iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** VIII **Month of publication:** August 2016

DOI:

Volume 4 Issue VIII, August 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Performance Analysis of Self-Organizing Networks

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Abstract: The capacity and coverage area of a radio network will vary due to changed environment, or malfunctioning in base stations. Suboptimal capacity and coverage area leads to the waste of network resources and the lower quality. Reacting on the changed situation manually is very expensive and time consuming. Therefore, 3GPP introduces Self-Organizing phenomenon for self-Optimization and self-healing technologies. Focus is on the self-optimization of LTE network and self-healing.
A generalized framework for performance analysis of SON is presented and discussed. In order to assess the performance of optimisation as a tool for Self-healing, simulations are performed as a comparative process among SON and LTE networks. New approaches to network optimization and management is taken, by "identification of cells and equipments by the continuous monitoring, for the suboptimal ends the transmission power altered depending on the condition. It is an iterative process and monitored continuously . It can avoid human intervention and additional cost for often upgrades and downgrade of configuration".
In conclusion, found that self-healing process can be used to identify cells and user equipments and optimise network. The process show that Self-organization technology can be an effective tool to achieve optimization and reduce operational cost.
KEYWORDS: Self-Organizing Networks; Self-healing; Coverage and Capacity optimization; LTE; 3rd Generation Partnership Project;

I. INTRODUCTION

The increasing demand of the wireless radio networks which are combined with the development of mobile broadband leads to the complex deployments through a high density of base stations as well as a high number of tuneable parameters. This type of deployments will require a high level of operation costs and human resources. The proficient usage of available network resources becomes very essential. In this context, new approaches for network operation and management must
be considered and network optimization becomes an significant tool
The objectives of this work is analysis of performance of self-organizing network by optimising load of overloaded cell and self-healing in the failure of the network by detecting the critical nodes and finding the alternate paths to communicate among user equipments and improving radio frequency range for the user equipments for the critical ones. Performance analysis is achieved by simulation, simulation results shows, system throughput and GoS of Self-Organising network is better than non SON network with lesser packet drop rate. Performance analysis made on simulation of proper network traffic, in views for realistic radio cellular network situations transmission is modelled.
Self-optimization process uses Key Performance Indicators as inputs. There are diverse sources for gathering of information about the condition of network, depending on RAT (Radio Access Technology), such as NodeB or eNodeB, and User Equipment, the Radio Network Controller in the case of UMTS or Mobility Management Entity in the case of LTE. While some KPI's can be vendor specific, there are standardized measurements that are also available[1]. A detailed list of LTE measurements that can be used as a support for SON is given in [2].

II. MOTIVATION AND CHALLENGES FOR INTRODUCING SON

The motivation behind the introduction of self-organizing functionality in mobile networks is both technical and economical. The technical motivation comes from the need to deliver high data rates and the increased complexity of mobile networks [3]. On the economical side, the main driver is represented by operational costs for configuration and optimization [4].
There are different challenges that appear with SON. Operators might be unwilling to give control of their network to a fully automated process, especially when it will control the parameters that have an important impact on network performance. Numerous SON processes can run at the same time and changes can be made by one process might impact another process. Also it is possible that several processes have control of the same configuration parameter. This can result in possible configuration conflict and in this case, coordination between SON processes becomes important[5].

III. SELF-OPTIMIZATION PROCESS

A. SON Architecture

There are three different architectures in which a SON solution can be deployed based on the network element where the SON process resides[3]. These can either be centralized, distributed or hybrid. The choice of architecture depends on the SON functionality that will be implemented. A centralized architecture can be used for processes that require global knowledge of the network. However, delays will be introduced by forwarding and processing all data at a central node. Also, the centralized approach creates a single point of failure in the network and thus redundancy must be considered. On the other hand a distributed architecture can be more responsive, but it loses the ability to make decisions based on an overall network status.

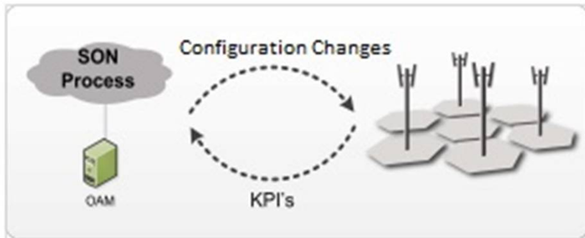

Fig.1. Centralized SON architecture

Self-healing can be implemented in a closed loop centralized architecture (Fig. 1). A global view of the networks performance and configuration is required in order to select cells, coordinate configuration changes and evaluate their impact. Furthermore, the centralized architecture does not require additional functionality at the base stations. Possible delays, introduced by using a centralized approach should be taken in consideration when performing configuration adjustments. However, even with a distributed architecture, these delays will be present to some extend since the impact of configuration changes will not be reflected instantly in the considered measurements.

B. Identification of UEs

The primary requirement for a self-optimization process is to automatic identify the user equipments that experience sub-optimal performance. The identification process depends on the Key Performance Indicators (KPI) and in the case of optimization for network; the KPI's should reflect the congestion due to an increased traffic demand.

Congested user equipment can be identified based on the Grade of Service (GoS) experienced by the users in that cell and the available resources at the base station. The GoS can be used as input in spite of Radio Access Technology (RAT). The definition of resource however will depend on the type of mobile network, e.g. WCDMA, LTE[6].

C. Optimisation process

The identification process should use KPI's, related to the GoS and resource utilization, and collected over a period of time. This time interval is required to establish if a user equipment or cell constantly experiences sub-optimal performance, i.e. congestion and filter out isolated events. A longer testing period will give correct results.

Depending on the interval at which KPI's are collected and averaged, the number of available values will differ. For example, if the KPI's are collected each hour, this will result in 24 values per day and a total of 24 Analysis Period values per cell. A detailed implementation based on the KPI's described in the sections above is presented next.

For every user equipment or cell, at each collection interval, e.g. one hour, the GoS for each service is compared against the threshold for that service. In this way each service can have different threshold values. If the GoS value is below the set threshold, one event is marked at that time for that service. The events are weighted, so that priority can be given to certain services. Each cell will have a number of events for each time interval the GoS was collected. In the last step, the events are averaged over the analysis period, giving a total number of averaged events equal to the GoS collection interval for each cell. For example, if GoS values are collected every hour and the analysis period is 30 days, each cell will have 24 events averaged over 30 days, each representing one hour of the day. The events are calculated as:

$$Cell\_Events = \sum_{i=1}^{N_s} \alpha_i$$

Volume 4 Issue VIII, August 2016
ISSN: 2321-9653

Cells that constantly experience congestion at a given time of day can be recognized by comparing the average number of events to a threshold. For example, if a cell with one service experiences congestion in the same time interval, for half of the days in the analysis period, the average number of events for that time interval will be equal to 0.5. The threshold value should be set according to the number of analysed services and the value of the weights for each service.

When the average number of events in a cell, for a given time interval is higher that the set threshold, the last step in the process is to check the resource utilization in that cell[7]. This is done to make sure that the sub-optimal performance in that cell is caused by congestion and that optimization can be employed. There might be cases when a cell has a low GoS, and thus creates a huge number of events, although the traffic in that cell is relatively low.

D. Optimisation by Transmitting Power

The next step after identifying a congested cell as a candidate for optimization is to select the best power transmitting level to the identified UEs included in the optimization process. The power level will be used to minimise some of the traffic faults in the congested cell. The following selection criteria are used:

1) Enhancements in level of power transmission to connect the UEs
2) Site location
3) Power level orientation
4) Resource availability

At a high level, Optimisation by power transmission can be defined as the process of changing or increasing the level of transmitting power of base station to optimise the failures and keep connecting the UEs to the base stations to avoid the failure, while a call is in progress. This means that the mobile crosses the border between two cells. The number of power transmission iteration to the congested UE gives a first indication on which UE's received power level is below the threshold. There are different decision methods for estimating RF power level transmission and these methods use either by using Received Signal Strength (RSS) measurements or Carrier to Interference (C/I) measurements[8]. The optimisation of network process is based on modifying the best coverage area of the congested cell and user equipments and the power transmission level. Finally, resource availability should be taken into account, to determine if the base station can support additional power transmission to the congested cells and user equipments[9].

IV. SIMULATION MODEL

The simulation model used in this paper considers the variations in received signal power caused by configuration adjustments. Simulation model practiced using Java network simulator. The model consists of few cells, arranged in a hexagonal pattern, with distance dependent path loss and random uniform distributed users. The main simulation parameters are given in table 1.

PARAMETERS	VALUES
Carrier frequency	2 GHz
Bandwidth	5 MHz
Data Traffic	Multimedia services(Voice, Video, etc)
User's position	Randomly distributed
User's direction	1)Static 2)Randomly moved
Max eNBs	9
Max UEs	100

Table 1. Simulation parameters

The users were generated randomly in the coverage area of the target cell (Fig. 2). The process was repeated many times, resulting in different user distributions. Also, the user positions changed randomly between consecutive trials, with a maximum distance (d) of their initial location. The movement can be made towards neighbouring cells or towards the centre of the serving cell.

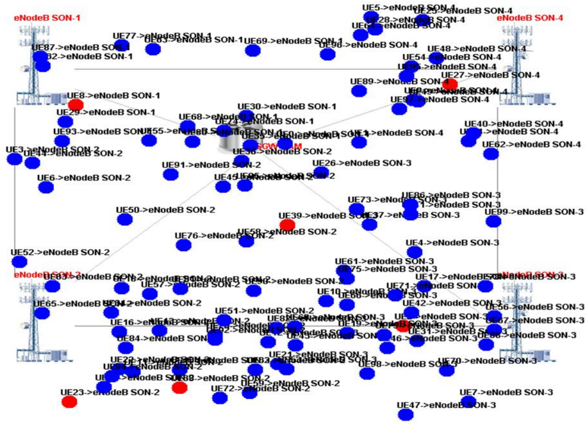

Fig. 2. Cell layout and user distribution

Finally, the results were averaged over all trials.

To capture the effect of configuration changes on signal to interference (SIR) ratio, the downlink inter-cell interference is considered. The SIR for user j, which is connected to cell i, is defined as:

$$SIR_j = \frac{P_{t,i} * \frac{G_{ij}}{L_{ij}}}{\sum_{k \neq i}^{21} P_{t,k} * \frac{G_{kj}}{L_{kj}}}$$

where Pt is the transmitted power, G is the antenna gain between the user and the respective cell, and L is the distance dependant path loss. While this type of interference modelling gives a pessimistic SIR estimation, it will still give an indication on the SIR variations caused by configuration changes, in this scenario[10].

V. RESULTS AND DISCUSSION

The simulations show the different outcomes of the simulation process in respect to the different parameters, beamwidths , throughputs and packet delivery ratio. The results were evaluated in terms of optimisation efficiency.

Fig.3 represents the comparison of Call Success Rate of SON-LTE network to the LTE network. X axis represents the number of user equipments, and y-axis represents the call success rate in percentage. Here the graph shows that the SON LTE gives better call success rate to non-SON LTE network. Fig.3 shows the call success rate for different number of user equipments.

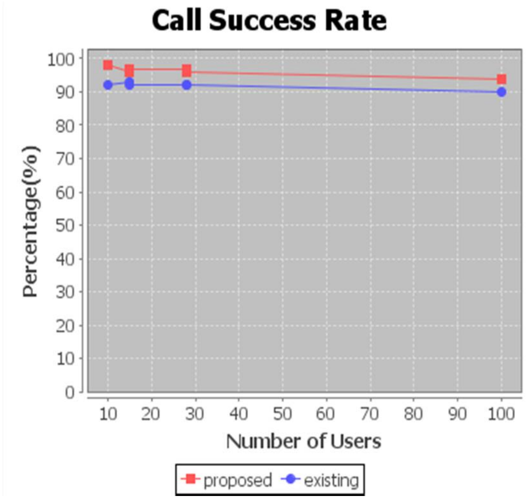

Fig.3. SON function of call success rate

Fig.4 represents the comparison of throughput of SON- LTE network to the LTE network. X axis represents the speed in km/hr, and y-axis represents the average throughput in Mbps. Here the graph shows that the SON LTE gives better system throughput to non-SON LTE network. Fig.4. shows the system throughput graph for different speeds.

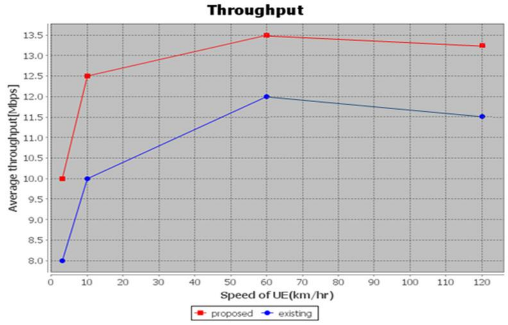

Fig.4 SON function of Throughput

Fig.5 represents the comparison of packet delivery ratio of SON- LTE network to the LTE network. X axis represents the speed of UE in km/hr, and y-axis represents the PDR in %. Here the graph shows that the SON LTE gives better PDR to non-SON LTE network. Fig.5. shows the PDR graph for different speeds.

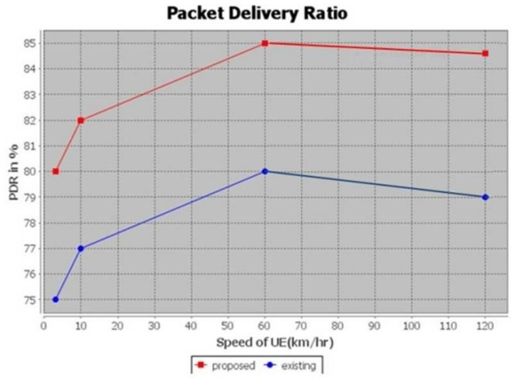

Fig.5. SON function of Packet delivery ratio

VI. CONCLUSION

In this research, Self-healing and optimization by means of self-Organization process can be build. The process should be able to automatically and independently respond to situations where sub-optimal performance is detected, by identifying cells and user equipments. During the peak hours self-healing and self-optimisation could be employed to improve the GoS, A centralized SON architecture was proposed for self-healing by enhancing radio RF power level transmission method for LTE mobile network.

System level simulations for a LTE network were performed, to illustrate the effect of power transmission level to optimise the failure in the network. The results showed that SON self-healing method can achieve a increase in the system throughput, packet delivery ratio and call success rate of an area where user equipments experiences a higher blocking rate compared to LTE network. Simulation studies are performed for best-effort traffic.

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BIOGRAPHY

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