An Integrated SON Experimental System for Self-Optimization and SON Coordination

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***Abstract*—**
In Self-Organizing Networks (SONs), a potentially large number of SON functions are available that autonomously perfom network management tasks. Different functions are e.g. available for the optimization of the network, and they can have conflicting goals. To ensure an effective optimization of the overall network, coordination of SON functions is necessary. For this purpose, we developed a policy-based coordination mechanism and a system to experiment with the coordination logic. The experimental system integrates a Long Term Evolution (LTE) radio network simulator, centralized self-optimization functions, and a SON coordinator. This setup allows for experimentation at the operational level of a SON-enabled network. We demonstrate the benefits of SON coordination by means of Coverage and Capacity Optimization (CCO).

I. Introduction

The introduction of Self-Organizing Network (SON) features aims at reducing the workload on operation and maintenance staff in order to free them from time-consuming and recurring tasks, so that they are able to focus on more sophisticated problems. The objective is to gradually move from human supervision and execution of low-level network operation tasks towards a purely monitoring and guiding of a SON-enabled system. Vendors are able to implement SON functions and integrate them one after another according to Next Generation Mobile Networks (NGMN) requirements [1]. These SON functions realize NGMN SON use cases and automatically perform the necessary actions. A SON system will contain a large number of independently acting SON function instances [2].

These functions act based on monitored network behavior, and this may lead to several function instances being active in the same network area. Hence, function instances have an impact on each other [3]. Uncoordinated execution of different functions with contradicting goals may cause conflicting or oscillating Configuration Management (CM) parameter changes and service degradation in the worst case. In order to assure an effective operation of the radio network, runtime coordination of the SON function execution is necessary.

II. Experimental System

The experimental system reproduces the behavior of a real network management system. The essential components are illustrated in Figure 1. We use a Long Term Evolution (LTE) network simulator, a set of centralized SON functions, and our SON coordinator. With the system, we perform radio network optimization as a continuous process that is based on the analysis of Key Performance Indicators (KPIs) [4]. We describe the relevant steps in the following.

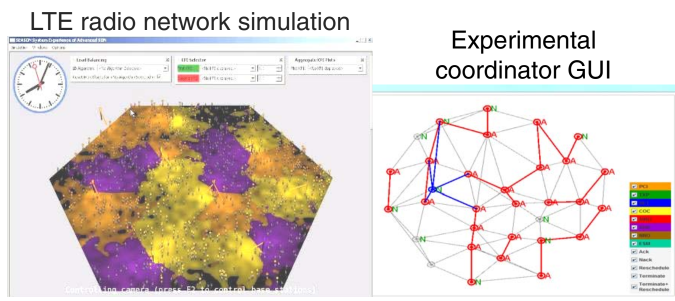


Fig. 1. Experimental system

- **Performance measurements:** The basis for radio network optimization are network performance measurements. In the experimental system, these measurements are provided by the LTE radio network simulator and aggregated into KPIs for further processing. A KPI combines different measurements with a particular focus, such as the number of Handover (HO) failures or Radio Link Failures (RLFs). These KPIs are analyzed to detect any non-optimal network operation, and the respective SON function instances request appropriate management actions, mostly configuration changes, to resolve the detected situation.
- **Coordination of SON function instances:** SON function instances request configuration changes for a limited set of Network Elements (NEs) and mostly target few parameters at a time. For this reason, concurrent execution of SON function instances is possible as long as there is no spatial and temporal overlap of the requested changes. If there is an overlap, i.e. conflicting changes are requested, the SON coordinator has to resolve the conflict. The need for SON function coordination has already been highlighted by [4], [5], for example.
- **Enforcement of CM changes:** For any acknowledged change request, the respective SON function instance computes a new configuration and assigns new parameter

values. The respective configurations are communicated back to the LTE radio network simulator and represent the basis for the following performance measurements.

The experimental system has been used to demonstrate coordination logic for a number of SON functions [6], [7]. The focus of our demonstration is on the coordination of SON function execution for Coverage and Capacity Optimization (CCO). Here, it is important that the cells of the network provide a complete coverage and optimal capacity at the same time. CCO is performed through adaptations of Remote Electrical Tilt (RET) and Radio Transmission Power (TXP). The optimization of each of these two parameters is performed through an independent SON function. Both functions can come from different origins, having been independently developed. Thus, the operator may flexibly choose to deploy only either one of them or to combine both in one network.

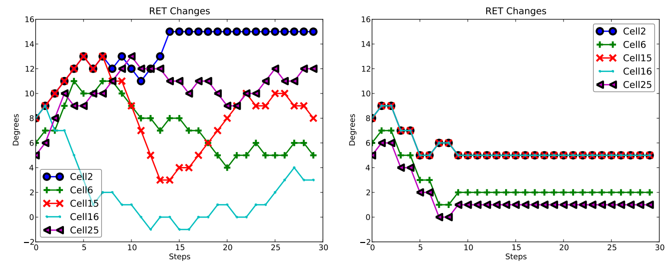
In the experimental system, policies are used to coordinate concurrent and subsequent RET and TXP change requests triggered by SON function instances. This refers to intra-function (such as RET/RET) as well as inter-function (such as RET/TXP) request sequences. Each single change request is processed by a set of policies that decide whether to acknowledge or reject the requested change. This decision depends on:

- the priority of the SON function that requested the change
- the target cell of the change request and adjacent cells
- the specific timing of the requested change
- previous changes that still have an impact on the current decision

As a result, undesired change requests are blocked by the coordination. In our demonstration, the coordination basically leads to a serialization, more precisely to an initial period of RET changes followed by a period of TXP changes.

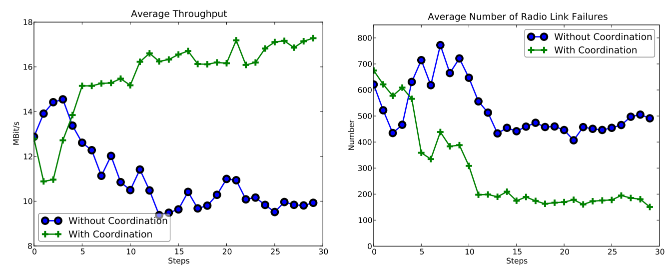
III. Results

For the demonstration, an initial network scenario is considered with sub-optimal RET and TXP settings that even lead to a coverage hole. Figure 2 shows the RET changes for the cells around the coverage hole without and with coordination, and Figure 3 shows the resulting KPIs. The uncoordinated execution of RET and TXP leads to a significant number of changes, especially for RET (Figure 2a), and these only start to stabilize for the 30 simulation steps shown. This behavior even results in an aggregated throughput for the cells that decreases from its initial value (Figure 3a). The number of coverage-induced RLFs initially fluctuates and then stabilizes at a reduced level (Figure 3b). With coordination, requested changes are only accepted in every second simulation step. Furthermore, RET change activity ceases after ten simulation steps (Figure 2b), and TXP changes may then occur (not shown in the figures). Through the coordination, the average throughput for the cells significantly increases (Figure 3a), and the average number of RLFs is significantly reduced (Figure 3b).



(a) Without coordination (b) With coordination

Fig. 2. RET changes for a set of Cells



(a) Throughput (b) RLFs

Fig. 3. Average KPI Values

IV. Conclusion

With an increasing level of automation enabled by SON, more instances of different SON functions are frequently active, hence keeping control over the network through SON coordination is important for a network operator. This demonstration shows that system performance can benefit from the coordinated execution of individual, but inter-related SON functions. The operator still benefits from a modular system of individual SON functions (for him potentially black boxes), but can control their basic behavior and dependencies. This happens with policies that can be modified even at runtime.

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