Self-Organizing Network (SON)

Introducing the Nokia Siemens Networks SON Suite – an efficient, future-proof platform for SON

Nokia Siemens Networks

Executive summary

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The self-organizing network, or SON, aims to leapfrog to a higher level of automated operation in mobile networks.

Today SON is part of the move to the next-generation of radio technology known as Long Term Evolution (LTE). But to make the most of the very real benefits of automation, SON's scope must be extended beyond LTE.

The twofold benefits of SON are easily summarized. It

- Boosts network quality
- Cuts operational expenditure (OPEX)

Traffic patterns in cellular networks are changing fast with mobile data closing in on voice services.

An intelligent network with the ability to quickly and autonomously optimize itself could sustain both network quality and a satisfying user experience.

SON offers tremendous potential and many ways of improving operating efficiency. A few of these are

- Self-configuration, where plug & play installation and commissioning require nominal human interaction
- Self-optimization, where network performance is improved with actions such as handovers that minimize site visits and drive tests
- Self-healing, where functions detect outages and quickly redress faults

Nokia Siemens Networks, a leading provider of telecommunications infrastructure, engages in intensive research and is a driving force in efforts to standardize SON.

The company proposes to implement SON using architecture engineered to strike an optimum balance and make the most of both central and distributed elements.

Simulated SONs have produced promising results, clearly indicating this type of network's potential for improving operating efficiency.

A hallmark of the Nokia Siemens Networks SON Suite is efficient, future-proof architecture.

Built on this superior architecture and geared to match operability requirements, the implementation's key components are SON-enhanced OSS, SON Workflow Coordinator, robust algorithms, and the ability to handle multiple technologies.

1. Introduction

In this context, the term *self-organizing network* is generally taken to mean a cellular network in which the tasks of configuring, operating, and optimizing are largely automated.

This breed of network aims to reduce operational expenses while enabling a gratifying user experience even under adverse conditions such as congested traffic.

Radio access elements account for a large share of cellular networks' installation, deployment, and maintenance costs. This is why efforts to introduce SON focus on the network's radio access assets first.

Though efforts to create a self-optimizing network have been underway for years, a 2006 decision by the Next Generation Mobile Networks alliance was instrumental in driving its development. NGMN singled out SON as a key design principle for the next-generation mobile network, and published a specifications paper in 2008.

Hence, SON is often associated with LTE technology. And sure enough, while drafting LTE specifications, the 3GPP standardization body introduced SON in its December 2008 Release 8. Subsequent 3GPP releases will cover further SON specifications, starting with auto-configuration functions.

While such standards ensure sufficient interoperability, they generally offer little guidance on implementation. Ultimately, SON's performance will hinge on the right architecture and algorithms. So now it is up to vendors to develop efficient and robust functions, and seize the many opportunities for differentiating their offerings.

Chances are LTE will rarely be deployed in greenfield environments. So, to make the most of SON's potential, its capacity must be extended to encompass legacy equipment and technology. Although Nokia Siemens Networks firmly believes this scope extends far beyond LTE, this paper focuses on LTE for reason of complexity. Of course, discussions of architecture and algorithms apply to other technologies as well.

Looking further ahead, SON's deployment will change the ways cellular networks are operated, with the focus shifting from hands-on configuration and on-site maintenance to planning and supervision.

2. Business drivers and functional overview

Many compelling reasons could be cited for automating cellular networks, most coming under one of two headings:

- The user experience
- Operating efficiency and cost

SON can markedly improve the user experience by optimizing the network more rapidly and mitigating outages as they occur. These are very important capabilities because time-to-operation and time-to-repair are such critical factors for every network operator.

A case in point is SON's ability to balance loads – also called capacity-based optimization – between cells in congested traffic. It can distribute bandwidth equitably among users and minimize overloads that deprive each user of bandwidth. Best of all, SON-driven load-balancing achieves such improvements in real-time.

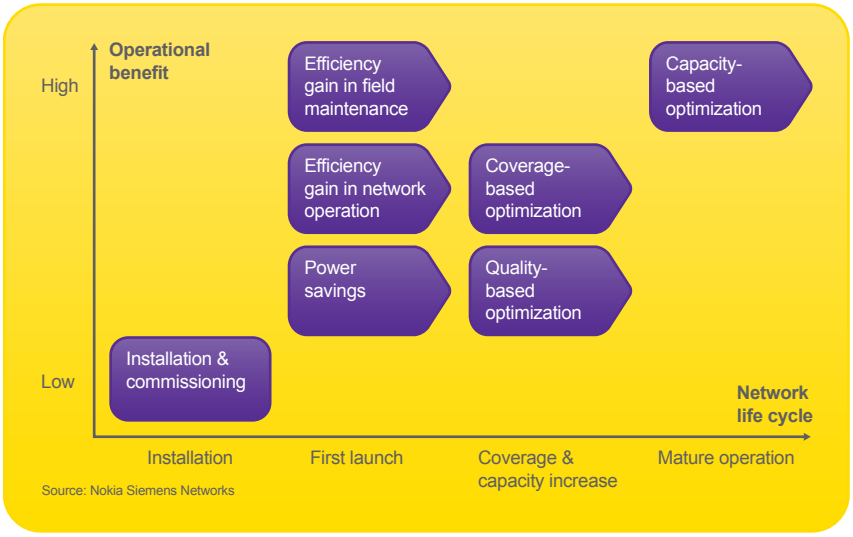

Figure 1: SON´s lifelong operating benefits

Operating efficiency, in turn, is all about simplifying and accelerating rollout, as well as running, maintaining, and optimizing the network more autonomously and more effectively. And minimizing extra operating effort seems a very good idea indeed in view of the complication of introducing and managing new LTE technology alongside legacy 2G/3G equipment.

SON delivers operating benefits throughout the network's lifespan. Beyond the upfront benefits of faster, easier, and more cost-effective installation and commissioning, it continues yielding long-term savings and contributes considerably to greater overall network efficiency.

Functional overview

Three classes of key functions figure prominently in SON.

Self-configuration comprises all tasks necessary to automate the deployment and commissioning of networks and the configuration of parameters. Network elements operate autonomously, running setup routines, authenticating and connecting to the OSS, as well as linking up and swapping parameters with need-to-know neighbors.

Self-optimization serves to improve or recoup network quality by tuning network parameters on the fly. Key tasks involve brokering handovers and balancing loads among neighboring cells.

Contributing to a greener network environment, SON offers advanced energy-saving features.

Self-healing encompasses a set of key functions designed to cope with major service outages, including detection, root cause analysis, and outage mitigation mechanisms. Auto-restart and other automatic alarm features afford the network operator even more quick-response options.

Self-planning combines configuration and optimization capabilities to dynamically re-compute parts of the network, the aim being to improve parameters affecting service quality.

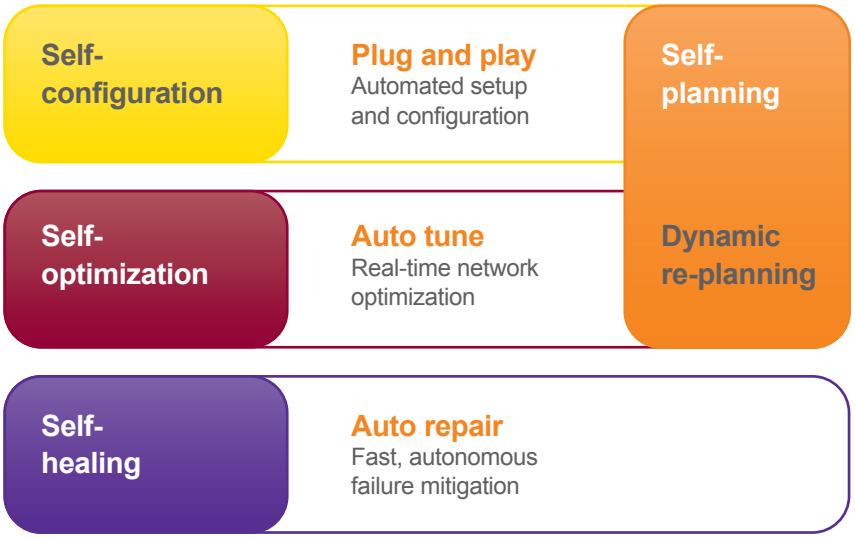

Figure 2: A look at SON functions

3. SON use cases

Maintaining a quality user experience

Surging loads in packet networks attest to changing traffic patterns and the shift away from voice towards data.

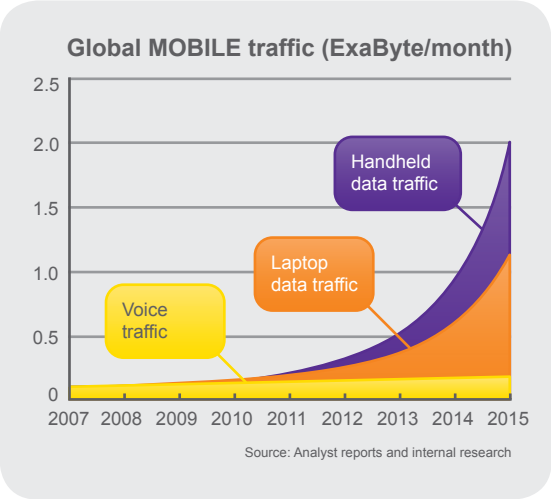

Figure 3: Global mobile traffic trend

Users' expectations and habits have evolved with the arrival of handhelds offering appealing email and Internet services. Now anything goes, anytime and anywhere. Accordingly, bandwidth and QoS requirements can fluctuate wildly, and the traffic load is far less predictable. Troughs are not a problem, but handling peaks requires a network that adapts to

- Allocate bandwidth equitably to users
- Optimize load distribution among cells
- Ensure robust mobility and handovers

A network's ability to heal itself can compensate for major outages. SON responds quickly, minimizing outage time and tasking neighboring cells to cover much of the affected area. Yesterday such an outage meant total failure pending on-site repair. Tomorrow it will constitute little more than a slight service downgrade, followed by far faster recovery and far fewer user complaints.

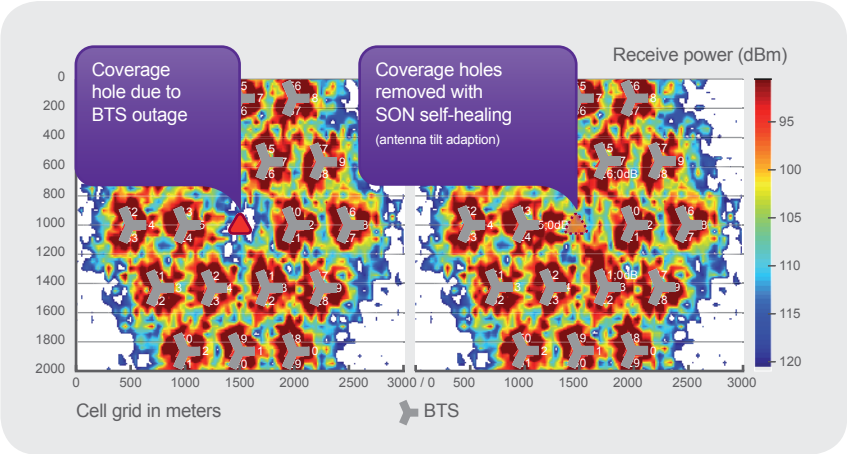

Figure 4: Self-healing – SON's ability to mitigate coverage holes

Driving down operating effort and cost

Plug & play rollout
This self-configuring capability will simplify network setup markedly.

The radio access network accounts for the lion's share of elements and expenses, so initially SON self-configuration focuses on the RAN in general and on base stations (BTS) in particular.

It makes installation and commissioning exercises in a plug-and-play convenience. Automated and autonomous routines handle typical setup chores such as connecting the OSS and network, downloading site-specific software, and applying configuration parameters.

This minimizes human error, for example, while configuring neighbor relations, and cuts costs because people spend a lot less time on site fussing with manual chores.

Self-configuration also reduces logistics costs. BTS are universally deployable, so special versions do not need be ordered for select sites. The self-configuring network uses GPS location ID to assign specific software, features, and licenses to the given site, all of which streamlines logistics and spare part management.

Finally, SON accelerates rollout and time to service. And the same goes for maintenance, for example, when adding or replacing a BTS.

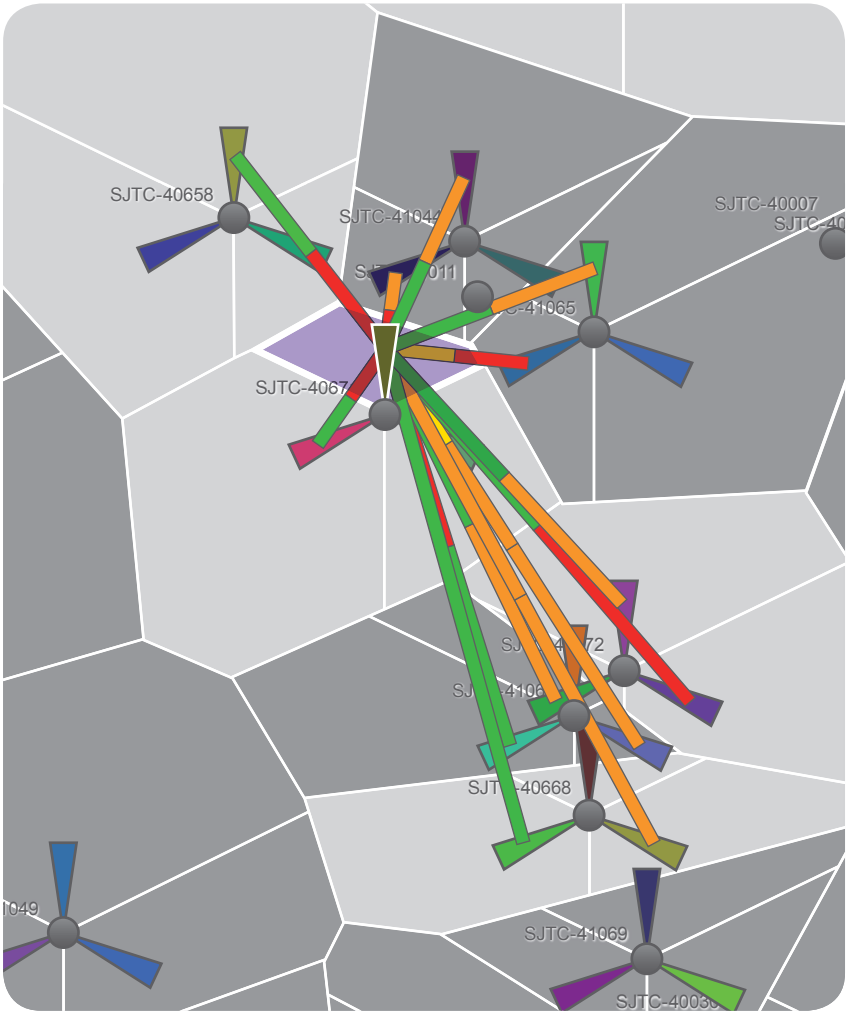

Figure 5: Automated Neighbor Relation (ANR) management

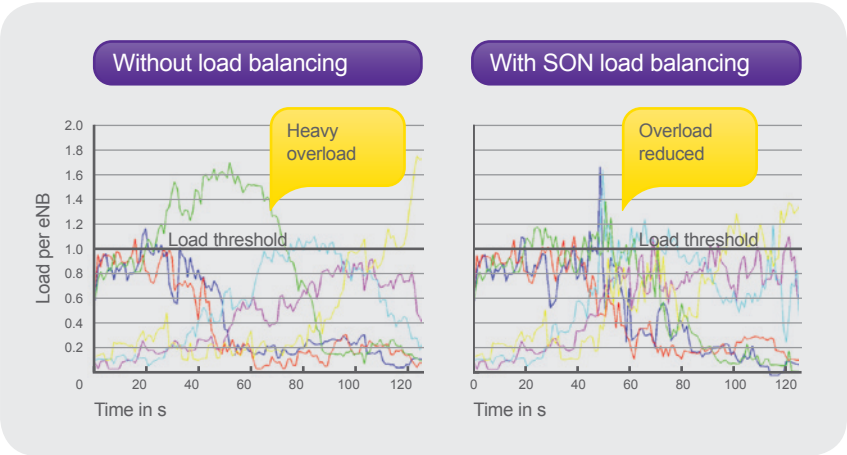

Figure 6: SON balancing the load in congested LTE eNBs

For a more gratifying customer experience

A self-optimizing network harbors great potential for treating users to a more gratifying experience. A network with the ability to tune and adjust parameters in real time can cope with problems on the fly, acting fast before performance suffers.

Human response, entailing site visits and drive testing, is slower and costlier. SON can minimize and, in many cases, eliminate both. For example, it detects handover failures, prompting the BTS to adjust HO parameters on its own while preventing ping-pong oscillations.

Congested and overloaded cells invite complaints because users get less bandwidth than they expect. Promising results with the current SON implementation suggest that this will soon change owing to its load-balancing powers. SON monitors the BTS, and when one cell is overloaded, hands over users at the cell's edge to a neighboring cell. This resolves the traffic problem and, under typical cell load conditions, decreases the number of dissatisfied users from about 10 to 2 percent.

Combating network complexity

Several radio access technologies are sure to coexist for years to come. Chances are this diversity will complicate and aggravate the task of operating cellular networks.

Well aware of this growing complexity, operators are of course keen to simplify network operations across the board.

NGMN seeks to counter the trend toward complexity by endorsing the introduction of SON alongside LTE.

Much of the money spent operating a network goes to analyzing the root cause of errors and correlating alarms. The latter reduces the number of alarms requiring response, facilitates root cause analyses, and prevents incorrect interpretations that prompt fruitless and pointless site visits.

Policy-driven actions such as auto restarts may be executed without manual intervention in urgent cases, at night, and at other opportune times.

SON detects service-related degradations or failures and triggers an alarm. If the problem is a cell outage, its self-healing mechanisms engage immediately, thereby reducing outage time in the affected area. This mitigating response includes adjusting the antenna tilt and power in neighboring cells. What's more, SON incorporates measures to boost reliability, for instance, redundancy and handovers to radio technologies operating in parallel.

Proper network planning requires accurate information on the actual configuration status, which calls for near instant status updates. Automated configuration and inventory management applications source this data practically in real time.

Vendors are porting more functions and features from hardware to software, which invites rather than inhibits automation. So software version management – including compatibility assurance, auto-distribution, and correlated licensing throughout the network – is a sure-fire way of stepping up operating efficiency.

Of course, engineers addressed much of the same issues before SON arrived on the scene, and SON itself is not a cure-all. Combinations of several functions – say, self-configuration linked with inventory management – are likely to spawn the greatest improvements. And that makes SON an integrative force enabling major efficiency gains.

4. Optimizing implementation

Exploring the challenges ahead in simulations

Taken on its own merits, each SON use case seems practicable, and even recommendable, with various implementation options in the offing.

But in the real world, these cases are connected rather than isolated. They will interact and influence each other in myriad ways, some of which have yet to be explored.

The nested loop provides a figurative analogy for the nature of SON, or more accurately, the great challenge of implementing such a network. Corrective control loops reside on several levels – in established radio functions and more recently in SON. As a rule, such nested loop constellations inherit the risk of instability.

Hence, processing or response time would appear to be an apt means of classifying functions. For example, radio resource management functions respond in milliseconds, while OSS-based network control and optimization takes place as part of regular, perhaps daily, network cross-checks. Obviously, SON needs to be carefully implemented with a broader view of network operations in mind so as not to jeopardize potential benefits.

Nokia Siemens Networks devotes considerable resources to research and is committed to building a sound case for implementation. To this end, a comprehensive simulator/emulator suite serves to proof architecture and algorithms.

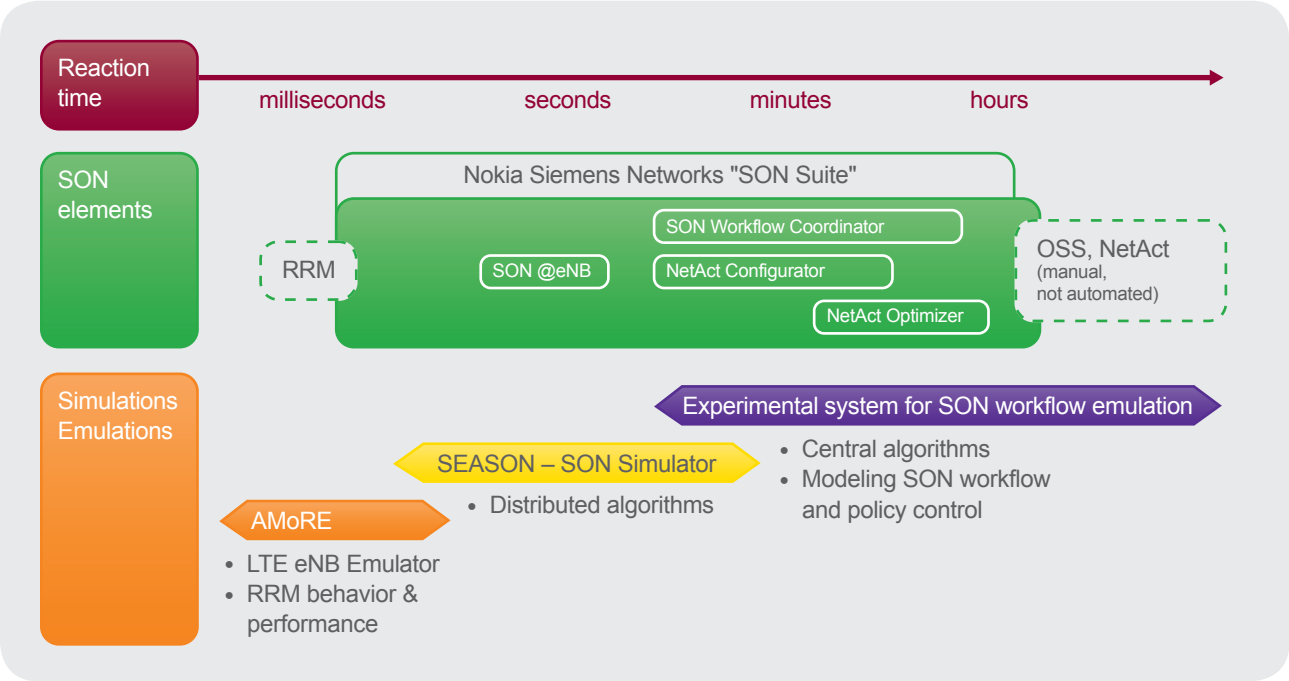

Figure 7: A comprehensive simulator/emulator suite

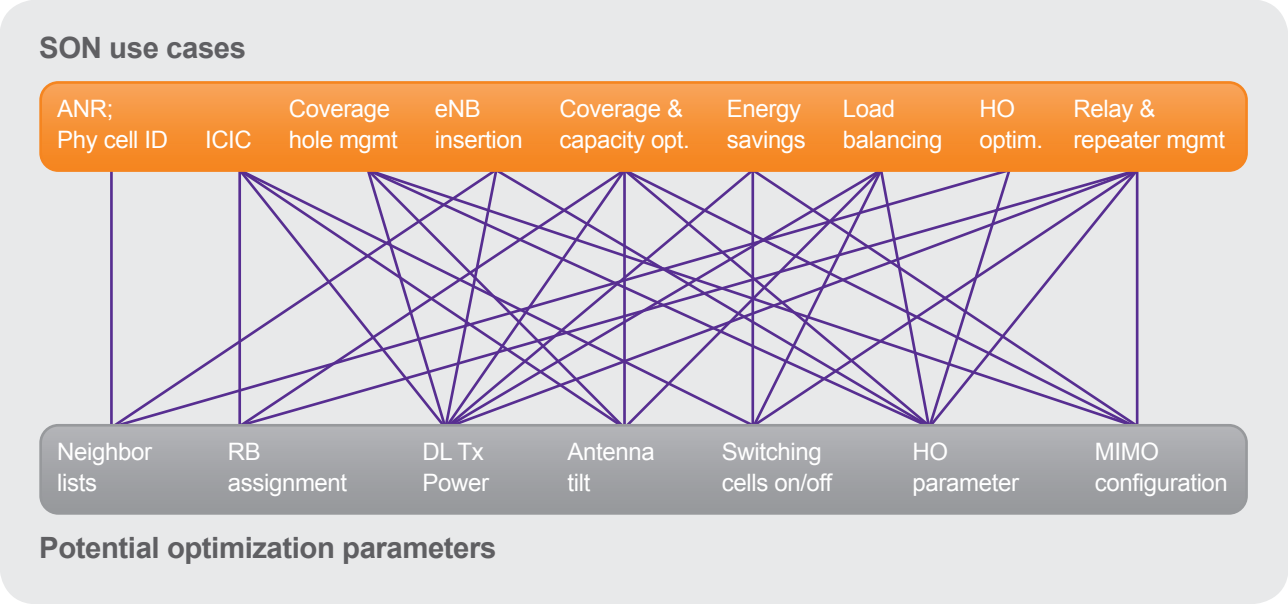

Figure 8: SON use cases and potential target parameters

What parameters need optimizing?

One of the key issues is pinpointing the parameters to be targeted for optimization.

Simulations have shown that a few key parameters can serve several SON use cases, and that certain parameters are a good match for a select use case.

This is a meaningful insight because it minimizes the risk of jeopardizing benefits and triggering conflicting or adverse effects such as oscillations when tuning several parameters at a time.

One of the key enablers for robust and converging algorithms will be to clearly define responsibilities among parameters.

In a real-world implementation, several optimization functions will run at the same time, making these clear definitions all the more important.

Where are SON functions best allocated?

Another issue is the allocation of SON's functions and algorithms. They could be executed locally at a single BTS, in distributed fashion at several eNBs, or from a central entity such as an OSS/EMS system.

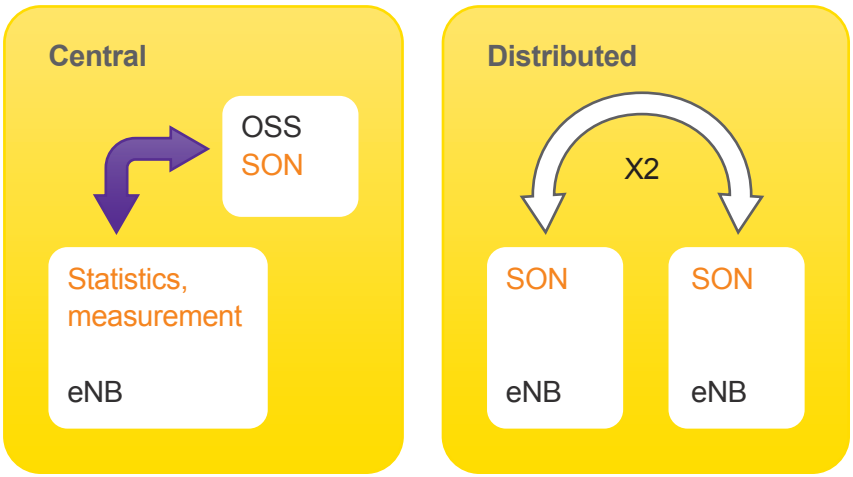

Figure 9: Options for implementing SON functions

There is much to consider when weighing the pros and cons of such allocations. Response time matters, as does complexity; that is, the number of parameters that must be factored into the decision. The size of database is another facet – how far back will the function go in its assessment of performance?

A closer look at use cases suggests that these functions are best separated into two main operating phases:

- The installation or pre-operational phase, where the individually deployed eNB is unaware of the greater network
- The operating phase, where quality and network operability requirements are much higher

5. Future-proof, efficient SON architecture – Introducing the Nokia Siemens Networks SON Suite

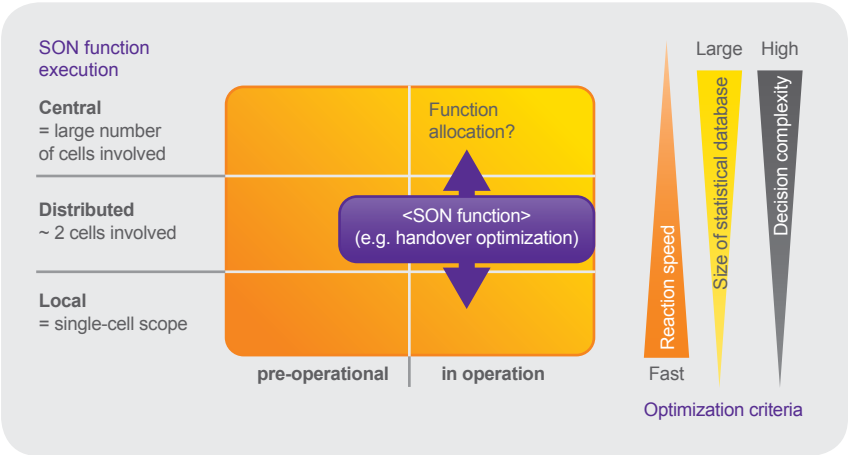

Figure 10: Key criteria for allocating SON functions within the RAN

Even a cursory glance at all these criteria is revealing: No single architecture stands out as superior, and implementing SON in a radio network will always be a tradeoff. Also, different use cases demand different ways of executing functions.

The best architecture will ensure:

- Sufficient performance/ response time
- The scalability/upgradability necessary to accommodate future functions
- The ability to also operate across several RAN technologies (MultiRAT)

Simulations and emulator demo systems have proven effective in evaluating and testing architectural options.

Superior architecture

Nokia Siemens Networks proposes implementing SON using architecture that strikes the best balance between and exploits the benefits of both central and distributed functional elements.

Some SON functions and algorithms are executed at the OSS level, others autonomously in the eNB or in a set of adjacent eNBs.

This diversified approach effectively meets the different requirements of SON use cases.

Near real-time actions take place locally at distributed components, while more complex and global network tasks are performed centrally.

This approach entails assessing SON use cases, carefully selecting the right parameters for optimization, and designing robust, converging algorithms.

A similarly thoroughgoing procedure is necessary to decouple the different optimization loops, reinforce operating stability, and enhance control capability.

Ultimately, this approach will enable efficient multi-technology SON. A central configuration and optimization entity, endowed with the necessary intelligence, will be able perform tasks addressing and affecting disparate technologies.

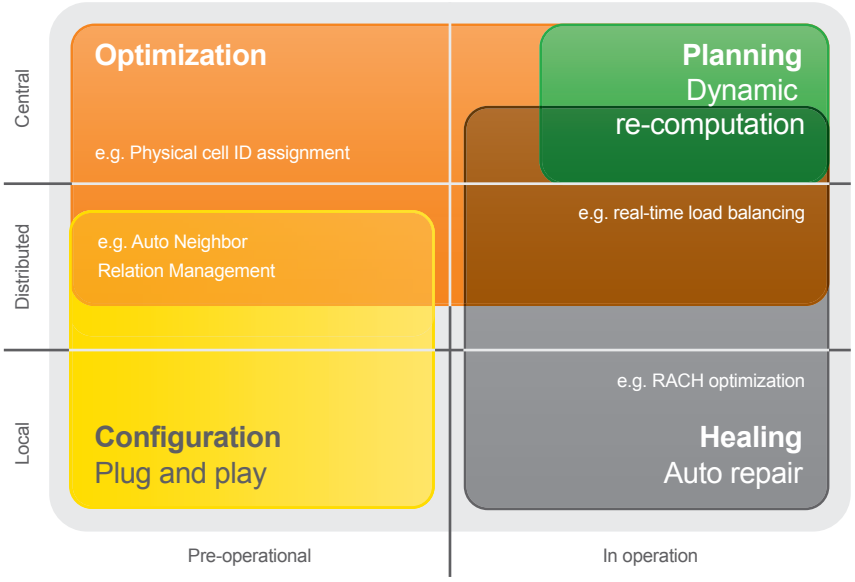

Figure 11: Guidelines for optimizing architecture

SON Suite – geared to meet operability needs

Nokia Siemens Networks has introduced specific central SON capabilities to NetAct Configurator and NetAct Optimizer. Both are proven tools for automating network configuration and optimization. Repurposed for this application, they interwork and align with OSS-based optimization loops.

These tools, employed centrally, also handle multiple radio access technologies (MultiRAT) such as GSM, WCDMA, and the like. NetAct Optimizer is MultiRAT-enabled from day one, so it can optimize LTE and GSM/WCDMA, jointly and efficiently. With no 3GPP standards in sight, multiple technologies could pose a real challenge for efforts to build purely distributed architecture.

The entire SON Suite is engineered to connect central and distributed intelligence, and promote effective interworking.

A policy control engine called SON Workflow Coordinator has been implemented specifically for this purpose. As the name suggests, this central entity harmonizes workflows for predefined SON optimization tasks. It also adapts to mobile operators' internal workflows, and introduces dedicated SON control functions such as enable/disable and stop-points to facilitate human interaction.

No additional or separate platforms are necessary to perform SON functions.

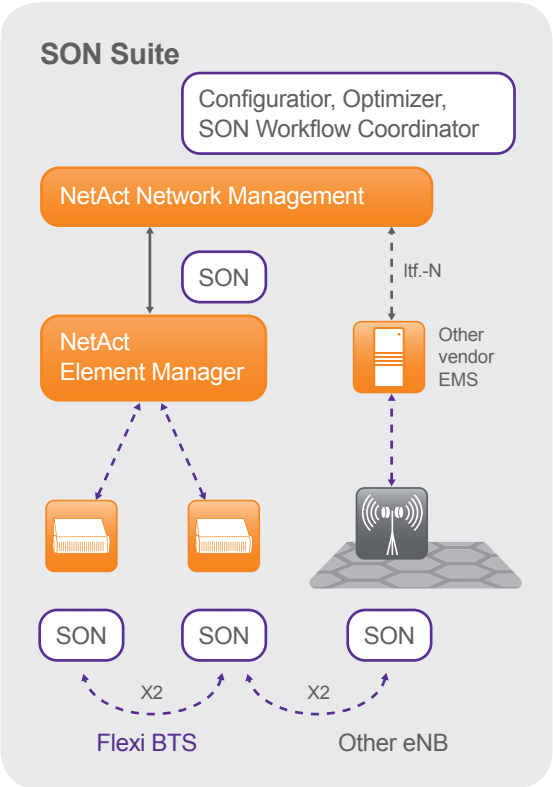

Figure 12: The Nokia Siemens Networks SON Suite architecture

A 3GPP-compliant northbound interface weds SON to other OSS systems, making that vital multi-vendor connection.

Distributed architecture, engineered to strike an optimum balance, supports today's specified SON use cases, and is flexible enough to accommodate tomorrow's. What's more, it affords the network operator total control over automated functions, which goes a long way in gaining operating staff's confidence in SON.

6. Conclusion

SON is designed to leapfrog to the next level of automated operation with the twin aims of improving network quality and driving down OPEX.

Various self-configuration, optimization, and healing functions cater to specified SON use cases, bringing big benefits to a wide range of operating scenarios.

While standardization efforts will assure the necessary interoperability, the real power behind SON performance is architecture and algorithms. This challenges vendors to turn up viable implementations and efficient, robust SON functions – and it affords them many opportunities to differentiate their offerings.

Indeed, the lack of a clear-cut implementation compels vendors to persist with rigorous research. Promising results have been achieved in SON simulations, indicating its potential for boosting operating efficiency.

As a leading provider of telecommunication infrastructure, Nokia Siemens Networks engages intensively in all areas of SON.

The Nokia Siemens Networks SON Suite features an efficient, future-proof architecture. Featuring SON-enhanced O&M, a dedicated Workflow Coordinator, robust algorithms, and multi-technology capabilities, this implementation meets operability requirements and satisfies the diverse demands of different use cases.

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Glossary

3GPP	3rd Generation Partnership Project
AMoRE	Advanced Mobile Radio Real-time Experience
ANR	Automated Neighbor Relation
BTS	Base Station
DL Tx	Downlink Transceiver
EMS	Element Management System
eNB	evolved Node B (LTE BTS)
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HO	Handover
ICIC	Inter Cell Interference Coordination
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
MultiRAT	Multi Radio Technology
NGMN	Next Generation Mobile Networks
OPEX	Operational Expenditure
OSS	Operations Support System
QoS	Quality of Service
RB	Resource Block
SON	Self-Organizing Network
WCDMA	Wideband Code Division Multiple Access

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