Vertical Handoff in Heterogeneous Networks

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Abstract

In today’s world, wireless networking is pretty significant and popular way of giving worldwide information access to users wherever they move. One of the important tasks for continuous mobility is to have a simple, strong vertical handoff. The main objective of handover/handoff is to maintain the ongoing calls without any call drop even when the user is in motion. Generally, it is initiated whenever the mobile is crossing the boundary of a cell or by drop/fall in quality of the signal in the current channel. Supposing if the user is in motion and as the user leaves the cell and the user is in call during that time, if handoffs are not used or unavailable then its ongoing call is disconnected. One of the major concerns in heterogeneous wireless networks is to give the support of robust vertical handoff/handover. It occurs whenever a mobile shifts from one network to another (e.g., from WLAN to CDMA, 3G to GPRS etc.).

Key Words and Phrases: Handoff, Vertical Handoff, Handover, Horizontal handoff.
1 Introduction

In cellular phone system, large number of base stations covering a small geographic area known as cells. Mobility[1][19] is the fundamental feature of a wireless cellular communication system. It is provided by cell phone systems. So, it is the essential requirement of the system that, as the mobile unit switches from one cell area to another cell area, it must be able to transfer the call from the base station of the first/primary cell, to that of the base station of the next/new cell without any drop in call. It is similar in satellite communications:[2] it is the method of relocating satellite control responsibility from one earth station to another earth station with no loss or interruption of service. In cellular communications, handover means the process of reassigning an ongoing call/data session from one channel connected to the core network to another channel on every occasion that the mobile is in motion or the mobile is in hole (weak spot or weak signal zone).

2 Handoff/Handover Process

Handoff or handover is a process of changing the channel, which is linked to current connection whenever a call is in process, if the mobile is in motion during the call. The handover process is initiated [3][16] with a request for handover. When the power received by the mobile unit from the base station of neighboring cell goes above the power received from the base station of the current cell for a precise value, it is known as the handoff threshold and it is a fixed value. For successful handoff, it must be implemented quickly before the current connection is lost by grabbing a channel. The Fig. 1 illustrates the basic handover process.

Fig. 1 Occurrence of Handoff
The handover process \cite{4} requires number of factors to be considered e.g. which handoff scheme are we using, how many channels in the cell are free for call. In the handoff process the quality of service have to be kept up to the standard. Handoff schemes which are poorly designed incline to generate thick signalling traffic and, therefore, the quality of service (QoS) dramatically decreased.

3 Types of Handoff

![Diagram of Handoff Classification](image)

Fig. 2 Different types of Handoff

Handoffs/Handovers are broadly classified\cite{5} into two forms- hard and soft handoffs. These are also referred as “make before break” and “break before make”. In the soft handoff, during the handoff process, not only the existing resources even the new resources are used but in hard handoff, current resources are freed before the new sources are in use. Generally, Hard Handoff occurs in GSM systems and soft handoff in CDMA systems.

A hard handover (or handoff) is a “break before make” handover \cite{6}. In hard handover/handoff, the connection or the call gets dropped before the user is linked to the new cell’s base station, this means that the mobile station is linked to one base station at a given time.
Hard handoff request must be served instantly in order to reduce the interruption to the call. Handoff Initiation begins when the signal strength at the mobile received from base station 2 is more than that of base station 1. The signal strength measures are truly the signal levels averaged over a chosen amount of time. The major problem [7] with this approach to handoff decision is that the received signal strength of both the base stations changes frequently. 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-pong.

![Diagram 3](image)

Fig. 3. Illustrates the conditions at which handover or handoff is successful or not.

In Code Division Multiple Access (CDMA) soft handover [8] (or handoff) is commonly used technique of Mobile Cellular Network. A Soft handover is a handover were the switching and establishing of connection with another base station will be completed before getting disconnecting from the existing base station in the network, so it is also referred as “Make-before- Break” Handoff. The main advantages of soft handover technology are, during the mobile crosses between the base stations the frequency/timing will not change due to this the dead zones (weak spots or hole) will be minimized. Due to this effect there is a small interruption in the connections face also the weak spots will not exist. When compared with hard handover, Soft handover
offers stable access continuity in network connection and very less possibilities of call termination in the course of switching between base stations. This is because of its intrinsic characteristic to handle instantaneous frequency channels, which rarely suffer from fading/interference at the same time and together. In soft handoff technology, the connections are equally permanent and the communication is very firm in comparison with other cellular technologies because in CDMA technology, all the repeaters use similar frequency channel for each mobile unit, regardless of the location. When compared with hard handoff, the practical execution of a Soft handoff is more costly and complex [11].

### 3.1 Horizontal Handoff

Horizontal handoff or handover is a handoff between two different wireless networks operated by same network service providers. Here mobility is performed on the same layers. In this handover technique the on-going calls are to be continued, even though the IP address changes due to the mobile node movement. This handover may be categorized according to the direction of handover invocation. This is the type of Handoff implemented till 3G technology.

### 3.2 Vertical Handoff

Vertical handoff or handover is a handoff between two different wireless networks operated by different network service providers. In vertical handover the mobility is performed between the different layers and the users can move between different network technologies. In vertical handover the mobile travels across many heterogeneous networks and not only changes the IP address but also the Quality of Service (QoS) characteristics and even changes the network interface. In 4G both horizontal and vertical handoff is used.

![Comparison of Horizontal Handoff vs Vertical Handoff](image)

Fig. 4 Comparison of Horizontal Handoff vs Vertical Handoff
4 Vertical handover process

The process of vertical handoff can be divided into three main steps namely handoff initiation, handoff decision, and handoff execution[1].

i) Handoff Initiation Phase: In this phase, in order to start the handoff event, information to be collected about the network from different layers like 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, authorization and the transfer of user’s context information are also included.

5 Handoff Management Issues

Handoff management has proposed several challenges[2][3] in the implementation of wireless technologies. The open issues are listed below:

5.1 Quality of Service (QoS)

The main issue to be considered is ensuring of same Quality of Service (QoS) as of that it is in the primary base station before handoff takes place. The key factors that impact the QoS disturbance during handover are - handover blocking due to inadequate resources, out-of-order cell delivery, cell losses, delay and delay differences. The minimization of Quality of Service (QoS) disturbance can cost buffering. Provisioning of the QoS also needed to address the timing and synchronization issues.
5.2 Rerouting Connections

The issues remain in improvement of processes for discovery of new route options, for reconfiguring the connection path and creation of signaling protocols for determination of the possibility of proposed solutions.

5.3 Point to Multipoint

It deals with the upgradation of protocols that address rerouting the point-to-multipoint links.

5.4 Mobile-to-Mobile Handoff

For a mobile to mobile connection, there is a need to address upgradation of current protocols in order to support connection routing and Quality of Service.

5.5 Optimization

Optimizing\textsuperscript{[15]} the Vertical handoff decision parameters (RSS, Bandwidth and Power etc..) for HetNets is as important as providing the user with best QoS continuously. Optimizing plays an important role in making use of the available resources in the best possible manner.

6 Conclusion

In wireless networks, handoff between cells is inevitable because it is very necessary to maintain the ongoing calls and thereby reducing the dropped call rate. There are incidents where a handoff is ineffective and lots of research is conducting in this area to reduce the dropped call rate. The handover initiation methods are composed on the basis of hysteresis, signal strength, and threshold. The basic concept of handoff in mobile cellular systems has been presented. Four conventional handoff schemes i.e., soft handover, hard handover, vertical handover and horizontal handover are briefed in this paper. Some of the important handoff management issues are also discussed in this paper.
References


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