# Vertical handoff algorithm for wireless network

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***Abstract:*** **the evolution of communication technology from 1G to 3G and from cordless phone to Wimax . beyond the 3G(B3G) and next generation wireless system(NGWS) toward 4G that integrate the communication technology. For that the seamless mobility management is required for seamless mobility the handoff management is required and for the NGWS the handoff management between different technology is called vertical handoff . for taken the handoff decision there are various vertical handoff decision(VHD) algorithm. VHD algorithms can be classified as RSS based bandwidth base, cost based, and combination algorithm. These algorithm needs to be designed to provide required quality of service (QoS).**

## Introduction:

Efficient VHD algorithms need to be designed to provide the required QoS to a wide range of applications while allowing seamless roaming among a multitude of access network technologies. There are two main areas for mobility management: location management and handover management. Handover is the process of maintaining a user's active sessions when a mobile terminal changes its connection point to the access network (called "point of attachment"), for example, a base station or an access point. Depending on the access network that each point of attachment belongs to, the handover can be either horizontal or vertical. A horizontal handover takes place between points of attachment supporting the same network technology, for example, between two neighboring base stations of a cellular network. On the other hand, a vertical handover occurs between points of attachment supporting different network technologies, for example, between an IEEE 802.11 access point and a cellular network base station. A handover process can be split into three stages: handover decision, radio link transfer and channel assignment. Handover decision involves the decision to which point of attachment to execute a handover and its timing. Radio link transfer is the task of forming links to the new point of attachment, and channel assignment deals with the allocation of resources. Classification of Handovers: Based on different factors used in the handover decision process, handovers can be classified in various ways. Some of the popular classifications are discussed below.

**Horizontal and Vertical Handover -** Depending on the network types involved, handovers can be classified as either horizontal or vertical. A horizontal handover or intra-system handover takes place between PoA supporting the same network technology, e.g., two geographically neighboring BSs of a 3G cellular network. On the other side, a vertical handover or inter-system handover occurs between PoA supporting different network technologies, e.g., an IEEE 802.11 AP and a 3G BS. An example of horizontal and vertical handovers is illustrated in Figure 1, where a horizontal handover happens between two cellular BSs and a vertical handover takes place between an AP of a WLAN and a BS of a cellular BS.

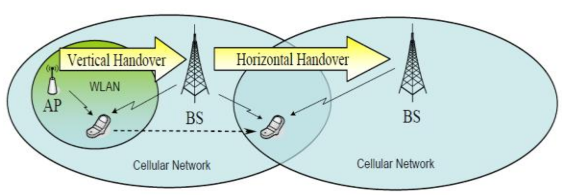


Figure 1: An example of horizontal and vertical handovers [4]

In heterogeneous Vertical handovers are implemented across heterogeneous cells of access systems, wireless networks. Which differ in several aspects such as bandwidth, data rate, frequency of operation, etc. The different characteristics of the networks involved make the implementation of vertical handovers more challenging as compared to horizontal handovers. The terms horizontal and vertical follow from the overlay network structure that has networks with increasing cell sizes at higher levels in the hierarchy. Vertical handovers are generally of two types namely, upward and downward handovers. An Upward vertical handover is a handover to a wireless overlay with a larger cell size and generally lower bandwidth per unit area. So, an upward vertical handover makes a mobile device disconnect from a network providing faster but smaller coverage (example WLAN) to a new network providing slower but broader coverage. A downward vertical handover is a handover to a wireless overlay with a smaller cell size, and generally higher bandwidth per unit area. A mobile device performing a downward vertical handover disconnects from a cell providing broader coverage to one providing limited coverage but higher access Speed.

Next generation wireless systems (NGWS) are expected to provide users with convenient global information access capabilities and personalized multimedia wireless communication services. Growing interest in 4G networks is leading to a convergence of various wireless network technologies. Recently ratified IEEE 802.21 MIH standard aims to support seamless roaming among a variety of wireless access network technologies, including GSM, UMTS, WiMAX, Bluetooth and WLAN, through different handover mechanisms.

**Vertical handover process:** The traditional horizontal handoff research involves handoff decisions based on the manual evaluation of RSS measured at the MS to support the "Always Best Connected" communications. These traditional handoffs are triggered when the RSS value of the serving BS falls below a specified threshold. On the other hand, an MS in a heterogeneous wireless environment can move between different ANs with different functionality and characteristics (bandwidth, latency, power consumption, cost, etc.) which cannot be directly compared. Hence, in case of vertical handoffs, RSS itself is not sufficient for making efficient and intelligent handoff decisions; other system metrics including, but not limited to, cost, network-load and performance, available bandwidth, security, and user preferences should be taken into consideration as well. On the other hand, the inclusion of multiple metrics increases the complexity of vertical handoff decisions and makes the entire process more challenging. A vertical handoff comprises of three phases as follows:

Network Discovery: An MS with multiple active interfaces can discover several wireless networks based on broadcasted service advertisements from these wireless networks. However, keeping all these interfaces active all the time can significantly affect the battery power of the MS.

Handoff Triggering and Decision: This is the phase where the decision regarding "when" to perform handoff is made. In this phase, the target wireless access network is selected based on multiple criteria, as discussed before.

Handoff Execution: This is the last phase of the vertical handoff process where the actual transfer of the current session to the new AN takes place. This requires the current network to transfer routing and other contextual information related to the MS to the newly selected AN as quickly as possible.

A handoff process can be thought of as having two major stages: handoff initiation and handoff execution. In the first phase, a decision is made regarding the selection of the new Base Station (BS), or Access Point (AP), to which the MS will be transferred. In the execution phase, new radio links are formed between the BS/AP and MS, and resources are allocated[1].

**Vertical handover decision criteria and metrics:**

**Received signal strength (RSS)** is the most widely used criterion because it is easy to measure and is directly relevant to the service quality. There is a close relationship between the RSS readings and the distance between the mobile terminal and its point of attachment. The majority of existing horizontal handover algorithms uses RSS as the main decision criterion, and RSS is an important criterion for VHD algorithms.

**Network connection time** refers to the duration that a mobile terminal remains connected to a particular access network. Determining the network connection time is very important for choosing the right moment to trigger a handover so that the service quality could be maintained at a satisfactory level. For example, a handover done too early from a WLAN to a cellular network would waste network resources or being too late would result in a handover failure. Determining the network connection time is also important for reducing the number of superfluous handovers, as handing over to a target network with potentially short connection time should be discouraged. The network connection time is related to a mobile terminal's location and velocity.

**Handover latency** is defined for a MT as the time that elapses between the last packets received via the old access router and the arrival of the first packet along the new access router after a handover. Handover latency can be considerably different between various technologies and this has a major impact on interactive applications. **Available bandwidth** is a measure of available data communication resources expressed in bit/s. It is a good indicator of the traffic conditions in the access network. **Power consumption** becomes a critical issue especially if a mobile terminal's battery is low. In such situations, it would be preferable to hand over to a point of attachment which would help extending valuable battery life.

**Monetary cost:** For different networks, there would be different charging policies, therefore, in some situations the cost of a network service should be taken into consideration in making handover decisions.

**Security:** For some applications, confidentiality or integrity of the transmitted data can be critical. For this reason, a network with higher security level may be chosen over another one which would provide lower level of data security.

**User preferences:** A user's personal preference towards an access network could lead to the selection of one type of network over the other candidates. RSS and network connection time based decision criteria are widely used in both horizontal and vertical handover decisions. Others are mainly seen in VHD schemes only.

**VHD Metrics:**

Handover delay: refers to the duration between the initiation and completion of the handover process. Hand-over delay is related to the complexity of the VHD process, and reduction of the handover delay is especially important for delay-sensitive voice or multimedia sessions.

Number of handovers: Reducing the number of handovers is usually preferred as frequent handovers would cause wastage of network resources. A handover is considered to be superfluous when a handover back to the original point of attachment is needed within certain time duration and such handovers should be minimized.

Handover failure probability: A handover failure occurs when the handover is initiated but the target network does not have sufficient resources to complete it, or when the mobile terminal moves out of the coverage of the target network before the process is finalized. In the former case, the handover failure probability is related to the channel availability of the target network while in the latter case it is related to the mobility of the user.

Unnecessary Handover probability: the handover is initiated but the attached network performance is best than the target network and the mobile terminal moves back to the previous attached point .so this is the wastage of resource and degrade the QoS.

Throughput: The throughput refers to the data rate delivered to the mobile terminals on the network. Handover to a network candidate with higher through-put is usually desirable.

**Classification of VHD algorithms:**

There are various ways to classify VHD algorithms. In this article, we have chosen to divide VHD algorithms into four groups based on the handover decision criteria used and the methods used to process these.

1) RSS based algorithms: RSS is used as the main handover decision criterion in this group. Various strategies have been developed to compare the RSS of the current point of attachment with that of the candidate point of attachment.RSS based horizontal handover decision strategies are classified into the following six subcategories: relative RSS, relative RSS with threshold, relative RSS with hysteresis, relative RSS with hysteresis and threshold, and prediction techniques. For VHD, relative RSS is not applicable, since the RSS from different types of networks cannot be compared directly due to the disparity of the technologies involved. For example, separate thresholds for each network. Furthermore, other network parameters such as bandwidth are usually combined with RSS in the VHD process.

2) Bandwidth based algorithms: Available bandwidth for a mobile terminal is the main criterion in this group . In some algorithms, both bandwidth and RSS information are used in the decision process. Depending on whether RSS or bandwidth is the main criterion considered, an algorithm is classified either as RSS based or bandwidth based.

3) Cost function based algorithms: This class of algorithms combines metrics such as monetary cost, security, band-width and power consumption in a cost function and the handover decision is made by comparing the result of this function for the candidate networks. Different weights are assigned to different input metrics depending on the network conditions and user preferences.

4) Combination algorithms: These VHD algorithms attempt to use a richer set of inputs than the others for making handover decisions. When a large number of inputs are used, it is usually very difficult or impossible to develop analytical formulations of handover decision processes. Due to this reason, researchers apply machine learning techniques to formulate the processes. Our literature survey reveals that fuzzy logic and artificial neural networks based techniques are popular choices. Fuzzy logic systems allow human experts' qualitative thinking to be encoded as algorithms to improve the overall efficiency. If there is a comprehensive set of input-desired output patterns available, artificial neural networks can be trained to create handover decision

algorithms .It is also possible to create adaptive versions of these algorithms. By using continuous and real-time learning processes, the systems can monitor their performance and modify their own structure to create highly effective handover decision algorithms.

**Implementation of RSS based algorithm:**

Wireless technologies are evolving toward broadband information access across multiple networking platforms, in order to provide ubiquitous availability of multimedia applications. Recent trends indicate that wide-area cellular networks based on the 3G standards and wireless Local Area Networks (WLANs) will co-exist to offer multimedia services to end users. These two wireless access technologies have characteristics that perfectly complement each other. By strategically combining these technologies, a converged system can provide both universal coverage and broadband access. Therefore, the integration of heterogeneous Networks is expected to become a main focus in the development toward the next generation wireless networks

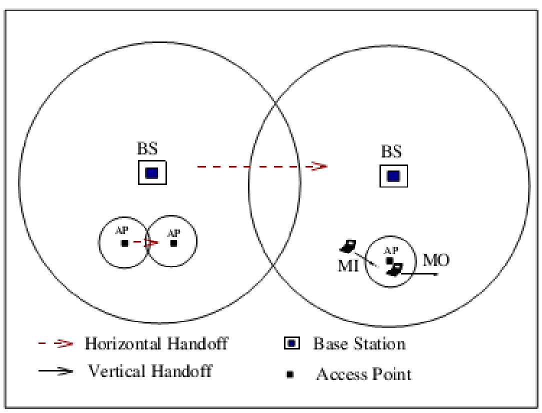


Figure 2. Handover scenario[1]

Mobility management is a main challenge in the converged network. It addresses two main problems: location management and handoff management. Location management tracks the Mobile Terminals (MT) for successful information delivery. For this purpose, Mobile IP (MIP) enables seamless roaming and is expected to be the main engine for location management in the next generation networks. Handoff management maintains the active connections for roaming mobile terminals as they change their point of attachment to the network. In the converged network, both intra-technology handoff and inter-technology handoff take place as illustrated in Figure 2.There are two main scenarios in VHO: moving out of the preferred network (MO) and moving into the preferred network (MI). In the converged model, it is highly desirable to associate the MT with the preferred network, as long as the preferred network satisfies the user application. This can improve the resource utilization of both access networks, as well as improving the user perceived Qos. Furthermore, this handoff should be seamless with minimum user intervention. It can satisfy the system handoff signaling load, as well as different application requirements by the tuning of an Application-based signal strength threshold (ASST).

The traditional HHO problem has been studied extensively in the past. Several approaches have been considered in cellular networks using the Received Signal Strength (RSS) as an indicator for service availability from a certain point of Attachment. Additionally, several handoff initiation strategies have been defined based on the comparison between the current attachment point RSS and that of the candidate attachment points

•RSS: handoff takes place if the candidate attachment point RSS is higher than the current attachment point RSS (RSSnew>RSScur).

•RSS plus threshold: handoff takes place if the candidate attachment point RSS is higher than the current attachment point RSS and the current attachment point RSS is less than a predefined threshold T (RSSnew>RSScur and RSScur <T).

In VHO, the RSSs are incomparable due to VHO's asymmetrical nature. However, they can be used to determine the availability as well as the condition of different networks. If the MI decision is based only on the preferred network Availability, the MT should start the MI process as it discovers the WLAN. In addition, if more than one WLAN APs are available, the MT should associate itself with the one having the strongest RSS as it does in HHO. When the MT is associated with the preferred network, it enjoys all the referred network advantages before moving out. Therefore, in the ideal MO scenario, the MT performs no more than one handoff at the WLAN edge when the network is expected to be unavailable. This ideal MO decision usually cannot be achieved. Thus, the main design requirements of a VHO algorithm are •minimizing the number of unnecessary handoffs to avoid overloading the network with signaling traffic,

•maximizing the underlay network utilization,

•providing active application with the required degree of QoS,

•prioritizing handoff to the underlay network over MO to the overlay net-work,

•avoiding MI to a congested network, and

•keeping fast users connected to the overlay network.

Within the WLAN, a log-linear path loss channel propagation model with shadow fading is used. The RSS is expressed in dBm as

$$RSS=PT-L-10n \log (d) + f(\mu, \sigma)$$

Where PT is the transmitted power, L is a constant power loss, n is the path loss exponent and usually has values between 2 - 4,d represents the distance between the MT and the WLAN AP, and f(μ, σ)represents shadow fading which is modeled as Gaussian with mean μ=0and standard deviation σ with values between 6-12 dB depending on the environment[2]. We assume that when the RSS is below a certain interface sensitivity level, α, the MT is unable to communicate with the AP.Based on the measured and estimated parameters, the MT will initiate the MO handoff at time k if the averaged received signal strength is less or equal to a predefined MO threshold, MOTWLAN, and the estimated lifetime is less than or equal to the handoff delay threshold.In the MI scenario, several factors need to be considered. The main one is the WLAN availability, which can be determined by the WLAN RSS. In addition, the QoS, specified in terms of the available bandwidth, is a key factor in the handoff decision. Other factors such as security, user preference can be considered. In this work, we consider a simplified model where the MT performs MI to the WLAN if RSS[k] > MITWLAN and the available bandwidth is greater than the required bandwidth.

**Transition probabilities:** The calculation of the transition probabilities is based on recursive computation of the handoff probabilities. In the integrated heterogeneous networking model, the following probabilities are required for handoff algorithm analysis.

•PW[k]: Pr {MT is associated with the WLAN at instant k}

•PC[k]: Pr {MT is associated with the 3G network at instant k}

•PW|C[k]: Pr {MT associates itself with the WLAN at instant k given that it is associated with the cellular network at instant k-1}

•PC|W[k]: Pr {MT associates itself with the 3G network at instant k given that it is associated with the WLAN at instant k-1}.

In our model, the MT is assumed to be attached to the WLAN at the beginning hence PW [0] = 1 and PC [0] = 0. PW[k] and PC[k] can be calculated recursively As follows

**Handoff Probabilities and the Number of Handoffs:**

The number of handoffs has major impact on the signaling traffic, which may overload the network resulting in degradation in the overall performance. The number of handoffs, denoted NHO, is defined as the sum of MOs and MIs between WLAN and 3G network as the MT roams across the network boundary. Hence, it is a random variable that depends on the instantaneous move out/in probabilities,

The MT movement between the two networks can be modeled by a two-state non-homogeneous Markov chain. Each state represents the network with which the MT is associated. The transition probabilities are PMO[k] and PMI[k]as shown in Figure 3. Hence, by using binary impulse rewards for the handoff transition. we calculate the average accumulated rewards for MO and MI transitions, which are equivalent to the expected number of MOs, NMO, and the expected number MIs, NMI, respectively. Hence, the expected number of handoffs.

E{NHO} = E{NMO}+E{NMI} .

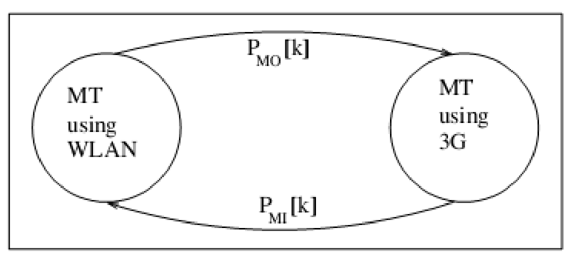


Figure 3. Markov Chain[1]

Numerical Results and the Optimization of ASST Simulation Model In addition to the above analysis, we have simulated the VHO algorithms using MATLAB. Table 1 shows the simulation parameter values. The WLAN parameters are used as, which are suitable to model outdoor suburban (e.g. with tree and low buildings along the road side which is similar to the characteristics of the commercial WLAN services) and indoor locations with wide areas (such as hotel lobbies and campuses). These parameters result in WLAN coverage of 100 meters approximately. The data rates shown in the table are used for performance evaluation only and have no effect on the handoff decision. Currently, IEEE802.11b WLANs are widely deployed and support rates vary from 11 Mbps to 1 Mbps depending on the distance between the MT and the WLAN AP. On the other hand, cellular service providers are still deploying their first phase of the 3G network that supports rates up to 144 Kbps The former support rates that vary from 54 Mbps to 6 Mbps, while the latter supports a peak rate of 2.4 Mbps on the forward link with an average throughput of 600 kbps. Hence, these values show that the service rate of WLANs is generally approximately one order of magnitude larger than that of the cellular network. Additionally, a simple mobility model is assumed in which a MT moving away from the WLAN access point in a straight line at a constant speed V. Additionally, the proposed algorithm will function with any mobility pattern since the algorithm dynamically adapts to the MT velocity, and the algorithm time Resolution is sufficient to track mobility pattern variation, especially for low speed MTs.. The flowchart is depicted in Figure 4.

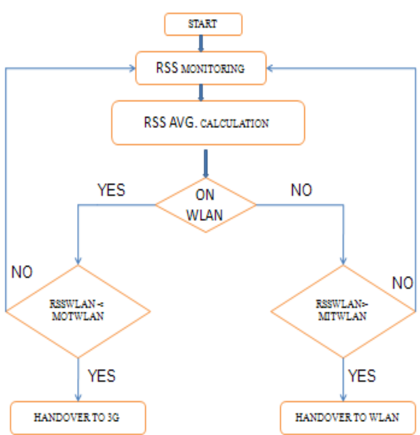


Figure 4. RSS Based Algorithm

Algorithm can be summarized as follows. First, by introducing the lifetime metric, the algorithm adapts to the application requirements and the user mobility, reducing the number of superfluous handovers significantly. Second, there is an improvement on the average throughput for the user because of the mobile terminal's ability to remain connected to the WLAN cell as long as possible. However, packet delays grow with an increase in the lifetime, due to the deterioration of the channel condition as the mobile terminal approaches the edge of the WLAN cell. This issue can be critical for delay sensitive applications and degrade their performance. To solve this problem, ASST is tuned according to various system parameters, including delay thresholds, mobile terminal velocities, and handover signaling cost.

**Simulation Parameter:-**

| Parameter | Value |
|---|---|
| Pt | 100mw |
| ASST | -90dbm |
| MOTW LAN | -92dBm |
| MITW LAN | -87 dBm |
| fc wlan | 2.4ghz |
| fc th_g | 2.0ghz |

Table 1: Simulation Parameter

Using this simulation parameter analysis of above RSS based algorithm and from that we have the value of RSS for LWAN network and 3G. The value of RSS arise as per the time and using this data we plot the RSS of both WLAN and 3G network as shown in fig.5.Also using the simulation count the number handoff between this two network the number of handoff with to time to time plot in the fig.6.

**Simulation Results:-**

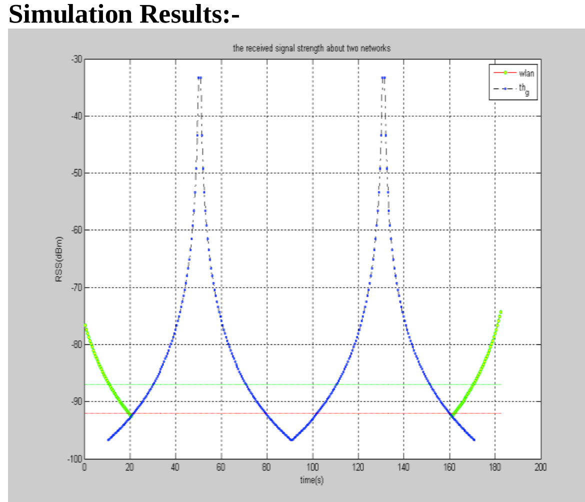


Figure 5.plot the value of RSS for the network WLAN and 3G

As seen in plot when the RSS value of WLAN network reaches at -92dbm and the MOTWLAN (=-92dbm) shown with horizontal line at this time the handoff can be done and MS handover to the 3G network. same as when the 3G network is ongoing with the MS and after some period the WLAN network can be detect the RSS value for WLAN when it's detect and is RSSWLAN=--92dbm the MITWLAN (=-87dbm) this value can be seen with horizontal line in plot and at this instant the MS will enter to the network of WLAN.

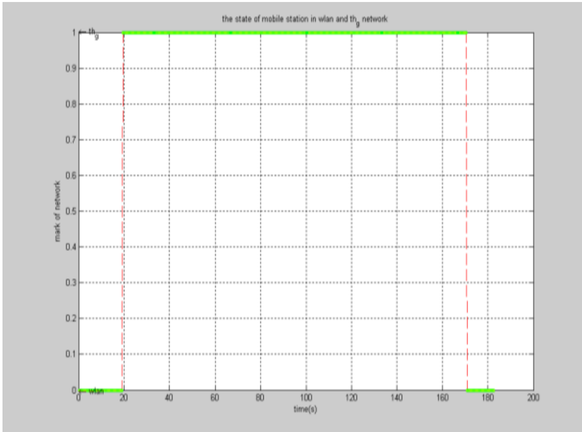


Figure6. Plot Number of handoff

As shown in the plot the number of handoff means how many times the MS will change from one network to another and in this simulation result the number of handoff is (=2).and seen from the both figure 13 and 14 the handoff occurs at the value of MOTWLAN and MITWLAN and at this time the value of time for both the plot is match.

Conclusion: in this paper the approach for the handoff decision can be taken on the basis of moving in [MI] and moving out [MO] threshold value of WLAN network while in the traditional approach the decision can be taken on the threshold value. The simulation result shows the RSS value and at which instant the handoff decision can be taken.

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