

Use of Self-Organizing Networks to Optimize Radio Access Networks

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Self-organizing networks (SONs) are collections of control and management methods and optimization algorithms that are attracting attention as a means of achieving economical services in the next-generation mobile network. The aim with them is to reduce the total cost of ownership (TCO) by having traditionally manual tasks like design, configuration, optimization, and operation/monitoring performed autonomously on the network side as much as possible. When a SON is introduced, it is important that the SON functions be applied with minimal impact on the existing network, that the entire network be optimized and not just the radio network, and that the SON itself be enhanced as needed. This article outlines the SON concept, describes the technologies of automatic load balancing and coverage/capacity optimization as SON use cases for optimizing a radio access network, and describes a system architecture for implementing SON.

1. Introduction

Recent years have seen a rapid jump in mobile network traffic due to expanded use of the mobile Internet via high-speed radio access systems. For network operators, this increase in traffic drives up both the cost of owning and cost of managing the network infrastructure, and reducing these costs and achieving economical network services are key issues in the development of future networks. In response to this situation, specifications are now being drafted at the 3rd Generation Partnership Project (3GPP) and other standardization organizations for achieving autonomous network management based on the concept of a self-organizing network (SON), targeting mainly radio access networks.^{1)–3)} The idea behind SON is to reduce the network operator's total cost of ownership (TCO) by having the network automatically perform tasks such as network planning, configuration, and operation that have traditionally been performed manually.

This article begins by providing an overview of the SON concept. It then describes two SON use cases (application examples) for optimizing the radio access network: the mobility load balancing (MLB) method and the coverage and capacity optimization (CCO) method. It also describes the architecture that is needed to realize SON and optimize a radio access network.

2. SON overview

The main operations of a mobile network can be classified into the three phases of planning, configuration, and operation, as shown in **Figure 1**. The aim with SON is to provide highly functional autonomous operations for each of these phases.

The following describes the operations associated with each of them and the approach taken with SON to handling these operations.

1) Planning phase

In the planning phase, the locations of base stations and network devices and the associated

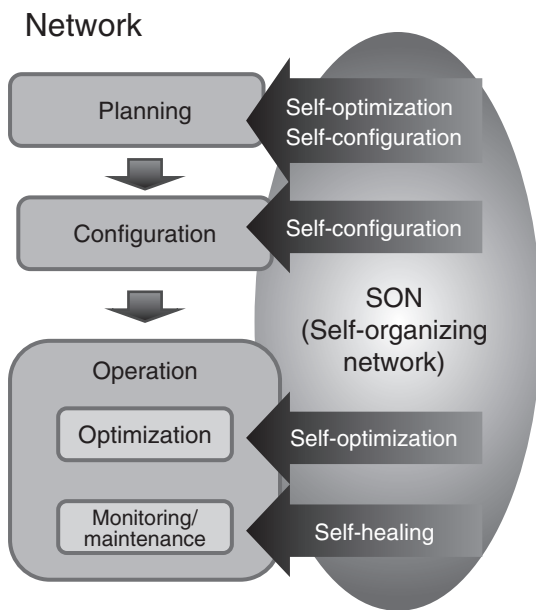


Figure 1
Network operation for mobile networks.

parameters (output power, antenna angle, etc.) are determined before the equipment is actually installed. The links between base stations and network devices are also designed. It is important in this design work to derive optimum values for the parameters so that the amount of manual labor is minimized.

2) Configuration phase

Once the base stations and network devices are installed, the parameters for each unit of equipment must be set and equipment testing must be performed. In this phase, the SON self-configuration function provides means for detecting equipment, downloading software, performing authentication, and testing equipment autonomously on the network side after equipment installation.

3) Operation phase

The operations carried out in this phase consist of network optimization and network monitoring/maintenance, as described below. The aim with SON is to automate these operations as much as possible.

- Network optimization
SON provides self-optimization functions

for collecting data related to network quality and radio signal quality from base stations and network devices during system operation and for modifying the parameters of this equipment on the basis of the values of the data collected. For example, the MLB method provided by SON can be used for balancing the traffic load across the base stations, the mobility robustness optimization (MRO) method can be used for improving quality during handovers, and the CCO method can be used for maximizing throughput in a cell.

- Network monitoring/maintenance

A SON provides self-healing functions for monitoring base stations and network devices for faults and for taking appropriate measures (such as restarting, switching to a backup system, and using other equipment to compensate for failed equipment) in the event of a network problem. A SON also provides a means for automatically upgrading network equipment.

As described above, the aim with SON is to minimize the amount of work that requires human intervention by performing tasks in each of the above phases on the network side as autonomously as possible.

3. Technologies for optimizing radio access network

This section describes two key technologies for optimizing the network as operations provided by SON. The first is automatic load balancing for efficiently using the radio resources of the base stations making up the radio access network, and the second is coverage/capacity optimization for autonomously maintaining the quality of the service area provided by the network operator in the face of changing conditions.

1) Automatic load balancing

With this technology, if the network detects an imbalance in traffic loads between cells, it autonomously adjusts the operation parameters in accordance with the load in each cell. The aim here is to hand over some terminals connected

to a base station with high-load cells to one with low-load cells and thus better distribute the total load. This improves the use of system capacity and increases average user throughput. Compared to manual techniques, autonomous control on the network side makes it possible to deal quickly and thoroughly with temporary concentrations of load.

Automatic load balancing can be achieved by adjusting the antenna angle to modify the radio coverage and/or by adjusting the handover parameters to change the logical cell size to achieve MLB.

The operating principle behind the MLB method is shown in **Figure 2**. The received radio signal quality of the terminal's serving cell and that of the adjacent cell are used to determine to which cell the terminal should be connected. In general, a terminal is handed over to the adjacent cell when the received radio signal quality for the adjacent cell is higher than that of the serving cell by a predetermined value (handover threshold). The MLB method adjusts the value of this handover threshold in accordance with the load conditions, resulting a virtual expansion or contraction of cell size and thereby increasing

or decreasing the number of terminals in the cell. The traffic load is thus more evenly distributed.

2) Coverage/capacity optimization

In actual field environments, the conventional approach to optimizing coverage and capacity has been to manually measure the radio environment by using a test car and then adjust the parameters accordingly. The CCO method uses various types of measurement data from terminals and base stations to detect dead zones (locations where radio signals from the base station are weak or nonexistent) in the service area and the presence of areas where communications are difficult due, for example, to base-station faults. Then, in response to these conditions, it autonomously adjusts parameters such as base-station transmit power and antenna angle. This autonomous adjustment of parameters on the network side serves to maintain radio coverage inside the service area while reducing the cost of manual measurement and also maintaining and improving service quality.

Figure 3 shows how a dead zone caused by a fault in a base station can be compensated for by adjusting the antenna angles in adjacent cells to distribute their radio signals more evenly. The circles indicate base stations, and the white and black regions indicate areas with good and poor radio signal quality, respectively. In **Figure 3 (a)**, a fault has occurred in the base station at the center of the figure, generating a large dead zone. The CCO method detects this state using information obtained from the base stations and eliminates the dead zone by adjusting the antenna angles for the adjacent cells. **Figure 3 (b)** shows the results: the areas covered by the other stations have been broadened, and the central dead zone has been eliminated.

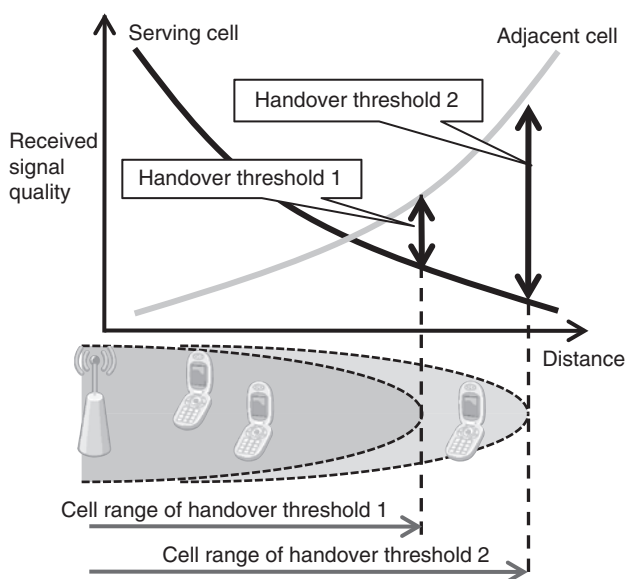


Figure 2
Mobility load balancing.

4. SON architecture

This section describes how the SON architecture can be used to optimize the radio access network as described in the previous

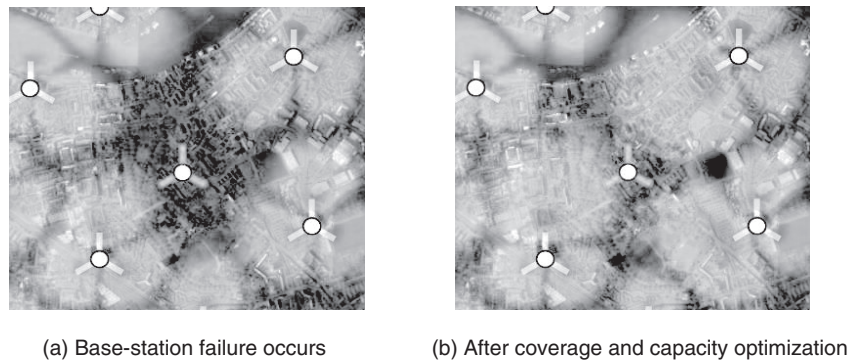


Figure 3
Radio quality map before/after optimization.

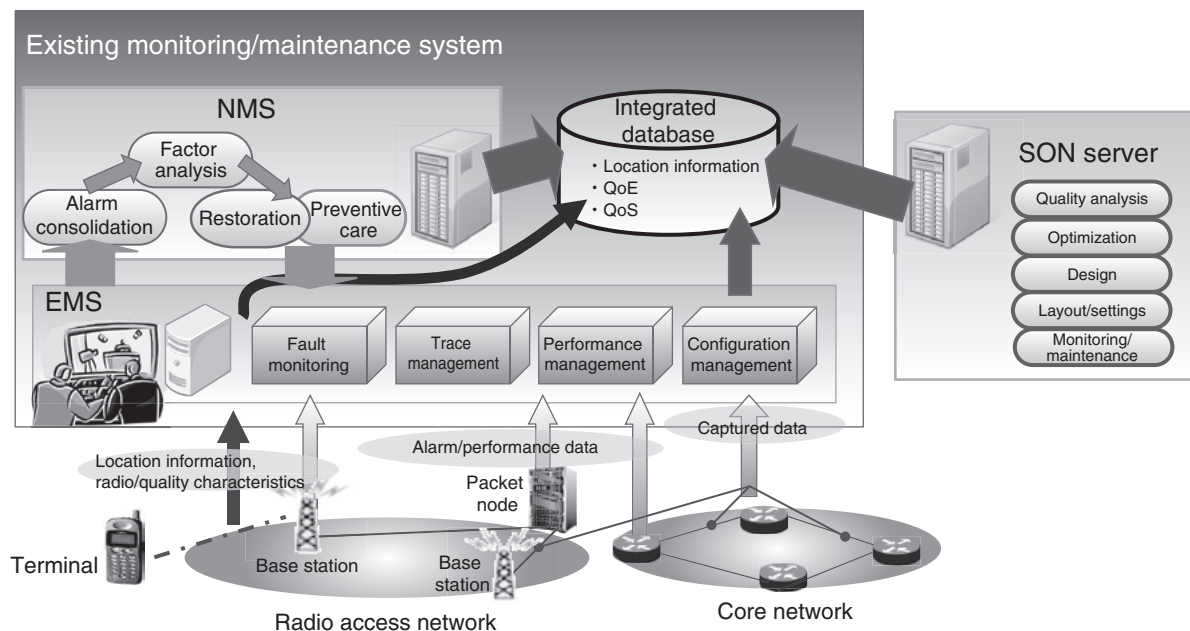


Figure 4
SON system architecture.

section. When applying a SON to actual networks, the following points should be taken into account:

- 1) The SON should be deployed while minimizing its impact on the existing network.
- 2) The entire network should be optimized after optimizing the radio access network.
- 3) The SON itself should be enhanced as conditions warrant.

The following outlines each of the above

points.

- 1) Deployment of SON in existing network

The architecture of the SON system is shown in **Figure 4**. As their names imply, existing monitoring/maintenance systems such as the network management system (NMS) and element management system (EMS) monitor and maintain network constituent elements such as those of the radio access network. The optimization technologies described above are implemented on a SON server installed

independently of these monitoring/maintenance systems. The SON server exchanges data with these systems via a database. To be more specific, the existing systems collect network quality data and store them in the database, which can serve as a trigger for running optimization algorithms. The SON server, in turn, analyzes that data either when it is stored or in a periodic manner and executes optimization algorithms on the basis of the analysis results. This system architecture, which creates a link between the SON server and existing monitoring/maintenance systems via a database, enables a SON to be deployed without having a large impact on existing systems.

2) Optimization of entire network

A model of SON evolution as a “rising sun” is shown in **Figure 5**. A SON is initially applied to the radio-access-network field in accordance with the requirements defined in technology standards established by the 3GPP and other standardization bodies. Then, the SON is expanded to be the core network and fixed access network, and beyond that, it is applied to the entire network including sensors and information networks. What this means is that the SON will eventually come to be applied to uncovering and solving problems throughout the entire network.

3) Enhancement of SON itself

The effects expected of the SON algorithms may not necessarily be obtained when a new

network is deployed given the relatively small number of network devices and terminals. The network environment may also change during operation. It is therefore desirable that SON optimization conditions during network operation be analyzed and that the optimization algorithms be revised as needed (revise the startup conditions for an optimization use case, revise the startup sequence, etc.). In other words, it is important to provide a “self-growing SON” that can autonomously revise its algorithms.

5. Conclusion

This article described the concept of the self-organizing network and presented examples of applying it to the optimization of a radio access network as use cases. It also described the SON system architecture for achieving this optimization. Important points for an operator to consider on deploying a SON are that SON functions should be applied while minimizing their impact on the existing network, that the entire network should eventually be optimized and not just the radio access network, and that SON itself should be enhanced as conditions warrant.

References

- 1) 3GPP, TS32.500: Telecommunication management; Self-Organizing Networks (SON); Concepts and requirements.

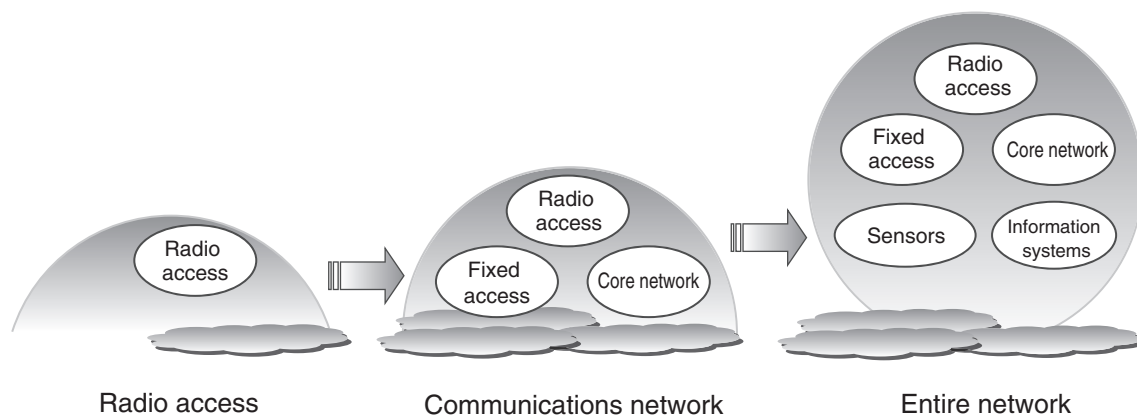


Figure 5
Image of SON evolution—“Rising SON”.

- 2) 3GPP, TR36.902: Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Self-configuring and self-optimizing network (SON) use cases and solutions.
- 3) 3GPP, TS36.300: Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2.



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