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OPTIMIZATION OF HANDOVER PERFORMANCE IN LTE USING THE TS 36.942 PATH LOSS MODEL AND LOG-NORMAL FADING

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Abstract

In LTE systems, handovers have to be glitch free and very fast because, unlike earlier mobile communication technologies, it does not support soft handover but instead it supports only hard handover and this makes handover particularly challenging in LTE networks. This research aims to optimise handover in LTE networks using a combination of the TS 36.942 Path Loss model and Log-Normal Fading. This work involves the design and comparative analysis of 3 LTE network scenarios in order to know the one that has the best handover performance. The first scenario uses a combination of COST 231 Path Loss model and Log-Normal Fading. The second scenario uses a combination of TS 25.814 Path Loss model and Log-Normal Fading. The third scenario uses a combination of TS 36.942 Path Loss model and Log-Normal Fading. Except for the Path Loss and Fading combinations, these 3 scenarios have the same features and network environments. These 3 scenarios were modelled and simulated using the LTE system level simulator. The results of the simulation show the quantity of throughput produced by the network in each of the scenarios. On comparing the values of throughput obtained for the 3 scenarios with each other, it would be observed that the highest network throughput occurred in the third scenario which combines the TS 36.942 Path Loss model and Log-Normal Fading, thereby indicating increased handover performance and better communication, therefore this combination optimises handover performance in an LTE network.

Keywords: Handover, LTE, eNodeBs, Path loss Model, User Equipment, Throughput.

1.0 Introduction

In cellular networks, mobility is of the essence. It is most undesirable to loose calls/data connection as a mobile network user moves from one cell coverage area to the other. A process called Handover ensures that connection is not lost as mobile equipment with call or data in session moves across cells. Handover occurs when a mobile equipment that has call or data in session transports from an area of coverage belonging to a particular cell to an area of coverage belonging to a different cell without losing the ongoing connection, call or data session. This is possible because very complex algorithms transfer the connection, call or data session from cell to cell. In LTE systems, handovers have to be glitch free and very fast because it has no soft handover capability unlike 2G and 3G systems, hence the need for optimization of handover.

In Balan *et al*, 2011, the authors proposed a technique that can minimize the signalling determined via the use of a handover self-optimisation algorithm. This algorithm calculates the appropriate values of the key handover control parameters according to the network performance observed. The technique for minimizing signalling is used as a stop condition since there is a point beyond which improvement of performance is hardly achieved as a result of shadow fading and coverage holes. Beyond this point, there will only be slight variation of performance with different control parameter settings. However, the gain observed will not make up for the likely instability and signalling load that these changes have brought about. Through the combined use of the signalling minimizing technique/mechanism and the handover self-optimization algorithm, the signalling load will be diminished quite significantly while network performance will be maintained.

Davaasambuu *et al*, 2015, proposed a scheme that employs self-optimization of handover hysteresis in addition to the use of relay nodes for dual mobile wireless networks deployed in high speed environments. The technique proposed configures the hysteresis and cell individual offset handover parameters in accordance with the vehicle’s velocity and handover performance indicator, thereby influencing the decision that triggers handover along with the performance.

However Lin *et al*, 2013 developed a new handover algorithm called Limited Coordinated Multipoint (Limited COMP) Handover algorithm to support joint processing in Coordinated Multipoint (COMP) transmission and thereby subdue the problem of system capacity. The results of the simulation make it clear that the “Limited COMP” handover algorithm has better performance than the open literature handover algorithm because it has shorter system delay as well as less system load and it also maintains a greater system throughput within a high congestion network. The simulation equally shows that in a saturated system where the number of UE ranges from 150 to 300, the system throughput could be improved using the proposed algorithm as against the “COMP” handover algorithm.

The publication of Akkamahadevi *et al*, 2016, reviewed different technologies employed in handovers in the LTE network. Some shortcomings were identified with these techniques such as in the case of handover optimizing algorithms: because they increase the rate of ping-pong handover, and in the case of handover prediction mechanism: because they fail to predict handovers when the mobile nodes are moving randomly. Also some of these techniques are negatively affected by the quality of the channel and the speed of the mobile nodes in the network.

Lee *et al*, 2010, proposed a self-optimizing cost based adaptive hysteresis scheme that featured a cost function that considered some major factors that concern Handover Failure Rate (HFR), performance like the velocity at which the UE is moving, the difference in load that exists between the target and serving cells and the type of service. Using the proposed scheme, a suitable value of hysteresis that is centered on the major factors is simply calculated in order to achieve handover performance optimization for the purpose of minimizing HFR. The results of the simulation show that the proposed scheme offers better HFR performance than the regular schemes.

Saeed et al, 2016, employed fuzzy logic in developing a new handover algorithm for LTE called Fuzzy Logic for LTE Handover (FLLH). It was hinged on obtaining the optimum handover margin that is needed for a handover process as well as obtaining the suitable time to trigger (TTT) that is needed for a successful handover using Fuzzy Logic. This proposed handover technique, in comparison with some four regular handover techniques, could attain minimum average number of handovers per user as well as offer maximum throughput than the other four techniques.

Kahaar, 2013, focused on evaluating handover performance. The mobile network for the analysis was built emulating real life scenarios using Qualnet simulator. The Path Loss and Fading models were altered into a combination of “Free Space and Ricean”, “Free Space and Rayleigh”, “Two Ray and Rayleigh” and “Two Ray and Ricean”. These combinations were simulated using the same network environment for comparison basis.

2.0 Research Methodology

The general procedure and the system flowchart for this research work are shown in figures 1 and 2 respectively. The 3 network scenarios were designed using the parameter settings in Table 1. Subsections 2.1 to 4.4 described the Path Loss models and Log-normal fading.

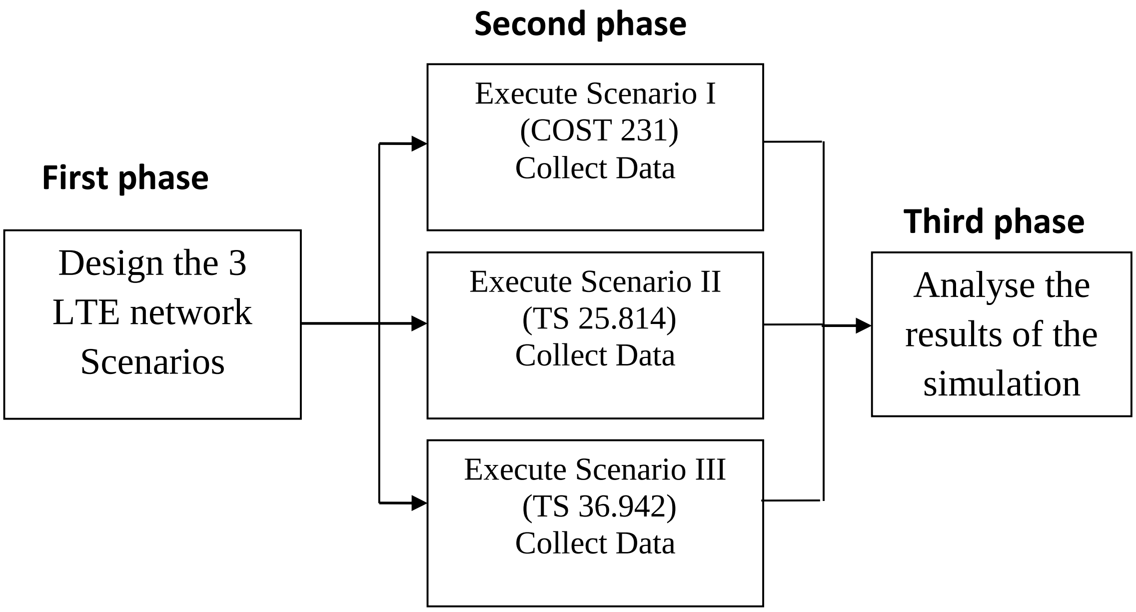

Figure 1: General System Procedure

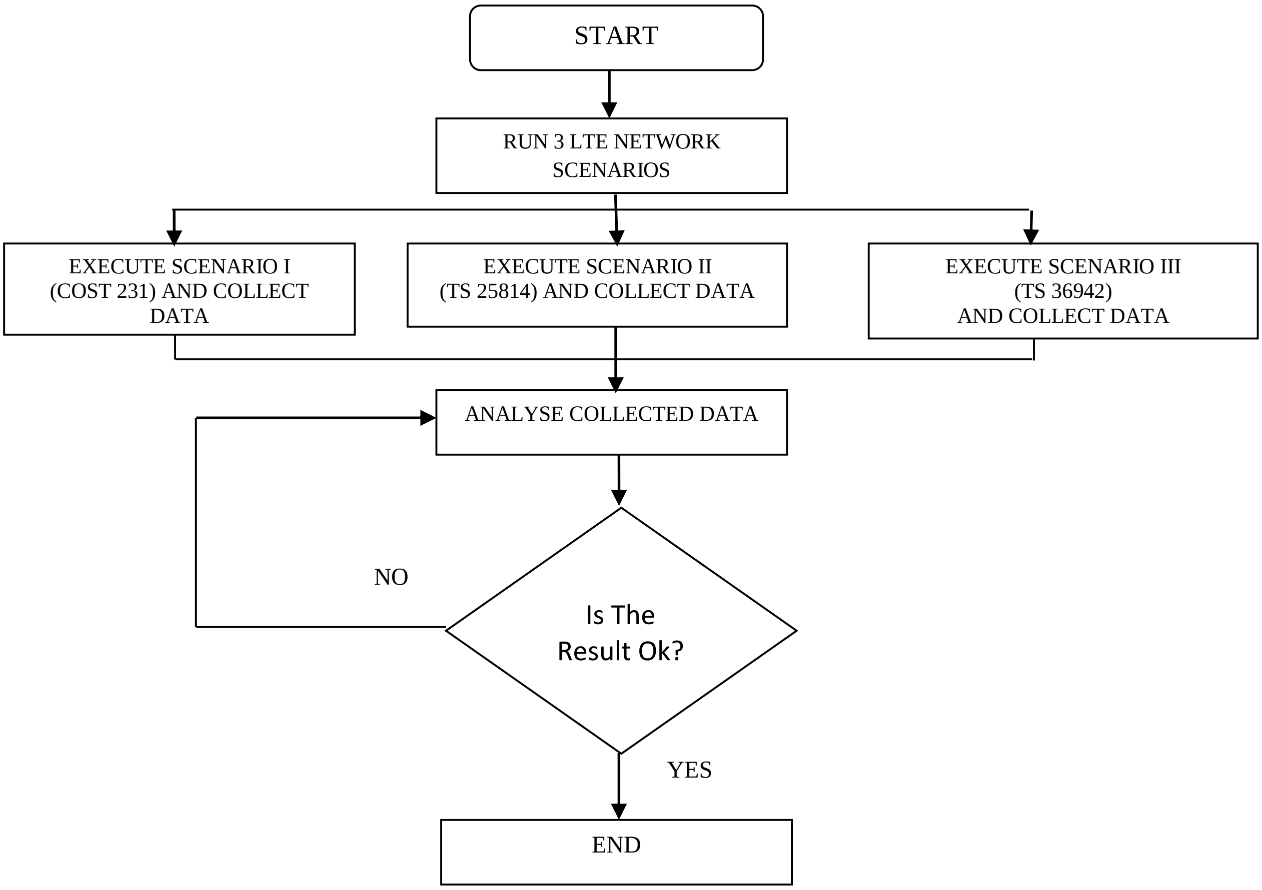

Figure 2: System Flow Chart

Table 1: System Parameter Settings

2.1

Parameter	Value
Frequency	2.0 GHz
Bandwidth	5 MHz
Path Loss Models Used	**COST 231** for the first scenario **TS 25.814** for the second scenario **TS 36.942** for third scenario
Fading Model	Log Normal (2D space-correlated) shadow fading
Antenna Model	Omnidirectional
User Equipment (UE) Position	Homogeneous. UEs located in target sector only. 5 UEs per sector.
User Equipment (UE) Speed	5 Km/h (1.38m/s)
Number of User Equipments (UE)	5
Number of eNodeBs	3
Inter eNodeB distance	500m
Simulation Time	0.1s
eNodeB Transmission Power	43dBm

COST 231 Path Loss Model

This model takes the following into consideration: the carrier frequency (f_c), Height of Base Station Antenna (h_b), Height of Mobile Station Antenna (h_m), Distance of the Transmission (d) (Singh, 2012).

The path loss "L" is expressed by the COST-231 model as follows:

$$L_{dB} = A + B \log_{10}(d) + C \quad (1)$$

"A", "B" and "C" are expressed as follows:

$$A = 46.3 + 33.9 \log_{10}(f_c) - 13.28 \log_{10}(h_b) - \alpha(h_m) \quad (2)$$

$$B = 44.9 - 6.55 \log_{10}(h_b) \quad (3)$$

C = "0" in the case of suburban areas and medium cities or **C = "3"** in the case of metropolitan areas.

$\alpha(h_m)$ is the correction factor for antenna height and is given as follows;

For Suburban Enviroment:

$$\alpha(h_m) = (1.1\log_{10}f - 0.7)h_m - (1.56\log_{10}f - 0.8) \quad (4)$$

For Urban Enviroment:

$$\text{--}\alpha(h_m) = 8.29(\log_{10}(1.54h_m))^2 - 1.1, \text{ if } 150\text{MHz} \leq f \leq 200\text{MHz} \quad (5)$$

OR

$$\text{--}\alpha(h_m) = 3.2(\log_{10}(11.75h_m))^2 - 4.97, \text{ if } 200\text{MHz} \leq f \leq 1500\text{MHz} \quad (6)$$

("COST_Hata_model", 2019)

2.2 TS 25.814 Path Loss Model

This model expresses the Path Loss in relation to the carrier frequency and Transmission Distance. The Path Loss "L" is given as follows:

$$\text{--}L = I + 37.6 * \log_{10}(R) \quad (7)$$

Where:

--"R" is the Transmission Distance (in km) between base station and UE

And
--**I = 128.1** when a 2 GHz carrier is used or **I = 120.9** when using a 900 MHz
Carrier ("LTE System Level Simulator", 2010).

2.3 TS 36.942 Path Loss Model

Here the Path Loss "L" is given as follows:

For Urban Areas:

--$L = 40*(1-4*10^{-3}*D_{hb})*\log_{10}(R)-18*\log_{10}(D_{hb})+21*\log_{10}(f)+80dB$ (8)

Where;
--"R" is the Transmission Distance (in km) between base station and UE
--"f" is the frequency of the carrier in MHz
--"D_{hb}" is the Height of Base Station Antenna in metres, obtained from the
Conventional rooftop level ("LTE System Level Simulator", 2010).

For Suburban areas:

--$L = 69.55+26.16*\log_{10}(f)-13.82*\log_{10}(H_b) + [44.9 - 6.55 * \log_{10}(H_b)]*$
--$\log_{10}(R)-4.78(\log_{10}(f))\ 2+18.33 * \log_{10}(f) - 40.94$ (9)

Where;
--"R" is the Transmission Distance (in km) between base station and UE
-- "f" is the frequency of the carrier in MHz
And
--"H_b" is the Height of Base Station Antenna (in metres) above ground.
("LTE System Level Simulator", 2010).

2.4 Log-Normal Fading

Log-Normal fading expresses that the mean value (average value) of the Log of the Path Loss has a normal distribution. This means that it occurs more frequently in the Path Loss distribution than the other values of the Path Loss such as the minimum value, maximum value, etc ("ELEX 7860: Wireless System Design", 2013).

2.5 Computer Simulation Tool

The computer simulation tool employed in this work is the "**LTE system-level simulator**". It is a MATLAB based simulation tool. It supports the Path Loss models and Fading model used in this work. This simulator is made available for free at http://www.nt.tuwien.ac.at/ltesimulator under a license that supports academic and non-commercial usage.

3.0 Simulation Results

The simulation yielded a total of 42 graphs of "throughput against time" for all the 5 user equipment (UEs) and all the 3 sectors of the 3 eNodeBs in each scenario. But for the purpose of brevity only 6 graphs are shown here, from figure 4 to figure 9. The metric for performance evaluation in this research is the throughput since throughput is defined as "the rate of successful message delivery over a communication channel" ("Throughput", 2019). Figure 3 shows the arrangement of the eNodeBs and UEs in the simulated network.

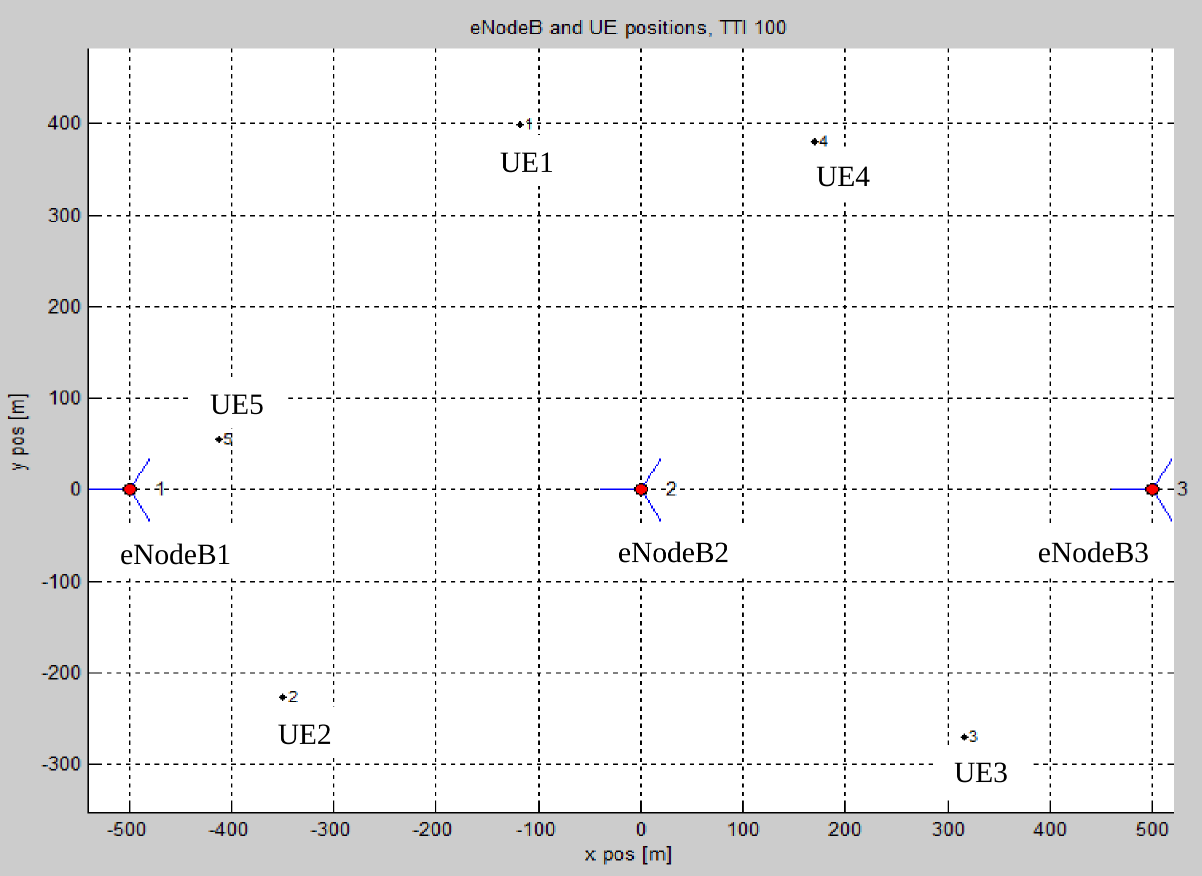

Figure 3: eNodeB and UE arrangement in the simulated network

Figure 4 to figure 6 shows the throughput produced by User Equipment 4 (UE4) in each of the 3 scenarios, while figure 7 to figure 9 shows the throughput produced by sector 2 of eNodeB2 in each of the 3 scenarios.

For the analysis of results, the values of throughput obtained from figure 4 to figure 9 are also shown in table 2 in row numbers 4 and 10 with the values from the remaining 36 graphs shown in the remaining rows.

3.1 UE4 Results for the first scenario

Figure 4 presents the throughput for UE4 in the first scenario. The value of the throughput at the end of the simulation is 0.549Mbps.

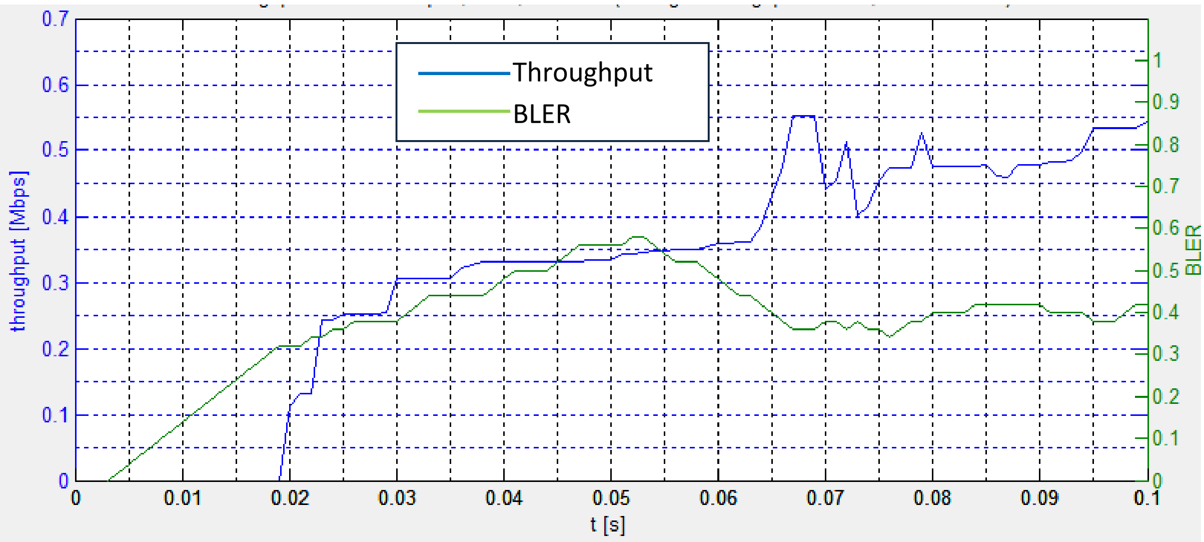

Figure 4: User Equipment4 (UE4) throughput for the first scenario

3.2 UE4 Results for the second scenario

Figure 5 presents the throughput for UE4 in the second scenario. The value of the throughput at the end of the simulation is 0.810Mbps.

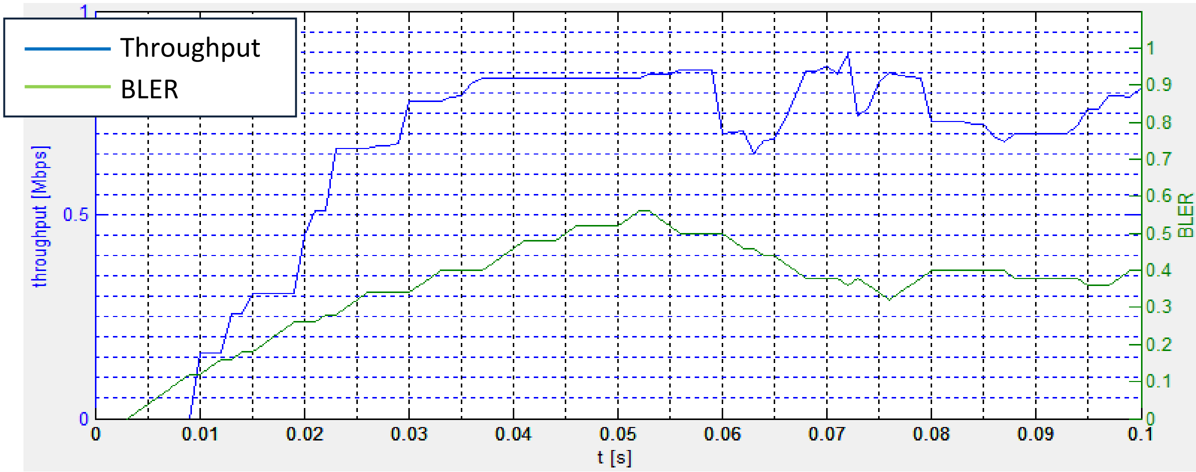

Figure 5: User Equipment4 (UE4) throughput for the second scenario

3.3 UE4 Results for the third scenario

Figure 6 presents the throughput for UE4 in the third scenario. The value of the throughput at the end of the simulation is 0.900Mbps.

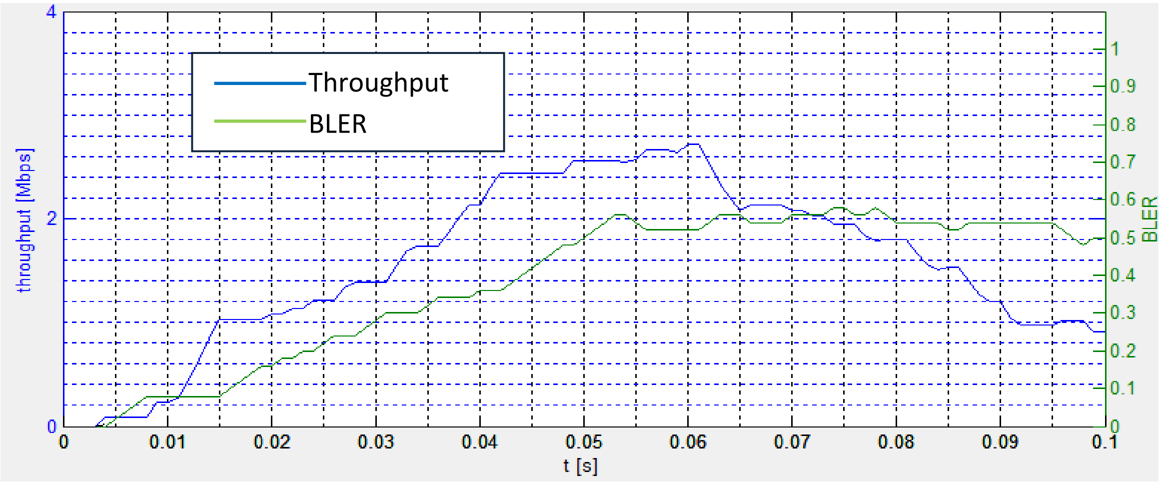

Figure 6: User Equipment4 (UE4) throughput for the third scenario

3.4 eNodeB2 Results for the first scenario

In figure 7 the throughput for sector2 of eNodeB2 for the first scenario can be seen. The throughput, as obtained when the simulation finished, is 0.160Mbps.

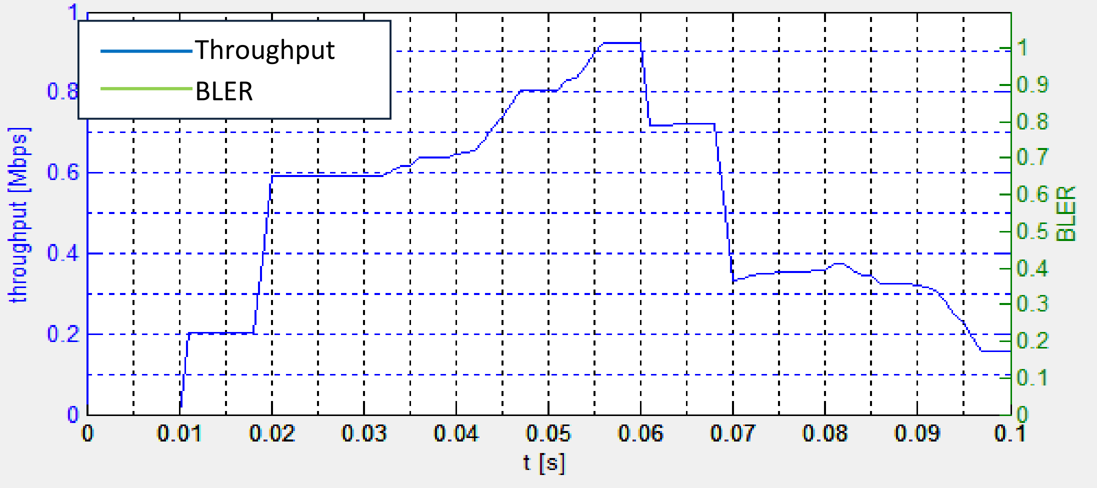

Figure 7: eNodeB2, Sector2 throughput for the first scenario

3.5 eNodeB2 Results for the second scenario

In figure 8 the throughput for sector2 of eNodeB2 for the second scenario can be seen. The throughput, as obtained when the simulation finished, is 0.240Mbps.

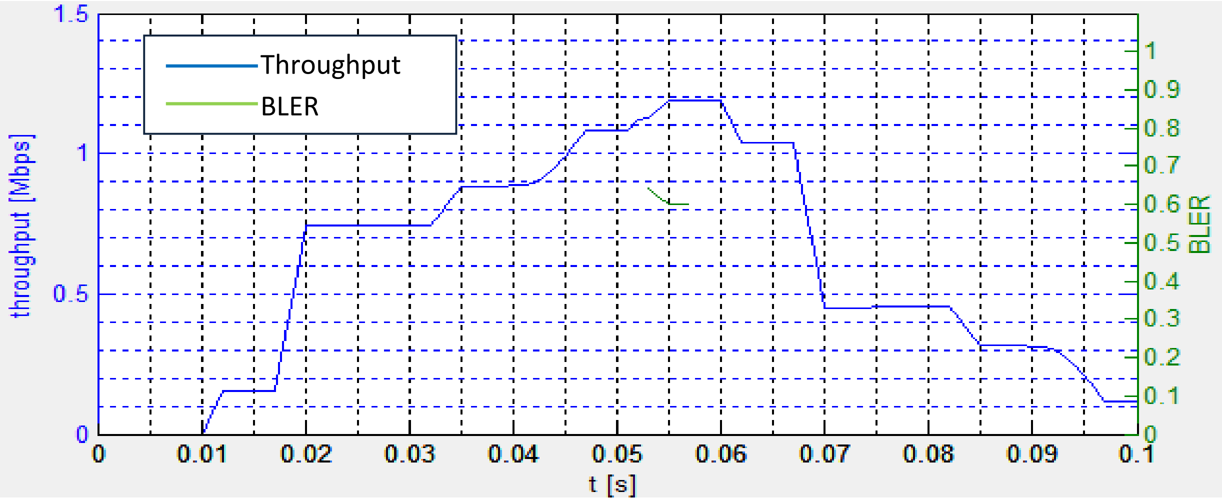

Figure 8: eNodeB2, Sector2 throughput for the second scenario

3.6 eNodeB2 Results for the third scenario

In figure 9 the throughput for sector2 of eNodeB2 for the third scenario can be seen. The throughput, as obtained when the simulation finished, is 0.520Mbps.

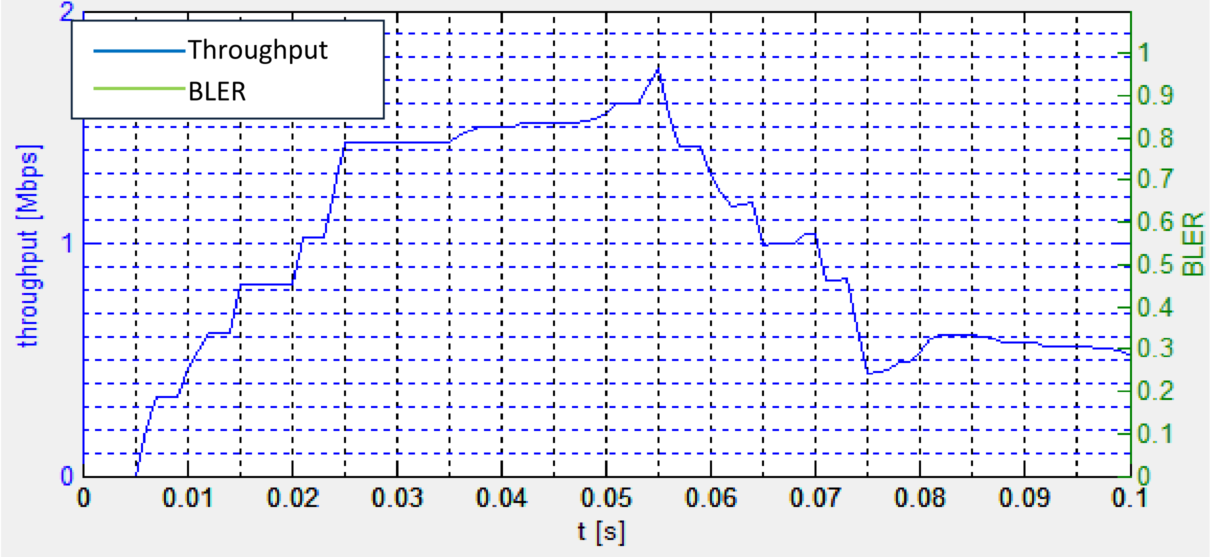

Figure 9: eNodeB2, Sector2 throughput for the third scenario

4.0 Analysis

Table 2 shows all the values of throughput at the end of the simulation (at t = 0.1s) of each of the 3 scenarios. The results were obtained from each of the 42 graphs produced during simulation, which means 14 graphs per scenario, hence 14 values of throughput per scenario.

Table 2: Throughput values for each scenario

S/N	**FIRST SCENARIO**		**SECOND SCENARIO**		**THIRD SCENARIO**	
		Throughput (Mbps)		Throughput (Mbps)		Throughput (Mbps)
1	UE1	0.285	UE1	0.150	UE1	0.090
2	UE2	0.140	UE2	0.140	UE2	0.650
3	UE3	0.275	UE3	0.190	UE3	0.600
4	UE4	0.549	UE4	0.810	UE4	0.900
5	UE5	0.430	UE5	0.500	UE5	0.270
6	eNodeB1 Sector1	0.740	eNodeB1 Sector1	0.200	eNodeB1 Sector1	0.157
7	eNodeB1 Sector2	0.560	eNodeB1 Sector2	0.650	eNodeB1 Sector2	0.430
8	eNodeB1 Sector3	0.000	eNodeB1 Sector3	0.000	eNodeB1 Sector3	0.000
9	eNodeB2 Sector1	0.520	eNodeB2 Sector1	0.850	eNodeB2 Sector1	0.900
10	eNodeB2 Sector2	0.160	eNodeB2 Sector2	0.240	eNodeB2 Sector2	0.520
11	eNodeB2 Sector3	0.320	eNodeB2 Sector3	0.390	eNodeB2 Sector3	0.240
12	eNodeB3 Sector1	0.000	eNodeB3 Sector1	0.000	eNodeB3 Sector1	0.000
13	eNodeB3 Sector2	0.000	eNodeB3 Sector2	0.000	eNodeB3 Sector2	0.000
14	eNodeB3 Sector3	0.180	eNodeB3 Sector3	0.131	eNodeB3 Sector3	0.055
	Total	**4.159**	**Total Network**	**4.251**	**Total Network**	**4.812**

	Network Throughput		**Throughput**		**Throughput**	

From all the simulation results the performance of the 3 scenarios can be analyzed. Each of these scenarios produced a different value for the total Network throughput. The first scenario produced a total throughput of **4.159Mbps**, the second scenario produced a total throughput of **4.251Mbps** and the third scenario produced a total throughput of **4.812Mbps**. The third scenario produced the highest value of throughput: this means that it had the best handover performance and that means the most amount of successful communication. Therefore in an LTE system, handover performance can be optimized by using the combination of TS 36.942 Path Loss model and Log-Normal fading.

Conclusion

It is of paramount importance to ensure that handover is seamless in LTE networks since LTE supports only hard handover. The aim of this research was to optimize the handover performance in an LTE network and the results of the simulation showed the performance, with regard to throughput, of each of the three scenarios and the third scenario had the highest throughput. Therefore, the TS 36.942 Path Loss model, in combination with Log-Normal fading optimizes handover performance in an LTE network.

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