CHAPTER I

INTRODUCTION

1.1 EVOLUTION OF WIRELESS NETWORKS

In recent years, a number of wireless access technologies [1] have been developed being a source of flexible and tetherless communication and it is accelerating continuously due to the growing demands of mobile users. In this era of wireless communication, the integration of access technologies is required to offer varied services and applications with promising quality as it is not possible for an individual network to cope up with the demands of users. The rapid increase of access technologies demands the interoperability and better mobility management techniques to fulfill the requirements of users. Based on coverage area and bandwidth, most of the wireless access technologies can be divided into three categories: Wireless Local Area Networks (WLANs), Wireless Metropolitan Area Networks (WMANs) and Wireless Wide Area Networks (WWANs) as shown in Fig. 1.1. The technologies with smaller coverage, high power consumption and high bandwidth are covered under WLAN. The coverage area of ten meters to few hundred meters can be served by these networks. WLAN standard [2] mainly comprises of the IEEE 802.11 series and ETSI's (European Telecommunications Standards Institute) HiperLAN. WMANs provide wireless connectivity to users between various locations within a metropolitan area. It enables users to roam within a range from hundreds of meters to a few kilometers. Broadband Wireless Access (BWA) networks are also becoming popular as they offer high speed Internet access to users without incurring the high cost of laying fiber or copper cabling and leasing lines. The standards being researched and developed to support WMANs [3] are High Performance Radio Metropolitan Area Network (HiperMAN), High Performance Radio Access (HiperACCESS) and IEEE 802.16 series. HiperACCESS, an interoperable standard, provides broadband access to a lesser coverage area and backhaul for mobile systems (e.g. W−CDMA, CDMA2000, GSM and GPRS) with a data rate of approximately 100 Mbps.

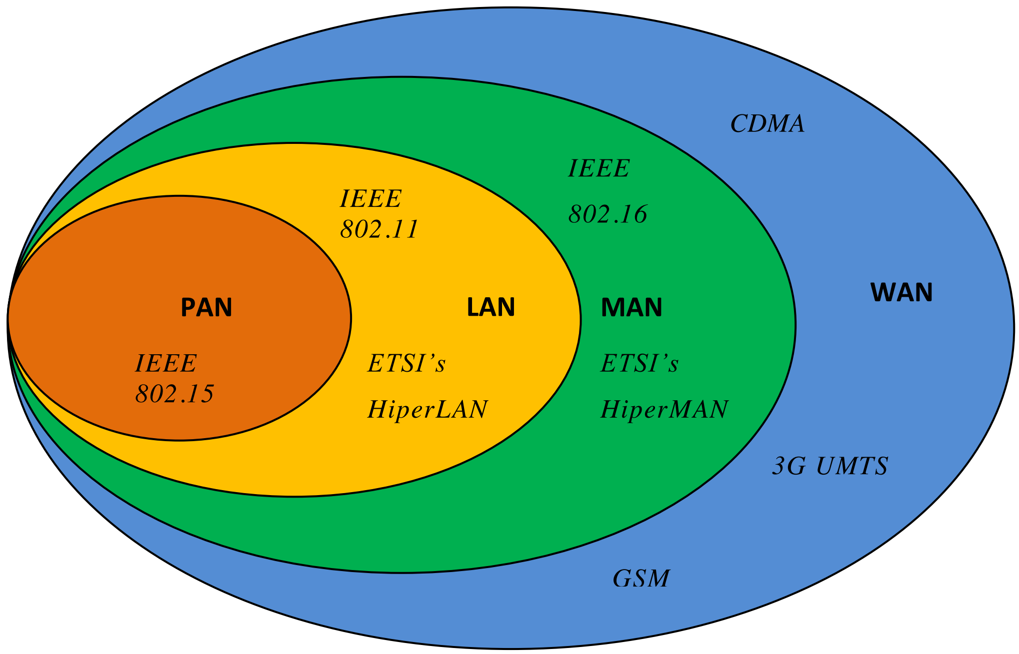

Fig. 1.1 Hierarchy of wireless networks

HiperMAN is designed for providing a broadband wireless solution for MANs. The air interface allows Point−to−Multi Point (PMP) configurations as well as flexible mesh network. HiperACCESS operates at high frequency bands (40.5 – 43.5 GHz) while HiperMAN is an interoperable broadband fixed wireless access system operating at radio frequencies between 2 GHz and 11 GHz.

The IEEE 802.16 standard referred to as WiMAX (Wireless Interoperability for Microwave Access), is a BWA technology, an alternative to wired last mile access links, and provides high bandwidth and low cost scalable solutions. The mobility is supported by IEEE 802.16e standard known as mobile WiMAX, which has been proved to be beneficial when high data rate and mobility services are required for users moving at high vehicular speed. IEEE 802.16 standard [4] defines PHY and MAC layers to promote interoperability among different vendors. WiMAX operates on two frequency bands: Unlicensed band (2 to 11 GHz) and Licensed band (10 to 66 GHz).

WWAN has a coverage area from a few kilometers to tens of kilometers. These access networks include different types of cellular networks such as Code Division Multiple Access (CDMA), Global System for Mobile Communication (GSM), High Speed

Downlink/Uplink Packet Access (HSDPA/HSUPA), General Packet Radio Services (GPRS), UMTS (Universal Mobile Telecommunication System) and LTE (Long Term Evolution) [5]. These wireless networks have been designed for some specific service requirements such as coverage area, data rate and delay.

The wireless networks, comprised of different radio access technologies including WLAN, GSM, CDMA, 3G UMTS and WiMAX, are known as heterogeneous wireless networks while homogeneous wireless networks comprise of the same kind of access networks. In the next generation of networks, users will be allowed to choose an optimum wireless network interface according to their requirement. While moving from one point to another, mobile users are required to switch from one network to another due to poor signal strength or specific user requirements. Advanced mobile stations are equipped with multiple interfaces and intelligent enough to take important decisions about its connectivity to the most suitable access link.

1.2 CONCEPT OF HANDOVER

Mobility is the term related to movement of users from one location to another, which leads to change in Point of Attachment (PoA) to the access network. Mobility management [6] is one of the important challenges in next generation wireless networks as it enables users to move across geographic boundaries of wireless networks. Mobility management comprises of location management and handover management [7]. The previous one tracks Mobile Node (MN) for successful information delivery and discovers its current PoA while the handover management maintains active connections for roaming mobile terminals. Handover can either be forced or unforced. The former is caused by changes in network conditions such as signal strength resulting from the user movements. The later refers to the change in the access network by user for better performance.

1.3 CLASSIFICATION OF HANDOVERS

The handovers can be classified into various categories [8] as shown in Fig. 1.2. Based upon the type of networks involved, the handover can be classified into two categories: Horizontal Handover (HHO) or Intra−domain handover and Vertical Handover (VHO) or

Inter–domain handover [Fig. 1.3]. Another basis of classification is the number of active connections, which defines two types of handovers: Hard handover and Soft handover. The handover can be initiated and controlled by either MN or Base Station (BS). So further classification, based upon handover decision, describes following types of handovers: network initiated, mobile initiated, network controlled, mobile controlled, mobile assisted and network assisted handover.

Horizontal handover or Intra–domain handover/Vertical handover or Inter–domain handover: Horizontal handover takes place when the MN moves between BSs supporting same network technology. In other words, horizontal handover is implemented between two neighboring cells of homogeneous networks, e.g. handover between two WLAN cells. On the other hand, vertical handover or Inter–domain handover is performed between BSs belonging to different wireless access technologies. The handover between an Access Point (AP) of WLAN and BS of WiMAX or 3G UMTS network, shown in Fig. 1.3, is an example of vertical handover. Vertical handover is more complicated than horizontal handover because the associated networks differ in various aspects including operating frequency, bandwidth and modulation techniques.

Hard handover and Soft handover: Hard handover is based on the principle of Break–Before–Make (BBM) which means that an MN can be associated to one BS at a time. In other words, the MN can be connected to the new link only after previous link is broken.

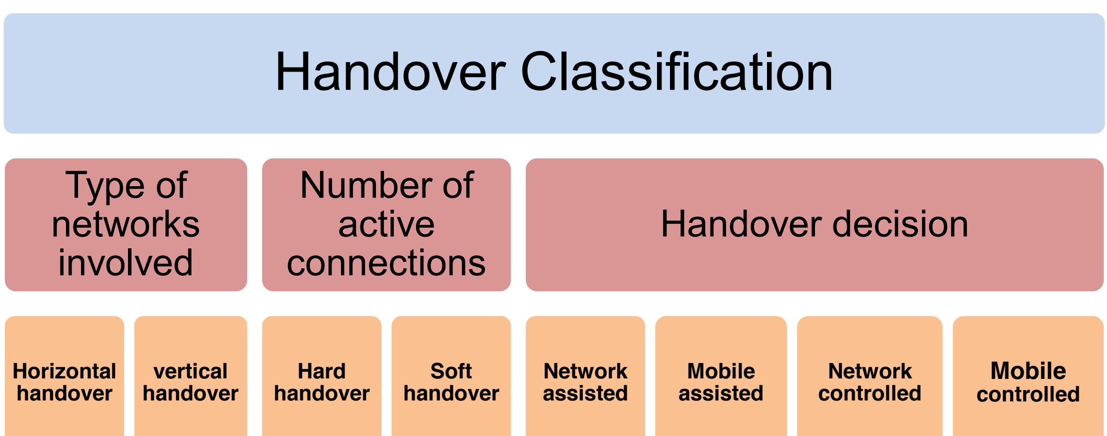

Fig. 1.2 Classification of handovers

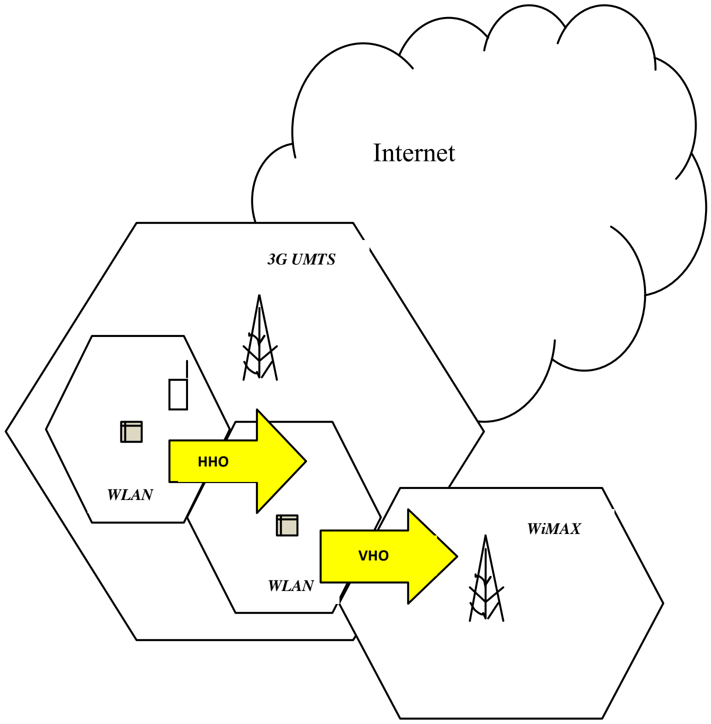

Fig. 1.3 Horizontal and Vertical handovers

The service is disrupted for a finite duration of time in case of hard handover. While in case of soft handover or make−before−break handover, the MN is capable of communicating with multiple access networks simultaneously. The connection to new link is established before the old connection is released thus services are not interrupted in case of soft handover.

Mobile initiated/Network initiated handover: If the MN is taking the decision to initiate handover, it is termed as mobile initiated handover while if the handover is initiated by the network then it is said to be a network initiated handover. In case of deterioration of the signal strength received from the Previous BS (PBS), the handover is initiated by MN. Alternatively; a BS may also initiate a handover to balance the distribution of traffic to prevail congestion on particular router.

Mobile controlled/Network controlled handover: The mobile has primary control over the handover process in case of mobile controlled algorithms while the network is responsible for the same in case of network controlled handover.

Mobile assisted/ Network assisted handover: In case of mobile assisted handover, the core network executes the handover using information from the MN while a network assisted handover is performed by the mobile with the assistance of the network.

In this thesis, mobile initiated, mobile controlled and network assisted handover has been considered.

1.4 HANDOVER PROCESS

The handover process is comprised of three phases as depicted in Fig. 1.4. These are referred to as: 1) handover initiation 2) handover decision 3) handover execution.

Handover initiation phase: The first step of handover procedure is to estimate the handover requirement to initiate the handover procedure. The initiation is recommended only after corroborating the necessity of a handover. Handover may be mobile initiated or network initiated depending upon system requirements. Usually, the MN initiates handover whenever there is degradation in radio link quality measured in terms of Received Signal Strength (RSS) and it goes below the specific threshold while network initiates the handover for resource management and maintenance reasons. For example, whenever there is congestion due to heavy traffic load on a particular router, some users may substantially be transferred to another access router. The traditional initiation algorithms initiate handover based upon RSS measurements only. However, in heterogeneous networks, RSS is not the sufficient parameter as an MN is supposed to roam among different kinds of networks having different characteristics including power consumption, bandwidth and cost. Hence, it is required to implement handover algorithms based on multiple criteria. The decision about time to fire a handover trigger is also taken at this stage.

Handover decision phase: In the second phase, the decision is taken regarding the selection of the target network, to which the MN will be transferred. At this level, measurements on neighboring radio transmitters are taken and eventual network policy information is also collected at this level. The best target can be identified taken into account the measurement of single or multiple parameters.

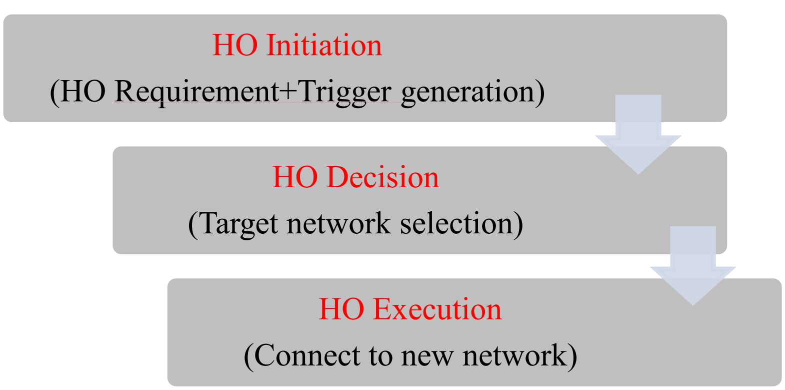

Fig. 1.4 Handover process

The existing network selection schemes can be categorized as network− centric, user−centric and collaborative method [9]. The network−centric approach allows network to take decision about the access network selection for its benefit, whereas the goal of user−centric method is to select an access network to optimize performance of user without considering load balancing or the benefit of other users. The third one, collaborative method takes into account the profits of both users as well as network. Multi-Attribute Decision Making (MADM) algorithms [10] fall into categories of user−centric and collaborative method, are extensively used to find the most suitable option based on the score obtained for all possible alternatives. Various MADM techniques such as Multiplicative Exponent Weighting (MEW), Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) and Gray Relational Analysis (GRA) have been proposed in literature. These techniques are designed in order to select an optimum target network which would ensure the best possible services according to the demands of the user at any time. The parameters, that can influence a decision, are assigned different priorities which are converted into weights using weight assignment strategies such as Analytic Hierarchy Process (AHP) [11], Fuzzy Analytic Hierarchy Process (FAHP), Analytic Network Process (ANP), Fuzzy Analytic Network Process (FANP) and Random Weighting (RW) [12].

Handover execution phase: After accomplishing handover requirement and target network selection procedure, handover execution is performed. At this stage, handover procedure is accomplished by forming new links between Target BS (TBS) and MN. The routing and other contextual information related to MN is transferred from previous access network to the new access network. At this stage, the MN is detached from the old access router and attached to the new one. The order of detach and attach events depends upon the type of handover (soft and hard handover). The re−routing of connections, acquisition of a new Care of Address (nCoA) and the registration procedure in Mobile Internet Protocol (MIP) are implied in this segment.

1.5 HANDOVER CRITERIA

Each network has distinct characteristics in terms of bandwidth, modulation and coding schemes, spectral efficiency and data rate. These characteristics or parameters have been considered as basis/criteria for handover decision. Some of these important parameters are listed below.

1. **Received Signal Strength (RSS):** The signal strength received at the MN from Current BS (CBS) and TBS give a measure of link quality. Most of the existing handover algorithms consider RSS as the main criteria for taking handover decisions [13−15]. The RSS decreases as the distance between BS and MN increases due to the fact that path losses introduced in the signal are directly proportional to the distance.
2. **Quality of Service (QoS):** The QoS perceived by the user can be measured in terms of throughput, jitter, Bit Error Rate (BER) and Packet Loss Rate (PLR). The requirements of QoS vary with type of application services such as voice, data and streaming, etc. The packet loss should be minimized in order to guarantee successful delivery of packets. To maintain QoS, this attribute is to be kept into consideration while performing handover. Data rate is a feature desired mainly in multimedia applications like video streaming. The end to end delay is defined as the time required for packets to reach from source to destination address. The variation in delay due to multipath is termed as jitter, which is not tolerable in some delay sensitive applications including conversational and interactive services.
3. **Available bandwidth:** The available bandwidth, a measure of available network resources, is also an important criterion to be considered in handover decision. The requirement for bandwidth varies according to the demands of users and type of service.
4. **Energy efficiency:** The energy efficiency can also be considered as a handover criteria while deciding for a handover. The simultaneous running of various applications demands more energy efficient networks to be available for use.
5. **Monetary cost:** The cost of different networks varies according to the different charging policies. While making handover decision, the cost of the network can also account for a network selection.
6. **Security:** Security level provided by access network plays the most significant role while selecting network for some specific applications. Security refers to the integrity or confidentiality of the transmitted data which is desired at the highest priority in the military like applications.

7. **Number of active users:** The number of users, accessing a particular network simultaneously, is the major criteria in case of network initiated handover. The system controller tries to avoid network congestion by balancing the load on co−existing networks.

1.6 HANDOVER CHALLENGES AND OPPORTUNITIES

To achieve internetworking among different networks, various issues need to be resolved. In this section, a brief discussion on handover challenges and opportunities is given below.

1. **Handover rate:** The total number of handovers experienced by an MN while moving from one cell to another is known as handover rate. Ideally, there should be one handover, which is to be executed at the boundary of the cell. But due to oscillations in RSS, the MN may undergo more than one handovers. 震荡
2. **The probability of handover failure:** The handover failure is the situation when signal strength received from serving network goes below a threshold level but the handover procedure is not completed. Thus, the probability of handover failure is defined as the probability of occurrence of handover at a point where sufficient signal strength is not received by MN from CBS and it has not been connected to the target network. Due to late initiation of handover, there may be a high probability of handover failure.
3. **Resource utilization:** If the handover is initiated too early, the resources of serving network are not utilized fully and the possibility of occurrence of this situation is known as the probability of false handover initiation. The problem of false handover initiation becomes more and more severe when the cell size decreases. The cell size of wireless systems is decreasing so that the capacity and data rate may increase. Hence, in advance wireless systems, it is important to select the proper value of the trigger time to reduce the false handover initiation probability.
4. **Probability of unnecessary handovers:** The ambiguity in handover trigger time may lead to enhanced handover rate, which will waste network resources and increase signaling load on the system unnecessarily. It is mainly caused when handover requirement is not estimated properly.

5. **Ping−pong effect:** Ping-pong effect is caused by frequent handovers between access networks due to fluctuations observed in RSS. This frequent changing of access technologies leads to unstable connection because MN is oscillating between two networks. Ping-pong effect results in an increase in handover rate, therefore need to be mitigated by using efficient handover algorithms.

1.7 THE CONCEPT OF CROSS LAYER DESIGN IN HANDOVER PROCESS

Mobile users are insisting anywhere and anytime access to high speed data, real and non−real time multimedia services from next generation wireless systems. Most of the current work on wireless network protocol analysis and design is mainly based on a layered approach. A TCP/IP protocol stack typically has five layers; Application layer, Transport layer, Network layer, Data link and Physical layer. Each layer of mobile protocol stack contributes to various functions related to mobility. In layered architecture, each layer has been assigned its individual function which is to be performed independently. It provides modularity and transparency between layers. However, the layered approach does not perform well in advanced wireless systems as recent wireless networks are based on all−IP structure. Thus, it becomes essential to consider parameters from higher layers while designing handover algorithms. In addition, the performance of one layer affects other layers and ultimately the overall system performance of wireless networks. For instance, poor link quality measurements at physical layer can lead to packet losses and finally 恶化 deteriorates the overall network performance [16]. It is, therefore, required that there should be a provision for exchanging useful information between layers, which can be utilized for enhancing system performance. This concept of exchanging information between layers is known as Cross Layer technique [17].

Most of the cross layer architectures fit out into one of the two categories: direct or explicit cross−layer communications and indirect or implicit cross−layer communications [18]. The first category, direct communications should be used when only a single cross layer optimization is planned. A combination of the cross layer signaling methods has been optimized using CLASS (Cross−Layer Signaling Shortcuts) based upon multilayer mobility management architecture. CLASS serves as a generic interface to enable the direct interactions among non−neighboring layers using light weighted messages [18]. The second category, indirect communications are realized with a common cross−layer entity in which handover decisions may be taken based on the information collected from various layers and coordinated through a well−designed cross layer interface manager [19]. Some popular cross layer signaling methods are packet headers, ICMP (Internet Control Message Protocol) messages, local profiles and network service method [18]. According to the packet header method, the IPv6 packet headers are extended to store cross layer information and to process them layer by layer. In the second method, the information across different layers is propagated through ICMP messages. These messages are encapsulated by IP packets and have to pass by the network layer. In the local profile method, separate profiles are designed to store cross layer information abstracted from each layer. In network service method, an entity referred to as Wireless Channel Information (WCI) server is responsible for gathering and managing information from lower layers. Interested applications access to the WCI server to fetch desired information.

Due to several beneficial features of cross layer technique, it can be used to meet the challenges that mobility poses. In this research work, the impact of cross layer technique of the handover performance of wireless networks has been explored. Cross layer based mobility management will allow mobile terminals to move seamlessly across wireless access networks while continuing to enjoy the services they are subscribed to in their home networks. The utilization of cross layer information in handover decision making process has been shown to improve the handover performance to a significant extent.

The Media Independent Handover (MIH) defined by IEEE 802.21 standard [20], enables interaction among different layers by introducing a technology independent function, MIHF. The authors in [21] and [22] describe the IEEE 802.21 concept to optimize handover performance. Assuming the ability of MN to support multiple interfaces, the MIH facilitates a fast handover by exchanging event information among entities from different technologies. The three functional components of MIHF to be used cooperatively to assist with seamless handover are MIH Event Service (MIES), the MIH Command Service (MICS) and MIH Information Service (MIIS). MIES is responsible for detecting events and reporting them from both local and remote interfaces. This type of service is to provide information like link deterioration and link unavailability from lower layers to upper layers. On the other hand, MICS defines commands for higher layers to control the lower layers regarding handovers. The configuration of network devices and the scanning of available networks come under MICS section. The commands follow a top−down direction as opposed to events and enable the higher layers to manage the behavior of the lower layers related to handover, connectivity and mobility. MIIS provides the mechanism for retrieving information on characteristics and services provided by the serving and neighboring networks to assist the handover decision. The information can be static link layer parameters like channel information or the Medium Access Control (MAC) address of the AP and available via both lower and upper layers through a query/response procedure.

The link triggers like Link Up (LU), Link Down (LD) and Link Going Down (LGD) triggers are defined by MIH, which play significant role in taking a handover decision [23][24][25]. LU and LD triggers are related to the events where the link to the access network has been established and broken respectively. The LGD trigger implies that a broken link is imminent. The trigger can be fired based upon the conditions associated with single or multiple criteria.

1.8 MOTIVATION FOR THE PRESENT RESEARCH WORK

In the past few years, momentous research has been carried out to perform handover seamlessly during movement of MN across different cells. To achieve a fast and smooth handover, the conventional layered architecture seems to be inefficient as the functions performed at various layers are interrelated. Some useful information among different layers is required to be exchanged to expedite the handover process. Cross layer in mobile networks has been the topic of interest for researchers for many years. However, most of these methods employ cross layer techniques to improve handover performance in one or two phases. The overall handover performance of a system depends on the effectiveness of handover algorithms in all the three phases during handover process. We can make the best use of capabilities of cross layer techniques by employing it in handover initiation, decision and execution phase as well. The capabilities of MIH drive us to exchange required information such as parameters measured, the link triggers, etc. from different layers to take decision about the handover. Also, predefined thresholds of parameters such as RSS, BER and distance do not perform well in dynamic environments. Dynamic environments correspond to changes in several parameters over time such as wireless channel conditions, the MN speed, user preferences and time required for performing a handover etc. It demands for handover mechanisms which are adaptive to dynamic environments. The inappropriate handover trigger generation can result in too early or too late handover initiation. If the trigger is generated too early, then there will be wastage of network resources while too late handover trigger may result into disruption in services. Due to the rapid progress in wireless technologies, millions of multimedia applications have been introduced. Consequently, the shortage of wireless communication resources is becoming a critical issue. In order to utilize the resources of networks to their best, effective mechanisms to generate handover triggers need to be incorporated. Afterwards, the selection of target network (to which handover is to be performed) is also a crucial task. To choose a network with the best features, the handover decision is to be taken based on multiple criteria like RSS, QoS, data rate, security, cost, power consumption. The priorities to these criteria may vary with time, user's choice, type of applications and situational context. To maximize end user's satisfaction, different weights to handover parameters are to be assigned based on their preferences, context and applications. The rationale of this research is as follows:

In most of the existing multi−criteria handover algorithms, fixed weights to handover design parameters are given irrespective of the changes in environments which could degrade system performance. Moreover, the handover algorithms, which give crisp value to weights, ignore the fuzziness and vagueness associated with characteristics of networks. Therefore, keeping uncertainty of network information in mind, fuzzy logic has been incorporated into the weight assignment technique.

The procedure for handover execution differs by type of the serving and target networks. For horizontal handovers, handover is performed at link layer while in case of vertical handovers; Layer 3 (L3) handover is invoked after Layer 2 (L2) handover. The vertical handover incurs more delay comparatively as reconfiguration of IP addresses is postulated. Many mobility management protocols [26] such as MIPv6 (Mobile Internet Protocol version 6), Session IP (SIP), Hierarchical MIPv6 (HMIP), and Fast handover for Mobile IPv6 (FMIPv6) have been proposed to enhance the performance of handover execution phase. Due to high delay associated with the execution of vertical handover, service disruption time is high. To address these issues, we incorporate a cross layer mechanism in handover process. The overlapping of functions of L2 and L3 can reduce handover delay to the remarkable extent.

1.9 OBJECTIVES OF THE THESIS

Based upon the discussion in Section 1.6 about research challenges posed by the next generation wireless networks, this research aims to resolve some important issues of handover functionality. The objectives of the present research work may be outlined as:

- To review the existing handover mechanisms in detail with their research contribution and limitations/gap.
- To compute optimum values of handover design parameters to minimize handover rate and handover delay for different velocities of mobile user.
- To provide seamless handover through efficient use of handover triggers.
- To design a dynamic mechanism for timely handover requirement estimation and target network selection using cross layer information.
- To implement TOPSIS and AHP for efficient handover decision.
- To propose a robust fuzzy logic based handover algorithm.
- To propose Quality of Service provisioning based handover decision algorithm responsive to end user information.
- To devise cross layer triggers for FMIPv6 execution.

1.10 RESEARCH METHODOLOGY

The following research methodologies have been opted in the present research work:

1. **Literature survey:** The research work related to handover process and existing handover techniques plus those utilizing cross layer concepts has been comprehensively studied. The related research work has been critically analyzed for deriving the motivation for the present research work.
2. **Simulation based approach:** The performances of the handover initiation and decision schemes have been compared with the existing techniques utilizing extensive computer simulation.
3. **Analytical formulation:** Handover performance measures, including handover failure probability, handover delay and handover latency (service disruption time) have been treated analytically. Performance improvement in handover execution stage is also verified through analytical formulation.

1.11 RESEARCH CONTRIBUTION

In this research work, intelligent and dynamic schemes are proposed to perform handover efficiently in wireless networks. The proposed schemes are based on the cross layer concept and have been designed for performance enhancement of three stages of handover: handover initiation, handover decision and handover execution stage. The following are the major contributions of the present research work:

- An efficient handover initiation algorithm utilizing optimum threshold parameters for signal strength and residual time was introduced. The proposed algorithm improves the handover performance by reducing handover rate and probability of call interruption by 30% and 80% respectively as compared to RSS based algorithms.
- We further propose three different methods of cross layer trigger generation. These include biased, neutral, and prediction based schemes of trigger generation. The numerical results show that the proposed handover trigger methods implemented in this research are able to reduce the probability of unnecessary handover, the probability of handover failure and false handover initiation by 55%, 70% and 25% respectively as compared to contemporary approach.
- Correct estimation of the handover requirement supports minimum wastage of network resources. In this research work, we have investigated three parameters for determination of the handover requirement. These parameters were incorporated into fuzzy logic based handover algorithm which yields significantly improved handover performance in terms of network resource utilization.
- We propose a dynamic method of target network selection which is capable of selecting the most suitable target network according the user requirements at any moment. The data rate, delay and security level have shown improvement of 43%, 35% and 17% respectively as compared to single criteria based algorithms which in turn improves QoS as perceived by the user.
- In this work, we have also explored handover execution in FMIPv6 protocol. Implementation of the cross layer triggers in the handover process has shown a noticeable latency reduction in terms of handshaking signaling.

1.12 ORGANISATION OF THE THESIS

This thesis is comprised of seven chapters with predefined goals which have been achieved successfully and mentioned at the end in the summary of each chapter. This thesis is organized as follows:

Chapter II gives an overview of the literature survey in this field. A comprehensive survey of existing algorithms is carried out in all the three stages of handover in wireless networks and then highlighted with the open issues present in this area.

The threshold estimation of handover parameters is performed in Chapter III. The performance of the handover algorithm based on signal strength and residual time is evaluated for different velocities and different signaling delay. Extensive computer simulations are carried out to compare the handover performance of the proposed method with the conventional handover algorithms.

Chapter IV presents the proposed methods for generating handover triggers and assessing its performance in different propagation environments. In this research, three methods for trigger generation are proposed to minimize probability of handover failure and to maximize resource utilization. The trigger generation methods are as follows.

1. **Biased handover trigger generation:** In this method of trigger generator, the priority of the network or requisite of a specific application is considered before generating trigger. Out of the two performance metrics, referred to as handover failure probability and false handover initiation probability, one will attain the desired value. One metric will attain the desired value at the cost of the other metric.
2. **Neutral handover trigger generation:** In this method, there is no biasing among the performance metrics. In contradiction to biased method, equal importance is given to both parameters in case of neutral method. Thus, an optimized solution is found by keeping both handover failure and false handover initiation probability at the same level.
3. **Prediction based handover trigger generation:** In this method, we make use of a prediction technique to estimate the signal strength which is expected to be received in the future. By predicting signal strength, appropriate time to generate handover triggers is estimated with minimum error which will reduce false handover initiation and unnecessary handovers.

In Chapter V, the dynamic handover mechanism is presented in which, the requirement for handover is examined and followed by a target network selection phase using cross layer information. The decision about target network is taken by using TOPSIS, an effective MADM technique. A dynamic weight assignment strategy is adopted which takes into account the end user information to vary the weight assigned to relevant parameter. To develop a more efficient handover algorithm the fuzzy logic and AHP are combined into the system. The proposed scheme intends to maximize the end user's satisfaction at every time and everywhere by choosing the best target network among all the alternatives.

Chapter VI explains cross layer based handover execution in which cross layer trigger concept is employed in the handover execution stage to reduce handover delay and signaling load on WiMAX networks. This is achieved by overlapping the functions of link layer and network layer with the help of various triggers and MIH. Also, the information about the location and direction of movement of MN is utilized to reduce scan delay.

Finally, conclusion and future scope are mentioned in Chapter VII.