Reducing Ping-Pong Handover Effects In Intra E-UTRA Networks

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Abstract— The ping-pong Handover (HO) in LTE is one of the most crucial problems which decrease the performance of the Handover. The impact of ping-pong HO on inter eNB handover in LTE networks is investigated. An object of the present work is to provide a mean for reducing the probability of ping-pong HOs in intra E-UTRA networks. A novel HO algorithm, based on keeping the old path between the source eNB and SGW/MME during the ping-pong movement and delaying the completion HO part, is presented. Simulation results of the proposed algorithm using TRIAS tool -supported with NS2 simulator- showed that the rate of ping-pong handover can be reduced and, consequently, the handover quality indicator increased. Results suggest that 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.

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

I. INTRODUCTION

Long Term Evolution (LTE) has developed 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. In LTE system, an Orthogonal Frequency Division Multiple Access (OFDMA) and a Single Carrier Frequency Division Multiple Access (SC-FDMA) are implemented 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. Radio control functions such as radio resource managements and admission control are applied 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 connected 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 a very crucial functionality of a mobile system, and it needs to be designed according to the distributed nature of the LTE architecture- comparing to 3G mobile sytems-. E-UTRA mobility is the most fundamental, vital, and frequent scenario in LTE. E-UTRA should support good mobility even when the radio environment changes suddenly, e.g., when the UE enters a tunnel or in a picocell scenario. The operator should provide a special mechanism to cope with such sudden changes in the radio environment such as ping-pong and minimize its side effects.

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. 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. There is a significant need for a mechanism that improves the HO performance during the ping-pong type of movement is required.

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Different research approaches tried to reduce the Ping-Pong effects in current mobile networks such as GSM and CDMA [4-8]. Limited information is available about the ping-pong HO in LTE networks[9-11].These approaches vary from statistical analysis [12, 13] up to handover preparation based on cross-layer optimization [14,15]and complex pattern detection algorithms [16]. However, the 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-. The ping-pong HOs in LTE networks have not been addressed as a main issue in the current research so far, and 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 present the effects of ping-pong on E-UTRA HO and will implement a new algorithm that can decrease the side effects. Inter LTE ping-pong HO is not considered in this work but it will be main part of our future work.

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. Simulation 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.

II. 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.

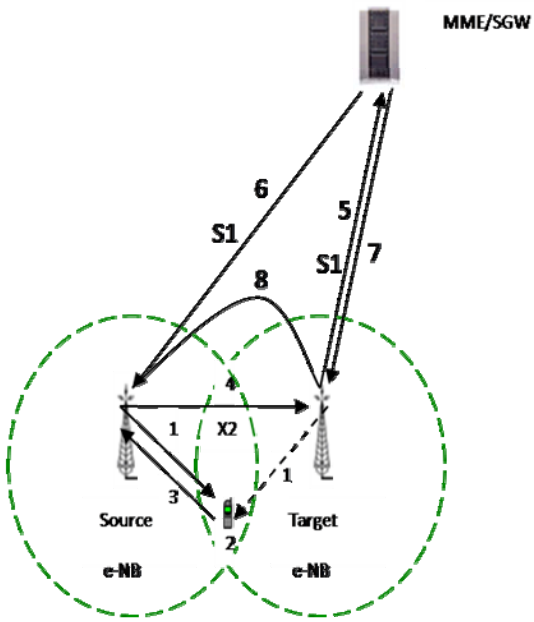

Figure 1: Summary of the different steps of preparation, execution and completion HO process which performs by eNBs. 1) Downlink HO measurements, 2) processing of downlink measurements, 3) uplink reporting, 4) HO preparation and execution via x2 interface, 5) path switch request, 6) release the old path, 7) Path switch acknowledgement, 8) Release resources [1 3].

III. 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. As soon as the received Signal Strength (SS) form the target eNB (SS-target) is stronger than the received one from the source (SS-source), then the HO preparation and execution part may be performed by both the source and the target eNBs. At the same time the timer can be set.

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).

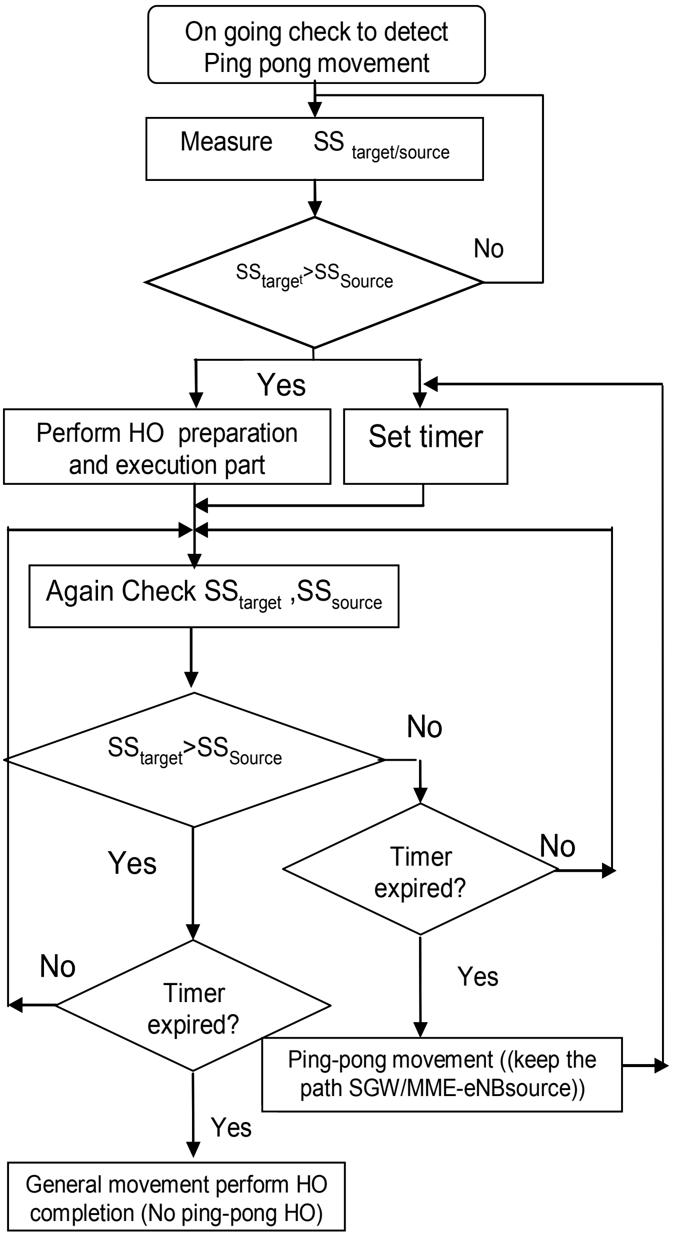

Fig.2 proposed procedure for ping-pong avoidance In Intra E-UTRA(Evolved Universal Terrestrial Access) networks

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 (Blue 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. It is good to say that in the completion phase the old S1 path is released and S2 interface is in use (New eNode will totally be responsible to serve the UE).

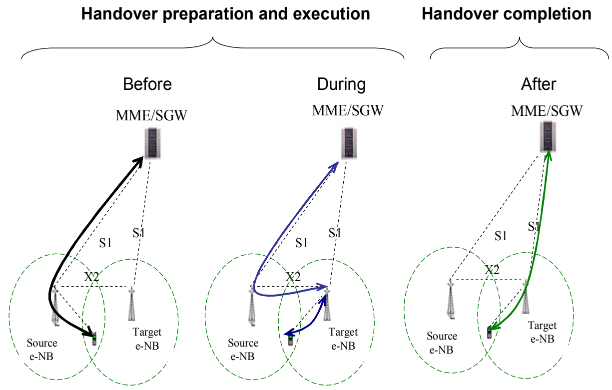

Figure 3 shows the phases of the proposed algorithm

IV. 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:

$$á =[2*R]/[V*Tm] \qquad (1)$$

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 as an indicator to evaluate the performance of the proposed algorithm which are selected to be the dropped calls rate and the ping-pong handover rate. We use TRIAS supported with NS2 simulator 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 data base also to work with NS2 simulator. The simulations have been accomplished in a big campus with 7 eNB (21 sectors), the main simulation parameters' value are listed in Table 1.

It is good to mention that we have used a fixed mobility for the UE and we have selected it 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 1500 meters by 1500 meters with the varying densities; other parameters assumptions used in our simulation are concluded below in table 1.

Handover measurement period is chosen to be 150 ms, and the timer value is selected to be 0.5, 1, 5 and 10 seconds respectively.

Parameters settings

Inter site distance 500 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 100 (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
Traffic model full buffer
eNode-B antenna gain 14 dBi
UE noise equal to 9 dB (-124 dBm/sub-carrier)
Number of admitted calls simulated 1000

Table 1: Simulation settings and Assumptions

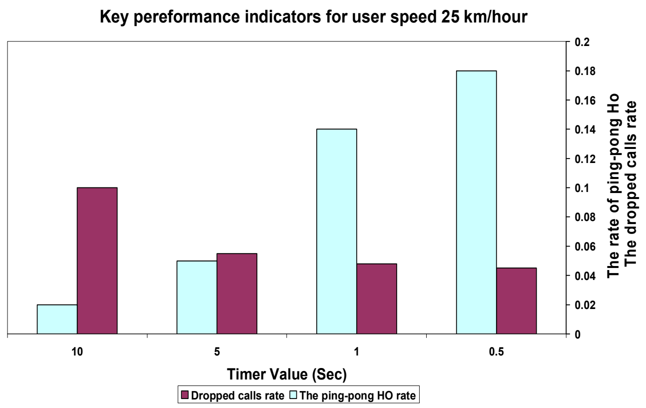

Figure 4 shows the dropped calls rate and the ping-pong handover rate in case of the speed of the UE equal to 25 km/hour.

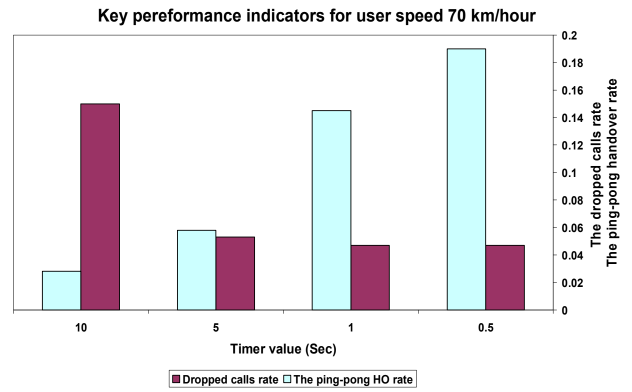

Figure 5 shows the dropped calls rate and the ping-pong handover rate in case of the speed of the UE equal to 25 km/hour.

As it appears from the graph 4, the probability of ping-pong HO is less than 2% for the timer value T=10 seconds. However, the dropped calls rate increases to 10%. Simulation results shows that the timer value should be selected carefully and should be set to reduce the of probability ping-pong HO and at the same time keep the dropped calls at the lowest levels. For timer value T=5 sec the probability of dropped calls and the ping-pong HO reached a good level approximately 5 %. In this case there is a reduction of the probability of ping-pong HO from 14% to 5 % when the timer value is increased from 1 sec to 5 sec. The probability of ping-pong HO can be reduced significantly if the timer value is higher than 1 sec. Results in graph 5 – when the user speed is 70 kmph- also indicate that the ping-pong avoidance algorithm could significantly minimize the probability of ping-pong HO to the lowest standard, also the optimal value for the dropped call rates and the probability of ping-pong HOs indicates to be 5 sec.

V. 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 performance 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 value was 5 seconds. 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 5 sec. 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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