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A Survey on Handovers Literature for Next Generation Wireless Networks

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Abstract:Mobility is the need of the hour— computing and communication devices of today are omnipresent and operate in heterogeneous environment. Terminologies such as "Always Best Connected", "Seamless Mobility" are considered as key features of Next Generation Wireless Networks (NGWN). The challenge for Next Generation Wireless devices is ensuring end-to-end connectivity by seamlessly migrating between Heterogeneous wireless technologies (viz. Wireless LAN, WiMax, Cellular, UMTS, and LTE etc.) This process of handover between different wireless technologies referred to as Vertical Handovers/Handoffs has significant importance among industry and academia researchers. The prime objective of this paper is to provide a one-stop literature store on basics of Handovers, Classifications, Algorithms, Factors influencing Handovers and desirable features of Handover mechanisms for NGWN.

Keywords:Hard Handoff, Soft Handoff, VHD algorithms, Multi Attribute Decision Making (MADM)

I.INTRODUCTION

The 4G Revolution has begun with many of the advantages in wireless technology.Wireless technologies such as LTE, WLAN, WiMAX, etc. were developed with different standards and these technologies offer variety of services, different data rates and diverse area of coverage. One of the forthcoming challenge in network management is to establish connection between end to end heterogeneous wireless technologies. To provide such end-to-end connection between heterogeneous networks we need to perform Handover. If the serving and target base station during Handover are of different wireless technologies then such a Handover is called as Vertical Handover/Handoffs. The term interworking is used to express interactions between heterogeneous networks with the aim of providing an end-to-end communication [1]. A Handover decision is a significant problem, in Next Generation Wireless Networks (4G). The paper discusses key concepts and terminologies associated Handovers as depicted in Figure-1. The structure of the paper is as follows: Section II provides background literature on Handover evolution Section III contains classification of Handover. Section IV Requirements for Handover decision Section V Classification of handoffs, Section VI describes Handover in heterogeneous networks. Section VII provides VerticalHandover (VHD) algorithms. In last section we conclude the paper.

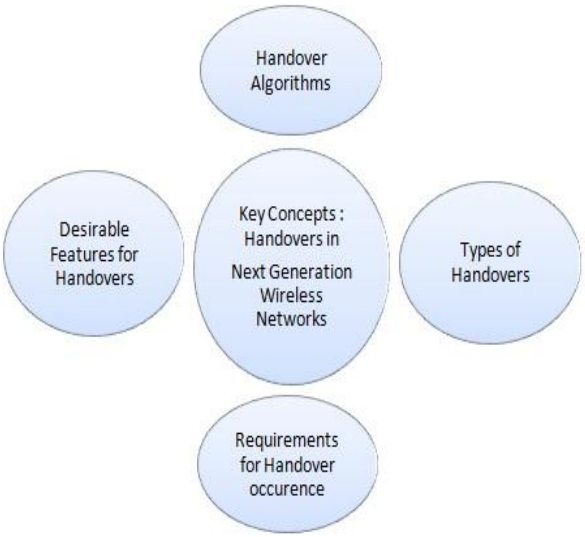

Fig.1. Broad Classification of Handover Concepts

II. BACKGROUND OF HANDOVER EVOLUTION

Handover/Handoff is an attribute of mobile devices since its inception (from 1st Generation to 4th Generation). At all stages Handovers is an attribute counted for mobility.

Initial Handover decisions were primarily determined by Received Signal Strength (RSS) later on other attributes were considered to make a decision of Handovers like Handover Latency, Power Consumption, User preferences,Network Costs etc. Today in 4th Generation wireless networks Handover decisions aren't based on one single attribute but on multiple attributes commonly referred to as Multi-Attribute Decision Making (MADM) [19].

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III. HANDOVERS

In 4G networks, the handoffs are classified into two main streams.

A. Horizontal Handoff

Handoff between two base stations (BSs) of the same system is called Horizontal handoff. Horizontal handoff involves a terminal device to change cells within the same type of network (e.g., within a CDMA network) to maintain service continuity [2]. It can be further classified into Link-layer handoff and Intra-system handoff. Horizontal handoff between two BS, under same Foreign Agent (FA) is known as Link-layer handoff. In Intra-system handoff, the horizontal handoff occurs between two BSs that belong to two different FAs and both FAs belongs to the same system and hence to same Gateway Foreign Agent (GFA)[2].

B. Vertical Handoff (VHO)

Vertical handoff refers to a network node changing the type of connectivity it uses to access a supporting infrastructure, usually to support node mobility. Vertical handovers refer to the automatic fall over from one technology to another in order to maintain communication [2]. The vertical handoff mechanism allows a terminal device to change networks between different types of networks (e.g., between 3G and 4G networks) in a way that is completely transparent to end user applications.

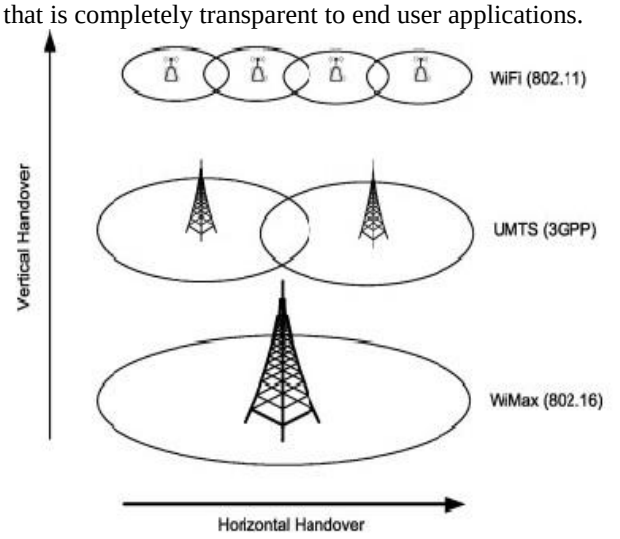

Fig. 2.Horizontal and Vertical handover

The vertical handoff process involves three main phases namely system discovery, vertical handoff decision, and VHO execution.

i)System discovery phase: the mobile terminal determines which networks can be used. These networks may also advertise the supported data rates and Quality of Service (QoS) parameters.

ii) VHO decision phase*:* the mobile terminal determines whether the connections should continue using the current network or be switched to another network. The decision may depend on various parameters or metrics including the type of the application (e.g., conversational, streaming), minimum bandwidth and delay required by the application, access cost; transmit power, and the user's preferences.

iii) VHO 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 [3].

IV. REQUIREMENT FOR HANDOFF MECHANISM

The requirement for handoff mechanism can be classified in to dynamic and non-dynamic requirements. The dynamic requirements include RSS, velocity, throughput, user preferences, handover latency, network load balancing as parameters and non-dynamic requirements include network cost, power consumption, network security and bandwidth as parameters [4].

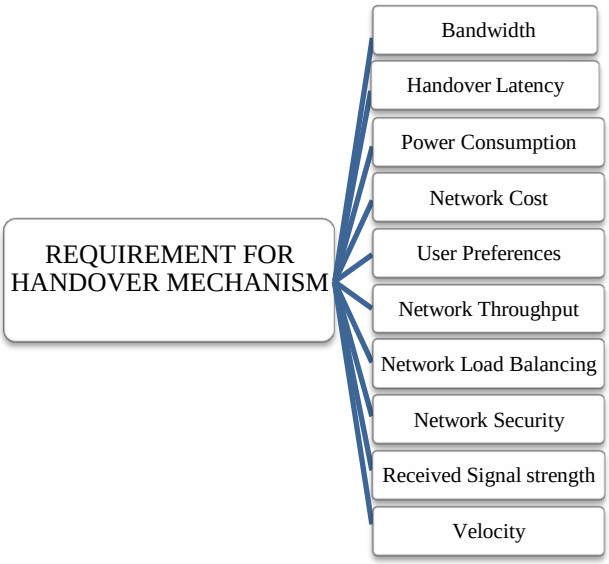

Fig. 3.Requirement for Handover

A. Bandwidth

To achieve seamless handoff for Quality of service (QoS) in wireless environment, there is a need to manage the bandwidth. Bandwidth is generally known as the link capacity in a network. Higher offered bandwidth ensures lower call dropping and call blocking probabilities hence higher throughput can be obtained.

B. Handoff Latency

The delay can occur during the process of Handover of calls between two BS (a frequent phenomenon). This delay is known as handoff latency. A good handoff decision model should consider minimizing handoff latency. Handoff Latencies affect the service quality of many applications of mobile users.

C. Power Consumption

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We need to find ways to improve energy efficiency in wireless networks. Power is consumed during mobile switching or handoffs. During handoff, frequent interface activation can cause considerable battery drainage. The issue of power saving also arises in networkdiscovery because unnecessary interface activation can increase power consumption. It is also important to incorporate power consumption factor during handoff decision.

D. Network Cost

The cost is to be minimized during VHO in wireless networks. The new call arrival rates and handoff call arrival rates can be analysed using cost function. Next Generation heterogeneous networks can combine their respective advantages on coverage and data rates, offering a high Quality of Service (QoS) to mobile users. Therefore, network selection cost is important in handoff decisions.

E. User Preferences

When handover happens, the users have more options for heterogeneous networks according to their preferences and network performance parameters. The user preferences could be preferred networks, user application requirements (real time, non-real time), service types (Voice, data, video), QoS etc. User Preferences can also be considered for VHO in 4G wireless networks.

F. Network Throughput

Network throughput is the average data rate of successful data or message delivery over a specific communications link. Network throughput is measured in bits per second (bps). Maximum network throughput equals the TCP window size divided by the round-trip time (RTT) of communications data packets. It is one of the important requirements to be considered for the VHO.

G. Network Load Balancing

It is important to balance the network load to avoid deterioration in quality of services. Variations in the traffic loads among cells will reduce the traffic-carrying capacity. To provide a high quality communication service for mobile subscribers and to enhance a high traffic-carrying capacity when there are variations in traffic, network load must be paid attention and network load is to be considered during effective handoff.

H. Network Security

Secure handoff has become an important factor in wireless networks. The network security consists of the provisions and policies adopted by the network to prevent and monitor unauthorized access, misuse, modification, and network-accessible resources. The security features such as highest levels of integrity, authentication, and confidentiality, network security should be embedded in the handoff policies.

I. Received Signal strength (RSS)

The wireless networks, performance dependon signal strengthof mobile node (MN) and access point (AP).The wireless signal strength in each direction determines thetotal amount of network bandwidth available along that connection. RSS depicts the power present in a received signal. A signal must be strong enough between base station and mobile unit to maintain signal quality at receiver. The RSS should not be below a certain threshold in a network during handoff.

J. Velocity

Velocity of the host should also be considered during handoff decision. Because of the overlaid architecture of heterogeneous networks, handing off to an embedded network, having small cell area, when travelling at high speeds is discouraged since a handoff back to the original network would occur very shortly afterwards.

V. CLASSIFICATION OF HANDOFFS

Handoffs can be classified as shown in figure-4. Factors that influence categorization of handoffs can be administrative domains involved, number of connections, network types, user based, necessity of handover and frequencies engaged.

A. Network Types Involved

This is the most common classification factor. Handoffs can be classified as either horizontal or vertical. This depends onwhether a handoff takes place between a single type of network interface and a variety of different network interfaces [5].

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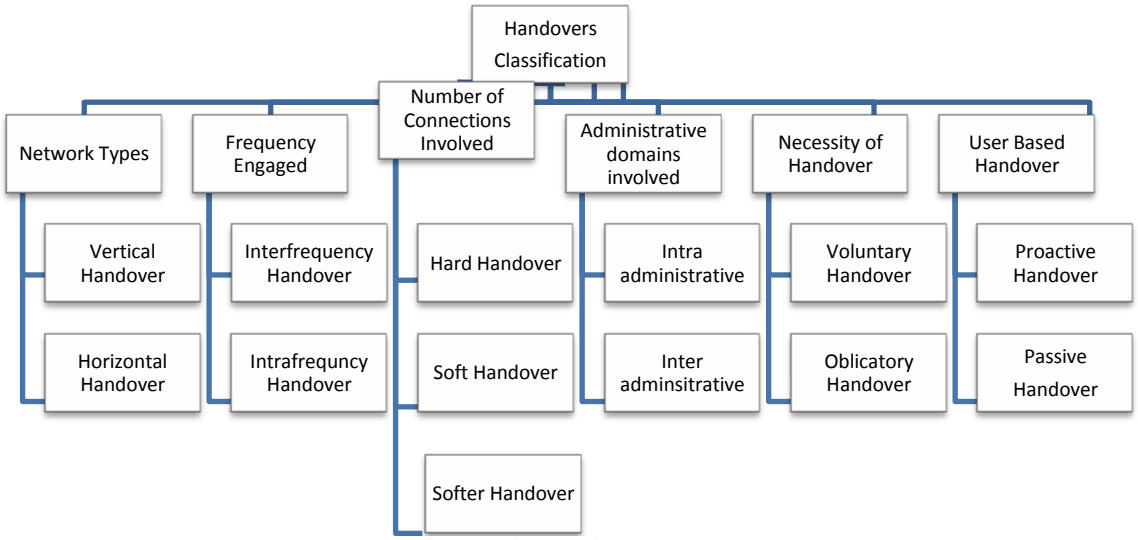

Fig.4.Classification of Handover

i) Vertical handoff:Mobile terminal can be handover to access points those supporting different network technologies. For example, the changeover of signal transmission from WiMax base station to LTE network is considered a vertical handoff process

ii) Horizontal handoff: Mobile terminal handover between access points supporting the same network technology. For example, the changeover of signal transmission between same type of network i.e. WiMax-to- WiMax base station is considered as a horizontal handoff process

B. Frequencies Engaged

i) Intrafrequency handoff:Process of handover for mobile terminal across access points operating on the same frequency. This type of handoff occurs in code-division multiple access (CDMA) networks with frequency-division-duplex (FDD).

ii) Interfrequency handoff: Process of handover for mobile terminal across access points operating on different frequencies. This type of hand -off is present in CDMA networks with time-division duplex (TDD) and is the only handoff type supported in GSM cellular systems [5].

C. Number of Connections Involved

i) Hard handoff: In a hard handoff the radio link to the old base station is released at the same time a radio link to the new base station is established. In other words, using hard handoff, a mobile node is allowed to maintain a connection with only one base station at any given time.

ii) Soft handoff:A mobile node maintains a radio connection with no less than two base stations in an overlapping handoff region and does not release any of the signals until it drops below a specified threshold value. Soft handoffs are possible in situations where the mobile node is moving between cells operating on the same frequency**.**

iii) Softer handoff*:* A softer handoff is very similar to a soft handoff, except the mobile terminal switches connections over radio links that belong to the same access point [5].

D. Administrative Domains Involved

It's a group of systems and networks operated by a single organization of administrative authority. Administrative domains play a significant role in 4G wireless networks as different networks, each controlled by different administrative authorities, become available. Consequently, the classifications of handoffs in terms of administrative domains are.

i) Intra-administrative handoff: a handoff process where the mobile terminal transfers between different networks (supporting the same or different types of network interfaces) managed by the same administrative domain.

ii) Inter-administrative handoff:a handoff process where the mobile terminal transfers between different networks (supporting the same or different types of network interfaces) managed by different administrative domains.

E. Necessity of Handoff

Handoffs can be classified based on need.

i) Obligatory handoff: In some situations it is necessary for the mobile terminal to transfer the connection to another access point in order to avoid disconnection.

ii) Voluntary handoff: In other situations transfer of connection is optional and may or may not improve the quality of service.

F. User Control Allowance

Handoffs can be classified as proactive or passive.

i) Proactive handoff: In a proactive handoff the mobile terminal's user is allowed to decide when to handoff. The handoff decision can be based on a set of preferences specified by the user. Proactive handoff is expected to be one of the radical features of 4G wireless systems.

ii) Passive handoff: The user has no control over the handoff process. This type of handoff is the most common in first, second and third generation wireless systems [5].

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VI. HANDOFFS IN 4G HETEROGENEOUS NETWORKS

NGWN consists of heterogeneous network managed by different operators like 2G, 3G mobile communication systems,WLAN, IEEE 802.16e (WiMax), satellite. Issues in 4G network can be mobility, when mobile user switches from one network to another network or from one Base Station (BS) to another the mechanism used is "Handover". So in heterogeneous network vertical handoff decision (VHD) is mainly used for continuous service. A handoff scheme is required to preserve connectivity as devices move about, and at the same time curtail disturbance to on-going transfers. Therefore, handoffs must exhibit low latency, sustain minimal amounts of data loss, as well as scale to large networks. [2]

A. Seamless Handoff

In 4G networks main goal is to provide ubiquitous high-speed wireless connectivity to mobile terminals [6]. In such an environment, it will be necessary to support seamless handoffs of mobile terminals without causing disruption to their on-going sessions. Seamless handoff with low delay and minimal packet loss has become a crucial factor for mobile users who wish to receive continuous and reliable services. One of the key issues that aid in providing seamless handoff is the ability to correctly decide whether or not to carry out vertical handoff at any given time [6].

B. Desirable Handoff Features

An efficient handoff algorithm can achieve many desirable features by trading off different operating characteristics. Some of the major desirable features of any handoff algorithm can be [6].

i) Reliable: A handoff algorithm should be reliable, i.e. quality of call should be good.

ii) Seamless: A handoff algorithm should be fast so that the mobile device does not experience service degradation or interruption.

iii) Interference prevention: A handoff algorithm should avoid high interference. Co-channel interference is caused by devices transmitting on the same channel. This is usually caused by a neighbouring detrimental source that is operating on the same channel.

iv) Load balancing: An algorithm should balance traffic in all cells, whether of the same or different network type. This helps to eliminate the need for borrowing channels from neighbouring cells that have free channels, which simplifies cell planning and operation, and reduces the probability of new call blocking.

v) Improving performance: The number of handoffs should be minimized. Excessive horizontal or vertical handovers lead to heavy handoff processing loads and poor communication quality. In a handoff scenario, the more handoff attempts, the greater the chances that a call will be denied access to a channel, resulting in a higher handoff call dropping probability. A high number of horizontal handoff attempts may result in more delay in the pro-cessing of handoff requests, which will cause signal strength to decrease over a longer time period to a level of unacceptable quality.

VII. VHD ALGORITHMS

A. RSS Based VHD Algorithms

In RSS based algorithms Received Signal Strength is the main criteria. Here comparison will be done based on RSS of the current point of attachment against the other to make handover decisions. The algorithm is proposed [7] 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 have 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 [8], 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. A travelling distance prediction based algorithm is developed to eliminate the unnecessary handovers which is introduced in the above method. The algorithm [9] considers the time a mobile terminal is expected to spend within the cell. The method relies on the estimation of WLAN travelling 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 travelling time inside the WLAN cell is larger than the time threshold. The 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 types of algorithms the available bandwidth is the main criteria for the handover. A QoS based algorithm is proposed [10], which takes residual bandwidth, user service requirements and state of the mobile terminal into account in deciding whether to handover from a WLAN to Wireless Wide Area Network (WWAN) and vice versa. 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 the throughput as the available bandwidth is considered as the main criteria for VHD. Also by taking application types into account, lower handover latency for

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delay-sensitive applications is achieved. To improve the overall system throughput an algorithm is developed [11] between WLAN and Wideband Code Division Multiple Access (WCDMA), which takes into consideration the Signal to Interference and Noise Ratio (SINR). SINR based handovers can provide user's 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 [12] is proposed. In this method the probability of unnecessary and missing handovers is combined and WDP is calculated.

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 be made accordingly. In multiservice based algorithm [13] 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, percentage of user satisfied requests is increased and handover blocking probability is reduced. Cost function based handover decision algorithms[14] in which the normalization and weights distribution methods are provided. A network quality factor is used to evaluate the performance of a handover target candidate. With this method high system throughput and user's satisfaction is achieved. A weighted function based algorithm [15] 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.

E. Combination Algorithm

In this 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 (ANN) [17] or fuzzy logic. 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. A fuzzy logic based algorithm [18] is developed which is used to handle handovers between WLAN and UMTS. In this method a pre-decision unit is used. This algorithm is able to improve the performance by reducing the number of unnecessary handovers and avoiding Ping-Pong effect.

VIII. CONCLUSION

The objective of this literature survey is to provide novice wireless network researchers a comprehensive idea on user mobility and Handovers that is an integral parameter of mobile wireless communications. Also the survey provides one-stop documentation on terminologies, concepts, classifications, popular algorithms and evolution of Vertical Handovers.

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