Reducing Ping - Pong Effect based on Keeping the Old Path between the Source Base Station and Serving Gateway in Cellular Networks

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Abstract **— Handoff management is the signal transmission from one base station to adjacent base station as the user moves around. Ping - Pong effect is the crucial problem which decreases the performance of the Handoff. In this paper, the mean for reducing the probability of Ping-Pong handoffs is proposed. A novel handoff algorithm is proposed, based on keeping the old path between the source and Serving Gate Way (SGW) during the Ping - Pong movement. Using the network simulator NS2, simulation results of the proposed algorithm shows that the rate of Ping - Pong handover can be reduced and, consequently, the handover quality indicator can be increased. Simulation results suggest that optimal timer value should be chosen carefully to reduce the probability of Ping - Pong handover and keep the dropped calls rate at the lowest level.**

Keywords — Ping - Pong; Signal Strength; Handoff; Serving Gateway.

I. INTRODUCTION

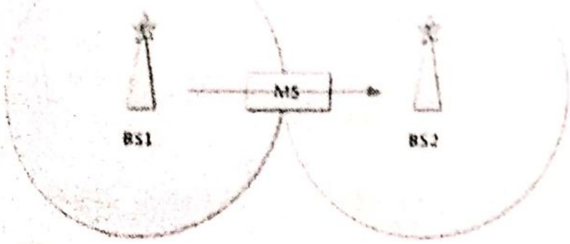

Figure 1: Handoff in Mobile Cellular Communications

The most important feature of wireless cellular communication system is mobility management. Within a call's duration when a mobile user or mobile station (MS) moves from one cell to another, the call should be transferred to the new cell's base station (BS). As the MS recedes, the link with the current BS becomes too weak so the call will be dropped. This type of ability of transference in a mobile cellular system is known as handoff (HO). Figure 1 shows HO

As the user transferred to the new cell's BS within the hard HO, the link to the prior BS is terminated. This means that a MS cannot be linked to more than one BS at a time. HO preparation may begin when the received signal strength (RSS) - target is greater than RSS – source.

There are two types of handoffs: hard and soft.

The signal strength measures are really signal levels averaged over a chosen amount of time [1]. This averaging is necessary because of the Rayleigh fading nature of the environment in which the cellular network resides. A major problem with this approach to handoff decision is that the received signals of both base stations often fluctuate. When the mobile is between the base stations, the effect is to cause the mobile to wildly switch links with either base station. The base stations bounce the link with the mobile back and forth. Hence the phenomenon is called Ping - Ponging. It has been shown in early studies that much of the time the previous link was well adequate and that handoffs occurred unnecessarily [1].

Usually handoff or handover (HO) from one cell to another cell supports seamless service [2]. Handoff is the process of changing the channel (frequency, time slot, spreading code or combination of them) associated with the current connection while a call is in progress. In a mobile system, Ping - Pong HO is a very common phenomenon which causes inefficiency, call dropping and degrading of the network performance. The Ping - Pong HO is occurred due to the coverage parameters, user location area and its movement and speed. The Ping - Pong HO occurs two subsequent HOs between the source and the target base stations (BS) and vice - versa. It occurs due to the repeated movement of mobile station (MS) between the source and the target BSs, or high signal fluctuation at the common boundary of the BSs.

II. Problem Statement

The next generation wireless networks, the handoff management technique faces several issues [21] such as signaling overhead due to the Ping - Pong HO, minimum power requirement for processing handoff messages, minimum guarantee of QoS, inefficient network resources, scalable, reliable and robust HO mechanism. To overcome these issues, a new algorithm is proposed to reduce the rate of Pong HOs, dropped calls and blocked calls.

III. Importance and Aims of Research

Since the Ping - Pong HO disperses the resources between releasing and reserving, and as a result decreasing the quality of service (QoS), it is essential for network operators to reduce this undesirable effect [3].

Since Ping - Pong HO is an open issue, there is an important need of technology is required to improve the HO performance during the Ping – Pong type of movement. Several research studies tried to reduce the Ping - Pong effects in current mobile networks such as GSM and CDMA [4-8]. In the literature study, a number of research papers have revealed the concerning problems related to the handover.

Approaches in literature vary from statistical analysis [8, 9] up to handover preparation based on cross - layer optimization [11, 12] and complex pattern detection algorithms [13]. Previous handover studies have revealed the techniques to improve the handover techniques and reduce the Ping - Pong effect. In [14], the method for determining the efficiency of a handover algorithm and its initiation control are given. In [15], decision to initiate a handover is an important component in the process because the success and efficiency of the handover depends on the accuracy and timeliness of the decision. In [16], the effects of hysteresis and threshold criteria on handover rate, delay, and link drops are studies in a GSM network. In [17], the study is based on a simplified model with two neighboring cells and a mobile move in a straight line from one cell to the other. A new handover algorithm and procedure are studied in [18], and the parameters affecting handover initiation are identified.

A novel algorithm is presented in this study that is able to perform successful handover without Hysteresis. This new algorithm focuses on reducing the number of Ping-Pong HOs and at the same time keeping the old path between the base station and Serving Gate Way (SGW).

Normal movement and Ping - Pong type movements are not distinguished by the earlier mobility techniques. In this new technique that selects the movement which may be Ping -Pong or general via setting a timer as a first step. In the next step, the new algorithm is suggested for delaying the completion of HO procedure and keeping the old path between source BS and SGW for the Ping - Pong type of movement. In the proposed algorithm, efforts are made to initiate the HO procedure and RSS as the value which is bigger than that from the source. And also, until the timer value is expired, HO procedure will not perform. In this work, efforts are made to develop an algorithm that decreases the Ping - Pong effect.

In the proposed work, attempt is done to reduce the number of Ping - Pong HOs, primarily concentrate to maintain the connection and avoid increasing dropped calls. This is happening to guarantee the seamless connection while the user is moving.

IV. Research Methods and Tools

This novel HO algorithm is based on keeping the old path between source BS and SGW during the Ping - Pong movement and delaying the completion handover part. This algorithm detects the MS movement and check whether the movement is general type or the Ping - Pong type. This algorithm is made using NS2 simulator. The rate of Ping - Pong HO and the handover quality indicator will be considered as a pointer to check the general performance of the algorithm.

A. Handover Preparation and Execution

When the MS moves to the cell boundary it sends a measurement report to the source BS, which decides to handoff the MS based on the measurement report and Radio Resource Management (RRM) information. The source BS informs a HO request message to the target BS by passing the information about the preparation of HO at the target BS. Then target BS prepares HO and sends the acknowledgement of HO request to the source BS. The source BS generates the HO command with the necessary parameters and forwards to MS. After receiving the command from source BS, MS performs synchronization to target BS. Then MS accesses the target cell and sends the confirmation message about the completion of HO procedure (preparation and execution) to the target BS.

B. Handover Completion

Figure 2 shows that after getting the confirmation message from MS, the target BS sends the path switch message to SGW to inform that the MS has changed its cell. The SGW switches the downlink data path to the target BS and then releases any User plane (U - plane) resources to the source BS. The target BS sends the release resource message to the source BS which can release radio and control plane (C - plane) related resources associated to the MS context.

By the end of this step the HO is totally completed and the target BS can start sending the packets received on the new direct (SGW - target BS). However, the target BS should first deliver all forwarded packets to the MS from X2 interface before delivering any packets from S1 interface (SGW - target BS).

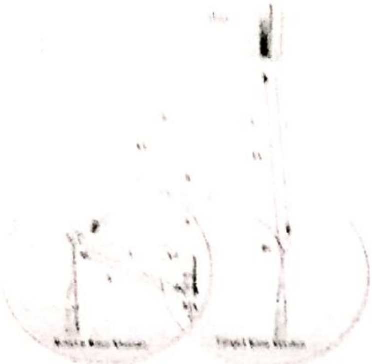

Figure 2: Different steps of preparation, execution and completion HO process which performs by source and target BSs.

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

V. Ping Pong Detection Algorithm for Handover

In this algorithm (Figure 3), the timer will act as a guide to select whether the ongoing HO is general or Ping - Pong type movement. If the received signal strength (RSS) from the target (RSS - target) is stronger than the received signal form the source (RSS - source), then the timer can be initialized and HO preparation and execution procedures of both source and target BSs. Since the RSS - target is sufficiently strong than the RSS - source, the timer is expired then the movement is general (no Ping - Pong movement). In this case the operator can immediately release all resources along the old path (SGW - source BS) and finish the HO completion.

But, if RSS - target is sufficiently stronger than the RSS -source then the movement is Ping - Pong type. In this case, the operator keeps the old path (SGW - source BS) during the Ping - Pong duration and delays the HO completion to avoid between releasing and initiating of the paths between SGW and BSs.

The proposed algorithm tries to initiate the HO procedure when the RSS - source is stronger than RSS - target but completion of HO will not perform until the timer is expired. As can be seen in the figure 4, the proposed system has 2 phases, one for HO preparation and execution which means that the new connection between MS and target is made by keeping the old path through S1 interfaces is still in use (dark line in figure 4).

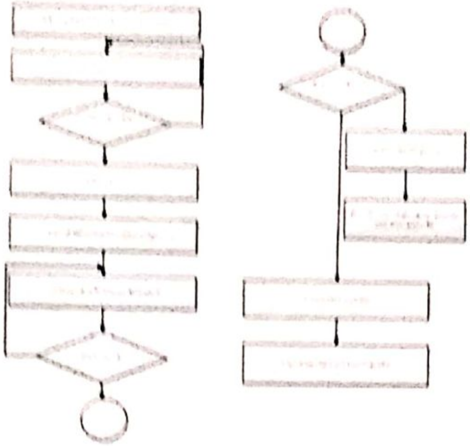

Figure 3: The Ping-Pong detection algorithm to reduce the number of Ping-Pong HOs

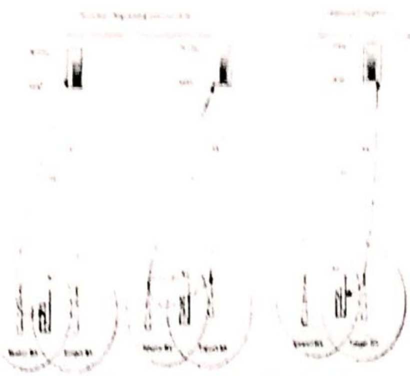

Figure 4: Phases of the Proposed Algorithm

VI. Analysis of The Proposed Algorithm

According to the difference between the received signal strength from the target (SS - target) and the received signal strength from the source (SS-source), HO decision is taken.

In [20], the mean signal strength has long - dependence of the distance (d target/source) between BS (target/source) and the MS the received signal strength from the target (SS-target) can be calculated as:

$$S(t)_{(Rec-target)} = K_1 - K_2 Log(d_{target}) + u_{(Rec-target)}(t) \quad (1)$$

Whereas, the received signal strength from the source (SS-source) can be calculated as:

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

where (K1, K'1) and (K'2, K2) depend on the transmitted power, antenna features in the Base and the transmission environments.

The rate of Ping-Pong HOs is defined as the number of Ping - Pong HOs per total number of HOs.

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

where $N_{(Ping-Pong)_{HO}}$ and $N_{HO_{total}}$ are the number of Ping-Pong HOs and the total number of HOs. respectively.

HO indicator should be defined for measuring the HO quality indicator is defined. [17] The parameters are used to evaluate the tested algorithm are HO rate, block and drop rates and delay of HO.

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

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

VII. Results and Discussion

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 calculated as:

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

From the equation (5), it can be inferred that by decreasing the number of Ping-Pong HO and decreasing the number dropped and blocked calls, the HO quality indicator can be improved. The above equation shows that the proposed algorithm reduces the Ping - Pong HOs rate and increases the HO quality indicator.

VIII. System and Simulation Model

In [18,19], user mobility parameter is defined as:

$$\acute{a} = [2 * R]/[V * T_m] \quad (6)$$

where V the uniform velocity the user is assumed to travel in the cell with the radius R during the call duration Tm.

In this work, two key performance indicators are used to evaluate the proposed algorithm which is dropped call rate and Ping - Pong HO rate. NS2 simulator has been used to evaluate the performance of the proposed algorithm. It is a very powerful tool to simulate the mobile network. Here the selected mobility of the MS to be 25 km/hour (low mobility) and 70 km/hour (medium mobility).

The simulation methodology is applied to choose the best HOs criteria. The results of the performances of different handover settings for this algorithm are evaluated by all different timer values for different user velocities in two scenarios like 25km/hour (low speed) and 70km/hour (medium speed).

Scenario 1: Low Speed Mobility (25 Km/Hour)

In this low speed scenario, the timer value is chosen as 0.3, 0.5, 1, 1.5, 2 and 4 seconds, respectively and the velocity of the MS is limited to be 25 km/hour. The proposed model gives the results as shown in the figure 5. The figure shows that in this simulation for the timer value 1.5, the probability of dropped calls has lowest value which is this main priority. At the same time the HO rate is decreasing while the timer value increases.

For the user speed 25 km/hour, the optimal timer value can be chosen as 1.5 sec. at which the probability of the dropped calls remains low and probability of Ping-Pong HO decreased efficiently. Timer value bigger than 1.5 sec should not be taken because the probability of the dropped calls increases, and the intern makes the chosen parameters are not appropriate to be used at timer value bigger than 1.5 seconds. So that in the simulation the optimal timer value can be chosen as 1.5 sec which gives lowest dropped calls rate and Ping - Pong HO rate.

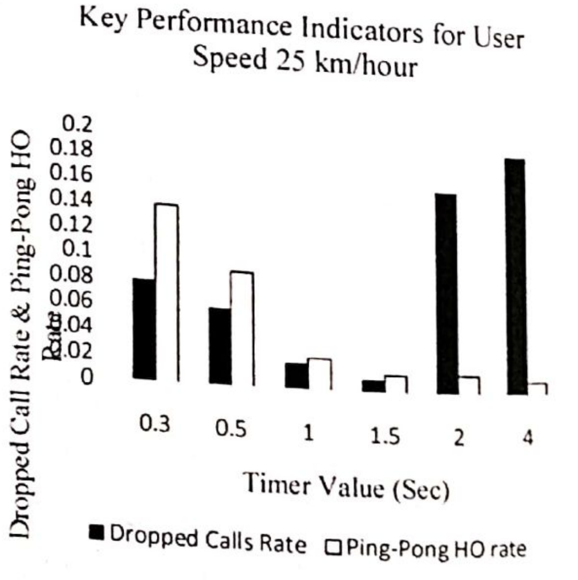

Figure 5: Dropped call rate and Ping-Pong Handover rate in case of the speed of MS equal to 25 Km/h

Scenario 2: Medium Speed Mobility (70 KM / HOUR)

In this medium speed scenario, the timer values are selected as 0.3, 0.5, 1, 1.5, 2 and 4 seconds, respectively and the velocity of the MS is changed from 25 km/hour to 70 km/hour. The proposed model gives the results shown in the figure 6. For the user speed 70 km/hour, the optimal value of timer is chosen as 4 sec; the probability of the Ping - Pong HO is very low but dropped calls rate is very high. But the timer value should be considered as 1 sec at which the probability of Ping-Pong HO rate and dropped calls rate are decreased. So that in this simulation the optimal timer value can be chosen as 1.5 sec which gives lowest dropped calls rate and which gives lowest dropped calls rate and Ping-Pong HO rate.

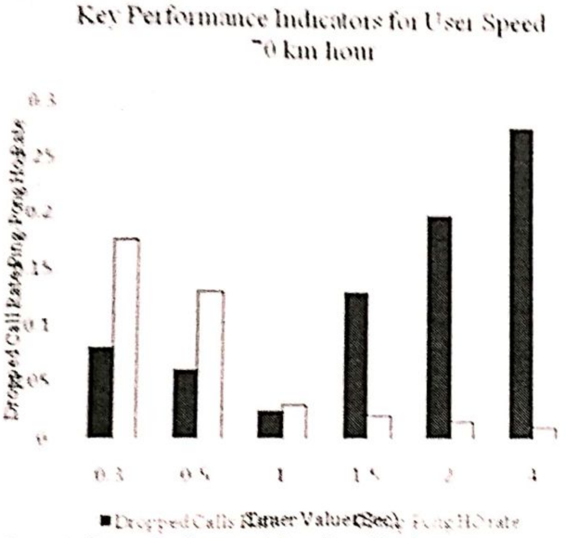

Figure 6. Dropped call rate and Ping-Pong Handover rate in case of the speed of MS equal to 70 Km/h

From the results given in figure 5 and 6, the proposed algorithm could significantly minimize the probability of Ping - Pong 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. Minimum probability of the Ping - Pong HOs and low level dropped calls rate lead to increase the handover quality indicator which improves the quality and the reliability of the connection and that recommends the equation 5.To get the optimal values of the handover procedures, the timer value can be chosen from 1 sec to 1.5 sec.

IX. Conclusion

The proposed algorithm distinguishes between the general and Ping - Pong type movement. In a Ping - Pong type movement, only the completion part of the HO procedure can be delayed to avoid the swinging between releasing and initiating the paths between the SGW and base stations. Evaluation of the algorithm shows that Ping - Pong HO movement can be reduced by keeping the old path between SGW and base stations. This model also shows that the timer value play significant role in reducing the probability of Ping -Pong HOs, however the higher timer value can cause dropped calls. So the optimal timer value can be chosen carefully to determine the best value to the timer value.

Current technology does not support a systematic and unbiased solution for the operators to perform a distinct Ping-Pong HO from the general HO procedure. But the proposed algorithm distinguish between the general and Ping - Pong type movement. As a future enhancement the setting of threshold and timer together should be concentrated for reducing the higher rate of dropped calls, blocked calls and Ping-Pong HOs efficiently.

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