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MASTER'S THESIS

GPS-based Mobility Management for efficient Handover in 5G

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Abstract

Graduate School of Fundamental Science and Engineering

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by Anosha MOHAMMADI

For the next wireless communication systems, the major challenges are to provide ubiquitous wireless access abilities, and maintain the quality of service and seamless handover for mobile communication devices in heterogeneous networks [8]. Due to rapid growth of mobile users, this demand becomes more challenging where the users always require seamless connectivity while they move to other places at anytime.As the number of users increase , the network load also increases, the handover process needs to be performed in an efficient way. However in many situations, the handover blocking, and unnecessary handover frequently happen, then affect the network and reduces its performance. The problem arises with the movement of mobile user between base stations while the link connectivity becomes weaker and the mobile node tries to switch to another base station to have a better link quality during a call for higher QoS.

In this thesis we aim to reduce the blocking error using the position of mobile node (MN) at the cell boundary, and the handover operation is performed by using geolocation information provided by a GPS system. Particularly, use the GPS system to calculate handover blocking probability. This thesis focuses on reducing the blocking error of handover at the cell boundary of the base stations. We use the two signals of GPS including PN(Pseudo Noise) code and carrier signal to find the error that causes at the cell boundary while performing handover. First, we obtain the doppler shift to identify the timing error for each of the signals. Then, we calculate the area of cell, and the area of each GPS signal to determine the area that blocks error occur.

Keywords: Handover blocking probability, GPS signal, Wireless communication systems, Timing error

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Anosha Mohammadi

Waseda University

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List of Abbreviations

3G	**T**hird**G**eneration
4G	**F**ourth **G**eneration
5G	**F**ifth **G**eneration
3GPP	**T**hird**G**eneration**P**artnership **P**roject
IP	**I**nternet **P**rotocol
VoIP	**V**oice over **I**nternet **P**rotocol
GPRS	**G**eneral **P**acket **R**adio **S**ervice
RAN	**R**adio **A**ccess **N**etwork
WLAN	**W**ireless **L**ocal **A**rea **N**etwork
LTE	**L**ong **T**erm **E**volution
WiMAX	**W**orldwide **I**nteroperability for **M**Microwave **A**ccess
GSM	**G**lobal **S**ystem for **M**obile
UMTS	**U**niversal **M**obile **T**elecommunication **S**ystem
WiFi	**W**reless **F**idelity
MIMO	**M**ulti **I**nput **M**ulti **O**utput
OFDM	**O**rthogonal **F**requency**D**ivision **M**ultiple
FDD	**F**requency **D**ivision **D**uplexing
TDD	**T**ime **D**ivision **D**uplexing
UDN	**U**ltra **D**ense **N**etwork
RAT	**R**adio **A**ccess **T**echnology
MN	**M**obile **N**ode
MU	**M**obile **U**ser
RNC	**R**adio **N**etwork **C**ontroller
HA	**H**ome **A**gent
AP	**A**ccess **P**oint
BLER	**B**locking **E**rror **R**ate

AS	**A**ctive **S**et
BS	**B**ase **S**tation
QoS	**Q**uality of **S**ervice
RSS	**R**adio **S**ignal **S**trength
SINR	**S**signal to **I**nterference **N**oise **R**tio
GPS	**G**lobal **P**ositioning **S**ystem
PN	**P**seudo **N**oise
HD	**H**andover **D**ecision

List of Symbols

Δf	Doppler Shift Frequency
f_1	Carrier Frequency
C	Speed of light
d	Distance of Mobile terminal from Base Station
V_{si}	Velocity of Satellite
V_{vi}	Velocity of Vehicle
C_{bv}	Clock bias variation

Chapter 1

Mobility in IP Networks

Introduction

When it comes to data networks the de-facto standard [1] that represented by the TCP/IP stark, with Network layer that dominated by the Internet Protocol (IP), in both IPV4 and IPV6.
Mobility Management protocols aim to enable IP connectivity and maintain the mobile node location updated. There are several mechanisms and protocols for changing the access point between IP networks. The known mobility protocol is Mobile IP [2]. Where the mobile nodes (MN) are able to change the attachment point to the network and the location could be tracked. There are two different types of Mobile IP, such as IPv4 and IPv6. For both the key point is home agent (HA) it is located in the mobile nodes home network, the HA is the node which always know the current location of MN.
Mobility in IP-based networks is a crucial step to provides connectivity for mobile users. When a MN changes its point of access (AP), it has the IP address configured by the host, the routing infrastructure establish the data path towards the new location. The IP address is an identifier, as it names a node in a network, as it allows the routing infrastructure to deliver packets to the node. So, for a moving MN, it would be necessary to change the location and keep the same name. If the IP address is changed during the connection to a new network, without any notification for the host name, the connectivity is maintained, but ongoing sessions need to be restarted, as these changes of IP address without producing any interruption and possibility of keeping active ongoing sessions in a seamless

manner for the user is called Mobility [1].

There are several different access technologies are available in heterogeneous network environment, including WLAN, 3G, GPRS, LTE. To access these different technologies, the devices need a vertical handover [2] support, a mechanism between the technologies. The below Figure illustrates states in a heterogeneous networks where mobile user moves between different environment such as WLAN, GPRS. The ongoing active sessions run during handover without any disconnectivity in the service.Where this mechanism is called Seamless handover.

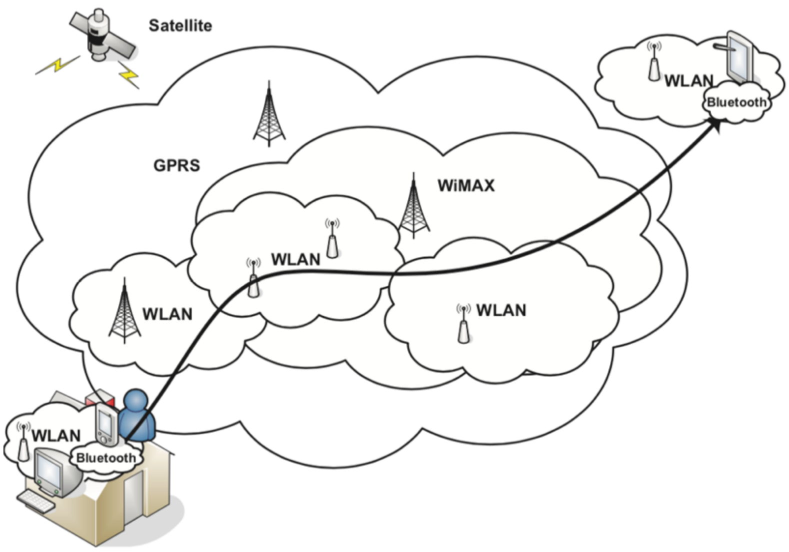

FIGURE 1.1: Movement of Mobile Node in a heterogeneous environment.

Motivation

First and second generation of mobile wireless networks are based on non-IP infrastructure where these networks support voice and low data rate services such as short message service (SMS). The next generation wireless networks are envisioned to have an IP based infrastructure [4] with the support of different RAT. In addition, IP-based wireless networks allow mobile users to have access in information, applications, and services over the internet because these wireless networks are integrated seamlessly with the internet. Any of wireless communication always try to provide best QoS and seamless connectivity to all mobile user.

Mobility management is a functionality of GSM or UMTS networks, which trace the real users and subscribers to provide mobile phone services. To deliver mobile phone services efficiently for mobile users a new mechanism of mobility management is required for the next-generation wireless networks where the location of every mobile user must be determined before the service is delivered. Location changes of mobile users form different types of networks, i.e. Homogeneous or Heterogeneous networks, when mobile terminals transferring their communication sessions from one radio access network (RAN) to another, this process known as handover. The problem arises with the movement of mobile user between Base Stations while the link quality become weaker and the mobile node tries to switch from one BS to another for better link quality during a call.

In Wireless Communication Network a mobile node is moving from one location to another and every time requires communication services. According to geographically area the fixed BSs are distributed which provides two-way connection between mobile node and the network. Whenever there is not enough resources to be allocated in the new network during an active call it would be disconnected. Each handover procedure needs resources in the network to reroute the call.An adaptive handover algorithm is required to reduce the load while switching the calls in the system, parallel to maintain quality of service. When a mobile node (MN) moves from its current network to the new network or base station, the probability of handover maximizes at the cell boundary of these two

Base Stations.
The aims of a handover algorithms are:

- Minimize handover blocking probability at the cell boundaries;
- Minimize handover delay time;
- To reduce the system interference while maintaining the boundary of cells;
- During handover maintain the QoS;

In our research, the handover algorithm is analyzed with the calculation of GPS information as a function of the exact location of the mobile nodes near to the cell boundary of base stations. It can intelligently reduce the blocking probability of handover at the cell boundary of the two base stations.

Organization

This thesis is organized as following. In the chapter 2, we give background knowledge of mobility management the handover types and process. In chapter 3, we give an overview of handover in heterogeneous networks and the analysis of handover algorithms with related works. In chapter 4, we give a brief description about mobility management in wireless networks. In chapter 5, we describe our proposed idea, *GPS-based handover management* and in chapter 6, we finish our thesis with conclusion.

Chapter 2

What is Mobility Management?

Introduction

Mobility management is a functionality of GSM or UMTS networks, which trace the real users and subscribers to provide mobile phone services. To deliver mobile phone services efficiently for mobile users a new mechanism of mobility management is required for the next-generation wireless networks where the location of every mobile user must be determined before the service is delivered. Location changes of mobile users form different types of networks, i.e. Homogeneous or Heterogeneous networks [5].

2.1 Location Management

Location management works on two major tasks (i) Location registration or location update, (ii) Call delivery or paging [5].
The mobile stations inform the current network about its current location by sending signals, that keep the database of its location that this procedures goes under location registration procedure. And according this information that are registered to network during the location registration procedure, the call delivery procedures or paging takes places that queries the network regarding the exact location of the mobile station to deliver the call successfully [5].
To design the location management techniques for intersystem roaming has the challenges as following:

- Reduces the signaling overheads and the latency of service delivery
- Guarantees of quality service (QoS) in different systems
- Fully overlapped of service areas in heterogeneous wireless networks,
  _Which mobile node and networks should perform location registration.
  _Which networks and the user location should be up-to-date to be stored.
  _Within a specific time how the exact location of the mobile node would be determined.

2.2 Handover Management

The mechanism by which an ongoing call is transferred from one point of attachment to another. In other words, when a mobile user travel from one coverage area or cell to another cell with a calls duration the call should be transferred to the new cells base station without any interruption.

Handover process has three stages [5], first the initiation of handover, that performs by mobile node or network agent or the changing conditions. The second phase is handover preparation where the networks must find a new resource for handover connection and perform any operation for new connections. And the third or final stage is handover execution where the data-flow controls need to keep the delivery of data from the old path connection to new path connection according to quality of service guarantees.
Based on movement of mobile devices there is many types of handover performs. In general, handover has two types: (i) horizontal handover or intra-system handover and (ii) vertical handover or inter-system handover. Handovers with homogeneous networks are also referred to horizontal handovers. And the vertical handover is occurring between two different networks or heterogenous networks and it may occur in the following scenarios: (i) When a mobile node moves from current base station and enters to neighbor base station. (ii) When a mobile user chooses the target base station as a handover network for his service requirements. (iii) When its required to distribute the overall load to different systems.

To design the handover management for all wireless networks these issues must consider : (i) To minimize the signal interference and power requirement for processing of handover procedure. (ii) Guaranty of Quality of service . (iii) Efficiently use of network resource . (iv) The handover must be reliable,robust.

2.2.1 Handover Types

Based on movement of mobile devices there is many types of handover performs [6].

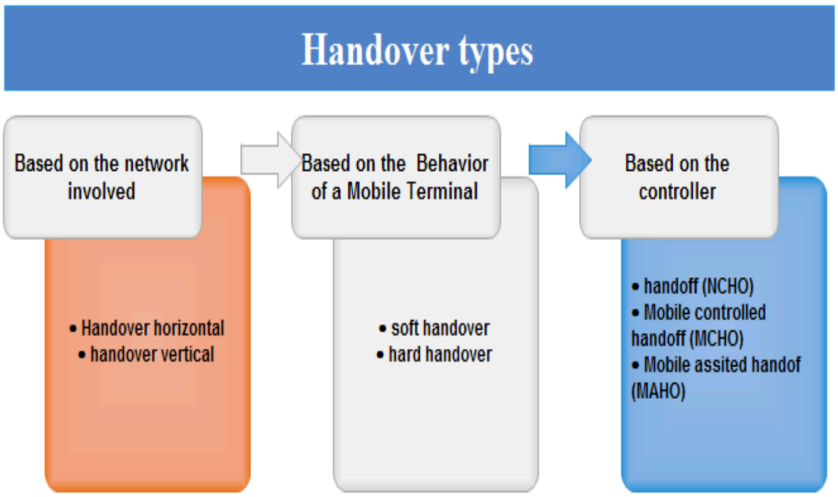

FIGURE 2.1: Classification of Handover.

2.2.2 Handover Based on the Network Involved

1. **Horizontal Handover**
   In Horizontal handover considered and occurred between wireless networks that are using the same access technologies. When a mobile device moves among two coverage area that are using the same technology this process is known as horizontal handover. In other words, maintaining the

running session by changing the IP address like in mobile IP or dynamically brining is also known as intra cell or intra system handover.

2. **Vertical Handover**

   Handover mechanism has been widely studied in cellular communications domain and its popularity increasing in IP-based wireless networks. The association of different wireless network technologies requires a seamless interoperability, convergence and integration among heterogeneous technologies. The handover is seamless when it maintains the connectivity of all applications in the mobile device running and provides continues end-to-end services within the same session during handover and offering both low latency and minimal data packet loss. The connection between different networks or heterogenous networks requires the usage of vertical handover techniques. In this thesis we mainly focused on vertical handover between different cell in cellular networks, respectively.

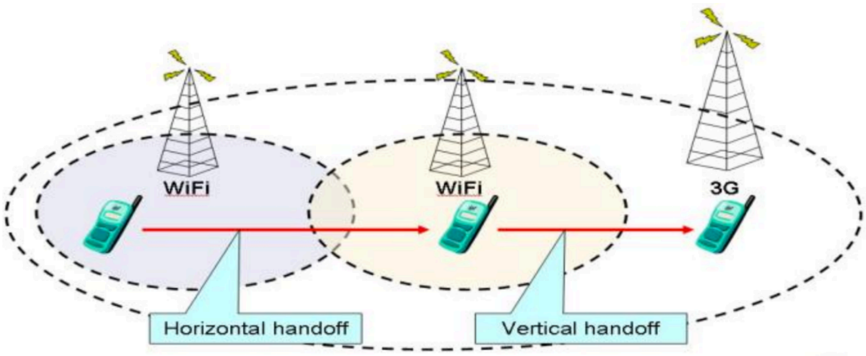

FIGURE 2.2: Horizontal and Vertical Handover.

2.2.3 Handover Based on the Mobile Terminal

1. **Hard Handover**

   When all the old radio links in the user equipment are removed before the new radio link is established. Where the hard handover can be seamless or non- seamless, it is a connection —break before make— which the communication goes under disconnection while transferring the data in heterogeneous networks [6].

2. **Soft Handover**

   The handover that occurs by the mobile means that old radio links in the user are equipment are not removed and the new radio links are establishing before breaking the old connection so for a while both links are working parallel until the target connection connects successfully this process is call make before break [6].

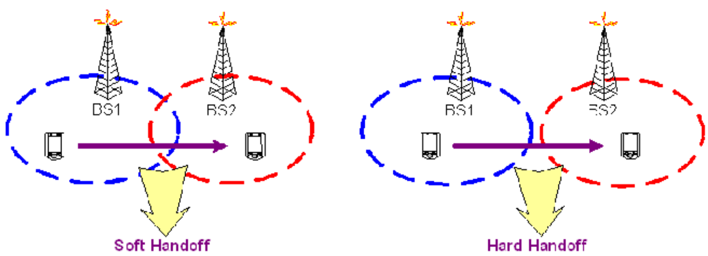

FIGURE 2.3: Soft and Hard Handover.

2.2.4 Controller based handover

When the handover decision phase and handover execution are performed by mobile station or controller. This type of handover is performed in there stages [6]:

1. **Network-controlled Handover (NCHO)**
   The handover decision stage in this mode is belong to the controller or network. where the handover initiation is belong to the mobile node. Firstly, handover initiates by the mobile node where mobile node detects the target point and inform the network to accept or reject the handover. Secondly, the controller or network decides the handover to be performed.

2. **Mobile-controlled Handover (MCHO)**
   The handover decision in this mode is up to mobile node based on local information. while other is network information that effects the handover process which is controlled by mobile node. The mobile nodes consider these parameters while making decision to the target network.

3. **Mobile-assisted Handover (MAHO)**
   This mode is belong to the mobile technologies and base stations help the mobile node to transfer the data with high channel quality and within strong signals.

2.3 Vertical Handover Process

- When a mobile user goes out of the current cell coverage area and enters to new cells coverage to continue communicating [7].
- While the mobile user faces significant interference on the current base station and needs to connect to another base station.
- When the number of mobile users is very large in the current base station and cause the deterioration of the quality service. The mobile node chooses the neighbor base station as a target destination.

In general, there are three phases for handover process [6].

1. **Handover Information Gathering**

   This phase is the handovers preparation and initiation, where the MN detects networks with its features as bit error rate, RSS, the interference level, batterys charging rate, performances terminal and the users speed which are useful information to perform handover.

2. **Handover Decision**

   This stage of the handover process is so critical and important for continuation of communication. Where the transfers decision is very important that could affect the current communication progress that improper decision may causes to decrease the quality of service and interruption in communication.

   Generally, this phase controls the connection of current network and evaluate the need of handover for selecting the target network also estimates transformation time accurately.

   By concerning the local information, user performance and the available characteristics of network, allows the user to choose the best network as destination network.

3. **Handover Execution**

   Once the best network selected and the authentication is performed, this stage starts its task where it changes the channel toward the new connection or base station by using the instruction that are provided in the decision stage.

Chapter 3

Handover Management in Heterogenous Wireless Networks

Introduction

With advancement of the wireless communication and technologies the number of mobile users also increases there is a growing demand for better mobility management techniques, interoperability will exist to accomplish the requirement of users [8]. The last years, different wireless networks such as Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WIMAX), Universal Mobile Telecommunication System (UMTS) and Long-Term Evolution (LTE) co-exist to provide best connection anywhere anytime without interruption to the ongoing sessions and to fulfill the users requirements. Within 4G systems, execution of handover is much complex because it covers both the horizontal handover and vertical handovers. Conventional handovers are received signal strength (RSS) based. Where in RSS based, the handover decision occurs based on measurement of received signals [8], mobile nodes measure the signal strength of current network continuously, if the signal of the current network gets weaker while MN is moving away from current station then the mobile nodes decide to perform handover to other neighbor base station that has strong signal.

3.1 Analysis of Handover Algorithm

Mobile networks and wireless networks are growing rapidly, the next generation of wireless network will provide seamless communication to mobile users, which they can move between terminals without distribution this process is unknown as handover.
Handover is the procedure that the mobile user changes the serving base station (BS) and connects to target base station (BS) and the best serving base station is desired target station. The conventional and popular way for selecting best target BS is received signal strength (RSS) level. The mobile node changes its current station if the neighbor station gives high RSS than the serving base station. It happens when the mobile user goes away from the current base station towards another base station. As the heterogeneity increases in cellular networks there is many other concepts need to be considered while selection the best serving BS. In general, the handover has three stages: Initiation, Preparation and Execution [6].

In initiation stage, mobile nodes periodically send message to serving base station the reference signals measurement of neighboring base station. And during the preparation phase, the serving base station, target base station and the admission controller exchanges signaling to each other. After that the admission controller decides about initiation of handover. when the handover criteria met, then user attempts to access target base station and release the serving base station. Under synchronization with target base station, the user equipment notifying the network the handover execution by send a confirmation message.Aforesaid handover process that involves signaling overhead between the user, core network, target base station and serving base station, which decrease the throughput of mobile nodes and interrupts the data flow. This interruption is happening due to the frequency that is the function of the relative values of the user velocity and base station intensity. The time duration of these interruptions from the initiation stage to the end of execution stage is called as handover delay time. It is desirable to decrease the frequency of handover interruptions at very high velocities and in dense cellular environments, which motivates the handover skipping scheme. The handover skipping decrease the frequency to sacrifice some of the best base station connectivity while performing the handover process. Hence, reducing handover delay also maintain longer service durations with the serving base stations [9].

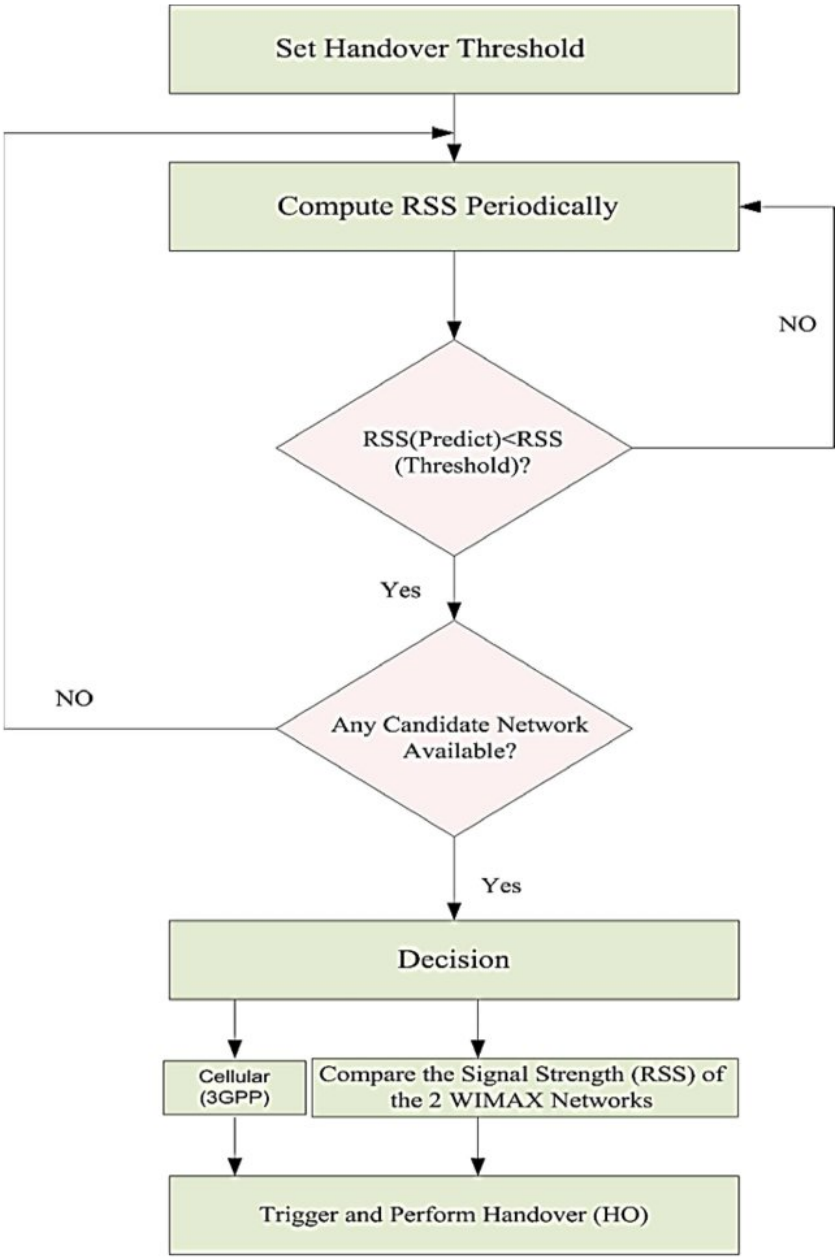

FIGURE 3.1: RSS based vertical handover in WiMAX networks

3.2 RSS Based Handover in Heterogeneous Wireless Network

The aim of handover algorithms is to maintain the call quality or in another words to maintain the packet loss or delay low a limited threshold [10]. It happens due to many reasons, when the network capacity is not enough, the quality of services goes down. The handover process occurs without any interruption in a milli-seconds that the users do not notice. Handover is the transfer a call from one network to another with different radio access technologies. And different radio technologies have different way to handle a call.

Nevertheless, they are different in type of application support, data rate and QoS which make the handover procedure more complicated. The next generation wireless network has been designed to support multi-connectivity and seamless mobility of the users within a network. The exists handover algorithms, the handover performs according to the Received Signal Strength (RSS) or some other parameters, such as the network capacity, available bandwidth, power consumption, user preference etc.

The traditional or conventional handover protocols are based on RSS or cost functions [10]. The MN measures the signal strength of current and neighbor stations by using moving average method:

$$\text{RSS current network} > \text{RSS old network}$$

When the RSS of the current network is greater than the old network the mobile node attempts to perform handover with the current new network. RSS based handover algorithms are so good in homogeneous network and are best method for network selection. And because of the wireless medium due to pathloss the fluctuation of signals exists, this is known as fading.

The RSS-based handover the received signal strength depends upon the distance of the mobile terminal from the base station. The author in [10] shows relationship between RSS and distance which is shown in Figure 3.2 [10]. As shown in the figure RSS value decreases when the MN moves away from the current base station.

The RSS is calculated using the following function [10].

$$RSS = 62.526.5 * \log_{10} d$$

d is distance in kms between a base station and mobile station.

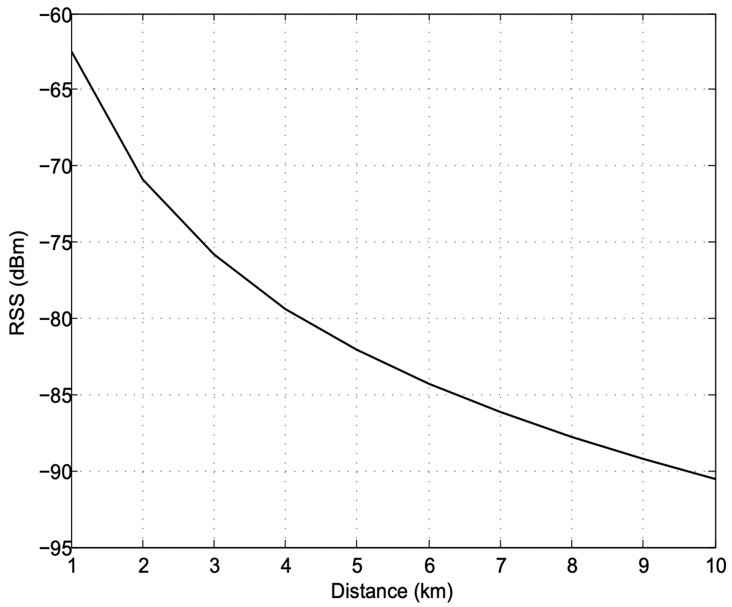

FIGURE 3.2: RSS vs Distance

3.3 Related Works

Most of the existing handover schemes are based on the SINR, bandwidth, RSS [11]. The author in [12] proposed, roaming between WiMAX network and Wi-Fi network, it would be good to perform handover to Wi-Fi network when the Wi-Fi is available it is because the Wi-Fi networks have high bandwidth and lower cost, in this case they do not consider about the handover probability. When the mobile user moves away, and handover should be performed, Wi-Fi networks covers very small area that the MU might require to perform handover frequently, thus the handover probability increasing and affecting the QoS. The authors in [13] proposed a handover scheme to use the received (SINR) and bandwidth from different access networks based on the handover criteria. Through the simulation the authors showed that SINR based vertical handover algorithm provides maximum available throughput to the mobile user during vertical handover. However, choosing a target network to perform handover with higher bandwidth is not always beneficial to serving base station because the environmental and networking factors affect which cause SINR variation. Thus, result is the handover probability increasing and might cause unnecessary handovers.

Chapter 4

Mobility Management in Wireless Networks

In this chapter we will describe about mobility management in mobile wireless communication networks is essential for understanding the parameters and procedure used to make it work.

4.1 Mobility Management in Cellular Networks

Between the different radio resource management functionalities, the mobility management is guaranteeing the maintaining of the services as the mobile user moves between different cells [14]. In general, the mobility of the user equipment between different networks are managed by handovers.

4.2 Mobility Management in 3G Networks

The third generation of cellular networks, such as Universal Mobile Telecommunications System (UMTS), and CDMA2000, that deliver data rate up to 2Mbps with wide coverage areas.
To deliver high data rate at local area access, wireless LAN (WLANs) are the best solution that support up to 54Mbps bandwidth at very low cost. The WLANs have small areas coverage with low mobility users.

Mobility in 3G networks are based on soft handovers, that the user equipment can sustain many active connections to two or more neighboring cells simultaneously. The cells that a user equipment is connected to, form a list called active set (AS). As the mobile user gets close to the boundaries of the serving base station, the neighboring base station becomes a part of the AS, and the transportation of data follows different streams between cell and mobile user. The signals from different cells are combined by the user equipment in the downlink. And in the uplink, if the AS belong to same station site and the data flows are combined by the Node-B, and this process is called softer handovers.
The soft handover has the capabilities of maintaining several links active and the service continuity is guaranteed. Hence, this functionality can only be applied to intra-frequency handovers. For inter frequency handovers the link with previous cells must be break before connecting to a new cell and this process is call hard handover and because of that, the user equipment are unable to exchange any data with previous cell during handover. In any of the above cases, Radio network controller (RNC) is an entity that make decision that which cell should serve the radio links, when the link should be broke, execute the admission control, and then decides when the handover should be performed.

4.3 Mobility Management in LTE Networks

The 3rd Generation Partnership Project (3GPP) developed the LTE wireless technology which contributed with fourth generation of mobile networks. LTE can support multimedia traffics with high data rates such as Voice over IP (VoIP) online conference, video call, video streaming and gaming over wireless network to access anytime and anywhere. Nevertheless, LTE networks support Multiple Input and Multiple Output (MIMO) technology and orthogonal Frequency Division Multiple (OFDM), Frequency Division Duplexing (FDD) as well as Time Division Duplexing (TDD) mode.

LTE networks implements hard handover process. In this procedure of handover, while the mobile user moves away from serving base station the connection should be broken before make the connection with new or target base station. And known as Break-before-Make handover.
The RNC entity does not exist in LTE networks. Therefor the eNBs are performing the handover decision and the admission control. Also, the eNBs support efficient and fast data forwarding during handovers.

4.4 Mobility Management in 5G Networks

Lately many engineers and researchers interested to work on 5G new technology, that would lead many challenges with its development [15]. The aim of 5G is to support high data rate, the data volume, the growth of devices, enhance end-user quality-of-experience (QoE), reduce end-to-end latency, and lower energy consumption. In order to achieve this, the network type will be designed an ultra -dense network (UDN) with increased bandwidth. The main features of 5G are the following [15]:
High Data Rate: With gravitate towards ultra-dense network (UDN) and increasing of bandwidth and advancing in MIMO techniques the 5G will support the high-speed data rate per request. It is expected that the amount of data would increase 1000 times from current 4G technology.
Bandwidth: 5G uses additional spectrum in the existing LTE frequency range to build on the capabilities of 4G, in order to increase the carrier frequency, it is necessary to increase the bandwidth.
Ultra Dense Network (UDN): Using UDN is an important feature in 5G it is because it uses high frequencies. Another important benefit is using small cells that allow to reuse the spectrum more often, and there will be less user per cell and each base station would be able to serve less users and therefore the traffic will be more bursty.
Multi-RAT: The networks will be increased to be heterogeneous network when we move towards 5G, Multiple RATs will support 5G technology as well as 3G

and LTE. To implement this scenario, there are many challenges regarding to the load of base stations, users are able to change base stations according to gains to specific base stations and the load.

Other topics are millimeter waves and massive MIMO. The main idea of the millimeter waves is utilizing the free spectrum where wavelengths are about 1-10mm, that requires many antennas to navigate the beams. Concerning the technique of massive MIMO, means to design and equip the base stations with large number of antennas, therefore it is focusing signals on very small areas. These two concepts are not be analyzed furthermore because it is out of our study scope.

Chapter 5

GPS-based Mobility Management

Introduction

Many studies have been done on handover management and on blocking handover probabilities with different techniques. The conventional is based on allocation of channels for handover users, although previous studies shows that the blocking probabilities of handover can be reduced by reserving resource for mobile users, that this mechanism in overall system performance only results in marginal increase, the blocking probabilities of handover increased due to allocation of channel to the users permanently, even there is no need of handover requirement. The geolocation of MNs has been used for handover management in the past few years in wireless environment. For the first time geolocation systems were used in cellular networks to support mobility. In [16] the author presents a method to enhance link layer and network layer handovers by using the geolocation information of MNs that are provided by a *GPS* system, to reduce the layer 2 discovery phase and the layer 3 new link detection which are the two significant points introduced in the handover process.In our proposal method we get the geolocation information from *GPS* satellites and compared timing error of *GPS* satellites signals in the cell boundaries of the base stations. We use a mobility model to calculate the users handover blocking probabilities with the two signals of *GPS* satellite.

5.1 GPS Doppler Processing

In global navigation satellite systems, the *GPS* is one of the most important system for analysis of movement and it is widely used to track the location of user and to record the trajectories of vehicles.
There are two types of signals are transmitting from a *GPS* satellite for positioning [17].

1. PN code signal

2. Carrier signal

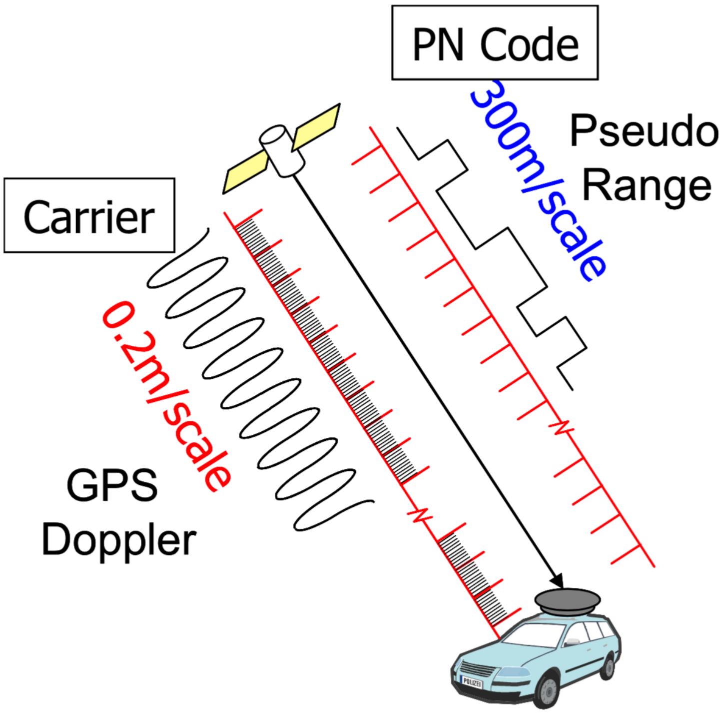

FIGURE 5.1: illustrates a simple example of distance resolution improvement using the two types of *GPS* signal.

The distance resolution of *PN code signal* is 300 m and the distance resolution for the carrier signal 0.2m in the case of measurements Fig 5.1 [17]. The distance resolution of the carrier signal is more accurate than the distance resolution of *PN code signal*. Thus, the carrier signal is used to find the accurate position like RTK-GPS, that requires received signal at a base station in case of measuring the

distance.
The *GPS Doppler shift frequency* $\Delta f[Hz]$ is obtained from equation 5.1.

$$\Delta f = \frac{f1}{C}(Vsi - Vvi + Cbv) \tag{5.1}$$

$$\Delta f = \frac{f1}{C}(Vsi) \tag{5.2}$$

The velocity of vehicle and clock bias variation compare to satellite is so less we ignored, we used the carrier frequency and speed of light with satellite speed to calculate the *GPS* doppler shift frequency using equation 5.2.

TABLE 5.1: Doppler Shift Frequency Notation

s

SYMBOL	MEANING	VALUE
f_1	Carrier Signal Frequency	1575.42x10^6 (Hz)
C	Speed of Light	2.99792458x10^8(m/sec)
Vsi	Velocity of Satellite	388.8 (m/s)
Vvi	Velocity of Vehicle	5-40 (m/s)
Cbv	Clock Bias Variation	0.8(m/s)

We calculated the doppler shift frequency to find the $timing\ error$ of carrier signal of GPS and $PNcode\ signal$ to calculate the handover blocking probability at cell boundary of the base stations.

5.2 GPS-based Handover Management

In general, when a MN moves from base station to base station the serving base station of the mobile changes based on the cell system planning design. When the MN travelling from current base station to one of the neighbors as a target base stations, the probability of the handover is designed to be maximize at cell boundary.
There are several algorithms have been proposed to perform handover decision

(HD) where the Received signal strength (RSS) is the conventional way to perform handover and to measure the service quality and the most widely used criterion. To read the RSS there is directly related to the distance from the Mobile station to its point of attachment. And this parameter is widely used for horizontal handover algorithms as main decision criterion [18].
By the growth of location-based services the mobile entertainment devices are equipped with location solutions of their own, such as network assisted positioning and Global positioning system (GPS).

5.2.1 The Proposed Approach

To calculate the blocking error for the handover of mobile nodes, it is not enough to focus on all the parameters that are gleaned through the handover performance. In our model the essentials are timing error of GPS signals and the frequency shifts that are transferred from *GPS* satellites. In our idea we used the timing error of carrier and PN code signals of satellites to calculate the probability of handover blocking inside and outside of the cell boundaries of base stations.
The proposed model in this study consists of two circular cells as BS1, BS2.

5.3 Numerical Results

The following analytical procedure has been implemented to evaluate:

1. The Doppler shift frequencies of two different satellite signals;

2. The timing error at the cell boundary of base station;

$$Timing - Error = \left| \frac{1}{\Delta f} \right| \tag{5.3}$$

By using equation 5.3 we can find the timing error of satellite signals when the receivers receive the signals. The Δf is the doppler shift frequency.

The timing error for two different signals of satellites are different as the carrier signal of satellite gives the precise value and the PN code signal of satellite

is 1500 times greater due to the distance resolution compare to carrier signal.
Using *GPS* system, we determine the location of MN whether the MN is inside the region or outside of that region.
When the MN located in the region of handover near to cell boundary of handover, it performs handover and we can calculate the blocking error of handover.

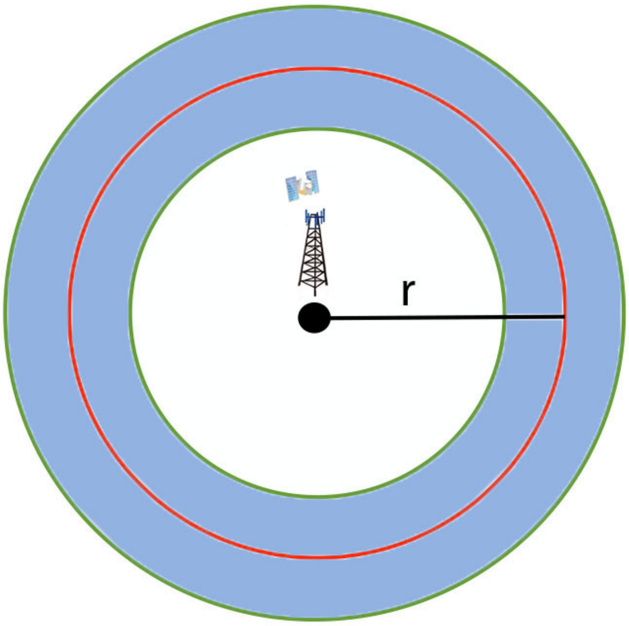

FIGURE 5.2: Timing error inside and outside of the cell boundary

The figure 5.2 shows the timing error of handover inside and outside of the cell boundary where the red line shows the exact radius of cell and the green lines inside and outside of cell show the effected area of errors, we assumed the base station as a circular cell with the radius of 150m.

Figure 5.3 shows the difference between the timing error of PN code signal of satellite and Carrier signal of the satellite, the X-axis shows the speed(m/s) of vehicle as it increases, and the Y-axis shows the Timing error for PN code and Carrier signals that the timing error of the PN code is more than the Carrier signals.

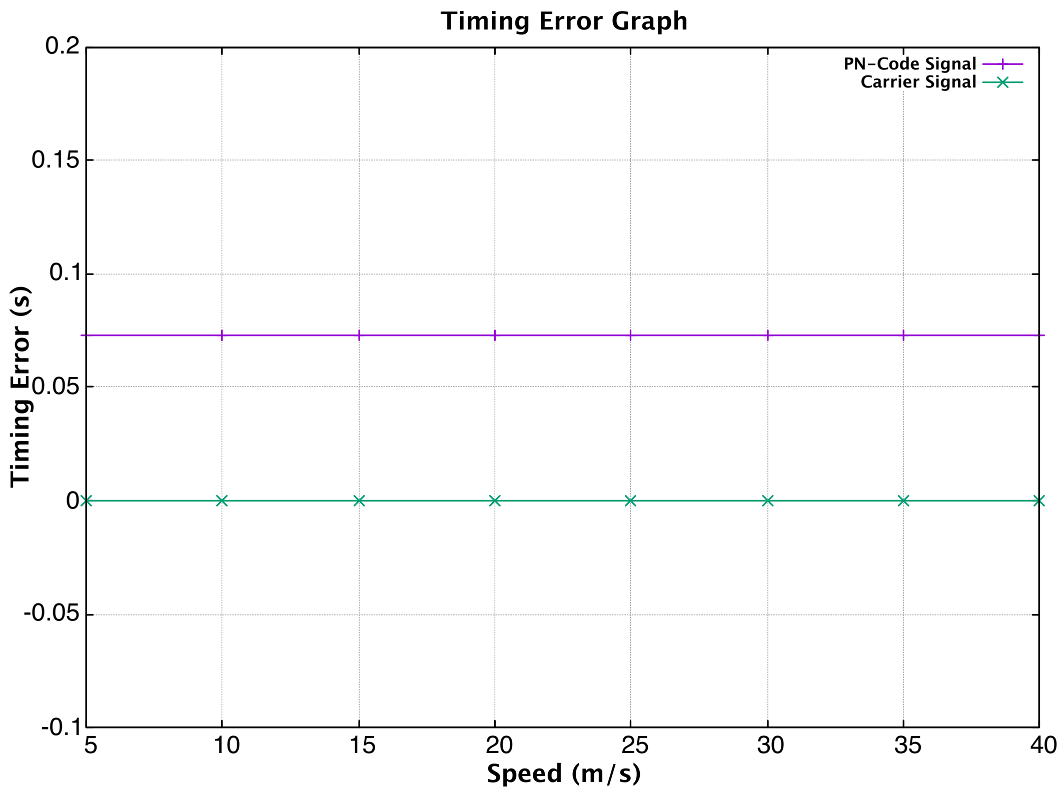

FIGURE 5.3: The Timing Error of Carrier signal and PN code signal versus Speed (m/s)

5.3.1 Handover Blocking Probability

We assume the base stations as a circular cell, we calculate the area of cell using equation 5.4.

$$A_{Cell} = \pi r^2 \tag{5.4}$$

Where r is the radius of cell and we assumed $150m$ and the value of pi is 3.14 and A_{cell} is the area of cell. By using equations 5.5 and 5.6 we calculate the error area of both signals of satellite, carrier and PN code signal inside and out of base station boundary that it forms a circular cell.

$$A_{GPS} = \pi \left[\left(r - \Delta t_{GPS} \times N_{PN} \times \sqrt{\frac{\Delta t_{PN}}{\Delta t_{GPS}}} \right)^2 - r^2 \right] \times (A)^2 \tag{5.5}$$

TABLE 5.2: GPS-based blocking handover Notation

SYMBOL	MEANING
A_{cell}	Area of the Cell
$PNsignal$	Pseudo Noise signal of GPS satellite
A_{GPS}	Area of cell effected by carrier signal
A_{PN}	Area of cell effected by PN signal

Equation 5.5 gives the error effected area of GPS carrier signal where N_{PN} is the number of rounds for PN code signal and $\sqrt{\frac{\Delta t_{PN}}{\Delta t_{GPS}}}$ is the time different eco-efficiency between two *GPS* signals. Â is handover efficiency and coefficient of *GPS* made over PN code.
And for PN code signal the effected error area can be get from equation 5.6

$$A_{PN} = \pi\left[\left(r - \Delta t_{PN} \times N_{PN}\times\right)^2 - r^2\right] \tag{5.6}$$

We can find the handover blocking probability at the cell boundary of each base station for *GPS* signals by using the following equations:

$$P_{PN} = \frac{A_{PN}}{A_{Cell}} \tag{5.7}$$

$$P_{GPS} = \frac{A_{GPS}}{A_{Cell}} \tag{5.8}$$

By using the above equations we compared the handover blocking for both signals of the *GPS* in the cell boundary of the base station.

Figure 5.4 shows the handover blocking probability of two *GPS* signals with respect to the speed of vehicle. As shown in the figure 5.4 the handover blocking probability increases when the speed of the vehicle is increasing. It is a simple

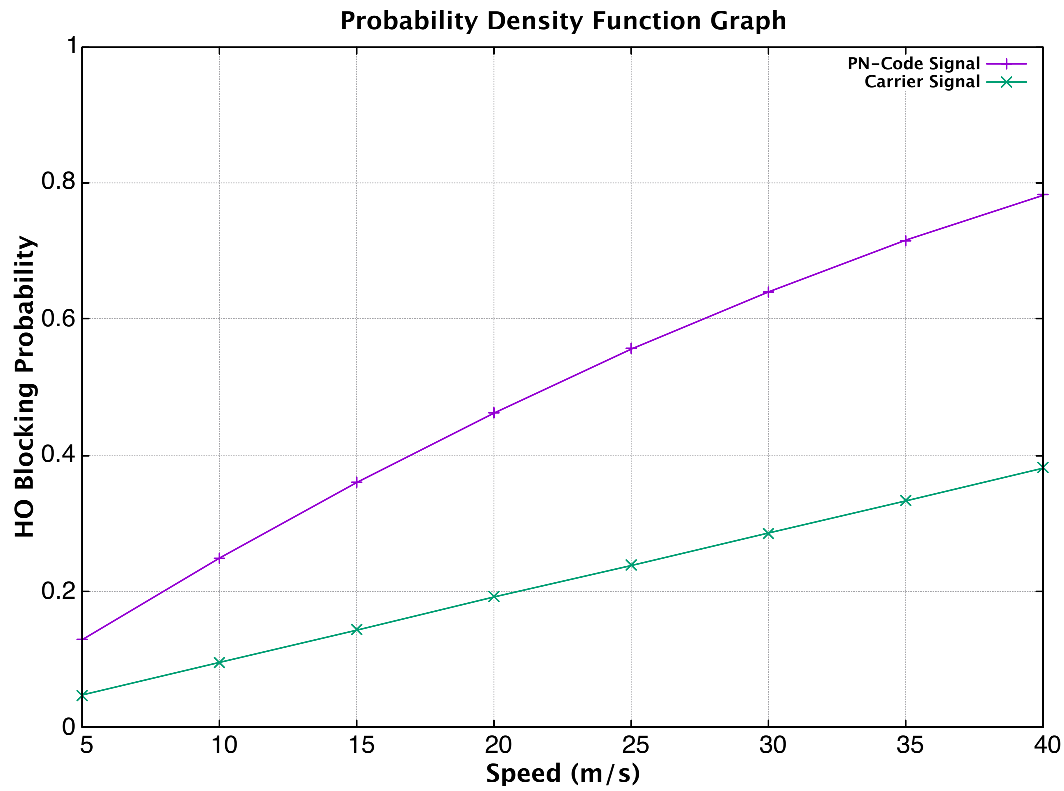

FIGURE 5.4: Probability density function graph

mobility pattern directional from one base station to another. The blocking probability for both signals have same tendency within limited speed and are applicable for many types of mobility. When blocking probability increases it means that that the handover is difficult to be performed, for this reason we need a threshold value for handover blocking probability that beyond this threshold the Handover can not be performed as figure shows we considered about 40 percent so less than this value the handover would be performed. In our proposal we can improve to reduce blocking probability, so the range increases from 17m/s speed in case of PN code signal into 40m/s with much longer applicable range for mobility in case of Carrier signal of *GPS*.

Chapter 6

Conclusion and Future Work

Nowadays mobile phones aim to achieve positioning in harsh environments. To support the location-based services and radio resource management the location tracking for mobile stations are required. In this thesis, the handover algorithm is analyzed with the calculation of GPS information as a function of the exact location of the mobile nodes nearby the cell boundary of base stations. It can substantially reduce the blocking probability of handover at the cell boundaries of the two base stations. We compare the handover performance at the cell boundaries using two signals of GPS satellite that are transmitted for positioning including carrier signal and PN code signal. We realize that the blocking probability for both GPS signals have same tendency within limited speed and are applicable for many types of mobility pattern. When blocking probability increases, the handover is difficult to be performed. Thus, we need a threshold value for handover blocking probability to define the suitable handover operation for the mobile. As a result, we can reduce blocking probability, and the applicable mobility speed range increases in case of Carrier signal of GPS compared to PN code signal. As a future work we will compare the performance of our GPS-based strategy with next wireless communication systems under the assumption that the received signal strength RSS is a function of the speed of the mobile nodes and the distance from base stations.

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