An Overview on Decision Techniques for Vertical Handoffs across Wireless Heterogeneous Networks

Akhila S, Jayanthi K Murthy, Arathi R Shankar, Suthikshn Kumar

Abstract- Wireless communication of the future will comprise of several heterogeneous networks whose access technologies will vary to a large extent on the network capacity, data rates, bandwidth, power consumption, Received Signal Strength and coverage areas. With their complementary characteristics, integration of these networks to offer overlapping coverage to mobile users pose many interesting research challenges to bring about anytime, anywhere connectivity. The best of these networks with their varying characteristics can be brought about through a process called vertical handoff. Vertical handoff is the seamless transfer of an ongoing user session between these networks and requires accurate and precise decisions about the availability of the networks and their resources for connection. A good handoff decision should avoid unwanted handoffs which leads to an increased computational load or should not miss making a handoff leading to an ongoing service being dropped causing packet loss. Many techniques for vertical handoffs have been proposed in literature which are based on several parameters, but there still exists some ambiguity as to which of these parameters give an optimum performance. This paper aims at providing an account on the various policies developed in the decision phase of the vertical handoff.

Index Terms- Heterogeneous Networks, Mobility Management, Vertical handoff, handoff decision.

I. INTRODUCTION

The main attraction of wireless communication lies in the ability to communicate and exchange information on the move. The demand for the available services anytime anywhere is accelerating at a very high rate which calls for an integration of the various wireless access technologies. With the current technologies varying widely in their bandwidths, latencies, frequencies and access methods, the next generation systems will allow global roaming among a range of mobile access networks.

This calls for a seamless transfer of the Mobile Terminal (MT) to the best access link among all available candidates with no perceivable interruption to an ongoing conversation[1]. It should also provide an end-to-end optimization that takes into account variables such as throughput optimization, routing optimization, delay profiles and economical profitability. The actual trend is to integrate complementary wireless technologies with overlapping coverage, to provide the expected ubiquitous coverage and to achieve the Always Best Connected (ABC) advantage [2]. The Always Best Connected concept should enable a user, to choose among a host of networks that best suits his or her needs and to change when something better becomes available. It requires a framework that supports mobility management, access discovery and selection, authentication, security and profile server. This calls for an efficient Vertical Handoff Decision(VHO) scheme which involves a tradeoff among several handoff parameters such as network conditions, system performance, application types, power requirements, mobile node conditions, user preferences, security cost and the Quality of Service(QoS). These parameters may have varying levels of importance in the decision process [3]. Also, the handoff solution should be network-layer-transparent and infrastructure-modification-free so that existing Internet server and client applications can painlessly survive the rapid pace of wireless technology evolution [4].

Akhila S :Assistant Professor, Dept of Electronics & Communication Engineering, BMS CollegeofEngineering,India (Email:bmsakhila@yahoo.co.in)

Jayanthi .K. Murthy: Assistant Professor, Dept of Electronics & CommunicationEngineering,BMSCollegeofEngineering,India(Email:jayanthi.ece@bmsce.ac.in)

Arathi R Shankar: Assistant Professor, Dept of Electronics & CommunicationEngineering,BMSCollegeofEngineering,India(Email:arathi.ece@bmsce.ac.in)

Suthikshn Kumar:Professor,Dept of Information Science, P E S Institute of Technology, Bangalore, India (Email:suthikshn.kumar@pes.edu

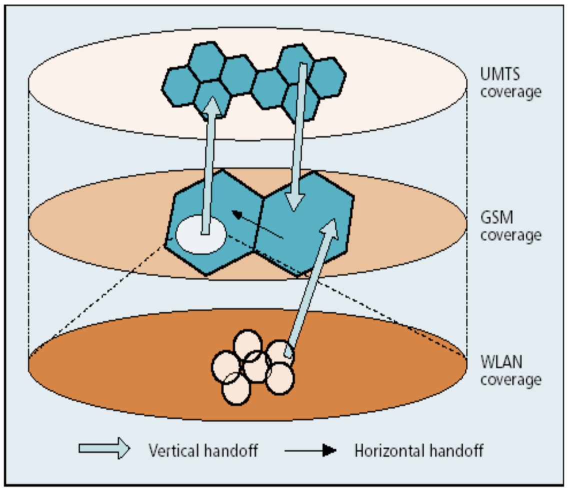

Fig. 1: Horizontal and vertical handoff

The handoffs are classified into two main streams, Horizontal Handoff (HHO) and Vertical Handoff (VHO). Figure1 illustrates horizontal and vertical handoff. The main distinction between Vertical Handoff and Horizontal handoff (HHO) is symmetry.

	VHO	*HHO*
Access Technology	Changed	Not Changed
QoS Parameters	May be changed	Not Changed
IP Address	Changed	Changed
Network Interface	May be Changed	Not Changed
Network Connection	More than one connection	Single connection

Table 1: Difference between Vertical and Horizontal Handoff.

While HHO is symmetric or an intra-technology based process, VHO is an asymmetric or an inter-technology based process in which the MT moves between two different networks with different characteristics [5]. The vertical handoff process involves three main phases [6] [7], namely system discovery phase, decision phase and execution phase.

During the *system discovery phase*, the MT scans for available candidate network for connection which may include several parameters like the supported data rates and QoS parameters. This phase needs to be invoked periodically, since the users are mobile.

In the *decision phase*, the mobile terminal determines whether the connections should continue using the existing network or be switched to another network depending on various parameters like the type of the application (e.g., conversational, streaming), minimum bandwidth available, delay constraints, cost, transmit power and the user's preferences.

In the *execution phase*, the connections of the mobile terminal are handed over to the new network in a seamless manner. Authentication, authorization, and transfer of a user's information is done during this phase.

Handover discovery and decision phase can sometimes overlap, since some situations may require more additional probing of the network condition. A delay in handoff process can be differentiated into three main mechanisms [10].

Discovery Time (t_d): During this period, the mobile terminal perceives its new wireless network range either through the trigger-based router solicitation or waits to receive a router advertisement from an access router in the visited network and gets its router advertisement (RA) from the new access router.

Address Configuration Interval (t_c): During this period, the mobile device receives the Router advertisement and updates its routing table. A new care-of- address (CoA) will be based on the prefix of the new router that is obtained from the RA.

Network Registration Period (t_r): This is the period during which the binding update(i.e., the association of home address with a care-of address) to the home agent as well as the correspondent node is sent and first packet from the correspondent node is received.

Since the binding acknowledgement from correspondent node is elective, optimizing IP-level vertical handoff delay would involve minimizing the discovery time and network registration period. The decision phase is the most important phase in VHO since it determines how meaningful the handoff is to the user. This needs an extensive research to find accurate ways of discovering precise decision techniques which may include one or more parameters. The objective of this paper is to show how decision parameters or policies affect VHO. A brief survey of the various decision making techniques used has been provided.

II. TECHNICAL FEATURES OF VHO

ISSN 2229-5518

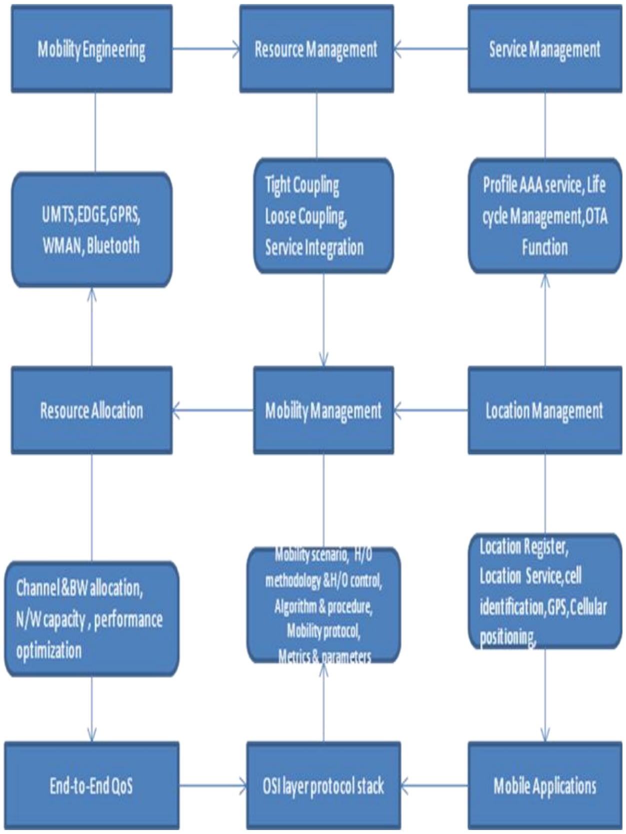

FIG 2: System Architecture of Vertical Mobility

Figure 2[9] shows the technical feature of Vertical handoff which describes three main categories- Mobility Engineering, Resource Management and Service Management.

Resource management consists of two m

[13].Stevens-Navarro E, Wong V," Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks", in Proc. of IEEE VTC'06, pp. 947-951

ain parts i.e. direct and indirect resource allocation in heterogeneous wireless networks. Direct resource allocation refers to channel and bandwidth allocation where as indirect resource allocation refers to network capacity and performance optimization. QoS is directly based on resource allocation whereas end-to-end QoS needs other managements such as packet's priority in router using header compression on wireless network and packet's buffering in routers and terminal. Mobility Engineering consists of heterogeneous networks and services such as mobility management, design and implementation of multiple protocols, middleware solution in OSI protocol stack layer [8],[9].Service management offers interactive mobile applications, location management, mobile services and service life cycle via over-the-air (OTA) provisioning functions used for upgrading and downloading the services.

III. RELATED WORK:

With the three phases available for performing a handoff in heterogeneous networks, the MT will have a choice of several networks to which it can connect to. But the outcome of the decision phase of the VHO, which is dependent on several parameters like available bandwidth, battery power status of the mobile terminal, cost, received signal strength (RSS), etc. will decide on the network to which a connection will be made. The performance of the network connection also depends, in part, on the signal strength which also depicts the power present in the received signal. Between a MT and access point (AP), the wireless signal strength in each direction determines the total amount of network bandwidth available along that connection. RSS has a great role in the horizontal decision process due to its compatibility between the current attachment point and that of the candidate attachment points. But in VHO, the RSSs are incomparable due to asymmetrical nature of the heterogeneous networks. However, it can be used to determine the availability as well as the condition of different networks. If more than one candidate network is available, the MT should associate itself with the one having the strongest RSS as it does in HHO.

Considerable work has been done in literature to determine the appropriate parameters that can be considered in the decision process for VHO. In [11], the authors have proposed a vertical handoff decision (VHD) algorithm that maximizes the overall battery lifetime of the mobile terminal in the same coverage area and also aims at equally distributing the traffic load across the networks. This algorithm when implemented in multiple Vertical Handoff Decision Controllers (VHDC) located in the access networks can provide the VHD function for a region covering one or multiple APs or BSs. The decision inputs for the VHDCs are obtained over the Media Independent Handoff Function (MIHF) of IEEE 802.21. This MIHF facilitates standards based message to be exchanged between the various access networks (or attachment points) to share information about the current link layer conditions, traffic load, network capacities, etc. Though the performance results which are based on detailed simulations show that the proposed algorithms perform comparatively better, the received signal strength which is a major indicator of the quality of service, should be considered to establish the superiority of the algorithm. It would have been a better option to study the probability of the number of unnecessary handoffs taking place or the probability of the number of handoffs being missed leading to increase in the probability of call dropping.

In[12], a decision method called ALIVE –HO(adaptive lifetime-based vertical handoff) is proposed which is based on the Received Signal Strength (RSS).This parameter is used to estimate coverage of the wireless network and the best network is selected using vertical handoff algorithms. An adaptive handoff based on the availability of the bandwidth till the time the MT stays in the network is considered. ALIVE- HO algorithm dynamically adopts to the Mobile Terminals (MT)velocity to decrease the unnecessary number of handoffs and ping pong effect but the probability of handoff increases with the distance from the AP. It is also established that the number of unnecessary handoffs using ALIVE handoff algorithm is less than that of algorithms based on traditional RSS hysteresis. According to the authors, the simplest method to increase RSS is to increase the transmit power, which needs further investigation , since an increase in transmit power might lead to an increase in interference leading to a decrease in QoS. This might be a practical solution only in open areas and may not be feasible in urban areas due the cluttered environment, in which case additional parameters need to be considered in the decision process.

Stevens *et. al* [13] have selected parameters such as bandwidth, delay, jitter and bit error rate (BER) to conduct their comparisons of some of the prominent decision algorithms in literature, that is, simple additive weighting (SAW), technique for order preference by similarity to ideal solution (TOPSIS), multiplicative exponent weighting (MEW) and the grey relational analysis (GRA).Good performance improvement of SAW and GRA over several vertical handoff decision algorithms has been obtained. The GRA decision algorithm provided a slightly higher bandwidth and lower delay for interactive and background traffic classes while MEW, SAW and TOPSIS provided almost similar performance.

The available bandwidth and delay encountered has been considered as decision parameters by Chuanxiong *et al* [10]. The performance of the algorithm is evaluated against throughput and unnecessary handoff rate that is experienced during a handoff process. Unique feature of this work is the capability of reacting to roaming events proactively and accurately with a small handoff delay. The proposed system reacts to roaming events proactively and accurately, and also maintains the connections' continuity seamlessly. The work of [14] employs the use of a cost function involving bandwidth, power consumption and financial cost for demonstrating the performance of the work with respect to the handoff latency encountered. All algorithms that employ cost functions require manual inputs by the user. This could be a disadvantage since the algorithm needs to cater to the users request as one of the input parameter and could result in poor handoff in the event of any fault in the input. In the dynamic decision model proposed by Pramod and Saxena[15], dynamic factors like the RSS and velocity of the mobile, and static factors like cost, bandwidth and power consumption of the mobile terminal has been taken into consideration for making a decision to handoff. This model has been developed using a three phase approach namely the priority phase, the normal phase, and the decision phase. Selecting the best network based on the dynamic factors is performed in the priority phase. A network with highest difference between the RSS and the threshold RSS is given priority. In the normal phase, cost function for each static parameter like cost, bandwidth and power is recorded based on their weight factors. Then the network with highest weight factor is selected. In the decision phase, decision as to which is the best network to handoff is made by obtaining a score function i.e., by multiplying the priority from the first phase with the cost function from the normal phase for each of the candidate network. The network with the highest score function will be the candidate network. This model aims at combining both static and dynamic parameters to perform a handoff. Though a reduction in the number of unnecessary handoff has been established this model is a simple model and is more suitable for soft vertical handoffs. However the authors need to elaborate on the interval over which RSS is calculated and how velocity of the mobile is calculated.

Algorithms dealing with both horizontal and vertical handoff scenarios with minimal changes in infrastructure which requires deployment of handoff servers only on the Internet was proposed by Ling-Jyh Chen et al[4]. The Universal Seamless Handoff Architecture (USHA) is an upper layer solution and provides a seamless handoff instead of using new transport protocol or new session layer through the middleware design strategy. The handoff, either vertical or horizontal, occurs only on overlaid networks using soft handoff technique. USHA may lose connectivity to upper layer application, if the coverage from multiple access methods fails to overlap.

IV. LIMITATIONS OF VERTICAL HANDOVER

Though the concept of vertical handoffs enables integration of networks with complementary features, like wide coverage area with low data rate or limited coverage area with high data rate, they still have some limitations:

- It handles all the connections in same manner.
- When all TCP/IP connections are automatically transfered from one interface to another, then, only one wireless interface, normally the one with end user specific application (the best one) is used at that instant. The second limitation is the need for same network interface. All wireless interfaces must be used as part of the same Mobile IP and

DNS infrastructure since mobile nodes and peers must be able to reach the Mobile IP and DNS server.

- Some networks may contain nodes that may not be a part of direct peer to peer infrastructure due to which, the very importance of wireless diversity is lost. Usually the peer to peer connections are most efficient because sometimes they offer shortcuts for slow and expensive infrastructure.

V. NEED FOR CONSIDERING INCREASED NUMBER OF DECISION PARAMETERS

Most of the Vertical Handoff decision algorithms developed use two or more parameters for the performance analysis of the algorithms. Some are based on the static parameters like access cost, security features and power consumption rate since these parameters maintain a relatively constant value over a period of time. The algorithms which are based on continuously changing values like available bandwidth, data rate, Received Signal Strength and Bit error rate are said to use dynamic parameters. A decision algorithm gives a better performance when several parameters are considered, more so when a combination of static and dynamic parameters are considered. But the tradeoff is with the increase in decision time and complexity of the algorithm. Considering fewer decision parameters, might cause an inaccurate decision leading to poor performance. Very few algorithms are available in the literature which calculates the probability of unnecessary handoffs or handoffs being missed that are encountered with each of the metric considered and which of these parameters when considered can lead to reduced number of wrong decisions to handoff. These conflicting reasons or requirements calls for algorithms which are neither too complex nor too simple. Since there are several algorithms available which are based on several parameters, deciding the best parameters which provides seamless mobility, reduced delay, reduced number of unnecessary handoffs' and deciding on the best algorithm that can be practically implemented becomes difficult. Though RSS is a major parameter that needs to be considered for obtaining a good QoS, this cannot be easily measured owing to the rapid variations in its value over short distances or even small intervals.

VI. CONCLUSION:

The ability to roam among the available networks with minimum modification in the infrastructure will be the future of wireless communication for which an efficient Vertical Handoff algorithm is an essential feature. It is the decision phase which has maximum responsibility for the whole process since it is this process that decides on the number of parameters to be considered along with the optimum time that should be allowed to make a decision. The system capacity and service quality improvement can be achieved through an efficient decision algorithm cost effectively. A survey of the current handoff decision techniques developed with various parameters considered and the effect of these parameters on the decision process has been made in this paper. The general implementation structure of VHO is given and several important static and dynamic parameters that are considered in the decision process of Vertical handoff has been emphasized. It can be concluded that a better decision can be obtained by employing as many measurable decision parameters possible, be it static or dynamic.

REFERENCES:

[1]. Xiaohuan Yany Y. Ahmet S,_ekercio_gluy Sathya Narayanan "A Survey of Vertical Handoff Decision Algorithms in Fourth Generation Heterogeneous Wireless Networks", Elsevier 2010.

[2]. E. Arun, R.S Moni, "A Novel Decision Scheme for Vertical Handoff in 4G Wireless Networks", Global Journal of Computer Science and Technology, Vol. 10 Issue 5 Ver. 1.0 July 2010.

[3].YawNkansah-Gyekye, Johnson I Agbinya, "Vertical Handoff Decision Algorithm for UMTS-WLAN", The 2nd International Conference on Wireless Broadband and Ultra Wideband Communications, (AusWireless 2007).

[4].Ling-Jyh Chen, Tony Sun, and Mario Gerla "USHA: A Practical Vertical Handoff Solution" Multimedia Services Access Networks, 2005. MSAN '05.

[5].Nishith DT, Nortel JHR, Hugh FV." Handoff in cellular systems", in IEEE Personal communications, 1998.

[6]. J. McNair and F. Zhu, "Vertical Handoffs in Fourth-generation Multinetwork Environments," *IEEE Wireless Communications*, vol. 11, no. 3, June 2004.

[7]. W. Chen and Y. Shu, "Active Application Oriented Vertical Handoff in Next Generation Wireless Networks," in *Proc. of IEEE ,WCNC'05*,.

[8] Xiaoxin Wu, Mukherjee B & Ghosal D," Hierarchical arc hitectures in thethirdgeneration- cellular Network", IEEE Wireless Communications 2004

[9] Mika Ylianttila, **"**Vertical handoff and mobility system architecture and transition analysis**",**

University of Oulu, 2005

[10].Rajiv Chakravorty ,Pablo Vidales◎ ,Kavitha Subramanian , Ian Pratt , Jon Crowcroft "Performance Issues with Vertical Handoffs – Experiences from GPRS Cellular and WLAN Hot-spots Integration", Pervasive Computing and Communications, 2004. PerCom 2004.

[11].SuKyoung Lee, Kotikalapudi Sriram, Kyungsoo Kim, Yoon Hyuk Kim, and Nada Golmie,"Vertical Handoff Decision Algorithms for Providing Optimized Performance in Heterogeneous Wireless Networks", IEEE transactions on vehicular technology, January 2009

[12]. Muhammad Amir Latif, Abid Aziz Khan" quality of service during vertical handoff in 3g/4g wireless networks", Blekinge Institute of Technology, 2009

[14]. Wang HJ, Katz RH, Giese J Policy,"Enabled Handoffs across Heterogeneous Wireless Networks", Proc. of ACM WMCSA. '99.

[15]. Pramod Goyal, and S. K. Saxena "A Dynamic Decision Model for Vertical Handoffs across Heterogeneous Wireless Networks", World Academy of Science, Engineering and Technology Vol. 31, July 2008.