A handover scheme with an adaptive triggering window mechanism in LTE-advanced systems

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Abstract: As we know, hard handover scheme is adopted for LTE systems in recent years. In order to improve the performance of the overall system, L3-filter, hysteresis, and time-to-trigger window are investigated. In this paper, we propose a new mechanism with an adaptive time to trigger window mechanism to overcome the ping-pong effects and improve the capacity of the whole system. In our simulation, the new mechanism shows less number of handovers, and reduces the number of ping-pong handovers to some extent. To decrease the complexity, our main subject is intra-frequency handover.
Keywords: Wireless Communication; handover; ping-pong; adaptive

0 Introduction

The main purpose of 4G generation wireless communication system is to provide high rate of data speed, improve spectral efficiency and lowering costs for each UE. As the time-variant character of communication channel, the QoS is not always guaranteed, fast and seamless handover are also weighty issues in 4G LTE-advanced systems.

There are two main handover mechanism in wireless mobile system, hard handover and soft handover[1], and hard handover is selected as the main RRC technology in 4G system, as soft handover is not feasible as orthogonal division multiple access technology.

Hard handover is break-to-make method, the old link between UE and the serving cell is released before the new link(between UE and the target cell) set up. One of our aims is to research the best cell as our target cell which will provide the seamless access to all of the service. It is well-known that the typical handover process consist of measurement, processing, decision and execution[2]. First, we measure the downlink carrier frequency of the serving and detected cell. After the L3 filtering, our handover algorithms are based on Reference Signal Received Quality(RSRQ) for improved handover performance and thereby decreased drop rate. [3], there are other LTE measurement which is listed in 3GPP 36.214.

To our best knowledge, the different parameters of LTE-advanced handover will result in quite various performances which sometimes will seriously affect the overall property. The simulation in 《performance and mobility management technique with simple handover prediction for 3G LTE systems》 [4] shows us the handover algorithms with various parameters. As is well known, the ping-pang effect will impact the Performance and decrease the system efficiency. To solve the problem, the adaptive TTT window mechanism depicts a adaptive method.

1 Adaptive TTT window mechanism

1.1 Introduction of adaptive TTT window and its effect

Headlines of diagram and table: the headline should be placed in the middle under the diagram, and above the table. Ping-pong effect is the serious problem in LTE-advanced system. The handover parameter such as Hysteresis, threshold, will effect the overall performance. The suitable parameter means the low rate of number of handover and less number of ping-pong handover.

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The cell in the system is defined as serving cell, detected cell and so on. The detected cell is defined as some of neighbour cells.

The algorithm with adaptive TTT window provide a new mechanism for handover technology to reduce the number of ping-pong handover. The TTT window mechanism shows as the next figure 1. The longer the TTT window, the less number of handover. The reason is that many handover conditions will not be satisfied as the time become longer. If TTT equals to 0ms, the number of handover will increase, as the communication channel is time-variant. When we make handover decision at first time, after a short time, this serving cell returns to the original cell which is one of the neighbor cells. Beside, if TTT is too long, this will result in much less number of handover, but if the serving cell has the bad RSRQ, the UE are not able to dwell in a target cell which will provide the high Qos as soon as possible, this will effect the normal service.

So, this algorithm will show us a mechanism which change the value of TTT window according to the condition of channel, and the value is not fixed.

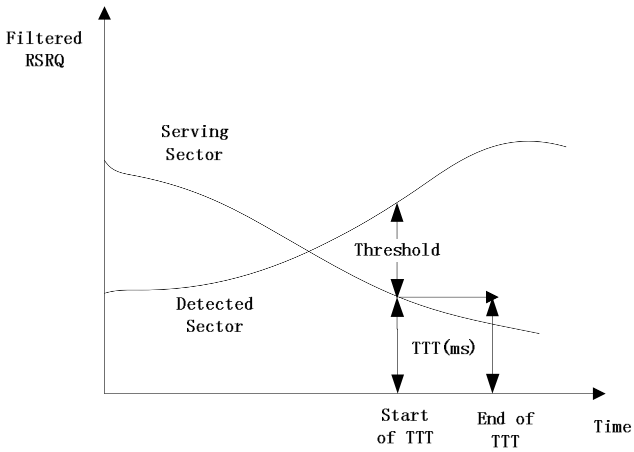


Fig. 1 Caption of Figure

1.2 RSRQ based handover

According to 3GPP R1-073041, RSRQ which is defined as a separate measurement can increase the reliability of the triggering, avoiding unnecessary or too early triggers. In the algorithm, we choose RSRQ as our basic measurement. Reference Signal Received Quality (RSRQ) is defined as the ratio $N \times$ RSRP / (E-UTRA carrier RSSI).(36.214). The filtered RSRQ is calculated every handover measurement period as defined in 3GPP 36.331 P62.

$$F_n = (1-a)\cdot F_{n-1} + a \cdot M_n$$

And, F_n stands for the updated filtered measurement result, RSRQ, F_{n-1} is the old filtered RSRQ, M_n is the latest received RSRQ value from physical layer, and $a = 1/2^{k/4}$, where k is the parameter received in the *filterCoefficent* field of the *QuantityConfig*, that is to say, we can configure this parameter from NAS layer in our simulation.

$$Mn - Hys > Ms$$

The algorithm is based on transaction 3, when the formula is satisfied, the handover process is beginning, in our simulation, in order to decrease the complexity we ignore the overload of the system.

1.3 Description of the adaptive mechanism and algorithm

According to the previous description, we have already acquired the necessary parameter prepared for handover in LTE systems. Next, we can give the more details for our algorithm.

First, at the initialization of simulation, we set the handover TTT window to a constant value, which we can modify according to our situation or needs.

Second, we set the adaptive TTT window for different UE base on the velocity, such as if the velocity exceeds the MAX_VELOCITY, the TTT window equals to the MAX_TTT_VALUE, or we will not change the TTT window. Of course, we can allocate all the UEs to different TTT window groups according to the velocity.

Third, check the rate of ping-pang handover for each UE in one period (such as one second), if this rate is greater than a certain value, e.g. the RATE_THRESHOLD (which we can configure), then we increase the TTT window for this UE by one step,

$$W_n = W_{n-1} + step$$

else, we decrease the TTT window by one step,

$$W_n = W_{n-1} - step\,.$$

Fourth, end.

2 Simulation Description

We implement the proposed handover mechanism based on our mobility management system, including location update, call setup, schedule, power control, handover and so on. A fully dynamic time driven system simulator is performed which simulates UL and DL simultaneously. The parameter shows in table 1. In the simulation, there are 19 cells, each sector has 3 sectors. Each sector has fixed antenna parameter. Wrap-round technique is used in order to avoid border effect. Full buffer scheme is considered as the model of user data, which will cause full load in each cell. Besides, the UEs are uniformly distributed in the simulation area. There are three velocities in our simulation, some UE are static, some are in random walk, others are in vehicle motion. The parameter and their assumption in our simulation are defined in table 2. Table 2 illustrates the LTE simulation parameters for advanced system level simulation.

Tab. 1 simulation parameters

Parameter		**Assumption**	
Cellular layout		hexagonal grid, 19sites, 51sectors, wrap around	
Inter-Site Distance		500 m	
Path loss		$L = I + 37.6\log_{10}(R)$, R in km I = 128.1-2GHz，I = 120.9-900MHz	
shadowing model		similar to UMTS 30.03	
Shadowing Standard Deviation		Urban Macro cell	4 dB
		Rural Macro cell	6dB
shadowing correlation distance		50 m（according to UMTS 30.03）	
Shadowing correlation	intra-eNodeB	0.5	
	inter-eNodeB	1.0	
penetration loss	3 km/h	20 dB	
	30 km/h	10 dB	
Horizontal antenna pattern		$A(\theta) = -\min\left[12\left(\theta/\theta_{3dB}\right)^2,\ A_m\right]$ $A_m = 20\text{dB}$，$\theta_{3\text{dB}} = 70^{\circ}$	
Carrier Frequency		2 GHz	
channel modeling		Typical Urban (TU)	
Velocity		3 km/h，3 0km/h，120 km/h，350km/h	
Total power(Ptotal)		43dBm-1.25，5MHz，46dBm-10MHz	
power hierarchy of UE		21dBm(125mW)，24dBm(250mW)	
inter-cell interference model		uplink：explicit modeling(all cells occupied by	

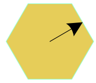
Parameter	Assumption
	UEs) dowlink：explicit modeling else cell power=Ptotal
the direction of base station	
UE distribution	Uniform distribution
minimum distance between UE and Site	>= 35 meters
simulation time	

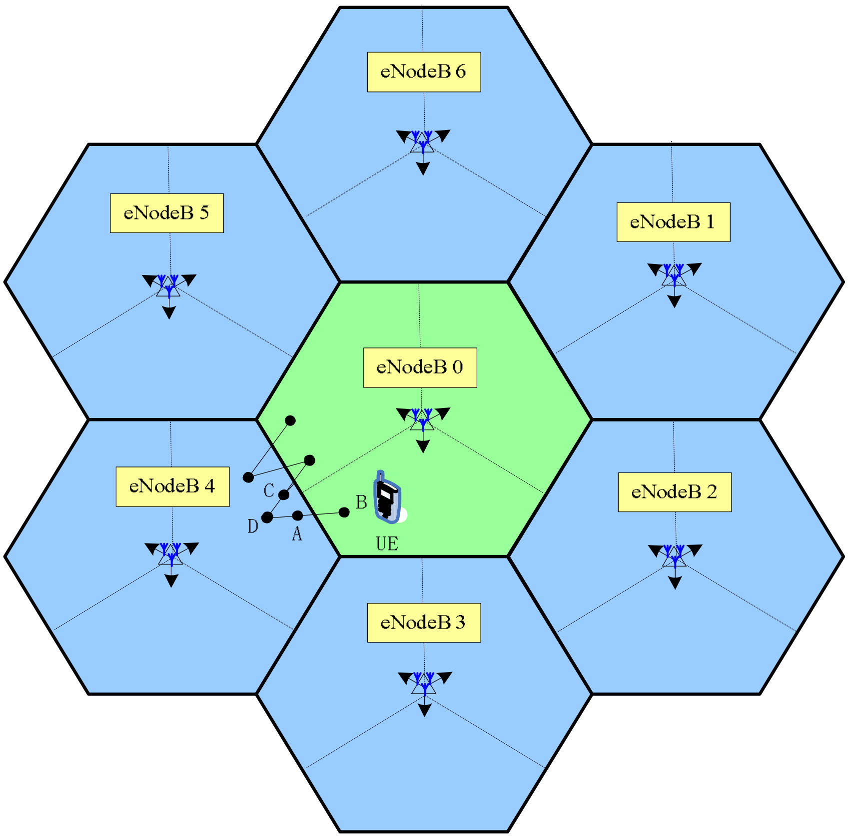
Table 2 shows us the simulation parameter. The simulation layout is also showed in table 2, that is, the network scenario assumes a hexagonal grid with 19 eNodeBs and 3 sectors per eNodeB with a corner-excited structure. The macro cell scenario provide high coverage. UEs are uniformly distributed in the initialization phase, the number of which is decided according to our needs. In our simulation, there are two scenarios, Urban Macro cell and Rural Macro cell, and the standard deviation of shadow fading in two scenarios is respectively 4dB and 6dB [9]. In our simulation, as for random-walkers, the direction involves $\{0^o, 90^o, 180^o, 270^o\}$, and the updating period is 3000TTIs, each TTI stands for 2 ms. Each UE in vehicular motion has a given uniformly random direction in the range of $(0^o, 360^o)$, and the updating period is 300 TTIs. The wrap-round technique is deployed in order to overcome the drawback of the limited area of our simulation network.

As for the calculation of RSRQ, our channel model covers pathloss, shadowing and frequency selective fast fading. Suzuki model is considered as our shadowing sample[5].We adopt rayleigh fading model as our fast fading sample. Rayleigh fading model is more accurate and scientific comparing to Jakes model. According to 25.996, the static and random_walker user use 4 paths model, as to vechiclar_motion user, 6 paths model is adopted.

The hard handover measurement is RSRQ, we use RSRQ for evaluating the best sector and making handover decisions. There are two reporting criteria in LTE protocol: periodical or a single event description which is our simulation measurement criterion. After receiving the RSRP and RSSI for intra-frequency purpose, we calculate RSRQ and reports to eNodeB immediately when we find the best alternative. In order to get more accurate RSRQ and obtain further stability, the 200 ms slide window is used as the measurement period.

3 Theoretical analysis

In our algorithm, the main target is to decrease the ping-pang effect which occurs in the system, which can affect the whole system performance, e.g. wasting the wireless resource, extending delay time for each UE. In this situation, this often occurs when the UE with higher velocity moves from the boundary of one cell to another.



Next, the motion trace is showed in the picture. UE moves from point B to A, then to D, next to C, and so on. In point B, the serving cell is eNodeB 0, we assume A and C are the handover point, the distance between A and eNodeB 0 is the same as that of C, where the handover event probably happens. After handover in A, the target cell (eNodeB 4) will become the serving cell. But in point C, after successful handover, eNodeB 0 will become serving cell again. We have to solve this problem to save radio resource and reduce complexity.

To facilitate the problem, we adopt the model introduced in transaction 1, which is

$$\begin{aligned} p_k(i) &= p[p_G(i,k) > p_G(j,k) + \Gamma \\ &= p[\xi(i,k) > 10\log((d_{i,k}^{\mu}/K)(p_G(j,k)+\Gamma))] \\ &s.t.\, j \neq i, \forall j \in C_{neigh} \end{aligned}$$

$p_k(i)$ is the probability that the path gain from the eNodeB i is greater than other eNodeBs by Γ at position k, that is to say, the serving cell will become eNodeB i. $d_{i,k}^{\mu}$ stands for the distance from UE and eNodeB i. Γ stands for handover decision threshold. Then we transfer the probability problem to distance problem, which is much easier. We assume the $p_k(i)$ equals to $1/2$, and can calculate the minimum distance $d_{\min}$, out of which handover event will probably happen. We can also point out the maximum distance $d_{\max}$ where the $p_k(i)$ equals to 0.9, where handover event will happen. The other parameter is showed in transaction 1.

We use d standing for the distance between UE and eNodeB, if $d_{\min} < d < d_{\max}$, and the motion trace for one UE is similar to the picture, when this UE reaches point A ($d_{\min}$), we start the handover timer. When UE moves to point C ($d_{\min}$), where handover event happens again, we can obtain a time T. Next, we adjust the TTT window according to formula a step by step, until TTT window exceeds T.

So, we can change the value of TTT window according to distance between UE and eNodeB, which is related to the velocity and angle. Besides, as an additional condition, this can decrease the ping-pong rate for the system.

As a result, this algorithm can decrease the overall ping-pong effect according to our analysis.

4 Simulation result

From the previous description, we probably know the simulation situation clearly. Besides, we adopt the relative handover decision, and, the handover threshold is definitely defined. But, we can configure the parameter flexibly. In our simulation the velocity of UE is 30kmph. For adaptive method, the initial TTT window is 300ms, and the max value of TTT window is 600ms, $step$ equals to 10ms. And we choose0.02 as the value of RATE_THRESHOLD.

Figure 2 shows that if we adopt different TTT window, the handover numbers per UE per seconds is different. We can conclude that, Hys going from 0 to 10dB, lead to a decrease in average number of HOs per UE per second. The TTT window of 400ms leads to less number HOs comparing to 300ms, and if we adopt adaptive TTT window, the number of HOs is better than TTT window of 300ms, and worse than that of 400ms.

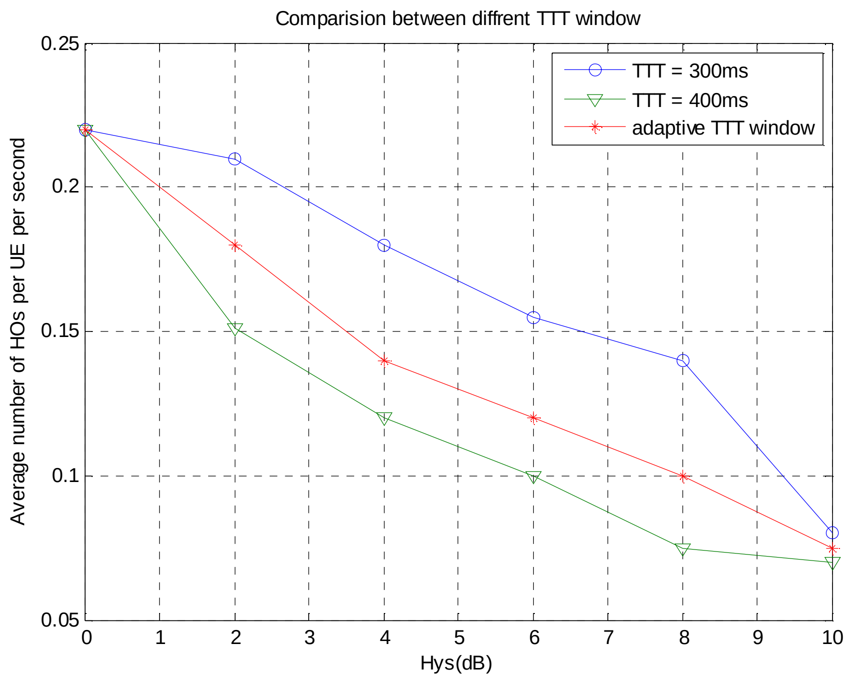


Figure 2 Comparison between different TTT window

Figure 3 shows s that the ping_pong rate varies if we adopt different TTT window value. From the figure, we can conclude that the ping_pong rate decreases according to the value of Hys. At the same time, we notice that increasing TTT window is a kind of ways to reduce the number of ping_pong handovers. But in order to ensure the Qos of communication, we have to select the proper TTT window which can also reduce the number of ping_pong handovers. In a word, the handover method of adaptive TTT window can decrease the overall ping-pong rate for the whole system, and guarantee Qos of communication.

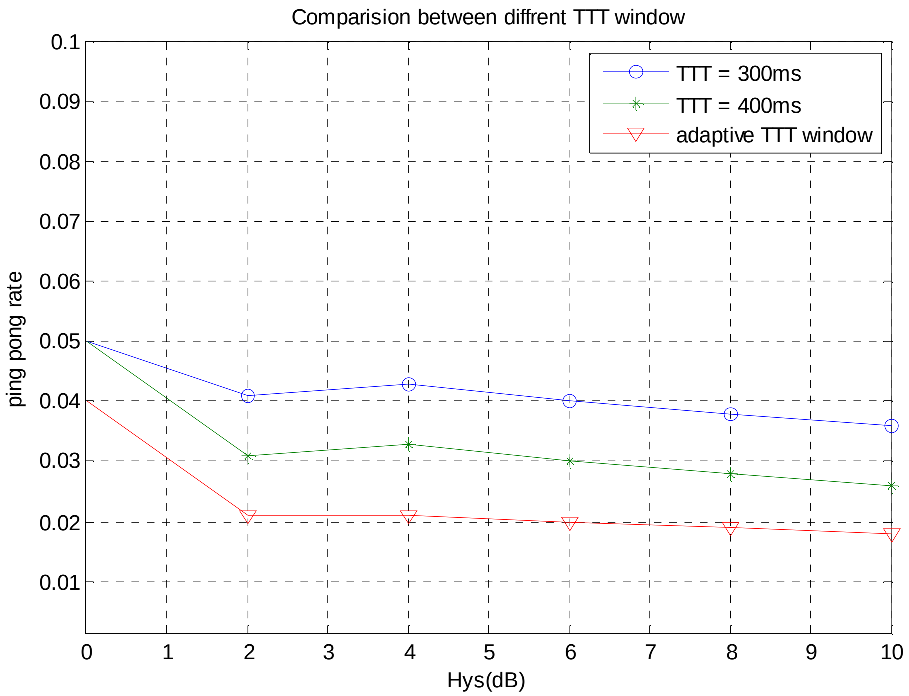


Figure 3 Comparison between different TTT window

5 Conclusion and future research

In the paper, we have proposed a new handover algorithm based on classic handover decision. As we know, handover plays an important role in mobile communication systems, and the handover rates can affect the whole system performance, especially for higher speed vehicles.

To simplify the simulation, we do not use the theoretical result, we just use the experimental result to carry out our algorithm, of course, this can affect the simulation.

But, the simulation result shows that our algorithm can really decrease the overall ping-pong rate for the whole system, which can optimize the performance of the system.

Next, we should pay more attention to the velocity and angle, which can affect the handover result, and research it more deeply.

References

[1] Junren Chang; Yajuan Li; Shulan Feng; Haiguang Wang; Chengzhen Sun; Zhang, P; A Fractional Soft Handover Scheme for 3GPP LTE-Advanced System Communications Workshops, IEEE International Conference on Digital Object ,2009 , Page(s): 1 - 5

[2] Anas, M.; Calabrese, F.D.; Mogensen, P.E.; Rosa, C.; Pedersen, K.I.;Performance Evaluation of Received Signal Strength Based Hard Handover for UTRAN LTE;IEEE On Vechicular Technology,2007 , Page(s): 1046 - 1050

[3] 3GPP R1-073041. Ericsson, Reference Signal Received Quality, RSRQ, measurement, 3GPP TSG RAN WG1 Meeting #46bis

[4] Anas, M.; Calabrese, F.D.; Mogensen, P.E.; Rosa, C.; Pedersen, K.I.; performance and amobility management technique with simple handover prediction for 3G LTE systems;

[5] Patzold, M.; Killat, U.; Laue, F.; A deterministic digital simulation model for Suzuki processes with application to a shadowed rayleigh land mobile radio channel; IEEE on Vehicular Technology;1996 , 45(2): 318 - 331

LTE-advanced 系统中基于自适应触发窗机制的切换模式

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摘要：众所周知，近年来 LTE 系统中使用的是硬切换模式。为了提升系统的整体性能，层 3 滤波器、合成器以及时间触发窗被研究出来。本文提出了一种新的基于自适应触发窗机制的来克服乒乓效应以及提升系统总体容量。方针结果显示，采用新的机制可以减少切换的次数并且在一定程序上减少乒乓切换。为了降低复杂度，本文主要研究频率间切换。

关键词：无线通信；切换；乒乓效应；自适应
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