WHITE PAPER

LTE Operations and Maintenance Strategy

Using Self-Organizing Networks to Reduce OPEX

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Long Term Evolution (LTE) provides greatly increased wireless bandwidth, enabling a number of new broadband applications such as high-quality mobile video and wireless online gaming. A key challenge for each LTE operator is to provide these new services in a high-margin, cost effective manner. To meet these cost constraints, Capital Expenditures (CAPEX) for the new LTE infrastructure and Operational Expenses (OPEX) associated with operating the LTE infrastructure must be carefully controlled. While controlling CAPEX costs remains an important issue for mobile operators, OPEX costs have become a more significant part of operators' cost structure. Operators have made excellent fundamental operations and maintenance a hurdle to the adoption of LTE technology. This paper will examine how the operations and maintenance strategies for LTE infrastructure management must be changed in order to meet the OPEX expectations of LTE operators.

A typical OPEX breakdown is shown below:

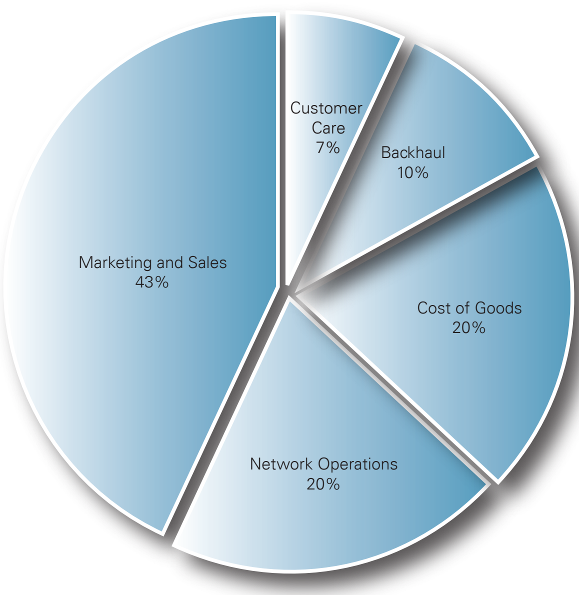

Figure 1: Typical OPEX Breakdown (source: Yankee Group)

OPEX-related costs generally become a greater portion of the overall spend as the network matures. 3G technologies have shown that network-related OPEX costs, averaged over the lifecycle of the product, are ~30% of the total costs associated with the network. This includes costs related to backhaul and network operations and maintenance. This portion of OPEX is directly influenced by the solution provided by the infrastructure vendor, and is the focus of this paper.

OPEX Drivers for LTE

Since backhaul and operations and maintenance are the key OPEX drivers influenced by infrastructure vendors, a significant driver in LTE is to reduce the cost in these areas. Current 3GPP/3GPP2 operators are striving to introduce an LTE network with little or no increase in operations and maintenance staff. This implies the following:

- LTE operations and maintenance must fit into the existing operations and maintenance workflows, allowing the same staff to manage LTE and legacy technologies.
- LTE operations and maintenance must have a greater degree of self-management. Existing 2G and 3G networks already tax the ability of operations and maintenance staffs to monitor, repair, optimize, and expand the legacy networks. If LTE equipment has the same management characteristics as 2G and 3G network infrastructures, existing operations and maintenance staff will be overwhelmed and the LTE operators will be forced to hire additional operations and maintenance personnel.

Given the consensus among vendors and operators that OPEX costs associated with infrastructure must be decreased, a significant push has been made in the LTE standards to change the operations and maintenance paradigm. The Next Generation Mobile Networks (NGMN) Alliance and 3rd Generation Partnership Project (3GPP) have standardized a set of capabilities known as Self-Organizing Networks (SON). SON will revolutionize the level of automation in operations and maintenance and significantly decrease the OPEX associated with operations and maintenance.

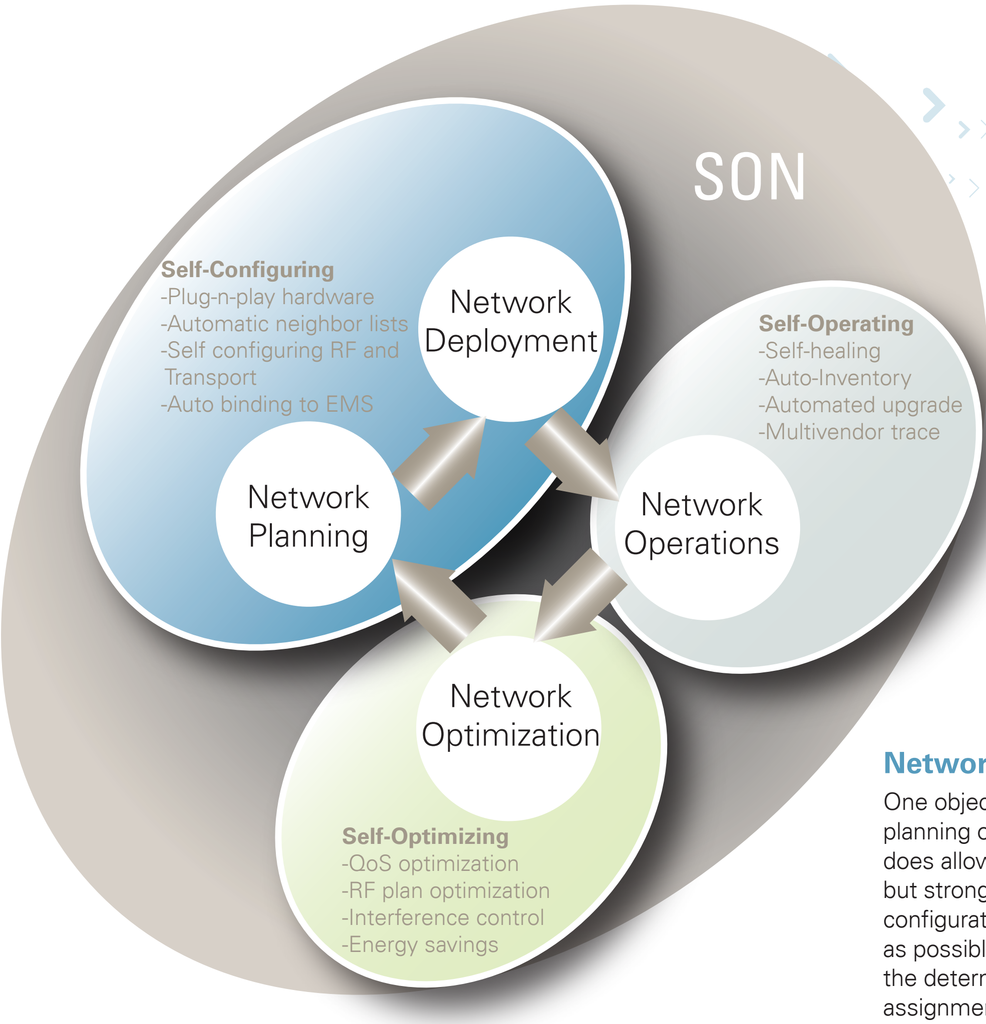

Figure 2: The Self-Orgainizing Network (SON)

Self-Organizing Networks

Telecom service providers have long desired infrastructure that is self-configuring, self-operating, and self-optimizing. Wireless telecom providers want BTS infrastructure that deploys quickly with no specialized technician expertise, automatically discovers its neighbors, automatically reconfigures around network failures, and automatically optimizes its radio parameters. In addition to this, backhaul and interconnect should be automatically configured, and QoS should be self-established and autonomously optimized. These capabilities, along with many others, are the vision of the Self-Organizing Network (SON).

SON is defined as a set of use cases that cover the entire network lifecycle: planning, deployment, operations, and optimization. SON is designed to be a multi-vendor solution, with standard interfaces utilized at key points to allow inter-operability between vendors. Some SON algorithms are not standardized in order to allow for differentiation and competition between the infrastructure vendors.

The key SON capabilities are outlined in the following sections.

Network Planning

One objective of SON is to eliminate as much pre-planning of network configuration as possible. SON does allow for pre-planned network configurations, but strongly encourages as much of the network configuration be automatically generated / discovered as possible. SON is driving into the network elements the determination of neighbor lists, automatic assignment of physical cell ids and RF parameters, and other typically pre-planned configuration.

Some key aspects of network planning, including IP address strategy and an initial QoS setup, will still require network planning in the initial stages of LTE.

Network Deployment

SON will radically change deployment times and procedures, especially in the deployment of an eNB. SON, as defined by NGMN and 3GPP, proposes a streamlined eNB deployment model, as outlined below:

- The eNB will support complete plug and play capability – no provisioning of hardware resources is required. Inventory information is automatically recorded and reported.
- The eNB will algorithmically compute its physical cell ID through communication with neighboring eNBs.
- The eNB will determine its neighbors with the help of user equipment. It will continue to optimize and refine this list in real-time, discovering new neighbors and deleting stale neighbors.
- The eNB will automatically determine and continually optimize its RF parameters, including antenna tilt, power output and interference control.

- The eNB will automatically setup its transport capabilities, establishing contact with the Element Management System (EMS), Mobility Management Entities (MME), etc.
- The eNB will support a complete self-test of itself, allowing the technician to easily verify operation of the eNB after installation.
- Upon connection to the EMS, the eNB will automatically authenticate itself into the network and update to the correct version of software, if necessary.

SON supports the pre-commissioning of network elements prior to deployment, further simplifying the network element deployment task.

Network Optimization

Perhaps the greatest reduction in OPEX will occur in the area of Network Optimization, which tends to be an ongoing task that is performed over the life of the network as new equipment is deployed, usage patters change, etc. SON optimization will provide:

- Automatic neighbor optimization, including the discovery of new neighbors and deletion of stale neighbors.
- Automatic interference reduction, including coordination of sub-tones and power levels across eNBs.
- Automatic handoff optimization, including monitoring KPIs to optimize intra/inter-RAT handoffs by iteratively adjusting target C/I and RSSI.
- Automatic Transport QoS optimization, including monitoring KQIs to iteratively adjust QoS configuration.
- Automatic energy savings, by examining service loading trends and determining when equipment can be powered down without adversely affecting service.

Network Operations

SON will significantly minimize the level of monitoring and adjustment required by the operations staff. In addition, multi-vendor troubleshooting capabilities will ease isolation of those problems that do require further investigation. SON operations will provide:

- Complete and standardized inventory reporting of all components from all NEs.
- Robust cell outage detection capabilities for latent faults.
- Integrated cell outage compensation capability that automatically reconfigures surrounding cells to offset the effect of a failed cell.
- First and second order root cause analysis and recovery of faults.
- Real-time PM data to verify service capability after a repair or reconfiguration.
- Multi-vendor subscriber and equipment trace, to aide system troubleshooting.

Operations and Maintenance Capabilities as a Differentiator

While much of the LTE operations and maintenance capabilities are specified in the standards, there is still significant room for differentiation between vendors. SON allows for differentiation in the area of optimization algorithms and in the accuracy and efficiency of the SON solution. SON also presents some key challenges that allow further differentiation.

Establishing Trust

The SON solution must allow the user to establish trust in the automatic network solution; initially, the SON solution should allow the user to review proposed changes prior to deploying them.

Chatter / Ping-Pong Effects

The SON solution must ensure there is no "chatter" or "ping-pong" effect in the automated optimization solutions; it is important that the automatic optimization algorithms created for SON avoid creating ping-pong configuration changes between network elements, or unnecessary chatter to the management system.

Convergence

The SON solution must establish a SON convergence heuristic, during which the network will focalize to a steady state. When SON is first enabled the operator could be flooded with notifications until the algorithm has reached steady state. It's important that a convergence period be defined to allow SON to reach a steady state without excessive notifications to the operator.

User Guidance

Finally, the SON solution must provide operator guidance of SON. While SON is intended to be an automated solution, it is important that the operator has controls over the SON solution.

Infrastructure vendors must address these issues as part of their LTE network operations solution. Motorola, for example, has developed the following capabilities to address these issues:

- *Review Mode* for SON, where the operator first reviews proposed changes before they are deployed. The operator can accept or reject any of the changes while in Review Mode. Once the operator has gained confidence in the SON algorithms and implementation they can switch SON to *Automatic Mode,* where changes are applied locally by the NEs and in real-time. In Automatic Mode, the operator can view the changes applied by SON at any time, and run reports to view all changes made by the SON algorithms.
- Integration of ping-pong / chatter elimination in its SON algorithms.
- Convergence heuristics for each applicable SON use case.
- Operator controls over SON, including the selection of Automatic or Review mode on a per-use case basis, the ability of the operator to enable/disable SON on a per-use case, per NE and/or per SON attribute basis. The operator can also control the allowed variation in the Motorola SON algorithms.

Getting It Right for LTE

The Importance of Understanding Operations and Maintenance Workflow

In order to reduce OPEX, it is important that the changes introduced by SON complement the existing operations and maintenance workflows. SON should simplify or eliminate existing workflows, fitting into the current workforce management tools of the service provider, rather than creating new workflows that must be managed and staffed separately. No matter how efficient new SON workflows could be, creating an entirely new operations and maintenance staff for LTE is a losing proposition.

In order to ensure SON capabilities don't create new technician workflows, infrastructure vendors must have a clear understanding of the service providers existing workflows. Motorola, for example, has invested thousands of staff hours in interviewing and observing its customers operations and maintenance. Motorola then worked interactively with its customers at profiling the workflows. Once Motorola gained a thorough understanding of the workflows, these workflows were formally modeled and are now checked as part of any new operations and maintenance deliverable. All SON capabilities will operate within these workflows.

The Importance of Experience in Self-Organizing Networks

Self-organization of any network is a complex task. Self-organization of a wireless broadband network is even more challenging. Infrastructure vendors need experience in building and deploying automated networks. Vendors must assure service providers that the SON solution is mature on Day 1, and that the initial deployment will not be a field test of the SON capability.

To this end, Motorola has heavily invested in automated network technology. Motorola established its Autonomics Research Laboratory in 2005 to enable self-configuring, self-healing, self-optimizing and self-protecting infrastructure, and hired industry experts in the field to lead this effort. In 2006, Motorola created a new operations and maintenance architecture based on SON, and established this as the standard architecture for operations and maintenance across the corporation. The first delivery of Motorola's SON-based management system and agent technology was completed in 2007. LTE will utilize release 3.0 of Motorola's SON-based management system and agent technology.

Architecture implications of Self-Organizing Networks

The introduction of SON presents a number of challenges to the operations and maintenance architecture. The real-time SON functions can be implemented using either a centralized or distributed architecture approach.

Centralized Architecture Approach

A centralized architecture approach can be used for deploying real-time SON functions, such as Automatic Neighbor Relations and Automatic Physical Cell ID. In this approach, the EMS is the key decision maker in the real-time SON functionality. This centralized approach has significant disadvantages.

In the centralized approach, the EMS is key to SON decision making and therefore becomes critical to system operation. If the EMS is down, no deployments, SON neighbor updates, or SON RF optimization can take place. The EMS must also handle large amounts of data in order to make the localized SON decisions across the network. As the network expands to thousands of eNBs this task becomes more burdensome on the EMS and is also exposed to the operator. Since decision-making is in the EMS, localized convergence is not possible; all data must be forwarded to the EMS, creating burst issues as SON algorithms at the network elements converge to a steady state. Chatter and ping-pong issues must be resolved at the EMS, further compounding the messaging and computation load on the EMS platform.

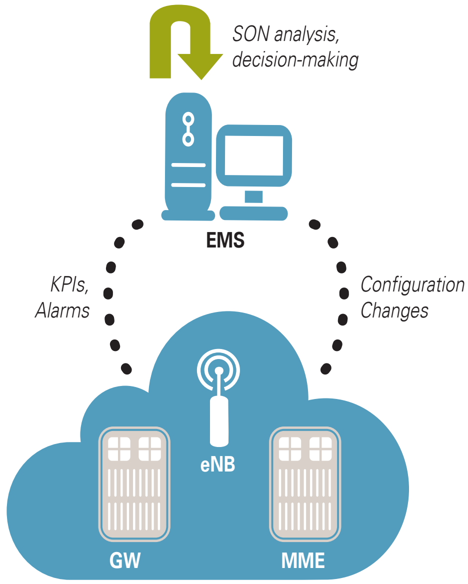

Figure 3: Centralized SON Approach

EMS-based SON functions also discourage multi-vendor networks and open network element interfaces. Multi-vendor SON capabilities within the same geographic region become very difficult, if not impossible, since the 3GPP itf-S interface is not standardized.

Another ramification of the centralized architecture is network-level SON changes must be introduced as a large set of individual micro-configuration changes, as opposed to policy directives that guide localized changes.

Finally, due to the volume of data and computation required at the EMS, the EMS can become a bottleneck for SON changes, introducing significant latency in the commitment of automatic SON changes.

Distributed Architecture Approach

SON is designed as a distributed technology. The SON use cases attempt to push SON functionality as far to the edges of the network as possible. A distributed architecture approach will yield better results for SON.

The distributed architecture leverages smart, autonomous network elements with local SON decision making. This reduces the complexity, footprint and availability requirements of the EMS. It also allows for local convergence, reducing EMS and operator load. The network element SON algorithms can hold back notification to the EMS until they determine they have reached steady state. Local SON decision making also allows for local control of ping-pong and chatter issues, reducing EMS and operator load.

The distributed architecture also enables open interfaces to the network elements by isolating the real-time SON capabilities within the network element. This simplifies support of multi-vendor SON in a single geographic area.

Another advantage of distributed SON architecture is that network-level SON changes can be introduced via policy changes at the network elements, instead of configuration changes. Since the network element understands real-time SON and contains the real-time SON algorithms, updates to the algorithms or to the user guidance capabilities are pushed as policy changes instead of micro-configuration updates.

Finally, the distributed SON architecture provides real-time performance in automatic mode. Changes are applied locally in real-time; the EMS tracks all changes so the user is always aware of the updates that have occurred in the network.

One of the biggest factors in the success or failure of SON is whether the network architecture is designed to support an autonomous, adaptive system. A distributed architecture is better positioned to deliver a successful SON solution. Motorola's SON architecture is distributed, with smart, autonomous network elements making local SON decisions based on a policy-based management scheme.

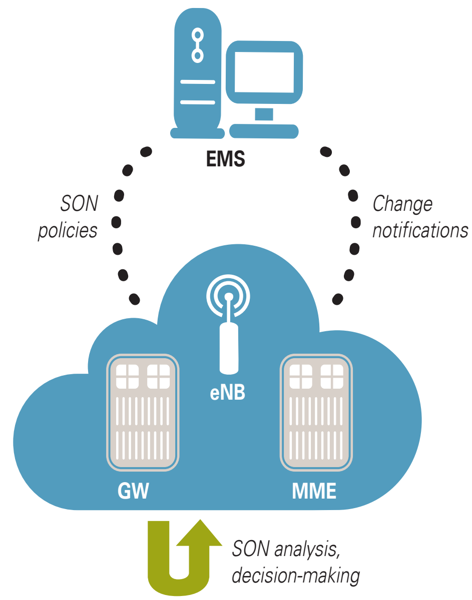

Figure 4: Distributed SON Architecture

Consistent Operations Approach

Excellent operability that leads to reduced OPEX costs requires a consistent set of operations mechanisms across all management control points in the network. One of the potential drawbacks to a distributed operations and maintenance approach is that the mechanisms for performing operations might be unique across the different classes of network elements. This will require increased training for operations personnel, and also increases the risk of error in carrying out operations tasks. It is important the vendor provide a consistent user experience across all network elements, with common CLI and GUI operations for administering the network elements.

Motorola network elements and element management systems have a consistent CLI and GUI experience. The CLI is based on the de-facto industry standard command line interface.

Bottom line: OPEX Savings

The bottom line in any operations and maintenance initiative is OPEX savings. Will the LTE operations and maintenance strategy deliver OPEX savings? SON can positively address the cost structure associated with LTE operations and maintenance. It also addresses OPEX considerations such as utility costs due to power consumption.

Motorola has done a detailed analysis of the potential operational savings due to Motorola's LTE Operability capability, including SON. This analysis compared the legacy 2G/3G operations workflows with the operations workflows in a SON-based LTE solution. The SON-based solution showed significant OPEX savings compared to the existing 2G/3G operations workflows. The estimated savings are generated from:

- Automation (elimination of tasks, operations efficiencies, and increased value of existing staff).
- Reduced expertise requirement.
- Reduced high-level oversight.

As an example of how the LTE operability paradigm shall revolution OPEX costs, consider the legacy workflow for optimization. The network optimization engineers mine data from the management systems in the network. Optimization tools are either purchased or custom built to analyze the gathered data. Based on both tool and manual analysis of the Key Performance Indicators (KPIs), configuration changes are recommended, scheduled, and manually deployed to the network. These changes are then verified via drive testing, customer complaints, and re-analysis of the KPIs. Finally, this labor-intensive process repeats indefinitely.

Compare this with the automatic SON optimization scenario. In LTE, each network element will autonomously self-optimize, based on iterative examination of its KPIs and by making its own micro-configuration changes in response to its KPI analysis. A centralized, multi-vendor SON function automatically consumes the network KPIs and Key Quality Indicators (KQIs), analyzes this data for macro-optimization changes across the network and automatically pushes these configuration updates to the network. The network optimization engineer is responsible for auditing the SON changes. As trust is developed in the autonomous solution, the auditing function is reduced or eliminated. Similar SON workflow improvements exist for the areas of planning, deployment and operations. In a SON-based solution, workflows are simplified or eliminated, and manual intervention is reduced at all levels in the operations hierarchy.

An estimate of the overall percentage OPEX savings due to Motorola's LTE operability approach was computed based on this analysis. The estimated OPEX savings are shown in the chart at right. Motorola anticipates operational efficiency improvements of 65% to 80% in the areas of planning, deployment, operations and optimization.

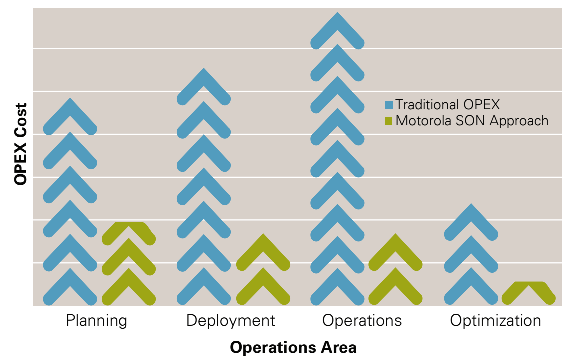

Figure 5: Estimated OPEX Savings with Motorola SON

Conclusion

Second and third generation wireless networks evolved wireless technology but largely left the operations paradigm of first generation networks intact. Unlike these legacy technologies, LTE enables significantly reduced OPEX. To realize these savings, LTE operators should demand a complete SON solution, enabled by a distributed operations and maintenance architecture, along with consistent operations capabilities that can be accessed anytime, anywhere. Due to an improved cost structure, operators that successfully deploy a reduced-OPEX LTE solution will have a significant advantage over their competition.

Motorola's LTE SON solution leverages our extensive expertise in planning, deploying, optimizing and managing commercial OFDM networks, our extensive laboratory work in network autonomics established in 2005 and our leadership in the 3GPP LTE standards to provide operators, an industry leading implementation with early availability of advanced features & leading algorithms.

For more information on LTE SON or to request a SON workshop, please talk to your Motorola representative.

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