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A CoMP-based Handover Algorithm in LTE-Advanced

Ying-Hong Wang[1*], Yi-Chia Tung[1]

[1] Department of Computer Science and Information Engineering, Tamkang University
New Taipei City, 25137, Taiwan
1inhon@mail.tku.edu.tw, esc0928@hotmail.com

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Abstract. 3rd generation partnership project (3GPP) Long Term Evolution-Advanced (LTE-A) defines a wireless network standard for high packet transmission rate and low packet latency provisions. When a user equipment (UE) moves away from signal range of serving cell may cause the received signal strength weakened, even if disconnected. To solve this problem, it is necessary to execute handover procedure. When executed handover procedure, it is may fail because the early handover, the late handover or handover to wrong cell and then occur packet loss or communication interruption problems. In this paper, we propose a CoMP handover algorithm in LTE-A. User equipment provides history information for eNBs to estimate the user equipment's location and velocity. Based on history information, our proposed mechanism can achieve to handover the appropriate target cell. Through selecting the target cell efficiently, we can reduce the rate of handover failure, Ping-Pong handover, and improve the UE's QoS. Finally, we conducted simulation integration, combined with the user equipment velocity prediction mechanism and trigger time adjustment mechanism. Experimental results show that compared with the standard user equipment handover process can significantly reduce the rate of handover failure and Ping-Pong handover.

Keywords: CoMP, handover, handover failure rate, history information, ping-pong handover rate

1 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 Long-Term Evalution-Advanced (LTE-A). Reducing the handover failure rate and ping-pong handover rate is the way that many papers focuses on, and the handover failure rate contains three cases which are too late handover, too early handover, and handover to wrong cell [1].

Although the existing Handover technique in LTE-A owns UE (user equipment) 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, too early or call drop, it can do nothing with anyone [2-6].

This study bases on the 3GPP Release 10 UE History Information. 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 [7].

The rest of this paper is organized as follows. In Section 2, we discuss information about handover. In Section 3, we show the proposed CoMP handover algorithm. Section 4 presents the simulation results, we show the superior of our approach and verify the effectiveness of the proposed scheme. Finally, we conclude this paper in Section 5.

* Corresponding Author

2 Related Works

In this section, the background standards and technologies will be briefly introduced. Two previously related researches are also presented.

2.1 LTE-A

LTE-A also known as LTE-A or LTE Release 10 is a mobile communication standard proposed by 3rd generation partnership project (3GPP) in 2009 as a major enhancement of LTE standard in order to satisfy the international mobile telecommunications advanced requirements issued by the international telecommunication union-radio communication sector.

There are number of key features introduced in LTE-A, including carrier aggregation, downlink and uplink spatial multiplexing enhancement, relaying nodes, heterogeneous networks compatible, and coordinated multipoint (CoMP) transmission and reception. Carrier aggregation offers high peak data rate of 1Gbps in downlink and 500 Mbps in uplink by bandwidth extension from 20 MHz up to 100 MHz. Downlink and uplink spatial multiplexing enhancement can be achieved by using up to eight-layer and four-layer multiple-input and multiple-output (MIMO) antennas, respectively. Both Relaying nodes and heterogeneous networks compatibility provide coverage and capacity in areas difficult or expensive to reach using the traditional approach.

CoMP transmission and reception is the key technique in LTE-A to improve the cell-edge throughput and/or system throughput. There are two types of CoMP schemes were evaluated for LTE-A system: Joint Processing (JP) and Coordinated Scheduling / Beamforming (CS/CB). JP provides multiple data transmission points for each UE among multiple cooperated eNBs while CS/CB only supports single data transmission for each UE at serving eNB with user scheduling/beamforming decisions made with coordination among cooperated eNBs.

2.2 Handover procedure

The 3GPP LTE-A handover procedure is defined by Tang et al. [6]. In general, LTE-A is divided into four parts as shown in Fig.1: UE measures the downlink signal strength and sends the measurement report to serving eNB, then processing handover preparation, handover execution and handover completion [8].

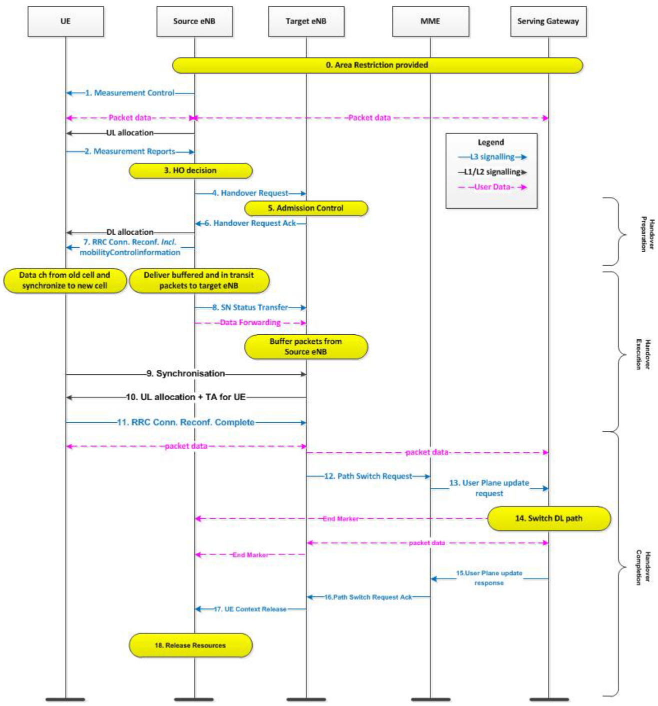

Fig. 1. LTE-A handover procedure

The handover failure caused by unsuitable parameter is defined in [9-10], 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 may be caused by a low value of TTT as shown in Fig. 2.

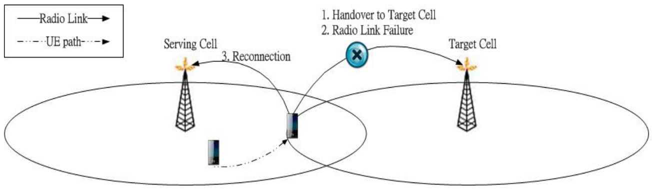

Fig. 2. Too early handoer

Too late handover. Radio link failure may be caused by a high value of time-to trigger (TTT) as shown in Fig. 3.

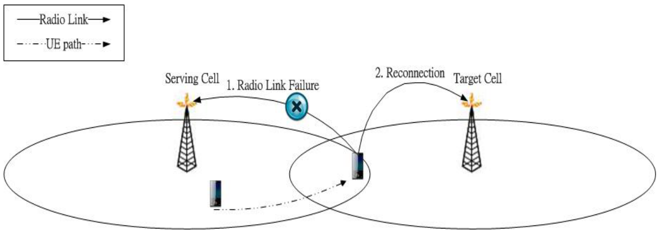

Fig. 3. Too late handover

Handover to wrong cell. The signal overlapping is existed, when UE is on the edge of eNBs, and UE may choice a wrong Target eNB to result in radio link failure as shown in Fig. 4.

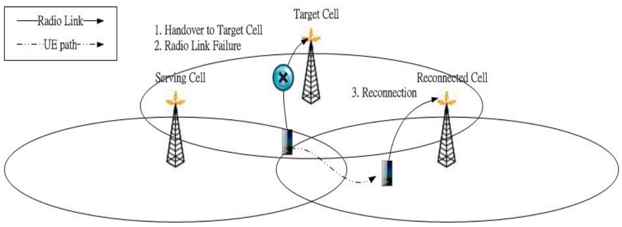

Fig. 4. Handover to wrong cell

Ping pong handover. UE moves on the edge of eNBs caused unnecessary handover in a short time as shown in Fig. 5.

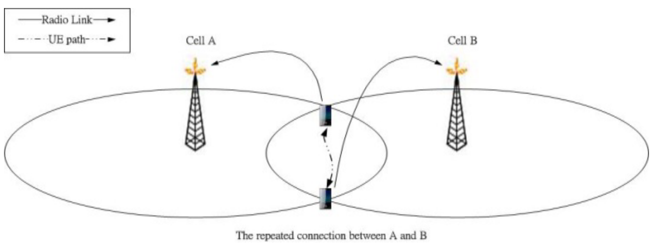

Fig. 5. Ping pong handover

2.3 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 and completed handover after a TTT administrator set, as depicted in Fig. 6 [11].

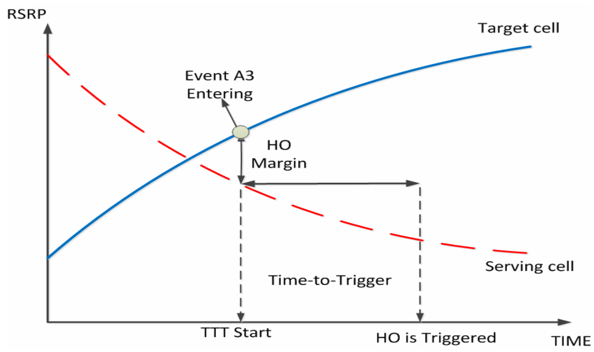

Fig. 6. Parameters Involved in the Handover-Trigger Decision

2.4 Time-to-trigger

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 Table 1 [12].

Table 1. UE history information

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

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

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 Table 2.

Table 2. 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		ENUMERAT ED (macro, micro, pico, femto)			
Time UE stayed in cell	O		INTEGER	In Seconds		

Note. The definition of 'Cell Type' is FFS.

In the long-term evolution technology, because of too much femtocell can cause unnecessary handover and ping-pong handover. It may occurr to reduce system capacity could even lead to breaking news, so Nurul'AinAmirrudin other scholars proposed a moving historical information provided by the device according to the user, Markov practiced forecast to reach mobile device users to move the track to reduce handover times and improve handover performance. In order to facilitate the subsequent chapters illustrate. We will compare with LCHA.

2.5 Related researches

Zhu et al. present the "On the performance of capacity integrated CoMP handover algorithm in LTE-Advanced" in 2012 [14], which will decide the candidate target cells when UE moves into the serving cell and UE need to report the reference singnal recevices power (RSRP) value of the target cells to serving cell anytime. The serving cell will collect the target cells with their RSRP values into measurement set. After that, serving cell selects some target cells, which satisfy the minimal conditions, and put them into CoMP cooperating set (CCS). One of the target cells in CCS has the highest RSRP value will be CTP. When the UE moves into the edge of serving cell, the handover procedure will be started, and the UE will be handover into the target cell of CTP. Comparing to standard CoMP handover procedure, this methodology can improve the total throughput of LTE-A networks. But, it also to increase the overloading of network systems and raise the system delay.

Lin et al. propose an improve algorithm from above one in 2013, Limited CoMP Handover Algorithm [15]. LCHA will show to represent it in this manuscript. The proposed flowchart of LCHA is follows, shown as Fig. 7.

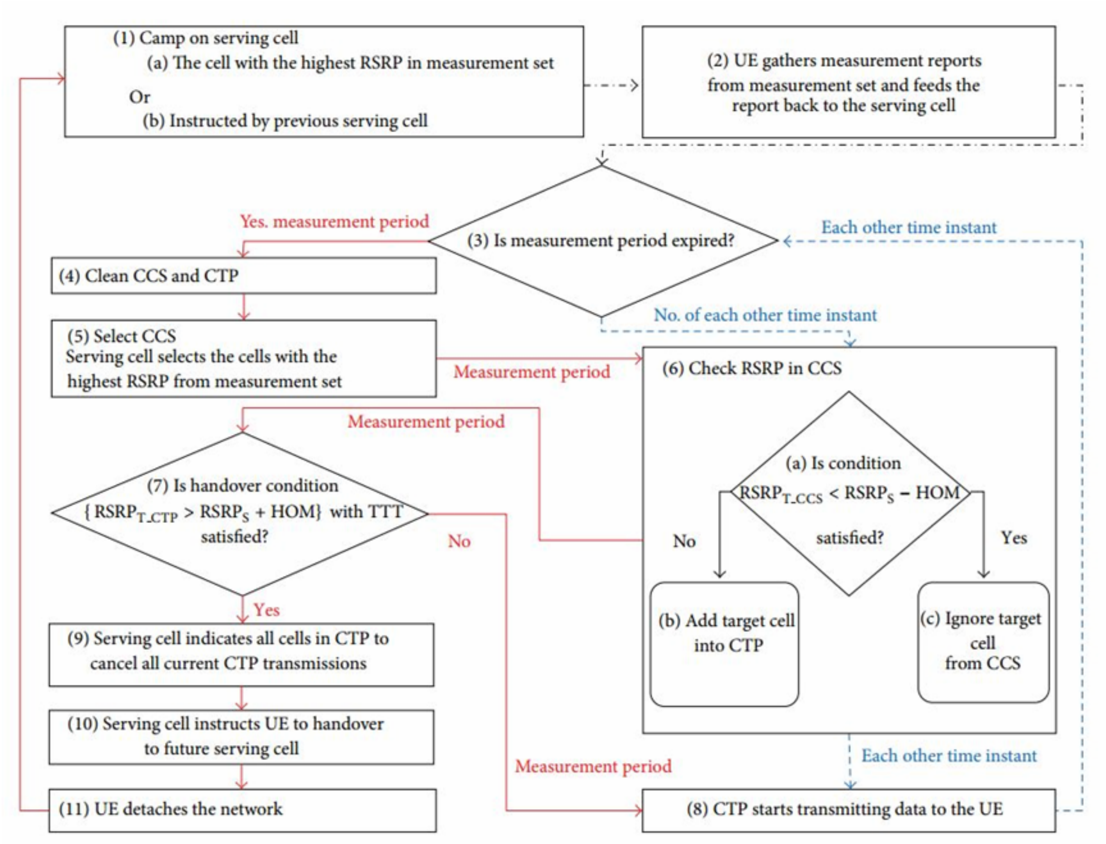

Fig. 7. Flowchart of LCHA for LTE-A

Even if LCHA can decrease the system delay and increase the totally throughput, however, due to it evaluates the candidate target only by RSRP value. Therefore, the handover failure still be happened possibly because it doesn't consider the moving speed and path.

Considering the drawbacks and the US history technology presented, we propose a revised CoMP-based handover algorithm with UE history. The proposed methodology will be described in next section.

3 A CoMP-Based Handover Algorithm in LTE-A

The algorithm of the process shown in Fig. 8, is divided into seven steps:

(1) Load user history information by a user equipment to the base station;

(2) Select the CCS and CTP measured from the collection;

(3) From the CTP and screening out the original service base station joint transmission;

(4) The judge hands decision-making;

(5) Interrupt joint transmission of CTP;

(6) start handover;

(7) Perform update history information, and the revised UE history information scheme is introduced as follows, shown in Fig. 9.

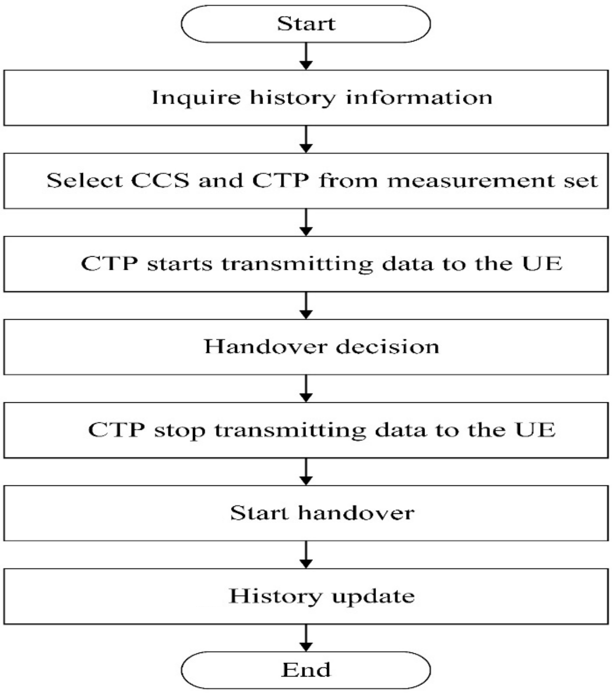

Fig. 8. The flowchart of proposed algorithm

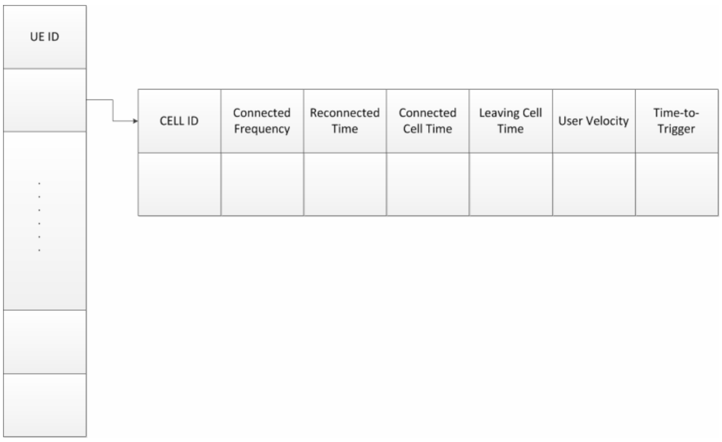

Fig. 9. the designed UE history information parameters

3.1 System model

In this research, we join six parameters into history information as follows:

- Connected Frequency: it records the number of UE connect base station.
- Reconnected Time: it records time of handover failure.
- Connected Cell Time: the purpose of it is to calculate the rate of movement of UE.
- Leaving Cell Time: the purpose of this is to calculate the rate of movement of UE.
- User Velocity: In order to adjust TTT, it needs to calculate the user velocity and record it.
- TTT: This parameter is recorded to deal with the handover failure caused by too early, too late handover, or handover to wring cell.

All the parameters will be updated when handover procedure is finished by Source eNB. The recording parameters will be modified base on the threshold and detected handover failure type. And the designed UE history information parameters for the proposed algorithm as shown in Fig. 9.

3.2 Algorithm procedure

Firstly, the UE will upload its UE history information to the Serving eNB, the Serving eNB will select the candidate target eNBs from measurement set and put them into CCS and choose the CTPs from CCS. The appropriate selected CTPs will start to joint transmission with Serving eNB. When the UE measures the signal from Serving eNB is less than the threshold, the handover decision will start up and judge to which Target eNB is the suitable one, the handover processes is beginning in accordance with the 3GPP standard specification, automatically delete and update the UE history information is completed after handover finished.

Where the steps of Serving eNB selects candidate target eNBs from measurement set to CCS and screening CTP by CCS will be introduced in 3.2.1; the subsection 3.2.2 describes how to judge the Target eNB in the Handover decision; and finally how to delete and update UE history information will be presented in 3.2.3.

3.2.1 CCS and CTP **selection**

Serving eNB will measure the radio strength of neighbor cells and establish a measurement set. Moreover, the Serving eNB finds some eNBs from measurement set according to their RSRP values are over the minimal criteria and put them into CCS. Finally, the candidate target eNBs will be selected from CCS as CTPs based on the formula equation (1). The flowchart of CCS and CTP selection is presented in Fig. 10.

$$RSRP_{T\_CCS} < RSRP_S - HOM \quad \textbf{(1)}$$

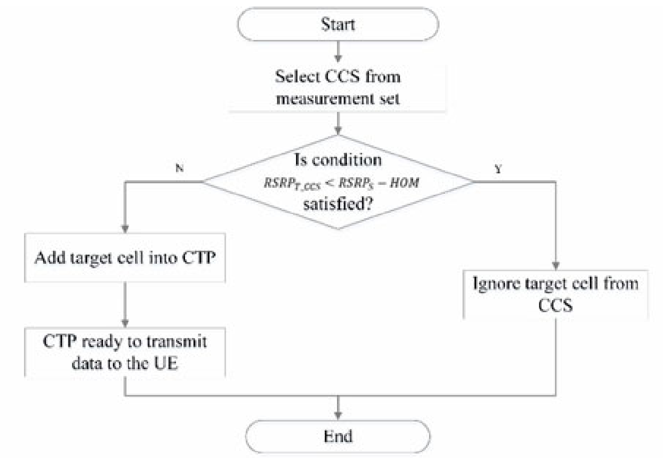

Fig. 10. The flowchart of CCS and VTP selection

3.2.2 Handover decision

Firstly, the Serving eNB makes sure whether the Target eNB had been connected, it is to confirm whether the user equipment is often connected to the Target eNB. If this eNB is not connected before, it will be added into the UE history information, then using traditional methods to make handover decision. If it had been connected, then the connection number will be increased for this eNB and the connection number of the Target eNBs will be separated into High, Medium or Low levels. Of course, the handover decision prefers the higher connection number and selects it to be candidate target eNB.

The second priority of UE history information is Reconnected Time. The eNBs have this information will be ignore from candidate eNB list for handover because to avoid the short-term time handover. It avoids the algorithm to choose the wrong base station. If a similar record values of all eNBs, this step will be skipped.

If there are more eNBs without Reconnected Time record, in order to setup a more accurate triggering time, the moving speed of UE needs to calculate for adjustment the TTT value to start handover processes. The steps of handover decision is shown in Fig. 11.

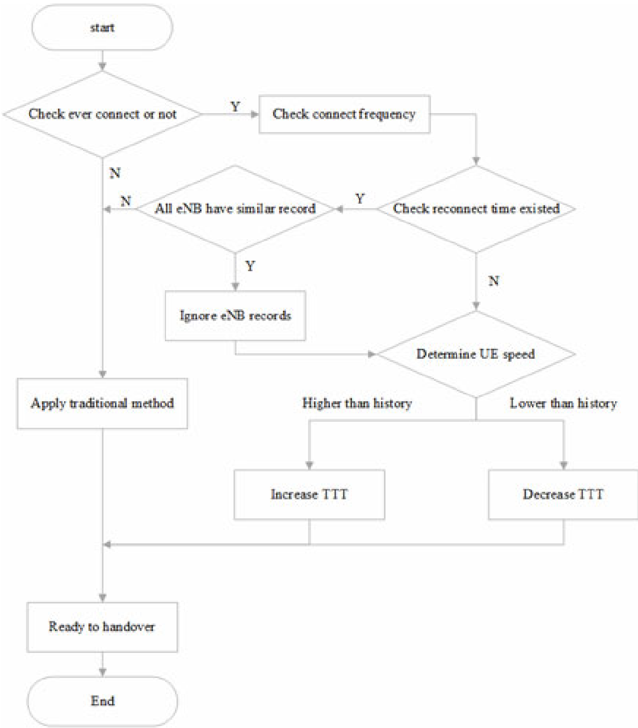

Fig. 11. The flowchart of handover decision

3.2.3 Maintenance of UE history information

Deletion of UE history records. The proposed methodology applies the aging mechanism to evaluate the UE history records and deletes the older and no more useful. The flowchart of deletion procedure is following Fig. 12.

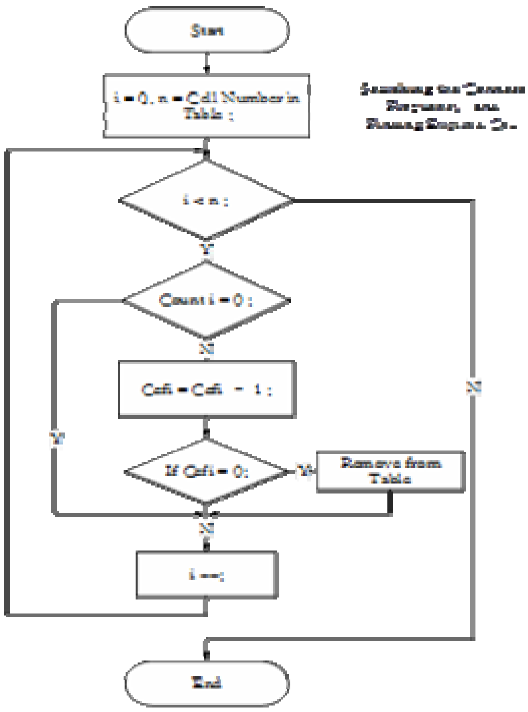

Fig. 12. The deletion flowchart of UE history records

Updating of UE history records. Finally, the UE history information needs to maintain and keep to the newest status. The proposed methodology will follow the steps of Fig. 13 to execute the updating of UE history information.

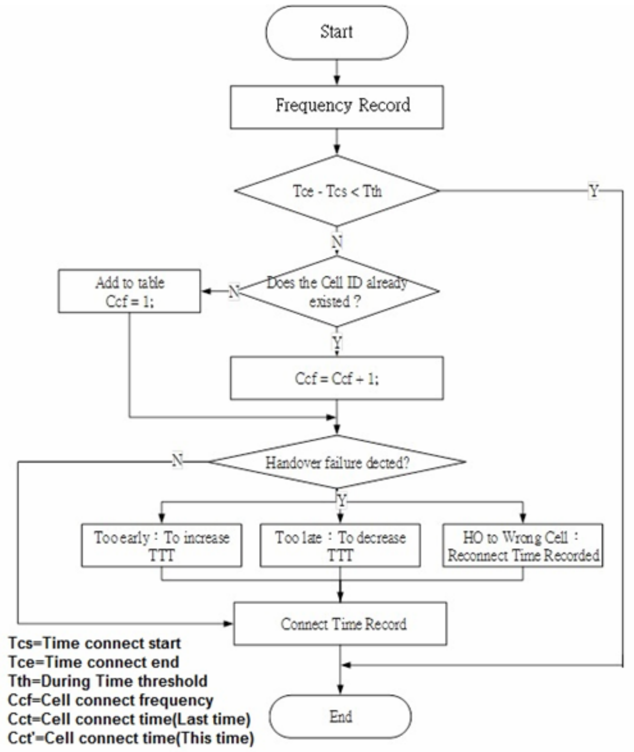

Fig. 13. The updating flowchart of UE history information

4 Simulation Results

In this section, the simulation environment is setup and the performance evaluation is compared to standard CoMP handover algorithm and LCHA methodology.

4.1 Simulation environment

We use a system level simulation of LTE-A networks based on Matlab [9]. The proposed methodology is compared with standard CoMP handover algorithm and LCHA method. The simulation parameters are summarized in Table 3 [13].

Table 3. Simulation parameters

Parameter	Valuue
eNB layout	19 sites
Number of UE	38
Distance between eNBs	100 meter
eNB transmission power	46 dBm
Shandowing standard deviation	8 dB
Initial Time-to-Trigger	320 ms
UE speed	3, 50, 120 km/hr
Mobility model	random direction
Handover margin	5 dB

The handover failure rate is defined as equation (2). And the ping-pong handover rate is defined as equation (3). The H means the total handover times, the H_f is the total handover failure times, and the

H_{pp} is the ping-pong handover times totally.

$$\text{Handover Failure Rate} = \frac{H_f}{H_f + H_{succ}} \tag{2}$$

$$\text{Ping-Pong Handover Rate} = \frac{H_{pp}}{H_{pp} + H_{succ} + H_f} \tag{3}$$

4.2 Simulation results and analysis

Fig. 14 provides the handover prediction accuracy according to history information of UE. Based on the simulation results, the proposed methodology will improve prediction accuracy comparing with standard CoMP handover method and LCHA, when the data items increases.

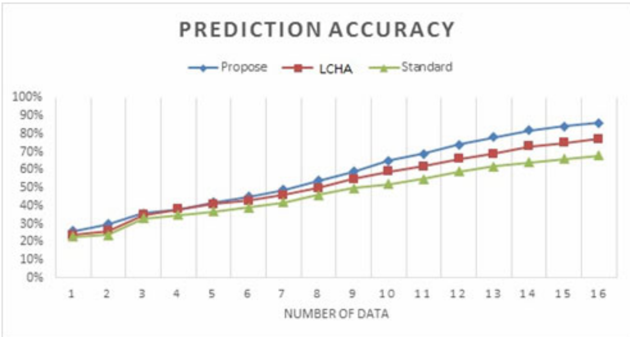

Fig. 14. Prediction accuracy with the number of data

In Fig. 15, 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.

Shown as Fig.16, it is obvious that the proposed prediction mechanism outperforms the standard method with Time UE stayed information when it in high velocity randomly moves. Because in the high velocity 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 slow velocity, the history information recorded after the last time randomly moving will affect the handover judgment next time, the proposed mechanism has connect frequency and adjust Time-to-Trigger, and the standard method has only one time parameter to judge.

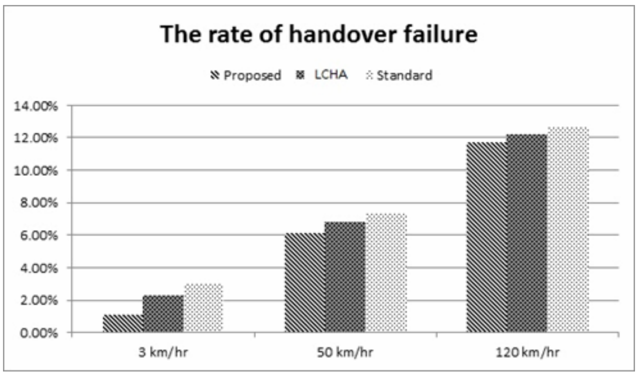

Fig. 15. The handover failure rate

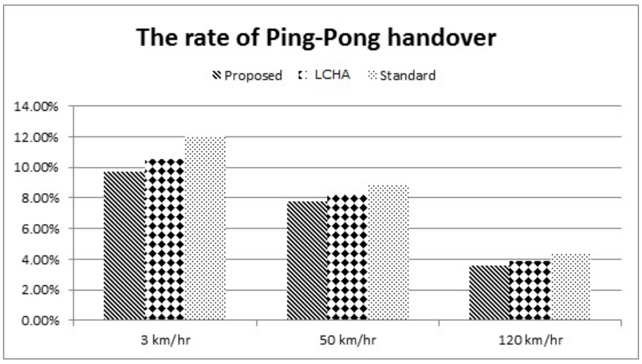

Fig. 16. The rate of Ping-pong handover

5 Conclusions

Seamless handover for UE moving is one of the most important issues in LTE-Advanced technologies. 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 shows it has 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 survey and define more efficient parameters using more different simulations.

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