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# Handover Parameters and Algorithms - A Survey

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**Abstract:** The future wireless communication consists of several heterogeneous networks and the QoS of these networks depends on various parameters like network capacity, bandwidth, data rate, Received Signal Strength (RSS), power consumption and etc. For the uninterrupted ongoing calls irrespective of the home location or visitor location registry, Handoff (Handover) is required so as to ensure the ongoing user session with seamless connectivity. Many interesting research challenges are carried out by different researchers in the field of handoff. A good handoff should avoid or reduce call drops with minimum resources and power consumption.

**Index Terms*:* RSS, WiMAX, 4G, Handoff, VHO.**

## I. INTRODUCTION

Entering into the new era of mobile communication, one should meet requirements of fourth generation (4G) wireless system so as to provide significantly higher data rates, QoS, cost and seamless mobility. This can be achieved by choosing the most appropriate access link among the available alternatives (including IEEE 801.11- WLAN and IEEE 802.16- WiMAX). In addition to the traditional cellular telephony networks which are almost universally accessible today. For a satisfactory user experience, mobile terminals must be able to seamlessly transfer to the best access link among all available so as to avoid call drop and allow uninterrupted ongoing calls. Such ability to hand over between heterogeneous networks is referred to as seamless vertical handovers [1]. Now a day's various research topics of wireless communication systems are based on vertical handover procedure and the mobility management. The vertical handover decision is carried out based on different parameters like received signal strength (RSS), latency, available bandwidth, power consumption, cost, user preferences and SNR. In this paper, we classify different vertical handover algorithms into three groups and offer a Comparative analysis of various algorithms in each group.

## II. BASICS OF HANDOVER

Handoff (Handover) is an event when a mobile station moves from one wireless cell to another. It can be classified into two basic types; horizontal (intra-system) and vertical (inter-system). Horizontal handoff means handoff within the same wireless access network technology, and vertical handoff means handoff among heterogeneous wireless access network technologies. Our primary focus is vertical handoff system due to which the detailed analysis of horizontal handoff is left to the readers and researchers. The vertical handoff process can be divided into three main steps [02] [03], namely system discovery, handoff decision, and handoff execution. During the system discovery phase, mobile terminals equipped with multiple interfaces have to determine which networks can be used and the services available in each network. The networks may also advertise the supported data rates for different services. During the handoff decision phase, the mobile device determines which network it should connect to. The decision may depend on various parameters including the available bandwidth, delay, access cost; transmit power, current battery status of the mobile device, and the user's preferences. During the handoff execution phase, connections need to be re-routed from the existing network to the new network in a seamless manner.

## III. HANDOFF DECISION

Figure 1 shows scenario of handoff decision. The decision-making process of handoff may be centralized or decentralized. The handoff decisions can be classified into:

1. Network controlled: In a network-controlled handoff protocol, the network

Makes a handoff decision based on the measurements of the MSs at a number of BSs. Network controlled handoff is used in first-generation analog systems such as AMPS (advanced mobile phone system).

2. Mobile assisted handoff: In a mobile-assisted handoff process, the MS makes measurements and the network makes the decision. This type of handoff decision is used in the circuit-switched GSM (Global System Mobile).
3. Mobile controlled handoff: In mobile-controlled handoff, each MS is completely in control of the handoff process.


**Fig. 1. Handoff Decision**

## IV. CLASSIFICATION OF VHO ALGORITHMS

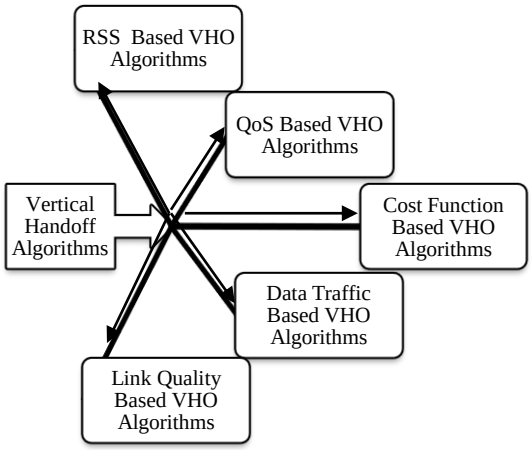


**Fig. 2. Criteria for Vertical Handoff Algorithm**

Figure 2 shows how VHO are classified into different groups. Many of the researchers concentrate their research work on one or more parameters of VHO as shown in figure 2. Considerable work has been done in the literature to determine the appropriate parameters that can be considered in the decision process for VHO.

In this section, we briefly discuss different VHO criteria. A representative set of VHO algorithms are also discussed and these algorithms are assigned into one of these criteria. It may possible that some of the algorithms may use more than one VHO criteria.

### *A. RSS Based VHO Algorithms:*

In this group, RSS is used as the main handover decision criterion and is the most widely used due to it's easily to measureable characteristics and QoS. RSS based VHO algorithms compare the RSS of the current point with the others to make handover decisions. [01] [ 05] [ 06]. Because of the simplicity of the hardware required for RSS measurements, a large number of studies have been conducted in this area [07] [08] [04] [05] [06] [09]. We describe some of the representative RSS based VHO algorithms.

*Zahran, .Liang & Saleh, proposed an adaptive lifetime-based handover algorithm* [04] in which a lifetime metric was considered. This algorithm involves two scenarios. In the first scenario, a handover from WLAN to the 3G network will happen if the RSS average of WLAN connection is less than predefined threshold. While in the second scenario, a handover is initiated if UE moves a 3G network to WLAN. The handover will be carried out if sufficient bandwidth is available on the WLAN network and if the threshold of 3G network is below average RSS value. [10] [11]. This algorithm have different advantages over traditional RSS based algorithms like; adaption to application requirements and user mobility, improvement on the available bandwidth. Along with these advantages, this algorithm has few drawbacks such as long packet delay and extra loop-up table.

Second approach was proposed by *Mohanty and Akyildiz viz RSS threshold based dynamic algorithm* [05]. Here the current RSS is compared with the dynamic RSS threshold and handover decision is taken. The dynamic RSS in dBm is calculated as

$$S_{dth} = RSS_{min} + 10\,\beta \log 10 \left(\frac{d}{d-L_{BA}}\right) + \in \ \ldots \ (1)$$

As proposed by authors, the use of a dynamic RSS threshold helps to reduce the false handover and increase mobile connectivity of the user. The advantage of this algorithm is, the handover failure probability from 3G networks to a WLAN cell is considered to be zero. And the major drawback is increase in RSS sampling delay.

### *B. QoS Based VHO Algorithms:*

For a successful handover, along with RSS, bandwidth and signal to noise ratio are the important parameters to be considered. Bandwidth is a measure of available data communication resources. It indicates different traffic conditions in the access network and provides delay information to the user. In this group, the focus is given on the available

Bandwidth for a mobile terminal and signal to interference noise ration. While discussing these Keeping in mind, before handover it is essential to check RSS before handover.

*Lee, Chen and Sun [12] proposed a QoS based VHD algorithm* which considers residual bandwidth and user service requirements for handover decision handover from WLAN to Wireless Wide Area Network (WWAN) and vice versa. Here the handover algorithm is initiated if the measured RSS is consistently below a threshold ($RSS_{T1}$). The algorithm also considers the state of the mobile terminal during handover. If the mobile terminal is in the idle state, a handover is performed; otherwise the handover decision is based upon the user application type. For delay-sensitive applications, a handover occurs only if the current serving WLAN is not able to provide enough bandwidth whereas WWAN is ready to provide bandwidth for the application. For the applications where delay is tolerable, a handover takes place if the WWAN provides higher bandwidth than the WLAN. When the mobile terminal is connected to a WWAN, a similar process is carried out if consecutive beacons from the WLAN with RSS above a threshold ($RSS_{T2}$) are received. The advantage of this algorithm is it able to achieve high system throughput, lower handover latency. However, its drawbacks are with higher bandwidth, a handover decision is difficult [12].

*Yang, Gondal, Qiu and Dooley devised a bandwidth based VHD method between WLANs and WCDMA using SINR* [14]. Here, the Signal to Interference and Noise Ratio (SINR) calculation of the WLAN signals is converted to an equivalent SINR to be compared with SINR of the WCDMA channel. Authors concluded; this algorithm performs handover to the network with larger SINR. Advantages of SINR based handovers over RSS based handovers are – it can provide users higher overall throughput, and results in a balanced load between the WLAN and the WCDMA networks. And disadvantage is it may introduce excessive handovers with the variation of the SINR causing the node to hand over back and forth between two networks [13].

### *C. Cost Function Based VHO Algorithms:*

The cost function based algorithms combine metrics in a cost function. The primary benefits of cost function based algorithm are it initiates handover for different applications with increased percentage of user request and reduced blocking probability. *Zhu and McNair presented a VHD algorithm which relies on a costs function* [2]. The algorithm gives its highest priority for the active applications and then algorithms, one should remember that RSS is the main and important criteria for handover. the cost of each possible target network for the service with the highest priority is calculated as;

$$C_s^n = \sum W_{sj}^n \, Q_{sj}^n \quad ; \quad E_{sj}^n \neq 0 \qquad \ldots (2)$$

The total cost is the sum of the cost of each QoS parameter, including the bandwidth, battery power and delay. The service is handed over to the network with minimum cost.

*Tawil, Pujolle and Salazer proposed a weighted function based VHD algorithm* [16] which relies on the VHD calculation to the visited network instead of the mobile terminal (MT). The weighted function of a network is defined as ;

$$Q_i = W_B \; B_i + W_{D_P} \; \frac{1}{D_{P_i}} + W_c \; \frac{1}{C_i} \qquad \ldots (3)$$

In this algorithm, an application with highest $Q_i$ is selected as handover target. By assigning the calculation to the visited network, the resource of MT can be saved for. The advantage of this is, with this the handover decision delay and blocking rate is reduced with increase in throughput. This method has few drawbacks like increase in additional latency and excessive load to the network.

## V. CONCLUSIONS

In this paper, we presented the performance comparison between different vertical handoff decision algorithms. These algorithms are divided into different groups such as RSS, QoS, Cost Function, Data Traffic and Link Quality Based VHO Algorithms.

Comparisons of all the above algorithms discussed above are done based on their functions, advantages, disadvantages which may affect the overall performance of the network.

- RSS based algorithms have different advantages as increase in user mobility, improvement on the available bandwidth, handover failure probability is considered to be zero.
- QoS based algorithms are proved better in performance due to its high system throughput and lower handover latency.
- While cost function based algorithms decreased the blocking rate with decrease in cost function parameters such as bandwidth, battery power and delay.

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