# An Overview of Vertical Handoff Decision Algorithm in Next Generation Wireless Networks

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*Abstract*: **The development of wireless communication is increasing day by day due to the advancement of cellular and broadband technologies. Everyone around the world likes to have best services through best network [Khattab, Omar] [10]. Therefore, the aim of NGWNs is to provide a good quality of services between various access networks. To access different networks, there must be a decision algorithm to decide which is the best network for a user for a specific application. This paper presents an Overview of handoff types, handoff process, the criteria involved in VHD, parameters, Existing work on the vertical handoff with comparison tables, Analysis and Various research issues.**

*Keywords*: **Vertical Handoff Decision (VHD), Next Generation Wireless Networks (NGWNs), Horizontal Handoff (HHO), Vertical Handoff (VHO).**

## I.    INTRODUCTION

The main feature of today's wireless networking system is Mobility. Mobility can be obtained by a handoff mechanism. In future, the users of wireless technologies will not be bound by subscription of one single network; they can choose one of the available networks depending upon the requirement at that moment. The wireless technology beyond 4G is known as NGWNs, Which will provide support for heterogeneous access technologies. This has led to the development of mobile devices with multiple network interface terminals. The mobile node can connect to any available network (e.g. GPRS, UMTS, WLAN, WI-MAX, BLUETOOTH etc.) These wireless networks are combined to offer high data rate and best services to the mobile nodes [Bhuvaneswari, A; et al.] [1]. But for accessing different wireless networks, there is a need for vertical handoff decision.

The rest of the paper explains different types of handoff, Criteria involved in vertical handoff (VHD), various process of vertical handoff decision making, various existing algorithms to make vertical handoff decision, various research issues in VHD; Finally, we conclude a comparative analysis of various algorithms. Types of Handoff in 4G networks:

## II.    TYPES OF HANDOFF

Handcuffs are extremely important to maximize spectrum utilization because of the cellular architecture employed. Handoff is the process of change of base station while maintaining continuity of service during roaming of a mobile terminal.

**1. Handcuffs are of two types based on the network involved:**

**a. Horizontal handoff:**  Handoff between two base stations (BSs) of the same network is called Horizontal Handoff. In Horizontal Handoff the mobile node moves from one cell to another of the same network (e.g. Within a UMTS network) to maintain service continuity. It can be further classified into Intersystem Handoff and Intra system Handoff.

**Intra system Handoff**: The horizontal handoff between two base stations (BS), under the same BSC is known as Intra system Handoff.

**Intersystem Handoff:** In Intersystem, handoff, handoff occurs between two base stations (BS) of different BSC. It takes place in intra system when a mobile terminal departs the regulated realm of one access router and enrolls into the

regulated realm of another access router within the same network. Horizontal handcuffs are typically required due to the limited coverage of the service access router.

**b. Vertical Handoff:** Vertical Handoff occurs between different network technologies such as between an IEEE802.11 access point and a base station of a cellular network. Vertical handoff is again classified into upward, downward, soft, hard, mobile controlled, network controlled, mobile controlled network assisted and network controlled mobile assisted handoff. Vertical handoff can be initiated for providing better Quality of service rather than connectivity. It takes place in intersystem when a mobile terminal moves in between different network technologies for quality of services demanded by the mobile user.

**2. Classification based on the behavior of a mobile terminal for allowing itself for a new connection. They are hard handoff and smooth handoff**

**a. Hard handoff:** Hard handoff also called "break before make", involves only one base station at a time. The mobile terminal must break its connection from the current access network before it can connect to a new network.

**b. Soft handoff:** It is also known as "make before break", a mobile station can communicate and connect with more than one excess network during the handoff process.

**3. Handoff are classified as four types with respect to 'Who controls the handoff decision**

**a. Network controlled handoff (NCHO):** In this, handoff decision is taken by network only [Krichene, Neila, et al.] [11]. But, these types of handcuffs cannot be initiated at the right time because they don't have the information about the current circumstances of the mobile terminal. Also, a network cannot be made aware of the characteristics of all other networks. Therefore, it is not suitable for vertical Handovers. A network controlled handoff is suitable for only Horizontal handoff. They are used in 1st generation cellular system and needs approximatly 100-200ms time for handoff completion.

**b. Mobile control handoff (MCHO):** In this, mobile terminal takes the handoff decision. As mobile terminals have better knowledge of its current circumstances, this type of handoff is a better choice for vertical handover. They need approximately 0.1 second time for the handoff completion process. They are used in Mobile IP networks.

**c. Mobile Assisted handoff: (MAHO):** In this, mobile terminal assists the network for handoff decision by collecting the primary information required for handoff [Krichene, Neila, et al.] [11].This type of handoff is used in 2nd and 3rd generation cellular system. They needs approximately 1 second for completion of handoff process.

**d. Network assisted handoff (NAHO):** In this, network assists the mobile terminal for handoff decision.

**4. Handoff can be classified as forced handoff and user handoffs**

**a. Forced handoff:** They are mandatory handoff and are initiated due to poor network conditions.

**b. User handoff:** They are initiated due to user preference rather than an inconvenience.
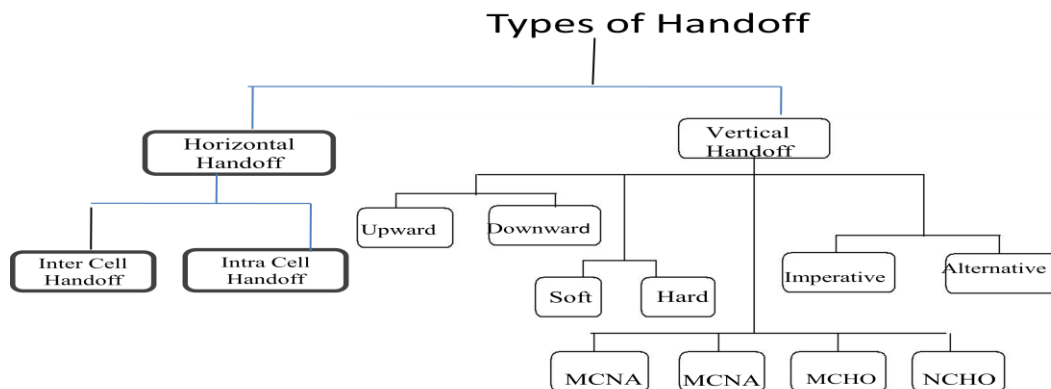


FIGURE 1 TYPES OF HANDOFF

## III.    THE CRITERIA INVOLVED IN VERTICAL HANDOFF DECISION:

The various parameters involved in vertical handoff are very important aspect to achieve continuous & uninterrupted services [Bhuvaneswari, A., et al. [1]. Figure2. Shows the most important criteria that must be used In VHD algorithms.

### A.   Received Signal Strength (RSS)

RSS is a primary decision attribute for vertical handoff because it can be measured easily and it is directly related to the Quality of service. Attribute RSS and the distance between the mobile terminal to the point of attachment is inversely proportional to each other. But RSS is not enough in vertical handoff decision.

### B. Available Bandwidth

This criterion is used for identification of network congestion and for the discovery of available resources of communication. This is a most important Criteria for delay sensitive applications.
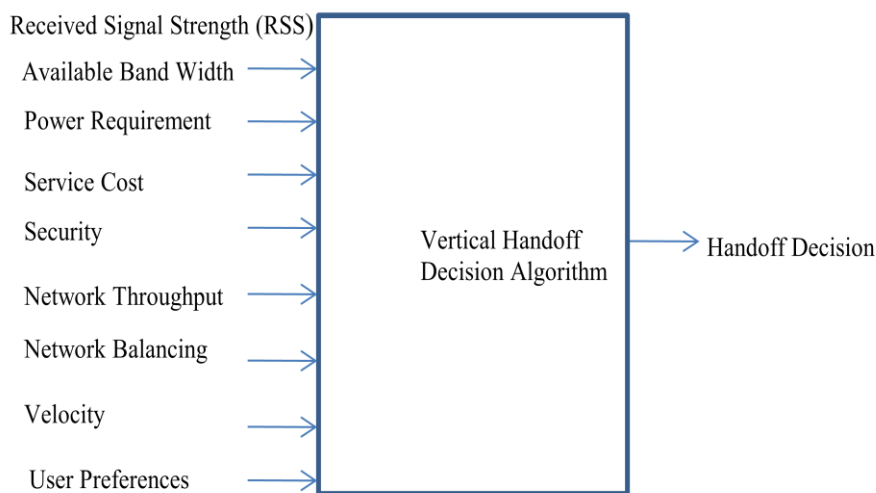


Figure 2 Handoff Decision Criteria

### C. Power Requirement

Wireless devices run on battery. Therefore, they must have limited power consumption, If a mobile device has low battery level, then switching from one network to another network with low power requirement (e.g. WLAN to a WWAN) would be a smart decision. This is because, in a WWAN the wireless transmission is unpredictable and the device is inactive for a longer time. Also, the mobile terminals are able to wait between transport activities, because there is no predefined arrival time and transmission of data.

### D. Security

The data transmission through a wireless network is less secure as compared wired network. As data is transmitted through the air interface and people do not have control on the accessibility of data. Therefore, to attain a higher level of security & confidentiality the network should prevent unauthorized access to network resources.

### E. Network throughput

Network throughput refers to the average data rate over a specific communication link. It is measured in bits per second. It equals to the TCP window size divided by the round trip of communication data packets.

**F. Network Balancing**

 Network load is an important criteria for effective handoff. Load balancing is required to maintain a uniform traffic among available networks and to avoid overloading of the particular network. The non- uniform distribution of traffic among network reduces the traffic carrying capacity and a quality of communication service. Therefore, it must be paid attention.

**G. Velocity**

Velocity and the direction of movement of the mobile node should also be considered during the handoff decision. If a mobile node is moving at a very high speed, then hand over the connection to a smaller coverage area network will be discouraged since a handoff back to the original network will occur very shortly.

**H. User Preferences**

 The user preferences and network performance parameter can be used to choose available network. The user preference could depend upon the type of application (real-time, non real-time), service type (voice, data, video), Quality of service, preferred networks etc.

 We have discussed the most important criteria, but other parameters such as network load, packet delay and bit error rate should be taken into account for a good vertical handoff decision (VHD) algorithm.

## IV.    VERTICAL HANDOFF PROCESS

The handoff process can be divided into 3 phases:

**B.   Phase 1. (Handoff   Information Gathering)**

This phase is used to collect the information about the network and the mobile node from the upper layers such as a transport layer, Link layer, and application layer. These layers provide the information in terms of received signal strength(RSS), Power requirement, link delay, link cost, user preferences and available bandwidth in order to trigger the handoff [Bhuvaneswari, A., et al.] [1]. Based on this information, the handoff will be triggered at an appropriate time.

**C.   Phase 2. (Handoff   Decision)**

In this phase, the mobile node decides whether to continue with the current network or to switch over to another network with the help of information collected during phase1.

**Phase3. (Handoff    Execution):** This Phase is used to transfer the user's context information and rerouting the connections to new network after authentication and authorization.

## V.    VERTICAL HANDOFF DECISION MAKING ALGORITHMS

In the literature survey, various vertical handoff decision algorithms are discussed. These decision algorithms can be grouped as follows:

A. Traditional B. User Centric C. Fuzzy Logic and Neural network D. Context Aware    E. Functional based   F. Multiple Attributes Decision Making

**D.   Traditional Method**

Traditional Methods uses RSS with other parameters as decision criteria. The algorithms based on RSS are easy to implement as they do not involve too much complexity. Such a solution is proposed by [K. Pahlavan, et al] [6]. The decision to transfer the mobile node from current network to another mainly depends upon received signal. The major drawback of received signal strength (RSS) algorithm is the generation of large numbers of handoff because received signal strength(RSS) cannot be measured accurately due to path loss and fading of the signal.

### E. User Centric Approaches

The User Centric Approaches considers only user preferences to achieve maximum user satisfaction. The preferences are given in the form of cost and quality of service (Qos) . It chooses the best utility function for user satisfaction rather than for applications. An algorithm is proposed by [Calvagna, G. ] [2] .In this the actual transfer rate of each network is calculated by the mobile terminal. It uses the predicted rate and utility function to determine which network is best for a complete transfer of data with maximum utility.

### F. Fuzzy Logic and Neural Network

The fuzzy Logic system allows coding in qualitative thinking of human experts Fuzzy Logic (FL) and Neural Network (NN) are two concepts used to choose when and to which network for the implementation of vertical handoff algorithm. The advanced algorithm with improved efficiency and decision criteria can be developed for both real and non real applications by combining the Fuzzy and Neural networks A vertical handoff solution that uses these two concepts was proposed by [Siddiqui, Farhan, et al.][19] to produce a very powerful system. In this algorithm neural network is used as a baseline system. The GA is combined with Fuzzy Logic and Neural Network to select the best network at a given time. In this solution, a string must encode n*c real valued parameter in which each coefficient encoded by 8 bits and scaled between [0~1]. After that the GA manipulates the most promising strings in its search for improved solutions.

### G. Context Aware

The Context Aware algorithms choose the best network among the available network based on the mobile mobile terminal and network information. They make a balance between user demand and network condition.. The decision algorithm based on Context Analytic Hierarchy Process (AHP) is presented by [T. L. Saaty, et al.] [20]. The handoff mechanism is designed for vertical handoff initiation and decision with respect to the changes in context. It is a much more complex algorithm and deals with a much difficult point which has not taken into account earlier.

### H. Functional Based

Vertical handoff decisions based on a cost function measures the benefit obtained from switching. The first policy enabled handover strategy is proposed by [H.J. Wang, et al.] [5]. They have used a cost function to select the best available network. This algorithm allows the users to express parameters such as cost, performance and power consumption with their weights. But the cost function presented in this paper is very preliminary and cannot handle complicated configurations.

Other Policy based work is proposed by [K. Radhika et al.] [15], where the Automatic Handover Manager (AHM) provides a solution for selecting the best target network based on automatic computing concepts. This paper describes how to compose the context evaluation function and formulate a policy.

Pramod Goyal & S. K. Saxena[14] have proposed dynamic decision model for Vertical Handoff Decision algorithm. They have calculated a score function for each candidate network. The network having a highest value of score function is selected as "Best Network" to handoff all the current information to the selected network.

### F. Multiple Attributes Decision Making

Multiple attributes decision algorithm chooses an alternative from a set of alternatives which are characterized in terms of their attributes. The various MADM methods are:

Simple Additive weighting method (SAW) [K. Savitha, et al.][18]: In this the overall score of a candidate network is determined by the weighted sum of all the attribute values.

K. Radhika, et al.[15], had proposed Gray Relational Analysis (GRA) to rank the candidate network and then selects the network with the highest ranking value.

D. Lee, Y. Han and J. Hwang [3], have proposed Quality dependent vertical handover decision algorithm for fourth generation (4G) Heterogeneous network.They have designed a decision function and cost factor calculation algorithm. The network with the highest quality and lowest cost is selected as the target network for handover.

# VI.   ANALYSIS

Table-1 outlines the Name of the algorithm, Method used for decision, Input parameters, Complexity of algorithms, Reliability, Advantages and their Drawbacks. Traditional method considers only few numbers of parameters. Whereas User Centric approach considers the user related parameter and preferences. On the other hand, Multi Attribute decision algorithm considers the maximum number of parameters for decision. Some uses Fuzzy based methods .Which is an intelligent approach. The Context aware decision algorithm considers the user and network context information. This is an efficient method, but with more constraints. The cost function based method uses both static and dynamic parameters for decision making. But there are only few papers which consider call dropping rate and handoff blocking rate as a decision parameter.

# VII.   RESEARCH ISSUES

The future Wireless system will be the integration of various wireless access technologies. Therefore, In order to provide seamless, continuous services many challenging issues must be solved**:**

### A. Security Issues

In a wireless transmission, the data are broadcast over the air interface and people do not have control over the transmission boundaries. Therefore, when a sensitive data is transmitted, it should be transferred in a secured manner.

### B. QoS Issues

Mobile nodes carrying real time and non-real time traffic should be provided with guaranteed Qos.

### C. TCP Performance Issues

When a handoff occurs from a low bandwidth, high data rate network to a high bandwidth, low data rate network then functioning of TCP gets affected. Therefore TCP performance should be considered.

# VIII.   CONCLUSION

The aim of heterogeneous wireless network is to offer high quality services. Vertical handoff is a most challenging issue for a heterogenous network to allow seamless roaming for mobile nodes. In this paper, various handoff strategies are discussed. It's clearly concluded that Advanced Analyical strategies are mandatory for an efficient handoff decision algorithm and every efficient handoff decision algorithm should determine the right time for handoff initiation. The various requirements for efficient handoff are low power consumption, balanced network load, network security, user preferences, throughput and low handoff latency. But establishing the requirement of a vertical handoff decision for NGWNs is a critical milestone.

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# APPENDIX - A

## TABLE 1:  OUTLINE TABLE OF VERTICAL HANDOFF DECISION ALGORITHM

| Method | Input Parameters Used | Handover target selection area | Complexity | Reliability | Advantages | Drawbacks |
|---|---|---|---|---|---|---|
| Traditional Method | RSS with Threshold | The Candidate network with the highest stable RSS | Simple | Reduced reliability because of fluctuation in RSS | Reduced number of handoff blocking | Low through put ,also the user preferences are not considered |
| Cost Function Algorithm | Static and Dynamic parameter such as cost, bandwidth, power, consumption,RSS | The candidate network with the highest score value | Simple | Reduced reliability because of the difficulty in accurate measuring of some parameters | Simplest & Fastest handoff process, | Ambiguous handoff decision |
| User Centric Approach | User related parameters and preferences RSS, bandwidth, power | The candidate network with the highest value of user satisfaction | Complex | Reduced reliability because it considers only user preferences.For a good handoff decision network network conditions and constraints should also be taken into account | Maximize the user's level of satisfaction | Network parameters are not considered |
| MADM | Network related and system related parameter (e.g. bandwidth, power, cost, delay, jitter, real & non-real time application) | The candidate network with the highest overall performance | Complex | High reliability | Reduces computational overhead and handoff latency | Qos parameters are not considered |
| Context Aware | User information, user device & network context information | The candidate network with the highest overall performance | Complex | High reliability but there are more constraints | Minimum number of handoff and less delay | Multimedia traffic is not considered |
| Fuzzy & Neural based Approach | Bandwidth , RSS, jitter, type of application (real,non real),delay,error rate | The candidate network with the highest overall performance | Very Complex | High reliability because of intelligent system | Excellent performance for delay sensitive application | Increases the complexity |
| MADM | Bandwidth,jitter,security, cost, loss | The candidate network with the highest overall performance | Complex | High reliability but there are more constraints | Reduces computational overhead and handoff latency | Increases the complexity |

**AHP-Analytical Hierarchical Process**

**SAW- Simple Additive Weight**

**MADM-Multi Attribute Decision Making**