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Soft Handover in 3G/4G Networks Using Multiple Sector Antennas

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ABSTRACT

Cellular technologies are rising up continuously. It supports high speed data transfer, email, web browsing, audio streaming, multimedia and video telephony. A significant characteristic of 3G/4G technologies is the handover which is a key concept to achieve mobility and this occurs when mobile node moves from base station to another; it makes it possible for the users to travel from one cell to another without interruption;, this is known as seamless connection. One of the advantages of mobile cellular systems is mobility. Mobile node can communicate anywhere and anytime with handover from one cell to another and continuous services can be achieved. In this paper we have focused on demonstrating the effects of using cell BS with three directional antennas over the soft handover procedures of mobile UE and parameters such as handover delay, throughput, Active set count and QOS of channels such as Ec / N_0 are obtained.

Keywords: *Handover, UMTS, OPNET, HTTP, FTP, RNC.*

1. OVERVIEW

Universal Mobile Telecommunication System (UMTS) is 3G [1]. Number of companies started to develop 3G technologies and an improvement and development has been made by 3GPP to the UMTS system to move toward Long Term Evolution (LTE) which is also known as 3.9G [2][3]. There was need to make cooperation between different standards so that the same technology can be used on 3G worldwide networks and mobile phone can operate in different countries over 3G networks with upgrading or changing the handset.

With the development in cellular communications, a major and important issue raised up is the call handover from one cell to another without dropping the connection with the base station. The user's movement is dynamic process considering the location of the nodes. In mobile communication, Handover is a process when users switched from cell to another without any interruption. Handover process is happened when the connection quality decreases between the base station and mobile equipment However, Handover failures occur when the quality of the connection is very less than the acceptable level or unavailability of the nodes in the target cell before the ongoing call is handed over. The network controller decides according to the measurement reports the strength of the connection quality between nodes and weather the hand over process is needed to another cell or not. The main aim of the handover process is to permit to mobile nodes to freely roam from one cell to another in the same or different network cell in order to free up capacity on the large cell for other fast traveling users and to reduce the potential interference to other users or cells.

1.1 Handovers requirements

In telecommunication a handover might be conducted for some reasons:

- When the cell phone is moving away from one cell to another cell, the call is transferred to the second cell in order to avoid termination of call when the cell phone gets outside the coverage range of the first cell. In some networks (ex. CDMA networks) in order to reduce the interference, handover maybe induced to smaller neighboring cell even when the cell phone still has excellent connection with the current cell.
- when the fast movement user connected to large cell (umbrella cell) then stopped, the call may be transfer to a smaller cell (macro cell) or to micro cell in order to free up capacity in the large cell for other fast traveling users and to reduce the potential interference to another users or cells.
- When the channel used by cell phone interfered with another cell phone use the same channel in different cell, the call transfer to different channel in current cell or to different channel in other cell in order to avoid the interference.
- When the capacity for new calls connecting to the cell is used up and new call from cell phone located in an area overlapped by another cell is made, the call will transfer to that cell in order to free capacity in first cell for the users who can only be connected to that cell.

1.2 Types of handover:

Horizontal Handovers

When ongoing calls are made from one cell to another cell having same access technologies the transformation of these calls called Horizontal Handover.

Vertical Handovers

When an ongoing calls are made from one cell to another cell having different access technologies then the transformation called vertical Handover.

Hard Handovers

Before the new connection is made between the user equipment and the network controller, the old channel is released first between the user equipment and the network controller for this reason this handover is also known as break-before-make.

Soft Handovers

In this handover the connection to the target cell is established before the connection of the user equipment and network controller of the source cell is broken, hence this handover is called make-before-break. In this case the channel in source cell is used in parallel with the channel in the target cell [4].

Softer Handovers

In the softer handover the signals can be added or deleted from the active set. This handover occur when signals are replaced by stronger signals from different sectors in the same base station within the cell..

2. INTRODUCTION

The Performance of UMTS Handovers mechanisms using different Quality of Services Classes are performed by [S. Ali, N. Saleem,2012] .they concluded that the soft handover has less delay than hard handover and suitable for real time services such as voice application and has less response time and delay for downloading and uploading ftp application. [S. Acharya, T.Gaba, 2014] studied the soft handover performance in city area network under UMTS handover conditions and he focused on UMTS network handover parameters in various simulation environments. He thinks that the UMTS handover performance can be improved by increase the value of Timer to 3350.

WLAN/WiMAX/LTE heterogeneous networks are proposed to study the performance of vertical handover [L. Nithyanandan and I. Parthiban, 2012]. By considering loose coupling and tight coupling architectures and employing gateway relocation and bandwidth reservation, they found that tight coupling with and gateway relocation and neighbour reservation provides better handover performance. This paper focuses on demonstration the effects of using node Bs with three directional antennas over the soft handover procedures of mobile UE with the help of related statistics.

3. THE SIMULATION MODEL

We have performed the simulation of the proposed scheme using Opnet Modeler 14.5. The implementation of the scenario easily used the tool by simply selecting the different technologies from start up wizard and dragging of different devices like RNC, Node B, etc, interconnecting them with the desired links. OPNET Modeler presents the specialized model and covers the specific needs for the simulation and UMTS networks which is based on the 3GPP specification. The model focuses on UE-UTRAN-CN architecture as shown in the figure 1.

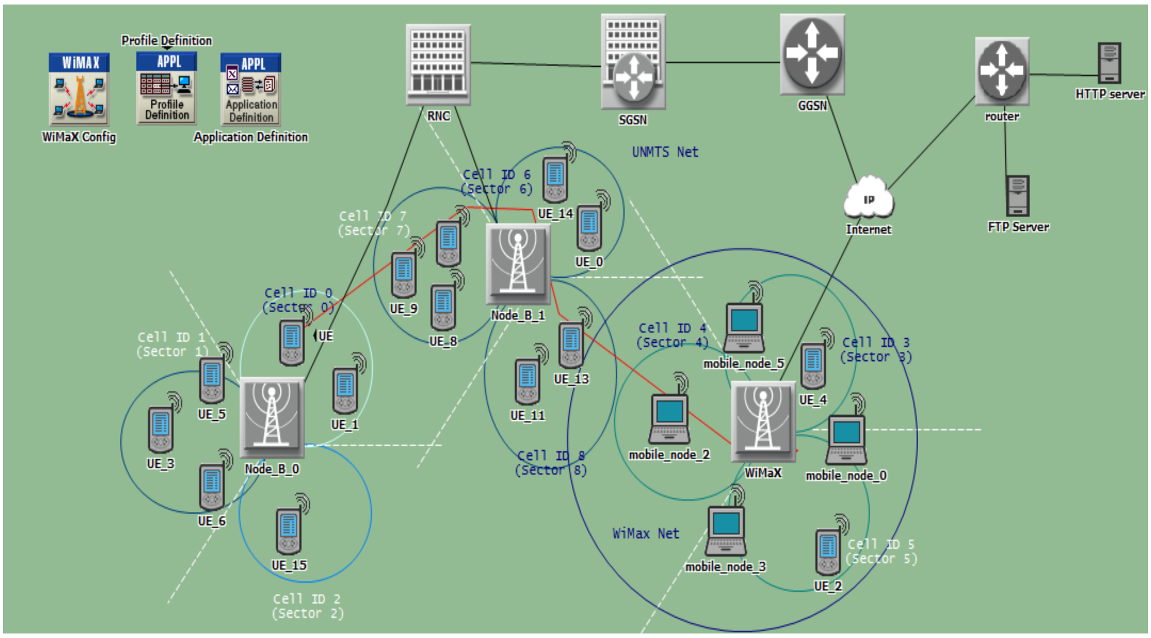

Figure1. UMTS/WiMax network model

We have selected different network elements and configured it according to the requirements of our scenarios. The entities which we have selected from the Object Palette in OPNET Modeler are:

- ✓ Profile Definition
- ✓ Application Definition

- ✓ UMTS node B
- ✓ Umts_RNC
- ✓ Umts_SGSN
- ✓ Umts_GGSN
- ✓ FTP and HTTP Servers
- ✓ Umts work stations

All these network entities are configured according to the requirements of the scenario. The Proposed Algorithm of the scenario is as following:

- ➢ The UMTS network architecture is presented with 3 Nodes using OPNET 14.5 simulator. Each Node has three directional antennas covering angle of 160 degrees and sectors/cells are positioned every 120 degrees starting from 0 degrees (0, 120, 240) as shown in figure-. So we introduced an overlap of 40 degrees between adjacent cells in the same Node.
- ➢ Different number of mobile nodes are employed and connected to node B0, node B1 and node B2, and initially has trajectory associated. All these nodes were connected using different connection links and we assigned the required attributes for each node.
- ➢ We used two servers, one for FTP application and another one for HTTP application. These servers are connected to (GGSN) node of the UMTS core network using IP cloud.
- ➢ Applications are configured in the application definition node and the profiles were defined in the profile configuration node to be used by the users. Trajectory for mobile user was defined as trajectory_4 based on simulation time.
- ➢ We created trajectory to perfume the mobility of the user equipment through the radio links.
- ➢ The global and node statistics were selected and the simulations are compiled with seed value (128), update interval 500000) events and simulation kernel is optimized.

3.1. The Node Layer:

The nodes are made up in the node editor using different transmitters, receivers, processors. The blocks of the nodes building up in the node layer are known as modules. These modules allow implementing the different node characteristics. The figure below shows the implementation of the UMTS Node B.

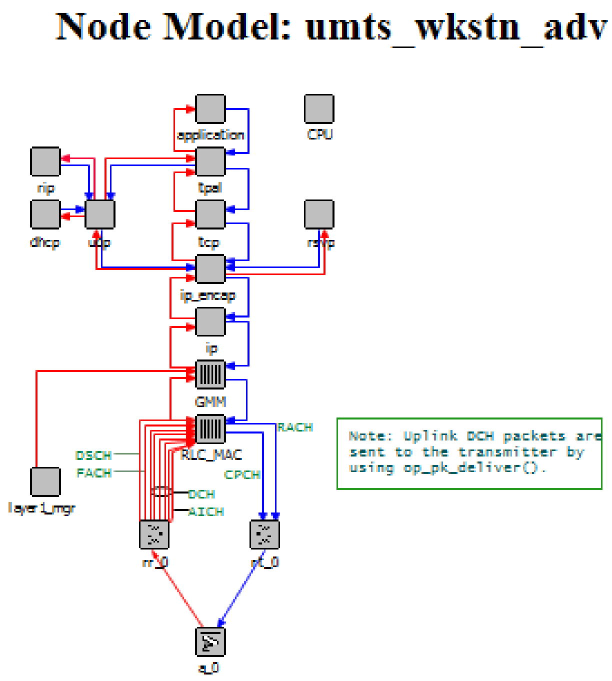

Figure2. UMTS work station node model

3.2. The Process layer

OPNET node objects represent different devices that can be connected together to form different networks. Programming of various modules is possible to implement and design various protocols in the node layer. The process editor use Proto-C, which is the programming language that can make the possibility of combining the state transition diagram and C/C++ language. OPNET has wide kernel standard procedures that are mostly used in the communication networks.

4. SIMULATION PARAMETERS:

The scenario is aimed to demonstrate the impacts of using Bs node with three sectors. The participating nodes in the scenario are considered as mobile. In the scenario, the number of deployed mobile nodes is 19 nodes having an environment size 30x30 kilometers. For the scenario the applications used were FTP and Http. The scenario is run in duration (one hour). The network design consist basic network entities with simulation parameters presented in the table below.

Parameter	Value
Transmission Range	0.5 W
Path loss model	Vehicular Environment
Number of nodes	19
Simulation Area Km	30x30
Traffic Type	Constant Bit Rate
FACH cell distance	· 2 Kilometer
Trajectory Inf.	Trajectory_4
Type of node	Mobile
Traffic Type	FTP, Http
Simulation	500000 events Based on Kernel type preference
Seed	128
Update Interval	500000
Values per Statistic	100

5. SIMULATION RESULTS AND ANALYSIS

The simulation performed using OPNET [8] and involved on how the single mobile station moves across three BSs at various speeds. The motion path from starting point toward each BS can have number of sectors per BS. In our simulation, each of the three BS's coverage is divided into three sectors.

5.1. HTTP Download response time

The HTTP page response time of the network started with 0.01 Second and increased to reach 0.17 second as the Simulation advanced. The response time decreased gradually to 0.078 second by the end of simulation.

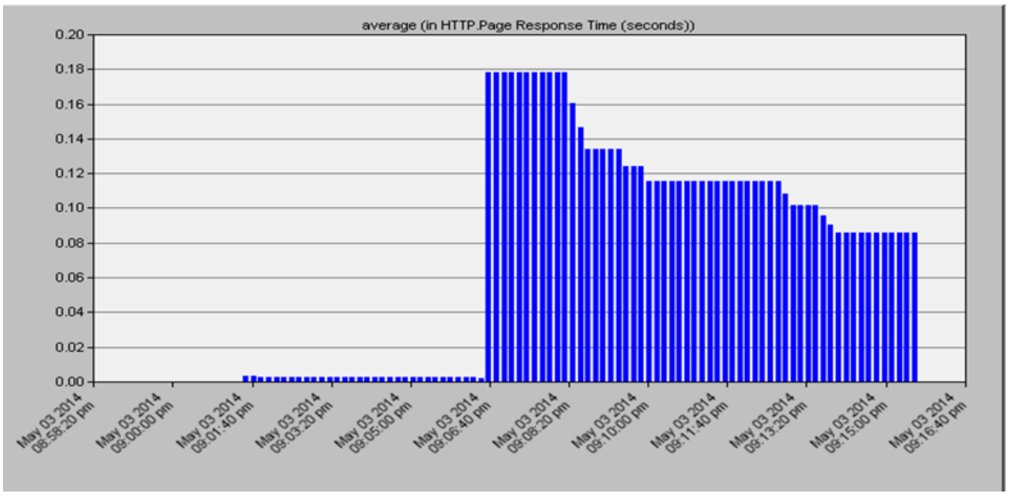

Figure3. HTTP Download response time

5.2. FTP response time

The FTP response time measured in seconds not stayed at a consistent value. It took approximately 10.84 seconds to respond to FTP requests and then gradually decreased to just less than 1 second by the end of the simulation. The mobile node moving from one network to another network need to wait until registration is completed in the new network. The ongoing traffic is routed via this tunnel reducing the handover delay and packet loss.

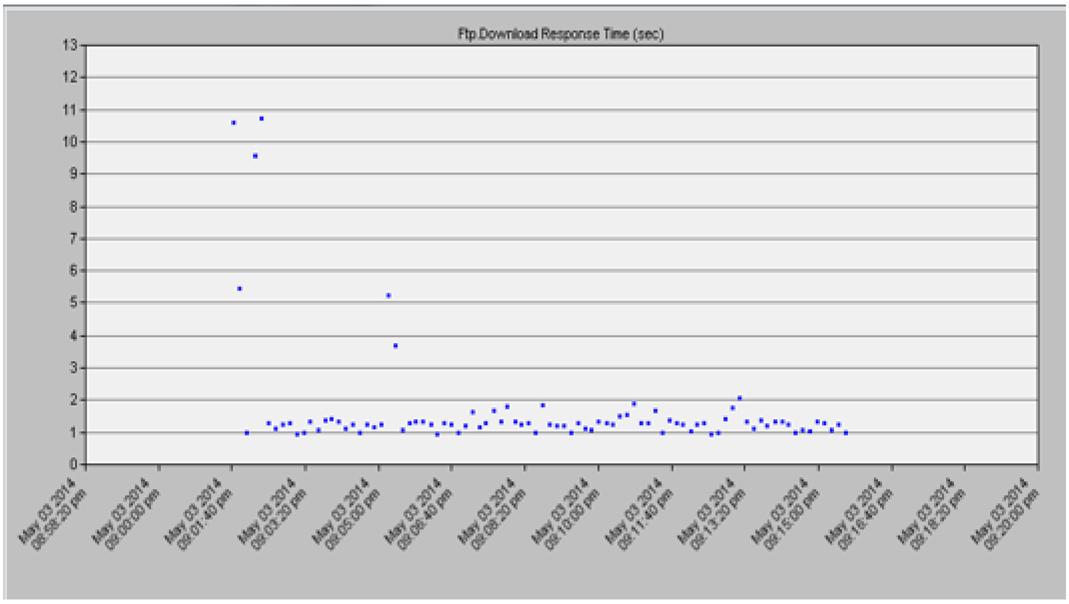

Figure4. FTP Download response time

5.3. Handover Active Set Cell Count

In our scenario there are three BSs Nodes. In the user equipment the signals and services are getting from active set which contain the number of BSs Nodes. The mobile node getting the strongest signal when simulation starts so it becomes member of active set. Figure 5 shows the added and removed cells in the active set. When the mobile node started movement the signal of cell_0 is decreased and signal from cell_7 is increased and got enough strong to be added in the active set. After that the cell 0 is removed from the active set due to weak pilot channel signal. When cell 6 get added into the active set the mobile node remains in softer handover as long as it is in the overlapped area between cells 6 and cell 7. When mobile node moved toward sector8 cell 8 is added to the active set and cell 7 is removed from active set then mobile node started to move toward Node B_2 and entered through cell 4 and remained for few seconds before moving toward sector 5 and dropping cell 8. While the UE surrounds Node_B_2, cell 5 added to the active set and mobile node reached again softer-handover state and stopped for some time at the edge of cell 4 and cell 5 before remaining in cell (5) coverage area and removing cell 4 from active set.

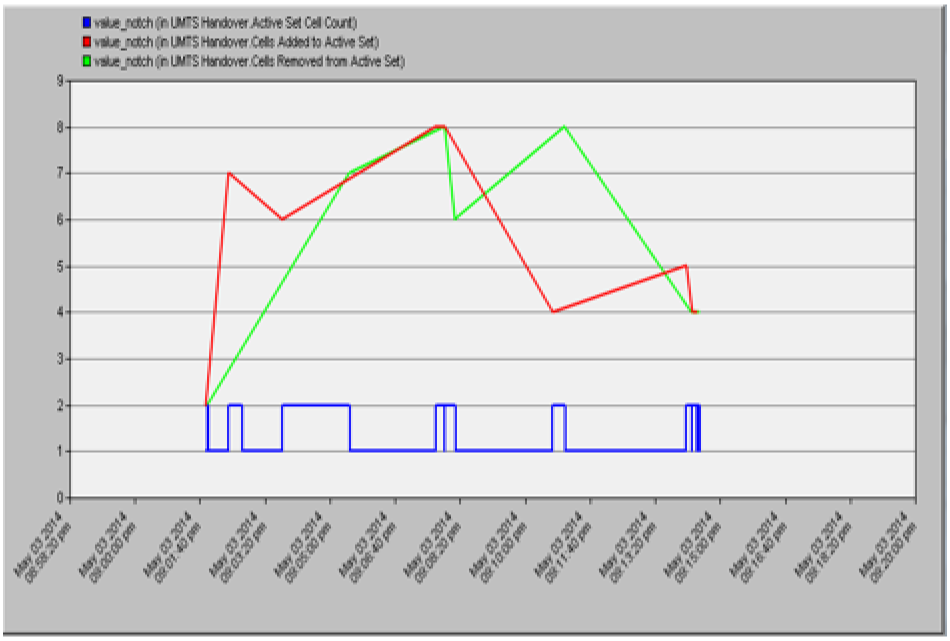

Figure5. Active set cell count.

5.3 End to End data throughput

A network throughput is the average rate of packets or amount of data that sent by sender (source node) successfully delivered to the receiver (destination node) and can be measured as bit per second (bps) or (packet/second). From figure (6) we can see that the downlink and uplink throughput is increased to achieve maximum value of 9.35 and drop to stay at a consistent value.

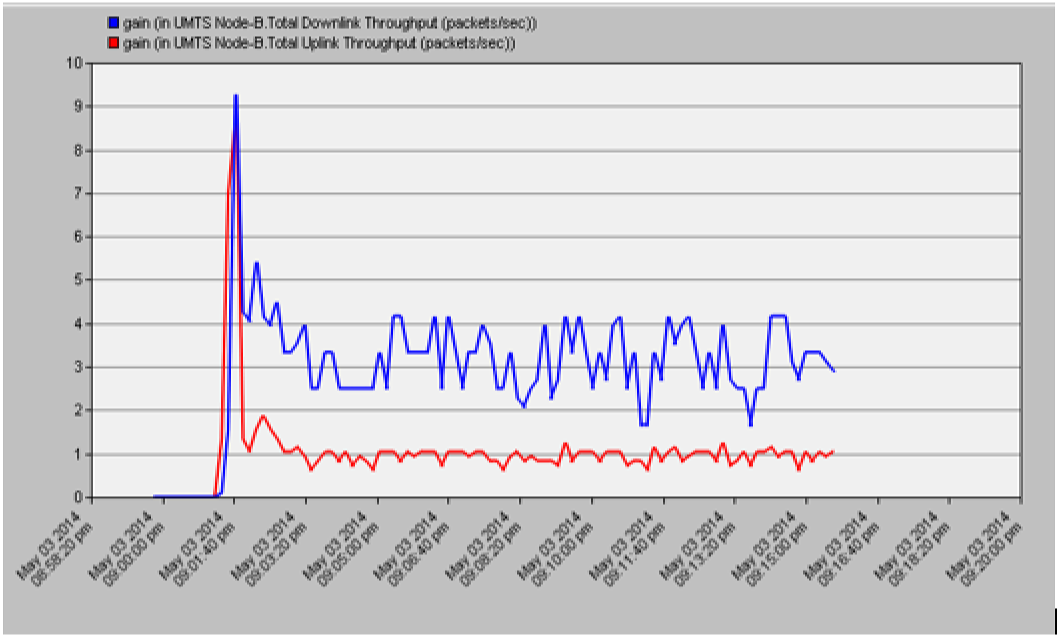

Figure6. The Downlink/Uplink throughput of UMTS user equipment.

From figure 7 it is visible that More FTP traffic is sent over the network and clearly shows that the mobile node received high number of packets during the handover. The amount of packets per second received was exactly the same as the amount of packets sent. No more traffic was lost on the network

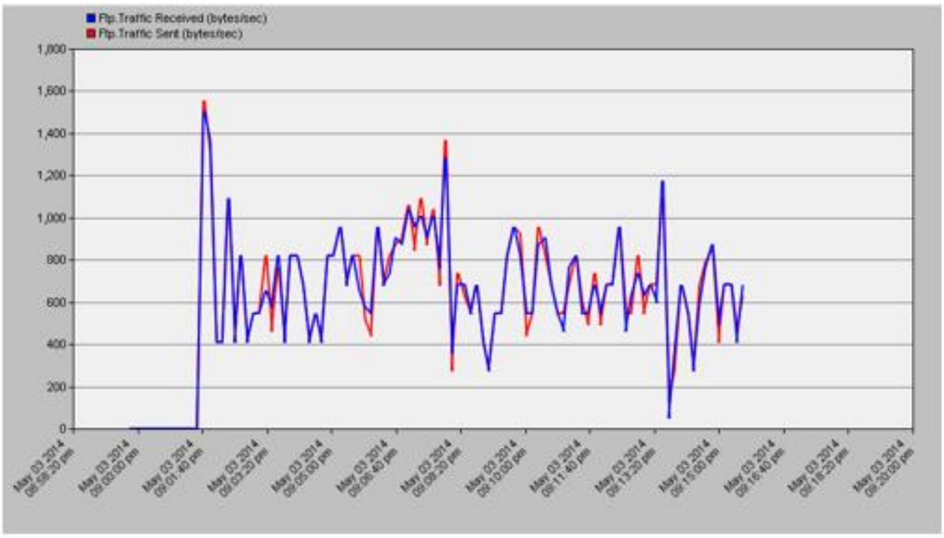

Figure7. UMTS traffic sent and received

5.4. Handover Energy to Noise ratio

In the graph (8) we can observe that the measurements of pilot channel signal are coming from all sectors included in the mobile node monitored set besides the cells that were part of the mobile node active set during the simulation.

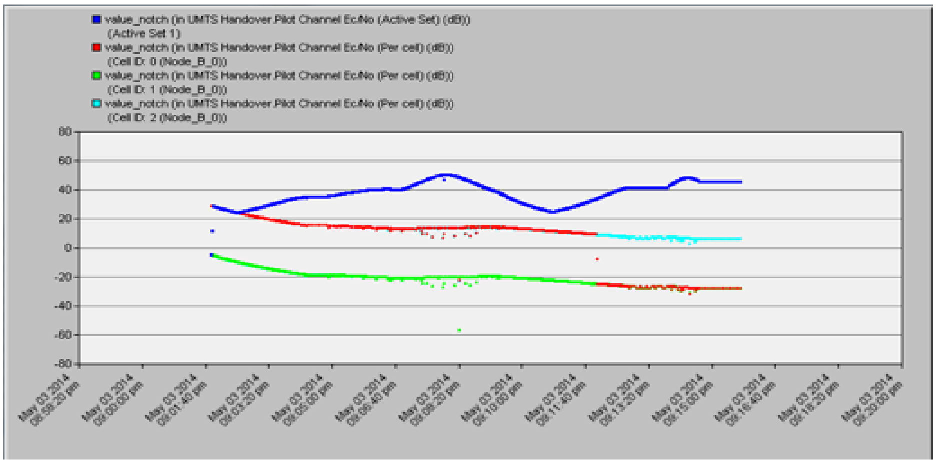

Figure8. UMTS handover polite channel E_c / N_0.

6. CONCLUSION

This paper presented a simulation to study the effects of using Node Bs of an UMTS network model with three sectors in an environment area. The simulation conducted is using OPNET modeler 14.5.

The simulation has focused on some statistics that are defined under UMTS Handover and demonstrated the soft handover procedures. These statistics showed the number of cells in the active Set and the cells are added into and removed from the Active Set. Results have showed the pilot channel Ec/No measured by UE for all the cells that belong to its active set. The results showed that when mobile node location is changed and gets closer to certain cell at certain time, the RNC is expected to handoff the mobile node between cells of the different NodeBs based on the measurement reports sent by the mobile nodes. We found that the HTTP page response time of the network started with 0.01 Second and increased to reach 0.17 second then gradually decreased to 0.078 second as the simulation advanced. No more traffic was lost on the network and the mobile node received high number of packets during the handover when more FTP traffics are sent over the network, the amount of packets received per second was exactly the same as the amount of packets sent. The results also showed that the soft handover has less response time and delay for downloading and uploading ftp and HTTP applications.

7. FUTURE WORK

- WiMAX and LTE are promising technologies provide wireless last-mile connectivity and achieved high data rate and larger coverage area. Therefore the upcoming challenge is to investigate the best possible way for the users to switch between the available different networks that use different technologies. In future, we will study different handovers algorithms and power control in WiMax-LTE networks and employ different QoS classes to measure the network performance.
- With the growing in wireless technologies and increasing demands for the heavy bandwidth applications, therefore we should take in consideration the bandwidth requirements before switching to the next BS.
- A more efficient handover algorithms can be adopted for UMTS ,WiMax, LTE networks using 6 sectors antenna.

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