Empowered by Innovation NEC

White Paper

Self Organizing Network

“NEC's proposals for next-generation radio network management”

February 2009, NEC Corporation

Executive Summary

As demand for wireless access to the Internet and Internet-based services is expanding, competitive advantages in the mobile business can be gained by offering enhanced user experience through cost-effective broadband mobile access. A promising approach is to maximize total performance of networks, i.e., provide not only wireless access with higher performance but also more efficient operation and maintenance (O&M). The Self Organizing Network (SON) introduced as part of the 3GPP Long Term Evolution (LTE) is a key driver for improving O&M. It aims at reducing the cost of installation and management by simplifying operational tasks through automated mechanisms such as self-configuration and self-optimization. While supporting 3GPP standard on LTE/SON, NEC’s hybrid management architecture will enhance robustness, scalability and response of self-X functions and enable effective integration into the existing operations. Moreover, NEC’s self-optimization will enhance user perceived qualities by optimizing intra-cell radio qualities with a radio planning tool.

Operator Benefit

The challenge faced by mobile operators is to ensure that mobile services are of a high quality while reducing capital expenditures (CAPEX) and operational expenditures (OPEX) of complex radio access network (RAN). By using SON we can remove several human interventions from network operations and maintenance. By leveraging its wide experience and advanced technologies on UTRAN, NEC supports cost-effective SON functionalities providing the following benefits as depicted in Figure 1:

・Reduction of CAPEX and OPEX

According to recent analysis, about 17 % of wireless operator’s CAPEX is spent on engineering and installation services [1]. SON’s self-configuring functions are expected to eliminate many on-site operations for the basic settings and subsequent updating of network equipments, and thus reduce CAPEX.

It is also known that about 24 % of a typical wireless operator’s revenue goes to network OPEX, which are the cost of network operation and maintenance, training and support, power, transmission, and site rental [2]. SON’s self-optimizing functions will reduce a workload for site survey and analysis of network performances, and thus reduce OPEX. Moreover, SON’s energy-saving functions reduce the costs of power consumed by the equipment.

・Improved user experience

Self-optimizing and self-healing architectures improve user perceived qualities by mitigating quality degradations that result from inaccuracies of the planning or equipment faults as early as possible and by optimizing the network parameters under interference and overload conditions.

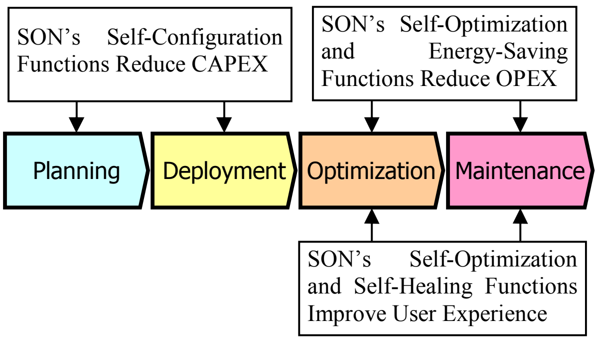

Figure 1. Merits of SON functions in typical wireless operator’s O&M workflow.

Key Technology Features

1) Hybrid Management Architecture

Scalability and real-time response of SON functions must be supported through a lean and reliable management framework for LTE. For example, the management plane architecture must support local and autonomous configuration for plug-and-play functions, as well as local and coordinated negotiation of radio resources between neighbors. The autonomous configuration result should also be monitored and switched back to manual configuration when necessary.

The current proposal of 3GPP relies on a hierarchical management architecture as depicted in Figure 2: SON functions are mainly located on the management side and controlled through vendor-specific Element Management Systems (EMSs); standardizing interfaces between EMSs can guarantee inter-vendor operability.

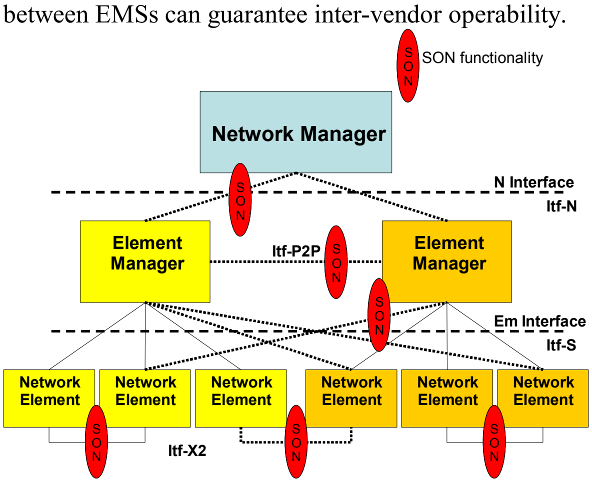

Figure 2. Simplified view of LTE network management structure.

While supporting the current Rel. 8 specifications, NEC is looking to overcome the classical stratification of management functions and it is elaborating a higher degree of automation for LTE networks. By leveraging on its long lasting experience on autonomic networking, NEC vision is to push some of the SON functions on the eNodeB itself. Because resources for the management plane must not be continuously re-planned when the LTE network is gradually deployed and extended, the resulting distributed architecture makes the benefits of self-management tangible on the complete deployment loop. Additionally, local self-optimization loops – such as enhanced Plug-and-Play, neighbor list, hand-over thresholds, energy saving modes – can be executed with low overheads and latency on the devices; enhanced robustness is also guaranteed, since single point of failures are avoided.

The most efficient approach for LTE seems that based on a hybrid architecture: the one which best exploits the benefits of SON functions and smoothly integrates with operators' existing practices. As illustrated in Figure 3, the existence and cooperation of SON functions both on the RAN side and on the backend management side allow a high degree of automation, while still guaranteeing control and inspection - when needed - of closed control loops.

Overall, the architecture supported by NEC can further bring sensible reduction in OPEX, by hiding information complexity and allowing gradual deployment of LTE networks.

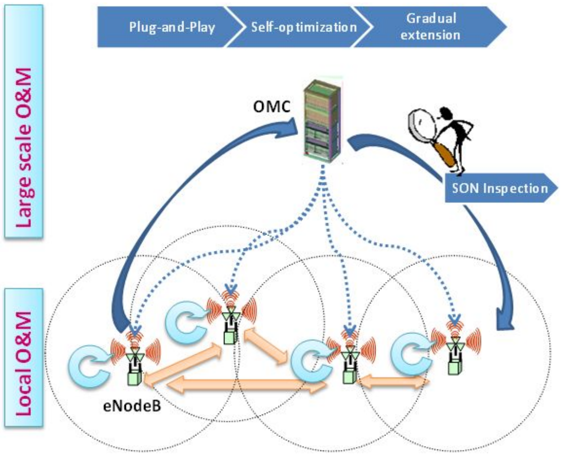

Figure 3. NEC Vision for scalable and reliable management architecture for LTE.

2) Self-configuration

To reduce the human interventions involved in the deployment of new network elements the process should be automated to as large extent as possible and only require a single visit to the installation site. The network elements shall automatically create the logical associations with the network and establish the necessary security contexts, providing a secure control channel between the new elements and the servers in the network. Technologies such as DHCP (with extensions) for auto-configuration and EAP or SIM-card-based security parameter configurations could be used. Configuration files can then be downloaded from a configuration server by using the NETCONF protocol [7], which provides an initial configuration for the element. Once the configuration and the latest software release have been downloaded, the element should perform a self-test to determine that everything is working as intended.

Finally, the network element can be taken into active service, but the configuration may still be improved using self-optimization.

3) Self-optimization

To maximize network performance, optimizing the configuration while taking into account regional characteristics of radio propagation, traffic and UE mobility in the service area is effective. However, optimization has not been frequently applied because it typically entails a heavy workload for site surveys, analysis of the performance statistics and decision of the optimal parameters. SON automates these tasks by using measurements from network equipments. Specifically, it substitutes measurements from eNodeB and UE for the site survey data. It detects problems with quality, identifies the root cause, and automatically takes remedial actions on the basis of the measurement and performance statistics from the OMC. This autonomous optimization allows problems to be handled faster and network performance to be improved. As depicted in Figure 4, NEC's self-optimization includes:

- **Neighbor list optimization**

This optimization automatically reconfigures a neighbor list so that the list contains the minimum set of cells necessary for handover. The neighbor list can be dynamically updated on the basis of UE measurement reports. For example, newly reported cells are added, and cells with very few handover attempts or frequent handover failures are removed from the list. These operations can be decided while considering operator's individual requirements managed in the OMC.

- **Coverage and capacity optimization**

This optimization aims at maximizing the system capacity and ensuring there is an appropriate overlapping area between adjacent cells. The optimal parameter setting is acquired by cooperatively adjusting antenna tilt and pilot power among the related cells. This optimization should operate with some effect even if the measurement reports from UE do not include their data on their own location.

- **Mobility robustness optimization**

To eliminate unnecessary handover and to provide appropriate handover timing, this optimization automatically adjusts the thresholds related to cell reselection and handover. The adjustment is triggered by the related KPI degradations and is processed while identifying the root causes of the degradations such as a handover that is too early or too late or the ping-pong effect.

- **Mobility load balancing optimization**

This optimization automatically gets some UEs in the edge of a congested cell reselect or hand over to the less congested adjacent cells by adjusting the thresholds related to cell reselection and handover. Load balancing should be done by using a minimum number of cell reselection or handover without causing the problem of mobility. Also it should minimize total investment in capacity by taking into account the different sides of load such as radio load, transport network load and HW processing load.

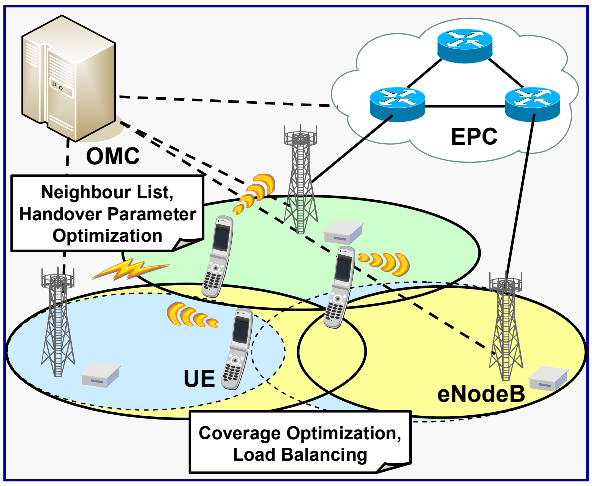

Figure 4. Self-optimization supported by NEC in LTE networks.

4) Automated Fault Identification and Self-healing

Fault management and correction requires a lot of human interventions and should be automated as much as possible; hence identification and self-healing of the faults is a significant solution. The following points are important parts of the solution:

- **Automated fault identification**

Equipment faults are normally detected by the equipment itself autonomously. However, fault detection messages cannot always be generated or transmitted when the detection system itself is damaged. Such unidentified faults of eNodeB are commonly mentioned as sleeping cells, and they are detected by performance statistics. However, sometimes it is hard to identify the sleeping cells, since the statistics at the cell level fluctuate largely as a result of variances in traffic and radio quality. NEC's SON accurately detects the sleeping cells by doing a statistical analysis of network logs, and distinguishes eNodeB faults from temporal quality degradation by detecting specific UEs near the area where radio quality is poor. Correlating multiple alarms is also used to automatically identify the root cause of the problem.

- **Cell outage compensation**

When an equipment fault is detected, SON analyzes internal logs of the equipment, identifies the root cause, and takes some recovery actions such as fallback to the previous software version or switching to the backup units. When the equipment fault cannot be resolved by these actions, the affected cell and the neighbor cells take cooperative actions to minimize user-perceived quality degradation. For example, in an urban area covered by multiple microcells, relocating users from the faulty cell to the normal cells by adjusting coverage and handover related parameters of the nearby cells cooperatively is effective. This results in a reduced failure recovery time and a more efficient allocation of maintenance personnel.

5）User Perceived Quality Enhancement

While raising the overall radio qualities of radio cells by self-optimization at cell level, NEC aims at enhancing user-perceived qualities by optimizing intra-cell radio qualities. The optimization should take many geographically and user-specific constraints into account, such as coverage in the public space, transportation network in the area, and the type of subscribers. The assessment depends on the operator's experience and cannot be precisely formulated; hence the optimization is hard to automate completely.

As shown in Figure 5, NEC's solution is to incorporate a radio planning tool into self-optimization. Doing this enables an operator to quickly find the best configuration while gradually iterating self-optimization. Specifically, the operator can plan a configuration change using self-optimization functions on radio qualities created by a radio propagation simulator. The measurements from UEs are collected and fed back to the planning tool. The operator can decide whether to rollback, modify or finalize the configuration after checking the effects of configuration change on the planning tool.

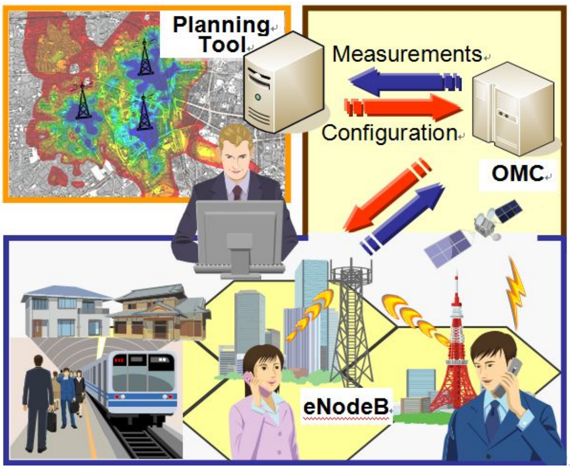

Figure 5. NEC's enhanced solution for improving user experience.

6）Energy Saving

Energy is a significant part of the operation expenses of a cellular network; hence reducing the energy consumption is a valuable optimization. The main savings potential results from variations in load over time, which would allow parts of the resources to be switched off, for example during night.

An eNodeB may switch off part of the resources on the basis of local decisions, but, if the whole eNodeB is switched off, other base stations need to make up for the reduction of coverage and capacity. Hence there is a need for coordination between eNodeBs.

An important piece of the functionality is how to switch the resources on again. The eNodeB should know when the switch on should be made; this can be a local decision or externally triggered. As a result of switching the eNodeBs on and off, neighbor list configurations in adjacent eNodeBs are automatically updated.

7）SON for Home eNodeB

Introducing home eNodeBs (aka femtocells) significantly increases the number of base stations in the network and it also means that the network operator has less control of the nodes. Therefore, there is an immediate need for self-configuration of home eNodeBs. This can be, to a large extent, handled by extensions to TR-069, the existing management protocol for broadband access network devices, but some problems require home eNodeB specific solutions. For example, a major challenge is the interference between home eNodeBs and macro cells. Therefore, there is a need to authenticate and identify the location of the home eNodeB before authorizing it to transmit in the licensed radio spectrum. The home eNodeBs also sniff the configuration information broadcast by the surrounding macro cells, and select appropriate physical cell IDs, location area IDs, etc.

To reduce the work required from the operator side and to improve the radio quality for the home eNodeB users, it is also possible to involve the users more actively in the management of the home eNodeBs. An example of this is to use a trouble-shooting assistant similar to one that is available in computer operating systems. The radio settings can also be optimized on the basis of measurements made with the help of the users in a way that is analogous to a drive test used for optimization of macro cells.

Standardization Status

3GPP has introduced SON items in its standardization path as required features for LTE deployments. Rel. 8

includes the first specifications on requirements, integration with operators' processes, and identification of main use cases. Rel. 9 is expected to define advanced features, which will introduce self-healing and self-optimization capabilities into LTE.

The SON related specifications are driven from the SA5 Working Group (WG) – mainly for architectural aspects– and the RAN3 WG – especially for the optimization of radio functions. Also, Rel. 8 defined the grounding documents for SON: "SON Concepts and Requirements" in TS 32.500 [3], and two main use cases– "Self-Establishment of eNodeB" and "Automatic Neighbor Relation" – in TS 32.501 [4], 32.502 [5] and 32.511 [6].

NEC favors the introduction of SON features in 3GPP and will contribute to the definition of key information elements in the SON architecture as well as specific use cases. To anticipate and support operators' expectations from SON, NEC is also looking at the activities of the NGMN consortium: NEC is working closely with NGMN operators and, among other discussion items, is driving the proposal of SON control interfaces for eNodeBs. By leveraging its long research on autonomic architectures, NEC is expected to contribute to the smooth and cost-effective integration of SON functions into operators' management systems.

Overall, the joint and coordinated participation to 3GPP, NGMN and world-wide NEC Research Laboratories is driving NEC products towards 3GPP-compliant SON functions as well as advanced and customized solutions to support LTE operators.

Conclusion

The evolving mobile business demands broadband mobile networks with high operability as well as high performance. A promising solution is LTE/SON as it allows operators to implement objectives such as robustness, better performance, and energy efficiency at a lower cost than that of traditional management approaches. As a total network supplier, NEC has a clear vision and strategy over LTE/SON from its long experience on UMTS and autonomic networking. By introducing the hybrid management architecture, NEC's LTE/SON solution will enhance robustness, scalability and response of the self-X functions and enable effective integration into the existing operations. Furthermore, the self-optimization with a radio planning tool will powerfully enhance the user's experience.

References

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[3] 3GPP TS 32.500, "Telecommunication management; Self-Organizing Networks (SON); Concepts and requirements (Rel. 8)", Dec. 2008.

[4] 3GPP TS 32.501, "Telecommunication management; Self-Configuration of Network Elements; Concepts and Integration Reference Point (IRP) Requirements (Rel. 8)", Dec. 2008.

[5] 3GPP TS 32.502, "Telecommunication management; Self-Configuration of Network Elements Integration Reference Point (IRP); Information Service (IS) (Rel. 8)", Dec. 2008.

[6] 3GPP TS 32.511, "Telecommunication management; Automatic Neighbour Relation (ANR) management; Concepts and requirements (Rel-8)", Dec. 2008.

[7] IETF, RFC 4741, "NETCONF Configuration Protocol", Dec. 2006.

Acronyms

CAPEX	Capital Expenditures
DHCP	Dynamic Host Configuration Protocol
EAP	Extensible Authentication Protocol
eNodeB	enhanced Node B
EPC	Evolved Packet Core
LTE	Long Term Evolution
O&M	Operation and Maintenance
OMC	Operation and Maintenance Centre
OPEX	Operational Expenditures
QoS	Quality of Service
RAN	Radio Access Network
SIM	Subscriber Identification Module
SON	Self Organizing Network
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network
WG	Working Group

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