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A New Framework for Self Optimization Networking in Next Generation Mobile Networks

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ABSTRACT — The aim of presenting a self-optimizing model in a cellular network is to maximize network functionality and increase the quality level of the provided services for the users of Macrocell and Femtocell considering limited resources for the access networks. The foundation of our proposed scheme is presenting a self-optimizing model based on neighboring indices by which we can make feasible the possibility of controlling resources and the respective indices relevant to neighboring connections of cellular network without the interference of human force and merely by relying on the network's intelligence. In order to better the efficiency of the intended scheme, we used the Big Data technique to analyze the data and network's better decision-making process in allocating resources. In a way that in the uplink direction, user's data from the user layer to the network core are analyzed in one register and based on semantic information extracted from these data, the decision-making center will be able to allocate resources in a more intelligent way.
KEYWORDS: *Self Optimization Networking (SON), Resource Allocation, Next Generation Mobile Networks (NGMN), Big Data, Automatic Neighbor Relations (ANR);*

Introduction

Widespread deployment of wireless telecommunication networks throughout the world has undoubtedly changed the face of communication in the last 2 decades in unimaginable ways. Due to this reason, standardization and movement toward the advanced wireless networks in order to offer new, better, reliable and high bit-rate services seems to be necessary [1]. On one hand, offering high bit-rate services requires using a more complex architecture of cellular networks as well as using more technical specifications. The increase in the complexity level of these types of networks can be addressed from 2 perspectives of network design and optimization. In this paper, in order to optimize the presented model, in addition to increasing the power of correct decision-making, Big Data technologies have been utilized. Due to the presence of 3 main features of Big Data in cellular networks, challenging Big Data management has been considered pragmatically in a considerable amount. Extraction of useful structured and worthwhile data about the presence of these features requires using advanced techniques of data analysis which enables analyzing big amount of data in a small time slot and extracting meaningful data from a set of useless data. Obtaining a logical relationship between two sets of telecommunication parameters as well as statistical parameters and events can help the cellular network system to better decide on how to use power and frequency and physical resources in the process of handover between different components [2,3].

In order to implement this scheme, we are going to face lots of challenges. We will deal with challenges of this kind in an specific way:

- How to find meaningful relationships among masses of data.
- Necessity of the self-optimizing model to be real-time.
- Modernity of the usage of data analysis methods in optimizing cellular networks.

The structure of this report is in a way that in the first part, an introduction of the outline of the work is firstly stated, the main problem is defined and the final aim is pointed out. In the second part, the proposed models in the field of optimization in multi-carrier mobile networks are presented. In the third part, we also discuss the presentation of the proposed model in which definition and components of the proposed model and an algorithmic assessment of model function are presented. Finally after presenting the results of statistical analysis related to dependability of KPI levels to decision process, conclusion and references will be mentioned.

Related Works

One of the solutions to increase the quality level of the offered service is to reduce the rate of periodical errors during the establishment of connection [4]. Reduction drop rate as well as increasing the rate of successful handover of HOSR can indicate the increase in the quality level of service delivery in cellular networks. In [5], we are dealing with an automatic NCL scheme which has more capabilities compared to similar schemes. In this scheme which is implemented to the core part of the network by adding an administrative register called NMS, the special capability of this scheme in the possibility of network scalability is provided. In [6] the Third-Generation Mobile Networks, the requirements of load distribution in the phase of network design are considered as well [10,11]. The authors in [7] have paid small attention to the degree of transferred power of downlink in addition to the indices which affect the degree of the level of cell's effective coverage. In addition, in the presented scheme in [8], the authors have introduced the Big Data technologies so as to optimize the fifth-generation of mobile networks which despite the high-capability of this technique in the field of new generation of mobile networks, this scheme has been posed as an idea only and the authors haven't posed the output in order to compare with similar schemes. In other schemes that have been presented in 2014 [9], authors have tried to present a self-optimizing scheme in order to optimize the indices of neighbor relation based on coverage of the available gaps in the covered area of the network which despite the presence of positive and efficient aspects in this scheme, has just considered optimization merely in determining ANR and as the algorithms of this scheme show, this scheme can only be used as a solution to increase the level of successful neighbor relations between the cells [12,13].

The Proposed Scheme

The components of our proposed system which contains a self-optimizing scheme based on Big Data are shown in figure 2. In the following, we will briefly deal with describing available parts in this structure.

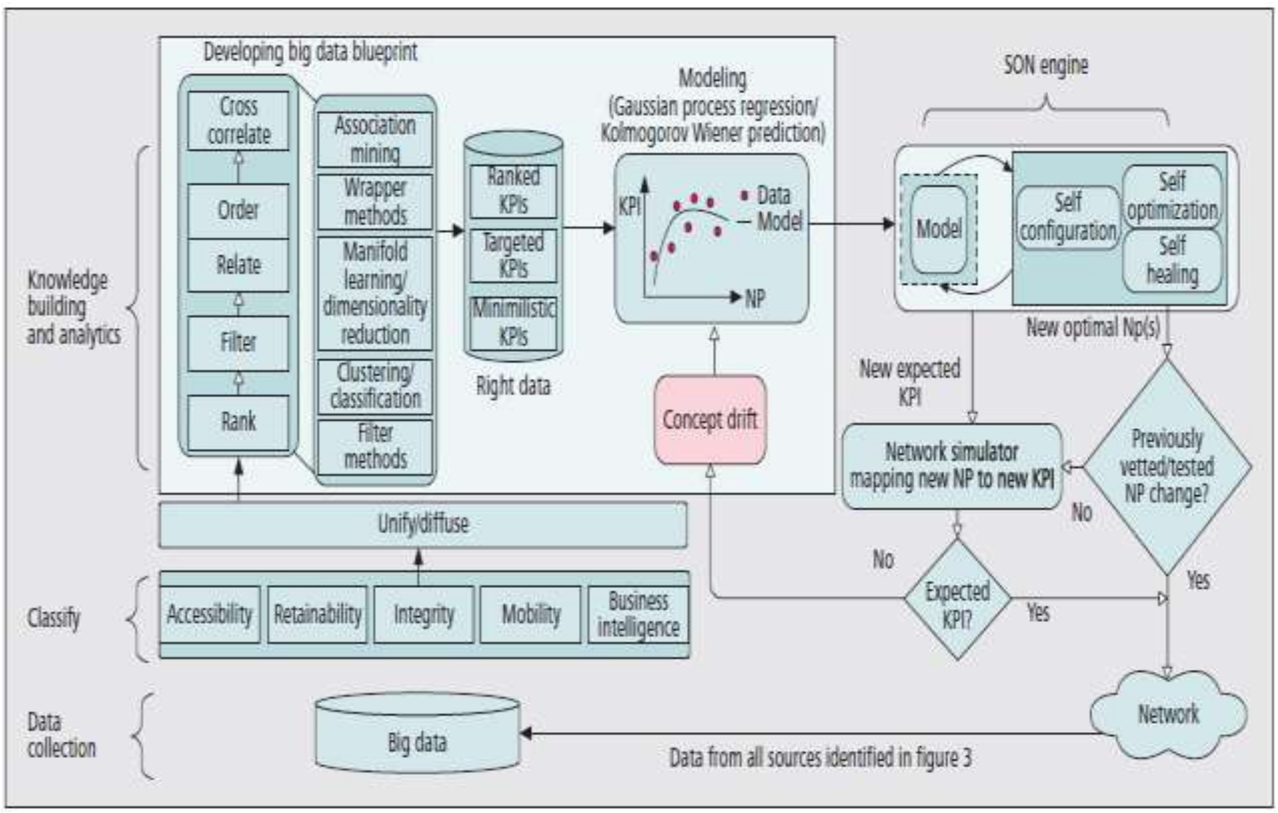

Figure 1: Components of the proposed method in diagram block

The general frame of this scheme is comprised of different parts that are linked to each other in a diagram block manner. In this pattern, a component of the network is able to regulate its functional parameters in a real-time manner based on the received information through the uplink. In order to better implement the self-optimizing scheme based on data analysis, the parameters under assessment are divided into two general types:

- Telecommunication KPI parameters
- Parameters relevant to statistical indices and events

Our intended self-optimization in this scheme is in respect to controlling parameters related to neighboring relation in the network which this problem will naturally be posed in the dimension of frequency and power resources allocation in such a field. Resource allocation on behalf of the network core to network NBs can be done based on our prediction of the load amount of the network locally in different moments which results in allocation of expected capacity to the subscribers in various situations. In addition, selecting the correct threshold limit of handover can be used for logical distribution of the resources as well as to control the signaling load level in different parts of the network during various time slots which this use of Big Data technology enables us to assess other than telecommunication indices such as the KPI kind, effective parameters of a different sort such as statistical parameters in analyzing the situation of network's future so that a more effective decision-making is yielded. Therefore, other than the KPI indices which we introduced, we have used other indices which we introduce in the following:

- The calendar index
- The movement direction of the subscribers
- The index of traffic distribution in a day (The day and night phenomenon)
- Atmospheric effects

In the following introduction of the self-optimizing model based on HO, algorithms which describe the function of this model are discussed. Each one of these algorithms indicate the function of part of the proposed model based on specific features of the model that are composed on the basis of new-generation mobile networks structure.

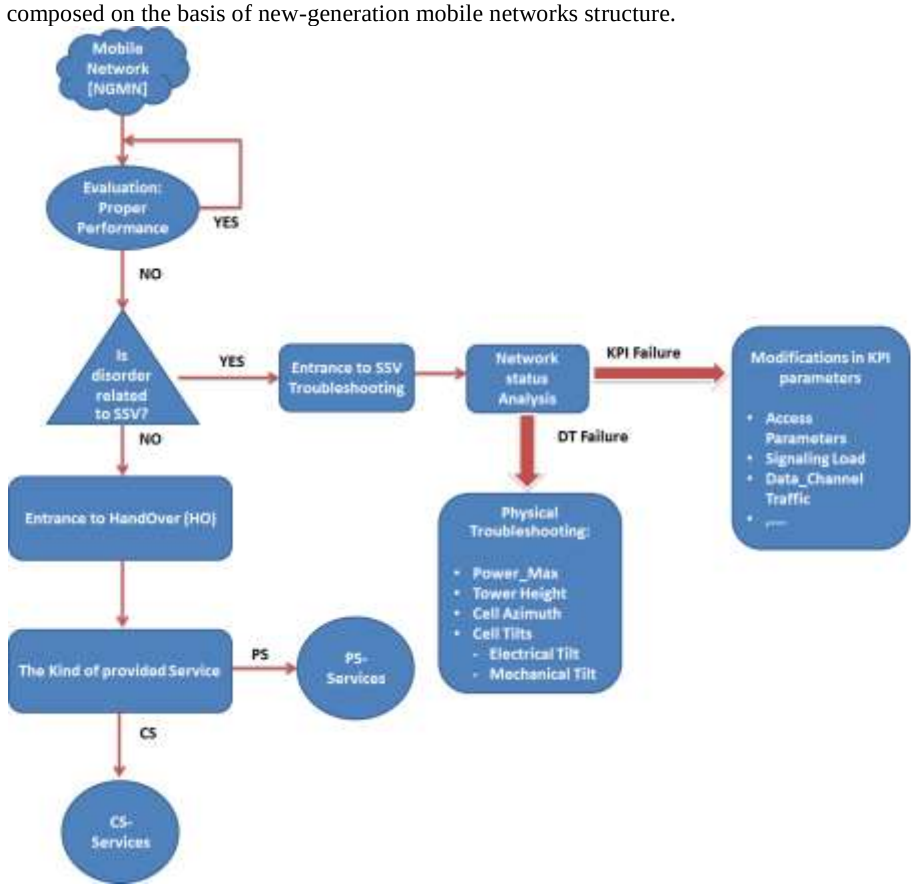

Figure 2: Functional algorithm of the self-optimizing model.1-The beginning of the process

According to the above algorithm, in case any types of dysfunctions are observed in a relationship, first we analyze that part of the network in isolate. Isolate analysis of one part of the network is in a manner that the site is checked from two perspectives of KPI and general indices. In case any types of defaults are observed in the general indices, the physical specifications of the network components must be checked such as:

- Power_Max
- Tower Height
- Cell Azimuth
- Cell Tilts (Electrical and Mechanical)

And of course in case the problem is with the KPI parameters, the setting of some parameters must be considered:

- Access_Min Parameters
- Signaling Levels
- Data Channel_Traffic
- …

Continuing our assessment of the function of this algorithm, if the present defaults weren't relevant to that specific part of the network, we will automatically enter the part of analyzing neighboring relations and the available connections of the intended sites with the neighboring sites. Entering this part requires the maintenance of the connection on a desirable quality level and prevention of any disconnections of a connection. In this point, the proposed self-optimizing model will show separate functions in two different parts based on the type of the provided service.

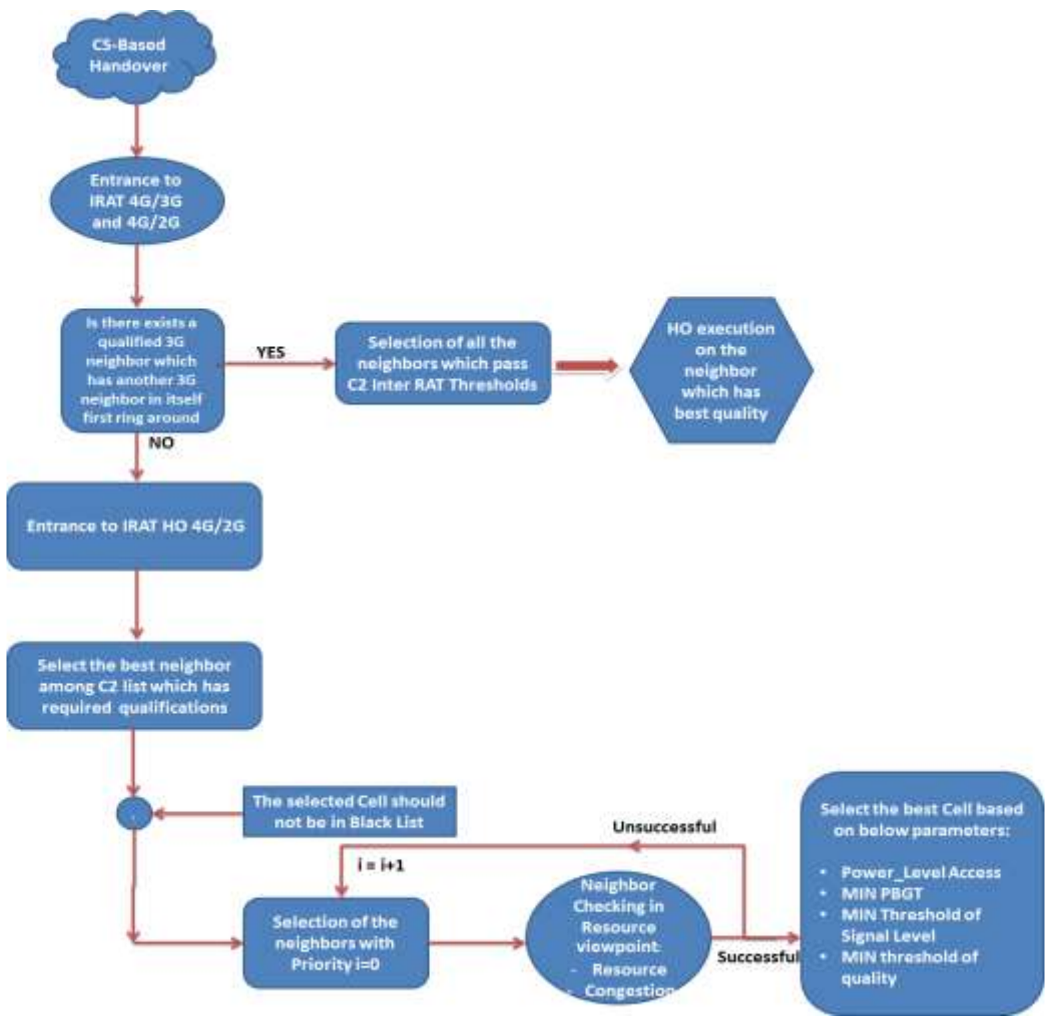

Figure 3: The functional algorithm of the self-optimizing model.2-Circuital services

In examining the procedure of self-optimizing algorithm, in case after entering the HO part, it was observed that the current offered service has been the CS kind, we must use the handover procedures of the Inter Radio Access Technology (IRAT). Thus in case a voice connection requires handover, the network must be analyzed based on the pre-determined procedures in IRAT. Regarding the fact that third-generation networks do not have the capability to make voice connections, the procedure put forward which is based on our self-optimizing model is in manner that we assume a connection based on packet service (PS) for a subscriber to the network and hypothesize that the request for a voice connection on behalf of that subscriber is presented to the network. In this way, the network inevitably makes connections between the subscriber and the cell that the lower-generation technologies benefit from. In case neighbors of these features are present in that part of the network, the best neighbor in terms of making connection with the best quality according to the threshold limit are defined in the following

- Quality Threshold level for applying prioritized Hierarchical cell reselection (QHCS) of neighboring cell when measurement quality is:
  - CPICH EC/N0
  - CPICH RSCP
- Quality Offset between serving cell and neighboring cell broadcast
- Timers (such as Penalty time)

That these qualitative assessments are done based on SIB12 and SIB11 transfer protocols. In the meantime, it must be considered that the values of Inter-System Measurement Trigger Threshold for cell reselection are determined on the basis of network and environmental conditions. Continuing our algorithmic assessment of this model, in case a neighbor with these conditions wasn't available, the network initiates a procedure of doing an IRAT between the current-level technology and the lower-level technology. In these conditions, we will look for next-priority neighbors. Consequently, we choose a cell as the target in the handover process from among all qualified neighbors which have the best qualifications in these 4 parameters. In assessing the function in PS dimension, the presented model will work as the following:

- Power_ level Access
- Min PBGT
- Min Threshold of Signal Level
- Min threshold of Quality

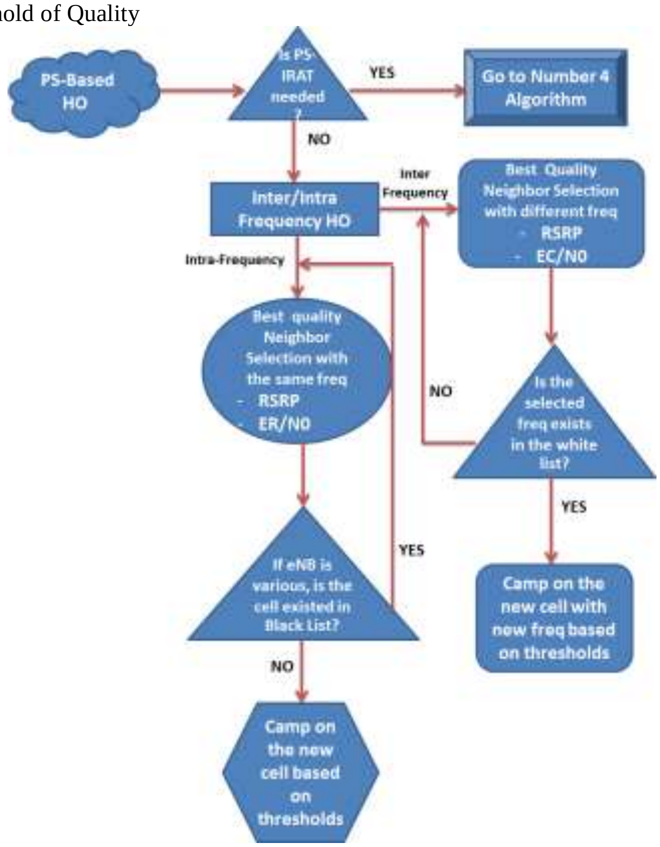

Figure 4: Functional algorithm of the self-optimizing model.3-Packet services without the need for IRAT.

We must bear in mind that inter-systemic handover will be in two destructive aspects in here. Firstly the handover intervals will be destructive and secondly when UE gets the service via LTE technology and we want the handover to be done on one lower generation technology from that one, the quality of the provided service will decrease drastically. Hence inter-systemic handover will leave way more destructive effects to CS in PS mode. Due to the multi-carrier nature of new-generation mobile networks, we must keep in mind that handover in these networks can be done based on carrier change and/or cell change or also change in another RNC. Accordingly, in this condition, the approach of a self-optimizing model can be divided into two separate procedures. The first procedure is related to handover inside the same running frequency with a neighboring cell and the second procedure is related to inter-frequency handover in which both the cell and the previous running frequency can change in this mode. In circumstances of inter-systemic handover of the inter-frequency type, we must first extract the used frequencies list from the list of frequencies with a good condition which are literarily called the White Frequencies and try to find the best neighbor in terms of RSRP and RSRQ on these frequencies. In case a neighbor has the best qualities in terms of coverage type and interference, but its frequency isn't a component of White Frequencies list, the previous stage must be repeated again.

- Inter-System Measurement Trigger Threshold for Cell Reselection

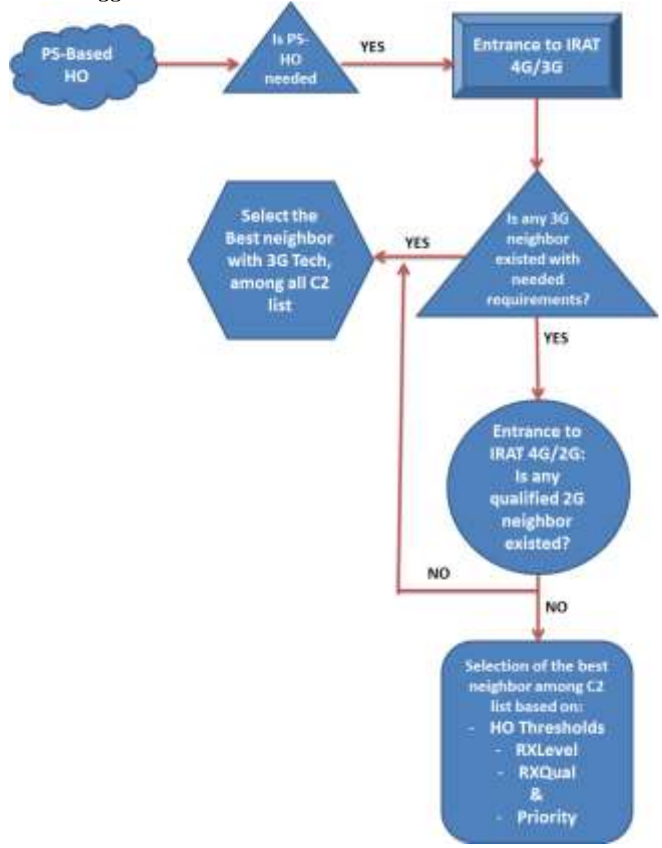

Figure 5: Functional algorithm of the self-optimizing model.4-Packet services doing the IRAT process.

Until now, the function of the proposed self-optimizing model has been explained in different states and circumstances and via algorithms but the point that has a high significance and must be considered is that the values are the threshold limit which is pointed out in these algorithms but no method has been presented for specifying them. An important question that comes up is whether different values of this parameter which comprises specification of the timer's amount and cell's reselection parameters and other threshold limits, can be done based on real-condition function of a mobile communicative system or that this threshold limit must be estimated only based on different software and hardware conditions of the system.

Big Data-Based Decision Making

The instrument we've used in order to make our model smart is Big Data. This technology has a high capability in increasing the function of our model. In the following, we will discuss the way an algorithmic function of the threshold limit specification works. As it was explained previously, the output of these algorithms will be used as values of the parameters and the used coefficients in the functional part of the proposed model. In order to implement this idea in the self-optimizing model, we group the previously mentioned factors along with their effectiveness coefficients into a relationship and the obtained answer amount will indicate network status in terms of those parameters. In the following, according to table 1, some profiles on the network status have been illustrated based on day and night status, atmospheric situation and also calendar events in order to simplify the wordings of our subject which by appropriately being in each of these four situations, the threshold limit of the functional parameters of self-optimizing model's algorithms can be estimated. In this logic table, in case the description value of each of the states equals one, that state will be referred to as the "State".

Table 1. Decision-making based on the conditions resulted from Big Data indices analysis.

State	Description	Conclusion	Results
I.	*N*.(1-*UWC*).(1- *TPE*)	Good Status	**Low-Load Signaling is needed**
II.	*D*.(1-*UWC*).(1-*TPE*)	Ordinary Condition	**Ordinary Signaling Load**
III.	*D .[UWC +TPE=UWC.TPE*]	Tight Condition	**High Signaling Load**
IV.	D.UWC.TPE	Very Tight Condition	**Over Load Signaling**

In these relations, the expressions are defined as the following.

- N: Night
- D: Day
- UWC: Unstable Weather Condition
- TPE: Temporal Populated Event

Our self-optimizing model has the capability to receive data in order to estimate each of these situations and the threshold limit will also be set in terms of the status that the network is in. According to above table, we can divide the conditions of the network to 4 status during all the 24 hours. Regarding to each status, our proposed self-optimization networking model can determine its level of signaling load in order to covering all of existing service requests. So we can conclude with degrading of useless signaling load in ordinary conditions, more source can be dedicated to physical data and call services as more number of channels which dedicate to transmission TRXs. So data services with higher throughput and call services with more quality level, will be provided.

Correlation Statistical Analysis of KPI Parameters Influencing the Handover

Correlation tests (two-variables) and relational hypothesis analysis: The statistical analysis part aims at specifying the correlation degree between the indices influencing the HO by the amount of handover rate. We have tried to use the correlation test to assess the degree of correlation between effective parameters influencing the inter-cellular relationships and handover and due to the feasibility of giving the test to a large number of independent and dependent variables, what sounded reasonable was to do it with the Pearson Test but we determined the degree of correlation between the variables and the final indices by using Spearman Test since the assumptions of Pearson Test weren't met. Absence of normal distribution of handover rate usually when our data aren't qualified to use the Pearson correlation coefficient, we use the Spearman correlation coefficient which isn't dependent on the data distribution.

P-value: The probability of denying the null hypothesis lies on the condition that it holds true in the observed data. This parameter actually expresses the coincidence degree of the seen variance from the null hypothesis.

The more the probability of this P-value is less; our confidence in the observed variance to be real will be more. Usually in statistical tests, the significance level of P-value is considered to be 0.05. Assessing the correlation of the indices influencing HO degree can be assessed by checking the effect of the index relevant to quality on RSRQ and RSRP basis on the IRAT effective rate of inter-systemic handover which acceptable output was resulted in terms of correlation between the parameter and the intended index per random samples. In this assessment which was done per samples with a different size than the threshold limit, the results show a medium correlation for this index. What necessitates in here is mentioning the pint that a change in this parameter can cause changes in difficulty and easiness degree of doing handover. In the next stage, we have explored this test for this parameter as well as the correlation test of other parameters such as timers in the amount of handover indices which almost all the explored parameters showed the required correlation with the original index which is relevant to handover rate. A general assessment of the test results on the variables and our intended parameters was in this way:

- Spearman Test with 10 samples:
  - Spearman Correlation Coefficient: 0.669
  - P-value=0.035

- Spearman Test with 30 samples:
  - Spearman Correlation Coefficient: 0.387
  - P-value=0.03

- Spearman Test with 50 samples:
  - Spearman Correlation Coefficient: 0.32
  - P-value=0.028

The more the sample, the more the probability to reach the significance level with a lower R. Usually the R correlation coefficients are determined for different levels of significance as the Table 2.

Table 2. Correlation test among indices influencing the HO rate.

R < 0.1	Very Low
0.1 < R < 0.3	Low
0.3 < R < 0.5	Medium
0.5 < R	High

According to table 2, and the results obtained, we can reach the conclusion that in spite of the fact that the correlation of these variables is clear, but the degree of correlation is not high. Different influence level of a parameter on the handover rate during different times as well as the fact that the influence of each one of the parameters are not independent from each other can be a reason for justifying that.

Conclusion and Future Works

As it was seen in this paper, our activity toward presenting a self-optimizing model based on Big Data was done in two aspects which one dimension of it was related to presenting a self-optimizing model for handover communications on an inter-cellular communication level which by making this model smart, the possibility to access the maximum efficiency of the network in different environmental conditions and popularity distribution won't be out of reach. In addition, in the second dimension of the scheme, implementing different procedures in the network's functional mechanism is analyzed by using the available data assessment in current mobile networks and the practicality horizon of the proposed self-optimizing model can be considerably widened by analyzing the obtained outputs. Also, from amongst the most important works that can be done as follow-up studies to the one done in this paper is presenting an empirical model between the parameters already introduced that naturally for an ever better description of this model, large amount of data must be evaluated.

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