

HANDOVER MANAGEMENT IN GSM CELLULAR SYSTEM

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ABSTRACT

Handover mechanism is extremely 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 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 I have presented an analytical framework that can enhance considerably the handover call mechanism in wireless network. Some advance schemes namely, guard channels, and handover queuing are discussed. . All these of prioritizations schemes have a common characteristic reducing the call dropping probability at the expense of increased call blocking probability. Efficient prioritization scheme accommodates a number of new calls while guarantees the quality of service (QOS) of handover call.

Keywords - GSM, Handover management, soft handoff.

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 intensive research toward 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 offer user maximum freedom of moment while using cell phones (mobiles). A cellular network is made up of numbers of cells (or radio cells). Each cell is allocated a band of frequencies and served by base station consisting of transmitter, receiver and control unit. Adjacent cells are assigned different frequencies to avoid interference or cross talk. 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. An approach can be used to cope with this situation to use the same radio frequency can be reused in different area for a completely different transmission. The degree of reuse determined by how apart cells must be reuse the same frequency is depending upon the actual implementation of the radio link. The reuse of frequencies in different cells is a form of space division multiple access and it requires that location of each mobile agent to be known this is provided through a service known location management or mobility management. 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. 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. Handover mechanism is

extremely important in mobile network because of the cellular architecture employed to maximize spectrum utilization.

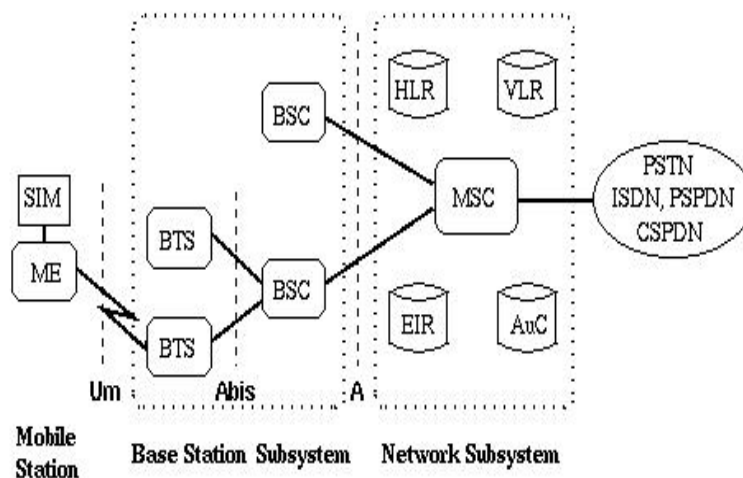
The main goal of this research is to investigate the GSM handover research issues and developing schemes which can handle handovers traffic in order to support on-going calls when mobile users are switching between base stations.

II 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 on three frequencies 900 MHz, 1800 MHz and 1900 MHz. To make efficient use of frequency bands GSM networks use combination of FDMA (frequency division multiple access) and TDMA (time division multiple access).

2.1 GSM Network Architecture

The general architecture of GSM network is given below. The GSM system consists 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 communicate 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 location area (LA) for the mobility management.



GSM Network Architecture

2.2 GSM Physical and Logical Channels

In GSM a number of logical channels multiplexed onto physical channels, which allows system to run multiple activates in parallel which does not require to use dedicated every slot transmission. Thus the logical channels improve the physical channels reuse capabilities to high level. Logical channels are linked on the physical channels so called laid over grid of physical channels. There are two types of channels.

2.2.1 BCH (Broadcast Channel)

Broadcast control channel is a downlink channel that is used by the BTS to broadcast information to mobile station and inform them about the incoming calls. It is required in initial to provide a time slot for a call. BCCH broadcast general information such power control parameters, access methods, network parameters etc required to set up calls. The three broadcast channels are defined. First broadcast channel is FCCH (Frequency Correction Channel), Second broadcast channel is SCH (Synchronization Channel) and Third is broadcast control channel (BCCH).

2.2.2 CCCH (Common Control Channel)

The common control channel is a combination of common control channels that is used between MSC and BSC before a dedicated control channel is allocated. There are three downlink paging, access grant and cell broadcast channels and one random access uplink channel. Paging channel (PCH) is activated for selective addressing of a mobile station during a connect request from the network. Random access channel (RACH) is transmitted by mobile station as uplink and to access the network and request channel capacity form the BSC to establish a connection. The access grant channel (AGCH) channel is transmitted by the BSC in response of random access from MSC. According to the call setup mechanism selected by network operator is allocated for call. Cell broadcast channel (CBCH) channel containing broadcast messages information about the traffic information etc.

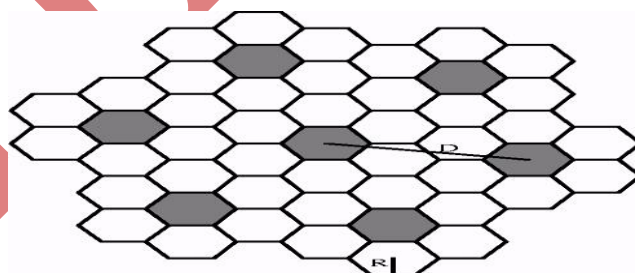


Fig: GSM Cellular Layout for Frequency Reuse

2.3 Frequency Reuse Distance and Cluster Size

A GSM cellular network is made of number of radio cells or cells served by fixed base station. These cells are used to cover different areas to provide radio coverage over wider area. These radio cells are combined into

clusters and each frequency is used once per cluster. The capacity in cellular network can be increased comes from the fact that the same radio frequency can be reused in different area for completely different transmission in a regular way. The reuse of frequencies enables a cellular system to handle huge number of calls with limited numbers of channels. GSM cellular layout typically involves the frequency reuse factor which is inversely proportional to K (where K is number of cell per cluster). The value of K is 7 for TDMA system. The co-channel interference is serious problem in this scheme while adjacent co-channel interference is not a big problem. Where R is the radius of the cell and D is the distance from the center of the cell to its neighbour using the same frequency. The minimum separation between two cells using the same frequency so that the two cells don't not interference with each other.

2.4 GSM Handover Procedure

Handover is the procedure that transfers an ongoing call from one cell to another as the user's moves through the coverage area of cellular system. The purpose of the handover procedure it to preserve ongoing calls when the mobile station moving from one cell to another.

2.4.1 GSM Handover Initiation

Handover initiation is the process of deciding when a request to a handover. Handover is based on received signal strength (RSS) from the current base station and the neighbouring base station. A mobile station is moving from one BTS (named BTS1) to another BTS (named BTS2). The RSS of BTS1 decreases as the mobile station moves away and increases as the mobile station get closer to the BTS2 as a result of the signal propagation. Movement of the MS between two Adjacent BTS for Potential Handover, Relative Signal Strength, Relative Signal, Strength with Threshold, Relative Signal Strength with Hysteresis, Relative Signal Strength with Hystersis and Threshold, Prediction Approaches.

2.4.2 GSM Handover Type

There are different categories of GSM handover which involves different parts of the GSM network. Changing cells within the same BTS is not complicated as the changing of the cell belonging to different MSC. There are mainly two reasons for this kind of handover. The mobile station moves out of the range station or the antenna of BTS respectively. Secondly the wire infrastructure the MSC or the BSC may decide that the traffic in one cell is too high and move some to other cells with lower load.

2.4.2.1 Intra-cell BTS Handover:

The terms intra-cell and intra BTS handover are used both for frequency change. There is a slight between them but usually they are considered the same. The term intra-cell handover in not real as it deals with the frequency change of a going call. The frequency change occur when the quality of the communication link degrading and the measurements of the neighbouring cells better than the current cell. In this situation the BSC which controls the BTS serving the MSC order th MSC and BTS to switch to another frequency which offers better communication link for the call. The communication link degradation is caused by the interference as the

neighbouring cell using the same frequencies and it's better to try another channel. In intra BTS handover cell involved are synchronized.

2.4.2.2 Intra-BSC Handover:

The intra-BSC handover is performed when the MSC changes the BTS but not the BSC. The intra BSC handover is entirely carried out by the BSC, but the MSC is notified when the handover has taken place. If the targeted cell is in different location area then the MSC needs to perform the location updates procedure after the call. In the intra-BSC handover both synchronized and non synchronized handover are possible. The figure X shows the intra-BSC situation.

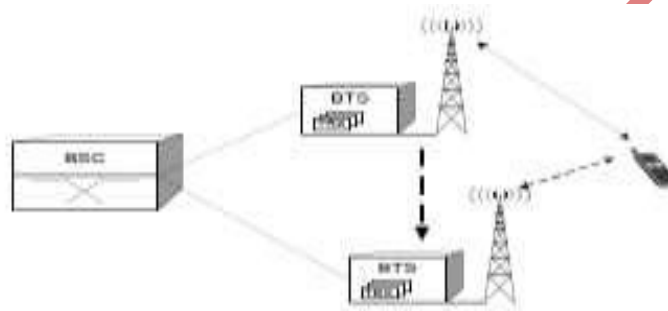


Fig: Intra-BSC Handover

2.4.2.3 Intra-MSC Handover:

In the intra-MSC handover when the BSC decides that handover is required but the targeted cell is controlled by different BSC then it needs assistance from the connected MSC. In comparison to the pervious handover discussed the MSC mandatory for this kind of handover. Responsibilities of the MSC do not include processing the measurements of the BTS or MSC but to conclude the handover. This kind of handover can be other intra-MSC or Inter-MSC. In the intra-MSC handover the targeted cell is allocate in different BSC connected by the same MSC. The MSC contacts the targeted BSC for allocation of the required resources and inform the BSC when they are ready. After the successful resources allocation the MSC instructed to access the new channel and the call is transferred to the new BSC.

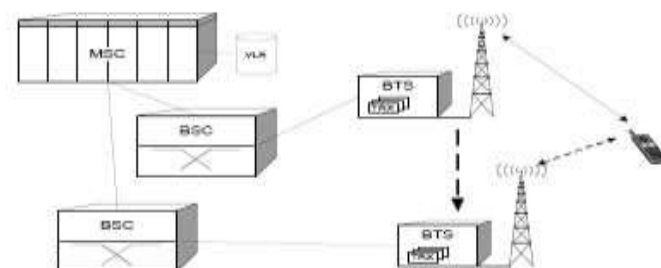


Fig: Intra-MSC Handover

2.4.2 Inter-MSD Handover:

The inter-MSD handover is performed when the two cells belonging to different MSD in the same system. In the inter-MSD handover the targeted cell is connected to different MSD (named as MSD-B) than the one currently serving the call MSD (named as MSD-A).

III GSM CALL HANDLING MECHANISM

In this section a couple of enhancements which can improve the performance of GSM handover algorithms are presented and studied.

3.1 Conventional Handover Mechanism

In GSM cellular network both the mobile station and the BTS regularly 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 under a minimal level I_{urge} , 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. Actually the BSC checks whether 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 cf. In conventional handover mechanism is very problematic from the users quality of service perspective, since user can much prefer block a fresh call rather than to be dropped a call in the middle of transmission.

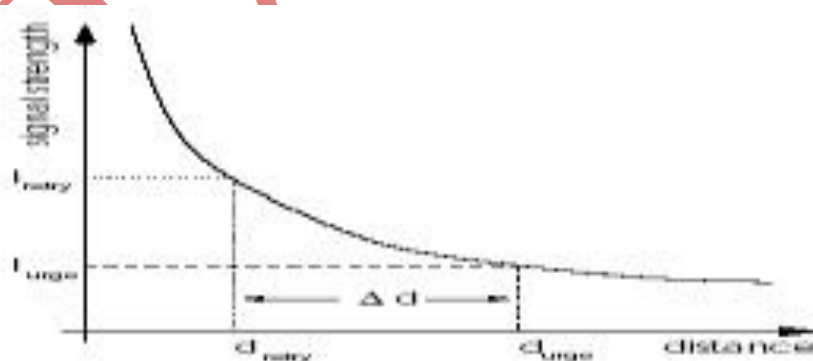


Fig: Signal Levels for Handover

3.2 Channel Carrying Handover Mechanism

The channel carrying mechanism allows a mobile station to carry its current channel from one cell to another when it moves across the boundaries under specific conditions. The channel carrying mechanism using a linear cellular system model in which cells or BTS are arranged in linear configuration with minimum reuse distance r . Suppose N be the total number of channels available for use in cellular system. Two cells can use the same set of channel as they are apart by distance r .

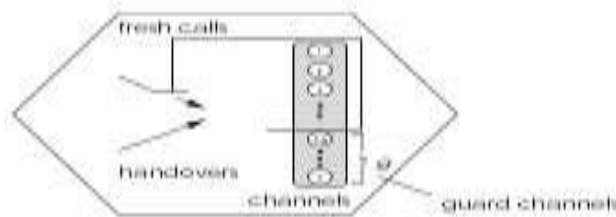


Fig: r and $(r+1)$ Channel Carrying

To avoid the co-channel interference an advance 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. According to the figure 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. In typical situation where the smaller the reuse distance the more amounts of channels is to be lost. The channel carrying mechanism does not require the complex power control or global channel coordination which simplifies its implementation.

3.3 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.

3.3.1 Guard Channel Prioritization Scheme

The guard channel scheme was introduced in 80s for mobile cellular systems. However the guard channel scheme are still used in telecommunications with the name of Cut-off Priority Schemes. GC scheme improving the probability of successful handover by simply reserving a number of channels exclusively for handover in each cell. The remaining channels can be shared equally between handover and new calls. GC are established only when the number of free channels is equal to or less than the predefined threshold g . In this situations fresh calls

are bypassed and only handover request are served by the cell until all channels are occupied. The GC scheme is feasible because new calls are less sensitive to delay than the handover calls.

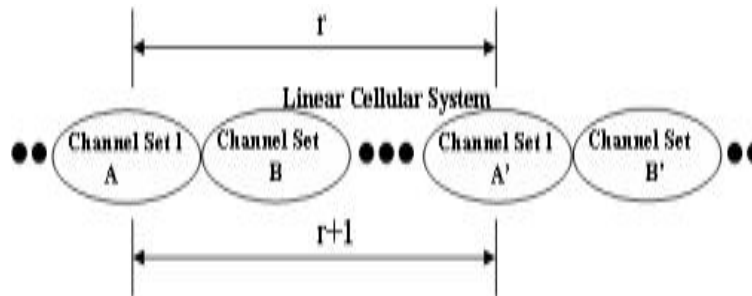


Fig: Guard Channels for Handover Request

According to GC scheme reserve channels for handover are $C-T$ where T is the predefined threshold. The GC will not accept any new call until the channel occupancy goes below the threshold. Therefore according to the cell occupancy by Markov chain it is straight forward to derive the steady state probability P_n that n channels are busy. Where,

$$P_n = \begin{cases} \left(\frac{\rho^n}{n!}\right) P_0, & 0 \leq n \leq T \\ \rho^T \left(\frac{\nu^{n-T}}{n!}\right) P_0, & T \leq n \leq C \end{cases}$$

$$P_0 = \left[\sum_{n=0}^T \frac{\rho^n}{n!} + \rho^T \sum_{n=T+1}^C \frac{\nu^{n-T}}{n!} \right]^{-1}$$

3.3.2 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. The CAC scheme can be classified into different schemes that consider the local information like (the amount of unused bandwidth in cell where the user currently resides), remote information (the amount of unused information bandwidth in the neighbouring cells) or local or remote information to determine whether to accept or reject a call. CAC based on knowledge of both network and user characteristics, keeps the track of available system capacity and accommodates new call request while ensuring quality of service for all existing users. Decisions in CAC are performed in each BSC in a distributed manner and there is no central coordination.

3.3.3 Handover Queuing Prioritization Schemes

Queuing handover call prioritization scheme queues the handover calls when all the channels are occupied in the BSC. When a handover call in the queue. The handover queuing scheme reduces the call dropping probability at the expense of the increased call blocking probability and decrease in the ratio of carried to admitted traffic since new call are not assign a channel until all the handover request in the queue are served . 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 neighbouring 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. This makes provision of the queuing the handover requests for certain time period equal to the time of the mobile host existence in the overlapping area. 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. By assuming the FIFO queuing strategy and infinite queue size at the base station is assumed.

Then the steady state probability is found as follow according to the Markov chain.

Where,

$$P(i) = \begin{cases} \frac{(\lambda_O + \lambda_H)^i}{i! \mu^i} P(0) & 0 \leq i \leq S_C \\ \frac{(\lambda_O + \lambda_H)^{S_C} \lambda_H^{i-S_C}}{i! \mu^i} P(0) & S_C < i \leq S \\ \frac{(\lambda_O + \lambda_H)^{S_C}}{S! \mu^S} \frac{\lambda_H^{i-S_C}}{\prod_{j=1}^{i-S} [S\mu + j(\mu_C + \mu_{h-dwell})]} P(0) & S < i \leq \infty \end{cases}$$

$$P(0) = \left\{ \sum_{i=0}^{S_C} \frac{(\lambda_O + \lambda_H)^i}{i! \mu^i} + \sum_{i=S_C+1}^S \frac{(\lambda_O + \lambda_H)^{S_C} \lambda_H^{i-S_C}}{i! \mu^i} + \sum_{i=S+1}^{\infty} \frac{(\lambda_O + \lambda_H)^{S_C}}{S! \mu^S} \frac{\lambda_H^{i-S_C}}{\prod_{j=1}^{i-S} [S\mu + j(\mu_C + \mu_{h-dwell})]} \right\}^{-1}$$

3.3.4 Cell Overlapping and Load Balancing Scheme (Proposed Scheme)

In order to improve the handover call prioritization scheme it is advisable to equalize the traffic load over the cells. Traffic reason and directed retry handover make use of this principal. First the new call to be served and if the receiver is able hear a neighbouring cell and are not considered in this situation. Traffic reason handover

can be used to transfer traffic from one cell to another neighbouring when they are closed to the congestion. The traffic reason handover idea is based on the neighbouring cell having an overlapping service area. The overlapping service area arises naturally in GSM cellular system especially in small-cell high capacity micro cellular configurations. The small-cells are capture by subdividing a congested cell each with his own base station. The call arising in the common area (overlapping) of cells have access to channels more than one base station. By appropriate control strategy a cell may select the base station to establish a connation and contribute to efficient spectrum management. By subdividing a congested cell into small- cell the frequency reuse distance is effectively increased which reduce the level of interference and increase the carrier the carrier to interference ratio at both side the mobile station and base station.

From the previous work it has been proved the directed retry an increase in the overlapping between cells leads to increases the quality of service of the cellular system. A large overlapping area gives more capacity than a smaller overlap, but even by just having a small overlap a significant gain is achieved. The overlap of $0.1R$ (where R is the radius of cell) results an overlapping area equal to 9% of the cell area gives a gain of at least 6% whereas if the overlap is equal to $0.5R$ means overlapping area is 75% of the cell area then the capacity gain is boost to 27%. The performance of this functionality is very dependent on the existing overlapping between cells since it is required that at least one neighbouring cell has sufficient signal level for the mobile station to be redirected.

According to the concept of cell radius when two or more adjacent cells overlap they form a set of individual regions which can be categorized into three types A, B, and C according to the number of cell they overlap. These regions can be assigned a channel from one of three cells. The importance of the regions and areas is to perform the channel allocation scheme based on either through the region or area. The number of channels for specific region depends on the size of the regions and specified channel can be used in that area. If we sum of the regions in one cell according to their overlap then they formed a cell area. The blocking probability of the cell can be calculated from those users who are able of choosing a channel from cells A, B, and C. This maintains the same lowest blocking probability and load balancing in every area.

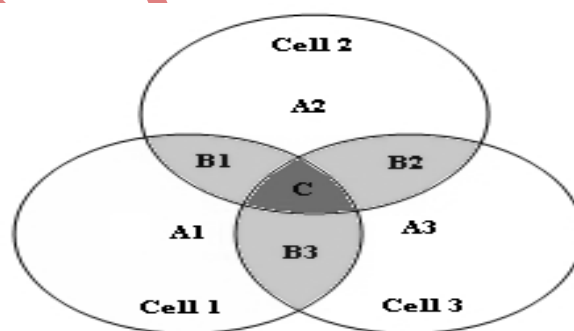


Fig: Areas A, B and C of three Cells

IV ANALYSIS

In this paper both the prioritized and the no prioritized handover scheme are presented. Moreover different prioritization schemes and their extensive classification are presented as well. All the handover prioritization schemes allocate channels to handovers more frequently than the new call to guarantee the users' perspective 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. The guard channel prioritization schemes are established only when the number of free channels is less or equal to predefined threshold. The value of the threshold directly affects the probability of the call blocking and call dropping. According to the cell channel occupancy by Markov chain it is straight forward to derive the steady state probability P_n that n channels are busy and then $P_b = \sum_{n=T+1}^N P_n$ and $p_f = P_c$. The equation $p_f = P_c$ shows that the handover failure probability is equal to the call completion probability.

In addition when a user moves into new cell, bandwidth is reserved in the new neighbouring cell and the reserved bandwidth in the cell which are no longer used to the new cell is released. However from the operation point of view there are several weaknesses in CAC scheme. First it seems difficult for CAC scheme to handle the user's request where the capacity is not enough to deal with all the requirements. In the situation the calls blocking and dropping probability increases which affects QoS of the wireless cellular network. But if the user has predefined priority then the CAC can distribute capacity according to each user so that the requirements of each with higher priority will be fulfilled prior to any other user. In such situation the CAC algorithms become more complicated and complex to meet with these requirements.

Several other strategies to allocate channel for the handover request in the queue discipline have been proposed. For example queuing of new call arrivals is possible and is less sensitive regarding the queuing time than the case of handover. Queuing of the new call request shows more improvement than queuing of handover calls. In this scheme new call will be accepted if the number of free channels apart of those reserved for handover is enough for the new request otherwise the call be placed in the queue. As soon as the channel is released by the completing a call or outgoing of the handover request then the new call is served immediately from the FIFO queue. The queuing of the new calls involves the concept of the guard channels and queuing schemes. The performance analysis of queuing new call shows; that the blocking of the handover call decreases with the queuing probability of the new calls and increased in the total carried traffic because new calls will be ultimately served. This scheme also achieves less force termination probability compared to other schemes.

V CONCLUSION

In this paper I introduce in greater depth the GSM network architecture and handover process which emphasizes the architecture, the several functional network elements and their dedicated channels associated with the call. Furthermore I have discussed the different performance metrics used to make the handover decision. Next I have presented the most important procedure of GSM handover initiation, handover types and their measurements

reports to ensure mobility in GSM network and to emphasize the fact that handover in GSM network are very important to maintain the quality of a call.

I also investigate the call handover prioritization schemes that prioritize handover calls in order to enhance the quality of service (QOS) of GSM wireless network. Extensive survey and analysis of the handover prioritization schemes that is guard channels, call admission control and handover queuing has been provided. Furthermore my research indicates that different system uses different schemes to execute the handover mechanism for a couple of enhancements to the handover mechanism are introduced and discussed. The idea of the cells overlap and load balancing scheme which tries to equalize the traffic over cells has been introduced. It has been analyzed theoretically and mathematically that capacity depends on the size of the overlapping area between adjacent cells, the numbers of channels per cells and distribution of traffic. The higher the overlapping area, the higher the trunking efficiency gains. The overlapping area can be used to reduce the call blocking and dropping probabilities. The attractive feature of this scheme is that it organizes traffic in distributed manner and doesn't increase the system complexity. At last I conclude that the implementation of mathematical formulas as mentioned in research will be great contribution in call handoff and for QOS's.

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