has been employed, namely a variant of the Self-Organizing Map (SOM) [3] known as Parameter-less Growing SOM [4]. The Load Level Estimation (LLE) NEM is constantly provided with measurements of network load, accompanied by parameters indicating the time and the location of the observation. The mechanism is then discovering the correlations, if any, between the time, the location and the load, in a way similar to how a human would observe, for instance, that "in the business area X, network usage is increased during morning and midday while in the residential area Y network usage is usually increased during afternoons, excluding Saturdays."

As far as it concerns the core segment of the infrastructure, this prototype showcases a solution to the problem of routing optimization with respect to different operator's policies. The solution is based on a heuristic algorithm that evaluates network's status and finds the optimal routing configuration, exploiting the capability of splitting traffic and forwarding it through different multiple MPLS paths, when this is needed. The main objectives that have been examined are i) load balancing and ii) energy efficiency. Load balancing is achieved through splitting traffic, while energy efficiency is achieved through the aggregation of traffic into minimum number of links and the successive deactivation of unused network elements. All these are accomplished through the ability of the Core NEM to monitor the network and to interact with other NEMs, as well as with the Coordination, the Knowledge and the Governance UMF entities.

The development of this use case prototype was based on several common software modules that were used by all of the involved UMF entities. The most fundamental of them is the RESTful web service module that offers to an entity the capability to expose its functionality publicly and to interact with other entities through a RESTful API. The automatic registration with the corresponding NEM registry has allowed the free selection of the host to execute a NEM and the ability to seamlessly restart it. In the next release of the prototyping environment, a common NEM skin will be used for the implementation of all the NEMs, homogenising in an even bigger extent their interaction with governance, coordination, knowledge and the UMF entities in general.

Use Case 6 prototype provides evidence that the time for the deployment of new services can be improved, as well as the time required in order to make changes in the network configuration. It also suggests that the cost of operating the network will be decreased, through the efficient and automatic configuration of the infrastructure, avoiding on site transportation expenses, human errors, etc. In general, it offers the means to validate that the operators' requirements are satisfied and that the corresponding expectations from the UMF are met.

In summary, the key achievements that the Use Case 6 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. Further use case scenarios will be executed as long as the management functionalities will be refined and elaborated. And the prototype implementation will evolve in parallel with UMF specifications, till they reach a profoundly mature and complete level.

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