CHAPTER

1

INTRODUCTION

1.1 Definition and Cell Structure:

A cell is the radio area covered by a transmitting station or a Base Station (BS). All Mobile Terminals (MTs) within that area are connected and serviced by the BS. Therefore, ideally, the area covered by a cell is a circle, with the BS being at the centre. Thus, actually cells are not hexagonal. Hexagon fitted the planed area nicely and hexagon is the greatest area in the circle with respect to any other shape. The cell is therefore approximated to a regular hexagon and side of the hexagon is the common chord of two adjacent cells. When any MT crosses a common chord of a cell, we can say that handoff has occurred from one cell to another cell.

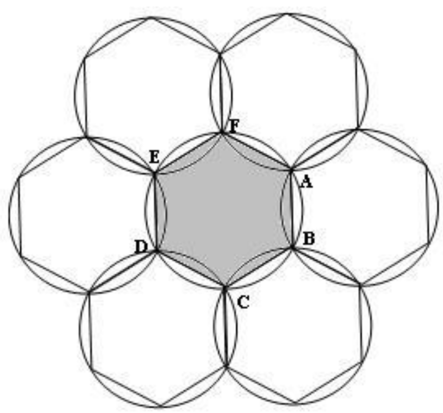

Fig. 1.1: Seven Cell cluster.

We consider a seven cell cluster in Fig. 1.1. ABCDEF is a regular hexagon. Here, these adjacent seven cells are fitted in such a manner that no vacant places are left between them and the common chord between two circular cells is the side of the hexagon. As the hexagon fitted the planed area nicely so we can imagine that the shape of the cell is a regular hexagon and it is the maximum area in the circular cell (shaded area) with respect to any other shape.

1.2 Types of Handoff:

Today‘s wireless world provides several communication networks, such as Bluetooth for personal area, IEEE 802, for local area, Universal Mobile Telecommunications System (UMTS) for wide area and satellite networks for global networking. These networks are complementary to each other. The best feature of the individual networks is to provide ubiquitous _always best connection‘[9] to the mobile users [10].

Mobility management contains two components: location management and handoff management [4]. Location management helps to track the locations of mobile users between consecutive communications. But handoff management process keeps its connection active even when it moves from one Base Station (BS) to another. Location management techniques for Next Generation Wireless Systems (NGWS) [6], [11] can be used in Architecture for ubiquitous Mobile Communications (AMC). But seamless support of handoff management in NGWS is an open issue [10].

In real scenario the integrated architecture may consists of many different wireless systems. In NGWS, two types of handoffs arise: horizontal handoff and vertical handoff [8].

- Horizontal handoff: handoff between two BSs of the same system. It can be further classified into
- 1) Link-layer handoff: Horizontal handoff between two BSs, under the same Foreign Agent (FA), *e.g.*, the handoff of a MT from BS10 to BS11 in Fig. 1.2
- 2) Intra-system handoff: Horizontal handoff 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), *e.g.*, handoff of MT from BS11 to BS12 in Fig. 1.2.
- Vertical handoff (Inter-System Handoff): Handoff between two BSs, belong to two different systems and two different Gateway Foreign Agents (GFA), *e.g.*, the handoff of the MT from BS12 to BS20 in Fig. 1.2.

In our thesis, we do not address the link-layer handoff. Our work will be on intra-system and inter-system handoff [10]. The large value of signaling delay associated with the intra-system and inter-system handoff [12] can be detrimental for delay-sensitive real-time services. We therefore try to minimize the signaling delay by reducing the probability of false handoff.

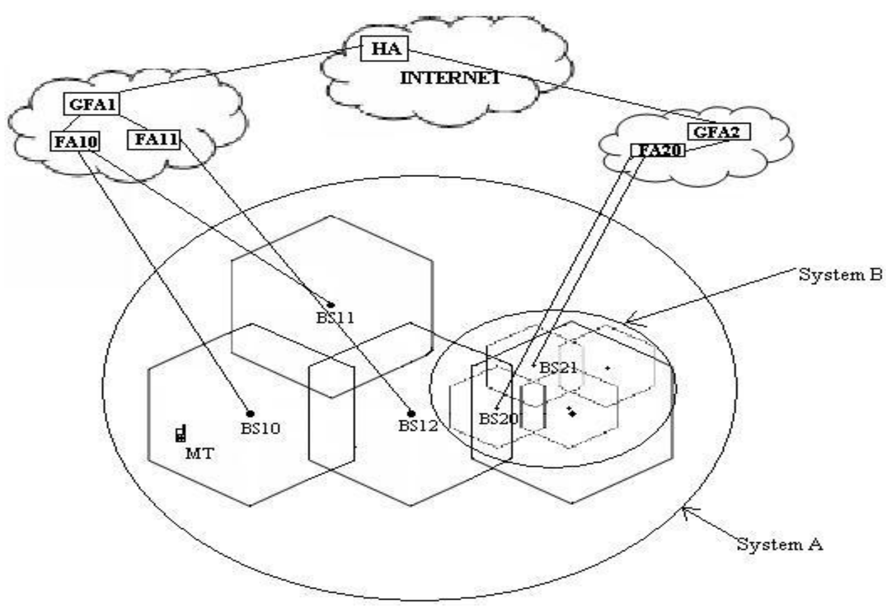

Fig. 1.2: Handoff in the integrated NGWS architecture

HA: Home Agent

GFA: Gateway Foreign Agent

FA: Foreign Agent

MT: Mobile Terminal

BS: Base Station

Handoff management protocols operating from different Layers of the classical protocol stack (e.g., link layer, network layer, transport layer, and application layer) have been proposed in the literature [10]. [1] focuses on integrating layer 3 handoff messages into layer 2 messages. It reduces handoff latency employing Frequency Modulation Internet Protocol-based WiBro system. In [2], we are introduced to a new enhanced Handoff Protocol for Integrated Networks (eHPINs), which localizes the mobility management enabling fast handoff. Application layer mobility using Session Initiation Protocol (SIP) is proposed in [12]. SIP based mobility does not require any changes to the Internet Protocol (IP) stack of the mobile users.

Hierarchical Mobile IP [13] and other micro-mobility protocols such as cellular IP [14], IDPM [15] and HAWAII [16] address the problem of high global signaling load and handoff latency by introducing another layer of hierarchy to the Mobile Internet Protocol (MIP) architecture to localize the signaling messages to one domain. MIP and micro-mobility solutions [16, 15, and 14] achieve reduction in registration signaling delay, but fail to address the problem of handoff requirement detection delay [10].

[3] Decreases the number of control packets for proactive caching and also proposes a superior replacement caching algorithm; which together enables reduction in handoff delay. A generic link layer technique is used in [7] to add the handoff protocols operating from the upper layers. Different link layer assisted handoff algorithms to enhance Received Signal Strength (RSS) value and thus reduce the handoff latency and handoff failure are proposed in [16] and [17].

We assume from the link-layer assisted handoff protocols implicitly that the handoff latency of the intra-system and inter-system handoff are constant. Based on this protocol, the link-layer assisted handoff protocols initiate the handoff when the RSS of the serving BS goes below a pre-defined fixed threshold value. In fact, signaling delay [8] of the intra-system and inter-system handoff depends on the traffic level in the backbone network, the wireless link quality and distance between the user and its home network at the handoff instance. So, a fixed delay for intra-system and inter-system handoff has poor performance when the handoff signaling delay varies.

In recent years, different wireless technologies have been implemented starting from 2G and 3G cellular system (e.g. GSM/GPRS, UMTS, CDMA 2000), metropolitan area networks (e.g., IEEE 802.16,WiBro), wireless local area networks (WLAN) (e.g., IEEE 802.11a/b/g, Hiper-LAN), and personal area networks (e.g. Bluetooth). All these wireless networks are heterogeneous in sense of different radio access technologies, the communication protocols that they use and the different administrative domains that they belong to [10]. The actual trend is to integrate complementary wireless technologies with overlapping coverage so as to provide the expected ubiquitous coverage and to achieve the Always Best Connected (ABC) concept [9].

1.3 Channel Allocation:

IEEE 802.11b standards have become increasingly popular and are experiencing a very fast growth upsurge as it is cheap, and allow anytime or anywhere access to network data. However, they suffer from limited coverage area problem and it is necessary to use this technology in the most prudent manner.

A Wireless Local Area Network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum) and usually provides a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network [19]. In mobile network WLAN is used to transmit and receive radio signals between mobile station (MS) and access point (AP) which can be either a main, relay or remote base station. A main base station is typically connected to the wired Ethernet. A relay base station relays data between remote base stations, wireless clients or other relay stations to either a main or another relay base station. A remote base station accepts connections from wireless clients and passes them to relay or main stations. Connections between "clients" are made using Medium Access Control (MAC) addresses [18]. IEEE802.11b and IEEE802.11g operates in the 2.4GHz Industrial, Scientific and medical (ISM) band and use 11 of the maximum 14 channels available and are hence compatible due to use of same frequency channels. The channels (numbered 1to14) are spaced by 5MHz with a bandwidth of 22MHz, 11MHz above and below the centre of the channel. In addition there is a guard band of 1MHz at the base to accommodate out-of-band emissions below 2.4GHz. Thus a transmitter set at channel one transmits signal from 2.401GHz to 2.423GHz and so on to give the standard channel frequency distribution as shown in Fig 1.3.

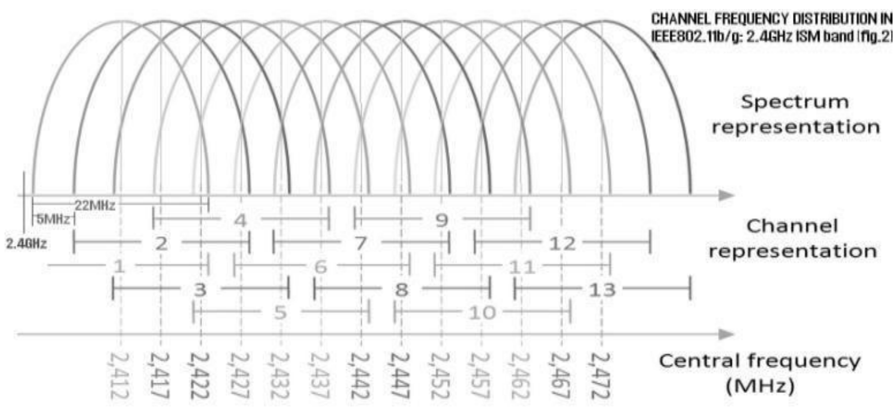

Fig 1.3: Channel allocation

It should be noted that due to overlapping of frequencies there can be significant interference between adjacent APs. Thus, in a well configured network, most of the APs will operate on the non-overlapping channels numbered 1, 6 and 11.

IEEE 802.11b based wireless and mobile networks [19], also called Wi-Fi commercially, are experiencing a very fast growth upsurge and are being widely deployed for providing variety of services as it is cheap, and allows anytime, anywhere access to network data. However they suffer from limited coverage range of AP, resulting in frequent handoffs, even in moderate mobility scenarios. Handoff, an inherent problem with wireless networks, particularly real time applications, has not been well addressed in IEEE 802.11, which takes a hard handoff approach [20]. Here a mobile host (MH) has to break its connection with its old access point (AP) before connecting to a new AP, resulting in prolonged handoff latency called link switching delay. Now-a-days, soft handoff procedure is in use. Here a mobile node is connected to its old AP till it makes connection with the new AP. This effectively reduces the packet losses incurred by hard handoff.

With the advent of real time applications, the latency and packet loss caused by mobility became an important issue in Mobile Networks. The most relevant topic of discussion is to reduce the IEEE 802.11 link-layer handoff latency. IEEE 802.11 MAC specification [21] defines two operation modes: ad hoc and infrastructure mode. In the ad hoc mode, two or more stations (STAs) recognize each other through beacons and hence establish a peer-to-peer relationship. In infrastructure mode**,** an AP provides network connectivity to its associated STAs to form a Basic Service Set (BSS). Multiple APs form an Extended Service Set (ESS) that constructs the same wireless networks.

The complete handoff procedure can be divided into 3 distinct logical parts: scanning, authentication and re-association. In the first phase, an STA scans for APs by either sending Probe Request messages or by listening for beacon message. After scanning all channels, an AP is selected using the Received Signal Strength Indication (RSSI) and CI ratio and the selected AP exchanges IEEE 802.11 authentication messages with the STA. Finally, if the AP authenticates the STA, the STA sends Re-association Request message to the new AP.

The overall delay is the summation of scanning delay, authentication delay, and re-association delay. According to [22], 90% of handoff delay comes from scanning delay. The range of scanning delay is given by:-

$$N \times T_{min} \leq T_{scan} \leq N \times T_{max} \qquad (1)$$

where N is the total number of channels according to the spectrum released by a country, T_{min} is Min Channel Time, T_{scan} is the total measured scanning delay, and T_{max} is Max Channel Time. Here we focus on reducing the scanning delay.

1.4 Classical Satellite System:

Satellite communication has become an essential criterion in mobile communication due to their coverage superiority. As cellular networks can provide mobile communication services with only a limited geographical coverage area, satellite communication network coexists with cellular networks to provide a global coverage to heterogeneously distributed user population. The information to be transmitted from a Mobile Station (MS) must be correctly received by a satellite and forwarded to one of the Base Station (BS) from the satellite. The BS keeps track of all Mobile Stations within its coverage range, controls the allocation and de-allocation of radio channels and performs most of the intelligent and decision making process to reduce the computational effort and the weight of the satellites. The architecture of Satellite communication is reflected in Fig 1.4.

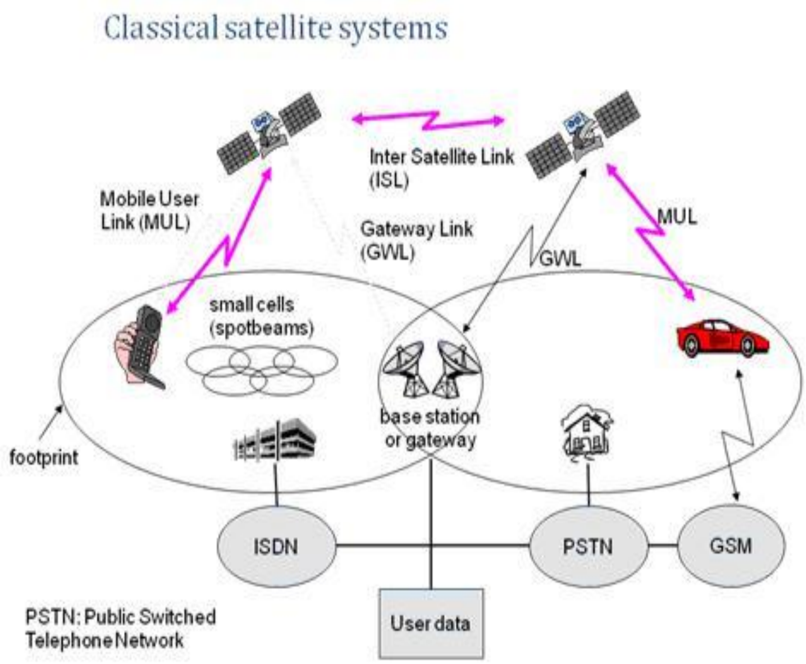

Fig 1.4: Satellite Communication Architecture

The satellites are controlled by the BS located at the surface of the earth, which serves as gateway. Inter-satellite links can be used to relay information from one satellite to another, but they are still controlled by the ground BS. For an originating call from MS, the MS at first connect itself with the overhead satellite. The satellite informs the nearest BS for the authentication of the MS. The BS then allocates the channel for the MS via the satellite and informs the gateway about additional control information. For an incoming call from the Public Switched Telephone Network (PSTN), the gateway helps to reach the closest BS which, in turn, indicates the satellite serving the most recently known location of MS. The satellite informs the MS about an incoming call by employing a paging channel to the MS and radio resources to use for the uplink channel (Uplink: connection between base station and satellite). Some of the terminologies related to satellite communication are elaborated below.

a) **Foot print**: Footprint is the area within which a mobile user can communicate with satellites.

b) **Spot beam**: To increase the capacity of the overall system, the coverage area of every satellite is divided into slightly overlapping cells, which are called spot beams. Fig 1.5 shows the spot beams created by a moving satellite with approximation of the spot beams for ease in calculations

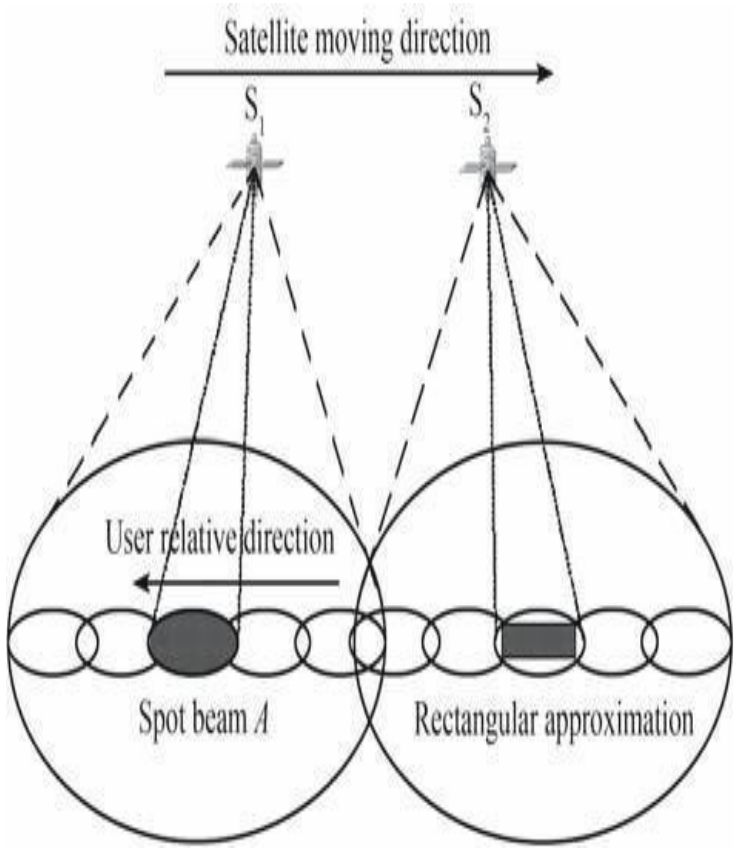

Fig 1.5: Spot Beams of Moving Satellite and its Rectangular Approximation

Whenever an MS moves from one satellite coverage area to a new area served by another satellite, the MS needs to be connected with the new satellite via BS rejecting the connection of old satellite. Several handoff phenomena can occur within the satellite communication area.

d) **Intra-satellite handover**: Intra satellite handover occurs when the mobile station (MS) moves from one spot-beam to another spot-beam in the same footprint of the satellite due to its relative motion with respect to the satellite.

e) **Inter-satellite handover**: Inter satellite handover occurs when the MS leaves the footprint of the current satellite and enters into the footprint of another satellite.

f) **Gateway handover**: This is the handover of connection from one gateway to another gateway i.e. the mobile station (MS) remains in the footprint of the satellite, but gateway leaves the footprint.

g) **Inter system handover**: This is the handover of connection from the satellite network to a terrestrial cellular network which is cheaper and of lower latency.

Four different types of satellite orbits can be identified depending on the shape and diameter of the orbit (also shown in Fig 1.6). The Geostationary Orbit satellites (GEO) revolve between 36000 km above earth surface, Low Earth Orbit (LEO) satellite revolves between 500 - 1500 km above the earth surface, Medium Earth Orbit (MEO) or Intermediate Circular Orbit (ICO) satellites revolve between 6000 - 20000 km above earth surface and Highly Elliptical Orbit (HEO) satellites which follow elliptical orbits and stay at over 35,786km.

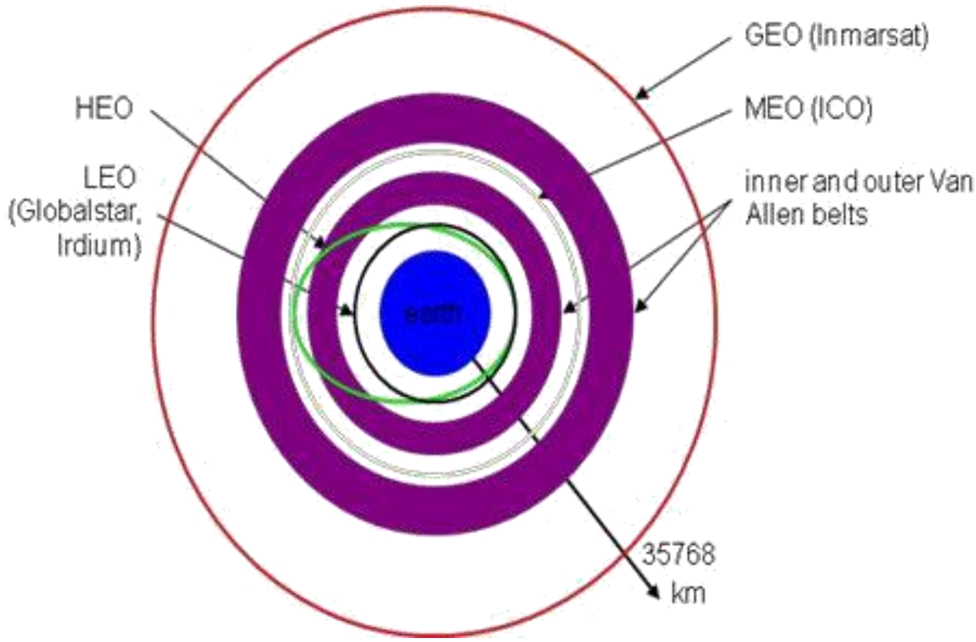

Fig 1.6: Diagrammatic Representation of Satellite Orbit

In low earth orbit (LEO) satellite networks, the spot beam handover is the most frequently encountered network function because of the relatively small spot beam areas of LEO satellite networks and the relatively high speed of the satellites [19].

1.5 Object and Scope:

The challenging issue in Next Generation Wireless Systems (NGWS) is seamless handoff during the mobility of mobile node between different integrated networks. To overcome this problem we have proposed a received signal strength measurement based handoff technique to improve handoff probability by calculating the speed of MN (Mobile Node) and signaling delay information and thereby taking the right decision of handoff initiation time. We have proposed another method to minimize the handoff failure probability by effectively placing a wireless local area network (WLAN) AP in the handoff region between two neighboring cells. Our next proposed work was to minimize the handoff failure probability by increasing the total number of channel with help of Mother Cell Child Cell concept.

A critical issue in IEEE 802.11 based wireless networks is the handoff and latency in the handoff process is a major concern. To overcome this problem we have proposed a mechanism to reduce handoff latency for IEEE 802.11 wireless networks with Neighbor Graphs (NG) pre-scanning mechanisms and with the help of Carrier to Interference ratio. We have proposed another handoff management architecture using signal to interference ratio of the present and neighboring base stations. We have also proposed a handoff scheme which takes handoff decision adaptively based on the type of network it presently resides and the one it is attempting handoff with through some predefined rules.

Handoff has become an essential criterion in mobile communication system, especially in urban areas, owing to the limited coverage area of Access Points (AP). Handover of calls between two Base Stations (BSs) is encountered frequently and it is essentially required to minimize the delay of the process. To overcome this problem we have proposed a mechanism to minimize the handoff latency by minimizing the number of APs scanned by the Mobile Node (MN) during each handoff procedure. We have also proposed selective scanning based on position, speed and direction of motion of the Mobile station using the neighbor graph to reduce the scanning delay. We have proposed another new scanning method in which we determine the distance of nearest access points from the middle node to bypass the main processes involved in increasing MCA layer handoff latency. We have proposed a new scanning technique in which we divide a cell in three sectors and thus reducing the number of APs to be scanned by fixing the neighbor APs with respect to each sector.

In satellite communication networks, low propagation delay and power requirements increase the plausibility of Low Earth Orbit (LEO) satellites over geostationary Earth Orbit (GEO) satellites. High relative speed and random direction of motion of LEO satellites provide a serious barrier for their applicability in global wireless communication. To reduce this problem, we have proposed two handover initiation algorithms (Angle and Distance based algorithm) with connection control.

1.6 Organization of the thesis:

The rest of the thesis is organized as follows. In Chapter 2, we have discussed about handoff failure probability, Received Signal Strength (RSS) measurement of WLAN and Mother Cell Child Cell concept for next generation wireless and mobile system. Interference ratio and receive signal strength, carrier to interference ratio for communication, signal to interference ratio and RSS based handoff in heterogeneous networks for next generation wireless and mobile system are discussed in Chapter 3. In Chapter 4, we have discussed about the concept of handoff latency for next generation wireless and mobile system and also estimated the latency by co-ordinate evaluation method, by distance measurement method and by cell sectoring method. In Chapter 5, we have discussed the angle estimation algorithm to show how LEO satellite networks work on handoff management. In Chapter 6, we have presented the summary of published papers in connection with this thesis. Finally, In Chapter 7, conclusions are drawn along with a discussion on the scope of future research in this direction.