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A Study on Vertical Handover Algorithms

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Abstract: In recent year's mobile services are increasing rapidly due to the need to access information anywhere, anytime. Handover is considered "seamless" when able to provide continuous connectivity for devices by handover from one network to other. Handover algorithms plays major role in deciding the best network for service. Handover algorithms are chosen. Based on parameters such as bandwidth, user preferences, RSS, velocity and network load etc... In this paper we classify HO algorithms such as RSS, bandwidth, cost based, combination, allocation, MADM algorithms.

Keywords: Multiple Attributes Decision Making, Handover, Algorithms, Next Generation Networks

I. INTRODUCTION

Now a day's Next Generation wireless system is providing multiple access networks to the user. So the mobile user can access a wide range of applications provided by multiple wireless networks. So when the mobile user moves from one place to another there is a need to handover the communication channel from one network to another by considering its features and user requirements [1]. Mobility is the most important feature of a wireless cellular communication system. Usually, continuous service is achieved by supporting handoff from one cell to another. Handoff is the process of changing the channel associated with the current connection while a call is in progress. It is often initiated either by crossing a cell boundary or by deterioration in quality of the signal in the current channel. Vertical handover decision (VHD) algorithms are essential components of the architecture of the forthcoming 4G heterogeneous wireless networks. These algorithms need to be designed to provide the required Quality of Service (QoS) to a wide range of applications.The users for variety of applications would like to utilize heterogeneous networks on the basis of their preferences such as real time, high availability and high bandwidth. When connections have to switch between heterogeneous networks for performance and high availability reasons, seamless vertical handoff is necessary. The requirements like capability of the network, handoff latency, network cost, network conditions, power consumption and user's preferences must be taken into consideration during vertical handoff.

The structure of the paper is as follows: Section II provides handover management process, Section III contains classification of vertical Handover algorithms such as RSSbased, Bandwidth based, cost based, combinational based, authentication based and MADM based algorithms.

II. HANDOVER MANAGEMENT PROCESS

Handover management process tells about how handover should be handled in VHD. Basically it works on phases, where each phase does the job of intended work. Handover process can be divided in to information gathering phase, decision phase, execution phase [2]

A. Handover Information Gathering

First phase in handover, the handover information gathering phase collects network information and also information about the rest of the components of the system such as network properties, mobile devices, access points, and user preferences.

B. Handover Decision

Second phase in handover, the handover decision phase is one of the most critical processes during the handover. This phase is also known as system selection, network selection or handover preparation. Based on the gathered information, this phase decides when and where to trigger the handover. This phase is also responsible for minimizing the number of handovers.

C. Handover execution

Third phase in handover, this phase performs the handover itself; besides performing the handover, the phase should also guarantee a smooth session transition process. In order to perform the VHO different handover strategies cooperate with control signaling, and the IP management protocols. This phase is usually known as Handover execution.

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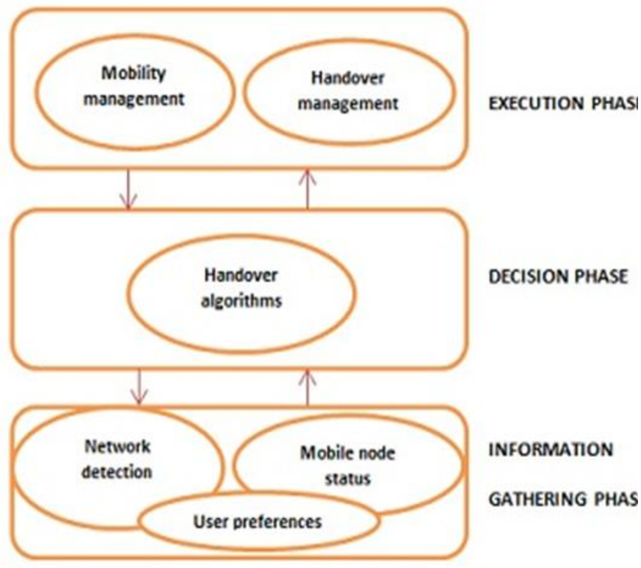

Fig. 1. Handover Management Process

III. CLASSIFICATION OF VHD ALGORITHMS

A. RSS based VHD algorithms

RSS is used as the main handover decision criterion in this group. RSS based VHD algorithms compare the RSS of the current point of attachment against the others to make handover decisions.

i) An Adaptive Lifetime Based Handover Heuristic:

Algorithm is proposed for handovers between 3G networks and WLANs by combining the RSS measurements either with an estimated lifetime metric (expected duration after which the mobile terminal will not be able to maintain its connection with the WLAN) or the available bandwidth of the WLAN candidate. Advantage of this algorithm is that it provides improvement on the available bandwidth. Its disadvantage is long packet delay and extra lookup table [3].

ii) An RSS Threshold Based Dynamic Heuristic:

Algorithm is proposed for a WLAN to 3G handover decision method based on comparison of the current RSS and a dynamic RSS threshold when a mobile terminal is connected to a WLAN access point. The use of a dynamic RSS threshold helps reducing the incidences of false handover initiation and keeping the handover failures below a limit. Its disadvantage is it may result in wastage of network resources [4].

iii) A Traveling Distance Prediction Based Heuristic:

To eliminate unnecessary handovers in the method presented in last Section, Yan et al. [5] developed a VHD algorithm that takes into consideration the time the mobile terminal is expected to spend within a WLAN 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 heuristic is that it minimizes handover failures, unnecessary handovers and connection breakdowns. But the method relies on sampling and averaging RSS points, which introduces increased handover delay.

B. BANDWIDTH ESTIMATION TECHNIQUES

This section describes existing bandwidth measurement techniques for estimating capacity and available bandwidth in individual hops and end-to-end paths. We focus on four major techniques: Variable Packet Size (VPS) probing, Packet Pair/Train Dispersion (PPTD), Self-Loading Periodic Streams (SLoPS), and Trains of Packet Pairs (TOPP).

i) Packet Pair Probing:

In [6, 7] estimates end-to-end capacity, the source sends multiple packet pairs to the receiver. From the measure of the dispersion experienced by the packet pairs, the receiver computes the end-to-end capacity. In order to cancel the influence of cross-traffic on the measurement of capacity a number of packet-pairs are sent and statistical methods are used to filter out erroneous measurements.

ii) VPS Probing:

In [8, 9] estimates the capacity of individual hops, multiple packets of a given size are sent. This technique uses the TTL field of the IP header to force the probing packets to expire at a particular hop. The source uses the ICMP error messages received from the routers to measure the RTT to that hop. TTLs of the probe packets can be suitably designed such that the TTL of a pair of probe packets expire at each hop. Thus VPS probing can be used to measure the capacity of each hop along a path.

iii) Self-Loading Periodic Streams:

SLoPS in [10] estimate end-to-end available bandwidth a series of equal-sized packet probe trains is sent at a particular rate. Depending on the trend of one way delays experienced by the stream, the sender varies its sending rate and attempts to bring the stream rate close to the available bandwidth. If the streaming rate R is greater than the path’s available bandwidth, the stream will cause a short term overload in the queue of the bottleneck link increasing the one way delays of the probing packets. On the other hand, if the streaming rate is lower than the available bandwidth, the one way delays of the probing packets will not increase. While SLoPS overcomes the inaccuracy in existing probing techniques, it requires a large number of packet streams and a very long measurement time which makes it unsuitable for real-time applications.

iv) Trains of Packet Pairs:

TOPP [11]estimate end-to-end available bandwidth, like SLoPS, sends packet streams and gradually increases the

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stream rate to measure the available bandwidth. The difference between the two methods is in the statistical processing of the measurements [12].

C. Cost Function Based VHD Algorithms

These algorithms chooses a combination of network and DE factors such as RSS, network covering area, service cost, available bandwidth, reliability, battery power, security and DE mobility model, etc. and define a cost function based on these factors to evaluate the performance of target networks.

i) Cost Function-Based Strategies (CFBS):

The Vertical handoff decision cost function is a measurement of the benefit obtained by handing over to a particular network. It is evaluated for each network n that covers the service area of a user. Weighted functions are summed with specific parameters. The network that is consistently calculated to have the lowest cost is chosen as the target network. Therefore, this cost function-based policy model estimates dynamic network conditions and also includes a stability period to ensure that a handoff is worthwhile for each mobile [13].The proposed policy-enabled handoff enables users to express policies to choose which is the best network and when to handoff. To achieve flexibility, the system separates the decision making scheme from the handoff mechanism. To achieve continues connectivity, the system considers user involvement with minimal user interaction (for automation). To improve system stability in the handoff mechanism, load balancing solution is proposed, it avoiding the handoff synchronization problem (simultaneous decision by many mobiles). For that synchronization problem the performance agent that collects the information on the current bandwidth usage at base stations, and periodically announces this information to its coverage.

ii) Based on User Preferences in Heterogeneous Wireless Networks:

The proposed vertical handoff decision is based on user preferences. if the user wants to use an application that has a high quality of service but a low price, the AP that has the maximum APQW may not be the best one, since its (APCW) may be unacceptably low (i.e., the network is too expensive). This also applies to the AP that has the maximum APCW (i.e., the AP that has the least cost) because it may have an APQW that is unacceptably low. Therefore, we define APBSW for solving these problems. An APBSW represents how well a particular AP satisfies the needs of the end user based on his or her user profile (which is selected by the end user's preferences) for a specific context. In determining an AP that best satisfies the needs of the end user, APBSWs based on fuzzy goals and fuzzy constraints have unequal importance to decision making, and the proper fuzzy decision making operator should be considered. The weighted additive model (which is widely used in vector objective optimization problems) can handle this problem; the basic concept is to use a single utility function to express the overall preference of decision making to draw out the relative importance of each criterion [14].In this case, a linear weighted utility function is obtained by multiplying each membership function of fuzzy goals by their corresponding weights and then adding the results together.

D. 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) [15]. 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. The fuzzy logic theory based quantitative decision algorithm[16] takes 3 quality of service (QoS) metric, received signal strength (RSS), available bandwidth (BW), and monetary cost (MC) of candidate networks as input parameters. The weight of each QoS metrics is adjusted along with the networks changing to trace the network condition.

E. 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 [17]. Authentication process can be explained in phases below:

1. The first phase of the handover process consists in deciding if there is a need for changing the AP, and if so, which AP the STA should be next associated with. This phase can last several seconds, but fortunately, most wireless LAN cards can do this without actually tearing down the connection with the currently used AP. 2. The next phase of the handover process contains an empty authentication step, which is the legacy of WEP (Wired Equivalent Privacy), the security architecture

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Group	Implemented Between	Input parameters	Target selection criteria	Complexity	Reliability
RSS based VHD algorithms	Between Macro cellular and Micro cellular networks	RSS as input	Network candidate with stable RSS	Simple	Reduced because fluctuation in RSS
Bandwidth based VHD algorithms	Between any heterogeneous networks	Bandwidth combined with RSS	Network candidate with the highest bandwidth	Simple	Reduced because of the changing availability bandwidth
Cost function based VHD algorithms	Between any heterogeneous networks	Cost, bandwidth and security	Network candidate with the highest overall performance	Complex	Reduced because of the difficulty in measuring some parameters
Combinational VHD algorithms	Between any heterogeneous networks	Different input parameters based on different methods	Network candidate with the highest overall performance	Very Complex	High reliability because of the training of system
MADM	Between any heterogeneous networks	Multiple attributes	Network candidate with the highest overall performance	Very Complex	High reliability because of multi attributes
Authentication Based VHD algorithms	Between any heterogeneous networks	Authentication details such as user name and password	Network candidate with the highest security	Very Complex	High reliability because of security

Table 1.Comparision of VHD Algorithms

2. The next phase of the handover process contains an empty authentication step, which is the legacy of WEP (Wired Equivalent Privacy), the security architecture specified in the original 802.11 standard. This phase does not actually provide any security, and it takes a very short time.

3. The next phase is the association phase, wherein the STA establishes a logical connection to the AP. The most important task of this phase is to inform the wired network about the fact that the given STA can now be reached through the new AP. The time needed for the association is negligible, so it is unnecessary to waste any efforts to speed up this phase.

4. The real authentication phase starts after the association phase. In this phase, the STA authenticates itself to the AAA server, which also helps to set up a shared session key between the STA and the AP. As we will see later, this phase can take a considerable amount of time, especially if the AAA server is remote.

5. Finally, the STA and the AP executes a four-way handshake, whereby they confirm the knowledge of the session key to each other, and they also derive new keys from the shared session key for various purposes. The four-way handshake is a necessary in order to be compliant with the 802.11i standard. It cannot be shortened, but fortunately it does not take too much time as it uses only local communication.

In [18], 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.

F. Multiple Attributes Decision Making

Due to nature of network selection problem, MADM methods represent a promising solution which can be applied to network selection problem. We categorize them into two kinds: (a) MADM weighting methods which includes many methods such as analytic hierarchy process (AHP), fuzzy analytic hierarchy process (FAHP), analytic network process (ANP), fuzzy analytic network process (FANP) and (b) MADM ranking methods which includes many methods such as technique for order preference by similarity to ideal solution (TOPSIS), grey relational analysis (GRA), distance to ideal alternative (DIA), multiplicative exponent weighting (MEW), simple additive weighting (SAW), VIKOR and Mahalanobis distance[1].Most popular algorithms are[19]:

i) Analysis hierarchy process (AHP):

This type of algorithms is based on the divide-and-win paradigm. The main decision problem is divided into sub problems, where each sub-problem is evaluated as a decision factor. From the set of alternative solutions, AHP finds the most optimal solution.

ii) Grey relational analysis (GRA):

This mathematical algorithm builds a grey relationship between elements (networks), one of them with the ideal quality values. So, the rest of the elements are compared and evaluated against the ideal solution. The option that better approaches this ideal solution receives the highest score.

iii) Technique for order preference by similarity to ideal solution (TOPSIS):

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Similarly to GRA algorithms, TOPSIS algorithms consider and ideal solution for performance comparison, considering as the best alternative the one nearest to the ideal solution, and as worst the one furthest from such solution.

iv) Simple additive weighting (SAW):

SAW algorithms are frequently used when MCDM is applied. This technique consists in scoring each alternative by adding the attribute values multiplied by its weight, in order to score the overall alternative, being the highest score the most optimal choice.

v) Multiplicative weighting exponent (MWE):

MWE works similarly to SAW algorithms. To score the overall alternative, it uses the weighted product of all attributes. Since this product does not have an upper-bound, it is advisable to compare the score against an ideal solution.

IV. CONCLUSION

There are various ways to classify VHD algorithms. In this article, we have chosen to divide VHD algorithms into six groups based on the handover decision criteria used and the methods used to process these. Handover algorithms are evolved rapidly recent years because of user preferences are changing enormously. Classified algorithms plays crucial role in their context. Here we discussed algorithms based on received signal strength, bandwidth, cost based, combinational, authentication and MADM.

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