

Scope of Automated Organizing Network in Telecom Industry

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Abstract— Self-Organizing Networks (SON) is a collection of functions to the radio and network components to interact among themselves to configure, tune, optimize and healing of cellular system in real time. It is considered to be a necessity in future mobile networks and operations, due to the increased cost pressure and minimizing trend of human intervention. This paper describes scope, architecture of reference model, evaluations on the use of some of the most important SON components. We also included the application of a revolutionary algorithm; genetic algorithm. The application of this algorithm in telecommunication network optimization has presented and shown with the effective choice of some important parameter values involved in optimization and the implementation strategies. Nowadays mobile networks are getting more complex to configure, optimize and maintain. SON functions will perform to give cost savings and performance benefits from the very beginning of a network deployment to its life-cycle.

Index Terms— 3G, 3GPP, CPICH power, eNodeB, Genetic Algorithm, GoS, LTE, SON, UMTS, UE.

1 INTRODUCTION

SELF-Organizing Networks (SON) are one of the critical factors for the widespread deployment of mobile network technologies. In present time, network complexity has reached the stage at which self-configuring, self-optimizing and self-healing functions are now indispensable for running a modern mobile network. Hence effective operation means the automation of as much network planning, design, build and optimization as possible. It is considered to be a major necessity in future mobile networks and operations mainly due to possible savings in capital expenditure (CAPEX) and operational expenditure (OPEX) by introducing SON shown in Fig.1 This paper considers SON for the 3GPP family (GSM, UMTS, and LTE) as well as Wi-max technologies.

In some recent research of Aircom,[13] they stated that traffic will grow at a 48% CAGR (compound annual growth rate) from 2010 to 2015, from 225PB (Petabyte) per month to 1603PB per month .In developed regions, revenue per gigabyte will fall from USD23.21 in 2010 to USD4.27 in 2015 .Not changing the current business model and cost structure puts in jeopardy the sustainability of the business.

In this situation SON will help us increase the revenue and lower the costs of continuous operation. To be more specific, the main benefits of introducing SON functions in cellular networks are as follows:

- Increases QoS and support.
- Reduced installation time and costs.
- SON brings benefits to all phases of a mobile network

life cycle.

- Reduced Opex due to reductions in manual efforts in connection with monitoring, optimizing, diagnosing, and healing of the network.
- Reduced CAPEX due to more optimized use of network elements and spectrum.
- Improved user experience.
- Improved network performance.
- Dynamic in resource utilization management.

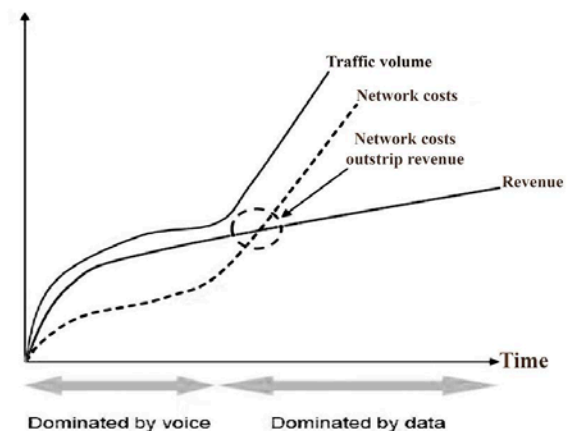


Fig. 1. Network Traffic & Cost Structure.

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2 SON ARCHITECTURE

There are three main alternatives regarding the architecture of SON functions in cellular networks. These are denoted as centralized, distributed, and hybrid architectures, Fig. 2 Different SON functions can be implemented by different architectures in the same network. In this chapter, we briefly describe the three different architecture options and discuss pros and cons

of the different types. [24][22]

This SON architecture has the ability to coordinate centralized SON functions and it can response quickly to changes at network element level.

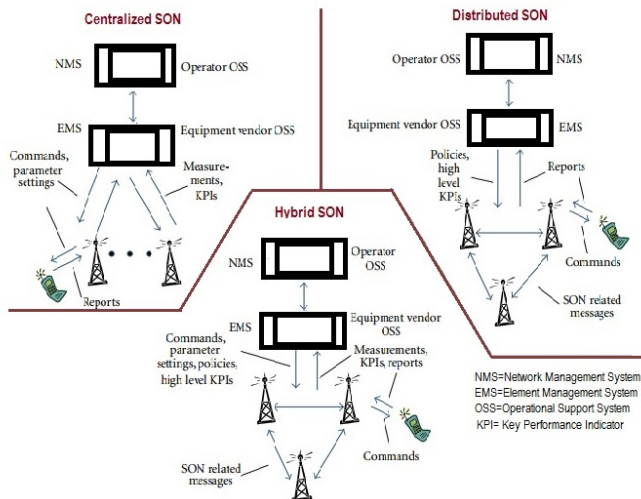


Fig. 2. Architecture of a Self Organizing Network.

2.1 Centralized SON Architecture

In a centralized SON architecture, the algorithms are executed at the network management level. Commands, requests and parameter settings data flow from the network management level to the network elements, while measurement data and reports flow in the opposite direction. The main benefit of this approach is that the SON algorithms can take information from all parts of the network into consideration. This means that it is possible to jointly optimize parameters of all centralized SON functions such that the network becomes more globally optimized, at least for slowly varying network characteristics. In addition, centralized solutions can be more robust against network instabilities caused by the simultaneous operation of SON functions having conflicting goals.

2.2 Distributed SON Architecture

In a distributed SON architecture, the SON algorithms are run in the network nodes and the nodes exchange SON related messages directly with each other. This architecture can make the SON functions much more dynamic than centralized SON solutions, so that the network can adapt to changes much more quickly. It is also a solution that scales very well as the number of cells in the network increases. However, in this architecture, optimizations are done in cell level, which may differs from network level optimizations.

2.3 Hybrid SON Architecture

Hybrid SON works in the network part by part. For example, part of its algorithm executes in network management level and part is run in network elements. This architecture is based on the advantages of centralized and distributed SON systems.

3. EVALUATION OF SOME SON APPLICATION

From an operator’s point of view, where the main issue will be the maturity and possible timing for deploying these features in mobile networks. We will also touch upon possible savings and performance gains by introducing SON but we must admit that the current knowledge is scarce and uncertain in some cases. The SON functions are usually categorized into three main groups; self-configuration, self-optimization, and self-healing. It should be noted that a given SON function can belong to more than one of these categories.

3.1 Self-Configuration

The Self-configuration is a collection of algorithms that aims at reducing the amount of human intervention in the overall installation process by providing “plug and play” functionality in network elements such as the E-UTRAN Node-Bs. [19]. This will result in faster network deployment and reduced costs for the operator. In addition to a more integral inventory management system that is less prone to human errors. Self-configuration system is a broad concept which involves several distinct functions that are covered through specific SON features, such as automatic software management, self-test, physical cell ID configuration (PCI), and automatic neighbour relations (ANR).

The later function is not only used during installation but is also an important part during normal operations.

Some scopes for self-configuration SON:

- Location verification and update.
- Self-configuration system identifier and parameters.
- Automatic neighbor discovery.
- Auto-configuration of physical radio parameters.
- Plug and play of various equipment and self-setup.

3.1.1 Automatic Neighbour Relation Update

Self-organizing network (SON) capabilities are an important feature of cutting edge mobile networks. An automated configuration of neighbour cell lists, technically known as Automatic Neighbour Relation (ANR) function, is one of the first SON features successfully deployed in commercial telecom networks. [18].By deploying this feature, even for light user densities, the network attains good handover performance within the first couple of hours. Without the Automatic Neighbour Relation (ANR) function, network planning data has to be used to determine the neighbour cells.

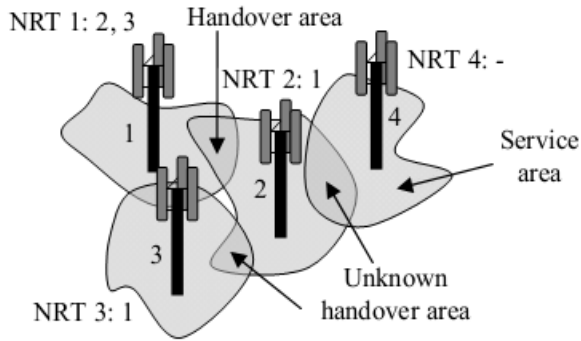


Fig. 3. Significance of Automatic Neighbour Relation.

Here we are considering eNodeB (enhanced nodeB) for LTE technology, shown in Fig. 3 Operator's engineers would have to manually download these neighbour relations on the eNodeBs after they have been installed in the field. This procedure is costly and might lead to a sub-optimal neighbour relation configuration, given that the level of detail of network planning data is limited. For instance, it might happen that handovers between a pair of cells occur in a network which could not have been predicted from the network planning data. Furthermore, with the increase of subscriber every time a new eNodeB is added, again a network planning step and manual configuration tasks are required to update the affected NRTs in Fig. 3 The base station maintains a neighbour relation table (NRT) for each cell. Roughly, each entry contains everything the base station needs to know about a neighbour. Cell 1 has a complete knowledge of its neighbours. Cell 2 only knows about Cell 1 and not Cell 3. This may be due to prediction errors as a result of inaccuracies in the signal propagation model and map based data used in a manual planning step. Cell 4 is newly installed cell and is thus it has not any information about its neighbour. A neighbour relation is information that a neighbour cell is a neighbour to an eNB. Each eNB holds a table of detected neighbour cells which are used in connection with handovers. But in the time of network expansion updating neighbour relations is continuous and hectic activity. If the ANR function is active, every active mobile terminal is configured to report discovered cells if their signal strength exceeds a predefined threshold. Thus the system can add necessary neighbour relation automatically and effectively.

3.2 Self-Optimization

Self-optimization functions are aiming at maintaining network quality and performance with a minimum manual intervention from the operator. This function monitors and analyses performance data and automatically triggers optimization action on affected network elements when necessary. [7][1]This significantly reduces manual interventions and replaces them with automatic adjustments keeping the network optimized at all times. Self-optimizing SON functions make it possible to introduce new automatic processes that are too fast, and/or too complex to be implemented manually. This will improve the network performance by making the net-

work more dynamic and adaptable to varying traffic conditions and improve the user experience. Some of the most important self-optimization SON use:

- Physical cell ID.
- Automatic energy saving.
- Inter-cell Interference coordination.
- Mobility robustness optimization.
- Mobility load balancing optimization.

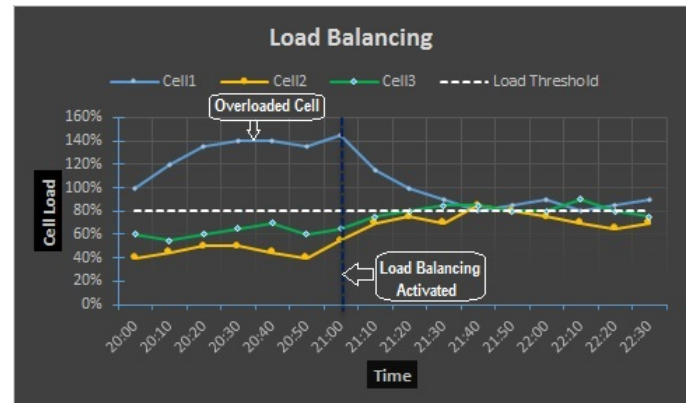


Fig. 4. SON application of Load Balancing.

3.2.1 Load balancing among cells

The objective of mobility load balancing (MLB) is to intelligently spread user traffic across the system's radio resources in order to optimize system capacity. MLB can be used to shape the system load according to operator policy, or to empty lightly loaded cells which can then be turned off in order to save energy. Support for mobility load balancing consists of one or more of following functions:

- Load reporting.
- Load balancing action based on handovers, traffic push between cells etc.
- Adapting handover and/or reselection configuration.

In Fig. 4 three neighbor cells traffic load illustrated. In this case, cell 1 was overloaded, carrying traffic more than 100%. Whereas, cell 2 and cell 3 were low utilized. However, after activation of load balancing some extra traffic of cell 1 has been shared among the other two cells. Thus the system become more stable and all cells loads were around the load threshold. This SON function not only ensures resource's proper utilization but also it provides quality service for the mobile subscribers.

3.2.2 Automatic Power Saving

With the introduction of new access technologies, such as Universal Mobile Telecommunications System (UMTS), High Speed Packet Access (HSPA), and Long Term Evolution (LTE), and with notably rising data volumes in mobile communication networks, operators have to deployed more and more equipment in the field. A typical critical cost for the operator is the energy expense which is unavoidable. Today, the energy demand for a major mobile network is on the order of

several thousand gigawatts per hour per year. [20][14]

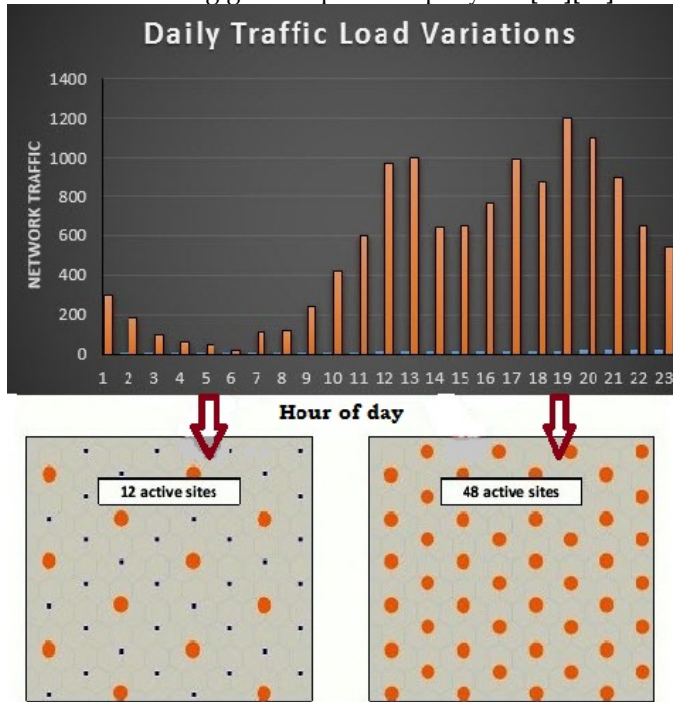


Fig. 5. Illustration of Automatic Power Save.

The objective of energy saving based on switch on/off of a cell. It results cut of operational expenses. To save energy, different strategies can be applied. They differ by their reaction time and complexity with respect to the impact on neighboring cells. From the energy consumption point of view, low loads should be avoided. Instead, two types of mechanisms should be applied to reduce idle and unused capacities. As a first step, all energy-consuming equipment should implement power-reduction mechanisms while operation mode is running, adaptation of the actual load (short-term strategies). Second, the traffic should be reshuffled to a smaller number of highly loaded sectors or processing entities and the others should be switched-off (long-term strategies). However, the coverage and the quality of service must not be degraded obviously. Some of the possible solutions are listed with the deployment of a large number of home eNBs, the energy consumed by home eNBs becomes a big consideration. Since some home eNBs are just deployed for some special time, dynamic activation and deactivation of home eNBs are proposed. The main issues are when to activate and deactivate the home eNBs and how. One solution is cell based and MME (MME is the key control node for LTE access network) involved activation and deactivation. If the transmission power is too high for the deployed area, it can also be reduced without impact on the whole capacity. The adaptation can be based on UE (user equipment) measurements. When power amplifiers and other hardware components are introduced that can be operated at different power levels, or parts of the can be shut down temporarily according to the traffic load, obviously a high power saving potential can be addressed. Fig. 5 shows the potential

energy savings when adapting the power consumption to the actual traffic load. This SON function successfully turn off some active sites when low traffic is monitored in the network. It is estimated that the average base station energy demand can be reduced by at least 50 percent by such methods.

3.2.3 Automatic Tilt Optimization

Antenna tilt is defined as the angle between the main beams of the antenna and the horizontal plane. It is measured in degrees and can have positive and negative values. Positive values mean that the beam is directed downwards, the procedure is called down tilting, and the tilt value is referred to as down tilt. Negative values mean that the beam is directed upwards, the procedure is uptilting and the tilt value becomes up tilt. [12][1] There are two methods by which tilt can be adjusted, either mechanical or electrical. Mechanical tilt implies adjusting the mounting brackets of the antenna in such a way that the whole antenna will be tilted in the desired direction, leaving the radiation pattern unchanged. Electrical tilt is achieved with a phase shifter in the feed network of the individual antenna's elements, which will allow for a uniform modification of the radiation pattern. This is a powerful parameter for optimization of a cellular network as it has the most direct impact on shaping the best-server boundary of a cell and hence on the coverage and interference parameters of the network. In 3G and wi-max networks only by physical optimization almost 50% optimization can be performed. With the advent of Remote Electrical Tilt (RET) antennas, tilt optimization lends itself well to antenna based Self Optimizing Networks (SON). In addition, antenna tilts are the most effective settings in the network to affect both coverage and signal quality, balancing and interference reduction. The adjustments consist in steps of down tilting for the congested cell and uptilting for the neighbours. The first step is down tilting the congested cell, followed by uptilting the neighbours. Since adjustments should be done automatically. Remote Electrical Tilt (RET) will be used. This implies that each base station antennas has to be equipped with a RET module.

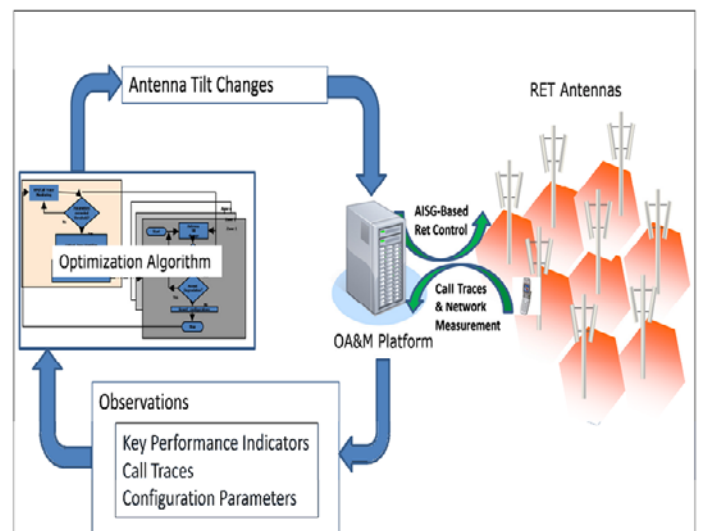


Fig. 6. Illustration of Automatic Tilt Optimization.

The required number of tilt changes will vary depending on the optimization target, i.e. FR (Full Rate) threshold, user location inside the congested cell and the granularity of tilt variations. Also, a trade-off must be made between the duration of the optimization process and its accuracy. Self-optimization of antenna tilt is suited for implementation in a centralized SON architecture, where the SON process resides on a dedicated server. This architecture has the advantage of providing global knowledge of the network, i.e. KPI's from all cells in the network will be gathered and analysed in one location. This is required both for the congested cell identification process and for neighbour cell selection. Once a congested cell is identified, the SON process will send up-tilt and down-tilt commands to the RET controllers of the selected cells. After the first commands are sent, the process in Fig. 6 will wait a defined period of time to analyse the impact of tilt changes and decide if further actions are needed or not. The tilt change is followed by a period of observation of the KPIs and call traces to study the impact of the change and keep evaluating the performance of the Critical Zone. At the end of the observation period, the change in the performance of the critical calls and the Critical Zone is evaluated particularly with respect to the performance indicators that identified the optimization problem and triggered the algorithm. If the performance has improved with respect to these KPIs, another small tilt change is made to the antenna which, according to the performance indicators gathered during the observation period since the last tilt change, would have the most impact on optimizing the Critical Cell and Critical Zone. This iterative process of tilt changes is repeated until an antenna tilt change results in performance degradation as indicated by the performance indicators gathered since the last tilt change.

3.3 Self-healing

Self-healing is a collection of SON procedures which detects problems and solves or mitigates these to avoid user impact and to significantly reduce maintenance costs. Self-healing is triggered by alarms generated by the faulty network elements. 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. It combines configuration and optimization capabilities to dynamically re-compute parts of the network. The two major areas where the self-healing concept could be applied are as follows:

- Self-diagnosis: create a model to diagnose, learning from past experiences.
- Self-healing: automatically start the corrective actions to solve the problem.

Diagnosis model creation based on the experience of already solved problems, using a database with faults and their symptoms. Automatic troubleshooting action can be done without

human intervention. Some scopes of self-healing SON are as follows:

- Cell outage recovery.
- Detection and solve coverage hole.
- Self-recovery of network element (NE) software.
- Interference coordination.
- Self-healing of board faults.

For the time being only cell outage is available in vendor's roadmaps others will come eventually. This SON function has two basic components, namely, cell outage detection (COD) and cell outage compensation (COC). COD uses a collection of evidence and information to determine if a particular cell is not working correctly. However, in the case of complete site failure, SON will be unable to take actions. For the moment the self-healing SON functions are at its initial phase and are not mature and stable, though some use cases have been indicated by the vendors, like cell outage detection and compensation. It is expected that in recent future vendors will be interested to work on self-healing SON and make SON family stronger.

4. GENETIC ALGORITHMS FOR NETWORK OPTIMIZATION

The idea of using genetic approaches for optimization originated from the adaptation in natural and artificial systems. This algorithm has been using in various optimization and machine learning process. For the optimizations of the parameters of a telecommunication network, i.e. UMTS network, especially for the capacity optimization of a given UMTS networks. [4][2] Let's consider two basic parameter of a UMTS network, antenna tilts and CPICH powers. The goal of this optimization process by genetic algorithm is to increase the capacity of the network. Let us consider a term GoS (grade of service), which denotes the ratio of served users over all existing users. [1] During the optimization process, GoS increases from an initial value of 95% until it has reached 100%. However, practical algorithm applies the following approach. When GoS reaches a value of 96%, new users are added to the network until the initial defined GoS 95% is reached again. Initially the value for CPICH power and antenna tilt values are defined randomly. After the initial phase the whole system evaluated by network simulator in Fig.7 In the next step the GoS of the best individual i.e. the set with highest cost value, is compared to the limit of 96%. If the GoS is higher than additional users are added if not it proceeds to four steps of genetic algorithm. The first one is selection of the individuals for the new population. In this case the system selects the best CPICH power and antenna tilt which offers best cost effective output of the network. These values are selected among the cells of that network. After selection process next one is recombination. This process takes account the quality of the cells, i.e. whether a cell is heavily loaded or not. To ensure this a several number of mobiles put to extreme condition and record the data of quality factor. After this the best genes for CPICH power and antenna tilt are taken from the parents of best quality-factor indicating cell. Mutation operator is performed with each individual of the population. CPICH power and antenna

tilt both separately muted with a mutation probability. For example, increase 0.5 dBm power for CPICH and decrease 0.5 degree in tilt or vice-versa. After evaluating the system there comes local optimization. Local optimization consists several processes like coverage shrinking or expanding by using the two given parameters. Thus the algorithm continues until it satisfies the termination condition.

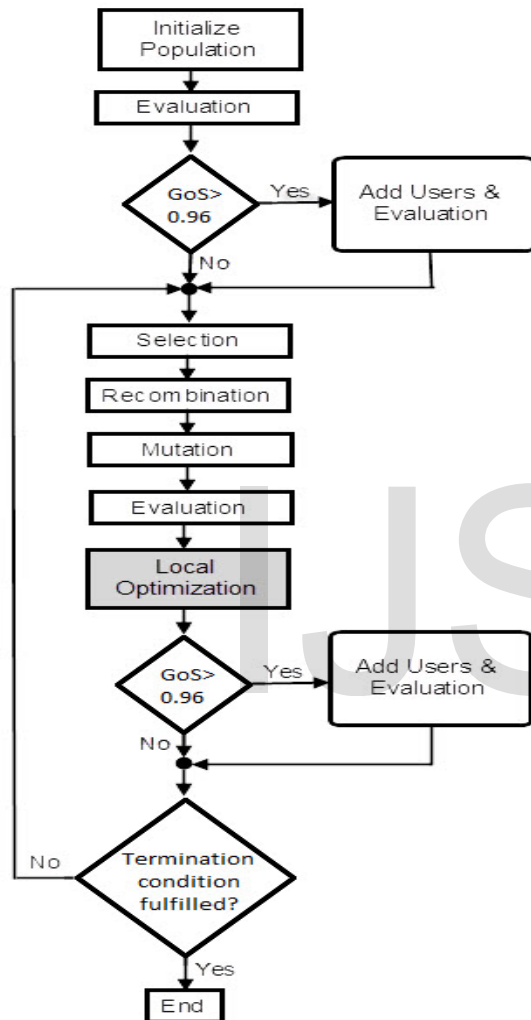


Fig. 7. Flowchart of Genetic Algorithm implementation.

5 SUMMARY

To sum up the discussion in this section we have highlight some of the main features that are important for an operator concerning SON:

- Timing of introduction of SON functions.
- Possible savings.
- QoS and performance improvements.
- Coordination between SON functions.
- Expertise for troubleshoot of SON system.

The self-configuration part of SON are mature and should be included at rollout while most of the self-optimization and

self-healing algorithms are not that important to include at roll-out and could be set in operation in two to three year time when the traffic load have increased. When it comes to possible savings and performance improvements we have only classified according to high, medium, and low since actual percentages will depend on several other factors which are outside the scope of this paper. Another important factor what SON can deal with in the energy save in the telecom industry. Hence reducing the energy consumption is a valuable optimization. We know in all automated system user level interface is always stress-free but it is very challenging when it requires any system renovation. To minimize this problem universal SON features can help to some extent. Moreover, algorithms are always constituted a popular choice. Choosing the perfect algorithm for each optimization is a challenge. Finally we can conclude that adaptability with different network system of SON module will increase its vast uses.

6 CONCLUSION

SON is designed to the next level of automated operation with the twin aims of improving network quality and driving down OPEX. It is therefore important to develop SON solutions for heterogeneous access technologies. This work has already started in 3GPP and for some SON functions. For operators, testing of SON functions will be important. The testing must include a variety of test cases from plain functional testing to large scale testing involving several SON functions where also the stability and interaction between SON components are tested also with high network load. 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. By analysis several alternative solutions may be compared to find optimal configuration of SON. Current centralized SON implementations are relatively simple and require little traffic between the network elements and the network management system. However, as more advanced and dynamic SON functionality are developed, this traffic will increase significantly. Hence, a distributed architecture with more autonomous network elements is expected to be the most future-proof solution for most SON functions. We all anticipate SON research and implementation must dominate next generation mobile network.

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