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Self Organizing Network Functions in 4G (LTE)

Madhu Bala, Santram Vashisht, Monika Thakur

Abstract: This paper deals with Self Organizing Network (SON) and its functions which play a very important role in the cellular network. Now a day's networks are getting more complex to configure, optimize and maintain. Manually it becomes very difficult to monitor the number of network parameters of increasing number of base stations in the network. SON provides the solution to network problem without any manual intervention. In other words we can say that SON is used to reduce the CAPEX (Capital Expenditure) and OPEX (Operational Expenditure) of mobile operator. Many SON functions will give cost savings and performance benefits from the very beginning of a network deployment. SON has the self healing capability when any fault occurs in the network. Basically SON module in the LTE network consist of many function called as SON functions such as MRO (Mobility Robustness Optimization), CCO (Coverage and Capacity Optimization), ANR (Automatic Neighbor Relation), PCI (Physical Cell Identity), MLB (Mobility Load Balancing) etc.

Keywords: SON, MRO, CCO, PCI, MLB, LTE.

1. INTRODUCTION

SON functions provide the Self – Planning and Self – Configuration which results in reduction in CAPEX. Also SON functions provide the Self – Optimizing and Self – Healing Operation which results in reduction in OPEX and improve the user experience. Here we have some overview of SON functions. In Figure 1 Network Life Cycle is shown and Benefits of SON functions MRO reduce Network Operator Expenditure and improve the network mobility performance.

CCO is a SON function to self-optimize LTE network coverage and capacity. CCO reduce the network operator's OPEX for coverage planning in the changing environment because radio propagation conditions change after installation of new eNBs, and construction of the new buildings. By self-optimizing cell coverage, network operators can minimize or avoid radio network planning. Reduction of Network OPEX for Optimization as it undertakes Drive Testing with expensive

measurement equipments, Post-Processing of filed measurement data.

ANR is nothing but the NCL (Neighbor Cell List) optimization. In principle, NCL optimization works on closed loop mode operation, but it also provides programmability and configurability for NCL optimization sub-processes via SON server. So, it is up to customer's decision how in-depth NCL optimization intervenes on the network operation. SON server can perform NCL optimization from zero entry to NCL.

PCI function automatically does the PCI optimization where new eNB are introduced. Basically PCI numbers are from 0 to 503 so we have to reuse these numbers in such a way that a cell in its neighbor does not have the repetition of same PCI.

MLB is a function responsible for optimizing the mobility parameter configuration between cells in order to even out the traffic load distribution in neighboring cells. Load balancing allows for a reduced CAPEX and OPEX. MLB realizes the

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uniform distribution of load across all network elements and it leads to less network infrastructure/equipment to support a given traffic model. MLB supports HO parameter auto-tuning for SON and it needs less manual intervention by operator.



Figure 1. Benefits of SON functions

SON is used to facilitate the cellular network, so it lies on the top of whole LTE (Long Term Evolution) architecture.

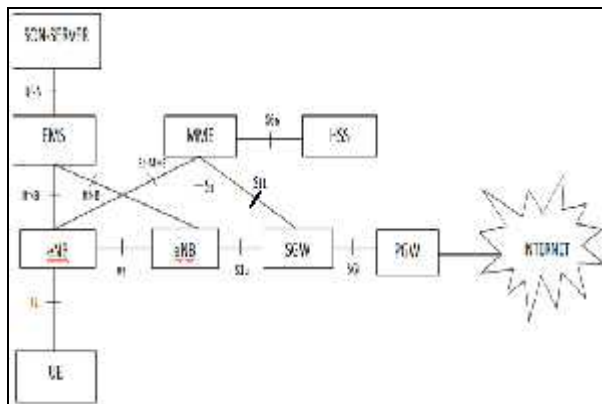


Figure 2. Architecture of LTE Network with SON

2. MOBILITY ROBUSTNESS OPTIMIZATION (MRO)

SON function MRO has the capability to self-optimizing mobility management performance. In other words it reduces the handover (HO) failures during mobility. There are various handover failures such as Too Late HO failures, Too Early HO failures, Ping-pong HO failures, HO to Wrong Cell F failures, HO to Wrong Cell R failures. Sometimes Ping-pong HO also termed as Rapid HO.

Too Late HO: A failure occurs in the source cell before the HO was initiated or during the HO procedure; the UE attempts to re-establish the radio link connection in the target cell (if HO was initiated) or in a cell that is not the source cell (if HO was not initiated).

Too Early HO: A failure occurs shortly after a successful handover from a source cell to a target cell or during a handover; the UE attempts to re-establish the radio link connection in the source cell.

HO to Wrong Cell: A failure occurs shortly after a successful handover from a source cell to a target cell or during a handover; the UE attempts to re-establish the radio link connection in a cell other than the source cell and the target cell. [1]

Ping-pong HO: After successful completion of HO, the UE is soon handed over back to the original source cell.

Rapid HO: After successful completion of HO, the UE is soon handed over to a cell different from the original source cell.

MRO works on a simple logic i.e. 1) It detects the failures; 2) it does the failure analysis, 3) and take the decision of parameter optimization. MRO optimizes the CIO (Cell Individual Offset) Parameter. Either the CIO increased or it is decreased based on the decision.

3. Coverage and Capacity Optimization (CCO)

Coverage and Capacity Optimization (CCO) is a SON function to self-optimize coverage and capacity in LTE networks. It works in the various phases. During measurement phase it collects radio quality information RSRP (reference signal received power) and RSRQ (reference signal received quality) of serving cell and neighbor cells from selected set of UEs by RRC periodic measurements.

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In Basic Monitoring phase it monitors the collected performance maintenance information to detect performance degradation both before and after RF parameter optimization.

In Monitoring phase, it monitors the collected radio quality information and collected relevant PM counters to detect performance degradation after RF parameter optimization.

In Analysis phase it generates ARFQ data, determines lower limit of transmit power and determines whether optimization phase will be executed. The PM counters will be used to analyze cell coverage and performance.

In Optimization phase it estimates the user throughput performance after changing RF parameters, and updates the eNB's RF parameter if performance gain is predicted. So here downlink maximum transmission power will be updated. So downlink power is optimized after taking the decision.

Benefit of CCOpt is to improve the perceived end-user quality of service. Because there is a fundamental trade-off between coverage and capacity, CCOpt can adjust the coverage according to the traffic load.

4. AUTOMATIC NEIGHBOR RELATION (ANR)

ANR function is basically the Neighbour Cell List (NCL) optimization function. NCL optimization function automates optimizing NCL on EUTRAN covering different level of mobility function; Intra-frequency handover, Inter-frequency handover, and Cell Re-selection functionality. NCL optimization functionalities are implemented on eNB, SON Server, and EMS (Entity Management Server). Each nodes work to optimize neighbor relations with minimum or zero intervention of operator's manual actions.

The eNB has capability to fast-track user experience, e.g., handover from source to target cell, so it is suitable to locate an immediate user statistics per cell level such as the collection of measurement reporting from UE. The neighbouring cell's information used on the live network is automatically evaluated by each eNB. The eNB suggests NCL update to SON Server via Entity Management Server (EMS) interface (I.e., Measurement statistics of RRC Measurement Report from UE).

ANR works mainly with three tables first is Neighbor Relation Table (NRT), after applying some rule on NRT we define the subset of NRT which is Neighbor Suggestion Table (NST) and after applying some rule on NST we obtain the NCL, so basically ANR does the NCL optimization. For NCL optimization, SON-S shall create NRT at the start up of SON-S via NRT preparation. The feature of Intra-LTE NCL optimization can be divided into three main functions, such as receiving Measurement Records (MR), updating NRT/NST/NCL, X2 link management. X2 link is between two eNBs.

5. PHYSICAL CELL IDENTITY (PCI)

PCI is a locally defined identifier for eNBs with a restricted range (0 to 503 i.e. only 504 values) and must be reused throughout the network. The PCI numbering of eNBs must locally be unique so that the UEs may be able to communicate and possible perform handovers. If PCI is not unique then PCI collision or PCI confusion may occur. In PCI confusion a cell has neighboring cells with the same PCI. If PCI confusion happens, the eNB cannot recognize a correct cell which UE is reporting for, and handovers to these cells will be deteriorated

In PCI collision PCI is not unique in the area that a cell covers. If PCI collision happens, UE cannot recognize the cell border and call drop will be increased.

The goal of PCI configuration is to set the PCI of a newly introduced cell. The PCI is contained in the SCH (synchronization channel) for user equipment (UE) to synchronize with the cell on the downlink. When a new eNB is established, it needs to select PCIs for all the cells it supports. Since the PCI parameters have a restricted value range, the same value needs to be assigned to multiple cells throughout the network and must be configured collision free, that is, the configured PCI needs to be different from the values configured in all the neighboring cells

In PCI function of SON it detects the PCI confusion and collision and resolves them.

6. MOBILITY LOAD BALANCING (MLB)

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MLB is a function responsible for optimising the mobility parameter configuration between cells in order to even out the traffic load distribution in neighbouring cells. MLB is located in eNB. Load balancing can address situations where load peaks in cells cause a drop in user experience and, in the worst case, call blocking or dropping. Without load balancing, to avoid these problems, the operator would have to provide enough capacity to cater for these peaks, even if the resources are under-utilized much of the time. Load balancing can offer effective use of resources that are already available. MLB will rely on the measurement data received over X2 interface to make a decision on HO parameter setting change. MLB has two main aspects.

Measurements: collection and exchange of internal and external load balancing measurements between neighboring cells.

SON MLB Algorithm: automated method of re-adjusting Cell Individual Offset (CIO) and Hand over (HO) triggers.

7. CONCLUSION

In this whole paper we basically discuss the optimization of various parameters through the SON function. Via MRO function CIO is optimized, CCO function optimize the RF transmission power, ANR function optimize the neighbor cell list, PCI function optimize the usage and re-usage of fixed number of PCI, MLB function optimize the mobility parameter in

order to evenly distribute the traffic load in neighboring cells.

As cellular networks continue to become more complex, and the performance requirements continue to increase, while costs need to be reduced To fulfill these kind of requirement we have to introduce the automated techniques such as SON, self-organising networks in the cellular network.

While they require significant levels of investment, the returns they can provide are even larger. This makes they use in the long term essential for all operators with sufficient funds to deploy them.

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Madhu Bala obtained her M.E from BITS Pilani Rajasthan in Embedded System in 2008. She is having more than 6.5 years of experience in different domains (academic and industrial). Now she is working in DCE Gurgaon MD University as Assistant Professor. Her research interest lies in the Signal Processing and Wireless Communication particularly towards 3G-4G



Santram Vashist obtained his M.Tech from NSIT, New Delhi in Signal Processing in 2006. He is having more than 8 years of experience in different domains (academic and industrial). Now he is working in DCE Gurgaon MD University as Associate Professor. His research interest lies in the Signal Processing and Wireless Communication particularly towards 3G-4G



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