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Review of Vertical Handoff Algorithms in 4G – Networks

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Abstract: 4G refers to the fourth generation of cellular wireless standards which is designed to facilitate improved wireless capabilities, network speeds, and visual technologies. It is an IP-based infrastructure with the support of heterogeneous access technologies which provides user best network connectivity. In 4G network user allowed to handover between networks with different types access technologies supporting vertical handoff. Due to this reason mobility management becomes a complex issue. Therefore Vertical handover decision (VHD) algorithms are essential components of the architecture of the 4G - networks. The main challenge while designing a vertical handover algorithm is minimizing handoff latency and packet drop keeping required level of Quality of Service (QoS). In this paper, we provide a complete survey of the VHD algorithms designed to satisfy these requirements along with their classification.

Key words: 4G – Networks, Mobility Managements, Vertical handoff, Handoff performance, fuzzy logic, etc.

I. INTRODUCTION

4G wireless systems expected to provide higher data rates and allow global roaming among a diverse range of mobile access networks [1]. It is a pure packet switched network with Mobile IPv6 as backbone. Since it is a pure packet switched network the available bandwidth is utilized efficiently. Today there are number of mobile access networks available such as General Packet Radio Service (GPRS), Enhanced Data for Global Evolution (EDGE), Universal Mobile Telecommunications System (UMTS), Wideband Code division multiple access (W-CDMA), Worldwide Interoperability for Microwave Access (WiMAX), Long Term Evolution (LTE) etc [2]. These networks vary in their features such as bandwidth, latency, cost, coverage and Quality of Service (QoS) etc. The following tables 1 gives the comparison of maximum download and upload speeds for some of the mobile access networks.

Table: 1 Comparison of upload and download speeds mobile access networks.

Generation	Standard	Download	Upload
2.5G	GPRS	114Kbps	20 Kbps
2.75G	EDGE	384Kbps	60 Kbps
3G	UMTS	384Kbps	64Kbps
	W-CDMA	2Mbps	153Kbps
3.5G	HSPA +	56Mbps	22Mbps
	WiMAX	6Mbps	1Mbps
	LTE	100Mbps	50Mbps
4G	LTE advanced	1Gbps	500Mbps

In 4G - network users allowed to roam between different network technologies without any interruptions [3]. The available different access networks will be used to meet the optimum cost and performance and to fulfill the requirement to be always best connected. Due to diverse characteristics of heterogeneous networks there are several open and unsolved issues namely mobility management, network administration, security etc. Hence, designing efficient mobility management to seamlessly integrate heterogeneous wireless networks with all-IP is the most challenging issue in 4G networks.

Mobility management contains two components: location management and handoff management [3]. Location management [19] enables the network to discover the current attachment point of the mobile node for call delivery. Handover management enables the network to maintain a user's connection as the mobile terminal continues to move and change its access point to the network. In 4G – Network there are two types of handovers namely horizontal handover and vertical handover. Handover in homogeneous wireless network is referred to as horizontal handoff and Handover in heterogeneous wireless network is referred to as vertical handoff (VHO). Therefore in 4G systems, handoff management is more complex to deal with. The following table gives the summary of comparison of horizontal and vertical handover.

Table: 2 Comparison of horizontal and vertical handover

Parameter	Horizontal Handover	Vertical Handover
Access Technology	Will not change	Changes
QoS Parameters	Will not change	May change
IP address	Changes	Changes
Network Interface	Will not change	May change
Network connection	Single	More than one

It is difficult to design the vertical handoff method with maintaining the various Quality of Service (QoS) requirements [18]. Handoff latency is a factor used to measure the performance of handoff algorithm and it is measure of amount of time spent in handoff. If handoff latency is too long, packets may get lost or disconnections may occur during the handoff leading to degradation of QoS. Therefore, fast and seamless handover is a major challenge for 4G heterogeneous networks. Moreover in order to support real-time high-speed multimedia applications require small handoff delay and high data-rate transmission.

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II. VERTICAL HANDOFF

A Vertical handoff is a handoff between two network access points, which are using different connection technologies. For example, when Mobile Node (MN) handovers from 802.11b network to a GPRS network, the handoff would be considered a vertical handoff. Since VHO is involves heterogeneous network, the MN moves between two different networks with different characteristics. The VHO operation should provide a minimum overhead, authentication of the mobile users and the connection should be maintained to minimize the packet loss and transfer delay [15]. Due to heterogeneous nature of 4G – Network, supporting seamless vertical handoff among heterogeneous networks is a crucial but challenging task, for different access networks having different unique networking characteristics such as mobility, quality-of-service (QoS), and security requirements. Vertical handoff can be divided into two subclasses namely upward and downward handoff. In Vertical Handoff, if the mobile switches from the network with a small coverage to a network of larger coverage then it is called as upward handoff. On the other hand, a downward handoff occurs in the reverse direction, i.e. from a network of larger coverage to a network of smaller coverage.

The vertical handoff process involves three main phases [4][5], namely system discovery, vertical handoff decision, and vertical handoff execution. System discovery phase involves determining available networks. The available networks parameters can be obtained from network base station. Network base station periodically advertises its parameter vales like supported data rates and Quality of Service (QoS). Since the users are mobile, this phase may be invoked periodically. In the vertical handoff decision phase, the mobile terminal determined whether handover to new network is needed or not based on collected parameter values. The decision may involve various parameters including the type of the application, minimum bandwidth and delay required by the application, access cost, transmit power, and the user's preferences. During the vertical handoff execution phase, the connections in the mobile terminal are re-routed from the existing network to the new network in a seamless manner. This phase also includes the authentication, authorization, and transfer of a user's context information. An extensive research work has been carried out in the area of designing a mobility management for heterogeneous network which optimizes the handoff delay, packet loss, packet delay, handoff failure probability etc., is the challenging issue for the researchers [20].

III. CLASSIFICATION OF VERTICAL HANDOFF ALGORITHMS

Various vertical handoff decision algorithms have been proposed in literature, which can be classified based on number of parameters considered for handoff decision. They are listed as below:

a. RSS based algorithms
b. Velocity based algorithms
c. User preference based algorithms
d. Context aware based algorithms
e. Multiple Attribute Decision based algorithms
f. Fuzzy Logic (FL) and Neural Networks (NN) based algorithms

A. RSS based algorithms:

This group of algorithms uses Received Signal Strength (RSS) as main criteria for handoff decision. The RSSs of the different candidate network are measured periodically and the network with the strongest signal strength is selected as target network. Various algorithms have been developed to compare the RSS of the currently connected network with that of the candidate network. Since heterogeneous wireless networks consist of different wireless access network, this group of algorithms cannot be applied to support vertical handoff in 4G – Network. Moreover their RSSs of different wireless access network cannot be compared directly [17][18].

B. Velocity based algorithms:

Velocity of the mobile can be considered during handoff decision. Handing off to an embedded network in an overlaid architecture of heterogeneous networks is discouraged when travelling at a high speed [12]. This is because a handoff back to the original network will occur very shortly afterward when the mobile terminal leaves the smaller embedded network. Therefore, if coverage radius of the Access Point is low mobile node moving with high speed then it is better to use its previous network without the handover. Different techniques have been presented to perform handoffs, using velocity as the main decision criterion. If the MS in a heterogeneous environment moves with a relatively high velocity, the probability of a call drop may be higher due to excessive delays caused by the handoff process. In [16] the authors proposed a multi-mode vehicle terminal based speed adaptive vertical handoff policy in vehicular heterogeneous networks.

C. User Preference Based Algorithms:

These approaches mainly take into account the end-users' preferences. Since 4G is a heterogeneous wireless network, different wireless network have different characteristic features. User preference in terms of MN's power consumption [9], associated service cost, offered security, and the QoS provided by a candidate network can be considered for handoff decision. These algorithms can be used to maximize the end-user's satisfaction while utilizing non-real-time applications [10].

D. Context-Aware (CA) Based Algorithms:

The context-aware handover concept is based on the knowledge of the context information of the mobile terminal and the networks in order to take intelligent and better decisions. Thus, a context-aware decision strategy manages this information and evaluates context changes to get decisions on whether the handover is necessary and on the best target access network [13][4]. In [17] the authors proposed a handover decision making process which uses context information regarding user devices, user location, network environment and requested QoS.

E. Multiple Attribute Decision based algorithms:

Multi-Attribute Decision Making (MADM) can be applied to problems which involves ranking or evaluating a finite number of alternatives with multiple attributes. Since vertical handover decision problem deals with making selection among available candidate networks with respect to different criteria this can be considered as MADM problem. The most popular classical MADM [14] methods are: Simple

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Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA) [15] etc. In SAW method the overall score of a candidate network is determined by the weighted sum of all the attribute values. In TOPSIS method the chosen candidate network is the one which is the closest to ideal solution and the farthest from the worst case solution. GRA for Vertical Handover Decision Schemes in Heterogeneous Wireless Networks compares two vertical handover decision schemes (VHDS), Distributed handover decision scheme (DVHD) [22] and Trusted Distributed vertical handover decision schemes (T-DVHD) [21]. AHP was used to determine the weights for the three models requiring information about the relative importance of each attribute.

F. Fuzzy Logic (FL) and Neural Networks (NN) based algorithms:

Fuzzy Logic and Neural Network concepts are applied to choose when and over which network to hand over among different available access networks [5]. Fuzzy logic based techniques allows to model the qualitative aspects of human experts' knowledge and reasoning behind the handoff process to be encoded as handoff algorithms [6]. If there is a comprehensive set of input-desired output patterns available, artificial neural networks can be trained to create handover decision algorithms [7]. Also these methods are combined with the MADM in order to develop advanced decision algorithms for both non-real-time and real-time applications. For example in [5] the author proposed a fuzzy approach for ranking alternatives in multiple attribute decision making problems based on TOPSIS.

IV. PERFORMANCE MEASURES OF VERTICAL HANDOFF

Performance of vertical handover is measured by the parameters such as handover delay, number of handovers, handover failure probability and throughput [18].

A. Handover delay:

It refers to the duration between the handoff initiation and handoff completion. It is also known as handoff latency. Handover delay depends on the complexity of the handover management process. If handoff delay is more, packet loss will be more. Therefore reduction of the handover delay is especially important for delay-sensitive voice or multimedia sessions.

B. Number of handovers:

Number of handovers must be reduced to avoid the wastage of network resources. A handover is considered to be superfluous when a handover back to the original point of attachment is needed within certain time duration and such handovers should be minimized (ping-pong) [20].

C. Handover failure Probability:

A handover failure occurs when the handover is initiated but fails to connect to the target network. This failure may be due to target network does not have sufficient resources to complete it, or when the mobile terminal moves out of the coverage of the target network before the process is finalized. In the former case, the handover failure probability is related to the channel availability of the target network while in the latter case it is related to the mobility of the user.

D. Throughput:

The throughput refers to the data rate delivered to the mobile terminals on the network. Handover to a network candidate with higher throughput is usually desirable.

V. CONCLUSION

In this paper we have presented a comprehensive survey of vertical handover decision schemes. 4G is a heterogeneous network environment which will provide features such as, "Always Best Connected", "Anytime Anywhere" and seamless connectivity. Due to heterogeneous nature of 4G there are several open and unsolved issues needs to be addressed such as mobility management. Vertical handoff algorithm should decide the suitable time, suitable new point of attachment and suitable criterions to initiate the handoff in heterogeneous networks. In this survey paper we have focused some issues related to mobility management in 4G – network as well as classification of existing vertical handoff algorithms are discussed.

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