# Implementation of Vertical Handoff in Heterogeneous Networks

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***Abstract***

*Vertical Handoff (VHO) is a major concern for different heterogeneous networks. VHO can be user requested or based on some criteria already designed by the researcher of that particular algorithm. It's about switching from one network to another while maintaining the session. Numerous algorithms have been given in this respect. In this paper a new implementable procedure has been introduced. It's a mechanism, in which multiple users having access to different networks can execute the VHO, in such a manner that when the handoff takes place it do not interrupt any ongoing call or data session. A server and clients have been created. A call was established and it was maintained by Session Initiation Protocol during switching from one network to another. By employing a technique called IP Assignment VHO was carried out successfully. The proposed scenario has made implementation of VHO practically possible.*

***Keywords:*** *Vertical handoff (VHO), Session Initiation Protocol (SIP), IP Assignment, Asterisk, X-lite*

## 1. Introduction

As the technology boosted up, the advancement occurred from 1G FDMA based networks to the 4G IP based networks. Large number of standards developed which provided higher data rates to the users along with the reliability and security. Now these standards are available to the service providers to serve the customers.

Different wireless networks are deployed around the world which can be personal area networks, wireless local area networks (WLAN) etc. All these wireless networks are heterogeneous because they use different access technologies to maintain their connections when switching to a cellular network [1]. For example, a wireless network which provides a service through a wireless LAN and is able to maintain the service when switching to a cellular network is called a wireless heterogeneous network. The emerging concept of mobile devices in heterogeneous wireless networks is to equip them with multiple network interfaces so that different wireless networks can easily be accessed.

When video streaming and video conferencing were achieved, it became need of hour to provide the users with a feature that promises users unremitting connectivity. This connectivity can be achieved if somehow all networks become compatible to each other, and the user who is using one technology can switch to the other according to its preference. User expects that the connection will continue while he is moving from one network to another and it will not be disrupted. This phenomenon is known as handoff or handover.

## 2. Background Study

Two types of handoffs occur in a heterogeneous network namely the Horizontal and Vertical Handoff (VHO). Horizontal Handoff is the type of handoff which allows the users to move from one cell to another using the same network technology. Here an ongoing connection is transferred from one BS to another [2].

### 2.1. Vertical Handoff

Vertical Handoff or Vertical Handover is a technique in which user using one technology can switch to another technology and during this transition the connection is not lost. This concept is mostly applicable to cellular networks, so to be more precise Vertical Handoff is a technique in which user moves from one Base Station to other Base Station having different access technology. For example the connection is maintained while user moves from WLAN to WIMAX.

Figure 1 shown below clearly tells how horizontal and vertical handoffs occur when user moves from one cell to another.

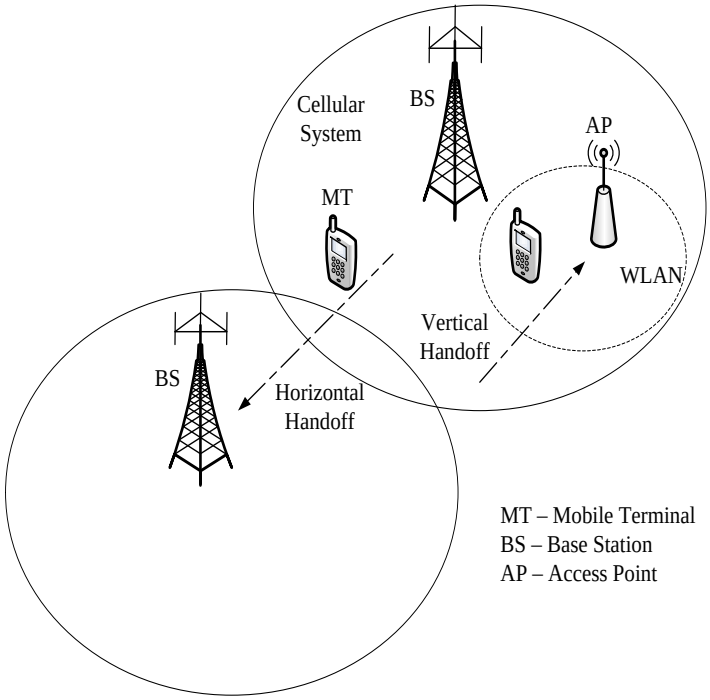


**Figure 1. Horizontal and Vertical Handoffs in Heterogeneous Wireless Networks [2]**

### 2.2. Steps of Vertical Handoff

To carry out VHO three steps are important [3, 4] namely System Discovery, Handoff Decision, and Handoff Execution.

**2.2.1. System Discovery:** To find out the available wireless networks and to decide which amongst them can be used is the responsibility of the Mobile Terminal (MT).

**2.2.2. Handoff Decision:** To connect to the network the MT evaluates different parameters like Transition Delay, Cost, Current Battery Status, Bandwidth, Transmit Power, and User's Preferences [5].

**2.3.3. Handoff Execution:** The connections should be transferred in a seamless manner from the existing network to the new network.

## 3. Literature Review

Processes like Vertical Handoff would be creditable only when there is a way to implement them. Vertical Handoff being an asymmetric process employs many factors like Time Delay, Quality of Service, Cost, Network availability and User Preference etc to be considered before real time implementation. Each algorithm tries to cater any or some of the factors but would sometime make a lot of assumptions in this regard which make it non implementable. Some short comings of different algorithms have been discussed in the paragraphs to come.

Handoff performance with help of Handoff Management Centre (HMC) was described in [5]. A HMC is buildup that connects upper layer interfaces with network that increases hardware in the system. It does not consider the computational time and the complexity involved in it.

In [6] proposed solution emphasis on choosing the correct VHO criteria between Wireless Standards, such that the equilibrium states for Handover and optimum load balancing can be achieved. The AI load will oscillate between maximum and minimum value if all the users switched at once to their preferred AI.

The Cross-Layer VHO Decision Model for Heterogeneous Wireless Networks has been proposed in [7]. It states that best network selection should be done by different layers, by modifying functionality of each layer. Due to layer three negotiations additional delays will be involved because change in subnet will occur during mobility.

Paper in [8] emphasizes on a concept which can provide mobility management services to the clients without making any change in the TCP layer. But on other side handover decisions results in a change in subnet which produces a lot of delay.

A technique in [9] was proposed to deal with the delay and bandwidth issues during a vertical handoff. The problem lies in it is that the method itself consumes a lot of time and bandwidth while collecting ACKs.

All discussed methods just emphasized on the selection of the best network from the available ones, on the basis of some algorithm. The work was supported by the help of simulation. These algorithms are fine in the theory but no emphasis was made on their practical implementation. This point led us to an idea of implementing VHO in real life. This paper of ours will provide a method by which VHO is practically implementable.

## 4. Proposed Model

Based on the numerous research reviews our emphasis was to come up with a practically implementable scenario of VHO. The need of implementation is to switch to any other network on the go, without interrupting the communication or transfer of data between two or more parties, if the provided network went down or become unavailable. The procedure adopted was to establish a call between multiple Clients. The Clients will communicate via a Server, which will help maintain the call during switching from one network to another. The job of the Server and Clients was given to three PCs, two PCs as Clients in the network and one as Server. This was all about the setting up of our communication network. The next step was to choose the server, clients, networks and the layer in OSI model to be worked on.

### 4.1. Session Initiation Protocol (SIP)

The selection of a layer and a protocol was a real problem. This problem actually took some time as each layer to be employed gives some good and some bad effects on the handover and also on the QoS of the network. We decided to use Session layer because of some key advantages of this layer and they are [10]:

- Call establishment to exchange data bit stream.
- Enable the two parties to coordinate and make consensus on some common parameters like protocols etc.
- Make recovery of any lost data easy.

Session layer has now been employed and to get minimum delays between handovers the protocol called SIP is used. The purpose of choosing SIP is that it helps establish, maintain and terminate a connection. Basically the requirement is to establish a call which remains connected between the Clients somehow while shifting from one network to another. Sip gives this opportunity, while switching it does not terminate the call at once. For some time it maintains the call and during that time the client can easily switch from one network to another without call termination. Successful voice communication between the users is the requirement, so SIP is selected to provide that support.

### 4.2. Server

A Server is required through which multiple clients can communicate with each other. Asterisk is chosen as the Server. Asterisk is a soft switch and is like a Private Branch Exchange (PBX). Asterisk system controls all routing information and holds all features such as voice mail, teleconferencing, queues, and hold music [11], so in our design we thought of making it the server. Secondly Asterisk supports SIP which is the most important component to establish maintain and terminate the connection. On the other hand Asterisk is also cost effective.

Asterisk follows list of instructions and sets of rules, these instructions change according to the dialup plan of the user, so some of the important files of the Asterisk have to be modified before it is used. These files are actually configuration files through which we were able to configure the Server. So to make the dial plan according to the design certain changes were made in the sip.conf and extension.conf files.

### 4.3. Clients

After catering with the issue of Server next thing is to decide about the Clients. We thought of choosing soft phones as Clients because the design is between different PCs. Asterisk support different soft phone and X-lite is one of them. Both Clients are provided with this software phone which has an ability to call or answer the incoming call. Some useful features of the soft phone are multiple incoming and outgoing channels, missed call indicators, phone book, volume control, Graphical User Interface (GUI),call waiting option, manual and automatic IP selection and Multimedia conversation. Based on these features X-lite is chosen as the soft phone.

### 4.4. Networks

Two networks are chosen namely Local Area Network (LAN) and Wireless Local Area Network (WLAN). Local area network (LAN) is the most primitive of all the available networks because of its higher data rates and cheap prices. LAN requires data link layer for its implementation and at network layer it uses Internet Protocol (IP). It requires different components like router, switches and cable modems [12].

WLAN links devices using a wireless distribution technology and usually takes into consideration different access points to provide internet services. This is very helpful to provide users mobility and coverage at a time. Major advantages of WLAN are no cabling, less infrastructure with lower costs, user mobility, handheld devices and exchange of information with other workers or central office. WLAN even made ad-hoc networking possible [13]. Based upon these advantages, these two networks are used, to check the creditability of the scenario. Secondly SIP and X-lite are also supported by these networks.

### 4.5. Practical Scenarios and Tools

Multiple scenarios have been created to check the credibility of our proposed practical solution.

- Client 1 has both facilities i.e. LAN and WLAN and client 2 has only LAN.
- Client 2 has both facilities i.e. LAN and WLAN and the other client has only WLAN.
- Both clients have both facilities i.e. LAN and WLAN.

Server may have both facilities or not but it should at least have one to stay connected with its clients all the time because it is just a static device. Following figure shows the system design. Here two users connect with the server. Two network technologies i.e. LAN and WLAN are provided. On basis of this design VHO will be carried out.

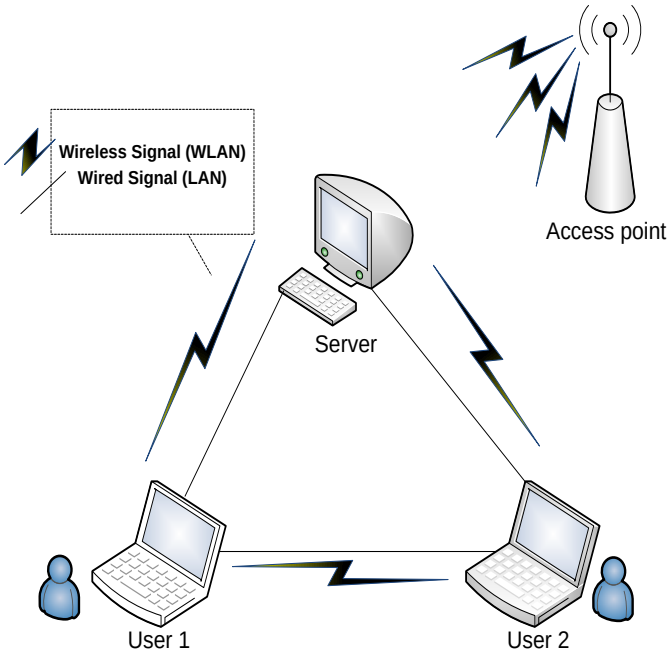


**Figure 2. Signals Availability**

We can choose any device as a client which is capable enough of having windows or may have Linux as an operating system in it. Choose any among them as it is clearly mentioned in the Figure 3.

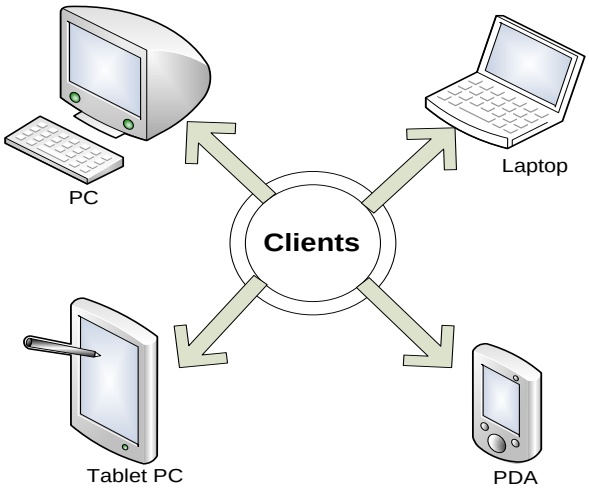


**Figure 3. Devices as Clients**

## 5. Implementation

Our main work is to access different networks, observe their signal quality along with delays during the handoff, and to deal with the IP assigning issue. So the practical work can be divided into three main parts:

- IP assignment
- Call establishment
- Call maintenance during handoff

### 5.1. IP Assignment

At the beginning not many considerations were taken on IP assignment issue but later on it became clear that it is the main crux of the design. Initially emphasis was to maintain the call during handover but there was no success. The reason was that as we move from one network/ technology to the other the IP also changed immediately with the technology and call dropped in no time. This problem showed us that as VHO happens the entire new network would not accept this Client as its part. So what we did is IP Assignment.

Our this technique makes the upcoming Client virtually as its part and after some delay of time, that is within a second, the new network accepts this user and allows it to use its services and maintain its call in a seamless manner. The delay produced here will not exceed certain time threshold. The delay is never too high to drop the call and when delay occur, SIP works in a manner that it struggles and tries to maintain the call during Vertical Handover. So the protocol selection helped a lot in this problem.

IP Assignment technique mentioned previously is a technique proposed to solve the issues regarding delay and session maintenance all together. IP Assignment actually makes a mask of an IP which works purely statically in a particular device. Whatever IP is assigned by the router or switch, this technique changes it into an IP of its own and makes it work on that and forget about the previous IP.

This work is same like having a single number of your mobile phone which makes you eligible to call, text or surf the internet not only at your home location but also at foreign location and the only thing happens is the registry of your number to Home Location Register (HLR). This HLR entry will automatically detect your movement and report it the new location i.e. visiting location and update your entry in Visiting Location Register (VLR) but in the end your mobile or cell number remains the same irrespective of location. This process is called roaming. In this case network and technology remains the same so it refers to Horizontal Handover.

In our case it is roaming with respect to technology change so we do IP Assignment to stay connected. The solution we proposed is practically achievable. After assigning IP the next step is to start or establish a call.

### 5.2. Call Establishment

To maintain the call certain preliminary steps are performed. They include:

- Turn "ON" both Clients who are participating in the conversation.
- Start the Server on a different computer using asterisk as a backend Server.
- On both Clients turn "ON" the X-lite soft phone.

First of all give both your Clients some account details like:

- Username
- Password
- Authorization name
- Domain address i.e. server's IP address
- Proxy address
- Security settings
- Voicemail option
- Topologies

Both Clients now get their required information and are ready to be registered with the Server. If asterisk faces no problem with its connection then it will immediately register both Clients. This can be clearly seen at the front panel of the Server as shown in Figure 4.

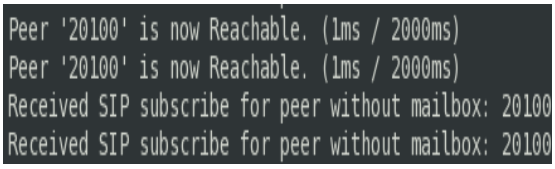


**Figure 4. Server Screen Showing Registered Clients**

Both the Clients are now ready so one Client must have to dial the phone number of the other Client to be called. After dialing number of the other party by the calling party, the

other Client will receive an incoming call alert at its soft phone. This Client has the authority to ignore the call or accept it by picking it up.

The call has been established between the two parties for time period of 30 seconds. If nobody sends any voice signal on the channel the call terminates. If the clients communicate in this specified time period then the call will be ended on the end of the conversation by any of the party. On the end of the call the asterisk will show some messages on its front panel as mentioned in Figure 5.

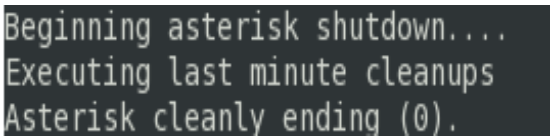


**Figure 5. Ending Messages**

### 5.3. Call Maintenance

Static IP assignment is important to maintain the call. This proposed solution is not just bound to the non-availability of any network but one could also be having a willful handover because of his personal liking or better service or speed of the network.

Our Server with SIP as its protocol is always there to maintain the call for the delayed duration and then it will be routed to the next network of user's choice. Just assign the respective IP i.e. mask it as your logical address and begin chatting or downloading etc.

## 6. Why Used Windows As The Operating System

We used Fedora at the first stage but the Client was unstable there. To overcome this problem we switched to windows and performed manual switching which resulted only in one way handoff. But lately through programming we successfully achieved two ways handoff i.e. from LAN to WLAN and vice versa.

## 7. Conclusion

Vertical Handoff (VHO) is a major concern for different heterogeneous networks. In this paper a new practically implementable procedure is proposed. Proper scenario is designed in which the server is implemented by the help of Asterisk, using SIP as a protocol. Clients are supported by a Soft Phone X-lite. Clients register themselves with the Server and a call is established. User switched from LAN to WLAN and vice versa and call is maintained till handoff is carried out in a seamless manner. This process gives a better QoS.

IP adjustment is a big achievement which opened a new room for 4G networks. Now with the help of this IP Assignment technique we are able to handle any existing network and scenario. Vertical Handoff is no more a dream for pure IP based networks.

## 8. Future Work

In future this method can be carried out for other wireless networks and the parameters which effect vertical handoff like cost, power, delay, losses etc can be dealt with. It can also be designed for interconnecting geographical areas each with its own server and multiple clients. Emphasis should be made on implementing it on large scale which will be a huge achievement.

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