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Handoff Review in Heterogeneous Wireless Network

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Abstract- *Ubiquitous connectivity facilitates mobile users to move freely across heterogeneous networks and communicate with the accessible applications. But it is not an easy task as it needs a proper mechanism to accommodate user and application needs, especially in terms of QoS.. In order to guarantee the QoS, and to choose the best candidate network and perform a fast handover, VHO techniques must carefully consider, user mobility and network conditions. This paper gives an overview of the research done in the area of handoff / handover decision making process in heterogeneous wireless networks.*

Keywords- Vertical Handover Decision (VHO), Mobility Management, QoS, Wireless Mobile Communication.

I-INTRODUCTION

The first three generations (1G to 3G) of mobile network evolved to enrich communication experience by increasing the data rates. The systems across 3G (B3G) or the 4G networks extended and enhanced mobility features, data rates and services [1]. With the development of wireless networks, users' wants for variety and quality of services are increasing. A single operator is not sufficient to fulfill these demands especially, when a user is nomadic. Being Nomadic, a user switches among variety of available networks (3G, Wifi,WiMax,CDMA,UTMS etc.) Generally known as heterogeneous wireless networks, to satisfy his wants for quality of service. This process of switching from one network to another is termed as a handover or handoff, especially *Vertical Handover* (VHO) due to the participation of heterogeneous wireless network.VHO are categorized into

Downward VHO: Handover between a network with higher area range& a network of lower area range, ex; 3G to Wifi.
Upward VHO: Handover between a network with lower area range to a network with higher area range, ex; WiMax to 3G.
While when the handover takes place between same access technology then it is refereed as *horizontal handover*, for example between Wifi and Wifi
And when the handover is between networks with common underlying technologies (Wi-XX to Wi-YY or vice versa) Such type of handover iscalled as Media Independent Handover (MIH) or Diagonal Handover .Ex: handoff between WiFi&WiMax.

Handover can be characterized in various types.

a) *Hard (*break before make) *Handover*
b) *Soft (*make before break) *Handover*

On the basis of location of the Handover decision mechanism, in a network entity or in the Mobile itself there is one more type of handover category:

- *Network Controlled Handover (NCHO)*: Here Network primarily controls the handover.
- *Mobile Controlled Handover (MCHO):* Mobile node take measurement of it's own parameters and initiates the handover decision.
- *Mobile Assisted Handover (MAHO)*: The evaluations of various parameters from the Mobile node are used by the network to decide handoff. This method is used in GSM.
- *Network Assisted Handover (NAHO)*. Information about the various parameters is collected by the network which is utilized by the mobile terminal for making handover decision. [3]

The major factor for handovers is mobility, but there may be different reasons why a handover might be conducted:

- When the mobile node is leaving one cell and entering another cell, the call is transferred to that another cell in order to avoid termination of the call.
- When the network load is full and an existing or new call located in overlapped area by another cell, is transferred to that cell so to free-up some for other users, who can only be connected to that cell;
- When a fast-travelling user, who is connected to a larger cell, stops then his call can be transferred to a smaller cell so as to free capacity in the larger cell for other fast-traveling users and also vice versa for a user whose speed is above threshold can be transferred to larger cell, so as to minimize the number of handovers.
- To get better QoS ,handover can be done from one network to other which gives better data rates or speed.[4]

Handover process consists of below mentioned phases
1.Handover Initiation
2. Handover Decision
3. Handover Execution

Homogeneous or Horizontal handover mostly considers received signal strength (RSS) value, in this case 'in which network' to handover is never a problem as handover takes place between same networking technology. However, in case of heterogeneous Handover, the process becomes complex as it includes handover between network with dissimilar radio access technologies. Thus, the criterion or parameters required for VHO can be classified as below:

- *Network related criteria:* Area covered by a network, available bandwidth, network latency, link quality , RSS (Received Signal Strength), CIR (Carrier to Interference Ratio), BER (Bit Error Rate), SIR (Signal to Interferences Ratio), monetary cost, security level, etc.
- *Terminal related criteria:* velocity of the mobile node, battery power left with the terminal, location of the mobile node, etc.
- *User related parameters:* User profile and user preferences which can be dependent on cost involved or the requirement to run an application.
- *Service related parameters:* service level capabilities, QoS.

These criteria are either static or dynamic. Static criteria such as user profile and the cost of the available networks, while the mobile terminal velocity & RSS values are dynamic in nature[3]

Mobility algorithms includes varied methods to implement a handover decision mechanism & Choosing a correct and more accurate algorithm is a crucial issue as it has direct effect on the quality of service and user experience [5].Comparison and the evaluation of these various VHO techniques would be able to give an proper hint about efficiency of a particular VHO process. This index of correctness of VHO mechanism, can be evaluated, on the below criterion:

Seamless : Handover process is considered to be ''seamless'' when it is capable of maintaining connectivity for all applications running on that particular mobile device, while providing a uninterrupted end-to-end data service within the same session during the switchover, providing low latency and minimal number of packet lost.

Packet loss (PL): it is actually the amount of packets dropped during the handover decision process. It should be as low as possible.

Throughput (TH): indicates to the data rate delivered to the mobile device during the handover. It is always desirable to have throughput value as high as possible.

Handover delay (HD): this is the time duration between the initiation and completion of the handover process. More complex the VHO process leads to more handover delay, which is undesirable.

Number of handovers (h): high number of handovers is undesirable, since frequent handovers causes wastage of network resources.

Handover failure probability (HF): when a handover is initiated and the target network does not have sufficient resources then handoff failure occurs.

Further, acceptable values of VHO evaluation matrices may vary from class to class of traffic. For example, non-real time traffic can manage large delays While real time traffic are highly sensitive to delay. [3]

Based on methodology usedin decision making scheme for VHO they can be classified as

1) RSS based VHO Schemes
2) QoS based VHO Schemes
3) Decision Function based VHO Schemes
4) Network Intelligence based VHO Schemes
5) Context based VHO Schemes
6) Cloud based VHO

RSS based VHOSchemes

Mobile nodes does the initial scanning of networkwhich helps to check available wireless networks present in the vicinity. RSS of the current point of attachment is

compared with the RSS of the other available target networks or with predefined RSS threshold, for making a handover decision. Since these method are simple, most of the traditional algorithms are based on signal strength only. But, these algorithms have large number of unnecessary handoff due to fluctuating RSS. Few of RSS based schemes are as follows

Dwell timer based Schemes. Dwell-time (TD) is defined as the time for which the MN persists with higher data rate even after the RSS level falls below the threshold. In [6]a handover is initiated if the RSS value of a network is continuously below a threshold value and smaller than the sum of the new RSS value and a hysteresis. The paper analyzed optimized value of the dwell-timer which was varying according to the scenario(entering or leaving the network) and user velocity and handoff delay. But this algorithm increases the risk of high dropping rate and low utilization.

Authorin [7] proposeda prototype considering dynamic dwell timer ,for this a centralized Radio Control Unit (RCU) is designed to adjust the dwell timer with respect to the coverage area of the network and speed of the user. As soon as the mobile node enters in to the coverage area its handover requirements are evaluated by the RCU and this estimation is given to the nearby RCUs. This assist in minimizing number of packet lost and handover delay due to pre-intimation.

In [8] a new handover method is introduced by combining different techniques: (1) *Detection of tendency of signal which estimates* the requirement of upward or downward vertical handover. (2)*Adaptive Threshold Fixing* that adjusts according to velocity and network parameters and it approximates the handover delays and, (3)*Dwell Timer* interval is reduced for high speed. This scheme efficiently minimizes handover failure rate and ping-pong effect but increases extra volume of signaling which rises number of packet lost.

Authors in [9] considered RSS threshold, estimated lifetime metric (An expected time after which a mobile node is unable to continue its connectivity) and Application Signal Strength Threshold (mixture of the channel BER and applications' QoS requirements) to minimize the number of unnecessary handovers and increase throughput. However, there is rise in packet transfer delay because of involvement of increase lifetime metric .

An application-aware scheme is proposed in [10],where they have modified the scanning time and amount of channels depending on application type but, this also adds in expenditure of battery power.

In [11] Handover is initiated only if the user is in the coverage and if users' approximated traveling time in that particular network is more than the threshold time. This scheme, reduces unnecessary handovers and possibility of handover failures. However, there is increase in handover delays as sampling & taking mean of RSS value is a lengthy process.

QoS Based Schemes

Generally RSS and SINR based methods are alike, but basically RSS helps in maintaining connectivity while, SINR helps in upgrading the QoS. QoS based VHO decision schemes are categorize in following ways :

Available Bandwidth based Schemes: Author of[12]considers available bandwidth and user preference for VHO.If the mobile node is idle then a handover is initiated otherwise, depending on the application type handover decision is made.The suggested method has higher throughput and low handover latency. This method has high blocking rate for recently arriving applications because of handovers implementation in idle state .

Authors in [13] has proposed mechanism, where due to the insufficient resources to handle heavy traffic loads, handover from one WLAN to cellular network is done only if no other WLAN network is available in the proximity. This mechanism has proper load balancing and optimizes battery life of the mobile and also minimizing the Ping-Pong effect and number of unnecessary handovers.

SINR Based Schemes: In [14] Handover is initiated if the mobile terminal obtains higher SINR from other available network. This scheme shows improved throughput and lower handover failure rates but, the quality of the scheme degrades at higher velocity. Also ithas increased latency and more number of unnecessary handovers.

In [15] &[16] authors have suggested new parameter called as *Interference-to-other-Interferences-plus-Noise Ratio* (IINR). If association costs are less than the association gains then the mean throughput can be improved. But, this mechanism is suitable for cooperative network scenario only. Author of [17], calculated the congestion status of the candidate point of attachment (PoA) beforehand. The proposed scheme minimizes the handover delay however, other parameters are required to

be considered for optimizing handover decision making process.

User Profile based Schemes: Such scheme [18] proposed the user preferences based VHO in order to satisfy users needs in terms of QoS and monetary cost. While [19] proposed to consider user velocity, RSS and user preferences as mobility decision parameters for VHO. This minimizes the handover delay and packet delivery delay but it consumes more resources of the networks as users switch frequently, causing ping-pong effect.

C. Decision Function based Schemes

As different access technologies have different characteristics and different purpose to achieve. Proper Handover decision and network selection gives rise to a multi-criteria decision making (MCDM) problem .There are different schemes depending on the decision function .

Utility Function based Schemes: Utility refers set of parameters such as monetary cost and other parameters required by specific applications , needed to achieve users' satisfaction level [20]. In [21] author proposed a user centric and interface management scheme where they opted terminal controlled handover solution. Later, power saving interface management scheme was proposed which considered velocity &battery lifetime of the mobile node, switched off inappropriate network interfaces. The major drawback of these schemes is that it does not offer proper network selection.

Cost Function based : in [22] depending on the application, the total cost of the available network is estimated by summing up the cost of QoS parameters like available bandwidth, battery requirement and delay related to network. The network with lowest cost for maximum services is selected for handover which helps to reduce call blocking probabilities. [23] Included the parameter like cost, security, velocity of user and power requirement of the mobile unit. These parameters are normalized and are assigned weights so as to calculate the performance of available network. These schemes have better throughput and user satisfaction. But, network parameters like security and signal interference are difficult to evaluate. Authors in [24] have used GPS and network maps to evaluate the current location of the user along with cost and user preference. Here authors have completely ignored RSS and effect onQoS.

*Multiple Attribute Decision Making (MADM)*scenario is usually defines the set of network parameters that belongs to the current running applications for instance RSS, available bandwidth, security, packet lost.some of the methods for making handover decisions are:

1. Simple Additive Weighting (SAW): The summation of the weights of all parameters values helps to estimate the score of available network.
2. Technique for order preference by similarity to ideal solution (TOPSIS): Network having score closest to the a paradigm solution and away from the negative ideal solution is selected..
3. Analytic Hierarchy Process (AHP): Any network is selected by identifying the parameter hierarchy of choices and criteria.
4. Gray relational Analysis (GRA): Every system in between systems with no information and systems with perfect information is defined as a greysystem. The network with the top score is chosen for the handoff procedure. [25]
5. ELECTRE (elimination and choice translating reality) ranks the best available network using pairwise comparisons of available parameters and evaluating each parameter individually.
6. VIKORis quite similar to TOPSIS which uses an score function that takes in to consideration closeness to the ideal solution.

Network Intelligence based Schemes

Intelligent schemes such as *Fuzzy Logic* (FL), *Artificial Neural Networks* (ANN) and genetic algorithm are applied in order to choose which network to handover. Fuzzy logic handle imprecise data efficiently and also helps to aggregate and compute many criterion concurrently [26]. A combination of Fuzzy logic& AHP method is been used in [18], which gives good results with respect to delay and throughput.

Artificial neural networks, have the ability to interpret complex information and memorize typical trends from it. Hence, ANN can be trained to predict a mobile node handoff by learning complex relationships among the various inputs and output criteria of a handoff system. A combination of neural networks& fuzzy logic can be considered to make vertical handoff decisions. Fuzzy Logic System (FLS) are rule based, and requires huge storing capacity and complex computational capability. By substituting the rule base in FLS by an ANN to achieve an adaptive algorithm that maintains high performance of FLS and imparts an efficient architecture for storage and computational needs.

Author in [27] suggested neural network based scheme that has three layers namely input , hidden &output layer.

The weights are altered in these layers with respect to the error in the output and thus the desired output is obtained. Author in [28] used back-propagation neural network considering RSS and traffic intensities. This reduces numbers of handovers but delays increases due to learning procedure.

In [29], a Vertical Handover Manager (VHM) middleware is proposed which uses neural networks-based approach. This middleware has three main components (1) Network Handling Manager, (2) Feature Collector, and (3) Artificial Neural Networks Training/Selector. If here the learning rate is properly tuned then the best available network is selected optimally but takes more time for performing handover process due to large size neural packages and time consuming training.

Similarly, [30] introduced fuzzy& neural network incorporated mechanism for making handover finding. FLC applies the predefined rules and networks having signal level and load above the values of thresholds are separated and then, best link provider network is chose. This beforehand selection reduces the Fuzzy logic controller complexity and requires less operating time.The proposed approach gives high latency and is suitable for little environment variations and is not adjustable to the latest network conditions.

Authors in [31] employed Packet Success Rate (PSR) as a link level evaluator in place of RSS and ANNs helps in learning the network behavior. This is due to the fact that PSR lowers the handover delay.

In [32] & [33]a fuzzy logic based VHO decision scheme is proposed where input parameters are converted as crisp values and fuzzy set respectively. Then they are evaluated in accordance with the predefined handover rules to obtain crisp value or single fuzzy decision sets and delivered to the defuzzifier to get the final decision for handover. This method minimizes handover delay & number of packet lost but increases the decision making delay because of the involvement of fuzzification and de-fuzzification processes.

The authors in [34], suggests that if the user and its velocity in WLAN network is more than required threshold velocity *then*, a handover is initialized in UMTS network to continue connectivity. In some proposed work, RSS values are predicted and accordingly pre-decisions are made for handoff, which reduces delay.

Authors in [35] focuses on completely centralized VHO while in [36] focuses on decentralized. Authors aims to lessen the power consumption of the mobile node and handover failure rate by managing respective interfaces. But it is seen that this scheme generates overheaddelay

Authors in [37] proposed two approaches: (1) fuzzy logic supported network selector depending on closeness of the new available networks and arriving calls, and (2) genetic algorithm based bandwidth allocator by measuring the amount of bandwidth required for call arrival, dropping and blockage. But this increases computation and overhead.

Authors in [38] considered node authentication in networks, for Mobile Controlled Handovers (MCHO). Where a authentication ticket is produced which helps to speed up verification of the newly approaching mobile nodes in a particular network. Here AAA mechanism is used which minimizes number of packet lost because all the data is rerouted to the preselected network.

Context based VHOSchemes

Context is basically information, related to the situation of an entity [39] [40]. It is required to have correct, accurate and timely delivery of information to mobile users.

Mobile agent based Schemes: In [41] a mobile agent dependent decision method is proposed, it's architecture has three parts: (1) a context management framework,(collecting and managing the context data)(2) a programmable platform(to download and install the required modules for contextual transfer) and (3) a service deployment scheme(to manage & synchronize the operation of all mobile agents). It uses rule based system for handover decisions. This reduces the handover decision delay and increases throughput but even one failure might damage the working of the system as there is no sharing of data. Also, when a handover is required then the intended mobile agents is supposed to be called, downloaded and installed from the service depository unit which maximizes the handover delay. Above this, it requires a frequent communication between the terminal and wireless network which adds signaling overhead.

Authors of [42] proposed mobile agent based architecture having three types of agent : (1) Multi-Access Provider (MAP) supports the activities of other agents (2) Wireless provider agents and (3) Terminal device agents. It uses a network controlled handover so as to avoid wastage of terminal resources. User preferences is

ignored as the approach is network oriented. Handover latency is more and there is an increase in signaling overhead.

Context-aware MADM based Schemes: [43] employed the AHP, considering network parameters (like BER delay and jitter) and mobile node parameters (like node speed, node memory capacity and battery life).Scores are allotted to the network parameters then, reachable networks are compared and are ranked, the highest ranked network is chosen. This scheme is suitable were more network are available.

Scheme in [44] minimizes call dropping rate during handover, power needed, According to traffic classes, and with the help of AHP weights are calculated for different network parameters. The perceived QoS is used as feedback to alter weights so as to improve perceived Qos.

In [45], suggested a network selection algorithm which considers battery level of the mobile node, to minimize undesirable handovers when the level of battery is critical. The algorithm involves AHP along with Grey Relational Analysis (GRA) to chose the best network based on user preferences. Similarly, [46] reputation based game theoretical model which focuses on recognizing the user behaviors based on the history for a particular network .

Context-aware Mobility Prediction based Schemes: A mobility prediction mechanism is proposed in [47] which takes parameters such as time of the day, time spent in that network, handover record, group for handover decision instead of RSS. Accordingly movement pattern is evaluated and then handover decision is made in anticipation. The major disadvantage is, if the user goes with a unusual routine with respect to time of day or his mobility pattern then all the calculations are required to be re-evaluate which increases handover delay and number of lost packets.

Authors of [48] suggested to maintain the historical data related to users' mobility pattern and whenever a mobile user follows similar path with steady velocity, handover is done to network which are already known. But if the user have unsteady velocity and or , if any intermediate network is switched off or unavailable then it affects the blocking rate and throughput.

In [49] GPS is used to recognize the location of the mobile node which helps in predicting the mobility pattern, speed and the transverse direction of the user. This method helps to minimizehandover latency and number of packet lost. But there is a problem of validity of the stored information since as speed changes many other information changes.

Context aware based Schemes for Cooperative handover: A game theory based, bidding model, handover decision scheme [50] considers monetary cost, delay, number of packet lost, Bandwidth jitter. Each network is denoted as a bid. The usefulness of the candidate network is evaluated with a function then, game progresses in number of rounds. This gives good load balancing but increases handover delay as a result of complex bidding process.

*Context-aware Schemes for MIH :*Media Independent Handover (MIH), [51] scheme carry out cooperative handover by gathering and storing neighborhood information from network and mobile both. In [52], authors proposed a novel architecture Improved Information Server (EIS) built for networks having MIH. Which could improve the cooperative VHO mechanism. EIS collects updated data about RSS values, location of the node & timing from the Mobile node needed for triggering the handover. This helps in avoiding the channel scanning which in turn reduces overall handover latency. Prior information gathering, result in increased signaling overhead.

An integration of MIH framework and SCTP protocol (used for multi streaming, ideal path selection and multi-homing) is proposed in [53]. Here it is assumed that the protocol requires to be aware regarding congestion in the network, while transferring context data and needs to adapt its transfer rate according to it. Due to this they are able to get low packet lost and less handover delay. A hybrid technique is proposed in [54] for IP based multimedia system handover using SIP, FMIP and MIH. Suggested scheme lessens service interruption time & packet losses by exchanging the contextual data in advance by MIH framework. This produces somewhat extra handover delay due to exchange of handshaking signals between various protocols.

Cloud based Schemes

(RSS), monetary cost, quality and mobile speed, risk parameter i.e secure access risk are given as input to cloud interface controller for *Risk-aware VHO Algorithm* in [55]. Performance of security access is significantly enhanced compared to fuzzy logic handoff. But achieves average throughput and satisfaction compared to fuzzy logic handover.

Cloud-based network selection scheme for vehicular network using game model is explained in [56]. The database is maintained in the cloud which helps the vehicles on the way to choose the best network. This scheme gives supports a larger network compared to conventional algorithm also gives balance system throughput and fairness, but it is a time consuming method.

Self adaption based handoff mechanism for multimedia service in cloud for mobile is introduced in [57]. The scheme incorporates multipath transmission for media transfer, and includes duplicate mode and the effective mode, which are altered with respect to the network state. Number of packet lost is less and enhances efficient use of always insufficient wireless bandwidth compared with the traditional handoff methods. Drawback of this system is increase in power consumption.

Network Selection for Autonomous Mobile Devices is considered in [58]. The mobile node has an intelligent agent that collects data depending on the approximation from the wireless environment, and shares this data between different mobile nodes through a common entity in the cloud. This helps to improve the Quality of Experience (QoE) with respect to network coverage area, data rate provided , and battery life time but this demands extra computing.

A Virtual Room based VHO cloud solution (VOOH application &Server) is proposed in [59] VOOH is a option, independent of network operator that uses existing wireless access technologies for the purpose of connectivity. It achieves Seamless voice cloud based service without making any alterations in the existing network architecture. High scalability and reliability. In this proposal the mobility of a user is not addressed.

IV. Conclusion

In this work, vertical handover decision methods are compared in terms of handoff evaluation matrices such as Handoff latency, number of handovers, number of packet lost, signaling cost, Handoff failure rate, Throughput, input parameters (RSS, QoS, User Preference, Bandwidth) their complexity and the methodology involved in choosing a network.

The RSS and QoS dependent schemes utilizes the values of RSS and bandwidth and hence are the simplest , cheapest & bears low signaling cost of all the methods. But are not efficient with respect to Handoff latency, number of Packet lost, Ping pong effect, unnecessary handoff, average throughput & average handoff failure rate. Decision or cost function based schemes are a bit complex since they need to collect and normalize varied network parameters. Which helps to get the weight of that network parameter and rank different available networks. They are having average handoff evaluation matrices. The network intelligence schemes and context aware schemes are more complex and difficult to implement, hence suffer from the long delays. Schemes using Fuzzy logic and neural network achieve better throughput but the difficulty is due to their bulky nature they cannot be employed in a larger environment. Network Intelligence and context based schemes afford to receive low handover failure rate as they employ distributed handover decision making methods.But , most of them are in conceptual stage or are very complicated to be implemented in the current scenario.

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