Smart Simplicity in radio network management

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Greater emphasis in recent years on simplified network management is in line with other efforts in the wireless industry to streamline operations and reduce costs. Network management encompasses common operator tasks such as planning, dimensioning, deploying, configuring and optimizing a cellular network.

The authors describe the rationale behind this trend and introduce Ericsson's Smart Simplicity concept, which focuses on means of increasing automation in today's increasingly complex networks in order to reduce operating expenses (OPEX). As an example of new automatic features, they describe an RBS deployment scenario that introduces cost-saving functions.

Background

Cellular networks are evolving to yield greater coverage, capacity and more advanced services, such as mobile broadband. In this challenging environment, maintaining control of OPEX is of paramount importance.

Ericsson is firmly committed to simplifying the overall network-management process. Operating expenses are derived from many areas including marketing and sales, customer care, interconnection and roaming fees, and site rentals. An especially large chunk of OPEX is directly associated with network management. Indeed, recent reports state that as much as one-fourth of an operator's OPEX can be attributed to network management.[1]

There are several ways to lower OPEX. Two specific examples are equipment enhancements that allow site co-location and the installation of hardware with low energy-consumption characteristics. In addition, Ericsson is exploring opportunities to simplify the work for operators by enhancing the operations and support system (OSS) to give better observation and visualization techniques.

The focus of this article is on the introduction of automatic features in the network that effectively eliminate certain manual tasks. Ericsson began working with automated features in earnest in the 1990s.[2-5] Some early examples still in the product portfolio are NCS/NOX and FAS/FOX – these are WCDMA and GSM tools that handle neighbor relations and frequency optimization.

Smart Simplicity concept

Ericsson will continue to simplify network operation for operators, in particular, by working on ways to reduce OPEX. Specifically, Ericsson is addressing daily management tasks and minimizing the number of actions associated with major network expansions. One example of these efforts is the introduction of a plug-and-play radio base station (RBS). This solution reduces the time an operator spends on installing and tuning a new RBS to just a few minutes. In addition, a bouquet of supporting functions makes the radio network run more efficiently and with fewer configuration errors. The main components in the Smart Simplicity concept fall into four areas: automation, supervision, visualization, and network extension.

Automation consists of automatic and semi-automatic functions that cover self-configuration, self-optimization and self-healing. Semi-automatic procedures halt to await operator confirmation before executing any changes in the network. These procedures might also propose configuration changes, each of which must be confirmed by the operator before execution. Self-configuration covers the pre-operational state until an RBS has been activated and is serving traffic. Major self-configuration activities are site planning and site installation. Self-optimization and self-healing features take over and run continuously when the transceiver is turned on. Neighbor cell relation management, cell identity management and power tuning are typical self-optimization activities. Some examples of self-healing include remedying disruptive events, such as hardware and software failure in the RBS, or limiting the impact of a poorly functioning RBS in the network.

This article does not focus on the remaining areas of Smart Simplicity, namely supervision, visualization and network extension (Figure 1). These areas relate to the processes of, for example, pointing out capacity problems, producing comprehensive views of radio and transport performance, and of upgrading the network from the time an order is placed until installation takes place. The goal is to make such processes fully automatic.

Smart Simplicity architecture

Successful development of high-level automatic network features is reliant on support from the underlying technology. Automatic features must be an integral part of the system and not an external extension. Otherwise they can never function optimally. Local network features can be employed over standardized interfaces to enable support for multiple vendors and multiple technologies.

Ericsson is convinced that concepts like its Smart Simplicity concept must operate in a multivendor environment. Operators need equipment from a multitude of technical domains with a variety of functionality, from application servers to radio base stations. Also, to manage costs effectively, they must be free to buy products from competitive vendors. Vendors, in turn, want to be free to develop and evolve their products at low cost and with a focus on customer value and innovation.

Finally, network operators must be able to trust or rely on the execution of automatic features. Accordingly, they must be able to

TERMS AND ABBREVIATIONS

3GPP	Third Generation Partnership Project
CGI	Cell global identity
FAS/FOX	Frequency allocation support/ frequency optimization expert
GSM	Global system for mobile communication
NCS/NOX	Neighboring cell support/ neighboring optimization expert
NMS	Network management system
O&M	Operation and maintenance
OPEX	Operating expenses
OSS	Operations and support system
PCI	Physical cell identity
RAT	Radio access technology
RBS	Radio base station
WCDMA	Wideband code-division multiple access
X2	Interface between base stations in LTE

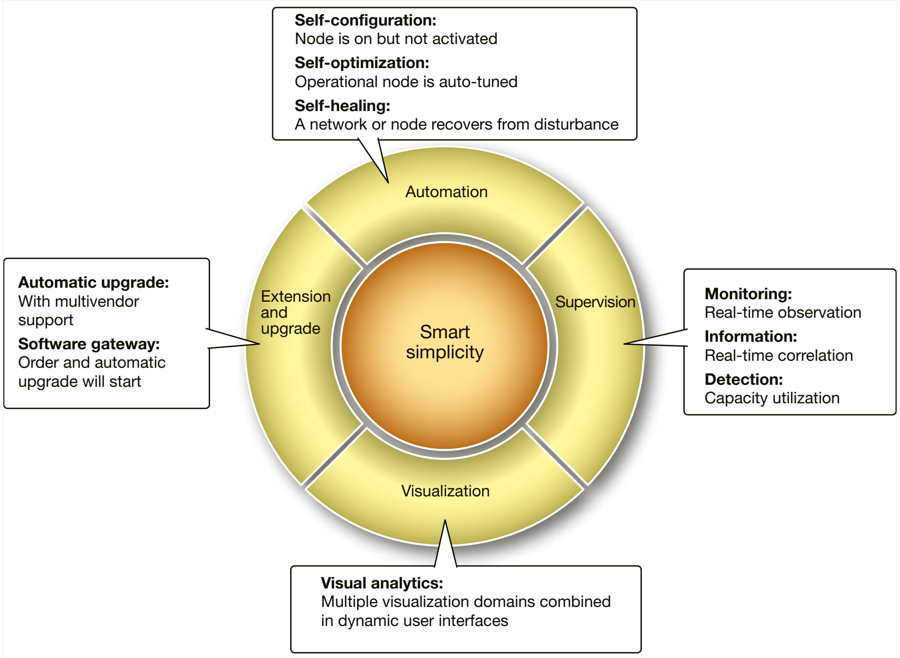
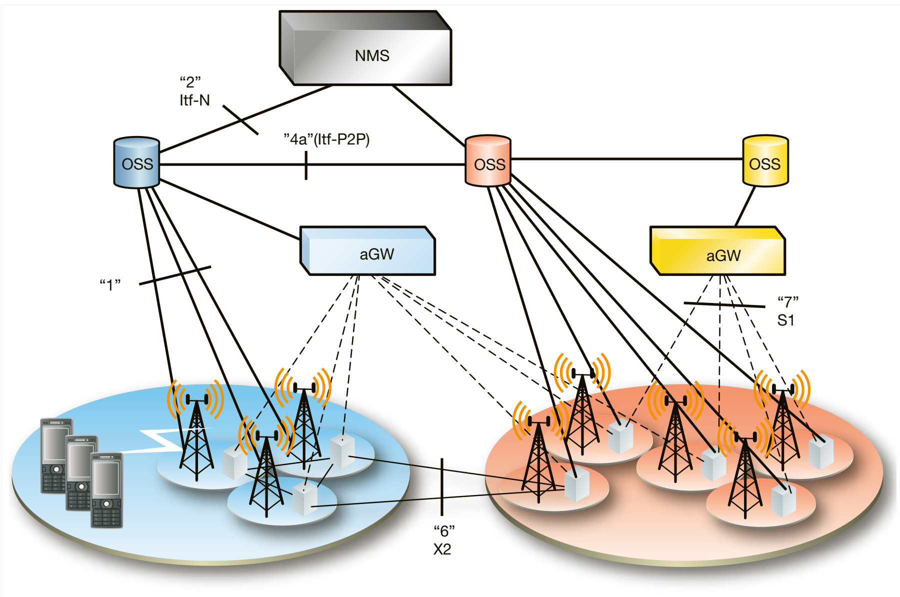


Figure 1
The Smart Simplicity concept.

Figure 2
One example of a network scenario with equipment from different vendors operated via two separate OSSs. Different feature components may be implemented in the RBS, OSS and NMS.



observe the automatic procedures that are running in their networks. O&M personnel might view automatic functions with suspicion or as a threat, believing they will eliminate the need for highly skilled personnel. This is perhaps one of the greatest obstacles to introducing automation. However, good observability and control tools will assist employees in understanding the behavior of the network at a higher level. Therefore, instead of fearing the risk of becoming redundant, they can focus their attention on other more important tasks that help reduce OPEX.

Vendors and operators can benefit from lower costs and shorter time to market (including standardization and product development) by using the O&M interfaces defined in 3GPP. Also, to guarantee interoperability, they should build on existing standardized interfaces between nodes. Doing so will give vendors the freedom to evolve their products in an environment that is open for competition.

As a consequence, the Smart Simplicity concept and its functions do not require any new interfaces or nodes. All functions may thus be deployed in either a management node or in a traffic node (see Figure 2); that is, in the

- network management system (NMS), using the northbound interfaces (2) in the operations support system (OSS);
- OSS, using the eastbound itf-P2P interface (4a); and
- RBS, using the X2 interface (6).

The criteria used for deciding where a function should reside are the round-trip time within which the function must respond and the location of information. Functions at the NMS level are relatively slow with response times measured in hours; functions in the OSS respond in a matter of minutes or seconds; and in the RBS, in milliseconds. In many cases, a combination of two or more node types must cooperate (Figure 2).

Self-configuration scenario

Consider a scenario in which a new site is to be introduced. To begin with, the planning phase can be simplified using default values for most parameters and by setting a few RBS-specific parameters, such as identity and connectivity information. A macro RBS corresponds to significant costs in terms of installation and site planning, which might warrant the extra cost of calculating suitable radio parameters using a planning tool such as TEMS CellPlanner.[7] This step is often omitted for micro RBSs. The site-planning and subsequent deployment phases are followed by the actual installation, with an on-site installer entering initial data (for example, RBS identity) and activating the self-configuring function. From this point forward, everything is handled in a chain of automatic steps. The required data for provisioning the RBS, such as software, license, and configuration, is placed on a central server to which the RBS has access. Once the RBS is connected, it automatically fetches all necessary data and configures itself. Initially, it verifies that the provisioning will be successful. This includes checking that the current installed software is compatible with the configuration. Otherwise it upgrades itself automatically. It also sets up a connection to the evolved packet core network (the S1 interface in Figure 2). Finally, it runs several diagnostic tests. If there are no errors, the installer can leave the site. The entire activity takes less than 15 minutes.

After successful installation, the RBS monitors its performance and traffic load, reporting to the operator when resources become scarce. Provided a hardware update is not required, operators may expand capacity without visiting a site.

Figure 3
Example scenario: A new site is deployed (red) in an area with existing deployment (green). The different colors illustrate the corresponding coverage area per cell.

Self-optimization scenario

After installation, self-optimization functions adjust the site configuration to match the current RBS environment.

In the example scenario (Figure 3), a radio network covers an industrial office environment. The area is primarily covered with macro cells with some micro cells covering parts of a complex where traffic demand is especially high. Although several micro cells surround the buildings, the average user bit rate is still unsatisfactory in certain parts of the area. Figure 3 illustrates the radio network coverage area, and the location of the newly deployed site.

Directly after deployment, the new cells have no knowledge about their neighbors. This is because the neighbor cell relation lists are all empty.

Each cell in the network is identified by a cell global identity (CGI). In addition, to help mobile terminals identify cells, each cell is assigned a physical identification sequence that corresponds to the physical cell identity (PCI). While each CGI is unique, the set of PCIs is limited and therefore non-unique. To avoid PCI planning, the PCIs are assigned to cells at random during deployment.

Now let us assume that a given mobile terminal, served by one of the newly deployed cells, moves closer to one of the micro cells near the office building. It detects and reports the candidate cell to the serving cell. This is a frequent task. Therefore, to save radio resources, the short PCI is used to identify the cell. If the candidate cell is new to the source cell, the mobile terminal is instructed to measure and report the CGI. This way, an LTE mobile terminal can determine the identity of neighboring cells (Figure 4).

The next step is to establish connectivity information about the new cell relation from an address database and to establish an X2 connection between cells (Figure 2). It would also be beneficial to make the neighbor cell relations mutual, and to share neighbor cell relation information with the OSS. Over time, more and more neighbor relations will be discovered as different users use the service in different parts of the cell. To guarantee robust handling of mobility from the very first handover, the activities described above are executed in the RBS; the extra time it takes to create cell relations must not affect handover performance.

Conflicts and ambiguities in the handover reports and neighbor cell relation lists might arise when physical cell identities are assigned randomly without careful planning – two neighbor cells with the same PCI but different CGIs would give rise to such a conflict. However, these conflicts can be detected by an RBS that uses the PCI in

Figure 4
Reporting of a candidate cell, including a subsequent request for CGI measurement and reporting. Specification work is ongoing.

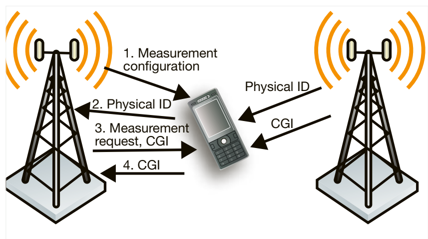


Figure 5
Coverage areas per cell when a new site is deployed with 10 dB less initial power than in Figure 3.

combination with the CGI. Once a conflict is detected, the detecting RBS notifies the OSS, which resolves the conflict. Solving conflicts in the OSS is preferable, because this simplifies the process of replacing a conflicting PCI. Moreover, this process is not time-critical – the RBS can handle the impact of conflicts but with the cost of additional CGI measurements.

Initially, new radio technology, such as LTE, will be deployed as islands in dense areas. Therefore, for mobility, an LTE-capable terminal will rely on additional coverage from, say, GSM or WCDMA. Inter-RAT (radio access technology) neighbor relation support will thus be important in the early releases of LTE. In theory, when deploying LTE in an area that is already covered by GSM, for example, one can "co-site" LTE with GSM. The inter-RAT neighbor lists can thus be generated directly from existing neighbor cell lists. In practice, however, different properties of different RATs make co-siting less attractive. For example, in the scenario depicted in Figure 3, GSM can be used in the macro cells, and LTE can be deployed via the micro cells. A similar procedure (Figure 4) can be adopted to generate inter-RAT neighbor cell lists provided the LTE terminal can measure and report the CGI of a GSM, WCDMA or CDMA cell.

Once the cell relation has been established, handover-optimization functions monitor and control handover performance. Clearly, all new cell relations must work properly, adding net value to the network. Although terminal measurements give the RBS a proper picture of radio conditions, terminals by themselves are not especially adept at supporting good handover performance.

Typical traffic patterns can sometimes resemble a game of ping-pong, with one terminal being handed over back and forth between two cells, which results in extra network signaling. A late handover decision could result in having the handover commend sent at weak signal stregnths, which might cause the terminal (connection) to be dropped.

RBSs, on the other hand, can learn cell traffic behavior from a multitude of terminals in different situations. And they can solve problems locally or in cooperation with the target RBS. More complicated patterns involve more than two cooperating RBSs. One such example occurs along roads where terminals traveling at high speed benefit from skipping a number of cells instead of being handed over in rapid succession to intermediate cells.

Conclusion

Following a long tradition, Ericsson continues the research and development of simplified radio network management under the name of *Smart Simplicity*.

By standardizing mobile terminal support functions in LTE and by introducing smart features in the network, Ericsson is creating advanced wireless networks that require only a minimum of management. The benefits are networks that require less planning and configuration, are faster to deploy, are less prone to errors, and allow a graceful introduction of new sites even during periods of heavy traffic.

Ultimately, the objective is to reduce the operating expenditures associated with deploying and running networks. All the features described in this article have been evaluated in simulators and some will soon be included in products.

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