PhD proposal:
Coordination and policy-based management of Self-Organizing Network (SON) functionalities in next generation radio access networks

Context

Future wireless ecosystem will consist of numerous coexisting Radio Access Technologies (RATs), each one of which having different layers (macro, micro, pico, femto), for the purpose of providing efficient and ubiquitous broadband wireless access to a wide variety of spectrum-hungry advanced multimedia applications. Besides, the requirement of introducing more spectrum-efficient technologies renders the networks more and more complex, and therefore, more difficult to monitor, control, configure and manage. In this challenging context, competing wireless operators are faced with the complicated task of running their networks while introducing new services and achieving goals in terms of customer satisfaction, benefit, market share, innovation, reputation etc.

In order to manage this complex structure of goals, the wireless operator has a different group of objectives at each level of its pyramidal business organization. At the very top level, the manager aims at accomplishing the high-level objectives. These can be short-term (e.g. maximizing the revenues, minimizing CAPEX/OPEX etc.), medium-term (e.g. decreasing the number of churns or "outgoing subscribers", building a new infrastructure etc.) and long-term (e.g. enhancing its reliability, keeping its reputation as the "most innovative wireless operator" etc.) objectives [1]. On the other hand, the radio engineer and the technician of the operational/research team targets at optimizing certain Key Performance Indicators (KPIs) such as call drop, call blocking, handover failure, coverage, capacity (typically throughput), delay etc. These metrics can be of different temporal scales, layers, contexts and domains. Currently, "the policy", i.e. the path that links these two levels (and these two sets of objectives) is long, slow and constructed on an ad-hoc basis. This is a shortcoming of the existing business operation. A dynamic response in terms of operator policies to changing operating conditions (market, technology etc.) in terms of low-level actions would facilitate the achievement of the high-level goals without compromising on the network quality [2]. This must be possible for the operator, not a burden, and should be carried out autonomously, with no or minimum human intervention.

Minimization of human intervention in wireless network management is realized by a novel concept called as Self Organizing Networks (SONs) [3]. SONs are considered today as a driving technology that aims at improving spectral efficiency thanks to RRM optimization, simplifying management, and reducing the operational costs of next generation RANs. SON refers to a family of functionalities used in operating a network in a highly autonomous manner, encompassing self-configuration, self-optimization and self-healing [4]. Several SON functionalities will coexist in the network and act on several parameters algorithms. These actions are not necessarily independent and may be conflicting sometimes. Indeed, these autonomic functionalities should act in a coordinated manner to fulfil a common objective defined by the operator policy.

In this context, there is a clear need on a new goal-driven management framework which will allow the operators to interact with the system at a high-level, setting policies and high-level objectives, rather than directly modifying the low-level SON parameter settings. This new goal-driven management framework provides a (vertical) *policy transformation* mechanism which translates those high-level goals/objectives into low-level network settings and operations using *coordinated* SON functionalities that enforce the high-level goals into low-level network operations. The coordination of SON functionalities will essentially involve detection and resolution of the conflicting SON operations to prevent undesired radio network behaviour.

[1] Aib I., Boutaba R., "Business-driven optimization of policy-based management solutions", Proc. 10th IFIP/IEEE Int. Symposium on Integrated Network Management, pp.254-263, 2007.
[2] Bandara A.K., Lupu E.C., Moffet J., Russo A.,"A goal-based approcah to policy refinement", *Proc. 5th IEEE Workshop on Policies for Distributed Systems and Networks*, NY, USA, June 2004.
[3] 3GPP TR 36.902 "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Self-configuring and self-optimizing network (SON) use cases and solutions.
[4] "NGMN Recommendation on SON and O&M Requirements", A requirement Specification by the MGMN Alliance, Dec. 2008.

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Thesis objectives and expected results

The main objectives of the PhD activity can be summarized as follows:

- ✓ identify high-level operator objectives on radio network performance. These objectives have impact on the higher-levels of the abovementioned pyramidal business organization such as revenues, benefits, CAPEX/OPEX, churns etc.
- ✓ identify requirements on the behaviour and performance of the SON system. These requirements will be non-functional like stability, scalability, robustness, resilience, observability, controllability etc., as well as functional/operational which define precise boundaries/limits/thresholds on the related KPIs.
- ✓ develop concepts, methods and algorithms for the transformation of the abovementioned high-level operator objectives and the requirements into dedicated execution policies and rules for individual SON functions and the operational SON coordination (top-down approach). This vertical translation mechanism will be based on a so called “abstraction and mapping layer” which will carry all the logic that will allow the gradual transformation of the high-level policies into the appropriate low-level actions to be taken by the available SON mechanisms. Obviously, the implementation of the autonomic policy management will require architecture evolutions in the management and control planes, including new interfaces and protocols in and in- between both planes, keeping in mind that these changes have an impact on future standards, like 3GPP LTE-A.
- ✓ develop concepts, methods and algorithms for an operational SON coordination that detects and resolves instabilities, conflicts and undesired behavior of the network caused by the SON system according to the policies and rules received from the abovementioned policy transformation. The SON coordination actions perform changes in the operation of SON functions by means of changes to the operational settings (e.g., suspend the execution, modify the temporal granularity, step-size, max/min parameter values) of the SON functions associated with the conflict and instabilities.

Required skills and techniques

- ✓ Knowledge on radio access networks (3G, LTE, LTE-A, HetNets), particularly on radio network optimization, radio resource management, OAM aspects, architectural aspects (this knowledge also involves a standardization component, namely 3GPP).
- ✓ Control theory basics (stability, observability, controllability, convergence)
- ✓ Optimization and learning basics (learning techniques, multi-armed bandits, neural networks, statistical optimization)
- ✓ Basic knowledge on probability and stochastic processes (Bayes theory, probabilistic inference)

Global planning of the thesis timeline

The research approach to be followed in the thesis comprises three main phases:

- ✓ Literature survey: A survey of the existing solutions, work, ideas and propositions concerning SON coordination and policy-based management framework.
- ✓ Requirements phase: Specification of use cases, reference scenarios and main modeling assumptions for the development of a policy-based-management of coordinated SONs in heterogeneous radio access networks.
- ✓ Development phase: Development and validation of solutions for the use cases specified in the requirements phase.
- ✓ Dissemination phase: Dissemination of the developed solutions in the form of academic publications, internal/ external presentations and possible input to 3GPP standardization.

External collaborations

SEMAFOUR (Self-Management for Unified Heterogeneous Radio Access Networks)
Small or medium-scale focused research project (STREP) proposition for ICT Call 8 FP7-ICT-2011-8

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