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VARIOUS HANDOVER MANAGEMENT TECHNIQUES IN GSM CELLULAR SYSTEM

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Abstract: Handover mechanism is very important in cellular network because of the cellular architecture employed to maximize spectrum utilization. Handover is the procedure that transfers an ongoing call from one cell to another cell as the user's moves through the coverage area of cellular system. One way to improve the cellular network performance is to use efficient handover prioritization schemes when user is switching between the cells. In this paper several different techniques to manage the handover in wireless networks are discussed. Some advance schemes namely, guard channels, call admission control and handover queuing are also given. All these of prioritizations schemes have a common characteristic reducing the call dropping probability at the expense of increased call blocking probability. At last fuzzy logic based handover procedure is discussed to enhance the QoS in GSM cellular system and to reduce the handover number.

I. INTRODUCTION

Due to rapid change in technology the demand for better and faster cellular communication also increases. This growth in field of cellular communication has led to increase research and development toward cellular system. The main reason of this growth is newly concept of mobile terminal and user mobility. The main characteristics of cellular communication system are to offer the user maximum freedom of moment while using cell phones (mobiles). A cellular network is made up of number of radio cells. Each cell is allocated a band of frequencies and is served by a base station. Adjacent cells are assigned different frequencies to avoid interference. As more customers use the cellular network with single base station, traffic may be build up so there are not enough frequency bands assigned to a cell to handle its calls. One solution of this problem is frequency reuse concept. The obstruction in cellular network involves the problem when a mobile user travels from one cell to another during a call. As adjacent cell do not use the same radio channels, a call must be transferred from one radio channel to another when a user crosses the line between the adjacent cells. The process of handover takes place that transfer an ongoing call from one cell to another cell as the user (MS) moves through the coverage area of a cellular network. In handover process cellular network automatically transfer a call from one radio channel to another radio channel while maintaining quality of services (QoS) of a call. Each handover require network resources to route the call to next base station. If handover does not occur at right time the QoS may be drop below an adequate level and connection will be lost.

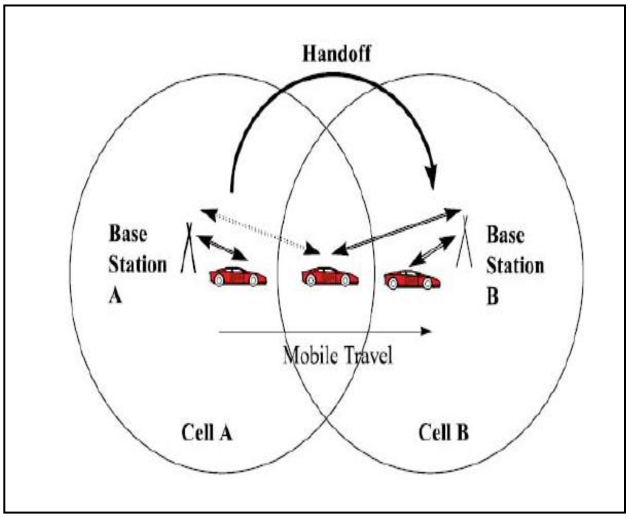

Fig.1. Handover

The main goal of this research is to investigate the several schemes which can handle handovers traffic in order to support on-going calls when mobile users are switching between base stations. In this research we will also study different handover mechanisms that reduce the resources utilizations of the GSM network while reducing the dropping possibilities of the user calls.

A. GSM (Global System for Mobile Communications)

GSM is a second generation digital cellular system. Digital transmission was used rather than analog transmission in order to improve transmission quality, system capacity, and coverage area. GSM works basically on three frequencies 900 MHz, 1800 MHz and 1900 MHz. To make efficient use of frequency bands GSM networks uses combination of FDMA (frequency division multiple access) and TDMA (time division multiple access). The general architecture of GSM network is shown in figure 2. The GSM system consist of several functional elements including mobile switching centers (MSC), base stations (BSC) with associated base transceivers (BTS), an operation and maintenance centre (OMC) and gateway MSC.GSM mobile terminal or mobile stations communicates across the Um interface, known as the air interface, with a base BTS in the small cell in which the mobile unit is located. This communication with a BTS takes place through the radio channels. The network coverage area is divided into small regions called cells. Multiple cells are grouped together form a locations area (LA) for the mobility management.

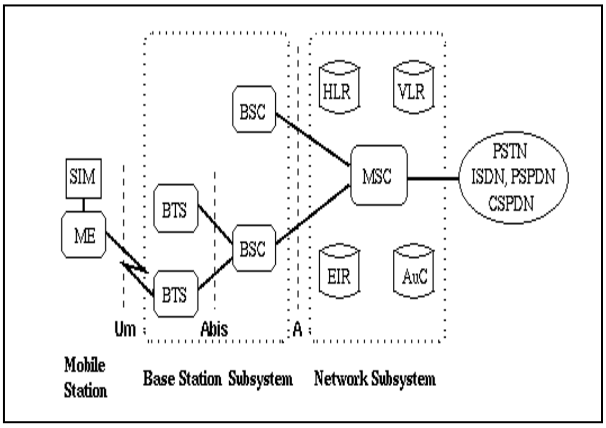

Fig .2. GSM Network Architecture

BSC are connected are connected to MSC through dedicated line or radio communication link. The BSC reserves radio frequencies, manages the handover of mobile station from one cell to another within the BSS (base station subsystem). MSC interface to the PSTN (public switched telephone network) is called the gateway MSC. MSC incorporate functions including home location register (HLR), visitor location register (VLR), authentication register (AuC) and equipment identity register (EIR) . The HLR and VLR together with MSC provide the call routing and roaming capabilities of GSM. The HLR stores information both permanent and temporary about each of the mobile station that belongs to it. The VLR register maintains information about mobile station that is currently physically in the region covered by MSC. VLR becomes important when user leaves the area served by his home MSC. The two registers are used for authentication and security purpose. The EIR is a database that contains a list of all valid mobile equipment on the network, where each mobile station is identified by its international mobile equipment identity (IMEI). It helps in security and prevents uses of network by mobile station that have been approved. The (AuC) holds the authentication and encryptions keys that are stored in each user SIM card for authentication and encryption over radio channel.

B. Requirements for GSM handover

The process of handover or handoff within any cellular system is of great importance. It is a critical process, if performed incorrectly handover can result in the loss of the call. Dropped calls are particularly annoying to users and if the number of dropped calls rises, user's dissatisfaction increases and they are likely to change to another network. Accordingly GSM handover was an area to which particular attention was paid when developing the standard.

C. Types of GSM handover

Within the GSM system there are four types of handover that can be performed for GSM systems:

Intra-BTS handover: This form of GSM handover occurs if it is required to change the frequency being used by a mobile because of interference, or other reasons. In this form of GSM handover, the mobile remains attached to the same base station transceiver, but change the channel or slot.

Inter-BTS Intra BSC handover: This form of GSM handover or GSM handoff occurs when the mobile moves out of the coverage area of one BTS into the coverage area of another but controlled by the same BSC. In this case BSC is able to perform the handover and it assigns a new channel and slot to the mobile, before releasing the old BTS from communicating with the mobile.

Inter-BSC handover: When the mobile moves out of the range of cells controlled by one BSC, a more complex form of handover has to be performed, handing over the call not only from one BTS to another but also from one BSC to another. For this the handover is controlled by the MSC.

Inter-MSC handover: This form of handover occurs when changing between networks. The two MSCs are involved to control the handover.

II. GSM CALL HANDLING MECHANISM

There are various call handling mechanism exists. In this section we will discuss several techniques to manage the GSM handover. Several enhancement techniques are given that can improve the performance of GSM handover.

A. Conventional Handover Mechanism

In conventional handover mechanism both the mobile station and the BTS measures the radio signal strength. The mobile station transmits its measurements reports continuously to the BTS. If the BTS detects a decrease in radio signal strength under a minimal level it initiates a handover request .The BTS then informs the BSC about the request, which then verifies if it is possible to transfer the call into a new adjacent cell. BSC checks weather a free channel is available in the new adjacent cell or not. In this situation the BSC does not differentiate between the channel requests either for fresh call or handover. If a free channel is available in the new adjacent cell then handover request can be satisfied, and the mobile station switch to new cell. If there is no free channel in the adjacent cell then it increases the dropping probability of handover call. The drawback of this handover procedure is the fact that the handover request for channel is same as used for fresh calls. Conventional handover mechanism is very problematic from the user's quality of service perspective, since user can much prefer block a fresh call rather than to be dropped a call in the middle of conversation. There are several variation of signal strength based handover algorithm including Relative signal strength, relative signal strength with threshold, relative signal strength with hysteresis, and relative signal strength with hysteresis and threshold.

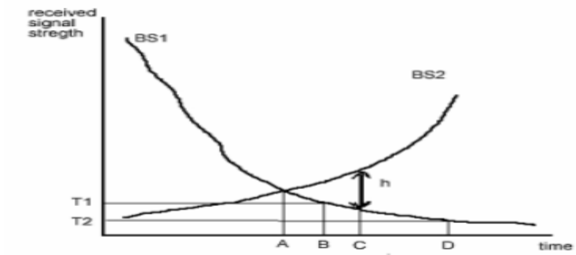

Fig.3 Movement of an MS in the handoff zone

1. Relative Signal Strength
In relative signal strength, the RSSs are measured over time and the BS with strongest signal is chosen to handoff. In Fig. 3, BS2's RSS exceeds RSS of BS1 at point A and handoff is requested. Due to signal fluctuations, several handoffs may be requested while BS1's RSS is still sufficient to serve the MS. These unnecessary handoffs are known as the ping-pong effect.

2. Relative Signal Strength with Threshold
Relative signal strength with threshold introduces a threshold value (T1 in Fig.3) to overcome the ping-pong effect. The handoff is initiated if BS1's RSS is lower than the threshold value and BS2's RSS is stronger than BS1's. The handoff request is issued at point B in Fig. 3.

3. Relative Signal Strength with Hysteresis
This technique uses a hysteresis value (h in Fig. 3) to initiate handoff. Handoff is requested when the BS2's RSS exceeds the BS1's RSS by the hysteresis value h (point C in fig 3.)

4. Relative Signal Strength with Hysteresis and Threshold
In this last technique the handoff is requested when BS1's RSS is below the threshold (T1 in Fig. 3) and BS2's RSS is stronger than BS1's by the hysteresis value h (point C in Fig.3). If we would choose a lower threshold than T1 (but higher than T2) than the handoff initiation would be somewhere at the right of point C. All the techniques discussed above initiate handoff before point D, which is the "receiver threshold". The receiver threshold is the minimum acceptable RSS for call continuation If the RSS drops below the receiver threshold, the ongoing call is than dropped.

B. Channel Carrying Handover Mechanism
The channel carrying mechanism allows a mobile station to carry its current channel from one cell to another cell when it moves across the boundaries of cell. Suppose N be the total number of channels available for use in cellular system. Two cells can use the same set of channel if they are apart by distance r. To avoid the co-channel interference a solution is proposed in which the distance of identical sets of channels is increased to r+1 instead of r. The distance r is the minimum reuse distance or reuse factor. Accordingly the total number of available channels in each cell is now reduced by amount of N/r+1 where N is the total number of available channels. Handover request are greatly favored over new calls compared to the Conventional handover mechanism. The main drawback of this handover procedure is that, it is not suitable for metropolitan environment due to the great amount of channels lost.

C. GSM Handover Prioritization Schemes
Different ideas and approaches are proposed to reduce the handover dropping probability. One approach is to reduce the handover failure rate is to prioritize handover call over new calls. Handover prioritization schemes have a significant impact on the call dropping probability and call blocking probability. Such scheme permits high utilization of bandwidth while guaranteeing the quality of service of handover calls. Basic method of handover prioritization schemes are guard channels (GC), call admission control (CAC) and handover queuing schemes. Sometimes these schemes are combined together to obtain better results.

1. Guard Channel Prioritization Scheme
In this scheme some of the total available channels in a cell are reserved for handoff calls only. Hence, less no of channels are available for originating call. This process increases the call blocking probability. However, Guard channel scheme provide better spectrum utilization under dynamic channel assignment strategies.

2. Call Admission Control Prioritization Scheme
The call admission control scheme refers to the task of deciding whether new call requests are admitted into the network or not. In the CAC the arrival of new call are estimated continuously and if they are higher than the predefined threshold level then some calls are restricted (blocked) irrespective of whether a channel is available or not to decrease the probability of handover calls. In the CAC both the new and handover calls have to access to all channels. If a new call that is generated in cell cannot find an idle channel the call is discarded immediately. There is no queue provided for the new calls to wait.

3. Handover Queuing Prioritization Schemes
Queuing handover call prioritization scheme queues the handover calls when all the channels are occupied in the BSC. When a channel is released in the BSC, it is assign to one of the handover call in the queue. The handover queuing scheme reduces the call dropping probability at the expense of the increased call blocking probability .In the handover queuing schemes when the received signal strength of the BSC in the current cell reaches to certain define threshold the call is queued from service a neighboring cell. A new call request is assigned a channel if the queue is empty and if there is at least of free channel in the BSC. The call remains queued until either a channel available in the new cell or the power by the base station in the current cell drops below the receiver threshold. If the call reaches the receiver threshold and no free channel if found then the call is terminated. Queuing handover is possible due to the overlap regions between the adjacent cells in which the mobile station can communicate with more than one base station. Queuing is effective only when the handover requests arrive in groups and traffic is low. First in first out (FIFO) scheme is the most common queuing scheme where the handover requests are ordered according to their arrival. To analyze this scheme it is necessary to consider the handover procedure in more detail.

D. Fuzzy logic for handover management
Fuzzy inference systems (FISs) are also known as fuzzy rule-based systems, fuzzy model, fuzzy expert system, and fuzzy associative memory. This is a major unit of a fuzzy logic system. The decision-making is an important part in the entire system. The FIS formulates suitable rules and based upon the rules the decision is made. This is mainly based on the concepts of the fuzzy set theory, fuzzy IF–THEN rules,

and fuzzy reasoning. FIS uses IF-THEN statements, and the connectors present in the rule statement are OR or AND to make the necessary decision rules. The basic FIS can take either fuzzy inputs or crisp inputs, but the outputs it produces are almost always fuzzy sets. Information can be represented by numbers or linguistic descriptions. Since humans usually think in terms of linguistic descriptions, giving these descriptions some mathematical form helps exploit human knowledge. As discussed above fuzzy logic is employed for decision making. Handover decision can also be performed by use of fuzzy inference system. The inputs to the system can be any of the parameter on which the handover decision depends. For example the linguistic variable signal strength, MS receive from the BTS, distance of MS from BTS, signal to interference ratio, velocity of the MS etc. These variables can be given input to the FIS. Fuzzy rule base is generated based upon human subjective knowledge. Finally the output of the system as a probability of handover occurring is evaluated. Lot of work has been done on the area of GSM handover decision by using fuzzy logic. As in [1] [2] [3] [4] author used the different combination of inputs to the fuzzifier. It has been shown that the handover number is reduced with proper lost calls number compare to other conventional methods. As handover is dependent on fading and other environmental factors, fuzzy logic give good results as it work with imprecise data.

III. CONCLUSION

In this paper several handover management techniques are given. Both the prioritized and the non-prioritized handover scheme are presented. All the handover prioritization schemes allocate channels to handovers more frequently than the new call to facilitate the users better QoS because new calls are less sensitive to delay than the handover calls. One of the simplest ways introduced in the above literature of giving priority to the handover calls is to reserve a number of channels exclusively for the handover in each cell to improve the performance of the cellular system. These schemes have the risk of underutilizing the frequency channels or insufficient spectrum utilization. Handover prioritization schemes decreases the call dropping probability at the expense of increase in call blocking probability. Furthermore fuzzy logic for handover decision procedure can be proved a better decision procedure. Handover number is reduced with proper lost calls number compare to other conventional methods. It also significantly reduces the cost associated with the false handoff initiation because it achieves lower false handoff initiation probability than existing handoff algorithms.

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