Handoff Strategies in Cellular System

[1]Nisha, [2]Sunil Kumar [3]Jyoti Bhatnagar,
[1,2]Department of Electronics and Communication Engg. DCRUST Murthal, Sonepat (Haryana)
[3]SB Institute of Engg. and Technology, Pundari, Kaithal (Haryana)
[1]nishha29@gmail.com, [2]kadyan_163@yahoo.co.in, [3]jbkrishna3@gmail.com

Abstract: Mobility is the most important feature of a wireless cellular communication system. This continuous service is achieved by Handoff (or Handover) from one cell to another cell. Handoff (also called Handover) is the mechanism that transfers an ongoing call from one cell to another cell as a user moves through the coverage area of a wireless cellular system. The main objective of handover is to maintain the ongoing calls. Many times it is initiated by crossing a cell boundary or by deterioration in quality of the signal in the current channel. Handovers are used to prevent an on going call to be disconnected. If handovers are not used then whenever a user leaves the area of a particular cell then its on going call is immediately disconnected. The handover process requires a number of parameters e.g. which handover scheme we are using, how many channels are free for call. In the handover process the QoS should be kept up to the standard. Handoff schemes which are poorly designed tend to generate very heavy signalling traffic and, therefore, there is a dramatic decrease in the quality of service (Qos). The reason for the critical handoffs in cellular communication systems is that in neighbouring cells always a disjoint subset of frequency bands is used, so negotiations must take place between the current serving base station (BS), the mobile station (MS) and the next potential BS.

Keywords: BSC, BS, HANDOFF, MSC, MS.

I INTRODUCTION

The basic concept of a cellular phone system is that it has a large number base stations covering a small coverage area known as cells, and as a result frequencies can be re-used. Mobility is provided by cell phone systems. So as a result, it is the very basic requirement of the system that as the mobile handset moves from one cell to another cell, it must be able to handover the call from the base station of the first cell, to that of the next cell with no interruption to the call. In satellite communications, it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service. In cellular telecommunications, handover or handoff refers to the process of transferring an on going call or data session from one channel connected to the core network to another.

A. HANDOFF PROCESS:

Handoff is a process of changing the channel (time slot, spreading code, frequency or combination of them) which are associated with the current connection while a call is in progress [1]. The handoff process is initiated by issuing of the handoff request. When the power received by the MS from BS of neighbouring cell exceeds the power received from the BS of the current cell by a certain amount, this is known as the handoff threshold and this is a fixed value. For successful handoff, handoff request must be grabted by a channel before the power received by the MS reaches the receiver's threshold. The area where the ratio of received power levels from the current and the target BS's is between the handoff and the receiver threshold [2]-[4], is called handoff area. Each handoff requires network resources to reroute the call to the new base station. Switching load can be minimized by minimizing the expected number of handoffs. Another concern is delay; the Quality of Service (QoS) may degrade below an acceptable level, if the handoff does not occur quickly. Minimizing the delay also minimizes the co-channel interference. During handoff, there is brief service interruption. The perceived QoS is reduced as the frequency of these interruptions increases. The chance of dropping a call due to factors such as the not availability of channels, increases with the number of handoff attempts. Handoff algorithms need to be enhanced, as the rate of handoff increases, so that the perceived QoS does not degrade and the cost to cellular infrastructure does not increase.

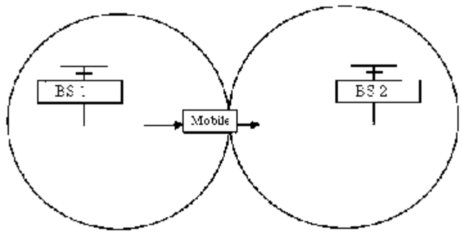

Fig.1 Handoff: a mobile moving from one cell to another

Handoff must be performed infrequently and successfully as possible and be imperceptible to the users. So to meet these requirements, a particular signal level is set standard, as the minimum usable for proper voice quality at the base station receiver, as a threshold, a slightly stronger signal level is used at which handoff is made.

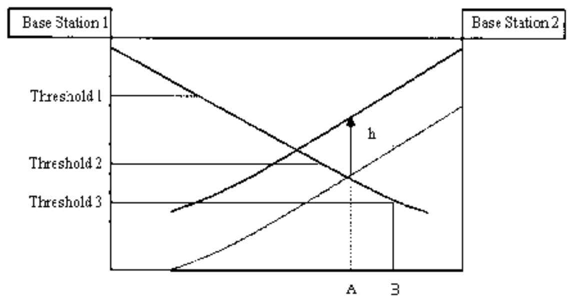

Fig.2: Handoff procedure

So the margin = $P_{r\ handoff} - P_{r\ minimum\ usable}$ must be kept as optimum as possible, because too large value of it can burden the MSC by unnecessary handoffs or too small value may be insufficient time to complete a handoff before call is lost due to weak signal conditions.

The handoff should take place at point A for the choice of Threshold 1 or Threshold 2. The handoff should take place at point B for Threshold 3 (see fig. 2). It has now been shown in practice that using the hysteresis margin greatly reduces the number of unneeded handoffs. However, there is a delay factor involved here. Optimum trade off values for the parameters threshold and hysteresis to obtain a tolerable delay may be set up.

B. HANDOFF GENERATIONS

i) Handoff in first generation:-

In first generation handoffs, the signal strength measurements are made by base stations and are supervised by MSC.

ii) Handoff in second generation:-

In second generation, handoff decision was mobile assisted. Every mobile station measures the received power from surrounding base stations and continually reports the results of the measurement for base station.

II REQUIREMENT, AIM and NECESSASITY of HANDOFF:

A. Handover of a call may be required in following situations:

a) When the received signal Strength is faded due to deep shadow (hole), then handover can be used to stop the drop-out of the call, if the received signal strength of the neighbouring cell is good.
b) The call has to be permanently handed over, when the mobile reaches a cell boundary.
c) In the systems which are based on channel rearrangement, when it is necessary to use a forced handover of an existing call to accommodate a new call or a handed over call.

B. Aim of a good handover strategy includes:

1. The number of drop-outs should be minimum,
2. The number of handovers should be minimum,
3. Quick switch over of the call without any disturbance to the call,
4. There should be minimum unnecessary handovers,
5. The effect on new call blocking should be minimum.

C. Why handoff is necessary:

In an analog system, once a call has been established, the set-up channel can not be used again during the period of the call. Therefore, handoff is always implemented on the voice channel. But in the digital systems, the value of implementing handoffs is dependent on the size of the cell and the handoff is carried out through paging or common control channel. For example, if the radius of the cell is 32 km (20 mi), the area is 3217 km^2(1256 mi^2). After a call is initiated in this area, there is a little chance that it will be dropped before the call is terminated as a result of a weak signal at the coverage boundary. Then why bother to implement the handoff feature? Even cell handoff may not be needed for a 16-km radius and if a call is dropped in a fringe area, the customer simply reconnects and redials the call. Now a day the size of cells becomes smaller in order to increase capacity. Also people talk longer, so the handoffs are very essential.

Handover must be performed fast and successfully, but there is a problem with faster handoff that we lose the benefits which are associated with signal averaging and hysteresis. This was helpful in removing unnecessary handoffs and ping pong condition. However, in microcellular systems, the time of handoff is critical and we may not tolerate the delay that comes with hysteresis windows. The handoff must be fast. The movement of the mobile station from one cell to another cell must be detected to initiate a handoff. Now, a reliable method to make this detection and to accommodate the movement of mobile station is to measure the received signal strengths from the user and to the base stations. In order to avoid the excessive and inaccurate handoffs, an averaging of the received signal levels is performed as well as hysteresis margin is also implemented. The total handoff delay is the sum of the hysteresis delay and signal averaging delay and seeks to make this delay small. [5] Develops an analytic approach to select the hysteresis delay and signal averaging time in order to obtain an optimum trade off between those two parameters as well as a trade off between the total delay time and the number of allowable unnecessary handoffs. Some important parameters are given mathematical expressions. The probability of an unnecessary handoff is given as:

$$P_u = \left[\int_{-\infty}^{\infty} f(x).\left(\frac{1}{2} erf\left(x - \frac{h-\Delta L}{\sigma}\right)\right) dx\right].\left[\int_{-\infty}^{\infty} f(x).\left(\frac{1}{2}\mathrm{erf}(x - h+\Delta L\sigma dx\right.\right.$$

Where f(x) is considered as:

$$\frac{1}{\sqrt{2\pi}}.e^{\frac{-x^2}{2}}$$

Where ΔL is the difference between the two received signal levels due to the path loss difference from the two base stations that are involved in the handoff and h is the hysteresis level.

The total delay time for macro cells is:

$$\delta_{hM} = \frac{T}{2} + K_{rv}.\frac{10^{\frac{h-\sigma}{k}} - 1}{10^{\frac{h-\sigma}{k}} + 1}$$

Where, T is the signal averaging window, K is the path loss constant and K_{rv} is the normalized distance from the mobile station to base station.

The total delay time for microcells is:

$$\delta_{hu} = \frac{T}{2} + T.\frac{h-\sigma}{4.dcor}$$

where, d_{cor} is the drop in signal level, experienced at a street corner and is determined experimentally.

This analysis shows that there exist compromises between the parameters of averaging time and hysteresis delay. It is also evident that for microcells we may wish to choose a larger hysteresis and short averaging time and the converse is clear for macro cells. The main thing here is that optimum parameter values may be selected for a tolerable delay in conjunction with some tolerable probability of unnecessary handoff.

III HANDOFF DECISIONS:

There are numerous methods for performing handoff, at least as many as the types of state information that have been defined for MSs, as well as the types of network entities which maintain the state information. The decision-making process of handoff may be centralized or decentralized (i.e., the handoff decision may be made at the MS or network). From the decision process point of view, there are three types of handoff decisions:

1) Network controlled handoff (MCHO)
2) Mobile assisted handoff (NCHO)
3) Network controlled handoff (MAHO)

1) Network-Controlled Handoff:

In a network-controlled handoff protocol, handoff decisions are based on the measurements of the MSs at a number of BSs and these decisions are made by the network. Information about the signal quality for all users is available at a single point in the network that facilitates appropriate resource allocation. In a network-controlled handover, connection rerouting is performed by the network and network collects statistics related to signal strength, traffic load, and other information to decide when to initiate a handover and which new BS is the target BS Network-controlled handoff is used in first-generation analog systems such as AMPS (advanced mobile phone system), TACS (total access communication system), and NMT.

2) Mobile-Assisted Handoff :

In a mobile-assisted handoff process, the network makes decisions and the MS makes measurements. In the circuit-switched GSM (global system mobile), the BS controller (BSC) is in charge of the radio interface management. This means allocation and release of radio channels and handoff management. The handoff time between handoff decision and execution in such a circuit-switched GSM is approximately 1 second. In a mobile-assisted handover, the MH monitors the signal strength and the presence of neighbouring BSs and conveys this information to the network controller. The network controller then uses this information to make handover decisions.

3) Mobile controlled handover:

In mobile-controlled handoff, each MS is completely in control of the handoff process and the MH is responsible for initiating a handover. This type of handoff has a short reaction time (on the order of 0.1 second). MS measures the signal Strength from surrounding BSs and interference levels on all channels. If the signal strength of the serving BS is lower than that of another BS by a certain threshold, then handoff can be initiated. It does this by evaluating the signal strength and traffic load conditions and detecting the presence of neighbouring BSs. When a MH decides to initiate a handover, it sends an explicit message to a mobility management node residing in the network.

IV TYPES OF HANDOFF:

Handoffs are broadly classified [6], [7] into two categories- hard and soft handoffs. They are also characterized by "make before break" and "break before make". In the soft handoff, during the handoff process, both existing and new resources are used but in hard handoff, current resources are released before new sources are used.

A. HARD HANDOFF-

A hard handoff is essentially a "break before make" connection. In hard handoff, the link to the prior base station is terminated before or as the user is transferred to the new cell's base station, this means that the mobile station is linked to no more than one base station at a given time. Under the control of the MSC, the BS hands off the MS's call to another cell and then drop the call. Hard handovers are intended to be instantaneous in order to minimize the disruption to the call. Initiation of the handoff may begin when the signal strength at the mobile received from base station 2 is greater than that of base station 1. The signal strength measures are really signal levels averaged over a chosen amount of time. 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.* Besides ping ponging this simple approach allows too many handoffs [8]. It has been shown in early studies that much of the time the previous link was well adequate and that handoffs occurred unnecessarily.

A better method is to use the averaged signal levels relative to a threshold and hysteresis margin for handoff decision. Furthermore, the condition should be imposed that the target base station's signal level should be greater than that of the current base station. Hard handoff is primarily used in FDMA (frequency division multiple access) and TDMA (time division multiple access), in which different frequency ranges are used in adjacent channels in order to minimize channel interference. So it becomes impossible to communicate with both BSs when the MS moves from one BS to another BS (since different frequencies are used).

1) **Types of Hard Handover**: there are two types of hard handover;

i) **Inter-cell Handover:**

The most basic form of handover is when a phone is redirected from its current cell (source) to a new cell, while call in progress. In terrestrial networks, the source and the target cells may be served from two different cell sites or from one and the same cell site. This type of handover, in which the source and the target are different cells (even if they are on the same cell site), is called *inter-cell* handover. So the purpose of inter-cell handover is to maintain the call as the subscriber is moving out of the area covered by the source cell and entering the area of the target cell.

ii) **Intra-cell Handover:**

In this handover, the source and the target are one and the cell is same and only the used channel is changed during the handover. So in this handover, in which the cell is not changed, is called *intra-cell* handover and the purpose of intra-cell handover is to change one channel, which may be faded or interfered with a new clearer or less fading channel.

iii) Microcellular Handover:

This handover technique is mostly used to meet high system capacity by reuse of frequency and is mostly used in populated areas. Fig.3 shows that there are three Base Stations in three streets. There is a line of sight (LOS) between BS1 and BS3 where as there is no line of sight (NLOS) between BS2 and BS1. Therefore we can say that there is LOS handover between BS1 and BS3 whereas between BS2 and BS1 there is NLOS handover.

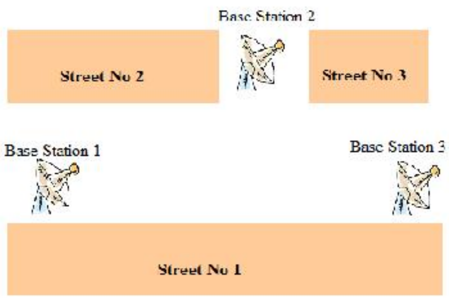

Fig.3

Base stations deployed in streets

When the Mobile Station misplace the LOS because of turning the corner with his current Base Station in NLOS then Received Signal Strength reduced. This RSS reducing effect is called the corner effect and in this situation fast handover algorithms are requires to avoid from call dropping because RSS drop quickly due to corner effect. The line of sight (LOS) attempts to decrease the unnecessary handover between the Base Stations whereas no line of sight (NLOS) must be as speedily as possible because of corner effects.

iv) Multilayer Handover:

In multilayer handover the microcells are superimposed with macrocell to decrease the number of handover and to raise the system capacity. In multilayer handover according to speed, users are consigned with each layer and to decrease the number of handover microcell layer is allotted to slow user where as macrocell allotted to fast user. For GSM900 the microcell and macrocell have area range from 500 meters to 35 Km. Handover calls are pour out to macrocell when the microcell layer distributes all of it channels to slow users then the handover call. It is feasible for microcell to allocate channels to new user, when the load in microcell decreases. This sort of handover is knows as take-back. When microcell becomes congested then in this situation macrocell not only work for fast user but also work for slow users.

2) Advantages of Hard Handover:

i) An advantage of the hard handover is that at any moment in time one call uses only one channel. The hard handover is usually not perceptible by the user and the event is indeed very short.
ii) Another advantage of the hard handover is that it is cheaper and simpler because the phone's hardware does not need to be capable of receiving two or more channels in parallel.

3) Disadvantage of Hard Handover:

A disadvantage of hard handover is that if a handover fails the call may be temporarily disrupted or even terminated abnormally.

4) **Applications of a Hard handover:**

i) A Hard handoff can be employed with more efficiency in FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access) network access systems, because in these systems, since different frequency ranges are used from adjacent channels so channel interference can be reduced.
ii) Broadband Internet access and e-mailing are more efficient and reliable when a hard handoff mechanism is used.
iii) A Hard handoff mechanism is particularly suitable for delay-tolerant communication traffic such as in broadband technology-enabled Internet, mobile networking technology such as mobile WiMax.
iv) Emailing and Broadband Internet access are more efficient and reliable when a hard handoff mechanism is used.

B. SOFT HANDOFF:

Soft handoff (or handover) is a mobile cellular network technology commonly used in CDMA (Code-division multiple access) systems that enables the overlapping of the repeater coverage zones, so that every mobile station is always well within range of at least one of the base stations. A Soft handoff mechanism works by first switching and establishing connection with another base station before disconnecting from the existing base station in the network, so it is also sometimes referred to as “Make-before-Break” Handoff. The soft handoff technology has many advantages like since there is no change in frequency or timing as a mobile set passes from one base station to another base station, so there are practically no dead zones therefore the connections face negligible interruption and the dead zones are practically non existent. If compared to hard handover, Soft handover offers more reliable access continuity in network connection and less chances of a call termination during switching of base stations. This is due to it inherent attribute to handle simultaneous frequency channels which rarely suffer from fading or interference at the same time and together. In soft handoff technology, the connections are relatively permanent and the communication is more stable in comparison to the other cellular technologies because in CDMA technology, all the repeaters use the same frequency channel for each mobile set, irrespective of the location. In comparison to hard handoff, technical implementation of a Soft handoff is more expensive and complex.

Now the soft handoff procedure is as follows: Suppose that the mobile station is linked and communicating with base station 1. Every base station is sending a pilot signal, which among other things, gives a measure of the signal strength to mobile users. When the signal strength of base station 2 exceeds the add threshold, base station 1 is notified to place base station 2 onto the candidate list. Further, when the signal strength of base station 2 becomes greater than that of base station 1 by some specified level, Base station 2 is placed on the active list and it also is allowed control of the call. Here, diversity combining is implemented. Now upon the signal level of base station 1 going below the drop threshold, the drop timer is activated. If it happens now that the signal level of base station 1 goes back above the drop level, the drop timer will be reset. However, if the signal strength level goes below the drop threshold and the drop timer expires; base station1 is dropped from activity with the call.

1) Advantages of Soft Handover:

- **i)** In soft handovers the connection to the source cell is broken only when a reliable connection to the target cell has been established and therefore there are lower chances that the call will be terminated abnormally due to failed handovers.
- **ii)** Other advantage is that simultaneously channels in multiple cells are maintained and the call could only fail if all of the channels are interfered or fade at the same time.

2) Disadvantage of Soft Handover:

The main disadvantage of soft handovers is that it uses several channels in the network to support just a single call. So the number of remaining free channels is reduced and thus the capacity of the network also reduces.

3) Applications of Soft Handover:

The application of Soft handoff mechanism is particularly in handling voice centric cellular networks particularly CDMA or GSM and latency sensitive communication services such as Videoconferencing.

4) Advantages of soft handover over hard handover:

1) In soft handoff, during handoff execution mobile does not lose contact with the system.
2) Ping ponging is eliminated and an extra measure of performance is obtained through diversity combining to mitigate fading.
3) More control may be given to the mobile in handoff decisions.

C. HORIZONTAL HANDOFF:

In Horizontal handover the users use the same network access technology and mobility perform on the same layers. In this handover the on-going calls are to be maintain and although the change of IP address because of the mobile nod movement. This handover may be categorized according to the direction of handover invocation.

D. VERTICAL HANDOFF:

Vertical handovers ensure universal roaming between different wireless networks operated by different network service providers. In vertical handover the mobility perform between the different layers and the users can move between different network technologies. In vertical handover the mobile node moves across the different heterogeneous networks and not only changes the IP address but the QoS characteristics and also changes the network interface [9].

Vertical handover process: The process of vertical handoff can be divided into three main steps [10], [11], namely handoff initiation, handoff decision, and handoff execution.

i) Handoff Initiation Phase:

In this phase, in order to start the handoff event, information to be collected about the network from

different layers likes Link Layer, Application Layer and Transport Layer. These layers provide the information such as RSS, power, link speed, cost, bandwidth, jitter, user preferences and network subscription, throughput etc. Based on this information handoff will be initiated in an appropriate time.

ii) Handoff Decision Phase:

In this step, mobile device decides whether the connection to be continued with current network or to be switched over to another one and the decision may depend on various parameters which have been collected during handoff initiation phase.

iii) Handoff Execution Phase:

In this phase, existing connections need to be re-routed to the new network in a seamless manner. In this phase, Authentication and authorization and the transfer of user's context information are also included.

Table 1: Difference between Vertical and Horizontal Handover [12]

	HORIZONTAL HANDOFF	VERTICAL HANDOFF
Network connection	Single connection	More than one connection
IP address	changed	changed
QoS characteristics	Not changed	May be changed
Network interface	Not changed	May be changed
Access technology	Not changed	changed

V HANDOVER PROTOCOLS:

In the design of a handover protocol [13], there are several factors that are to be considered. These factors are related to handover performance issues and constraints imposed by the operating environment. The handoff protocols can be classified into four categories [14]:

1. *Full Connection Re-routing*:

A new VC is established here as if it is a new call. Handoff scheme proposed in [15] makes use of external processors called Inter-Working Devices (IWDs) to manage handoff. These techniques are latent due to the need of computation of new routes but also optimal.

2. *Route Augmentation*:

This protocol offers a simplest means of achieving handoff, since it requires little buffering, no cell sequencing and not much additional routing. It involves route extension by adding a route from last position to current position of MT. It does not provide optimal path.

3. *Partial Connection Re-routing (Incremental Re-establishment)*:

In this technique, a part of route is preserved for simplicity, while the rest is re-routed for optimality. In this, the Nearest Common Node Rerouting (NCNR) algorithm presented in [16], routes the connection according to the residing zone of MT. This NCNR attempts to perform the rerouting for a handoff at the closest ATM network node which is common to both zones involved in the handoff transaction. The Hybrid Connection algorithm presented in [17] consists of Cross-Over Switch (COS) discovery and in case of intra-cluster handoff; the cluster switch itself performs the handoff at COS. In this type of handoff, the COS discovery process is initiated based on the handoff hint message provided by the MT. A partial path is set up between the COS and target switch, while the rest of the old path is preserved. This technique requires computation of nearest node or COS, buffering and cell sequencing but provides better resource utilization and reduced signalling.

4. *Multicast Connection Rerouting*:

This method is the combination of above three techniques and it pre-allocates resources in the network portion surrounding the macro-cell where the mobile user is located. Whenever a new mobile connection is established, a virtual connection tree (VCT) [18] is created, which connect all Base Stations (BSs) including the macro-cells towards which the MT might move in the future. So, the mobile user can freely roam in the area covered by the tree without invoking the network call acceptance capabilities during handover. The allocation of the VCT may be static or dynamic. This approach is fast and can guarantee the negotiated QoS in case of network handover. It may not be efficient in terms of network bandwidth utilization, because there exists the possible denial of a connection due to lack of resources and high signalling overheads, especially in the case of dynamic tree allocation.

VI HANDOFF MANAGEMENT ISSUES:

Handoff management has proposed several challenges in the implementation of wireless technologies. The open issues are listed below:

1) **QoS (Quality of service):**

The main issue to be considered is guaranteeing of negotiated QoS. The critical factors that influence the QoS disruption during handoff are - handover blocking due to limited resources, out-of-order cell delivery, cell losses, delay and delay variations. The minimization of QoS disruption can cost buffering. Provisioning of the Qos also needed to address the timing and synchronization issues. Discusses local and global adaptive synchronization criteria based on Lyapunov stability theory for the uncertain complex delayed dynamical networks [19].

2) **Rerouting Connections:**

The issues remain in development of algorithms for finding new route options, creation of signalling protocols for the determination of the feasibility of proposed solutions, and for reconfiguring the connection path.

3) **Point to Multipoint:**

This includes the development of protocols that address rerouting the point-to-multipoint connections of MTs.

4) **Mobile-to-Mobile Handoff:**

For a mobile to mobile connection, there is a need to address up gradation of existing protocols in order to support connection routing and QoS (Quality of Service).

5) **Optimization:**

This includes the development of efficient methods that allow an existing MT connection to be periodically rerouted along the optimal path.

VII CONCLUSION:

In wireless networks, handoff between cells is unavoidable because it is very necessary to maintain the ongoing calls. There are occurrences where a handoff is unsuccessful and lots of research was conducted regarding this. The main reason was found out in the late 80's. In adjacent cells, when a user moves from one cell to another frequencies cannot be reused; a new frequency must be allocated for the call. The user's call must be terminated if a user moves into a cell when all available channels are in use. Also, there is the problem of signal interference where adjacent cells overpower each other resulting in receiver desensitization. In this paper, we study the efficient channel allocation and handoff strategies to guarantee continuous service with good Qos (Quality of service) to mobile multimedia users. The handover initiation techniques are composed on the basis of hysteresis, signal strength, and threshold. The basic concept of handoff in mobile cellular radio systems has been introduced. Four conventional handoff strategies i.e., soft handover, hard handover, vertical handover and horizontal handover have been summarized in this paper. Details on handoff protocols, handoff management issues and handoff decisions are also discussed in this paper.

VIII REFRENCES:

[1] QING-AN-ZENG and DHARMA P.AGARWAL, " Handbook of Wireless Networks and Mobile Computing", John wiley & sons, Inc.,2002

[2] A.Iera, A. Molinaro and Marano, "Handoff Management with mobility Estimation in Hierarchical Systems",IEEE Transactions on Vechicular Technology, vol. 51, Sept 2002, pp 915-934.

[3] Nasser.N, Hasswa. A and Hassanein. H, "Handoff in Fourth GenerationHeterogeneous Networks", IEEE Communications Magazine, vol. 44, pp96-103, 2006.

[4] Yoo, S.-J.,et al. "Analysis of fast handover mechanisms for hierarchical mobile IPv6 network mobility", Wireless Personal Communications, 48(2), 215-238., 2009.

[5] Mahmood Zonoozi, Prem Dassanayake, M.faulkner, "Optimum Hysteresis, Signal Averaging Time and Handover Delay", IEEE Vehicular Technology Conference, March 1997,pp 310-313.

[6] H.Mitts, H.Hansen, J. Immonen, S.Veikkolanenl: Lossless handover for wireless ATM. Mobile Networks and Applications. 1(3), 299-312(1996).

[7] Jiang, Kakola: Microcellular Handover in Wireless ATM. Proceedings of the 32nd Hawaii International Conference on System Sciences. 1-9 (1999).

[8] Mikael Gudmundson, "Analysis of Handover Algorithms.", *IEEE Vehicular Technology Conference* July 1991, pp537-542.

[9] R. Katz, The case for wireless overlay networks. In Proceedings of Multimedia Computing and Networking (MCN' 96), January 1996.

[10] "An Overview on Decision Techniques for Vertical Handoffs across Wireless Heterogeneous Networks" – Akhila S, Jayanthi K Murthy, Arathi R Shankar, Suthikshn Kumar, *International Journal of Scientific & Engineering Research, Volume 3, Issue 1, January-(2012).*

[11] "An Overview of vertical decision strategies in heterogeneous wireless networks" – Meriem Kassar *, Brigitte Kervella, Guy Pujolle, *Science Direct, January (2008).*

[12] "SMIRT with Call Admission Control (CAC) Based Vertical Handover Decision for Seamless Mobility in Multi-Access 4G Heterogeneous Wireless Overlay Networks", -P.Vetrivelan and P.Narayaasamy, IMECS (2012), Hong Kong.

[13] C.-K. Toh, The design and implementation of a hybrid handover protocol for multimedia wireless LANs. In Proceedings OF THE First ACM International Conference on Mobile Computing and Networking (MOBICOM' 95), November 1995, pp.49-61.

[14] I. Akhyldiz: Mobility Management in Next generation Wireless System. Proceedings of the IEEE. 87(8), 1347-1384 (1999).

[15] B. Rajagopalan: Mobility Management Integrated Wireless ATM Networks. ACM-Baltzer Journal of Mobile Networks and Applications (MONET). 1(3), 273-285 (1996).

[16] B. Akhyol, D. Cox: Re-routing for handoff in Wireless ATM network. IEEE personal communications. 3(5), 26-33 (1996).

[17] C. K. Toh: A Hybrid Handover Protocol for Local Area Wireless ATM Networks. ACM-Baltzer Journal of Mobile Networks and Applications (MANET). 1(3), 313-334 (1996).

[18] A.Acampora: An architecture and methodology for mobile-executed handoff in cellular ATM networks. IEEE Journal of Selected Areas in Communications. 12(8), 1365-75 (1994).

[19] Z. Yang, Z. Liu, Z. Chen. Yaun: Adaptive Synchronization of Uncertain Complex Delayed Dynamical Networks. *International Journal of Nonlinear Science. 3(2), 125-132 (2007).*