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Reducing Ping-Pong Handover Effect in LTE Mobile Networks Using TRIAS

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□ ABSTRACT □

Improving system performance in terms of data rate, mobility and cost is the scope of Long Term Evolution (LTE) system. In LTE networks the handover (HO) decision is performed by the evolved base station (eNB). The ping-pong movement in LTE is one of the most crucial problems which reduce the quality of the connection and degrade the performance of the handover. In this paper, the impact of ping-pong handover on inter eNB handover is investigated. The main object of the present work is to provide a method for reducing the number of ping-pong handover in the intra E-UTRA networks. A novel handover algorithm, based on keeping the old path between the source eNB and SGW/MME during the ping-pong movement and delaying the completion handover part, is presented. The ping-pong detecting algorithm for intra E-UTRA can be a tool to reduce the number of ping-pong handovers and control the demand of the network resources.

Different values for the timer have been implemented and the probability of dropped calls and the ping-pong HO rates have been shown. Optimal timer value should be chosen carefully to reduce the probability of ping-pong HO and at the same time keep the dropped calls rate at lowest levels. Low and medium fixed user speed were implemented in this simulation mainly they are 25 km an hour and 70 km an hour. The analysis of the proposed algorithm showed that the rate of ping-pong handover can be reduced and, consequently, the handover quality indicator increased. Simulated results using TRIAS tools supported with NS2 simulator show that there is a significant reduction in the probability of the ping-pong handover when applied our proposed algorithm.

Keywords: Mobility management, Ping-Pong, Handover, dropped calls rate.

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تخفيض تأثير ظاهرة الانتقال المتكرر والمتذبذب في شبكات LTE النقالة باستخدام برنامج TRIAS

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□ ملخّص □

يتركز مجال الاهتمام لنظام LTE بشكل أساسي على معدل إرسال البيانات، وقابلية الحركة والانتقال، وتكلفة النظام. إن أمر التسلّم والتسليم (Handover decision) بين الخلايا المتجاورة في نظام LTE يتم إقراره في المحطة القاعدية المطورة (evolved Base station). من أهم المشكلات التي تخفض جودة الاتصال، وتضعف الأداء في أثناء عملية الاستلام و التسليم بين المحطتين المتجاورتين هي حركة الانتقال المتكررة المتذبذبة (ping-pong HO) لمسار الاتصال بين المحطة المصدر والمحطة الهدف، ويستعرض هذا البحث تأثير هذه الظاهرة في أثناء عملية الاستلام و التسليم في شبكة LTE النقالة، ويهدف إلى تقديم طريقة جديدة لتخفيض عدد مرات التأرجح لمسار الاتصال بين الخلية المصدر و الخلية الهدف في شبكات LTE. تم اقتراح خوارزمية جديدة للاستلام والتسليم بين المحطات تعتمد على الاحتفاظ بالمسار القديم للإشارة (بين المحطة المصدر والبوابة المخدمة) في أثناء فترة التأرجح، وتأخير عملية إكمال الجزء النهائي من عملية الاستلام والتسليم. يمكن أن تشكل الخوارزمية المقترحة حلاً لتخفيض عدد مرات التأرجح غير المرغوبة، والتحكم بإدارة الحركة للنظام، والحفاظ على مصادر الشبكة اللاسلكية.في التحليل المقدم للخوارزمية تم اعتماد قيم مختلفة للعداد المستخدم في الخوارزمية، وتم عرض معدلات المكالمات المنقطعة، واحتمال حدوث الانتقال المتكرر المتذبذب. إن تحديد القيم المثلى لعداد التأخير يتطلب عناية ودقة ليضمن تخفيض معدل احتمال حدوث الانتقال المتكرر المتذبذب، وليضمن في الوقت نفسه بقاء معدلات المكالمات المنقطعة في أدنى المستويات. كذلك تم اعتماد سرعتين ثابتتين للمشترك في مجال السرعة المنخفضة والمتوسطة؛ وهما بشكل رئيس 25 و70 كم/سا. أثبتت نتائج هذه الدراسة أنه بالإمكان تخفيض معدل الانتقال المتكرر والمتذبذب بين الخلايا المتجاورة، وبالتالي تحسين قيمة مؤشر النوعية لعملية الاستلام والتسليم. وأظهرت نتائج النمذجة المعتمدة على برنامج TRIAS حدوث انخفاض ملحوظ في احتمال حدوث الانتقال المتكرر المتذبذب في أثناء عملية التسليم والاستلام عند تطبيقنا للخوارزمية المقترحة.

الكلمات المفتاحية: إدارة الحركة، الانتقال المتكرر والمتذبذب، الاستلام والتسليم، معدل المكالمات المنقطعة.

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INTRODUCTION:

Long Term Evolution (LTE) is under developing to meet the increasing users' requirements and at the same time decrease the operating costs. It is under consideration to develop a new radio interface and radio network architecture that provides a high data rate, low latency, packet optimization, and improved system capacity, coverage and mobility. For an LTE system, an Orthogonal Frequency Division Multiple Access (OFDMA) and a Single Carrier Frequency Division Multiple Access (SC-FDMA) are used in downlink and uplink transmissions, respectively. Many aspects in the LTE system have been changed such as architecture, mobility and related operations comparing to that in 3G mobile networks. Changes on the radio part are performed on the eNB which involve a new radio interface based on OFDM technology and a completely different RAN architecture, where radio functionality is distributed into eNBs. All radio control functions such as radio resource managements and admission control are implemented in the eNB. The Evolved Universal Terrestrial Radio Access Network (E-UTRAN) consists of eNBs which provide the E-UTRA user plane and control plane protocol terminations towards the User Equipment (UE). The eNBs are interconnected with each other by means of the X2 interface. The eNBs are also connected by S1 interface to the MME/SGW (Mobility Management Entity /Serving Gateway). On the other hand, the changes on the core network side are mainly driven by the evolution toward having all services based on IP and the convergence of multiple access technologies under the same core network [1-3].

The handover (HO) process is being one of the most significant functionality of a mobile system, and it needs to be designed according to the distributed nature of the LTE architecture. E-UTRA mobility is the most fundamental, vital, and frequent scenario in LTE. The ping-pong HO is a very common phenomenon in the mobile networks, which can cause inefficiency, call dropping and degrading of the network performance. Coverage parameters, user location area and its movement and speed are the main considerations that can cause the ping pong. The ping-pong HO in LTE means two subsequent HOs between the source and the target eNB and vice versa. The ping-pong effect occurs due to the frequent movement of UE between the source and the target eNB, or high signal fluctuation at the common boundary of the eNBs [4-6].

IMPORTANCE AND AIMS OF RESEARCH:

Since the ping-pong HO disperses the resources between releasing and reserving, and as a result decreasing the QoS, it is essential for network operators to reduce this undesirable effect. However, the current technology does not offer a systematic and objective solution for the operators to perform a separate ping-pong HO from the general HO procedure.

The ping-pong HO has been defined as an open issue in LTE; therefore, a significant need for a mechanism that improves the HO performance during the ping-pong type of movement is required. Different research approaches tried to reduce the Ping-Pong effects in current mobile networks such as GSM and CDMA [4-8]. A number of papers and studies have appeared in the literature concerning problems related to the handover.

Some information is available about the ping-pong HO in LTE networks [9-11]. In [10], the performances of LTE handover in terms of number of handovers, time between two consecutive handovers and UL SINR are studied. Approaches in literatures vary from statistical analysis [12, 13] up to handover preparation based on cross-layer optimization [14, 15] and complex pattern detection algorithms [16].

Several handover studies have been done previously to improve the handover technique and reduce the side effect of the ping-pong movement on LTE networks. In [17], the settings for determining the efficiency of a handover algorithm and its initiation control are studied. The performance metrics include call dropping probability, probability of ping-pong handover, duration of interruption, and handover delay. In [18] It is assured that the decision to initiate a handover is an important component in the process since the success and the efficiency of the handover, to a large extent, depends on the accuracy and timeliness of the decision. In [19], the effects of hysteresis and threshold criteria on handover rate, delay, and link drops are studied in a GSM network. The study in [20] shows some trade-offs between handover hysteresis, Time-to-Trigger, and Layer 3 filtering coefficients in a handover algorithm for 3G WCDMA networks. These studies are based on a simplified model with two neighbouring cells and a mobile moves from one cell to the other cell in a straight line. In [21] the objective of the master thesis was to optimize handover algorithm in LTE with the focus on decreasing the number of handover failures. A new LTE handover algorithm and procedure are studied in [21], and the parameters affecting handover initiation are identified. Also the author in [21] tuned the setting {Hysteresis/TTT} to evaluate the methodology defined in Section 3.3 of the thesis.

In our study we will present an innovative algorithm that can apply in LTE network and be able to perform successful handover without Hysteresis. The implemented algorithm concentrate in reducing the number in ping-pong HOs and at the same time keep the probability of the dropped calls at the lowest levels.

Previous mobility techniques do not distinguish between the normal movement and the ping-pong type of movement. In this work we will present a simple technique which can select whether the movement is ping-pong or it is general one via setting a timer as a first step. In the next step, the proposed algorithm suggests to delay the completion part of the HO procedure and keep the old path between the source eNB and MME/SGW for a short time – for the ping-pong type of movement-. Our proposed algorithm will try to initiate the HO procedure as soon as the received signal strength from the value is bigger than that from the source, and the completion of the Ho procedure will not perform until the timer value is expired. In LTE networks, more research can be done to reduce the unwanted effects of the ping-pong HO and control the demand of the network resources and tackle the phenomenon. In this work we will concentrate on the effects of ping-pong on E-UTRA HO and will implement a new algorithm that can decrease that. Also the effects of different timer values for different user velocities on the dropped calls rate and the probability of the ping-pong HOs will be discussed in this work.

Although we are trying to reduce the number of ping-pong handovers in LTE networks, the first priority is to maintain the connection and avoid increasing the dropped calls. That is because the handover is made to guarantee the continuity while the user is moving. It is good to mention that inter LTE ping-pong HO is not considered in this work but it will be main part of our future work.

RESEARCH METHODS AND TOOLS:

A novel handover algorithm, based on keeping the old path between the source eNB and SGW/MME during the ping-pong movement and delaying the completion handover part will be presented. The proposed algorithm detects the ping-pong type of movement and selects whether the movement belongs to the general or the ping-pong type of movement. System model of the proposed algorithm will be made using TRIAS tool supported with NS2 simulator. Also, the rate of ping-pong handover and the handover quality indicator will be considered as a pointer to check the general performance of the algorithm. This work supposed that the velocity of the User Equipment (UE) is under 70 KM/Hour- Low and Medium mobility-, high user speeds will be investigated in our future work.

LTE INTRA-EUTRA HANDOVER PROCEDURE

In LTE, the eNB is responsible for accomplishing the HO decisions without connecting the MME. The required HO information is exchanged between the eNBs via the X2 interface. The HO procedure is divided into two main steps mainly HO preparation and execution and HO completion. Figure 2 shows the intra-EUTRA HO steps. A summary of the HO procedure is summarised below. In this study the HO procedure is divided into two parts mainly: Handover preparation and execution part and the Handover completion part.

HANDOVER PREPARATION AND EXECUTION

When the UE approaches the cell boundary it sends a measurement report to the source eNB, which decides to hand off the UE based on the measurement report and Radio Resource Management (RRM) information. The source eNB issues a HO request message to the target eNB passing necessary information to prepare the HO at the target side. The target eNB prepares HO and sends the HO request acknowledgment to the source eNB. The source eNB generates the HO command with the necessary parameters towards the UE. After receiving the HO command, UE performs synchronisation to target eNB and accesses the target cell. After UE accession, it sends the HO confirm message to the target eNB to indicate that the HO procedure (preparation and execution) is completed for the UE [1 3][17 19]. By the end of this stage the HO preparation and execution are now performed.

HANDOVER COMPLETION

The rest of the HO procedure is to inform the MME/SGW via the S1 interface about the new changes in the wireless link. After receiving a HO confirm message from the UE, the target eNB sends a path switch message to MME/SGW to inform that the UE has changed its cell. The MME/SGW switches the downlink data path to the target eNB, and then it can release any User plane (U-plane) resources towards the source eNB. The target eNB sends release resource message to source eNB which then can release radio and control plane (C-plane) related resources associated to the UE context. By the end of this step the HO is totally completed and the target eNB can start sending the packets received on the new direct (MME/SGW-target eNB). However, the target eNB should first deliver all forwarded packets to the UE from X2 interface before delivering any packets from S1 interface (MME/SGW-target eNB)[1 3][17 19].

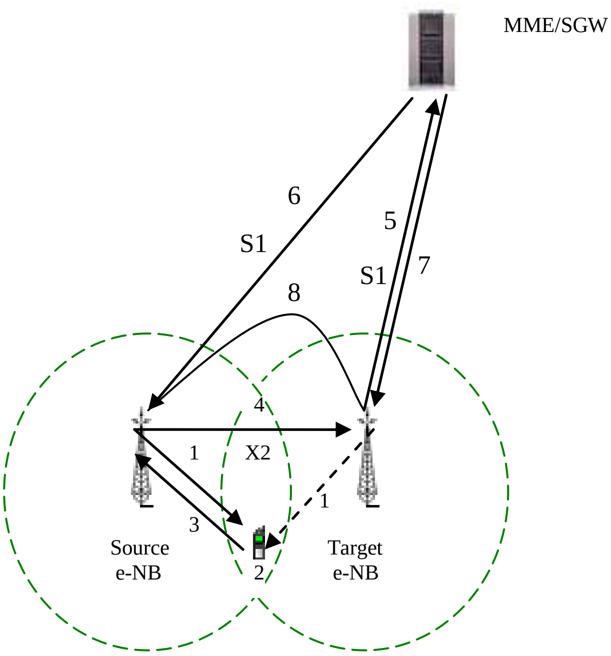

Figure 1: Summary of the different steps of preparation, execution and completion HO process which performs by eNBs.

1) Downlink HO measurements, 2) processing of downlink measurements, 3) uplink reporting, 4) HO preparation and execution via x2 interface, 5) path switch request, 6) release the old path, 7) Path switch acknowledgement, 8) Release resources[1 3].

PING-PONG DETECTION ALGORITHM FOR INTRA LTE HANDOVER

In the proposed algorithm explained in Fig. 2 a timer is used as a guide to select whether the ongoing HO belongs to the general or the ping-pong type of movement as explained here. If the received Signal Strength (SS) form the target eNB (SS-target) is stronger than that received from the source (SS-source), then the timer can be set and the HO preparation and execution part may be performed by both the source and the target eNBs. If the difference between the SS-target and SS-source always shows that the SS-target is sufficiently strong than the SS-source, and the timer is expired then the movement is general (no ping-pong movement). The operator in this case can immediately release the resources along the old path (MME/SGW-source eNB) and finish the completion HO part. However, if the difference between the SS-target and SS-source does not show that the SS-target is sufficiently stronger than the RSS-source then there is a ping-pong type of movement. In this case, the operator can keep the old path (MME/SGW-source eNB) during the ping-pong duration and only the completion part of the HO procedure can be delayed to avoid the swinging between releasing and initiating of the paths between the MME/SGW and eNBs (Fig. 3).

Our proposed algorithm will try to initiate the HO procedure as soon as the received signal strength from the target is bigger than that from the source, and the completion of the HO procedure will not perform until the timer value is expired.

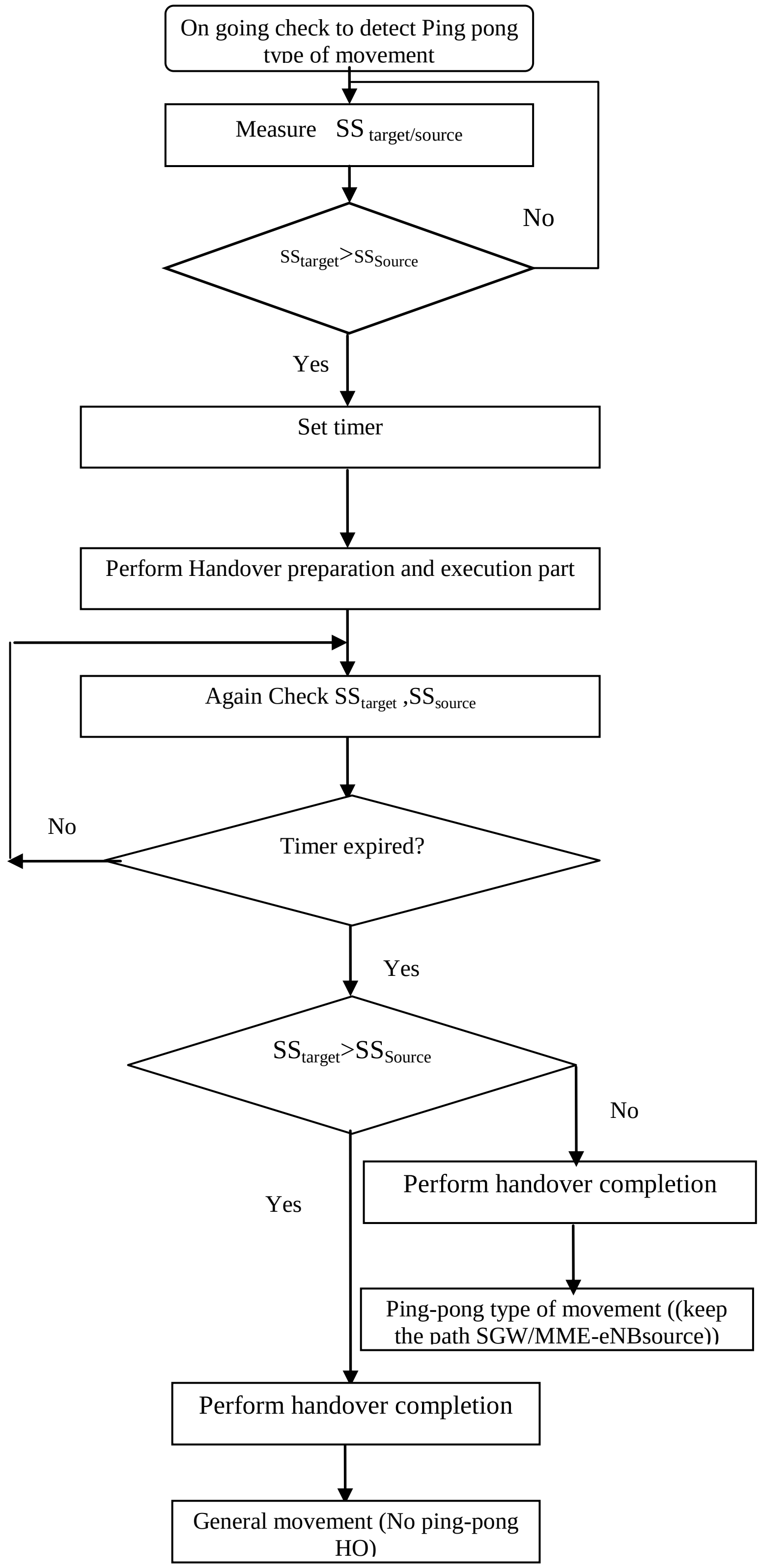

Figure 2 shows the ping-pong detection algorithm that presented in our work to reduce the number of ping-pong HOs in LTE networks

The proposed algorithm has 2 phases as explained below. As it can be seen in the figure 3, the preparation and execution HO phase means that the new connection between the UE and the target is made but the old S1 interface is still in use (dark line in figure 3). For the HO completion part there is completely new connection path via new S1 interface as it is shown in figure 3.

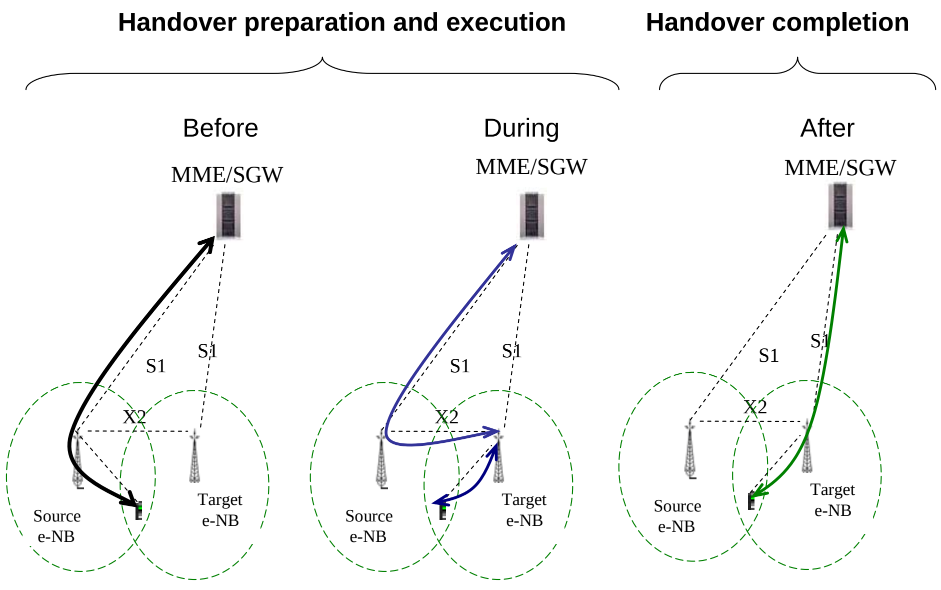

Figure 3 shows the phases of the proposed algorithm

ANALYSIS OF THE PROPOSED ALGORITHM

In our proposed algorithm the HO decision is taken according to the difference between the received Signal Strength from the target (SS-target) and the received Signal Strength from the source (SS-source).

The mean signal strength has a log-dependence of the distance ($d_{target/source}$) between eNB $_{(target/source)}$ and the UE [11], the received Signal Strength from the target (SS-target) can be calculated as:

$$S(t)_{(eNB-target)} = K_1 - K_2.Log(d_{target}) + u_{(eNB-target)}(t) \qquad (1)$$

Whereas, the received Signal Strength from the source (SS-source) can be calculated as:

$$S(t)_{(eNB-source)} = K'_1 - K'_2.Log(d_{source}) + u_{(eNB-source)}(t) \qquad (2)$$

Where (K_1, K'_1)and (K'_2, K_2) depend on the transmitted power, antenna features in the eNB, and the transmission environments.

The rate of ping-pong HOs is defined as the number of ping-pong HOs per total number of HOs.

$$P_{(ping-pong)_{HO}} = \frac{N_{(ping-pong)_{HO}}}{N_{HO_{total}}} \qquad (3)$$

Where $N_{(ping-pong)_{HO}}$ and $N_{HO_{total}}$ are the number of ping-pong HOs and the total number of HOs, respectively.

To be able to measure the performance of the ping-pong detection algorithm, the HO quality indicator is defined. The parameters used to evaluate the tested algorithm are HO rate, block and drop rates, and delay of HO [20].

$$P_{HQI} = \frac{N_{HO_{total}} - N_{(ping-pong)_{HO}}}{N_{HO_{total}} + N_{Block} + N_{Drop}} \qquad (4)$$

Where N_{Block} and N_{Drop} are the number of HO call blocked and number of HO call dropped respectively.

RESULTS AND DISCUSSIONS :

By applying the ping-pong detection algorithm, the parameter $N_{(ping-pong)_{HO}}$ in the equation (3) will decrease and the HO quality indicator will be enhanced.

$$P_{HQI} = \frac{\cancel{N}_{HO_{total}}\left(1 - \frac{N_{(ping-pong)_{HO}}}{N_{HO_{total}}}\right)}{\cancel{N}_{HO_{total}}\left(1 + \frac{N_{Block} + N_{Drop}}{N_{HO_{total}}}\right)} = \frac{(1 - P_{(ping-pong)_{HO}})}{\left(1 + \frac{N_{Block} + N_{Drop}}{N_{HO_{total}}}\right)} \qquad (5)$$

From the previous equation, the HO quality indicator can be improved by decreasing the number of ping-pong HO and decreasing the number of dropped and blocked calls. Ping-Pong detecting algorithm for intra E-UTRA HO decreases the number of ping-pong HO which in turn improves the HO quality indicator as it appears in equation 5. Previous Equations show that the proposed algorithm reduces the rate of ping-pong HOs and increases the HO quality indicator.

SYSTEM AND SIMULATION MODEL

In this work, a model is considered where the user is assumed to travel with uniform velocity V throughout the cell with cell radius R. In [21, 22] user mobility parameter á is considered and defined as:

á =[2*R]/[V*Tm] (6)

where Tm is the mean call duration. More details regarding the effect of user mobility on handover performance will be presented in our future work.

In this work, two key performance indicators are used to evaluate the proposed algorithm which are selected to be the dropped calls rate and the ping-pong handover rate. TRIAS supported with NS2 simulator has been used to evaluate the performance of the proposed algorithm. TRIAS is a very powerful tools to simulate the Mobile Networks, it has the capability to work with database also to work with NS2 simulator and other external servers, more details can be found in [23-25]. The simulations have been accomplished in a big campus with number of cells in hexagonal grid is 7 with 3 sectors each (total of 21 sectors). The number of users is constant through the simulation and supposed to be 300 users, and Max DL Power 20 W. The main simulation parameters' values are listed in Table 1. We have selected the mobility of the UE to be 25 km/hour(Low mobility case) and 70 kmph (Medium mobility case). High speed user will be presented in our future work.

We supposed that the eNodeBs are laid out over an area of 4.5 kilometres by 4.5 kilometres with the varying densities and medium load, other parameters assumptions used in our simulation are summarized below table 1.

Parameter settings

Inter site distance 1000 m
System bandwidth 5 MHz
Sub-frame/TTI duration 1 ms
Number of PRBs for data transmission 48
Number of PRBs for control transmission 2
Users multiplexed per TTI 8
UE distribution Uniform distribution
Number of UEs 300 (fixed during simulation time)
Traffic model full buffer
Duplexing TDD
Minimum distance between UE and cell 25m
correlation distance = 50m
HARQ Synchronous, Adaptive
UE speed 25 kmph, 70 kmph (2 cases)
Distance dependent path loss 128.1 + 37.6 log10(r) distant in KM
Log-normal shadowing standard deviation = 8 dB
UE direction randomly chosen within [0, 360] degree
UE antenna gain 0 dBi
User arrival rate 1-6 users/cell/s
Number of total subcarriers 300 (fixed during the simulation)
eNode-B antenna gain 14 dBi
UE noise equal to 9 dB (-124 dBm/sub-carrier)
Number of admitted calls simulated 1000
Noise Factor 8dB
The simulation is 80 sec
Average signal-to-interference-plus noise ratio (SINR) > 4 dB

Table 1: Simulation settings and Assumptions used in our simulation.

The simulation methodology is applied to choose the best HOs criteria. To have a comprehensive understanding of the performances of different handover settings for our algorithm, the results evaluated by all the different timer values for different user velocities will be listed in two scenarios, mainly low speed UE (chosen to be 25 km/hour)and medium speed UE(70 km/hour). Also, our major concern is to keep the dropped calls rate at the lowest rate and after that reduce the probability of ping-pong HOs.

In this simulation the timer value is selected to be 0.3, 0.5, 1, 1.5, 2 and 4 seconds respectively, also the probability of the blocked calls is chosen to be neglected (our chosen load is medium and the number of users in the simulation is chosen to be fixed during the scenario and equal to 300 UE, also the radio resources and the capacity is sufficient).

Scenario 1 low speed mobility (25 km/h)

In this scenario- the velocity of the UE is selected to be 25 km/hour-, than our model gives the results shown in figure 4. As it can be seen from figure 4, the probability of the dropped calls has the lowest value in our simulation for the timer values equal to1.5 seconds. This means that we should consider the timer values to be 1.5, to assure that the probability of dropped calls is remaining at lowest levels which is our main priority. At the same time the ping-pong HO rate is decreasing while the timer value is increasing, and it reaches to a very low rate for the timer value increases.

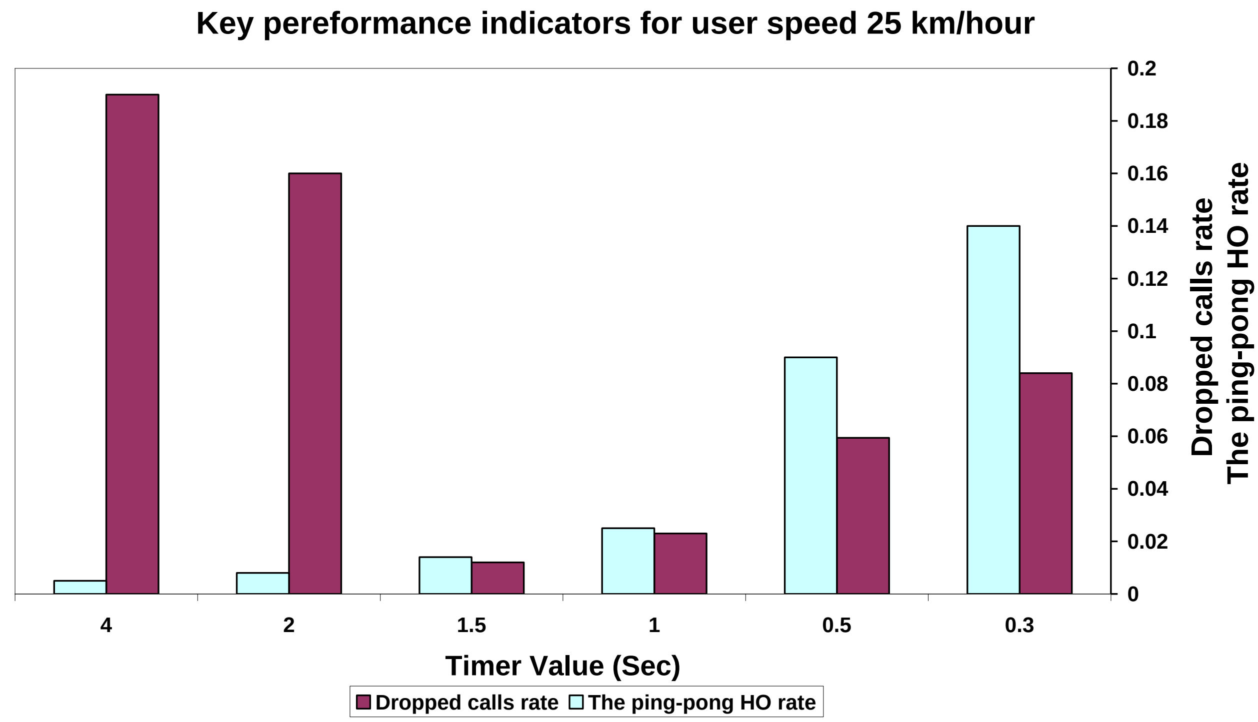

Figure 4 shows the dropped calls rate and the ping-pong handover rate in case of the speed of the UE equal to 25 km/hour.

For the speed 25 km/hour, the optimal value of the timer should be choose to be 1.5 sec, and then we will have the probability of dropped call remains low (1.2%) and at the same time the probability of ping-pong HO decreased efficiently as it appears in figure 4. Timer values bigger than 1.5 sec should not be considered because the probability of the dropped calls increases, and that intern makes the chosen parameters are not appropriate to be used at timer value bigger than 1.5 seconds. So that our simulation suggests that the optimal timer value that can give us the lowest dropped calls (1.2 %) and at the same time the ping-pong HO rate is low (1.4 %) equals to (T=1.5 sec).

Scenario 1 medium speed mobility (70 km/h)

In this scenario the timer value is selected to be 0.3, 0.5, 1, 1.5, 2 and 4 seconds respectively, also the parameters of this scenario (UE velocity is 70 KM per hour) remains the same, only the velocity of the UE is changed from 25 to 70 km/hour.

As it appears from the figure 5, the probability of ping-pong HO is less than 1% for the timer value T=4 seconds. However, the dropped calls rate increases to 28%. Simulation results shows that the timer value should be selected carefully and should be set to reduce the of probability ping-pong HO(as it is our main priority) and at the same time keep the dropped calls at the lowest levels. For timer value T=1 sec the probability of dropped calls and the ping-pong HO reached a good level approximately 3 %. In this case – timer value equal to 1- there is a reduction of the probability of ping-pong HO from 5.9% to 3 % (approximately 50%) when the timer value is increased from 0.5 sec to 1 sec. Figure 5 also shows that the probability of ping-pong HO can be reduced significantly if the timer value is higher than 1 sec. So for our optimal results in case of the UE is 70 km/hour, the timer value can be selected to be 1 second. For this value (1 sec) both of the dropped calls rate and the probability of ping-pong HO achieved a very good values and proper results.

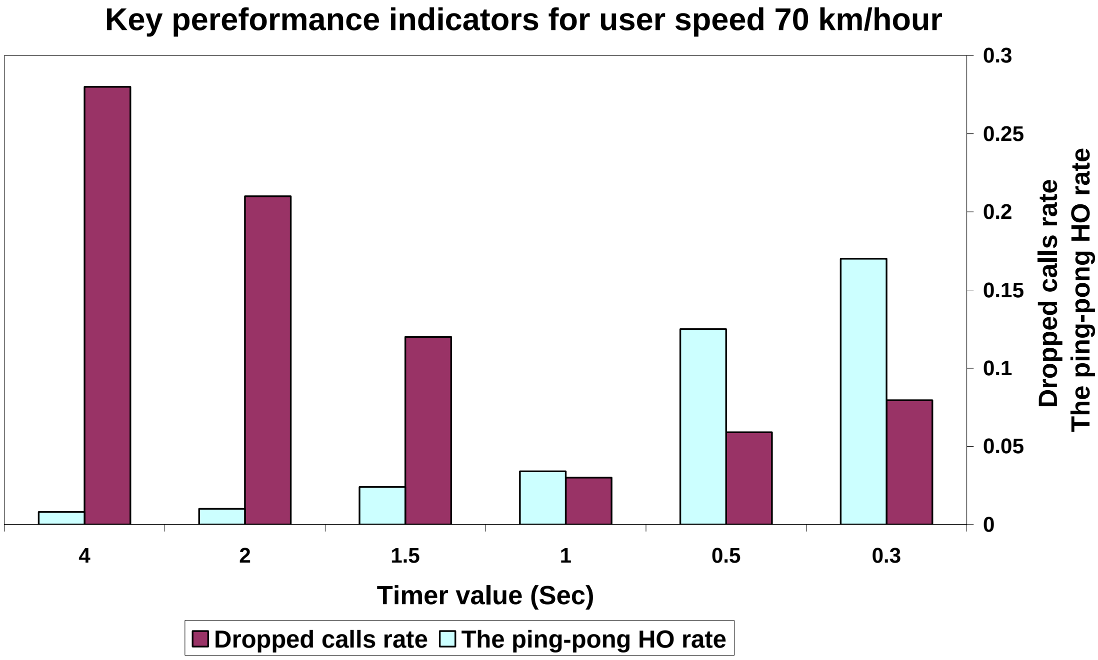

Figure 5 shows the dropped calls rate and the ping-pong handover rate in case of the speed of the UE equal to 70 km/hour.

Results in figure 4 and 5 indicate that the ping-pong avoidance algorithm could significantly minimize the probability of ping-pong HO to lowest standards, also the optimal value for the dropped call rates and the probability of ping-pong HOs indicates to be 1.5 and 1 sec depending on the user velocity. Minimizing the probability of ping-pong handover and keeping the dropped calls rate at very low value lead to increase the handover quality indicator which in terms improve the quality and the reliability of the connection, and that agree with the equation 5.

In comparison with the results obtained in [21], for the cell radius equals to 1000. Our obtained results show that the probability of the dropped calls in our simulation gave better results for medium UE velocity. In our results the probability of the dropped calls is 3% for the velocity of 70 km/hour and in[21] the handover loss rate for the velocity of 50 km/hour reached 4%. Moreover, The percentage of Ping-Pong effect for the timer value 1 and 1.5 sec (for the user velocity of 25 and 70 km/h respectively) are within the good range and they show significant reduction in comparison with that in previous research.

It is crucial to make a trade-off between the HO criteria to get the optimal values of the handover procedures. So from our simulation and results we can see that the timer value should be chosen to be lower than 1.5 sec and higher than 1 sec. We still should consider the probability of the dropped calls as our major concern because the main task of handover in LTE is to guarantee the continuity of the ongoing connection across cellular boundaries to perform a seamless wireless communication. So dropped calls rate is considered as the primary. Selecting the timer value to be higher than 1.5 sec makes the rate of ping-pong to be very small value and at the same time the dropped calls rate increases slightly which is something we are trying to avoid it.

CONCLUSIONS:

In this paper, the HO preparation and execution and the HO completion in E-UTRA were studied. The effects of ping-pong phenomenon in LTE networks were investigated. A novel ping-pong avoidance scheme to detect the ping-pong type of movement and keep the old path for a short time in E-UTRA was also presented. The presented scheme distinguished between the general and the ping-pong type of movement. In ping-pong type of movement, only the completion part of the HO procedure can be delayed to avoid the swinging between releasing and initiating the paths between the MME/SGW and eNBs. The evaluation of the algorithm showed that keeping the old path in the case of ping-pong movement can reduce the rate of ping-pong HO and its undesirable effects and enhance the HO quality indicator. Simulated results showed that the timer values play significant role in reducing the probability of ping-pong HOs, however, high timer value can cause dropped calls. So the optimal timer value can be chosen carefully to determine the best value to the Timer value. In our simulation the best values were 1.5 and 1 sec for the user speed of 25 and 70 km per hours. Also the results from our simulation illustrated that the velocity of the UE can increase the dropped calls if the timer value is higher than 1.5 sec. The timer value should be selected to be adaptive upon the velocity of the user. Future work will take into account high speed movement of the UE and study the packet loss rate during ping-pong type of movement.

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