Impact Signal Propagation Parameters to UMTS-LTE Handover

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Abstract: Handover mechanism is to maintain continues connection by migrating users from one to other channel within a base station or different ones. As wireless channel is heavily depending on signal propagation, the propagation parameters are important factors in handover decision. This papermodelsmobile node path through three base stations and analyses the propagation parameters impact on softhandover performance between UMTS and LTE networks. Simulation results on the designed model show that the greater the value of the velocity then the point of sampling that occurs will be less and the number of handover will be greater. Conversely, if the speed is lower than the sampling point that occurs will be more and the number of handover will be smaller. It is found that the speed at 10 m / s is the best speed because the RSCP (Received Signal Code Power), and RSRP(Reference Signal Received Power) signal strength values are -99 dBm and -111 dBm respectively with the number of sampling points being 57 and the number of handing over is 2 times.

Keywords: Handover, Propagation Parameters, UMTS, LTE.

1. Introduction

The telecommunication development experiences tremendous improvement as demands on communication increases. Cellular networks rely on capacity and mobility(Marwan Al-Akaidi, 2015). Capacity improvement moves technology from UMTS (Universal Mobile Telecommunication System) to LTE (Long Term Evolution). However, even dough operators intent to migrate UMTS to LTE, the implementation deals with customer satisfaction (Kalbande, 2014)]. So as for solution, LTE is implemented gradually along with existing UMTS networks.

On the other hand, mobility with less disconnections and high speed switch requires sophisticated handover algorithm. The drawback on the system results customer dissatisfaction as speed and signal degrades when handover in progress. Signal strength and obstacles are the main problems (Sravani, Mesala., 2015).

In order to make sure that handover occurs smoothly, signal degradation and power threshold should be determined precisely (Wardana Lingga, 2010). Soft handover is preferred than the hard one as communication disconnection is less frequently (Halgamuge, 2006). Even dough, signal strength variations caused propagation and threshold for handover decision should be taken into consideration carefully. This paper models the soft handover from UMTS to LTE networks with three base stations involved. The paper also analyses the impact of propagation parameters to handover performance.

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2. Method

The propagation model describes the average propagation of signals in an area. The magnitude of these propagation losses varies according to the spectrum and the nature and the environment. Estimating the losses of the signal radio is very important. One of them is the losses generated by signal propagation. Loss of propagation is fairly difficult to predict. This loss is directly affected by the state of the environment surrounding the signal. Experts have produced some mathematical models that can provide good enough value to approach real-world circumstances. Among the radio signal propagation channel models are large-scale propagation models(Pinem, 2014). The system is modelled with three base stations as depicted in Figure 1, where mobile node moves from BTS1 to BTS 3. The three BTSs have the same transmitting power. Each of BTS is placed on a Cartesian coordinate system of $BTS_i(XBTS_i, YBTS_i)$ and distance $d_{i,k}$is the distance from the MS to each k-th sample of BTS_i shown in equation 1 , 2 and 3 (Pinem and Fauzi, 2018).

$$d_{i,k} = \sqrt{(X_k - X_{BTS_i})^2 + (Y_k - Y_{BTS_i})^2} \quad (1)$$

$$X_k = r \cos \theta_{k-1} + X_{k-1} \quad (2)$$

$$Y_k = r \sin \theta_{k-1} + Y_{k-1} \quad (3)$$

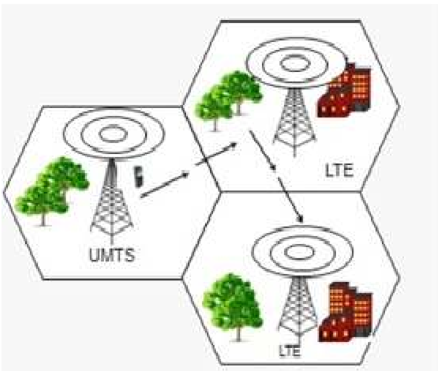

Fig.1. System model

The RSCP (Received Signal Code Power) and RSRP (Reference Signal Received Power) are the propagation parameters that are measured and observed. The received pilot signal strength (RSS) based handover are employed where hysteresis-threshold is chosen as soft handover algorithm.

The UMTS network uses Maximum Allowable Path Loss(MAPL) to determine maximum propagation loss. The link budget employed in this simulation is taken from (Sauter, 2011)as shown in Table 1.

Table 1. UMTS link budget

Parameter	UM TS
Transmitter - Node B	
Tx Power (dBm)	2,542 ,474
Tx antenna Gain (dBi)	1,742

	,531
Cable Loss (dB)	2
EIRP (dBm)	4,685 ,005
Receiver - UE	
Thermal noise density (dBm/Hz)	-174
Receiver noise figure (dB)	8
Receiver noise density (dB)	-166
Receiver noise power (dBm)	- 100.16
Spreading Gain (dB)	24.98
Required Eb/No (dB)	7
Interference Margin (dB)	6.02
Required signal power (dBm)	- 112.17
Softhandover Gain (dB)	1
Shadow fading std dev.(dB)	6
Shadow fading margin (dB)	7.2
Maximum Path Loss	146.4 7

The radius of BTS is obtained by using Cost 231 model shown in equation 4 and 5(Rappaport, 2002).

$$R_{m=} 10^{\frac{MAPL-46,3-33,9logfc+13,82loght+a(hr)-3(hr)}{44,9-6,55loght}} \times 100 \qquad (4)$$

$$a(hr)= 3,2(log11,75hr)^2 - 4,97\ dB \qquad (5)$$

The MAPL on LTE is based on parameters shown in Table 2(Sainju, 2002). The radius of BTS is obtained by using Erceg Greenstein model show in equation 6(Rappaport, 2002).

Table 2. LTE link budget

Parameter	**L TE**
Transmitter - eNode B	
Tx Power (dBm)	4 6
Tx antenna Gain (dBi)	1 8
Cable Loss (dB)	2
EIRP (dBm)	6 2
Receiver - UE	
UE Noise Figure (dB)	7
Thermal Noise (dB)	- 104.5
Receiver noise floor (dBm)	- 97.5

SINR(dB)	-9
Receiver Sensitivity (dBm)	-106.5
Interference Margin (dB)	4
Control Channel Overhead (%)	20
Rx Antenna Gain (dBi)	0
Body Loss (dB)	0
Maximum Path Loss	163.5

$$R_m = 10\frac{MAPL-80,76-15,81-6log\left(\frac{f}{2000}\right)-\left(-10,8log\left(\frac{ht}{2}\right)\right)}{43,75}x100 \quad (6)$$

The simulation by using RSS based handover method is implemented inUMTS-LTE network. The UMTS handover parameter is RSCP. RSCPis determined by usingEquation 7(Halgamuge, 2006).

$$\text{RSCP} = \text{Ptx}\_{\text{UMTS}} + \text{Gain}\_{\text{UMTS}} - L_{\text{feederTx}} - \text{Pathloss} + \text{Ec/Io}_{(\text{dB})} \quad (7)$$

Where for Gain$_{\text{UMTS}}$ is 18 dBi and L_{feederTx} is 2dB. The pathloss shown in equation 8 and 9(Halgamuge, 2006).

$$Pathloss = 46{,}3+(33{,}9.\log(f))-(13{,}82\log(h_b)\alpha+((44{,}9-6{,}55\log(h_b))\log(d))+3 \quad (8)$$

$$\left(\frac{E_c}{I_o}\right) = \frac{P_{pilot}.r_1{}^{-\alpha}10^{\frac{\zeta 1}{10}}}{N_{th} + P_{T1}.(1-\alpha)r_1 - \alpha 10^{\frac{\zeta 1}{10}} + \sum_{k=2}^{M} P_{Tk}\, r_k - \alpha 10^{\frac{\zeta k}{10}}} (9)$$

Urban area $\alpha = 4$ and shadowing (ζ) is 8-10 dB. The correlation between the pilot signal power (P_{pilot}) with the transmit power (P_T) Node B shown in equations 10(Chen, 2003).

$$P_{pilot} = (1-\gamma)P_T \quad (10)$$

Where γ is the power allocated for the traffic channel. If P_T is assumed to be the same for all NodeBs, and $N_{th}$is assumed to be much less than of interference receivedtoUE shown in equation 11.

$$\left(\frac{E_c}{I_o}\right) = \frac{(1-\gamma)}{(1-\alpha)+\sum_{k=2}^{M}\left(\frac{r_k}{r_1}\right).-\alpha 10^{\frac{\zeta k-\zeta 1}{10}}} \quad (11)$$

The RSRP is employed to determine cell selection, cell reselection, and handover. The value is approximated by equation 12(Sauter, 2011). Fading and path loss are determined by equation 13 and 14(Chen, 2003).

$$\text{RSRP} = \text{EIRP} - Pathloss_{(\text{to UE})} + Shadow\ Fading_{(\sigma=3)} \quad (12)$$

$$Shadow\ Fading = \frac{e^{-\frac{[(M-m)^2]}{2\sigma}}}{3(2\pi)^{1/2}} \quad (13)$$

$$Pathloss = A + \left(10 \times \alpha \times \log\left(\frac{d}{100}\right)\right) + Shadow\ Fading + k_f + k_r \quad (14)$$

The soft handover algorithm is designed as follows:

1. If the active set contains BTS1, $\hat{S}_1(d) > \hat{S}_{min}$ and absolute difference of $\hat{S}_1(d)$ and $\hat{S}_2(d)$ is higher than hysteresis value HYST_ADD, then active set stays in BS1.
2. If $\hat{S}_1(d)$ and $\hat{S}_2(d) > \hat{S}_{min}$ and absolute difference of $\hat{S}_1(d)$ and $\hat{S}_2(d)$ is lower than HYST_ADD, then active set is BTS 1BTS 2.
3. If $\hat{S}_1(d)$ and $\hat{S}_2(d) > \hat{S}_{min}$, the absolute difference is higher than HYST_DROP, thenis BTS 2.
4. If $\hat{S}_1(d)$ and $\hat{S}_2(d) < \hat{S}_{min}$ then active set are not either BTS1 or BTS2.

In the simulation, it is assumed that BTS 1 is part of UMTS network while BTS 2 and BTS 3 are LTE and then the input parameters used in the system model are shown in Table 5.

Table 5. Parameter input

Parameter input	Nilai
MAPL UMTS	146,465
MAPL LTE	163,5
Frekuensi (MHz)	2100 &2600
EIRP UMTS (dBm)	40,85
EIRP LTE (dBm)	62
Height ofantenna (m)	1,5
Height ofbase station (m)	30
Threshold UMTS (dB)	-100
Threshold LTE (dB)	-113
Hysteresis ADD (dB)	8
Hysteresis Drop (dB)	10
Distance MS to BTS (m)	8000
Sampling time (s)	1
Speed (m/s)	2
Iteration	1

3. RESULTS

The design model system that has been implemented in Matlab is shown in Figure 2.

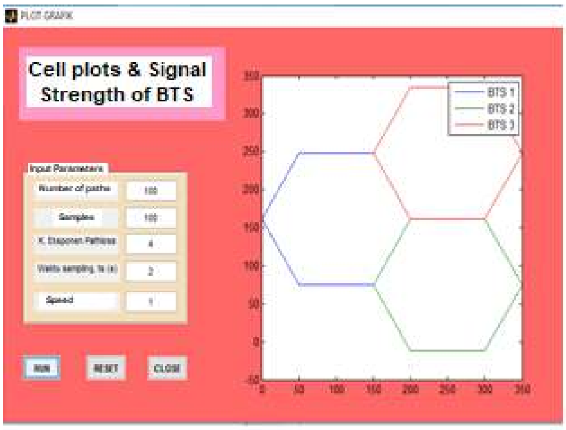

Fig.2. System Model

The RSCP values on UMTS network decrease as distant from BTS increases. It is about 0 dBm when closes to BTS, but decreases exponentially when moves away from BTS. The plot is in Figure 3.

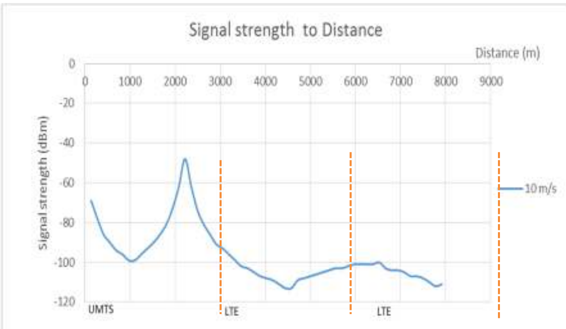

Fig.3. Signal strength to distance at v = 10 m / s

Figure 3shows the distance traveled from 0 to 8000 m, where at a distance up to 1000 meters is still connected by the BTS 1 of UMTS network. By determining the threshold value of -100 dBm for UMTS, the RSCP is -99 dBm, while in LTE the threshold value is -113 dBm, so the RSRP value is -111 dBm. Figure 3 also showsthatthe distance that can be handled by UMTS (BTS 1) is up to 1000 m. Distance of 2000 m to 5000 m is handled by BTS 2.Distance 5000 m to 8000 m is handled by BTS 3. The signal strength is shown in Figure 4.

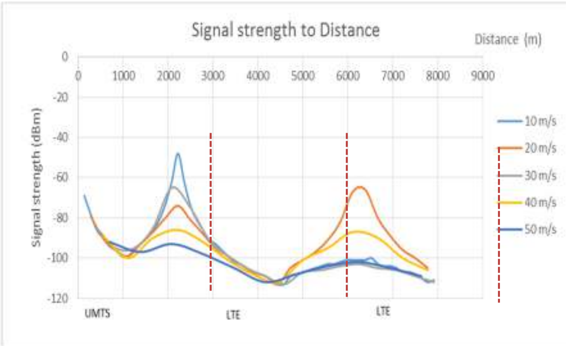

Fig.4. Signal strength to distance on v = 10 m/s, v = 20 m/s, v = 30 m/s, v = 40 m/s and v = 50 m/s

Figure 4 shows that RSCP and RSRP of various speed have different values. The greater the speed,the sorter the distance travelled. It is shown by the smaller sampling value. Table 4 plots the values.

Table 4. Signal strength for different speeds.

Distance (v)	RSCP (dBm)	RSRP (dBm)	Sampling (N)
v = 10 m/s	-99	-111	57
v = 20 m/s	-99	-105	28
v = 30 m/s	-95	-107	19
v = 40 m/s	-97	-112	14
v = 50 m/s	-97	-112	11

Table 4 shows the sampling at different speeds. Figure 5 shows the relationship betweenhandover numberand speed. The number of handover tends to increase when speed increases.At speed v = 10 m/s,handover occurstwice. It increases to three times for speed of 40 m/s.

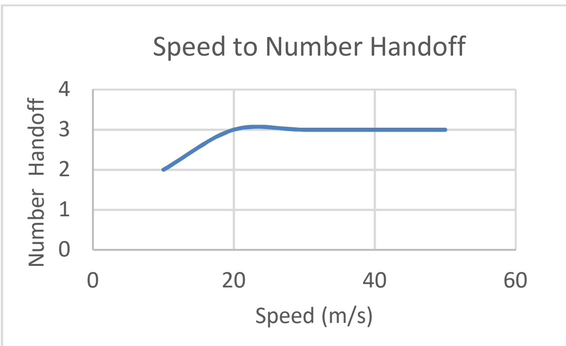

Fig.5. Speed and number of handover

Figure 6 shows the signal strength of the UMTS-LTE network for 3 BTS. Thehandover occurs when MS moving at speed of 10 m / s.

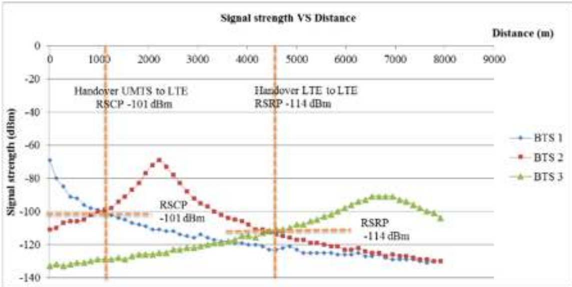

Fig.6. Handover at 3 BTS and soft handover performance in UMTS-LTE

Figure 6 shows that at distance of 1250 m, handover occurs in BTS 1 withRSCP -101 dBm, sampling point 10 and active set is BS 2 with RSRP -98 dBm. BS 2 to BS3 handover happens at distanceof 4583.33 m with RSRP -114dBm. The sampling point 34 and active set is BS 3 with RSRP -111 dBm.

4. Conclusions

It can be concluded that among the propagation parameters that affect the performance of soft handover on UMTS-LTE network is the sampling point and speed. The greater the speed, the lower the point of sampling, and the more frequent the handover. It was found that 10 m/s is the best speed as the RSCP and RSRP signal strength are -99 dBm and -111 dBm respectively with the number of sampling points 57 and the number of handing over is 2 times.

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