Self Organizing Networks: A Self- Healing Framework

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ABSTRACT *The 3rd Generation Partnership Project (3GPP) initiated successor of UMTS called Long Term Evolution in its 8th release. In its first (8th) and subsequent releases, it included Self Organizing Network (SON) that promises improvements for future wireless network. Fault Management is an important aspect of SON aiming to automatically diminish the fault by triggering appropriate recovery needed and hence satisfy the operator-specified performance requirements as much as possible. This paper aims to present a Self-healing framework and analyzes the various use-cases and control parameters including Physical Channel Transmit Power, antenna tilt and uplink target received power level P_0.*

Keywords: *Cell Outage Compensation, Cell Outage Detection, Long Term Evolution (LTE), Self-healing, Self-Organizing Network (SON).*

1. Introduction

In recent years, the world has experienced tremendous growth in mobile network leading to more complex cellular network which requires huge human effort. Moreover, emerging 5G in few years will increase cost and complexities drastically [1]. These requirements lead to concept of Self Organizing Network (SON).

SON is the key component in LTE network developed by 3rd Generation Partnership Project. It can be defined as the concept of continuously monitoring and making intelligent moves to reduce undesired results [2]. Automation, configuration and optimization processes done automatically instead going for manual work in SON can help to reduce OPEX and CAPEX [1].

There are 3 architectures according to the residing of SON algorithm- Centralized, Distributed and Hybrid. SON functionalities are broadly categorized in 3 types: Self Configuration, Self Optimization and Self Healing.

Self Configuration reduces the amount of human intervention in installation of eNBs(base stations) by providing plug-and-play function. It provide various features such as Automatic Neighbor Relation Configuration, Automatic Software management and Self Test. Self Optimization functions such as Mobility load balancing (MLB) and RACH optimization[3] adapts the network according to the changing environment to improve the network efficiency. Self Healing function does troubleshooting tasks of the performance failures that affect network without any human interference.

2. Self Healing

Self healing is the most critical aspect of SON that deals with automatic detection, diagnosis and correction of the defects occurred. There are four main stages [4] under this-

- Cell Outage Detection- It may be generated by any software or hardware failure or even external failures. Software failures may include channel processing error or radio board failure etc. Power failure, connectivity issues or even misconfiguration are other concerns.
- Cell Outage Compensation- Various corrective steps are taken to compensate the outage occurred like changing the neighboring operational cell's parameters.
- Cell Outage Recovery- If the changed environmental setup recovers the outage; the things go back-on-track. Else, roll-back to their initial settings.

3. Cell Outage Detection

Cell Detection and management forms the major part of Self Healing Framework[5]. Several Key Performance Indicators (KPIs) can be used for detection purposes. To check KPI, neighboring cell communicates with the Network Management System (NMS) through S1 interface. Cell Outage is announced if the observed values are less than threshold values which is then tried to resolve using some Compensation algorithm. The threshold values used are determined by the network operators. There can be other indications too. Decreased cell efficiency, handover abnormality and forced call drops are some of them.

A novel cell outage detection algorithm that is based on the neighbor cell list reporting of mobile terminals[6]. A degraded cell still works but less-efficiently carrying much lesser traffic that lowers

feasibility. As the result, cell is no more visible to neighboring eNBs or user but from network point of view, it only appears empty and still operational. Using statistical classification techniques and already available measurement data heuristic, the algorithm is able to detect most of the outage situations in less time.

3.1 Cell Outage Detection Algorithm

Step 1: Compute long term throughput value and build Key Performance Indicator (KPI) profile in OAM (Operation and Maintenance) Centre individually.

Step 2: INPUT: Various measurements from base station and OAM Centre.

Step 3: OAM keep monitoring e-NODEs and keep exchanging the information and other measurable parameters such as Radio Link Failure (RLF) etc.

Step 4: Compare current value of KPI of enodeB with profile built in OAM

IF(any deviation from profile is encountered)

Trigger alarm, declared cell outaged and start cell outage compensation

ELSE

no action required

ENDIF

4. Cell Outage Compensation

Once the cell outage is acknowledged, cell outage compensation algorithms are used to adjust the parameters of the neighboring cells and to meet the operator's performance requirements. These algorithms are typically iterative processes of parameter alteration and evaluation.

Antenna tilt plays an eminent role in cell compensation. By adjusting antenna tilt with respect to its axis, elucidation is directed further down reducing coverage in more remote location and concentrating energy to the direction of out-aged cell[7]. . This paper presents a heuristic approach for autonomous re-optimization of antenna of the nodes having mutual inference with tilt vector $Ø_t$ and cluster C_j of sector j_t. This increases system's efficiency by 10% and average cell edge efficiency by 5% quantile. This algorithm can be implemented to both centralized and distributed architecture that improves efficiency even up to 100%.

Thus applying antenna tilt changes signal propagation that is determined by the type of electrical and mechanical tilt. Typically, range for tilt angles of these antennas vary from 0to 12based on the vertical beam width and this selection is depended on antenna and site configuration.

The downtilt angle is the balance between other cell's interference reduction and coverage threshold. An optimum downtilt depends on the few factors in which the geometrical factor ($\boldsymbol{\theta}_{geo}$) has the most significance expressed in [6] as :-

$$\boldsymbol{\theta}_{geo} = \tan^{-1}\left(\frac{h_{bs} - h_{ms}}{d}\right) . \qquad (1)$$

where h_{bs} stand for height of base station; h_{ms} stands for height of mobile station antenna and d stands for sector dominance area.

Beside the antenna tilt which is the dominant control parameter in cell compensation, there are other control parameters too that play significant role.

Physical Channel Transmit Power is another control parameter that is used to overcome cell outage[7]. Neighboring cells can extend their service area by increasing their respective Physical Channel Transmit Power. Some neighboring cells also decrease the same to reduce their service area so that interference is diminished.

PUSCH (Physical Uplink Shared Channel) is yet another parameter used in compensation algorithms. Uplink transmit power can be described from target received Power density (P_0)[9]. P_0 is selected as the adjustment parameter because it provides efficient trade-off between coverage and quality for different scenarios. Increased P_0 intensifies the coverage probability in case of outage. On other hand, P_0 allows more remote terminals to connect to a given base station by lowering inter-cell interference level leading to better throughput.

A compensation algorithm is based on HandOver(HO) margin modifications, including the faulty cell and its neighbors[9]. It uses HO which has been earlier used as a part of cell optimization for load balancing whenever congestion occurs.

4.1 Cell Outage Compensation Algorithm

Step I: Initialize

Step II: INPUT:

List of all outaged cell and the control parameters

Step III: DATA STRUCTURE:

Make list of cell to be optimized using neighboring cell

Step IV: do

Select any cell from list and change parameter of that neighboring cell to reduce outaged area

IF(outaged cell is not compensated)

WHILE(new parameter are lesser than threshold values)

set the parameters again to the new values

IF(cell is not compensated)

IF(new parameters exceed threshold limit)

rollback to initial state

goto LABEL1

ELSE

goto LABEL2

ENDIF

ELSE

goto LABEL1

ENDIF

LABEL2: set the parameters again to the new values

ENDLOOP

ENDIF

LABEL1: selected next cell

WHILE(until are cell are optimized)

Step V: IF(and cell is not optimized)

cell is to compensated manually

ENDIF

5. Conclusion

This paper presents SON's healing functionalities and has summarized how different researches used different control parameters for developing their compensation algorithms. An automatic adjustment of antenna tilt [8] is used in the case of outage that substantially reduce network operating cost so the little communication in needed between nodes. To enhance coverage, the split between the reference signal(RS) and physical downlink shared channel(PDSCH) can be adjusted that raises the RS power(PRS)[7], at the cost of reduced PDSCH power and hence it reduce traffic handling capacity. Also, an adjustment combining all these parameters can be used to generate a new algorithm that may get better results enhancing the performance of the system.

6. Future Approach

For outage detection, false alarm minimization is the big issue; future works will evaluate these false alarms by differentiating them with the actual ones. All the different control parameters discussed in this paper for cell compensation motivates further work, generating a new algorithm by collaborating and tuning all such parameters and simulating it on different scenarios.

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