A Survey on Vertical Handover in Heterogeneous Networks

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***Abstract*- One of the major design issues in heterogeneous wireless networks is the support of vertical handover. Vertical handover occurs when a mobile terminal switches from one network to another (e.g., from WLAN to CDMA 1xRTT). Seamless handover between different access technologies is a great challenge as it needs to obey different performance of QoS and security constraints. Vertical handover decision algorithms are essential components of the fourth generation (4G) heterogeneous wireless networks. These algorithms should be designed so as to provide the required Quality of Service (QoS) to a wide range of applications. In this survey paper, we study the vertical handover algorithms and the problems in the solution for achieving an efficient seamless handover and lower call drop ratio.**

***Index Terms*— Handover, VHD, Algorithm, Networks, Bandwidth.**

I. INTRODUCTION

After more than two decades of development, modern mobile cellular networks have now almost approached to the commercial level of fourth generation communication networks. For each of the mobile solutions, there are special attributes but also similarities compared to the other competitive solutions though relationship between the old and the new generation solutions still exists. During communication, the handover procedure is a very important concept that may affect the connection quality and continuity. 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. So, efficient and reliable handover schemes and algorithms are required for seamless mobility between heterogeneous wireless access networks.

The handover process can be carried out in three phases (as shown in Fig. 1) [6, 11]:

• **Handover Initiation Phase**: It is also called as handover information gathering or system discovery. It is used to gather all the required information to identify the need for the handover and then initiate it.

• **Handover Decision**: It is also called as network or system selection. It is used to determine whether to do handover and how to perform it by selecting the most suitable network according to the handover selection criteria and also by giving the subsequent instructions to the next phase that is handover execution phase.

• **Handover Execution**: It is used to select the network according to the handover decision phase.

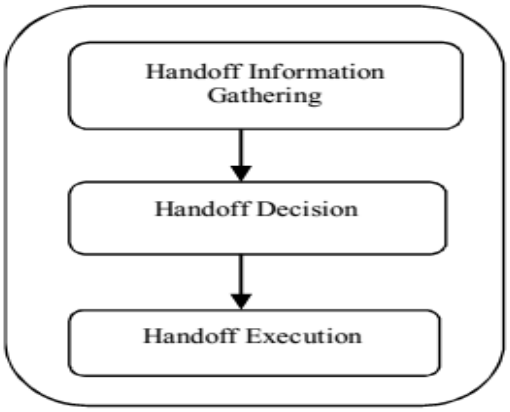

Fig 1. Handoff management process

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. The main capabilities of Vertical handovers over Horizontal handovers are:

1. Vertical handovers use different access technology.
2. Vertical handovers use multiple network interfaces.
3. Multiple IP addresses are used in Vertical handovers.
4. QoS parameters can be changed in Vertical handovers and multiple parameters are used.
5. Multiple network connections are used in Vertical handovers

The vertical handover decision criteria (as shown in Fig. 2) that have been proposed in the research literature for use in the VHD algorithms.

• Received signal strength: handover decision is a handover initiation phase in homogeneous environment.

RSS is the traditional handover decision criteria in almost all existing horizontal handover algorithms. RSS is also an important decision criteria in the VHD algorithms. Received signal strength (RSS) is the most widely used criterion because it is easy to measure and is directly related to the service quality. There is a close relationship between the RSS readings and the distance from the mobile terminal to its point of attachment. Majority of existing horizontal handover algorithms use RSS as the main decision criterion, and RSS is an important criterion for VHD algorithms as well.

Network connection time: It is referred to as the duration that a mobile terminal remains connected to a point of attachment. Determination of the network connection time is very essential for selecting the right moment to initiate a handover so that the satisfactory level of service quality could be maintained.

For example, in a handover between WLAN and cellular network, a handover done too early from a WLAN to a cellular network would waste network resources while being too late would result in a handover failure. So the network connection time estimation is also important for reducing the number of false handovers, as handing over to a target network with comparatively short connection time should not be expected. It is related to a MT's location and velocity. Both these factors affect the RSS at the MT. The variation of the RSS then determines the time for which the mobile terminal stays connected to a particular network. Network connection time is especially important for VHD algorithms because heterogeneous networks usually have different sizes of network coverage.

• **Available bandwidth**: It is a measurement of available or consumed data communication resources expressed in bits per second. It is a good indicator of traffic conditions in the access network and is especially important for delay-sensitive applications.

• **Power consumption**: If a MT's battery is low it becomes a critical issue, in such case it would be preferable to handover to a PoA 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.

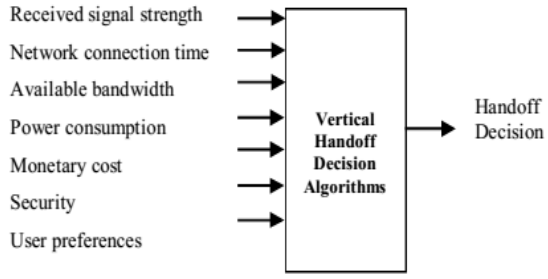

Fig. 2. Parameters used for making vertical handoff decisions

There are various ways to classify VHD algorithms [5,7]. Here, we have chosen to divide VHD algorithms into four groups based on the handover decision criteria used and the methods used to process these.

a) **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 [8,13,17].

b) **Bandwidth based algorithms**: Available bandwidth for a mobile terminal is the main criterion in this group [2,6,16]. In some algorithms, both bandwidth and RSS information are used in the decision process [3,17]. Depending on whether RSS or bandwidth is the main criterion considered, an algorithm is classified either as RSS based or bandwidth based.

c) **Cost function based algorithms:** This class of algorithms combine metrics such as monetary cost, security, bandwidth and power consumption in a cost function, and the handover decision is made by comparing the result of this function for the candidate networks [4,11,18]. Different weights are assigned to different input metrics depending on the network conditions and user preferences.

d) **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.

e) **Multiple Attributes Decision Making Based Algorithms**: The multiple attributes decision making based algorithm (MADMA) [20] calculates the quantitative value of each normalized attribute and evaluates the target systems through the weighted function of the quantitative values, the final decision can then be made.

f) **Authentication Based Algorithms:** Authentication during handover is one of the main challenges. The user has to execute multi-pass authentication procedures in order to get access to the other network. This causes overhead on the AAA server and increases the delay of authenticating the user and that is because of unnecessary and repeated procedures and protocols. These algorithms provide proactive handover and authentication process that maintains QoS and reduces the handover delay.external

II. LITERATURE SURVEY

Vertical Handoff involves three phase's handoff initiation, handoff decision and execution. In initiation phase information between different layers such as RSS, bandwidth, link speed, throughput, jitter, cost, power, user preference etc. are collected and new access network is selected.

In decision phase the connection re-switch decision is made and in execution phase authentication and authorization is done before transferring user context information. Many algorithms have been proposed in each of these phases and in this survey, we examine all the phases and identify the areas of improvement. This work will identify the open areas in vertical handover, so that our future work will address solutions for these open issues. Previously many surveys have appeared, but they generally address only one stage like initiation, decision or execution. Our survey will be comprehensive and address the all the problems from handover initiation to handover completion. The below mentioned Table. 1 gives overall work done by several authors on vertical handover to achieve better services to mobile users in heterogeneous wireless networks.

Author	Work done	Problems
Issaka Hassane [1]	By using RSS method they able to reduce the number of handover failures and unnecessary handovers	RSS was the only parameter used for deciding handover.
Riaz HUSSAIN [2]	Based on a geometrical model he derived the probability distribution of traversal length and provided a linear approximation of the pdf	Increased number of unnecessary handovers
Sassi Maaloul [3]	Based on knowledge of the mobile node and the provided context information of the network to take an intelligent and optimized decision	It is not scalable and latency is high
Gamal Abdel Fadee [4]	Applied SINR prediction based method to achieve smooth vertical handover	Prediction mechanism model can be improved.
QElaheh Arabmakki [5]	By using this mathematical model the probability of handover was derived and used for handover decision making.	Based only on RSS is not sufficient in 4G
José María Rodríguez [6]	Addressed the vertical handover from the view of energy conservation at the mobile terminal	Not covering the full 4G mobility scenarios

Table 1: Summary of the Survey

Open Issues: As we see the survey we notice following problems in the solutions

a) Most solutions are specific for particular network combination and not generic to all networks.

b) The solutions pay little attention to the energy saving at user equipment side.

c) Many solutions don't address re-association delay and mechanism to reduce it.

d) The vertical handoff decision process can use multi criteria and current network condition instead of RSS alone.

III. CONCLUSION

Unfortunately currently proposed VHD algorithms either lack a comprehensive consideration of various network parameters or the studies reporting these algorithms lack enough detail for implementation. So therefore our paper summarizes the current works in the vertical handover on all three fronts' initiation, decision and execution. We explored the problems in the current solutions and identified the open areas for further research.

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