2015 18th International Conference on Network-Based Information Systems

A Handover Prediction Mechanism Based on LTE-A UE History Information

Ying-Hong Wang*
Dept. of Computer Science and Information Engineering,
Tamkang University,
Taiwan, R.O.C.
inhon@mail.tku.edu.tw

Jui-Lin Chang
Distance Education Development Sector,
Tamkang University,
Taiwan, R.O.C.
142734@learning.tku.edu.tw

Guo-Rui Huang
Dept. of Computer Science and Information Engineering,
Tamkang University,
Taiwan, R.O.C.
ray77720@hotmail.com

***Abstract*—In response to the rapidly developing of wireless communication technology, the deployed of eNB is denser and more complex. The research of how to handover accurately and fast in LTE-A are discussed much in recent years .In 3GPP Release 8, the UE History Information recorded by eNB was first proposed, it's proposed to provide eNB to judge the target eNB when handover. The history information includes the Cell ID and Time UE stayed in cell. We proposed an advance UE history information, reducing the handover failure rate and ping-pong handover rate by using the history information like Region-Domain, Time-Domain and Time To Trigger.**

Keywords: Handover; LTE-A; Handover failure rate; Ping-ping handover rate; UE History

I. Introduction

Since the user's mobility is inevitable, the reduction of the handover failure rate will be the key to improve quality of service. Therefore, accurate prediction and handover to the Target eNB is an important issue in LTE-A. Reducing the handover failure rate and ping-pong handover rate is the way that many papers focuses on[1][2][3], and the handover failure rate contains three cases which are too late handover, too early handover, and handover to wrong cell[4].

Although the existing Handover technique in LTE-A owns UE History Information, while using the Time UE stayed in cell, the eNB which stays longest is chosen as the Target, but the eNBs UE which passes by always connects but it doesn't stay long. As for the Handover which is too late or too early , it can do nothing with both.

This study bases on the 3GPP Release 8 UE History Information[5]. It designs a Handover prediction mechanism improve the service quality by reducing handover failure rate and ping-pong handover rate. We propose advanced historical information, and add some parameters for the handover judgment and using to predict the Target eNB accurately.

II. Related Work

2.1 Handover Procedure

The 3GPP LTE-A handover procedure is defined in [6].In general is divided into four parts as shown in Fig.1: UE measures the downlink signal strength and sends the measurement report to serving eNB(1), then processing handover Preparation (2), Handover Execution (3) and Handover Completion(4).

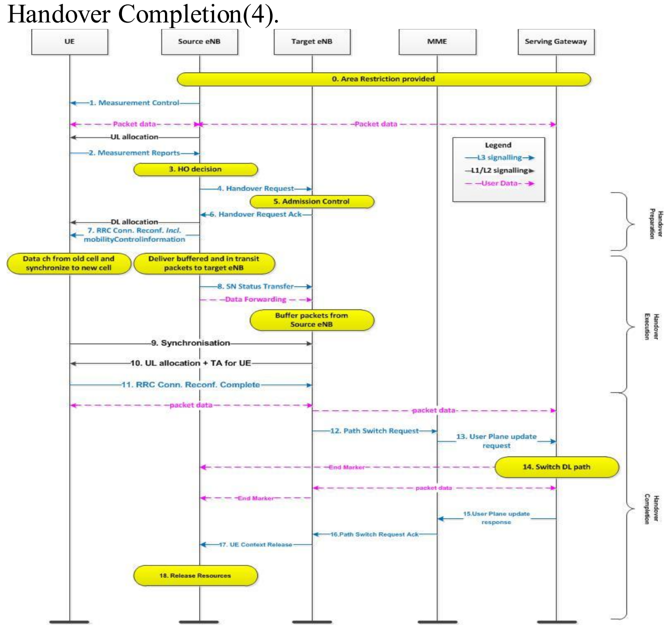

Fig.1: Handover Procedure

2.2 Time To Trigger

The Time To Trigger(TTT) is a length of time, and when the signal strength of Target eNB is greater than the signal strength of serving eNB plus a Hys value, it will enter the event A3 condition[7] and completed handover after a TTT administrator set, as depicted in Fig.2.

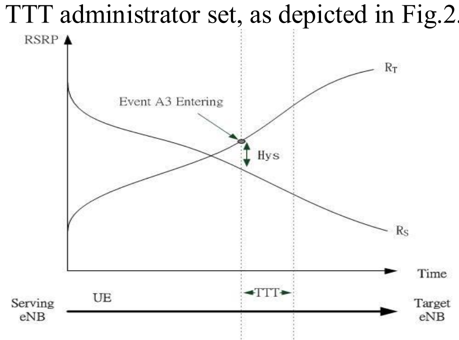

Fig.2: The scene of A3 condition

978-1-4799-9942-2/15 $31.00 © 2015 IEEE
DOI 10.1109/NBiS.2015.29

And the TTT is set to 16 values by 3GPP as shown in Fig.3.

0ms	40ms	64ms	80ms	100ms	128ms	160ms	256ms
320ms	480ms	512ms	640ms	1024ms	1280ms	2560ms	5120ms

Fig.3: 16 values of TTT

2.3 Handover Failure and Ping-pong Handover

The handover failure caused by unsuitable parameter is defined in [5], and divided into three cases ;Too early handover, too late handover and handover to wrong cell. And the ping-pong handover will burden the eNB with unnecessary handover.

- Too Early Handover

Radio link failure caused by a low value of TTT as shown in Fig.4.

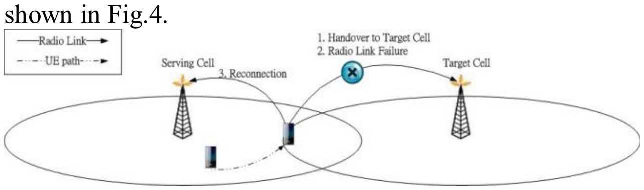

Fig.4: Too Early Handover

- Too Late Handover

Radio link failure caused by a high value of TTT as shown in Fig.5.

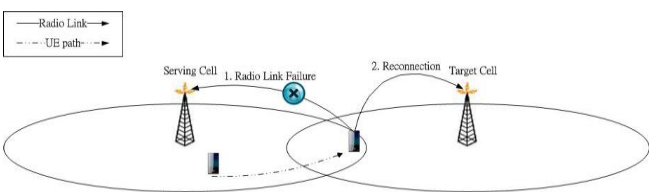

Fig.5: Too Late Handover

- Handover to Wrong Cell

The signal overlapping when UE is on the edge of eNBs, and UE choice a wrong Target eNB result in radio link failure as shown in Fig.6.

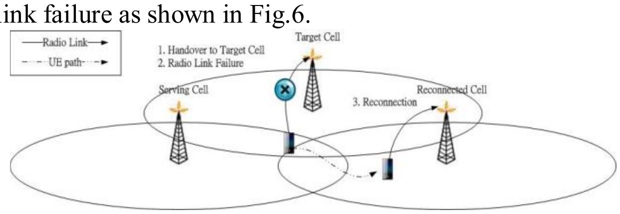

Fig.6: Handover to Wrong Cell

- Ping Pong Handover

UE moves on the edge of eNBs caused unnecessary handover in a short time as shown in Fig.7.

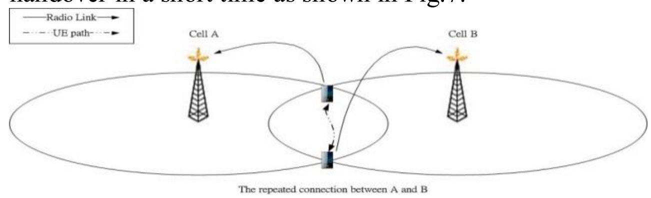

Fig.7: Ping Pong Handover

2.4 UE History Information

Collect information about the UE for as long as the UE stays in one of its cells, and store the collected information to be used for future handover preparation as shown in Fig.8[5].

9.2.3 UE History Information

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Last Visited Cell List		1 to MaxNrOfCells		Most recent information is added to the top of this list		
>Last Visited Cell Information	M		9.2.4			

Editors Note: Maximum size of the list (MaxNrOfCells) is FFS.

Fig.8: UE History Information

At handover preparation, add the stored information to the Last Visited Cell and include the UE History Information in the HANDOVER REQUEST message, and the Last Visited Cell information as shown in Fig.9.

9.2.4 Last Visited Cell Information

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Global Cell ID	M		9.2.16			
Cell type	M		ENUMERATED(macro, micro, pico, femto)			
Time UE stayed in cell	O		INTEGER	In seconds		

Editors Note: The definition of 'Cell Type' is FFS

Fig.9: Last Visited Cell information

III. Handover Prediction Mechanism

This chapter presents the Handover Prediction Mechanism which aims to reduce the handover failure rate and ping-pong handover rate.

3.1 System Model

In this research, we will present Five parameters by categorizing four of them into two domains, Region-Domain and Time-Domain. The last one uses to adjust the TTT. In order to avoid the increase of delay, the parameters will be delivered along with the Handover Request message by X2 interface.

And when the UE is in idle mode and changing Source eNB, the history information is keeping into HLR, until the UE change to active mode, the Source eNB will download the history information. We will use the aging algorithm to choose when to delete the old data.

- Region-Domain

The mobility of UE, such as work and school route, is similar. Therefore the Connect Frequency Between UE and eNB is recorded for prediction.

- Time-Domain

The UE is in the same region but the direction of movement is different when the time changes, the Reconnect Time, Day Connect Time and Day Connect Duration Time are recorded to deal with the handover prediction

- Time To Trigger

This parameter is recorded to deal with the handover failure caused by too early or too late handover.

All the parameters will update when Handover is finished by Source eNB. The recording of the parameters will base on the threshold and detected handover failure type . And the history information record as shown in Fig.10.

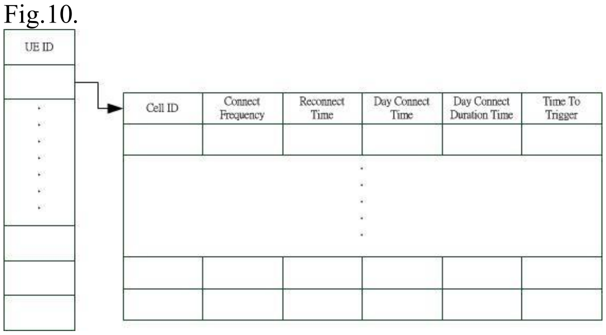

Fig.10: History information record

3.2 Proposed Mechanism

- Connect Frequency

The record unit which is the number of connecting times will increase until the maximum times the administrator sets are achieved. To prevent the meaningless connecting times resulted from Ping-Pong Handover, a connect duration time threshold will be set .

From the viewpoint of the administrator, to set an interval will be easy to tell where the region UE usually appears as shown in Fig.11.

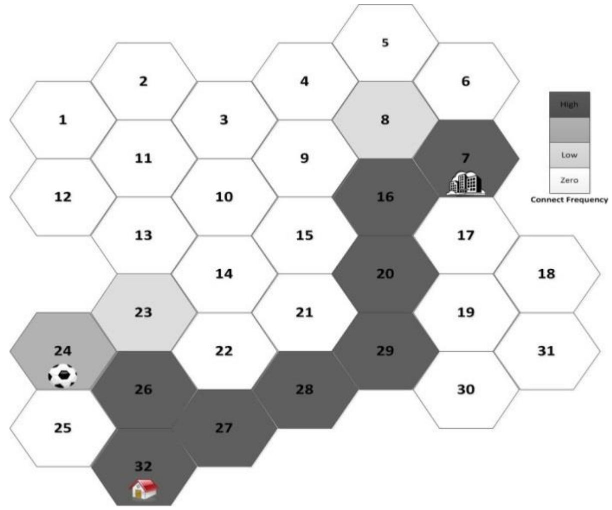

Fig.11: Interval of connect frequency

- Reconnect Time

The parameter includes hours and minutes, and it will be recorded after the Handover to wrong cell detected. This record is using to avoid the Handover to wrong cell happened again. When the Target eNB has the record and the record time is similar, this eNB will be ignored when handover prediction. And if all the Target Cells have similar record, the record will be ignored and deleted.

- Day Connect Time

The parameter includes hours and minutes, and it will be recorded after the Connect Frequency reaches the day connect duration time threshold. This parameter is to deal with the handover in the same region but in different time , and it just records the connect time once within 24 hours.

When the Connect Frequency are in a similar interval, it can be used to predict a Target which has more similar historical information as shown in Fig.12..

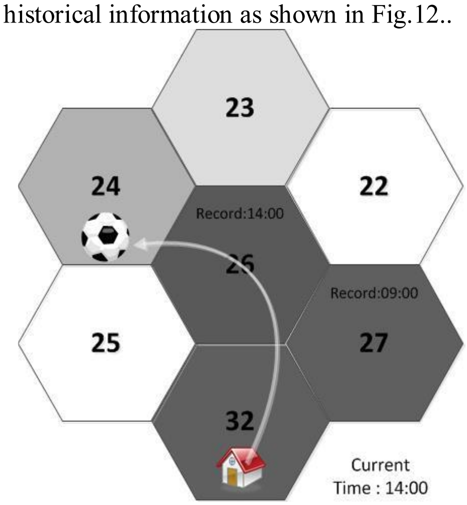

Fig.12:Example of Day Connect Time

- Day Connect Duration Time

The parameter includes hours, minutes, and seconds. It is recorded at the same time with Day Connect time. When UE is in the same region and in the same time, we can use the Day Connect Duration Time to predict the target eNB. Also it can be used when a UE is in the edge of cells by determining the Day Duration Time to predict the eNB to avoid Ping-Pong Handover.

When someone is moving at a cell edge and the Connect Frequency and Day Connect Time can't help to predict, it can be used to predict which eNB UE probably stay as shown in Fig.13.

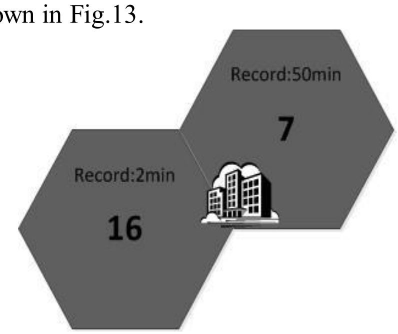

Fig.13: Example of Day Connect Duration Time

- Time To Trigger

The Time To Trigger parameter is defined as 16 values. When the handover failure detected, it will increase a value of TTT if it caused by the too early handover, otherwise it will decrease a value. There have many MRO (Mobility Robustness Optimization) algorithm for the failure detected[8].

3.3 Flow chart

This section presents how we maintain the history information record, and the steps of mechanism.

When the aging algorithm administrator used is triggered, the deletion will run when the next time handover finished. In Fig.14, the deletion of the old information depends on the Connect Frequency.

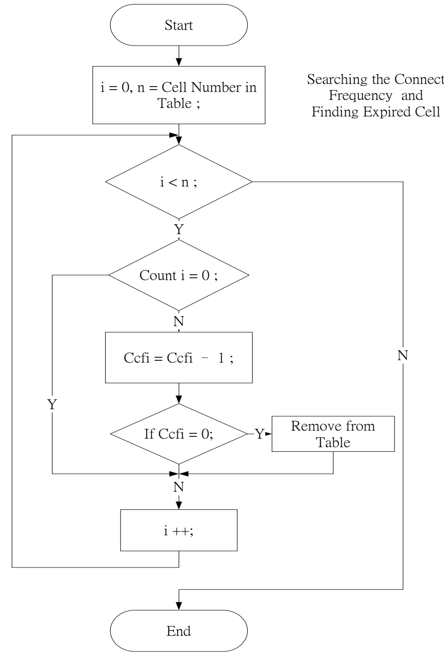

Fig.14: The deletion of history information record

The update of history information follows the threshold and detected failure type as shown in Fig.15. The connect frequency will be first record after the threshold determined.

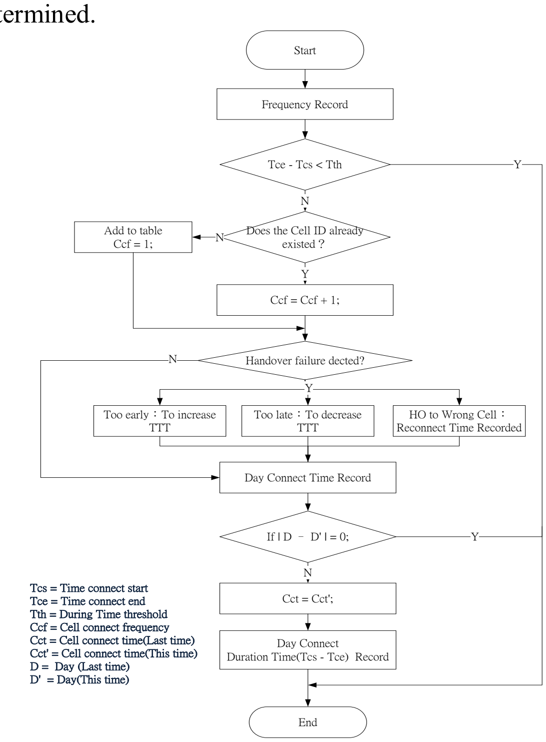

Fig15: The update of history information record

Then it will detect if the handover failure happened, and processing according to the failure type. Increasing

TTT value when too early handover, decreasing TTT value when too late handover and recording the Reconnect Time when handover to wrong cell happened. After the failure detecting or failure type processing, it will judge whether the connect is not at same day and record. And it will record the Day Connect Duration Time after the Day Connect Time recorded.

The flow chart of the prediction mechanism as shown in Fig.16, if the standard can't be chosen by RSRP/RSRQ, the decision will be made according to the parameters we proposed.

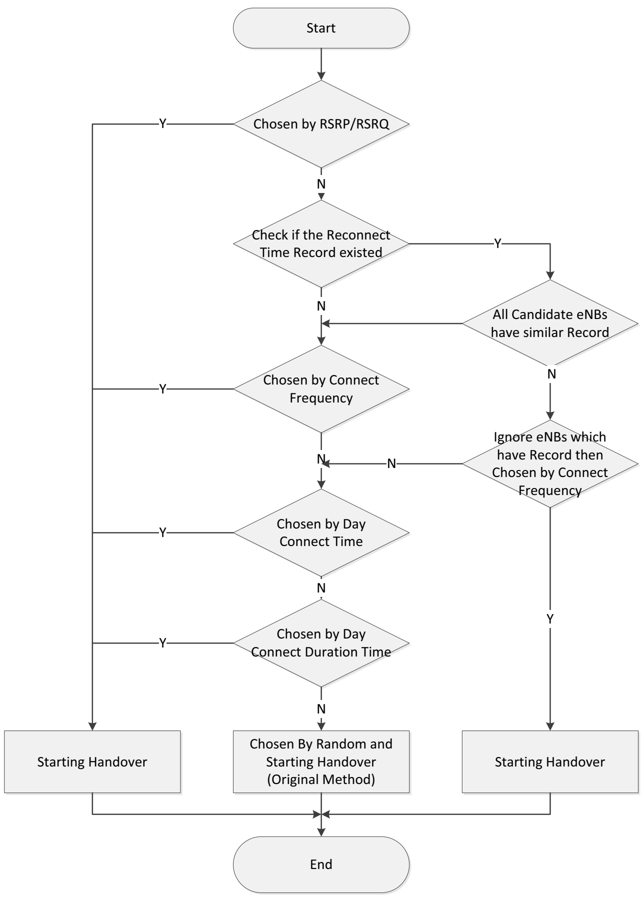

Fig.16: The flow chart of the prediction mechanism

It will check if the Reconnect Time record existed, and according to the record, there will divide into three cases. Normally it will judge by the connect frequency, Day Connect Time and Day Connect Duration Time step by step when the eNBs have no reconnect record. If all candidate eNBs have similar Reconnect Time record, those records will be deleted and ignored, then processing the same step as normal. The last case is not all candidate eNBs have Reconnect Time record, and the eNBs which have record will be ignored after the following judgment. And if all the parameters we proposed cannot judge the target eNB, it will judge by the original way.

Proposed handover mechanism predicts and history information maintains when the handover is processing, as depicted in Fig.17.

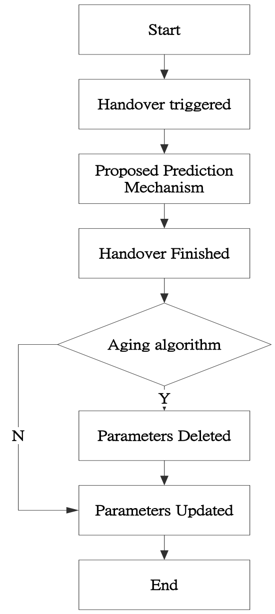

Fig.17: The deletion of history information record

Prediction mechanism will process after handover triggered, and the history information will maintain after handover finished.

IV. Simulation and Analysis

4.1 Simulation environment

We use a system level simulation of LTE networks based on Matlab[9]. Compared with standard method with Time UE stayed information.

Normally, the route is regular, however, it might be chosen randomly under 50 and 10 percent while handover. And the initial Time To Trigger set to 320ms. The other simulation parameters are summarized in Table I.

Table I. Simulation parameters

Parameter Assumption	
eNB layout	57
Receiver noise value	9 dB
Transmission power	46 dBm
Shadowing standard deviation	8 dB
Traffic model	Full buffer
Initial Time To Trigger	320 ms
Hysteresis	5 dB
Mobility model	Regular move with 10% and 50% random

The handover failure rate is defined as Eq. (1). And the ping-pong handover rate is defined as Eq. (2). The H is the handover times in total, the $\mathrm{H_f}$ is the handover failure times in total and the $\mathrm{H_{pp}}$ is the ping-pong handover times in total.

$$\text{Handover Failure Rate} = \frac{H_f}{H} \quad (1)$$

$$\text{Ping-Pong Handover rate} = \frac{H_{PP}}{H} \quad (2)$$

4.2 Simulation Results

In Fig.18. it shows that whether in the high or low probability randomly moves, the proposed mechanism are better than the standard method with Time UE stayed information.

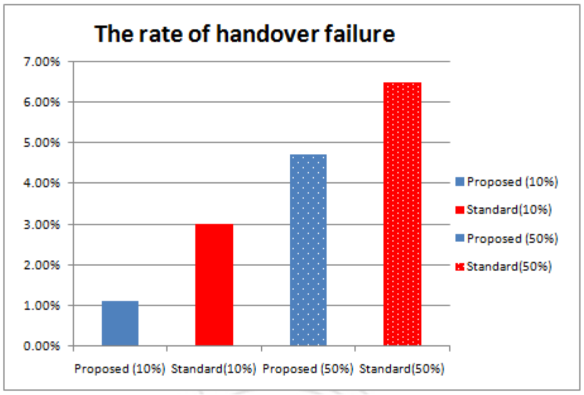

Fig.18: The handover failure rate between proposed and standard

In Fig.19. It is obvious that the proposed prediction mechanism outperforms the standard method with Time UE stayed information when it in high probability randomly moves. Because in the low probability scene, the proposed mechanism and the standard method are using the similar time parameter called Day connect Duration Time and Time UE stayed in cell, respectively.

When in high probability scene, the history information recorded after the last time randomly moving will affect the handover judgment next time, the proposed mechanism has connect frequency and Day Connect Time before the Day Connect Duration time, and the standard method has only one time parameter to judge

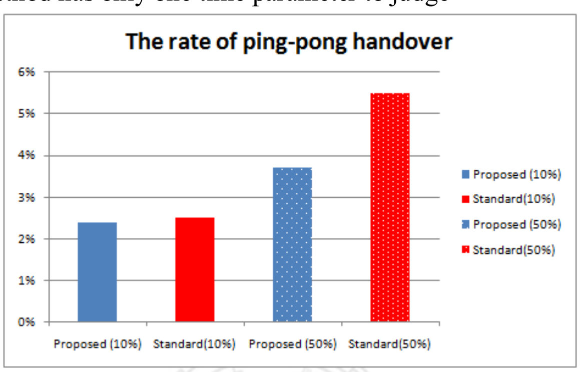

Fig.19: The handover failure rate between proposed and standard

V. Conclusion and Future Work

Seamless handover when UE moves is one of the most important issues in LTE-A. This paper proposed a prediction mechanism to reduce the handover failure rate and ping-pong handover rate, in order to avoid the delay increasing and burdening eNB with too much data, we proposed some simple parameters to predict. In the simulation with two acting models, the proposed method showed better performance of handover failure rate and ping-pong handover rate.

In the future, we plan to increase more different parameters if the eNB allows. And, we will try to find the more efficient parameter by way of more different simulation.

References

[1] Bo Wang, Xiangming Wen, Wei Zheng and Yong Sun, '"A Novel Optimising Handover Method Based on User Behavior," 2010 Asia-Pacific Conference on Wearable Computing Systems (APWCS), pp. 326-329.

[2] M. Carvalho and P. Vieira, '"An enhanced handover oscillation control algorithm in LTE Self-Optimizing networks," 2011 14th International Symposium on Wireless Personal Multimedia Communications (WPMC), pp. 1-5.

[3] T. Jansen, I. Balan, S. Stefanski, I. Moerman and T. Kurner, '"Weighted Performance Based Handover Parameter Optimization in LTE,"2011 IEEE 73rd Vehicular Technology Conference (VTC Spring), pp. 1-5.

[4] 3GPP TS 36.300 version 9.2.0 Release 9 "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2"

[5] 3GPP TS 36.423 V8.0.0 Release 8 Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (EUTRAN);X2 application protocol (X2AP)

[6] 3GPP TS 23.401 version 9.4.0 Release 9; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.

[7] 3GPP TS 36.331; Evolved Universal Terrestrial Radio Access (E-UTRA);Radio Resource Control (RRC);Protocol specification. 2011.

[8] Zhenzhen Wei, '"Mobility robustness optimization based on UE mobility for LTE system," 2010 International Conference on Wireless Communications and Signal Processing (WCSP), pp. 1-5.

[9] J.C. Ikuno, M. Wrulich and M. Rupp, '"System Level Simulation of LTE Networks," 2010 IEEE 71st Vehicular Technology Conference (VTC 2010-Spring), pp. 1-5.