Handoff Strategies in Cellular System

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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 ongoing call to be disconnected. If handovers are not used then whenever a user leaves the area of a particular cell then its ongoing 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 signaling 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 neighboring 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.
Key words: 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.

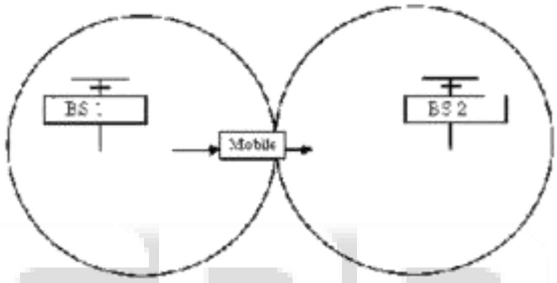

Fig. 1: Handoff: a mobile moving from one cell to another

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.

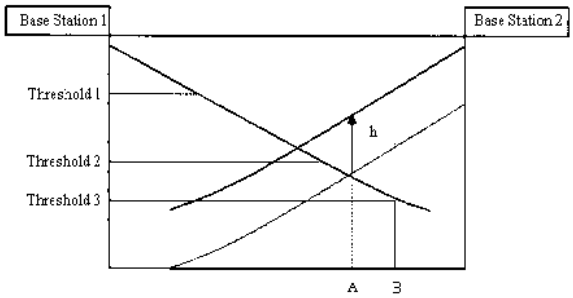

Fig. 2: Handoff procedure

So the margin = Pr handoff – Pr 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. 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

1) Handoff in first generation:-

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

2) 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:

- 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.
- The call has to be permanently handed over, when the mobile reaches a cell boundary.
- 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:

- The number of drop-outs should be minimum,
- The number of handovers should be minimum,
- Quick switch over of the call without any disturbance to the call,
- There should be minimum unnecessary handovers,
- 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 increases capacity.

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 decisionmaking 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:

- Network controlled handoff (MCHO)
- Mobile assisted handoff (NCHO)
- Network controlled handoff (MAHO)

A. 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.

B. Mobile-Assisted Handoff:

In a mobile-assisted handoff process, the network makes decisions and the MS makes measurements. In the circuitswitched 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.

C. 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 categorieshard 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 stationis 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).

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 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.

V. HANDOFF MANAGEMENT ISSUES:

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

A. *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].

B. *Rerouting Connections:*

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

C. *Point to Multipoint:*

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

D. *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).

E. *Optimization:*

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

VI. HANDOVER PREDICTION STRATEGY FOR 3G-WIFI

In 3G-WLAN overlay network environments; a UE is apt to lose the WLAN signal without any notice by moving while it connects to WLAN because it can be apart from the WLAN coverage suddenly. In this case the on-going services are disrupted by unexpected link corruption. Hence, it needs to execute quickly the handover to 3G network as soon as it detects the lost of WLAN signal. However, as the 3G access has many network signaling operations additionally including IP mobility operations for service continuity, it requests more enough processing time for the operations, which increases the handover latency causing the service interruption. Therefore it is important to predict the time when the UE will get out of the WLAN coverage. By the handover prediction, the UE can prepare the connection to 3G network before breaking off the WLAN connection. This paper shows several handover prediction algorithms to reduce the handover latency by fast handover triggering. The correctness of the algorithms is compared by simulation. The next generation wireless networks is envisioned as a convergence of different wireless access technologies providing the user with the best anywhere anytime connection and improving the system resource utilization. The integration of Wireless Local Area Network (WLAN) hotspots and third generation (3G) cellular network has recently received much attention. While the 3G-network will provide global coverage with low data-rate service, the WLAN will provide high data-rate service within the hotspots. Although increasing the underlay network utilization is expected to increase the user available bandwidth, it may violate the Quality-of-Service (QoS) requirements of the active real-time applications. Hence, achieving seamless handover between different wireless technologies, known as vertical hando(VHO), is a major challenge for 4G-system implementation. Several factors should be considered to realize an application transparent handover such as application QoS requirements and handover delay. In this paper, we present a novel framework to evaluate the VHO algorithm design impact on system resource utilization and user perceived QoS. We used this framework to compare the performance of two different VHO algorithms. The results show a very good match between simulation and analytical results. In addition, it clarifies the tradeoff between achieving high resource utilization and satisfying user QoS expectations. In 3G-WLAN overlay network, when a UE (User Equipment) currently connecting to 3G network enters to WLAN coverage, it can determine on changing the connection into WLAN. If the UE decides and executes the handover to WLAN, it has to carry out the series of procedures like WLAN access procedures including an AP (Access Point) association, a subscriber authentication and an IP address allocation, and also like the IP layer mobility operations . In this case, as the UE can break off the 3G link after completing of these basic procedures. Accordingly, the link break time is insignificant and there is no impediment in a service. But in case of the handover to 3G network from WLAN, the UE is apt to lose the WLAN signal without any notice by moving and it can be apart from the WLAN coverage suddenly before connecting to 3G network. Hence the services are disrupted by unexpected link corruption and the handover latency becomes very serious problem. Accordingly in this case, the most important thing the UE has to do is to execute the handover to 3G before losing the WLAN signal in link layer as soon as possible. However, until the service is connected to 3G network, it is requested that the many signalling procedures for 3G access and additionally IP mobility operations. The 3G access procedures include the service request procedure with subscriber authentication and the PDP (Packet Data Protocol) context activation procedure with IP address allocation. If it takes too much time to finish those, handover latencies are increased and in conclusion the service gets to fail. If the link layer can previously predict the lost of WLAN signal and the connection to 3G network can be made in advance before link disruption, the link break time is quite decreased and the services can be continued without any interruption. Hence the handover prediction for link triggering is very important for seamless mobility. In this paper, we consider the five handover prediction algorithms for applying to the handover to 3G network from WLAN. The handover prediction algorithms previously decide the handover based on various data which are periodically gathered by the UE such as RSS (Received)

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.

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