Paper ID: VESCOMM 27

A SURVEY ON VERTICAL HANDOVERS FOR NEXT GENERATION WIRELESS NETWORKS

Ajay Yelegaonkar
E&TC
S.E.S. Polytechnic, Solapur
Solapur, India
ajay_yelegaonkar@hotmail.com

Associate Prof. Sajid Shaikh
E&TC
V.V.P.I.E.T, Solapur
Solapur, India
sajid0077@gmail.com

Abstract — Every user expects the best service network rather than best connected network. Due to the various heterogeneous wireless network availability, users get a choice of selecting the best service network, based on various preferences. Mobility is possible due to handoff process. 4G networks are known for their seamless connectivity between existing networks which include GSM, wireless LAN, Bluetooth etc. Such next generation 4G networks are represented by heterogeneous environment with different access network technologies that vary in bandwidth, latency and cost. Seamless Connectivity in such networks entirely depends on efficient handoff mechanisms. In this paper we study various proposals of handoff decision strategies.

Keywords— Mobility, 4G Networks, handoff mechanism, heterogeneous wireless networks.

I. INTRODUCTION

The 4G networks would be heterogeneous in nature where there would be multiple service providers, equipped with varied technologies offering varied services for the benefit of the users. In 4G networks a mobile node in network could access services and bandwidth offered by other service providers [1]. Handoff or Handover is the process of maintaining user's active session when a mobile terminal changes its point of attachment. Depending on point of attachment the handoff can be either horizontal or vertical as expressed in Figure 1.

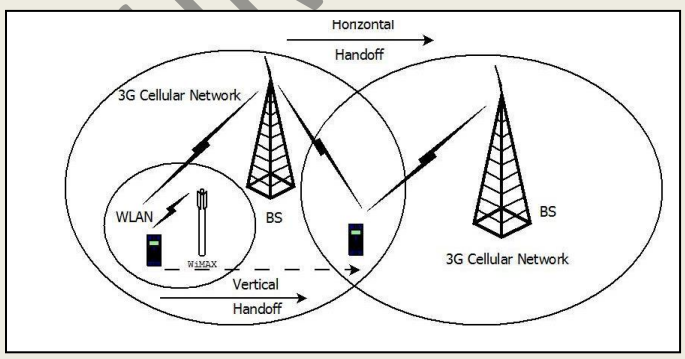

Figure 1: Horizontal and Vertical Handoff

Horizontal handoff takes place between point of attachment supporting the same network technology e.g. between two neighbouring base stations. Vertical handoff takes place between points of attachment supporting different network technologies e.g. between an IEEE 802.11 access point and a cellular network base station [2]. Vertical handoff can be initiated for convenience rather than connectivity reasons. 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.

II. VERTICAL HANDOVER

A. Vertical Handoff Process:

A handover process can be split into three stages: handover decision, radio link transfer and channel assignment [1].

- **Handover decision:** This process involves the selection of the target point of attachment and the time of the handover.
- **Radio link transfer:** It is the task of forming links to the new point of attachment.
- **Channel Assignment:** It deals with the allocation of channel resources. VHD algorithms are useful in the way that they help mobile terminals to choose the best network to connect to among all the available candidates.

B. Criteria for VHD:

In this literature several parameters have been proposed for use in the VHD algorithms. We briefly explain each of them below.

- **Received signal strength (RSS)**: RSS is the one of the mail criteria for VHD. The RSS is easy to measure and it is directly related to the quality of service. 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:** For choosing the right moment to trigger a handover, determining the network connection time is very important. Network connection time refers to the duration that a mobile terminal remains connected to a point of attachment.
- **Available bandwidth:** It is a measure of available data communication resources expressed in bit/s.
- **Power consumption:** When mobile terminal's battery is low the power consumption becomes critical issue. In such situations, it would be preferable to handover to a point of attachment which would help extending valuable battery life.
- **Monetary cost**: In some situations the cost of a network service should be taken into consideration in making handover decisions because for different networks, there would be different charging policies.
- **Security**: A network with higher security level may be chosen over another one which would provide lower level of data security when confidentiality or integrity of the transmitted data can be critical.
- **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.

III. CLASSIFICATION OF VHD ALGORITHMS

There are various ways to classify VHD algorithms [5]. VHD algorithms are divided into four groups based on the handover decision criteria used and the methods used to process these are as follows:

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 [3].

b. **Bandwidth based algorithms:** Available bandwidth for a mobile terminal is the main criterion in this group [7]. 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.

IV. VHD ALGORITHMS

a. RSS Based VHD Algorithms:

In RSS based algorithms Received Signal Strength is the main criteria. These types of VHD algorithms compare the RSS of the current point of attachment against the others to make handover decisions. The algorithm is proposed [17] for handover between 3G networks and WLANs by combining the RSS measurements either with an estimated lifetime metric or the available bandwidth of the WLAN candidate. We can describe the method using following two scenarios.

In the first scenario, when the mobile terminal moves from the coverage area of a WLAN into a 3G, a handover to the 3G network is initiated. When RSS average of the WLAN connection falls below a predefined threshold, and the estimated lifetime is less than or equal to the handover delay, the handover is triggered. In the second scenario when the mobile terminal moves towards a WLAN cell, the handover to the WLAN is triggered if the average RSS measurements of the WLAN signal are larger than a threshold and the available bandwidth of the WLAN meets the bandwidth requirements of the application. An algorithm is proposed [4], between WLAN and 3G which is based on comparison of the current RSS and a dynamic RSS threshold when a mobile terminal is connected to a WLAN access point. The dynamic RSS threshold is useful in the way that it reduces the incidences of false handover initiation and keep the handover failures below a limit.

To eliminate the unnecessary handovers which is introduced in the above method, a travelling distance prediction based algorithm [4] is developed. The algorithm considers the time the mobile terminal is expected to spend within the cell. The method relies on the estimation of WLAN traveling time (i.e. time that the mobile terminal is expected to spend within the

WLAN cell) and the calculation of a time threshold. A handover to a WLAN is triggered if the WLAN coverage is available and the estimated traveling time inside the WLAN cell is larger than the time threshold. The main advantage of this method is that it minimizes handover failures, unnecessary handovers and connection breakdowns however increased handover delay is introduced.

b. Bandwidth Based VHD Algorithms:
In these type of algorithms the available bandwidth is the main criteria for the handover. A QoS based algorithm is proposed [6], which takes residual bandwidth and user service requirements into account in deciding whether to handover from a WLAN to Wireless Wide Area Network (WWAN) and vice versa. The algorithm also takes the state of the mobile terminal into consideration. If the mobile terminal is in the idle state, a handover to the preferred access network is performed; otherwise the handover decision is based upon the user application type. This method is able to achieve high throughput as the available bandwidth is considered as the main criteria for VHD. Also by taking application types into account, lower handover latency for delay-sensitive applications is achieved. To improve the overall system throughput an algorithm is developed between WLAN and Wideband Code Division Multiple Access (WCDMA), which takes into consideration the Signal to Interference and Noise Ratio (SINR). The SINR calculation of the WLAN signals is converted to an equivalent SINR to be compared with the SINR of the WCDMA channel. SINR based handovers can provide users higher overall throughput than RSS based handovers since the available throughput is directly dependent on the SINR, and this algorithm results in a balanced load between the WLAN and the WCDMA networks. However these algorithms may also introduce ping-pong effect. To reduce the unnecessary handovers a Wrong Decision Probability (WDP) prediction based algorithm [2] is proposed. In this method the probability of unnecessary and missing handovers is combined and WDP is calculated.
This algorithm is able to reduce the WDP and balance the traffic load.

c. Cost Function Based VHD Algorithms:
The basic idea of a cost function based vertical handoff decision algorithm is to choose a combination of network and DE factors such as RSS, network covering area, available bandwidth, service cost, reliability, security, battery power and DE mobility model, etc. and define a cost function based on these factors to evaluate the performance of target networks. The handoff decision can then be made accordingly.
A multiservice based algorithm relies on a cost function which calculates the cost of all possible target networks. In this algorithm all the active applications are prioritized and then cost of each possible target network for the service with the highest priority is calculated. This method is beneficial due to the use of cost function, also the percentage of user satisfied requests is increased and handover blocking probability is reduced. Cost function based handover decision algorithm with normalization and weight distribution is proposed in which the normalization and weights distribution methods are provided [4]. A network quality factor is used to evaluate the performance of a handover target candidate. With the help of this method high system throughput and user's satisfaction is achieved. A weighted function based algorithm which delegates the VHD calculation to the visited network instead of the mobile terminal. The network candidate with the highest weight function is selected as the handover target. The advantage of this method is handover decision delay is reduced, low handover blocking rate and high throughput.

d. Multiple Attributes Decision Making Based Algorithms:
The multiple attributes decision making based algorithm (MADMA) 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. In Simple Additive Weighting (SAW) based MADM [6], different factors are assigned different weights which could be dynamically adjusted according to network state and various user services, therefore, it is possible to guarantee different user QoS requirement and improve the performance of the whole network meanwhile. Gray Relation Analysis Based Algorithm (GRAA) is an analytical method to determine correlation degree of different factors based on the similarity and difference of factors represented by grey relational coefficient (GRC). GRC is applied to calculate the correlation of each candidate network with user current network and the candidate network with highest correlation of current network is chosen as handoff destination network. GRA can also be combined with other methods such as fuzzy logic and AHP to improve the performance of vertical handover algorithm. GRAA is able to analyze different system factors given only few data and the trend of system development can be measured quantitatively, thus GRAA is very suitable for dynamic network analysis, however, the computation complexity is large which limits the practical application.

e. Combination Algorithm:
Combination algorithms combine various parameters in the handover decision such as the ones used in the cost function algorithms. These algorithms are based on artificial neural networks or fuzzy logic. A VHD algorithm is developed based on artificial neural networks (ANN) [8]. The mobile device collects features of available wireless networks and sends them to a middleware called vertical handover manager through the existing links. The vertical handover manager consists of three main components: network handling manager, feature collector and ANN training/selector. A multilayer feed forward ANN is used to determine the best handover target wireless network available to the mobile device, based on the user's preferences. Fuzzy logic method

can be designed to solve vertical handoff problem with fuzzy parameters. A fuzzy logic based algorithm is developed which is used to handle handovers between WLAN and UMTS. A pre-decision unit is used in this method. This algorithm is able to improve the performance by reducing the number of unnecessary handovers and avoiding ping-pong effect.

f. Authentication Based Algorithms:
In NGN, security is considered as one of the most challenging problems introduced by mobile networking. User mobility increases the risk of illegal users masquerading as legal users. So there is a need that the handover process should provide security as well as authentication scheme. Also it should be able to reduce the authentication delay during the handover process. An authentication scheme for fast handover between WI-Fi access points is proposed, in which the author has used the EAP-SIM (Extensible Authentication Protocol). The scheme uses the pre-authorization and it eliminates the need for communication with the remote server when the handover actually takes place. This scheme is capable of reducing the authentication delay and the linear dependency on the RTT (round trip delay) between the AP and the authentication server is also broken. In [9], the author has proposed a holistic approach that eliminates the repeated steps of authentication without affecting the security level, to optimize QoS parameters during handover. In this method a valid certificate is issued at the time of registration of MN with AAA server. This valid certificate is in consensus with all the service providers which will be unique and valid for each network. This method reduces the number of repetitions which will save the bandwidth, time and cost. Reduction is handover latency, packet loss and cost is obtained.

V. CONCLUSION

In RSS based algorithms the RSS is considered as the main criteria. In terms of complexity the RSS based algorithms are the simplest algorithms. In bandwidth based algorithms the RSS is combined with bandwidth, these algorithms are also simple. In terms of complexity the cost function based, combination, MADMA and authentication based algorithms are more complex as more parameters are taken into consideration. Combination algorithms combine various parameters to determine the target network for handover helping to select the best available network as per the user's preferences. However, they are mostly in the theoretical analysis stage or still too complex for implementation. Authentication based algorithms provide security also reduction is delay, packet loss and cost. So the computational power of handsets should be improved to implement several VHD algorithms in a handset and adopt adaptive methods that choose an algorithm intelligently based on conditions and user preferences.

References

[1] Sarla More, Dr.Durgesh Kumar Mishra, "4G Revolution: WiMAX Technology", Professor and Head Department of Computer science and EngineeringThakurShivkumar Singh Memorial Engineering College Burhanpur, India 2010.

[2] NidalNasser, "Handoffs in Fourth Generation Heterogeneous Networks" University of GuelphAhmedHasswa and HossamHassanein, Queen's University2010.

[3] S. Mohanty, I.F. Akyildiz, A cross-layer (layer 2 + 3) handoff management protocol for next-generation wireless systems, IEEE Transactions on Mobile Computing 5 (10) (2006) 1347–1360.

[4] X. Yan, N. Mani, Y.A. S_ekercioglu, A traveling distance prediction based method to minimize unnecessary handovers from cellular networks to WLANs, IEEE Communications Letters 12 (1) (2008) 14–16.

[5] Xiaohuan Yan, Y. Ahmet S ekercioglua,, Sathya Narayanan "A survey of vertical handover decision algorithms in Fourth Generation heterogeneous wireless networks" —Department of Electrical and Computer Systems Engineering, Monash University, Melbourne, Victoria, Australia 2010.

[6] Lahby Mohamed, Cherkaoui Leghris and Adib Abdellah, Network Selection Decision Based on Handover HistoryinHeterogeneous Wireless Networks,International Journal of Computer Science and Telecommunications Volume 3, Issue 2, February 2012.

[7] K. Yang, I. Gondal, B. Qiu, L.S. Dooley, Combined "SINR based vertical handoff algorithm for next generation heterogeneous wireless networks", in: Proceedings of the 2007 IEEE Global Telecommunications conference (GLOBECOM'07), Washington, DC, USA, November 2007, pp. 4483–4487.

[8] N. Nasser, S. Guizani, E. Al-Masri, "Middleware vertical handoff manager: a neural network-based solution", in: Proceedings of the 2007 IEEE International Conference on Communications (ICC'07), Glasgow, Scotland, June 2007, pp. 5671–5676

[9] Ganti,S. Ambudkar, B.,"Fast Authentication During Handover In NGN", International Conference on Communication Systems and Network Technologies (CSNT), 2012