TECHNICAL ANALYSIS AND SIMULATION OF 4G WIRELESS NETWORK HANDOFF DECISION

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ABSTRACT

This paper presents the technical analysis and simulation of 4G wireless network handoff decision. The integration of numerous new technologies into 4G services which provide faster wireless internet access, makes 4G technology an extremely complicated technology. Vertical handoff poses a great challenge in communication channel and this contributes to unbearable life for subscribers. The method used involves the handoff process for inter-nodes handoff, together with matching network loads using three phases of operation. The performance of the four handoff algorithms was optimized, compared and evaluated using MATLAB/Simulink. The results obtained shows that at 6ms of time to trigger, the results of the proposed handoff algorithm had the highest optimized ratio value of 18225.701 and also, at 1 beta level, the proposed algorithm had the lowest optimized ratio value of 9255.701. Again, at 1.5 alpha level, the proposed algorithm had the highest optimized ratio value of 3012.701. The experimented results produced the minimum handoff delay of 1000.701 when compared with the other three algorithms. In conclusion, the results realized have improved the handoff decisions in order to achieve a reliable signal strength in wireless network.

Keywords: *Handoff algorithm; internet access; 4G wireless network, MATLAB/Simulink*

INTRODUCTION

The Global system for mobile communications (GSM) is a wireless digital network standard designed by standardization committees from Europe operators and manufacturers in telecommunications. The fourth generation and long term evolution (4G/LTE) network provides compatible services to all its mobile users across several million customers throughout the world (Bhat and Gojanur, 2015).

The wireless telephony system has changed with advancement of the technology to the demand of end users. The first such impact was voice telephony system in 1G and the need of the end user was shifted to benefit the voice communication mobility. After this the wireless technology evolved as GSM and the second generation (2G) in which the data service was embedded with mobility. Due to increase in demand of data services the advancement of technologies of wireless system was developed from 3G to 4G (Amit and Sujata, 2014).

The most important aspects of a mobile cellular telecommunications system are the break of the coverage area into several little cells providing good spectrum coverage and utilization. Again, as the mobile users move from one mobile station to another base station, it must be sufficiently possible to keep the connection without having a drop call. Dropped calls are frustrating to users and if the number of incidences of dropped calls raises and dissatisfaction increases, it can make a subscriber to change the network (Ashish *et al.,* 2013).

When mobile operators move from the location of one network access point to another location, this makes the operators to experience handoff. The majority of the handoffs that take place in between access points of the identical network are called horizontal handoffs while the handoffs that take place on several access positions owned by several operating networks such as wireless local area network (WLAN) to general packet radio services (GPRS) are called vertical handoffs (Krishan and Jatin, 2016).

Mobility is a very important aspect of a 4G wireless networks system. Mobile terminals should be capable of choosing the best network among the available networks including satellite systems, WLAN, WiMAX and then make handover (Mesala *et al.,* 2015).

Transparent mobility has enabled mobile users to seamlessly move across networks with minimal disruption to packet flows. A mechanism that can enable this has to exhibit a low handoff latency, data loss, adapt different environments, and finally act as a conjuncture between heterogeneous environments and technologies without compromising on key issues related to security and reliability (Ali *et al.,* 2014).

However, handover process in cellular network automatically transfers a call from one radio link to another radio link while maintaining good quality of services of the call. The number of cell boundaries increases because smaller cells are deployed in order to meet the demand of increased capacity. Each handover demands network assets to link and connect the call to the next base station (Sonal and Mankar, 2016).

Galadima *et al.,* (2014) investigated the analysis of inter cell handover methods in a mobile system network. Their work was based on studying and enhancing inter-cell handover changes in Airtel network system. In their results, seventy-two percent (72%) of cells considered performed below NCC targets for call setup success rate (CSSR), sixty-four percent (64%) failed to achieve handover success rate (HSR) and standalone dedicated control channel blocking rates targets, twenty-one percent (21%) failed to achieve congestion targets and the average call drop rate per cell was predicted to be six percent (6%).

Prithiviraj *et al.,* (2016) proposed a fuzzy logic-based decision-making algorithm to optimize the handover operation in HetNets. The authors carried out a comprehensive principle that shows the test-bed using the fuzzy logic based algorithm and guaranteed seamless connection. Their results gave 1.6% improvement in reducing the handover delay and 1.3% in packet loss reduction, thereby their system improves the transmission quality.

Umesh and Rajeev, (2017) developed an efficient communication of mobile assisted handoff (MCHO) method that applied in cellular networks technology. In their research, the inter system handovers where a calls connection was transported from one access point system to another GSM/UMTS handoff to WiFi and vice versa. Their results show that in MCHO, the mobile station was in control of the handoff measured and also. the mobile station keeps on measuring signal strength from all the surrounding base stations.

Elsanosy *et al.,* (2018) investigated the performance improvement of hard handoff call return rate in microcell of mobile network system by the application of Eldolil Traffic Model. Their results depict that the rate of completed handoffs was directly proportional to the handoff call return rate with different levels depending on only handoff in its minimum value. Again, the rate of completed handoffs was inversely proportional to the handoff mobile device call arrival rate with various different levels depending on only handoff*s* in its maximum value.

The statement of problem is that the combination of numerous new technologies into 4G networks due to several networks such as wireless local area network and wide band code division multiple access makes this technology complex. The objective is to carry out technical analysis and simulate their performance for improvement in 4G network.

METHODOLOGY

The materials required in this paper are 4G evolution advanced toolbox, block set for Math Works, physical layer simulator, an OFDMA wireless system and MATLAB/Simulink.

The method used for the handoff decision incorporates three phases of operation such as preparation, execution and completion phase. The preparation phase commences when the source node makes a handoff decision and send out a handoff request message to the target node.

Also, if the target node accepts the handoff request message, it will assign a suitable buffer size for the incoming user equipment and inform the source node the channel endpoint where the forwarded data was expected to be received in the handoff request acknowledgment message. When the source node receives the handoff request message, it sends out the handoff command message to the user equipment requesting to execute a handoff action.

Again, in the execution phase, the source node forwards the recently arrived packets to the target node and the target node sends out all packets to the user equipment with a handoff confirm message to complete the execution phase.

Also, in the completion phase, the target node sends out a handoff notification message to the gateway and the gateway then modernized its path to the corresponding user equipment by sending a handoff complete acknowledgment message. The source node then releases all the resources after getting released resource message from the target node.

Considering when a mobile call is moving away from the serving cell, the reference signal received power (RSRP) from the serving cell degrades with time and a handoff decision has to be made for the entire time to trigger (TTT) as shown in equation (1).

$$\mathrm{RSRP_C} > \mathrm{RSRP_S} + \mathrm{HOM} \quad (1)$$

where $\mathrm{RSRP_C}$ is the received signal from the target cell, $\mathrm{RSRP_S}$ is the received signal from the serving cell and HOM is the handoff margin.

The signal strength for the algorithm is given in equation (2).

$$\overline{\mathrm{RSS}}(\mathrm{nP_m}) = \beta\mathrm{RSS}(\mathrm{nP_m}) + (1-\beta)\overline{\mathrm{RSS}}\big((\mathrm{n}-1)\mathrm{P_m}\big) \quad (2)$$

where $\overline{\mathrm{RSS}}$ is the filtered received signal strength, (P_m) is the handoff measurement period, n is the n-th interval, β is the forgetting factor between 0 and 1 as given in equation (3).

$$\beta = \frac{P_m}{T_w} \quad (3)$$

where T_w is an integer multiple of Pm.

The signal strength comparison is implemented using equation (4).

$$\overline{\mathrm{RSS}}(\mathrm{nTw})_\mathrm{C} > \overline{\mathrm{RSS}}(\mathrm{nTw})_\mathrm{S} + \mathrm{HOM} \quad (4)$$

where $\overline{\mathrm{RSS}}(\mathrm{nTw})_\mathrm{C}$ is the filtered received signal strength of the target cell and $\overline{\mathrm{RSS}}(\mathrm{nTw})_\mathrm{S}$ is the filtered received signal strength of the serving cell.

The calculated reference signal power difference is shown in equation (5).

$$\mathrm{DIFs_{r(t)}} = \mathrm{RSRP_C(t)} - \mathrm{RSRP_S(t)} \quad (5)$$

where $\mathrm{RSRP_C(t)}$ is the reference signal power from the target and $\mathrm{RSRP_S(t)}$ is the reference signal power from the serving cell at time t and $\mathrm{DIFs_r}(t)$ is the reference signal power difference of the user at time t.

The computed filtered RSRP difference is shown in equation (6).

$$\mathrm{FDIFs_{r(t)}} = (1-\alpha) \times \mathrm{FDIFs_{r(t-1)}} + \alpha \times \mathrm{DIF}s_r\mathrm{(t)} \quad (6)$$

where α is the proposed variable and it is a fraction between 0 and 1, $\mathrm{FDIFs_r}(t)$ is the filtered reference signal power difference value of the user at serving cell at time t.

The optimize reference signal power is calculated as shown in equation (7).

$$\mathrm{RSRP_{opt}} = \frac{\sum_{\mathrm{n}=1}^{\mathrm{Rn}} \mathrm{RSRP_{opt}}}{\mathrm{R_n}} \quad (7)$$

where $RSRP_{opt}$ is the optimize reference signal power obtained by the user from serving cell and R_n is the total number of periods.

The average reference signal power constraint is shown in equation (8).

$$RSRP_C(t) > RSRP_{opt} \tag{8}$$

where $RSRP_C$ (t) is the current signal power received from the target cell.

The handoff decision can be set when equation (8) is satisfied with two other conditions stated in equations (9) and (10).

$$RSRP_C > RSRP_S + HOM \tag{9}$$

$$HO_{trigger} \geq TTT \tag{10}$$

where $HO_{trigger}$ is the handoff trigger.

RESULTS AND DISCUSSION

The simulated results were obtained using MATLAB/Simulink to determine the optimize ratio from the input values of the handoff algorithms. The user equipment speed used in the simulation are 3Km/hr, 30Km/hr, and 120Km/hr.

The handover margin values that are to be changed are 0 to 10 and the time to trigger values to be changed are 0 to 6. The handoff algorithms used during the experiment are LTE hard handoff algorithm, RSS based TTT window algorithm, LTE integrator handoff algorithm and the proposed handoff algorithm (LHHAORC).

The optimize ratio that determine the performance of each handoff algorithms at each time interval are 1 to 6ms for TTT scenario, 0.1 to 1.5 for beta scenario and 0.1 to 1.5 for alpha scenario.

The parameters selected during the simulation results are handoff margin of 5dB, beta scenario of 1ms and reference signal power of 9 and 2 for the target cell and serving cell respectively. Table 1 shows the handoff distance at different time interval.

Table 1: Handoff distance at different time intervals for TTT scenario

Handoff distance				
TTT(ms)	LHHAORC (Proposed Protocol)	LTE Hard Handoff Algorithm	RSS Based TTT Window Algorithm	LTE Integrator Handoff Algorithm
1	1025.701	1025.701	1025.701	1025.701
2	11948.701	9259.701	10150.701	9059.701
3	13896.701	11809.701	12092.701	10039.701
4	14586.701	13481.701	14585.701	12901.701
5	16455.701	15127.701	16235.701	14260.701
6	18225.701	17025.701	16945.701	16703.701

In figure 1, it is observed from the plot that at each time interval, the top of each bar represents the distance covered by each handoff algorithm. At 1ms, the proposed handoff algorithm has the same optimize ratio value of 1025.701 with all the other handoff algorithms. Also, at 6ms, the proposed handoff algorithm has the highest optimize ratio value of 18225.701 compared to 17025.701, 16945.701 and 16703.701 values for LTE hard handoff algorithm, RSS based TTT window algorithm, and LTE integrator handoff algorithm. In comparison, the simulated proposed handoff algorithm has the highest optimize ratio values of handoff distances of 1025.701, 11948.701, 13896.701, 14586.701, 16455.701 and 18225.701. The results obtained shows that, the proposed handoff algorithm at TTT scenario of 3km/hr improves the handoff decisions better than the existing handoff algorithms.

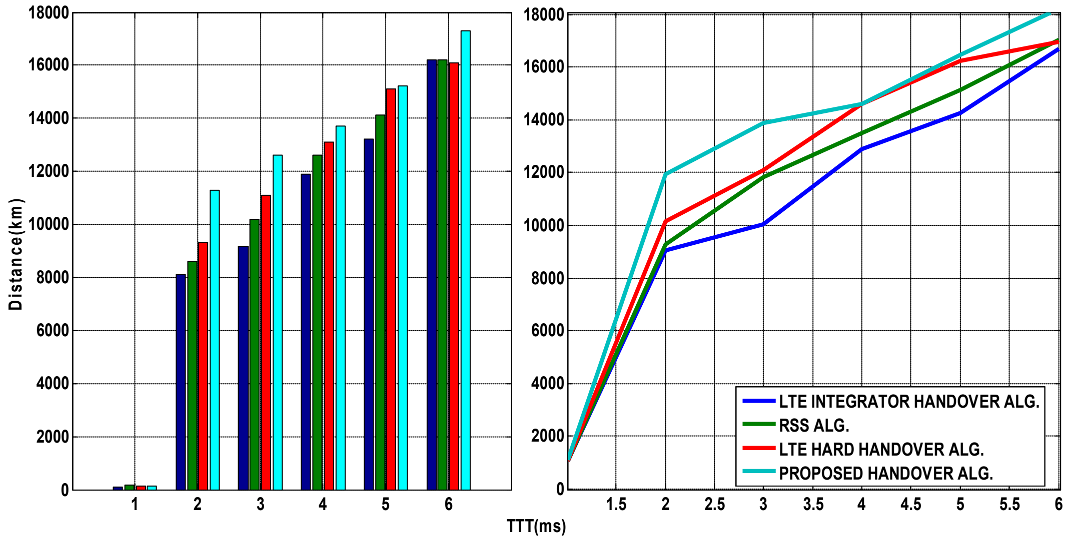

Figure 1: Plot of distance against time to trigger at 3km/hr.

Table 2: Handoff distance at different beta levels

Handoff distance				
Beta level	*LHHAORC (Proposed Protocol)*	*LTE Hard Handoff Algorithm*	*RSS Based TTT Window Algorithm*	*LTE Integrator Handoff Algorithm*
0.25	1025.701	1025.701	1025.701	1025.701
0.5	12785.701	11145.701	11025.701	10915.701
0.75	15025.701	12945.701	13895.701	11585.701
1	9255.701	7235.701	8235.701	6145.701
1.25	17145.701	15027.701	15905.701	14235.701
1.5	20805.701	18890.701	19135.701	17025.701

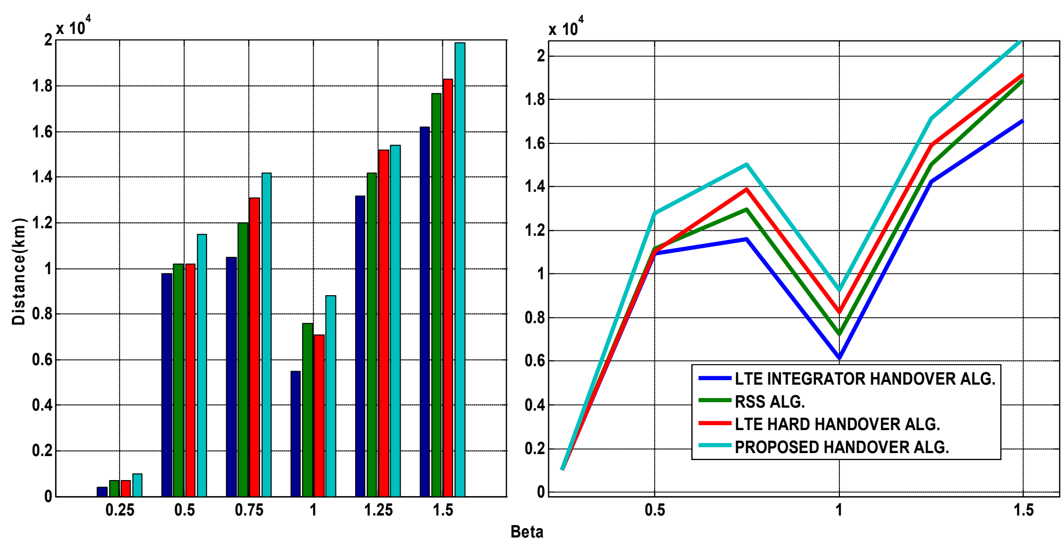

Figure 2: Plot of distance against beta level at 30km/hr.

Figure 2 shows the plot of distance against beta level. At 0.25, the proposed handoff algorithm has the same optimize ratio value of 1025.701 with all the existing handoff algorithms. Again, at 1.5, the proposed handoff algorithm has the highest optimize ratio value of handoff distances at all beta levels during change of cells. The results obtained shows that, the proposed handoff algorithm at beta scenario of 30km/hr improves the handoff decisions better than other handoff algorithms.

Table 3: Handoff distance at different alpha level

Handoff distance				
Alpha level	*LHHAORC (Proposed Protocol)*	*LTE Hard Handoff Algorithm*	*RSS Based TTT Window Algorithm*	*LTE Integrator Handoff Algorithm*
0.25	1025.701	1025.701	1025.701	1025.701
0.5	13225.701	12259.701	12825.701	11325.701
0.75	2701.701	2575.701	2605.701	2525.701
1	1926.701	1870.701	1904.701	1835.701
1.25	2585.701	2526.701	2559.701	2514.701
1.5	3012.701	2916.701	2925.701	2825.701

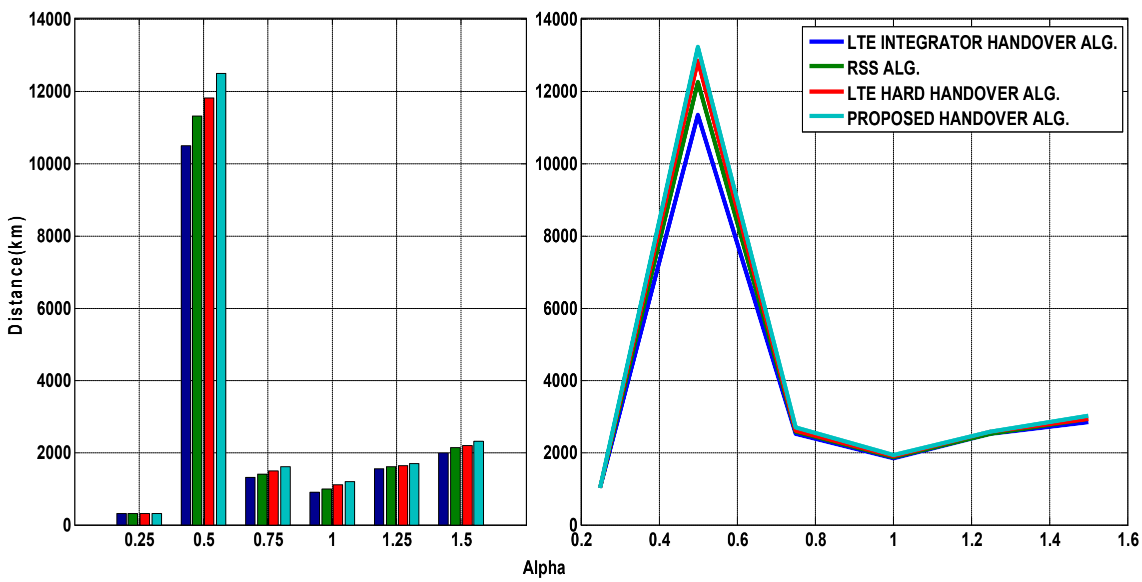

Figure 3: Plot of distance against alpha level at 120km/hr

Figure 3 shows the plot of distance against alpha level. It was observed that at 1 alpha level, all handoff algorithms drop below 2000 km while the proposed handoff algorithm had a better handoff than the existing handoff algorithms.

Also, 0.5 alpha level, the proposed handoff algorithm has the highest optimize ratio value of 13225.701 compared to the other handoff algorithms. The results obtained shows that, the proposed handoff algorithm at alpha scenario of 120km/hr improves the handoff decisions better than other handoff algorithms.

Table 4: Handoff delays in handoff algorithm

UE SPEED (KM/HRS)	*LHHAORC (Proposed Protocol)*	*LTE Hard Handoff Algorithm*	*RSS Based TTT Window Algorithm*	*LTE Integrator Handoff Algorithm*
0	200.7012	144.7012	113.7012	194.7012
80	200.7012	144.7012	113.7012	194.7012
100	200.7012	144.7012	113.7012	194.7012
120	1000.701	1344.701	1113.701	2194.701
140	2600.701	3144.701	2713.701	5294.701
160	4600.701	5344.701	4713.701	8794.701
180	7400.701	8344.701	7513.701	13094.701

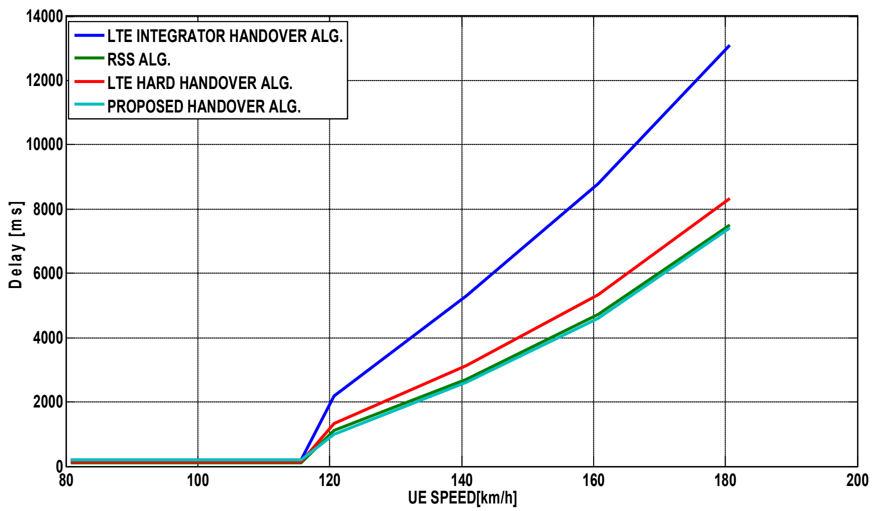

Figure 4: Handoff delay for selected algorithms

Figure 4 shows the system delay of four handoff algorithms in three speed scenarios of 3km/hr, 30km/hr and 120km/hr. At 3km/hr and 30km/hr, the four handoff algorithms produce the same handoff delay. Also, at 120km/hr, the proposed handoff algorithm produces the least delay value of 1000.701 compared to LTE hard handoff with delay value of 1344.701, RSS hard handoff with delay value of 1113.701 and LTE integrator handoff with delay value of 2194.701.

The implication of this results is that the proposed handoff produces the lowest percentage of 19.96% compared to LTE hard handoff with the percentage of 22.93%, RSS hard handoff with the percentage of 20.20% and LTE integrator handoff with the highest percentage of 36.91%.

CONCLUSION

The theoretical and practical implication of the study is that the optimized handoff algorithm can effectively minimize the unnecessary number of handoffs. Again, highest optimize ratio value leads to a set of optimized parameters of the selected handoff algorithm for a specific speed by minimizing the average number of handoffs per user equipment per second.

However, once a handoff decision was made, a receiving radio access port has to be determined and the applicant became the receiving access port to be selected on the grounds of signal quality. It is evident that mobile terminal arriving to an access port as a consequence of a handoff compete for the same radio resources with terminals having selected at that particular access port.

Again, the total sum of the system delay produced during simulation are 18612.91ms, 16395.91ms, 29962.91ms for the LTE hard handoff algorithm, RSS handoff algorithm, LTE integrator handoff algorithm and 16204.91ms for the proposed handoff algorithm.

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