iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** V **Month of publication:** May 2014

DOI:

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

Improving Quality of service in EVDO Wireless Broadband Networks.

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Abstract: This paper focuses on improving quality of service for end user by throughput optimization in an 1900MHz EVDO (Evolution Data optimized) wireless broadband network. An optimization algorithm is devised for finding the best values of antenna tilt and forward carrier power. This algorithm is a parametric method, based on a set of rules. Optimization techniques thus evaluated on actual wireless broadband network in Hayatabad locality of Peshawar city (21sectors).In this scenario, an significant increase in user throughput per carrier per cell is observed.

Keywords: EVDO optimization, Total forward channel carrier power, Antenna tilt, Quality Factor

I. INTRODUCTION

The Evolution data optimized (EVDO) radio interface can carry voice and data services with various data rates, traffic requirements and quality of service (QoS) targets [2]. But here it's planned and operational as a data network only. Careful configuration of the network and cell parameters is required and is crucial to a network operator because they determine the capability to provide services, influence the QoS, and account for a major portion of the total network deployment and maintenance costs [1].Optimization is needed, both in the planning stage to optimize the network configuration for investment saving as well as after the deployment of the network, to satisfy the growing service demand. However, there are numerous configurable parameters which are multi-dimensional and interdependent. Hence, finding the optimum network configuration is a very complex and time-consuming task. Optimization algorithms are needed to perform the optimization process quickly and effectively, with minimal contribution from the operational expenditure. The content of this paper is based on an algorithm and is an extension of the rule-based approach presented. The new algorithm achieves a higher user throughput and thus improving the desired quality of service. Furthermore, it needs less iteration and thus saves computational time. The designed algorithm optimizes forward channel carrier power and antenna tilt settings. These cell parameters have the most significant influence on network throughput per cell per carrier .For the evaluation of the network configuration; a static EVDO frequency division duplex (FDD) network simulator is used. The Simulations are carried on Mentum Planet planning tool. Coverage, capacity and quality of service related issues can be easily analyzed with this tool. The network configuration and user distribution are input into the simulator manually. The uplink and downlink are jointly analyzed, and the simulation results comprise coverage and capacity information, traffic statistics and soft handover(SHO) statistics.

The paper is organized as follows.

In section II, The influence of the configuration parameters is analyzed.

In Section III, The optimization process with Rule-based algorithm is presented

In section IV, Results of the Simulations are shared.

Finally section V has the conclusion drawn.

II. OPTIMIZATION PARAMETERS

There are numerous configurable base station parameters which influence and determine the capacity of the network, for example:

• Antenna settings (tilt, azimuth, height, antenna pattern),

• Forward carrier TX power, and

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

• Soft Handover parameters.

All these parameters have a strong influence on the interference of the planned wireless broadband network and therefore on the number of served users. In this paper, focus is on optimizing the existing 1900MHz EVDO wireless broadband network by forward channel carrier power and antenna tilt only.

1. EVDO Forward Carrier Power

The EVDO Forward Carrier Power is used by BTS to obtain the initial coverage of the forward carrier and to aid the channel estimation for the dedicated channel. After turning on the power and while roaming in the network, a mobile phone determines its serving cell by choosing the best Pilot signal available. Thus, Pilot power determines the cell coverage area. Increasing or decreasing the Pilot power will enlarge or shrink the cell coverage area. Therefore, by appropriately adjusting the Carrier power of the base stations, the number of users per cell can be balanced among neighboring cells, which reduces the inter-cell interference, stabilizes network operation and facilitates the process of Radio resource management.

On the other hand, the constraints of setting the Carrier power values too high will create interference called "pilot pollution" with the neighboring cells, which will decrease the network throughput per cell. Setting Carrier power too low will cause coverage loopholes between cells. In an uncovered area, the Carrier power is too weak for the mobile phone to decode the signal, so network access is impossible.

2. Antenna Tilt

Antenna tilt is defined as the elevation angle of the main beam of the antenna relative to the azimuth plane. Antenna down tilt is often used in wireless networks to control the coverage and thus the QoS. User traffic in all cells is simultaneously monitored and improved via alterations of the antenna tilts. The desired effect is a reduction of the other-to-own-cell interference ratio I, which is defined according to as,

I =i (others)/i (own)…………………………… (1)

In (1), i (others) denote the inter-cell interference and i (own)is the intra-cell interference. By down tilting the antennas, the other-to-own-cell interference ratio I can be reduced: The antenna main beam delivers less power towards the neighboring base stations, and therefore most of the radiated power goes to the area that is intended to be served by this particular base station[9]. Moreover, antenna tilts should be limited to reasonable values because it directly affects the probable cell coverage area.

3. Influence of Carrier Power and Antenna Tilt

Adjusting the EVDO forward carrier power and antenna tilt can increase the user throughput per cell per carrier by reducing inter-cell interference and pilot pollution, optimizing base station transmit power resources, load sharing and balancing between cells, and optimizing SHO areas.

III. OPTIMIZATION TECHNIQUE

In this section, the algorithm devised is explained. The rule-based QoS algorithm, which is presented in this paper, is an extension of the QoS improvement approach introduced .The optimization of the base station parameters, in our case Forward carrier power and antenna tilt, begins with a first evaluation of the network. After analyzing the results of the first evaluation, the iterative optimization process is started. Each loop includes three steps. In the first step, the parameters are changed according to a rule-based optimization technique, described in subsection3 of this section. This new technique changes carrier power and antenna tilt together. After changing these parameters, the network is evaluated again. This iterative optimization loop continues with subsequent changes in the parameters. Figure 1 shows the flow chart of the optimization process.

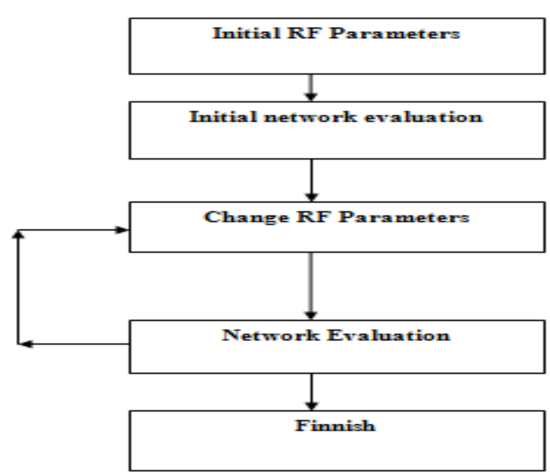


Figure1 Flow diagram of optimization process

Vol. 2 Issue V, May 2014

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

2. Designed QoS Algorithm Loop and Cell Quality Factor (CQF)

The Proposed QoS algorithm is shown in Figure 2 below. During the execution of this Self optimization process, an indicator is used to characterize how many users can be provided with a desired service. This can be estimated by values obtained from an indicator called Cell Quality Factor (CQF).CQF actually identifies the health of a particular cell (sector) and based on the number of active users it executes the optimization algorithm. Active Users denotes the total number of served users in a defined area but under the influence of a single transmitting antenna .Here the threshold numbers of users are predefined that an carrier per cell can accommodate. As long as the numbers of served users are within limits the QoS algorithm is not executed. However, the network has the ability to accept and later connect more users but compromising its user's experience. Thus, our optimization algorithm applies the following approach: When the CQF and T(Load) values reach a threshold value , new users are added to the network until or unless predefined CQFlimits of 0 to .2 are reached . In the following, this function is referred to as ADD_USERS and subsequently losing active users per cell per carrier is executed by the function named REMOVE_USERS.

For the evaluation of the network, a function has to be defined. The function represents the optimization goal that has to be eventually served. In this paper, the quality of service of the planned wireless broadband network can be improved by maximizing the downloading throughput per cell per user per carrier.Herethe main focus is to limitize the number of active users to near end and midpoint and to increase the average throughput per user. To describe the quality of a cell in the network, a performance indicator denoted as Cell Quality Factor (CQF) is introduced. The CQF indicates whether a cell is heavily loaded or not and its is determined by the following ratio named T (load).The parameter T (load), is a measure of the downlink cell loading condition and is defined as

$$T\,(\text{load}) = {}^{\eta}/_{\eta(\text{thres})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

In (3), "$\eta(\text{thres})$" denotes the planned downlink cell load (users), and "η" is the actual cell loading (active users). The second value, T (Pwr), is a measure of base station (BS) carrier transmit power in the downlink .Based on the value of T (Load) CQF (Cell quality function) is mathematically calculated as

$$CQF = 1 - T\,(\text{load}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

The CQF value varies i.e. low (negative) value of CQF describes a heavily loaded cell and a high (positive) value CQF describes a weakly loaded cell. Therefore, by using the CQF as the QoS indicator, forward carrier power and antenna tilt settings can be adjusted adaptively according to the downlink loading conditions of a cell.

3. Changing Forward carrier Power and Antenna Tilt

In each iteration of the optimization loop as illustrated in Fig. 2, the CQF is computed for each cell, while the Carrier power and antenna tilt are changed according to the predefined rules, as shown in Table 1.The rules are designed in such a way that a highly loaded cell($CQF \le 0$) having high number of active users is required to shrink its coverage area by decreasing the forward carrier power and increasing the antenna downtilt stepwise. Conversely, if the cell has a low user density ($QF > 0.2$), it has to expand its coverage area to cover more users by increasing the Forward carrier power and antenna uptilting.With this approach, load balancing within the cells in a network can be achieved, resulting in higher user throughput per cell per carrier.

Table 1. Carrier power and antenna tilt step size and limitation settings.

QoS Indicator	Remarks
$CQF < 0$	Decrease carrier power and increase antenna down tilting
$.8 \le CQF \le .2$	No change in the forward carrier power and antenna down tilting
$CQF > .2$	Increase forward carrier power and increase antenna up tilting

EVDO Forward Carrier power and antenna tilt modifications are controlled by a set of rules with different limitation settings, as shown in Table 2 below. One rule consists of one instruction for the Forward Carrier power and one instruction for antenna tilt. Tilting depends on the CQF value of individual sector. With this strategy, forward carrier power and antenna tilts are adjusted adaptively according to the loading condition of a cell. The modification of antenna downtilt and carrier power has to be limited (lower limit for Carrier power and upper limit for antenna downtilt) in each rule by a set of parameter limitations.

Furthermore, the developed algorithm is based towards reducing the initial carrier power and increasing the antenna downtilt. When the optimization process is launched, the algorithm identifies the previous Step Size of the designed algorithm and executes the next in line stepsize as per the defined rules set (e.g. from Table 2).In Table 2, Modified parameters are specified with the limitations for a maximum allowed adjustment of carrier power and antenna tilt settings per iteration. Limit describes the lower or upper variation of the parameters and iterations specify how often the rule can be applied at most.

Table 2. Forward carrier power and antenna tilt Benchmarking

S. No	Function Executed	Rule	Parameter	Max Limit	Timer
1	Remove_Users	1	Forward carrier Power	41(dBm)	10Mins
1	Remove_Users	1	Antenna Tilt	2(degrees)	10Mins
2	Remove_Users	2	Forward Carrier Power	39(dBm)	10Mins
2	Remove_Users	2	Antenna Tilt	4(degrees)	10Mins
3	Remove_Users	3	Forward Carrier Power	37(dBm)	10Mins
3	Remove_Users	3	Antenna Tilt	6(degrees)	10Mins
4	ADD_Users	1	Forward carrier Power	37(dBm)	10Mins
4	ADD_Users	1	Antenna Tilt	6(degrees)	10Mins
5	ADD_Users	2	Forward Carrier Power	39(dBm)	10Mins
5	ADD_Users	2	Antenna Tilt	4(degrees)	10Mins
6	ADD_Users	3	Forward Carrier Power	41(dBm)	10Mins
6	ADD_Users	3	Antenna Tilt	2(degrees)	10Mins

According to Table 2, the algorithm proceeds to rule number 2 after the first 5iterations. As long as the CQF value is between 0 and .2; the new result is not accepted. The algorithm terminates when either all rules of the rule set have been processed or if the CQF in each cell is between 0 and 0.2.This can be seen in Table 2.This means the network is balanced, or that the algorithm cannot process further due to the limits for carrier power and tilt.

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

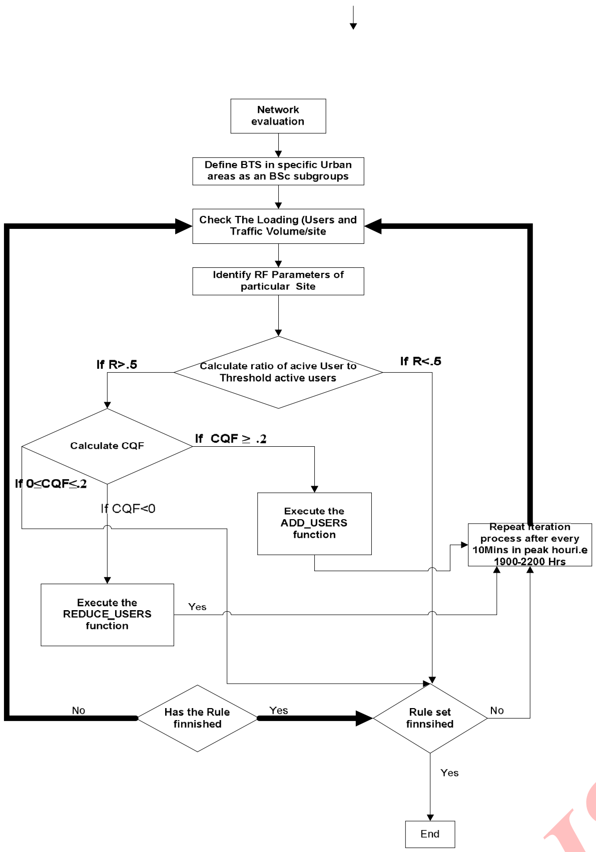
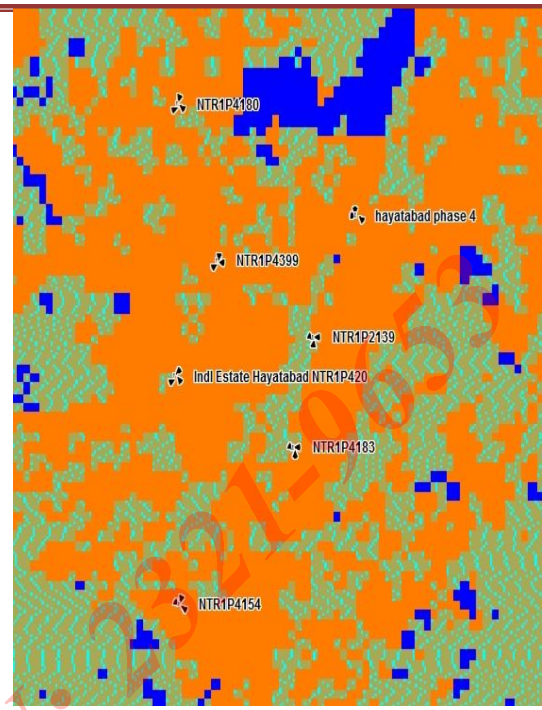


Figure2. A detailed flowchart of the optimization loop

IV. SIMULATION RESULTS

In the network scenario, 7 base stations equipped with 3-sector antennas are used, thus comprising 21cells (sectors). The distribution of the mobile terminals was assumed according to the population density, with a broadband service of 1000kbps data users. The initial number of active users is estimated in the planned WLL network by the simulator. The distribution of the base stations as well as the distribution of the users in the Hayatabad locality is predefined.



Based on the loading of the Cell (sector)the stepwise approach for adding users and removing users is executed. The value of the CQF is observed and actions are taken as required. The simulations are carried out using Mentum Planet Tool with the most important parameters used in the simulation scenario being introduced in Table 3 below.

Table 3. Simulation parameters

Parameters	Value
Number of sites	21
Number of sectors per site	3
Number of sites in optimization area	10
Total number of initial users	100 per sites per carrier
Max BS TX power	41
Max terminal Tx power	23
Antenna height	25
BS antenna	65/18dbi
Terminal antennas height	1.5m
Active set size	3
Active set window	3
Initial Forward carrier power	41
Initial antenna tilt	2

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Table 4 below shows the results of the simulations. Before and after optimization, 15 snapshots with different user distributions are simulated. The optimization process itself is performed with fixed user distribution. Based on the stepwise rules to be followed the cell offloading is achieved with 10-15% improvement in user throughput per cell per carrier. Even though the number of served users decreases while following the remove users function but the overall user experience improves a lot. It is observed that deviation in the number of served users with respect to required throughput after the application of the self-optimizing QoS algorithm is very effective. This means that the optimized network is less stable regarding the user distribution. A possible approach for reducing this dependence would be to use different user distributions during the optimization process

Table 4. Optimization results.

S. No	**Mechanical tilt**	**Electrical DT**	**Txn Power**	**Users served**	**Average Throughput per user per cell per carrier**	**Percentage Difference**
1	2	2	43	32	1138.057	10-15%
2	2	2	41	26	1281.153	10-15%
3	2	4	39	20	1480.822	10-15%
4	2	6	38	14	1690.057	10-15%

CONCLUSION

In this paper, a rule-based algorithm for optimizing the two most important parameters of a EVDO base station, Forward carrier power and antenna tilt. The main difference to the algorithm is that with the new algorithm the forward carrier power and antenna tilts are changed together and this change being presented is possible during the optimization procedure. The new algorithm gives a higher user throughput per cell per carrier. The evaluation of our rule-based algorithm was done on a PTCL WLL network planned in Hayatabad locality in Peshawar with 21 cells using Mentum Planet's static EVDO network simulator. For this scenario, an increase in User throughput per cell per carrier of 10-15% percent is observed through simulations.

ACKNOWLEDGEMENT

The author would like to thank Prof.Muhammad Shahid Khalil of the Institute of Communication Technologies, Islamabad for their support and encouragement.

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