Technology Digest

Monthly bulletin of telecom technology

Issue 17, November 2012

Telecom Regulatory Authority of India

In this issue

Self Organizing Networks

Current mobile market scenario with dropping average revenue per user(ARPU), competitive pressures and escalating demand for new diversified service ranges is forcing operators to reduce operating expenditure (OPEX), while making investments in new wireless technologies such as LTE /WiMax and implementing solutions such as traffic offloading and convergence of networks. Persistently increasing multi-technology, like2G,3G,4G,WiFi etc, and multi-vendor networks are becoming more multifaceted than ever before and substantial network planning and management effort is required to ensure satisfactory end-user Quality of Experience (QoE). Next Generation Mobile Networks (NGMN) Alliance and 3rd Generation Partnership Project (3GPP) have standardized a set of capabilities known as Self-Organizing Networks (SON), in an effort to decrease configuration requirements of multi-technology infrastructure, reduce O&M associated OPEX costs and improve end-user Quality of Experience (QoE). Self-organizing network is generally taken to mean a cellular network in which the tasks of configuration, operations and optimization are largely automated. These networks will enable operators to simplify network operation and extend their network in plug & play manner. SON brings in the level of automation in operations and maintenance to curtail the life cycle cost through reduction in operating expenditure (OPEX) of running a network, by eliminating manual configuration of equipment during the time of deployment, dynamically optimizing radio network performance and self-healing in case of failure and default in the network during operation.

3GPP initiated the work towards standardizing self -organizing capabilities for LTE, in Release 8 and Release 9. These standards deliver intelligence, automation and management features in the network in order to configure and optimize the wireless networks automatically in varying radio channel conditions, leading to reduction in cost and improved network performance and flexibility. This effort has continued in Release 10,11 and 12 with additional enhancements in each of the above areas as well as in new areas such as allowing for inter-radio access technology(RAT) operation, enhanced inter-cell interference coordination(ICIC), coverage and capacity optimization, energy efficiency, minimization of OPEX, inter-RAT saving management and multi –vendor plug and play connection to the network.[1][9]

Globally companies like Ericsson and Nokia Siemens Networks (NSN) have started delivering SON-capable mobile radio equipment since 2009. According to Ericsson SON features have resulted in 40% faster rollouts, and approximately 90% reduction in daily maintenance for new LTE networks. Likewise, NSN who is using SON to balance network congestion in the radio access network (RAN), have seen a drastic reduction in the number of dissatisfied customers i.e. from 10% to 2%. NSN has deployed SON for Japanese mobile operator KDDI which manages its 3G and 4G networks to ensure that people receive consistent voice and data service irrespective of the network they are using.[3]

According to ARCchart an independent research and consulting firm, the global SON market will grow at a compound annual growth rate (CAGR) of nearly 70% between 2012 and 2017, eventually accounting for $4 billion in revenues by the end of 2017. As per the report full implementation of SON in the network can automate nearly 3/5th of all tasks that is typically performed by a RAN optimization engineer. Additionally, it will help carriers to cope with network configuration challenges by automating the planning and optimization of the network with minimal human intervention, thereby facilitating significant cost savings in both network OPEX and CAPEX.

The report further states, while local factors such a labour costs and spectrum regulation will have an impact on the SON-associated cost savings for each region, a typical Tier 1 carrier, on average, can save nearly 37% in OPEX and 18% in CAPEX in future RAN infrastructure deployments with SON functionality. Additionally, it can also enable energy savings of as much as 3/10th within a carrier network, by dynamically turning off the number of active cells that are under low load conditions. Lucrative cost and energy saving opportunity has made carrier to make investments in SON software solutions, and the market for SON is expected to reach $300 million by the end of 2012. While the SON technology is still in its nascent phase, ARCchart estimates that as many as 80% of all LTE deployments presently utilize SON software, in addition to generic SON features embedded into LTE RAN infrastructure itself.[2]

Increasing prevalence of multi-technology networks like 2G, 3G, 4G ,Wi-Fi etc. and rapidly growing numbers of femto-cells, pico-cells and distributed antenna system(DAS) in the network will lead to more complex and heterogeneous networks in future. This will create significant operational and network complexity for parameters like inter-technology handover; inter-cell interference etc. in addition to increased O&M associated OPEX costs. SON will help overcome these challenges besides offering a better Quality of experience (QoE) to customers by way of optimizing the network performance.

Functionality of SON

The main functions of SON are as follows:

Self-planning

It combines self-configuration and optimization capabilities to dynamically re-compute and optimize the network requirements. Through this functionality SON can lead to improvement in parameters affecting service quality.

Self-configuration

This functionality of SON enables deployment and commissioning of new network elements in plug and play manner. It reduces human intervention thereby reduces cost while ensuring that new network elements integrate correctly into the overall network. The main areas are automated deployment of new base stations, which covers following activities:

Automatic configuration of initial radio transmission parameters

For automatic configuration of initial radio parameters a technique called Dynamic Radio Configuration (DRC) is used which allows the base station to become adaptive to the current radio network topology. The DRC configures a variety of items including the cell ID, initial power and antenna tilt settings, etc.

Automatic Neighbour Relation (ANR) management

One of the major problems for mobile network operators is updating the neighbour cell relationships to facilitate easy handovers. The manual update of neighbor cell relationships become more intricate as the network needs to decide if it can handover to a neighbour cell which is having similar radio access technology (RAT) or having different radio access technology i.e. from 4G to 3G. Therefore, it is essential to have the correct neighbour relationships in place, otherwise this will end in dropped calls as a result of handovers failing to complete correctly.

Self Configuration functionality of SON mitigates above errors by automatic neighbour cell configuration, optimized and up to date lists of correct neighbour lists facilitating number of successful handovers thereby reducing the network load from additional set-ups required for poor handovers.

Automatic connectivity management

This feature enables new base station to automatically connect to its domain management system. There are multiple stages involved in the set-up of the connectivity. First, IP addresses are allocated to new base station to enable backhaul connectivity to be established. The initial security between base station and backhaul connection is established based on use of keys so that secure communication channel is available for data transfer. Initially configuration data to be used is defined as most sites require some pre-configuration data. Subsequently, final configuration and transport parameters are downloaded. Initial security set up is replaced by establishing new security connection based on either Transport Layer Security (TLS) or Internet Protocol Security IPsec).

Self-test

It is done to ensure the correct operation of the equipment prior to activating the services.

Automatic inventory

It is necessary for the SON self-configuration software to perform an inventory check before proceeding further. In order for base station to ascertain its capabilities it identifies as to which hardware boards are fitted, what is the software level, antennas, etc.[11]

Self-optimization

This functionality of SON works in operational stage which starts when RF interface is switched on. The main purpose of this functionality is to fine tune network parameters and dynamically recalculate these parameters in case of network and traffic changes. Optimization of network is based on live measurement. There are a various areas where self-optimisation of the network is undertaken which are as follows:

Neighbour list optimization

Through this functionality a neighbor list can be reconfigured so that the list covers the minimum set of cells needed for handover. The neighbor list can be dynamically updated on the basis of user equipment (UE) measurement reports. For example, newly reported cells are added, and cells with few handover efforts or frequent handover failures are removed from the list. These operations are decided while considering operator's individual requirements which are managed in the Operations and Maintenance Center (OMC) which is the central location in the network for operations and maintenance.

Coverage and capacity optimization

It maximizes the system capacity and maintains appropriate overlapping zone between adjacent cells. The optimum parameter setting is achieved by cooperatively adjusting antenna tilt and pilot power among the related cells.

Mobility robustness optimization

In order to mitigate unnecessary handover and to provide appropriate handover timing, this functionality automatically adjusts the thresholds related to cell reselection and handover. The adjustment is triggered by the related key performance indicator (KPI) degradations and is processed while recognizing the causes of the degradations in the network such as a handover that is too early or too late, or handover to wrong cell.

Mobility load balancing optimization

This functionality 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 is done by using a minimum number of cell reselection or handover without causing the problem of mobility thereby minimizing total investment in capacity by taking into account the different sides of load such as radio load, transport network load and hardware processing load.[5]

Self-Healing

Self-healing capability enables automatic detection and localization of faults and users remain unaffected while repairs are done on the cellular network. There are several self-healing mechanisms which are mentioned below:

Cell outage detection

It ensures that the operator knows the fault before the end user does .It uses a collection of evidence and information to determine that a network element is no longer working correctly. Detection includes active notification in which Operation and Maintenance center (OMC) is aware of the fault.

Cell outage compensation

When it is identified that network elements are not working properly, SON examines 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 fault cannot be mitigated by these activities, the affected cell and the neighbor cells take cooperative actions to reduce user-perceived quality degradation. For example users in an urban area enclosed by multiple microcells are relocated from the defective cell to the normal cells by adjusting coverage and handover associated parameters of the nearby cells cooperatively. This results in minimizing failure recovery time and a more efficient allocation of maintenance personnel.[1]

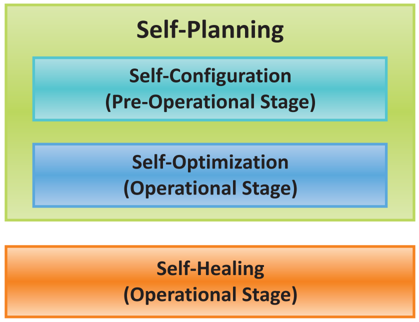

Figure 1 : Functionality of SON

SON Architecture

According to location of execution of SON algorithms, the architecture of SON can be divided into following categories:

Centralized SON

In centralized SON, SON algorithm are executed in the element management system (EMS)/network management system (NMS) which resides at higher level in the architecture. EMS/NMS is the key decision maker in SON functionality. This architecture has certain limitation such as when EMS/NMS goes down, deployments, neighbor updates and RF optimization cannot take place. Moreover, as the network expands to thousands of eNBs (notation for base stations in LTE), this task becomes more burdensome on the EMS/NMS. It also discourages multi-vendor networks as different vendors have their own EMS/NMS. In future, due to data explosion, complex computation is required at the EMS/NMS. As a result the EMS/NMS can become a bottleneck for SON changes by introducing significant latency in the network.

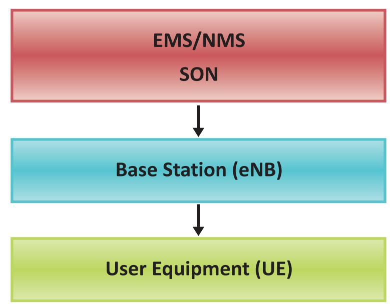

Figure 2 : Centralized SON

Distributed SON

In distributed SON, SON algorithms are executed in eNBs. SON functionality resides in many locations at lower level in the architecture. It provides impetus to its functionality to the distant edges of the network even if the number of eNBs increases. In this architecture, eNBs are equipped with smart and intelligent SON functionality in an autonomous manner leveraging decision making process as well as reducing complexity, load associated with EMS/NMS. It also enables open interfaces to the network elements by isolating SON capabilities within the network element. This facilitates support for multi-vendor SON in a single geographic area.

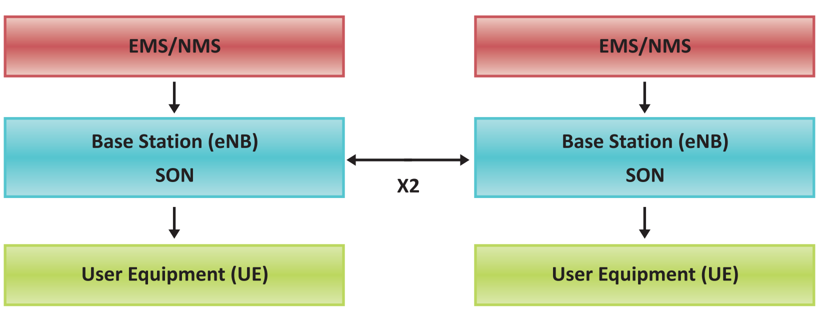

Figure 3 : Distributed SON

Hybrid SON

In Hybrid SON, part of the SON algorithms are executed in the EMS/NMS while others are executed in eNBs. In this architecture simple optimization schemes of SON algorithms are implemented in eNBs and complex optimization schemes of SON algorithms are implemented in EMS/NMS system. Therefore, it is very flexible to support different kinds of optimization cases. It also supports SON features between different vendors through X2 interface. But this architecture is expensive in deployment and interface extension work.

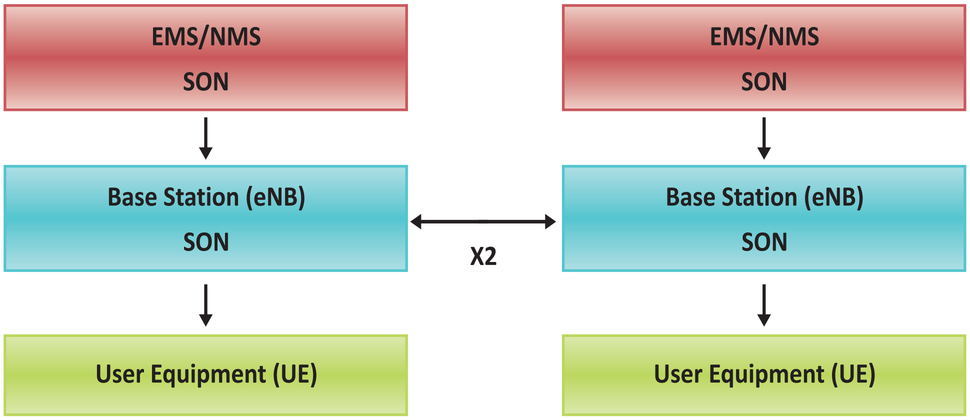

Figure 4 : Hybrid SON

Deployment of SON

In future, due to unprecedented forecasted growth of data, mobile networks may not be able to handle data traffic commensurate to traffic generated. One way to overcome this issue, by way of increasing spectral efficiency, is to serve the traffic nearer to where it is generated, making sure that the available Signal to Interference plus Noise Ratios (SINRs) is always high and the system can function using the best modulation and channel protection scheme at lower transmit power level. Such a paradigm will lead to deployment of a heterogeneous network where a variety of base station transmitters will be used to flexibly accommodate the higher traffic demand in different environments: Home, office, dense hot spots, and isolated high demand areas. The network will comprise of planned macro base station deployments that transmit at high power level overlaid with several low power nodes such as pico base stations, distributed antennas, femto base stations (HNB/HeNB)* and repeaters. Low power remote radio heads (RRH) and Pico cells are connected to the macro base station using a high bandwidth low-latency dedicated connection. These radio heads have autonomous intelligence and act as extensions of the base station antenna ports.

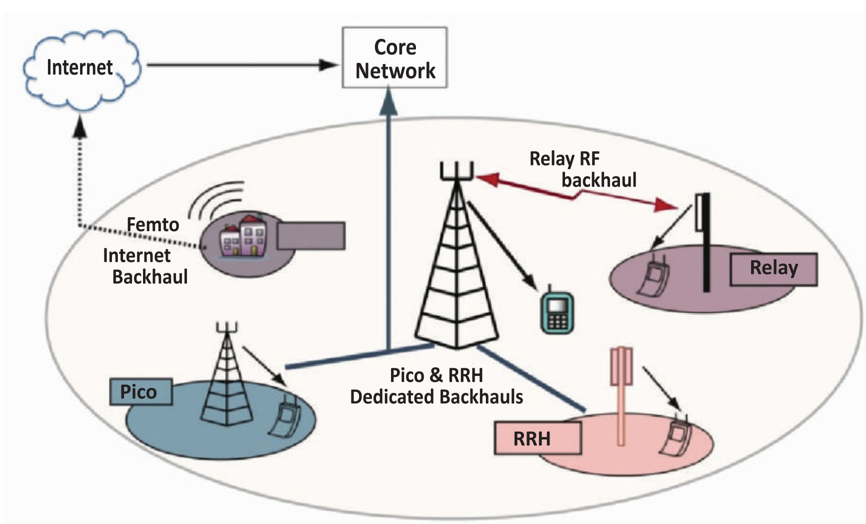

Figure 5 : Heterogeneous Networks

*3GPP refers 3G femtocells as home node Bs (HNB) and where as LTE femto cells as Home evolved Bs (HeNBs).

Implementing SON in such a heterogeneous network environment can help in managing and optimizing the network. For example, SON can take care of automatic neighbor relation (ANR) requirements in which ANR mechanisms can be made aware of the type of base station during the procedure, this allows the system to make appropriate handover between macro and micro cells based on user device speed and cell capacity.

Further, vendors often provide coverage solution networks along with radio access networks in Distributed Antenna System (DAS). However, EMS /NMS are separate for both the networks. Consequently, the performance input from RAN is not readily available to the coverage solution networks. Therefore, the SON benefits are not readily available to coverage solution networks. Moreover, each host eNB may host multiple DAS nodes but is unaware of the hosting relationship. These issues can be overcome by developing a coordination mechanism between coverage solution network EMS and RAN EMS, developing a mechanism that provides a host eNB visibility into whether it is deployed as a DAS network host and facilitates communication between the host eNB and the DAS node(s).[1]

Conclusion

Various studies have forecasted huge growth in demand for data services in the mobile network. With finite amount of spectrum available, operators will deploy various solutions like femtocell, picocell , DAS, as well as Wi-Fi access points in order to drive increase in coverage and capacity. These trends are expected to increase radio access network complexity. Also, there is ever increasing demands upon service providers in the areas of network performance and network operation to provide a better quality of Experience to users. In addition operators are working hard to reduce O&M costs to be able to survive in competitive markets. Traditional network management will become inadequate for managing the growing data volume and network complexity in an efficient manner. SON will be an important tool for operators to improve network management, reduce operational costs, improve user Quality of Experience (QoE) and overall efficiency.

References: There are many to be individually acknowledged, the primary ones are cited here:

1. "Self-Optimizing Networks : The Benefits of SON in the LTE ", 4G Americas, July 2011
2. "Self-Organizing Networks : Market Analysis and Forecasts", ARCchart, November 2012
3. "Expanding SON into the Mobile Backhaul Network", Tellabs, 2012
4. "Self-Organizing Networks(SON) in the 3GPP Long Term Evolution ", Sujuan Feng et al, Normor Research GmbH, May 2008
5. "Self Organizing Networks", NEC Corporation, 2009
6. "Self-Organizing Networks : State-of-the-Art, Challenges and Prespectives", Nicola Marchetti et al, IEEE, 2010
7. "Towards Self-Organizing Networks", Comarch, 2009
8. "Self-Organizing network (SON) : Introducing the Nokia Siemens Networks SON Suite-an efficient, future-proof platform for SON", Nokia Siemens Networks, 2009
9. "3GPP Standards : Self Organizing Networks", Christian Toche et al, 3GPP, October 2012
10. " Self-Organizing LTE/SAE Network-Operator Requirements & Examples" ITG Fachtagung , September 2006
11. www.Radio Electronics.com

Published by: Telecom Regulatory Authority of India
Editorial responsibility: TD Division, TRAI
Contributions, comments and suggestions: tdra@trai.gov.in, tdra.trai@gmail.com