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Improvement Performance of Soft Hand Over on UMTS Network

Lamia Bakri Abd elhaleem Derar and Amin Babiker Abd elnabi Mustafa

Department of Communications, Faculty of Engineering, Al-Neelain University

Abstract In this paper we present a soft handover algorithm for wide band CDMA has been developed and implemented in the framework of a system level UMTS simulator, this algorithm depend on measurement of Average Received Signal and speed of user, the evaluated under the uplink and downlink UMTS system, the performance of the proposed algorithm is evaluated under different speed scenarios for User Equipment(UE) It shown via OPNET simulation, the proposed handover algorithm can effectively reduce the delay compared with Integrator Handover Algorithms, provided solution to improvement the performance in UMTS network by minimizing delay(Queuing sent delay, Uplink tunnel delay, Down link tunnel delay) and Packet loss ratio and BER and busy. Moreover, the total system throughput higher, the comparative analysis for all metrics carried out and gave the best performance for the proposed algorithm.

Keywords UMTS, OPNET, QoS, Handover, Delay, Packet loss, Throughput, Jitter, BER.

1. Introduction

With the evolution of mobile networks and popularity of smart phones, all applications are requiring Quality of Service (QOS), the new technologies devices, smart phones are now capable of displaying high quality videos or real time video traffic, which will definitely affect on cellular networks capacity. Therefore, the increasing requirements for high data rate traffic are bringing new challenges to a cellular network, in terms of user's capacity and the increasing data throughput. The number of mobile broadband subscriptions is growing fast. According to CISCO, the number of mobile subscribers is expected to reach around 3.5 billion by 2015, the majority of them are expected to be smart phone subscribers [1] so we need to make great changes and improve the telecommunications network and provide better solutions. Mobility management is of a great challenge in the current and future radio access networks. The users of third generation (3G) networks experienced quality of service (QoS) under the movement of User Equipment (UE). The mobility from one mobile cell to another cell is improved by implementing Soft Handover (SHO). Soft Handover makes it possible to have connections on several Base Stations (BS) simultaneously. Code-Division Multiple Access (CDMA) supports Soft Handover which results in smooth transition and enhances communication quality. Soft handover offers multiple radio links that operate in parallel. The User Equipment (UE) which is near the cell boundary is connected with more than one Base Station (BS). Consequently, in soft Handover UE is able to get benefit from macro diversity. Soft handover can, therefore, enhance both QOS and the capacity of CDMA based cellular networks [3-8].

1.1. Objectives

The objectives of this thesis is to increase and enhance the signal's quality and improve spectrum's efficiency, besides, developing measurements for Key Performance Indicator (KPI) values, the analysis of handover performance testing specifically for 3G to allow each client to remain best connected at all times and best connected.

The processing is focused on downlink direction, because the direction of data transmission usually require high data rate.

1.2. Proposed Solution

We presented design and implementation of a soft handover algorithm and its use in WCDMA-based on UMTS networks, track the location and the speed and average received signal of an UE, the algorithm added optimal solutions when we compare it with another algorithms which rely only on the position and average Received Signal. This method improves the process of Handover because it added another measurement (speed of users) and the result under different UE speed scenarios. It is shown via OPNET simulation, the proposed handover algorithm can effectively reduce the delay when compared to Integrator Handover Algorithms and it provides extra feature for better communication for the users, greater capacity with the same Quality of service, and gives much time to get to the desired node B which directly effects the blocking probability and reduces it. It also reduces the call dropping probability and no break in transmission.

2. Soft Hand over Algorithm

We provide a description of the algorithm that was implemented according to specific values for thresholds and sampling intervals. Firstly, the mobile node is maintaining connections with more than one Base Stations, the active Set includes the cells that form a soft handover connection to the mobile station, the Neighbor/Monitored Set is the list of cells that the mobile station continuously measures, but their signal strength is not powerful enough to be added to the Active Set but monitoring signal strength, speed and the user position and direction of movement. The determination of the Active Set is based on the following conditions: If the signal strength of the measured quantity (not currently in the Active Set) is greater than the strongest measured cell in the Active Set (subtracting the soft handover threshold) for a period t (t = time to trigger) and the Active Set is not full, the measured cell is added to the active set. This event is called Link Addition. If the signal strength of the measured quantity (Currently in the Active Set) is less than the strongest measured cell in the Active Set (subtracting the soft handover threshold) for a period t, then the cell is removed from the Active Set. This event is called Link Removal. If the Active Set is full and the strongest measured cell in the Monitored Set is greater than the weakest measured cell in the Active Set for a period T, then the weakest cell is replaced by the strongest candidate cell (i.e. the strongest cell in the Monitored Set). This event is called Combined Radio Link addition and Removal. With respect to the handover trigger criteria, the implemented algorithm samples the signal strength of the surrounding base stations every 1 sec and uses 3dB as the threshold for soft handover and 6dB as the threshold for hard handover. The size of the Active Set may vary but it usually ranges from 1 to 3 signals. In this implementation it was set at 3[10]. The simulation performed was based on OPNET Simulation model, after each interval the simulator checks whether the position and velocity of the users has changed. If the users' position and velocity has changed the system starts handover if necessary.

2.1. Mobility management

On top of the Radio Link Control (RLC) there is the Radio Resource Control (RRC).

It is responsible for a reliable connection between the UE and the UTRAN and especially manages radio resources. It is also involved in handovers. The Signal Connection Control Part (SCCP) and on top of that the Radio Access Network Application Part (RANAP) manage the connection between the UTRAN und the CN. The RANAP also supports mobility management signaling transfer between the CN and the UE. Those signals are not interpreted by the UTRAN. It also manages the relocation of RNCs , radio access bearer (RAB) etc.

On top of this layers UMTS Mobility Management (UMM) provides mobility management functions.

In a UMTS network a SGSN manages one or more RNCs and a RNC manages many Node Bs.

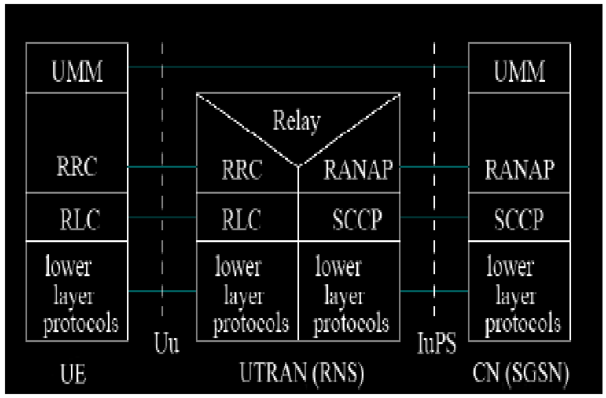

Figure 1: Control plane of UMTS mobility management between UE – UTRAN and cn – CN [14]

To track the location of an UE some geographical groups are defined within the UTRAN Figures [2-3] illustrates a general state flow diagram of the hand off algorithm performed.

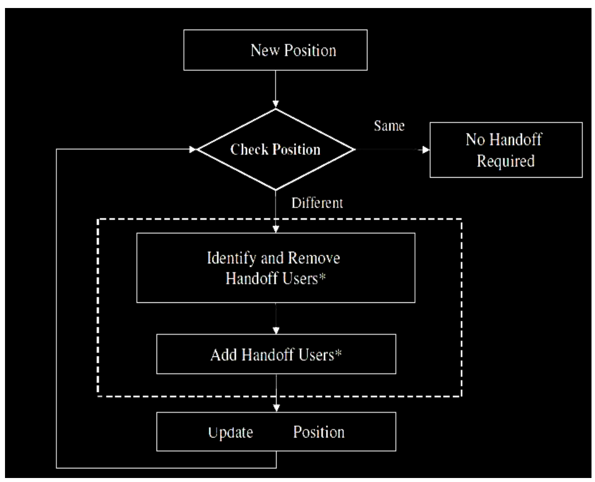

Figure 2: Immediate Handoff Initiation Algorithm

The algorithm evaluating according to the average received signal and the position and the speed of user. All users who have experienced changes must firstly be identified and be removed temporarily from the system and they must then be added back into the system and connected to the new cell.

This is to eliminate the case where users are being dropped from a cell that is waiting for some of its current users to be connected to another cell. This simulation was performed to allowing users to be connected to any base station within range. The simulation assumed cell overlap was allowed, the users were potentially able to connect to a number of BSs depending on their received power and the minimum received power threshold that defined the boundaries of a cell. Furthermore, the users will be connect to the BS that has the most available channels [9]. It is worth mentioning that most of the current devices are smart devices, therefore the cell classifies the number of Users that have been removed and it changes their state to “try again”. The code goes through the “trying again” users in numerical order to attempt to connect them to anew cell. The Handover will be successful or unsuccessful, depending on whether the new cell has any available channels. When cells overlap with each other, the users will connect to the cell with the most available channels users always connect to the closest virtual base station, the Handover, in this case, is initiated. Algorithm illustrated in Figure 2 is repeated, with the differences that the users are not identified based on their received power but on their distance from the virtual base station. This is based on the assumption that users will not be connecting to the virtual base station with the lowest loss but the ones that are physically close Thus, to identify (and remove) the hand over users we use their distance from all virtual base stations (after any change on position and speed).Also, when adding the user back to the system, the cell is chosen based on the distance of the user from the centre of the cell. In some of the simulations, in order to improve the dropping probability a number of channels have been reserved from being allocated to the new users. Thus, these channels are dedicated to the handoffs.

More specifically 10% of the total numbers of channels have been reserved for hand over in order to provide sufficient flexibility for handling handover without causing significant blocking.

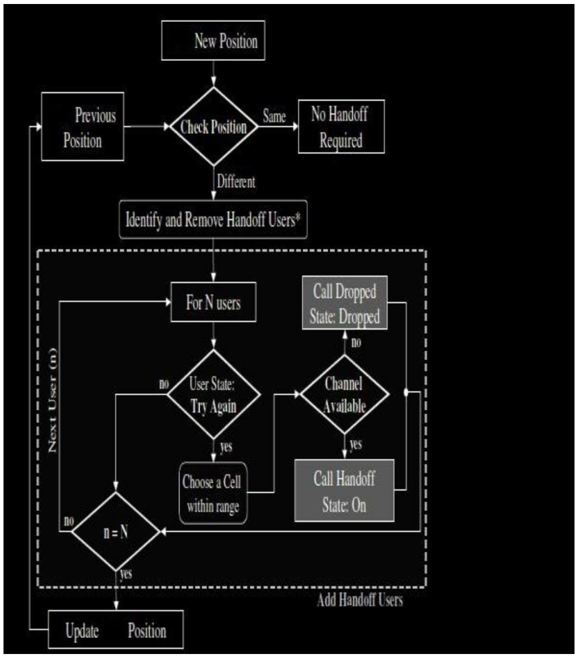

Figure 3: Add Handoff Users

Simulation Methodology

The nature of the algorithm depends on the following-up, monitor and observation of the location and speed of users. The idea of observing and monitoring the speed of the users is considered Cautionary indicator for the neighboring cells to create a number of channels until the process of Handover to complete successfully, Algorithm added optimal solutions when we compare it with another algorithms which rely only on the position and the average received signal. This method improves the process of Handover because it added another measurement (speed of users). If the speed changes by high degrees this may lead to a higher proportion of blocking and loss, particularly when those users in cars or on trains because that may make a number of handovers at the same time. So, the observation of speed functions as a cautionary indicator to the neighboring cells.

The operation of the algorithms was simulated in OPNET simulator. Each simulation scenario is defined by a variety of parameters. Traffic, propagation and mobility models are defined based on [11].

For the sample scenario, an urban and vehicular environment is modeled, which consists of a macro cellular topology of size, the antennas are Omni directional and are defined at a height of 15m.

The mobile nodes were moving and the propagation model used was the COST231 Hata model.

Traffic was introduced in the simulation according to a traffic mix combining applications corresponding to sound, high interactive multimedia, narrowband, and wideband services.

Once the environment is created and the mobile nodes are spread in the topology the simulation is run for 3500 sec. Results for three runs of the same scenario initiated with a different random speed are taken and the results are averaged.
Simulations were run for mobile node speeds of 50 Km/h and 120 Km/h.

3.1. Description for Simulation scenario

Each UE is connected to its Primary node B, and keeps an Active Set. Each UE measures the SIR received from the surrounding cells and monitors the path and the speed of UE according to the following steps:

(a) UE gets the strongest signal from sector 1 so it becomes the only member of the initial active set
(b) UE starts moving at 110 sec After some time when it reaches the edge of sector 0 (170 sec) this gets added into the active set, the UE is now in soft handover between sector 0 in Node -B-0 and sector 1 in Nobe -B-1 while it remains in this position (aprox. 1 min). Notice how during soft handover the sectors 1 and 2 reports at the same time uplink throughput coming from the UE, when that happens all duplicated packets are eliminated at the Node B and are not delivered to the RNC.
(c) At 270 sec the UE travels to sector 2, now, when it goes into sector 2 and while it remains in the overlapped area between sectors 1 and 2, the UE enters in soft handover state again and the UE moving with different speed .
(d) The UE continue moving along its trajectory, this time going to the center of sector 2, losing Sector 0 and still moving in Node -B-2 but on other path or direction. According to the figures [5-17] the simulation model shows better results in terms of delay which is the most important element to achieve quality of service.

Illustrates a general state flow

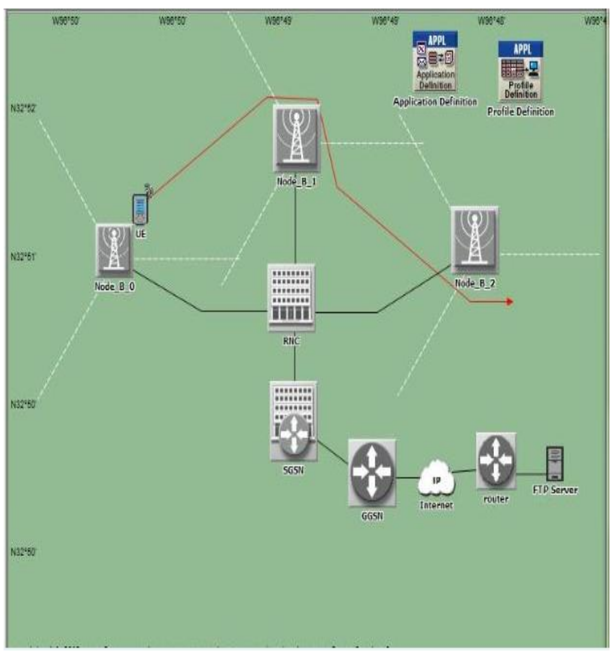

Figure 4: Network diagram by using OPNET

3.3 simulation results

Delay

The duration of the handover procedure is an important criterion of the efficiency of a handover mechanism. When a handover takes too long, service disruption can be experienced or connections can timeout and will be lost. For example, a real time video call could experience a temporary disruption when a handover takes longer than 400 ms.

If the delay is even longer, the call could be terminated entirely. To provide a seamless and efficient handover, this delay should be as short as possible. The delay is measured from the execution of the handover algorithm until the algorithm completes the handover procedure and the client is successfully connected to the other access point, see figure [4-5].

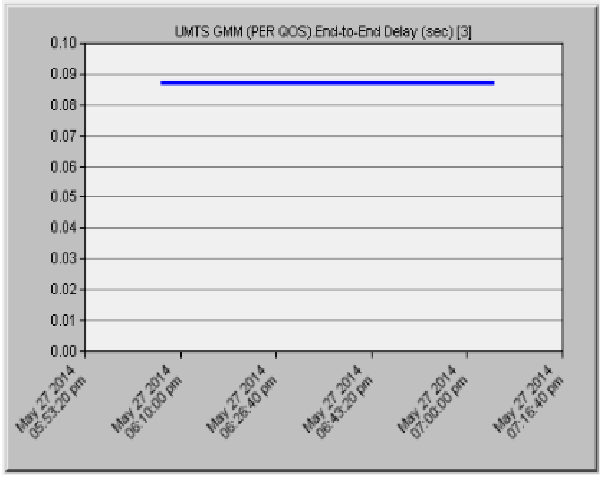

Figure 5: Show End to End delay

Queuing delay

Due to queuing and different routing paths, a data packet may take a longer time to reach its destination, the end-to-end delay experienced by the packets for each flow the individual packet delay are summed and the average is computed.

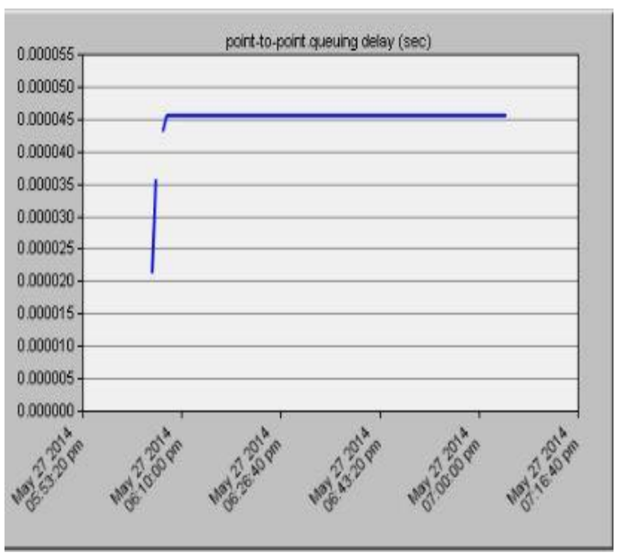

Figure 6: Point to point Queuing delay

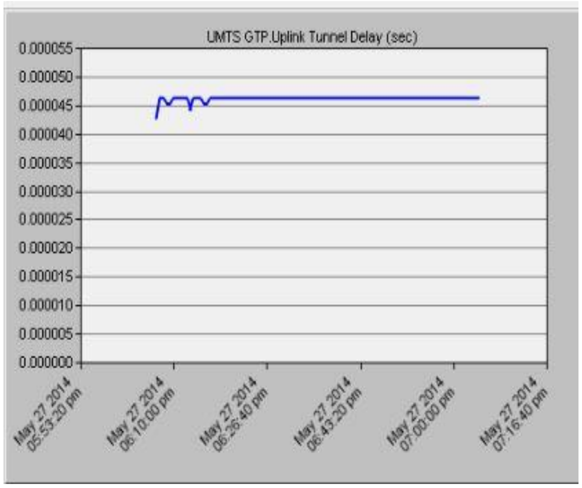

Figure 7: Uplink tunnel delay

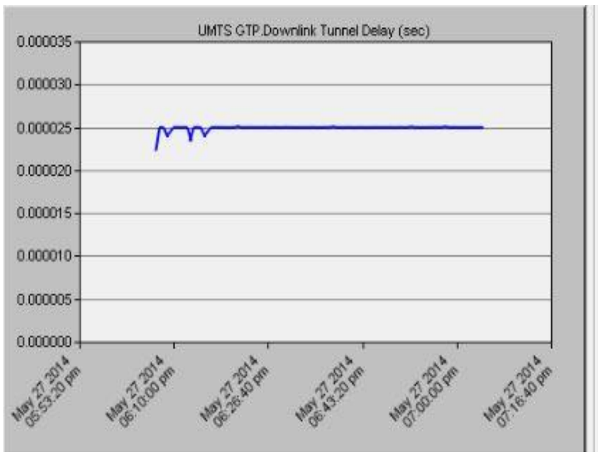

Figure 8: Downlink tunnel delay

Packet loss ratio

An optimal handover mechanism provides handover without packet losses on the other hand no packet or/data loss is almost impossible so the less packet loss a mechanism generates, the more efficient the mechanism is the ITU has also got a QoS parameter for this and states that the probability for a packet loss shouldn't be more than 1×10–3 [6].

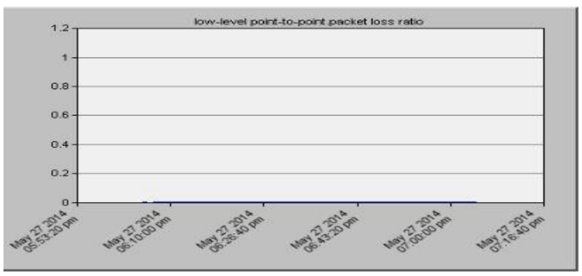

Figure 9: Packet Loss Ratio

Downlink Capacity

In UMTS the another soft hand optimization can be done by increasing the downlink capacity because the downlink capacity also effect the whole system capacity so in order to increase the downlink capacity it needs to reduce the downlink interference.

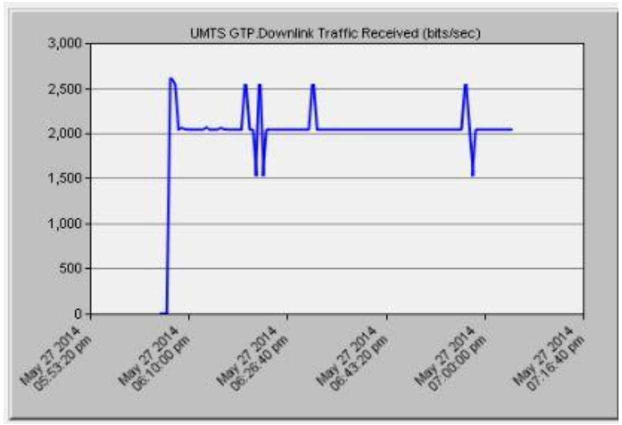

Figure 10: Downlink Traffic Received Packet

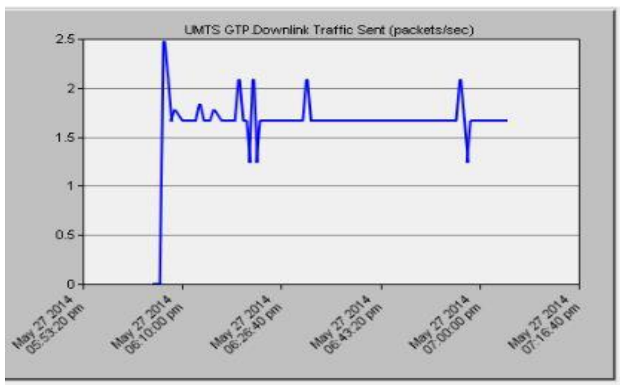

Figure 11: Downlink traffic sent packet

Figures [10-11] show downlink traffic and during those moments the downlink transmitting power of the Primary BS is increased by at most 3dB to maintain the necessary SIR given that the UE is getting out of range .In the uplink direction the value for UE Trx Power MIN=-49 dB and for UE Trx Power MAX = 21 dB giving a range of 70 dB.The SIR Target is a value provided by the outer loop power control and aims at providing the necessary quality. The SIR target is affected by the speed of the mobile node. While in the uplink direction, the decision taken by the UE is affecting all base stations in its Active Set Fig [12-13] show UMTS Uplink Traffic Sent (bits\sec) and UMTS Uplink Traffic Received (bits\sec).

Throughput

This parameter expresses the average rate of successful message delivery over Communication channel. It is measured in bits per second (bit/s or bps) and sometimes in data packets per second or data packets per time slot. Due to varying load from other users sharing the same network resources, the bit-rate (the maximum throughput) that can be provided to a certain data stream may be too low for real time multimedia services if all data streams get the same scheduling priority.

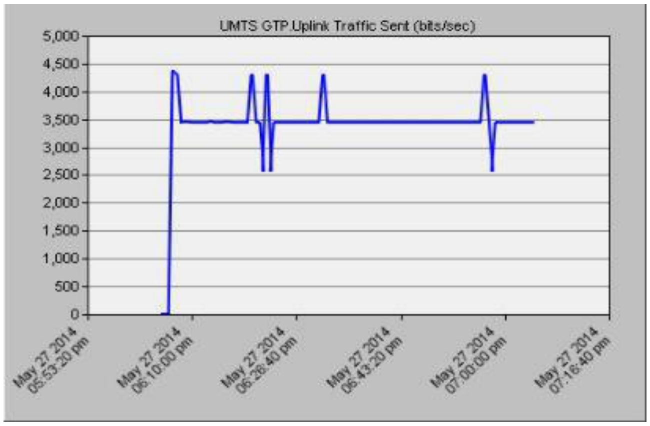

Figure 12: Uplink Ttraffic Sent

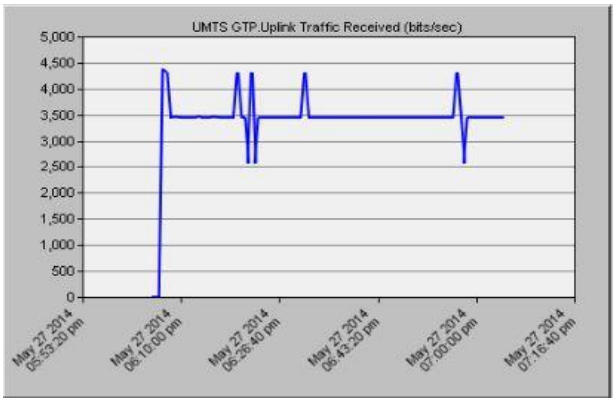

Figure 13: Uplink Traffic Received

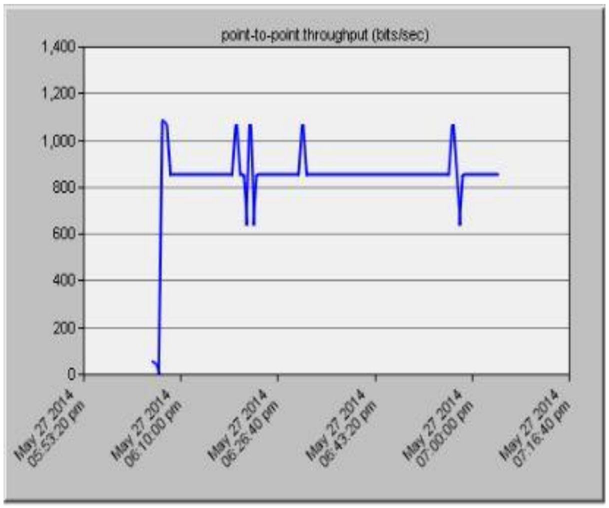

Figure 14: Throughput uplink

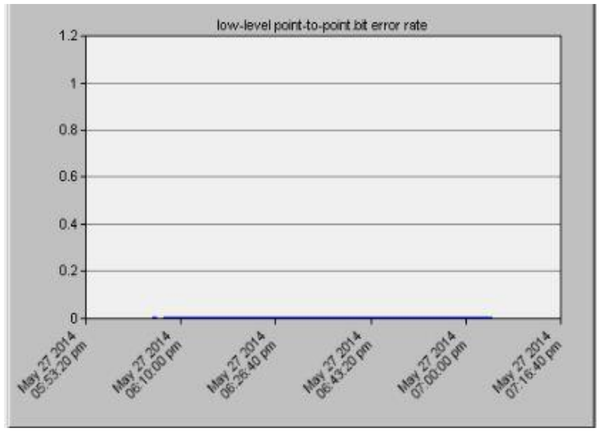

Figure 15: Bit Error Rate

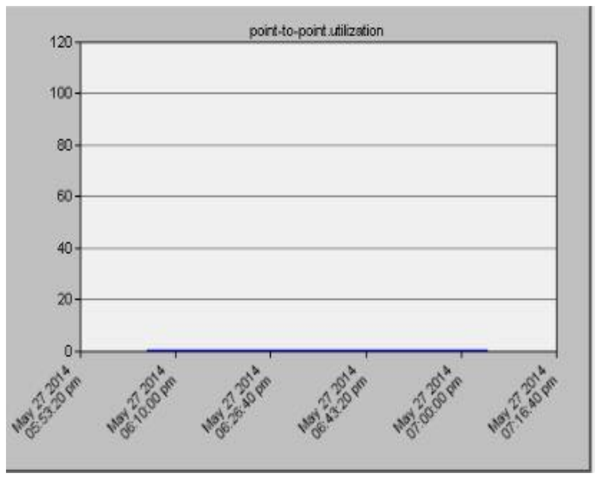

Figure 16: Utilization

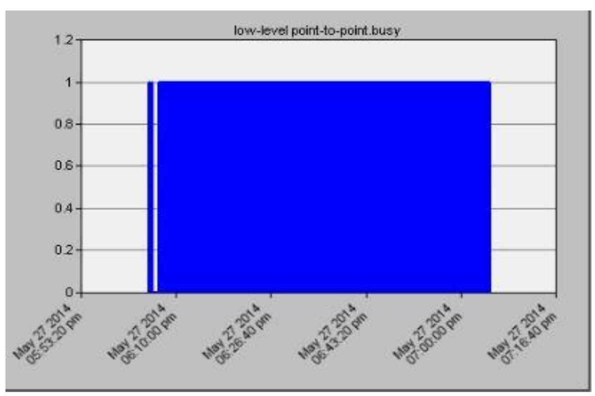

Figure 17: Low Level Point to Point Busy

Conclusion

This paper presented the design and implementation of a soft handover algorithm and its use in WCDMA based on UMTS networks, it evaluated under different UE speed scenarios. It is shown via OPNET simulation.

Algorithm added optimal solutions when we compare it with other algorithms which rely only on the position and the average received signal. This method improves the process of Handover because it added another measurement (speed of users), it provides solutions and improves the performance in UMTS network by minimizing delay (Queuing sent delay, Uplink tunnel delay, Down link tunnel delay) and Packet loss ratio and Bit Error Rate (BER), moreover the total system throughput is higher, also, show the possibility of analysis options for the future.

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