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Performance analysis of predictive trigger algorithm for Mobile Wimax Networks.

THESIS

By

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Presented as a partial fulfillment of the requirements for the degree of
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Major in Telecommunications

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Abstract

A major consideration for mobile WiMAX is Seamless Handover. Cellular-based standards have the advantage of many years experience in handover for voice calls, while for broadband mobility in itself is no mean feat, and handover is still a challenge. IEEE 802.16e (Mobile WiMAX) is a wireless metropolitan area network standard with high transmission speed and great coverage.

This work will address the handover process; an important issue of Mobile WiMAX system. This thesis considers the importance to have the correct handover initiation process. By using a predictive algorithm, in hands of the threshold that triggers the handover process based on RSSI.

We study in this thesis the intracellular and intercellular handover process in Mobile WiMAX system. We focus in particular on the impact of use a predictive trigger algorithm in order to ensure a success handover process.

We demonstrate that using a predictive algorithm offers a significantly advantage over the traditional algorithm of handover process.

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LIST OF ACRONYMS

AAA: Authentication, Authorization and Accounting

AMC: Adaptive modulation and Coding

AES: Advanced Encryption Standard

ASN: Access Service Network

BS: Base Station

CBR: Constant Bit Rate

CINR: Carrier Interference Noise Ratio

CSN: Connectivity Service Network

CTBS: Cost Effective Target BS selection Scheme

DL-MAP: Downlink Map Message

DSL: Digital Subscriber Line

DCD: Downlink Channel Descriptor

FDD: Frequency Division Duplex

FDMA: Frequency Division Multiple Access

FFT: Fast Fourier transforms

FTP: File Transfer Protocol

FEC: Forward Error Correction

FBSS: Fast BS Switching

HO: Handover

HHO: Hard Handover

ISI: Inter Symbol Interference

IE: Information Element

LOS: Line Of Sight

MAC: Medium Access Control

MPDU: MAC Protocol Data Units

MSDU: MAC Sevice Data Units

MPEG: moving pictures experts group

MS: Mobile Station

MDHO: Macro Diversity Handover

NLOS: Non-Line Of Sight

nrtPS: non-real-time Polling Service

NWG: Network Working Group

OFDM: Orthogonal Frequency Division Multiplexing

OFDMA: Orthogonal Frequency Division Multiple Access

PDA: Personal Digital Assistant

PER: Packet Error Rate

PHY: Physical Layer

PMP: Point to Multi-Point

QAM: Quarter Amplitude Modulation

QoS: Quality of Service

rtPS: real time Polling Service

SDU: Service Data Units

SNR: Signal to Noise Ratio

SS: Subscriber Station

TDD: Time Division Duplex

TDM: Time Division Multiplexing

TDMA: Time Division Multiple Access

UCD: Uplink Channel Descriptor

UGS: Unsolicited Grant Service

UL-MAP: Uplink Map Message

VBR: Variable Bit-Rate

VoIP: Voice over IP

WLAN: Wireless Local Area Networks

WMAN: Wireless Metropolitan Area Network

WiBro: Wireless Broadband

WiMAX: Worldwide interoperability for Microwave Access

Chapter 1

1.1. Background

Mobility is the most important feature of a wireless cellular communication system. Usually, continuous service is achieved by supporting handover from one cell to another. The IEEE standard 802.16e-2005 provides enhancements to IEEE standard 802.16-2004 to support subscriber stations (SS) moving at vehicular speeds. It thereby specifies a system for combined fixed and mobile broadband wireless access without compromising the capabilities of fixed IEEE 802.16 subscribers. Functions to support handover at higher layers between base stations are specified.

The concept of handover consists of the transition that takes place when we happened of the action rank of a cell to the rank of action of another one. Handover, therefore, is the process in charge to maintain the service of content way and of which the transitions between a cell and another one are sufficiently small like happening unnoticed through the users.

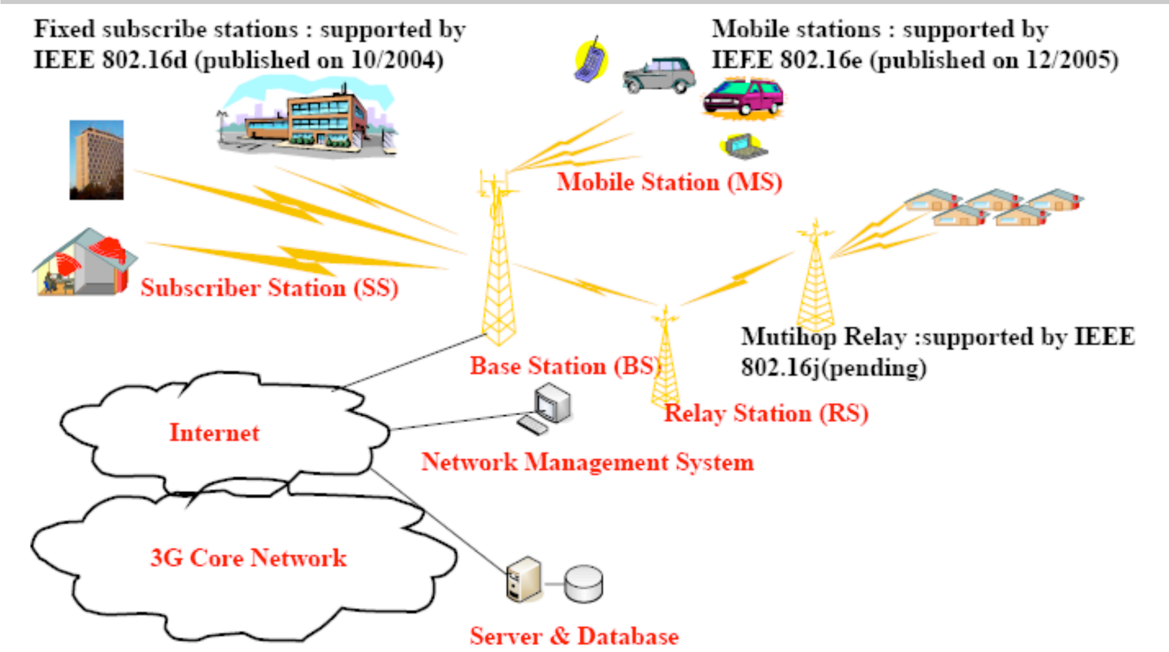

Figure 1: Interoperability in Wimax Network.

1.2. Objective.

The necessity to maintain the effective connectivity in relation to the mobility of the users is the constant challenge of the tendencies of communication systems, by consequence the process of adoption of new technologies are obtained with standards and interoperability.

According to the mobility framework of IEEE 802.16e, a Mobile Station (MS) should scan the neighbouring Base Stations (BSs) for selecting the best BS for a potential handover. However, the standard does not specify the handover initiation algorithm.

Moreover, thus improving the overall handover performance.

Simulation results …more effective than the conventional IEEE 802.16e handover scheme in terms of handover delay and resource wastage.

1.3. Contribution

This thesis presents an analysis and performance of handover predictive trigger algorithm in Mobile Wimax network, based on RSSI as a parameter of handover decision in order to reduce the time of link connect using the RSSI that have been predicted.

1.4. Organization

This thesis is organized as follows:

- Chapter 2 gives a description of the basic concepts of Wimax and the extension of Mobile WIMAX and Handover.
- Chapter 3 gives a description of the basic concepts of Handover.
- Chapter 4 describes the Handover process in Mobile Wimax.
- Chapter 5 explains the Trigger Predictive algorithm used for the Handover performance analysis in Mobile Wimax Networks.
- Chapter 6 shows Results and future works research.

Chapter 2

Wimax Technology

2.1. WIMAX background.

WiMAX (also known as IEEE 802.16) is a wireless digital communications system that is intended for wireless "metropolitan area networks" (WMAN).

It can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. In contrast, the WiFi/802.11 wireless local area network standard is limited in most cases to only 100 - 300 feet (30 - 100m).

WiFi-like data rates are easily supported in WiMAX, but the issue of interference is less. Operating on both licensed and non-licensed frequencies, it provides a regulated environment and a viable economic model for wireless carriers.

WiMAX can be used for wireless networking in much the same way as the WiFi protocol. WiMAX is a second-generation protocol that allows for more efficient bandwidth use, interference avoidance, and is intended to allow higher data rates over longer distances.

The IEEE 802.16 standard defines the technical features of the communications protocol. The WiMAX Forum offers a means of testing manufacturer's equipment for compatibility, as well as an industry group dedicated to fostering the development and commercialization of the technology. Soon, WiMAX will be a very well recognized term to describe wireless Internet access all over the world.

The IEEE 802.16 group was formed in 1998 to develop an air-interface standard for wireless broadband. The group's initial focus was the development of a LOS-based point-to-multipoint wireless broadband system for operation in the 10GHz–66GHz millimeter wave band. The resulting standard—the original 802.16 standard, completed in December 2001—was based on a single-carrier physical (PHY) layer with a burst time division multiplexed (TDM) MAC layer. Many of the concepts related to the MAC layer were adapted for wireless from the popular cable modem DOCSIS (data over cable service interface specification) standard.
The IEEE 802.16 group subsequently produced 802.16a, an amendment to the standard, to include NLOS applications in the 2GHz–11GHz band, using an orthogonal frequency division multiplexing (OFDM)-based physical layer.

Additions to the MAC layer, such as support for orthogonal frequency division multiple access (OFDMA), were also included. Further revisions resulted in a new standard in 2004, called IEEE 802.16-2004, which replaced all prior versions and formed the basis for the first WiMAX solution.

These early WiMAX solutions based on IEEE 802.16-2004 targeted fixed applications, and these will be referred to as fixed WiMAX [19]. In December 2005, the IEEE group completed and approved IFEEE 802.16e-2005, an amendment to the IEEE 802.16-2004 standard that added mobility support. The IEEE 802.16e-2005 forms the basis for the WiMAX solution for nomadic and mobile applications and is often referred to as mobile WiMAX [ref].

Note that these standards offer a variety of fundamentally different design options. For example, there are multiple physical-layer choices: a single carrier- based physical layer called WirelessMAN-SCa, an OFDM-based physical layer called WirelessMAN-OFDM, and an OFDMA- based physical layer called Wireless-OFDMA.

Similarly, there are multiple choices for MAC architecture, duplexing, frequency band of operation, etc. These standards were developed to suit a variety of applications and deployment scenarios, and hence offer a plethora of design choices for system developers. In fact, one could say that IEEE 802.16 is a collection of standards, not one single interoperable standard.

With the completion of the IEEE 802.16e-2005 standard, interest within the WiMAX group has shifted sharply toward developing and certifying mobile WiMAX[ref] system profiles based on this newer standard. All mobile WiMAX profiles use scalable OFDMA as the physical layer. At least initially, all mobility profiles will use a point-to-multipoint MAC. It should also be noted that all the current candidate mobility certification profiles are TDD based. Although TDD is often preferred, FDD profiles may be needed for in the future to comply with regulatory pairing requirements in certain bands.

For the reminder of this chapter, the focus is only on WiMAX and therefore only aspects of IEEE 802.16 family of standards that may be relevant to current and future WiMAX certification are discussed. It should be noted that the IEEE 802.16e-2004 and IEEE 802.16-2005 standards specifications are limited to the control and data plane aspects of the air-interface. Some aspects of network management are defined in IEEE 802.16g. For a complete end-to end system, particularly in the context of mobility, several additional end-to end service management aspects need to be specified [2].

2.2 IEEE 802.16 MAC

IEEE 802.16 Medium Access Control (MAC), which IEEE 802.16e MAC generally follows,has a network topology of point to multi-point (PMP), with support for mesh network topology.

Its backhaul can be either ATM (asynchronous transfer mode) or packet-based (such as IP networks). From the reference model as illustrated in Figure 2, there are three sub-layers in the MAC:

_ *Service Specific Convergence Sub-layer (CS*): providing any transformation or mapping of external network data through CS SAP (CS service access point).

_ *MAC Common Part Sub-layer (MAC CPS)*: classifying external network service data units (SDUs) and associating these SDUs to proper MAC service flow and Connection Identifier (CID). Multiple CS specifications are provided to interface with various protocols.

_ *Privacy (or Security) Sub-layer*: supporting authentication, secure key exchange, and encryption.

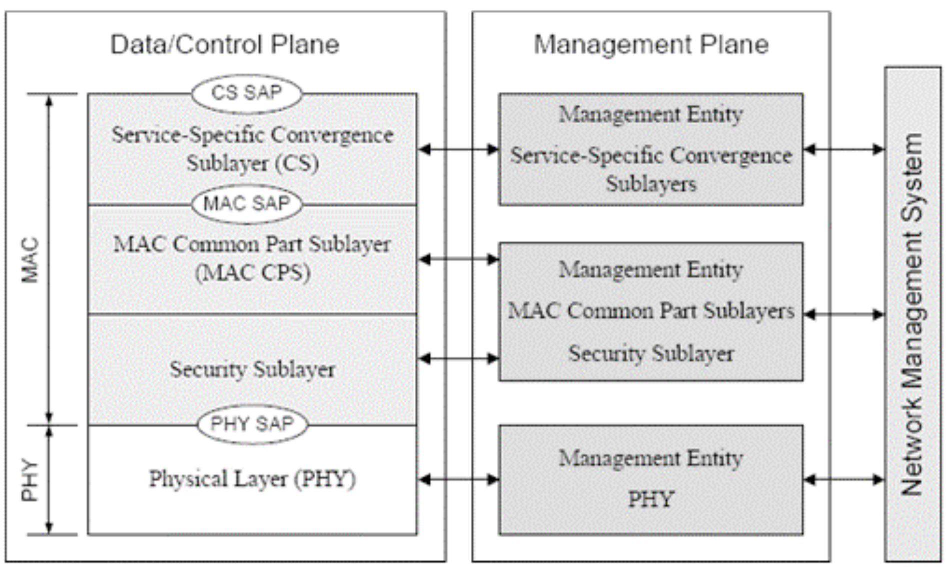

Figure 2. Reference Model of IEEE 802.16

Different from typical MACs using random access techniques in the IEEE 802, IEEE 802.16 MAC is connection oriented, and similar to time division multiple access (TDMA). Once a subscriber station (SS) enters the network, it creates one or more connections to communicate with the base station (BS). It also performs link adaptation and automatic repeat request (ARQ) functions to maintain the target bit error rate. To further support multimedia traffic, IEEE 802.16 MAC may have to use radio resources, and provide quality-of-service (QoS) differentiation in services, which are not considered typical MAC functions. To support OFDMA PHY, the MAC layer is responsible for assigning frames to the proper zones and exchanging this structure information with the SSs in the DL and UL maps. Transmit diversity and adaptive antenna system (AAS), as well as MIMO zone, are included.

IEEE 802.16 MAC is connection-oriented. As BS controls the access to the medium, bandwidth is granted to SSs on demand. At the beginning of each frame, the BS schedules the uplink and downlink grants to meet the negotiated QoS requirements. Each SS learns the boundaries of its allocation under current uplink sub-frame via the UL-MAP message. The DL-MAP delivers the timetable of downlink grants in the downlink sub-frame.

To deal with mobility in Mobile WiMAX, IEEE 802.16e the MAC specifies MAC layer handover procedure, while the exact handover decision algorithm is not specifically defined.

Handover happens in two possible situations:

- _ When the mobile station (MS) moves and needs (due to signal fading, interference level, etc.) to change the BS that is currently connected, in order to provide a better signal quality.
- _ When MS can be served with higher QoS at another BS.

Prior to handover, network topology acquisition must be achieved in three steps:

1. *Network topology advertisement*:ABS broadcasts information regarding the network topology (typically using MOB NBR-ADV), which might be obtained from the backbone.

2. *MS scanning the neighboring BSs*: For the purpose ofMSseeking and monitoring suitability of neighboring BSs as handover candidates, BScan allocate time interval(s) toMSand such a scanning duration is known as a scanning interval. Once a BS is identified through scanning, MS may attempt to synchronize with its downlink transmission and estimate the quality of physical channel. The serving BS may buffer the incoming data during the scanning interval until the exit of the scanning mode.

3. Association: Association is an optional initial ranging procedure during the scanning interval with respect to one of the neighboring BSs. The function of association is to enable the MS to acquire and to record ranging parameters and service availability information for the purpose of proper selection of the handover target.

After network topology acquisition, the handover process proceeds for a MS migrating from the air-interface (or radio resource) provided by one BS to that provided by another BS, as the following stages:

_ *Cell re-selection*: MS may use neighboring BS information, or may request to schedule scanning intervals to scan/range, in order to evaluateMSinterests in handover to neighboring BS.

_ *Handover decision and initiation*: A handover begins with a decision for an MS to switch from a serving BS to a target BS. Such a decision can be originated by either MS or serving BS.

_ *Synchronization to target BS downlink*: MS in handover process first synchronizes to downlink transmissions of target BS to obtain DL and UL transmission parameters (such as MAP).

If the target BS has previously received handover notification from serving BS through backbone, the target BS may allocate a non-contention-based initial ranging opportunity.

_ *Ranging*: The target BS may get information from the serving BS through the backbone network. The MS and target BS will conduct either initial ranging or handover ranging to set up the correct communication parameters.

_ *Termination of MS context*: This is the final step in handover, to terminate service at the serving BS. An MS may terminate handover at any time prior to termination.

2.3. Mobile Wimax (802.16e)

MobileWiMAX is generally considered to be the IEEE 802.16e-2005 adopting OFDMA PHY. The IEEE 802.16e-2005 supports both time division duplexing (TDD) and frequency division duplexing (FDD) modes. However, the initial release of Mobile WiMAX profiles only considers the TDD mode of operation for the following reasons:

_ It enables dynamic allocation of downlink (DL) and uplink (UL) radio resources to effectively support asymmetric DL/UL traffic that is common in Internet applications. The allocation of radio resources in DL and UL is determined by the DL/UL switching point(s).

_ Both DL and UL are in the same frequency channel to yield better channel reciprocity and to better support link adaptation, multi-input-multi-output (MIMO) techniques, and closed loop advanced antenna technique such as beam-forming.

_ A single frequency channel in DL and UL can provide more flexibility for spectrum allocation.

Specifications are provided such that mobility of the MS at 120 KMPH is allowed. Orthogonal frequency division multiple access (OFDMA) is used as the physical layer scheme. Channel coding is provided by use of mandatory CC and optional BTC, CTC and low-density parity check codes (LDPC).

Data is randomized and interleaved to avoid loss of carrier recovery and burst errors. In addition to AAS, STC, optional multi input multi output (MIMO) scheme has been specified.

Code division multiple access (CDMA) codes are used along with the random window length based contention control algorithm for initial ranging, periodic ranging, bandwidth request and handoff. The inter BS communications have been defined, which will be used as a backbone network between the BS's to aid the inter-cell mobile subscriber station (MS) handoff.

In 802.16e-2005 for mobile access. OFDMA delivers QoS at high speeds with the following features:

- Scalable channel bandwidths from 1.25 to 20MHz3 with Fast Fourier Transform (FFT) size.
- Resistant to interference with subchannel orthogonality and reduction of Intercarrier and Inter-symbol interferences with guard band.
- Time Division Duplex (TDD) support for asynchronous data traffic and implicit

channel side information via channel reciprocity.

- Significant cell range extension due to concentrated transmit power in uplink and with assignment of more power to distant users in downlink.
- Hybrid-Automatic Repeat Request (HARQ) reliability support for high mobile situations.
- Frequency selective scheduling and subchannelization with various flexible permutation options.
- Sleep and idle mode support for power management.
- Optimized hard handover and support for soft handover.

Chapter 3

Handover in Wireless Technologies

3.1 Why Handover?

In cellular telecommunications, the term handover refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another.

There may be different reasons why a handover might be conducted:

• When the phone is moving away from the area covered by one cell and entering the area covered by another cell the call is transferred to the second cell in order to avoid call termination when the phone gets outside the range of the first cell.

• When the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell.

• In non-CDMA networks when the channel used by the phone becomes interfered with by another phone using the same channel in a different cell, the call is transferred to a different channel in the same cell or to a different channel in another cell in order to avoid the interference.

• Again in non-CDMA networks when the user behavior changes, e.g. when a fast-traveling user, connected to a large, umbrella-type of cell, stops then the call may be transferred to a smaller macro-cell or even to a micro-cell in order to free capacity on the umbrella cell for other fast traveling users and to reduce the potential interference to other cells or users (this works in reverse too, when a user is detected to be moving faster than a certain threshold, the call can be transferred to a larger umbrella-type of cell in order to minimize the frequency of the Handovers due to this movement).

• In CDMA networks a soft handover may be induced in order to reduce the interference to a smaller neighboring cell due to the "near-far" effect even when the phone still has an excellent connection to its current cell.

3.2 Types of Handover

Handovers are broadly classified into two categories—**hard** and **soft handovers**. Usually, the hard handover can be further divided into two different types—**intra-** and **inter- cell** handovers. The soft handover can also be divided into two different types—**multiway soft handovers** and **softer handovers**. In this thesis work, the focus is primarily on the hard handover.

A hard handover is essentially a “break before make” connection. Under the control of the MSC (Mobile Switching Centre), the BS hands over the MS’s call to another cell and then drop the call. In a hard handover, the link to the prior BS is terminated before or as the user is transferred to the new cell’s BS; the MS is linked to no more than one BS at any given time.

Hard handover is primarily used in FDMA (frequency division multiple access) and TDMA (time division multiple access), where different frequency ranges are used in adjacent channels in order to minimize channel interference.

So when the MS moves from one BS to another BS, it becomes impossible for it to communicate with both BSs (since different frequencies are used).

The figure below illustrates hard handover between the MS and the BSs. Intra cell/domain handover refers to handover occurring when a MS moves from the vicinity of one BS to another BS within the same operator or backbone (referred to as (A) in the next figure).

Inter cell/domain handover refers to a similar activity where the BSs are from different operators or backbones (referred to as (B) in the figure 3.

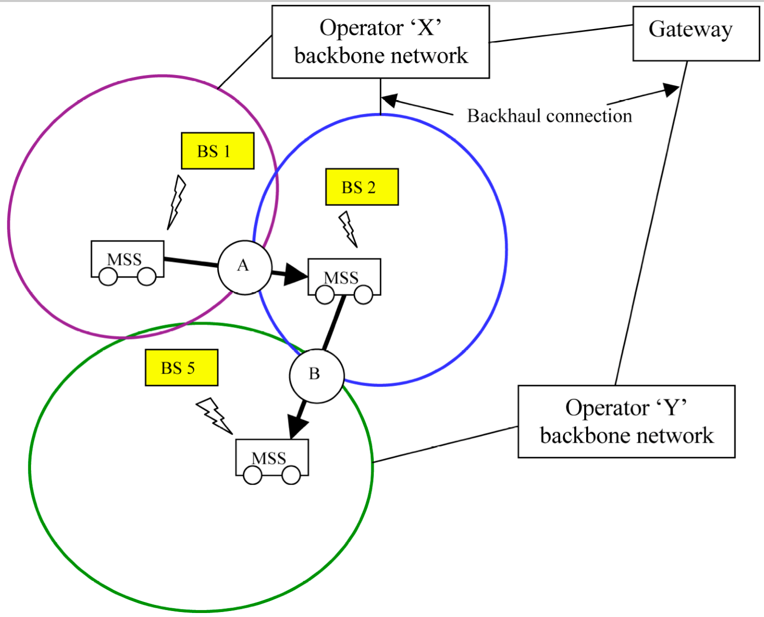

Figure 3: Inter and Intra Cell handover.

An advantage of the hard handover is that at any moment in time one call uses only one channel. The hard handover event is indeed very short and usually is not perceptible by the user. In the old analog systems it could be heard as a click or a very short beep, in digital systems it is unnoticeable. Another advantage of the hard handover is that the phone's hardware does not need to be capable of receiving two or more channels in parallel, which makes it cheaper and simpler. A disadvantage is that if a handover fails the call may be temporarily disrupted or even terminated abnormally. Technologies, which utilize hard handovers, usually have procedures, which can re-establish the connection to the source cell if the connection to the target cell cannot be made.

However re-establishing this connection may not always be possible and even when possible the procedure may cause a temporary interruption to the call.

One advantage of the soft handovers is that the connection to the source cell is broken only when a reliable connection to the target cell has been established and therefore the chances that the call will be terminated abnormally due to a failed handover are lower. However, by far a bigger advantage comes from the mere fact that simultaneously channels in multiple cells are maintained and the call could only fail if all of the channels are interfered or fade at the same time.

Fading and interference in different channels are unrelated and therefore the probability of them taking place at one the same moment in all channels is very low. Thus the reliability of the connection becomes higher when the call is in a soft handover.

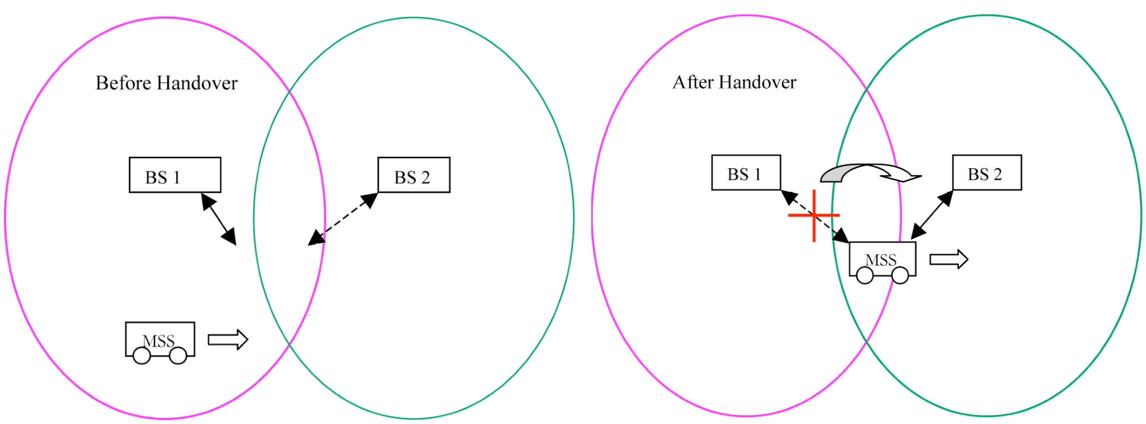

Figure 4. Hard Handover between MS and BS.

Because in a cellular network the majority of the handovers occur in places of poor coverage, where calls would frequently become unreliable when their channel is interfered with or fading, soft handovers bring a significant improvement to the reliability of the calls in these places by making the interference or the fading in a single channel not critical.

This advantage comes at the cost of more complex hardware in the phone, which must be capable of processing several channels in parallel. Another price to pay for soft handovers is the use of several channels in the network to support just a single call. This reduces the number of remaining free channels and thus reduces the capacity of the network.

By adjusting the duration of soft handovers and the size of the areas, in which they occur, the network engineers can balance the benefit of extra call reliability against the price of reduced capacity.

3.3 Stages of Handover

3.3.1 Handover Initiation

A hard handover occurs when the old connection is broken before a new connection is activated. The performance evaluation of a hard handover is based on various initiation criteria. It is assumed that the signal is averaged over time, so that rapid fluctuations due to the multipath nature of the radio environment can be eliminated. Numerous studies have been done to determine the shape as well as the length of the averaging window and the older measurements may be unreliable. The next figure shows a MS moving from one BS (BS1) to another (BS2).

The mean signal strength of BS1 decreases as the MS moves away from it. Similarly, the mean signal strength of BS2 increases as the MS approaches it. This figure 4 is used to explain various approaches described in the following subsection.

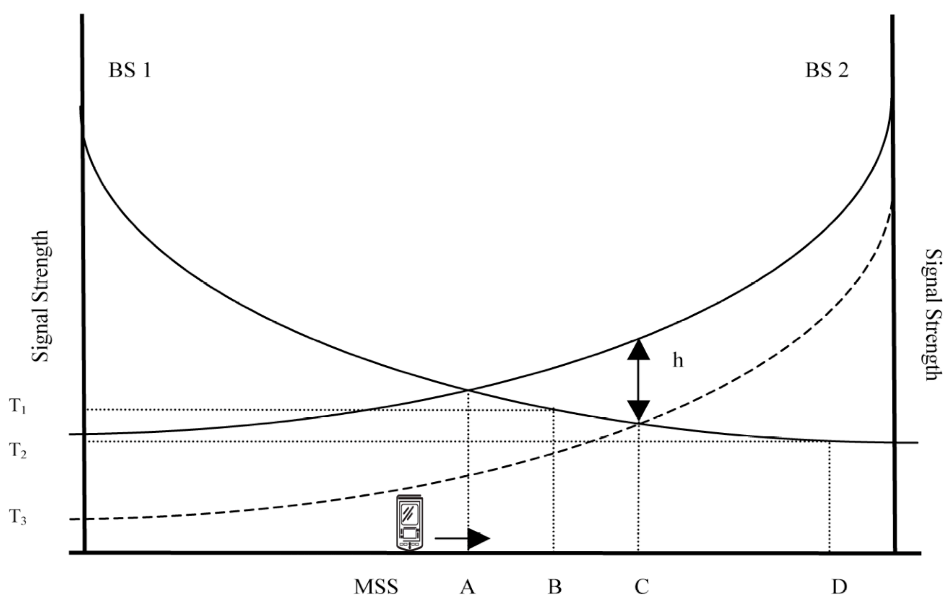

Figure 5. Signal strength and hysteresis between two BSs (potential handover)

3.3.1.1 Relative Signal Strength

This method selects the strongest received BS at all times. The decision is based on a mean measurement of the received signal. In Figure 6, the handover would occur at position A. This method is observed to provoke too many unnecessary handovers, even when the signal of the current BS is still at an acceptable level.

3.3.1.2 Relative Signal Strength with Threshold

This method allows a MS to hand off only if the current signal is sufficiently weak (less than threshold) and the other is the stronger of the two. The effect of the threshold depends on its relative value as compared to the signal strengths of the two BSs at the point at which they are equal. If the threshold is higher than this value, say T1 in Figure 4, this scheme performs exactly like the relative signal strength scheme, so the handover occurs at position A.

If the threshold is lower than this value, say T2 in Figure 4, the MS would delay handover until the current signal level crosses the threshold at position B. In the case of T3, the delay may be so long that the MS drifts too far into the new cell.

This reduces the quality of the communication link from BS1 and may result in a dropped call. In addition, this results in additional interference to co-channel users.

Thus, this scheme may create overlapping cell coverage areas. A threshold is not used alone in actual practice because its effectiveness depends on prior knowledge of the crossover signal strength between the current and candidate BSs.

3.3.1.3 Relative Signal Strength with Hysteresis

This scheme allows a user to hand off only if the new BS is sufficiently stronger than the current one. In this case, the handover would occur at point C. This technique prevents the socalled ping-pong effect, the repeated handover between two BSs caused b rapid fluctuations in the received signal strengths from both BSs. The first handover, however, may be unnecessary if the SBS is sufficiently strong.

3.3.1.4 Relative Signal Strength with Hysteresis and Threshold

This scheme hands a MS over to a new BS only if the current signal level drops below a threshold and the target BS is stronger than the current one by a given hysteresis margin. In the last figure, the handover would occur at point D if the threshold is T3.

3.3.1.5 Prediction Techniques

Prediction techniques base the handover decision on the expected future valueof the received signal strength. A technique has been proposed and simulated to indicate better results, in terms of reduction in the number of unnecessary handovers, than the relative signal strength, both without and with hysteresis, and threshold methods.

3.3.2 Handover Decision

There are numerous methods for performing handover, at least as many as the kinds of state information that have been defined for MS, as well as the kinds of network entities that maintain the state information [ref].
The decision making process of handover may be centralized or decentralized.

From the decision process point of view, one can find at least three different kinds of handover decisions.

3.3.2.1 Network-Controlled Handover

In a network-controlled handover protocol, the network makes a handover decision based on the measurements of the MS at a number of BSs. In general, the handover process (including data transmission, channel switching, and network switching) takes 100–200 ms. Information about the signal quality for all users is available at a single point in the network that facilitates appropriate resource allocation. Network-controlled handover is used in first generation analog systems such as AMPS (advanced mobile phone system), TACS (total access communication system), and NMT (Nordic Mobile Telephony).

3.3.2.2 Mobile-Assisted Handover

In a mobile-assisted handover process, the MS makes measurements and thenetwork makes the decision. In the circuit-switched GSM (global system mobile), the BS controller (BSC) is in charge of the radio interface management.

This mainly means allocation and release of radio channels and handover management. The handover time between handover decision and execution in such a circuit-switched GSM is approximately 1 second.

3.3.2.3 Mobile-Controlled Handover

In mobile-controlled handover, each MS is completely in control of the handover process. This type of handover has a short reaction time (on the order of 0.1 second). MS measures the signal strengths from surrounding BSs and interference levels on all channels. A handover can be initiated if the signal strength of the SBS is lower than that of another BS by a certain threshold.

Chapter 4

Mobile WiMAX Handover

4.1 Mobility Management Architecture

The WiMAX mobility management architecture was designed to

• Minimize packet loss and handover latency.

• Maintain packet ordering to support seamless handover at vehicular speeds.

• Supporting macro diversity handover (MDHO) and fast base station switching (FBSS).

• Minimize signaling to execute handover (number of round trips).

• Support IPv4 and IPv6 based mobility management o Accommodate multiple IP addresses and simultaneous connections.

• Maintain the possibility of vertical or inter-technology handovers and roaming between network service providers (NSPs).

The WiMAX network supports two types of mobility:

4.1.1 ASN-anchored mobility (intra-ASN mobility or micro mobility)

It supports handover situations in which the mobile moves its point of attachment from one BS to another within the same ASN (Access Services

Network). This movement activity is unknown to the CSN (Connectivity Services Network) and has no impact at the IP layer or network layer level. The WiMAX standard defines three functions that provide ASN anchored mobility management.

The **data path function** (DPF) is responsible for setting up and managing the bearer paths needed for data packet transmission between the functional entitites (BSs and ASN gateways) involved in a handover. This includes setting up appropriate tunnels between the entities for packet forwarding, ensuring low latency, and handling special needs (such as multicast and broadcast).

The **handover function** is responsible for making the handover decisions and performing the related signaling procedures. It supports both mobile and network initiated handovers (FBSS and MDHO). Like the DPF, this function is also distributed among many entities.

Context function is responsible for the exchange of state information among the network elements impacted by handover. It is implemented using a client/server model.

4.1.2 CSN-anchored mobility (inter-ASN mobility or macro mobility)

It refers to mobility across different ASNs (across multiple foreign agents [FAs]). WiMAX specification (Release 1) limits CSN anchored mobility to between

FAs belonging to the same network access provider (NAP). CSN anchored mobility involves mobility across different IP subnets (therefore requiring IP layer mobility management). As a WiMAX network supports IPv4 and IPv6, the CSN anchored mobility management for IPv6 is different from IPv4 case (mobile IPv4 is different from mobile IPv6).

4.2 Standard Procedure in IEEE 802.16e

4.2.1 Explanation

In WiMAX, the handover procedure requires support from layers 1, 2, and 3 of the network. Although layer 3 determines the final decision for the handover, the MAC and PHY layers play a crucial role by providing information and triggers required by layer 3 to execute the handover.

In order to be aware of its dynamic radio frequency environment, the BS allocates time for each MS to monitor and measure the radio condition of the neighboring BSs. This process is called scanning, and the time allocated to each MS is called the scanning interval. Each scanning interval is followed by an interval of normal operation, referred to as the interleaving interval.

The scanning process starts when the BS issues a MOB_SCN_REQ message that specifies to the MS the length of each scanning interval, the length of the interleaving interval and the number of scanning events the MS is required to execute.

4.2.2 Phases

The total handover procedure in Mobile WiMAX comprises of the following distinct phases. As mentioned in [ref], firstly, network topology acquisition is carried out before a HO request. Then, the actual HO process including HO decision, initiation, ranging and re-entry process is performed.

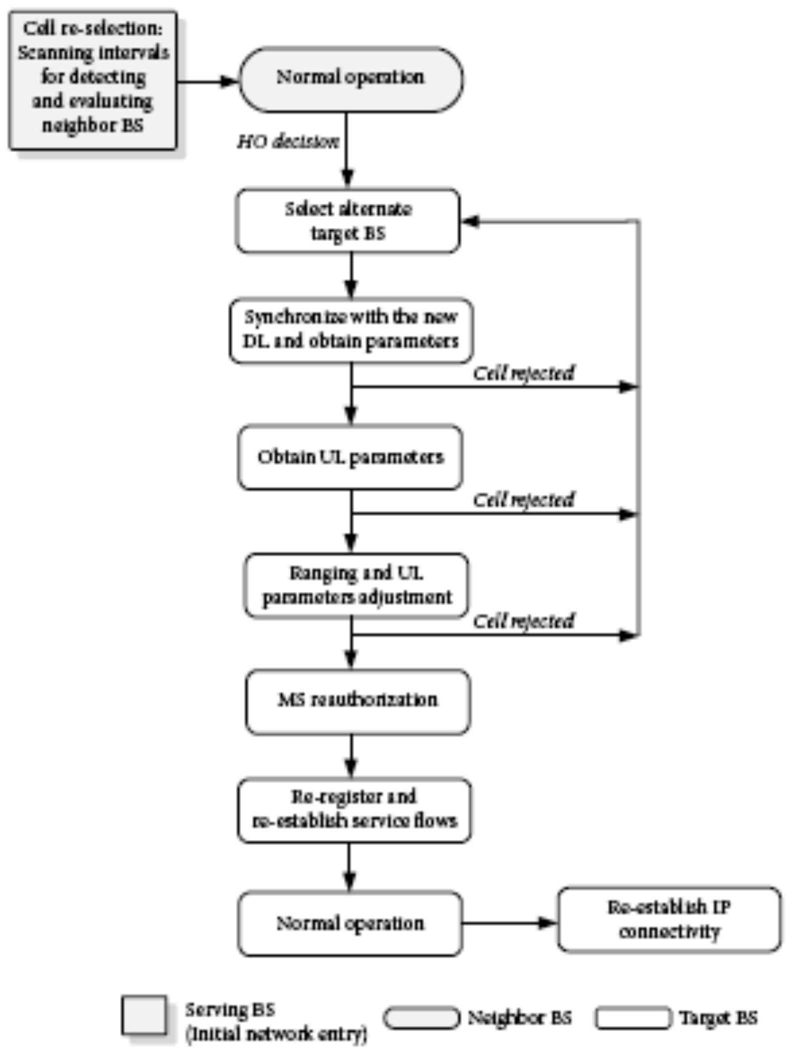

Figure 6. MAC layer handover procedure

4.2.2.1 Network Topology Acquisition Phase (NTAP)

During the NTAP, shown in figures 6, 7 and 9, the MS and the SBS, jointly with the help of the backbone network, gathers information about the underlying network topology. Using MOB_NBR-ADV messages, the SBS periodically broadcasts the network topology information or channel information of the available neighboring BSs for a potential handover. Then the MS is able to synchronize with neighboring BSs without listening to their DCD/ UCD (downlink / uplink channel descriptor) broadcast messages.

Next step is scanning of neighboring BSs. A MS initiates the scanning process by transmitting the Scanning Interval Allocation Request (MOB_SCN-REQ). The message contains the estimated scan duration and, for scanning multiple times, the interleaving interval and the number of iterations.

Additionally, the MS indicates the intended scanning of one or several neighboring BSs. Like this, the BS can negotiate over the backbone a uncast ranging opportunity (instead of contention-based ranging) for the intended neighboring BSs. The uncast opportunity will be granted to the MS at a specific rendezvous time.

The SBS responds to the scanning request with the Scanning Interval Allocation Response (MOB_SCN-RSP), which either grants or denies the request. If the scanning interval is granted, the response contains the start time of the interval and the rendezvous time for each of the recommended neighboring BSs. The scanning can be either MS or BS initiated. If it is BS initiated, the BS indicates the scanning interval to the MS by only transmitting the MOB_SCN-RSP message.

Following the response message granting the request, a MS may scan for one or more BSs during the time interval. Beside the recommended BSs, the MS can look for any other BS during the scanning interval. When a neighboring BS is identified through scanning, the MS attempts to synchronize with its downlink transmissions.

The MS scans the advertised BSs to select suitable candidates for the potential handover activity. The scanning is done within specific periods (frames) allocated by the SBS on request of the MS. During the scanning process, data transmission is paused and all incoming data to the MS is buffered by the SBS.

Thus, scanning intervals should be assigned carefully so that the MS's throughput is not degraded more than necessary. The MS can terminate the scanning by transmitting any PDU, a BW request during the contention interval, to the BS.

For a proper selection of a target BS, the MS needs to acquire and record meaningful service availability information. Beside the quality of the DL channel, the MS can optionally associate to the neighbor BSs by performing initial ranging (contention / non-contention-based). By setting and storing the initial ranging values during the scanning interval, the MS may be able to reuse them for future HO.

The BS's ranging response (RNG-RSP) further contains a service level prediction, which indicates the available services and the expectable level of QoS. There are three types of association during which the MS obtains information of the PHY channel characteristics of the selected BSs. The scanning type is negotiated during the MOB_SCN-REQ / MOB_SCN-RSP message exchange.

4.2.2.2 Actual Handover Phase

When MS migrates from the SBS to the target BS HO process is performed as follows. Figure 9 shows a detailed diagram of this phase.

4.2.2.2.1 Cell reselection

MS conducts cell reselection with information obtained from network topology acquisition stage. Since it refers the same operation with network topology acquisition, this stage can be abbreviated.

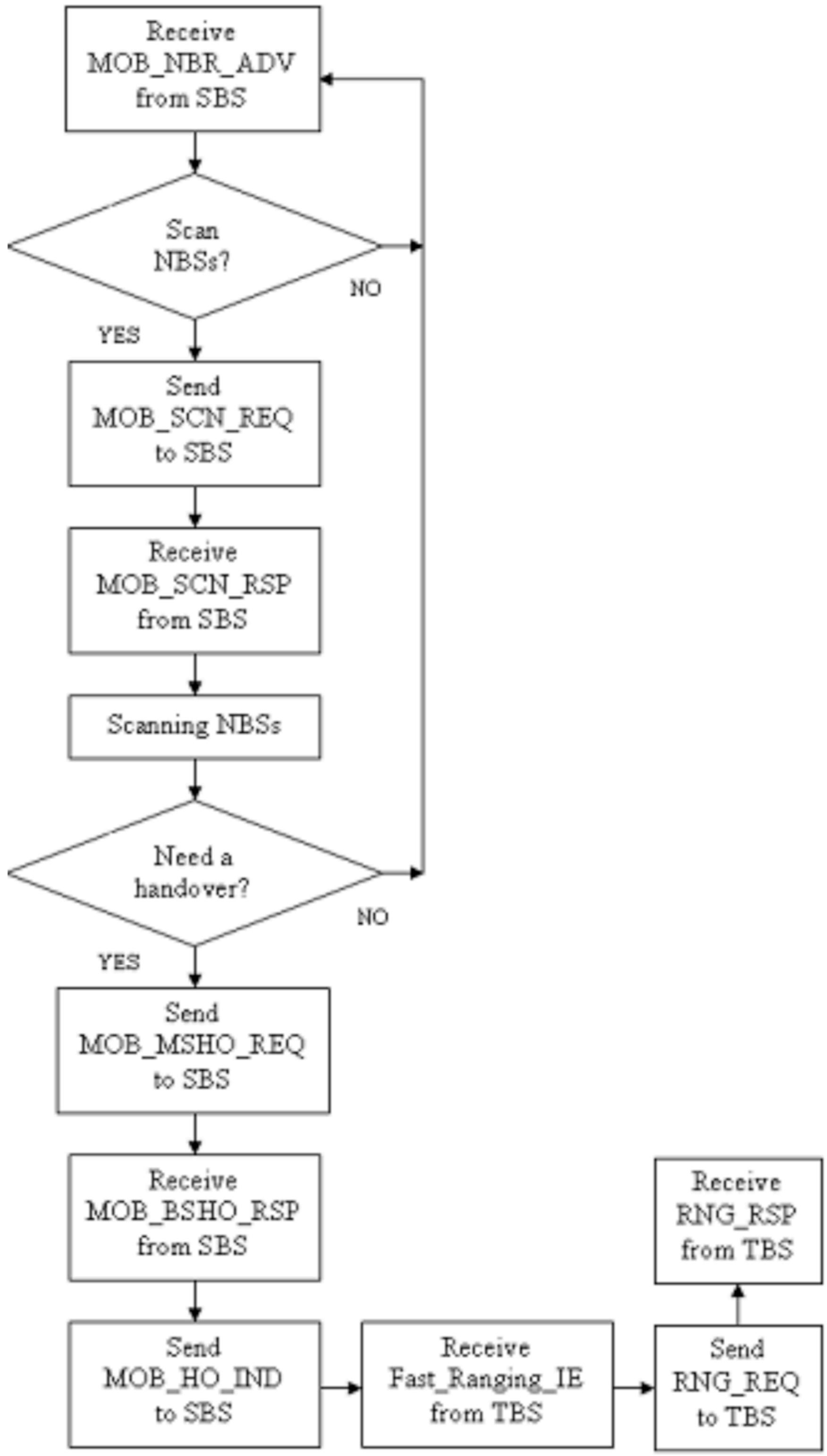

Figure 7. MS initiated HO as seen by MS

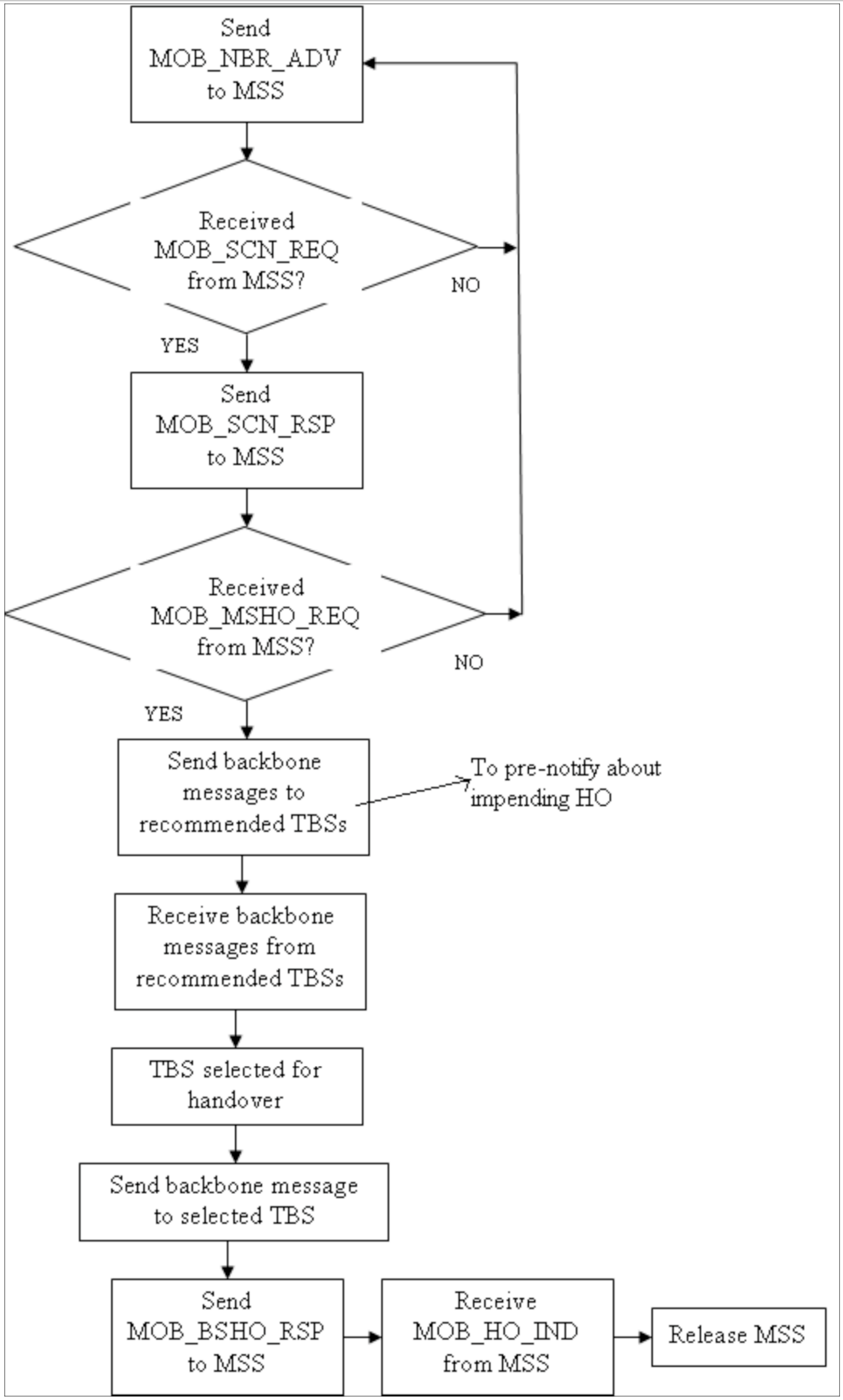

Figure 8. MS initiated HO as seen by the SBS

4.2.2.2.2 Handover decision and initiation

The handover process begins with the decision for the MS to migrate its connections from the SBS to a new target BS. This decision can be taken by the MS, SBS, or some other external entity in the WiMAX network . When the handover decision is taken by the MS, it sends a MOB_MSHO_REQ to the SBS, indicating 1 or more BSs as handover targets.

The SBS then sends a MOB_BSHO_RSP message back to the MS indicating the target BSs to be used for this handover process. The MS sends a MOB_MSHO_IND message indicating which of the BSs indicated in MOB_BSHO_RSP will be used for handover.

When the BS takes the handover decision, it sends a MOB_BSHO_REQ message to the MS, indicating 1 or more BSs for handover target. The MS then sends a MOB_MSHO_IND message indicating receipt of the handover decision and its choice of target BS.
After the handover process has been initiated, the MS can cancel it at any time.

4.2.2.2.3 Synchronization to the target BS

Once the target BS is determined, the MS synchronizes with its DL transmission, beginning with processing the DL frame preamble of the target BS. The DL frame preamble provides the MS with time and frequency synchronization with the target BS. The MS then decodes the DL-MAP, ULMAP, DCD and UCD messages to get information about the ranging channel.

This stage can be shortened if the target BS was notified about the impending handover procedure and had allocated unicast ranging resources for the MS.

4.2.2.2.4 Ranging with target BS

The MS uses the ranging channel to perform the initial ranging process to synchronize its UL transmission with the BS and get information about initial timing advance and power level. This initial ranging process is similar to the one used during network entry. The MS can skip or shorten this stage if it performed association with the target BS during the cell reselection stage.

4.2.2.2.5 Terminating serving BS

After establishing connection with the target BS, the MS may decide to terminate its connection with the SBS, sending a MOB_HO_IND message to the BS. On receipt of this message, the SBS starts the resource-retain timer and keeps all the MAC state machines and buffered MAC PDUs associated with the MS until the expiry of this timer. Once the timer expires, the BS discards all the MAC state machines and MAC PDUs and the handover process is assumed to be complete.

A call drop during a handover process is defined as the situation when an MS has stopped communication with its SBS in either DL or UL before normal handover sequence has been completed. When the MS detects a call drop, it attempts a network reentry procedure with the target BS to reestablish its connection with the network.

4.2.3 Scanning

The operation of an MS can be assumed as follows. Although, it can be an implementation issue to decide when an MS starts to scan neighbor BSs and performs handover to other BSs

As shown figure 8, an MS should scan neighbor BSs frequently in handover region. The MS or the SBS may request periodic scanning if the MS is considered in the handover region.

- An MS can measure the signal power from the SBS without any scanning request message.
- An MS starts to scan neighbor BSs, if the signal power from the SBS is lower than a given threshold for Tscan time.
- The handover procedure will be started, if the signal power of other BS is higher than that of SBS for Tho time.

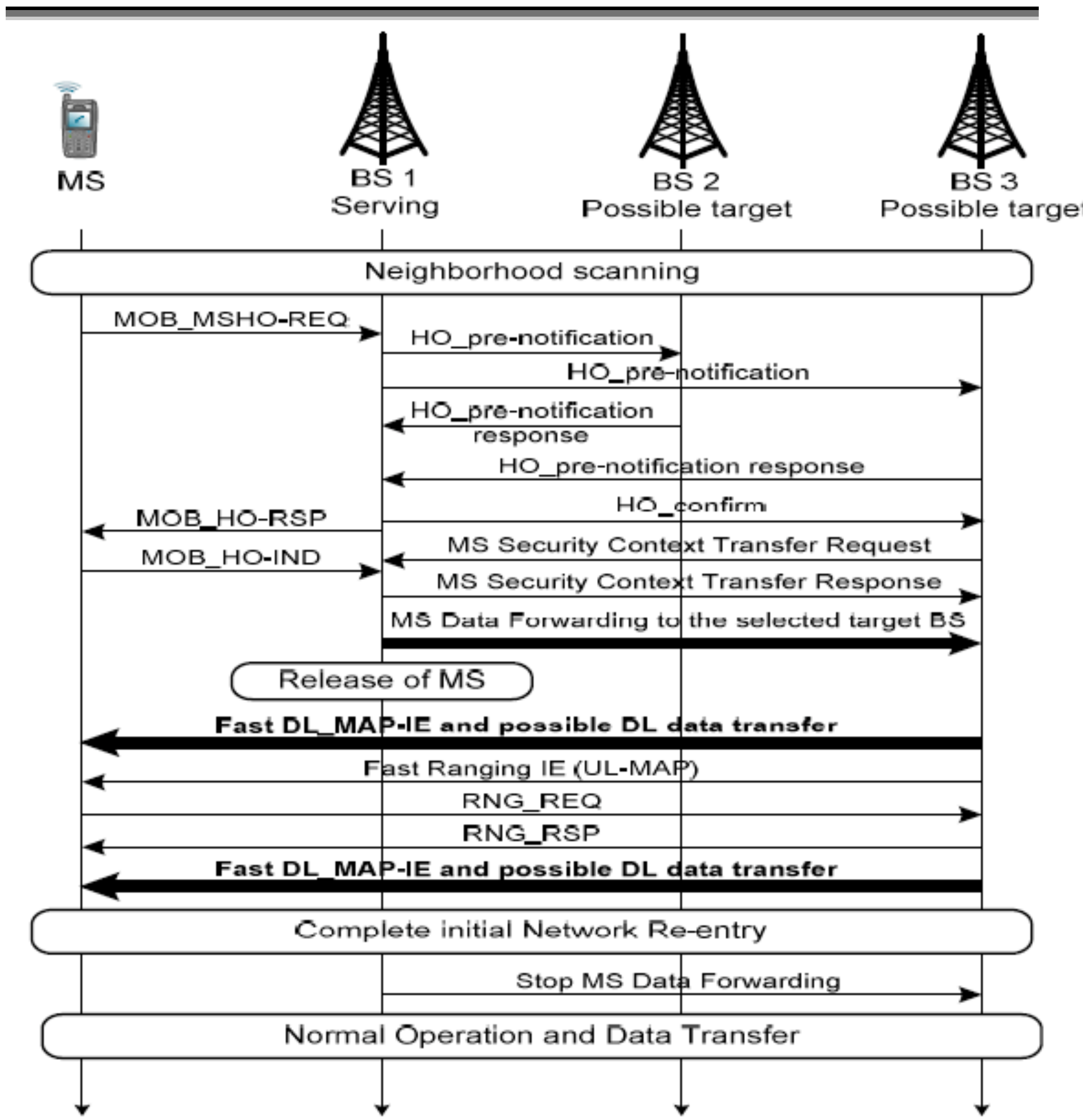

Figure 9. Example of Scanning.

4.2.4 Ranging

Since each MSS has a unique distance from the BS, it is critical in the uplink to synchronize the symbols and equalize the received power levels among the various active MSS. This process is called ranging. When initiated, ranging requires the BS to estimate the channel strength and the time of arrival for the MSS in question. Downlink synchronization is not needed.

In WiMAX, four types of ranging procedures exist: initial ranging, periodic ranging, bandwidth request and handover ranging. If the ranging procedure is successful, the BS sends a ranging response (RNG-RES) message that instructs the MSS on the appropriate timing-offset adjustment, frequency offset correction and power setting. If unsuccessful, the MSS increases its power level and sends a new ranging message, continuing this process until success.

Chapter 5

Proposed Trigger Predictive Algorithm

5.1 Handover Scenario and Analysis Deductions

Basic scenario based on processed signal strength, two base station BS1 (serving), BS2 (target), MS moving from BS1 to BS2 assuming the same transmitting power.

The two base stations are separated by D meters with a mobile station moving from BS1 to BS2, with constant speed (120km/h). The mobile measures the signal strength for each BS in dBm.

The signal levels r1 by BS1 and r2 by BS2 are given by the Log Normal Shadowing Model [9].

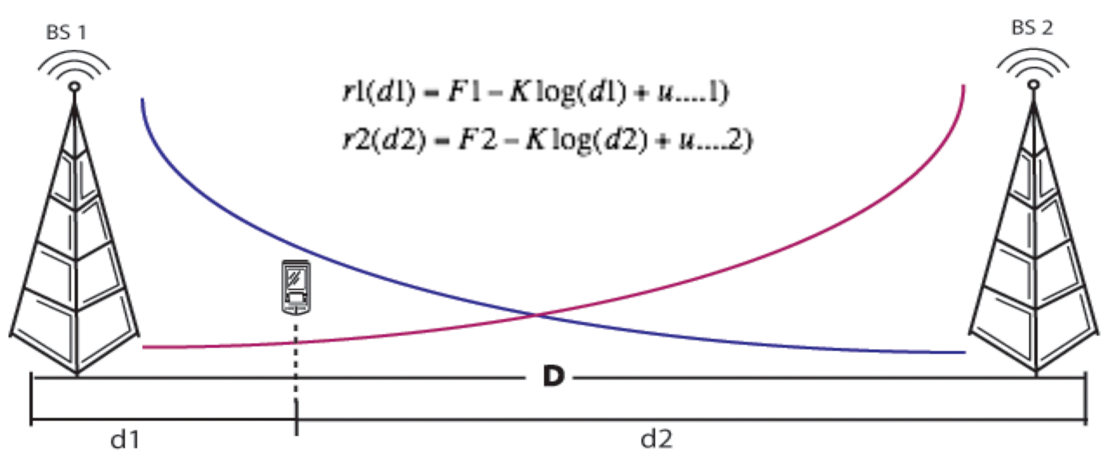

Figure 10. Model of Handover

The main problem in the handover initiation is the right criterion that will be used to take the decision of start the process.

The received signal levels from both BS's are observed every k seconds and the Handover decisions are based on the statistic Zk, from 1) and 2) i obtain:

The handover decision algorithm is based on indentifying the value of Zk in differents periods of time K. Using Zk only 2 regions of decision to trigger handover are identified and causes unnecessary HO's.

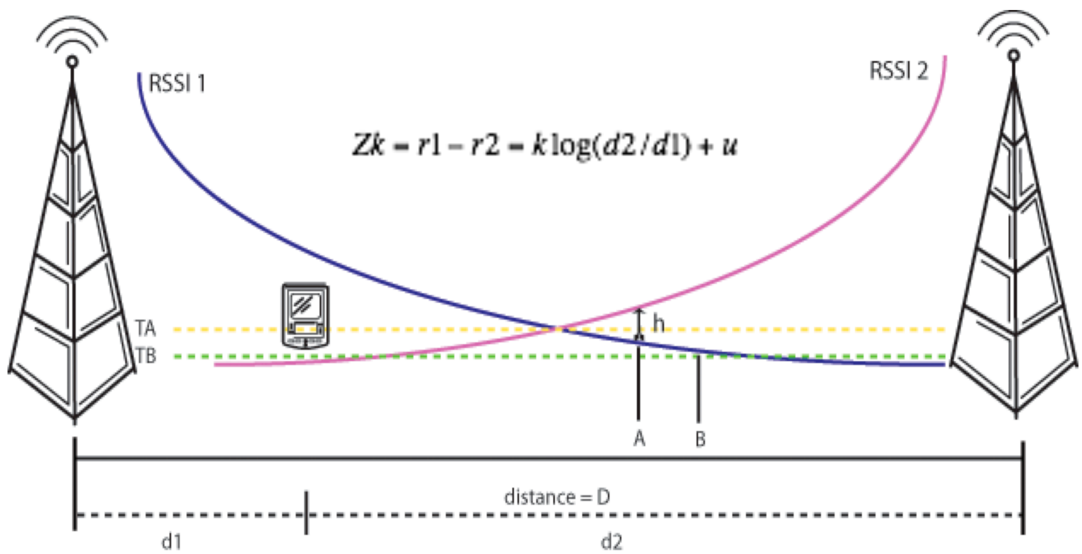

Figure 11. Model of Propagation

HO takes places is 2 conditions are satisfied:

1. The RSSI of serving BS falls below a trigger Threshold T in (dBm).
2. RSSI of target BS exceeds the RSSI of the current BS by at least h (dBm).

Zk becomes 0 and negative when RSSI from current Bs drops below Hysteresis level.¨If H is small many unnesessary HO's may occur. ¨If H is large HO's process is delayed may result lost calls.

5.2 Evaluation of Handover Algorithms in Mobile Wimax.

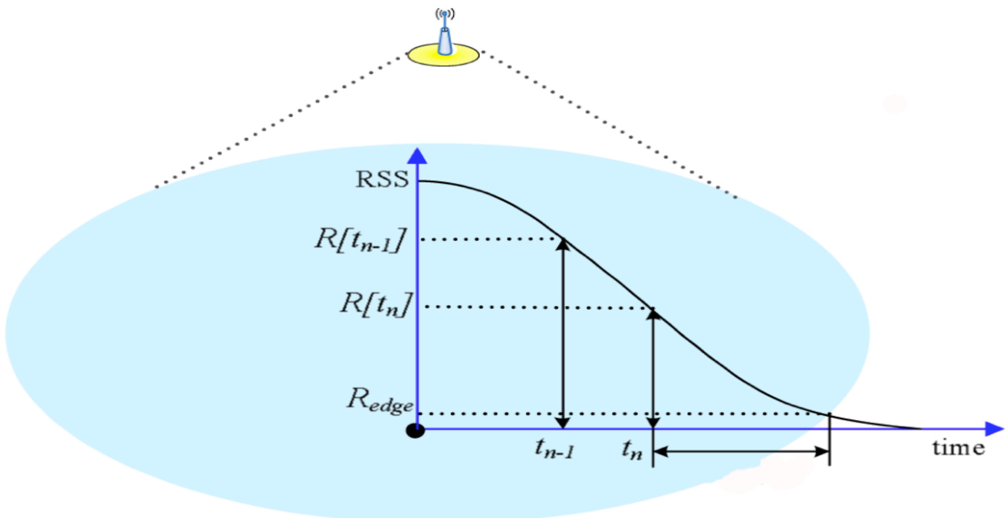

Figure 12. Description of the symbols.

•Criteria that represents the duration time of that MS is expected to connect to the current BS see figure 13.

•Tn = time at certain point n

•R[Tn]=RRS at Tn, depend distance from BS

•Redge=RSS Treshold value at edge of BS

•If RSS<Redge , MS don't conect with BS

•Fixed Tresholds don't reflect dynamic radio conditions

$$PHT[t_n] = \left| \frac{R_{edge} - R[t_n]}{\Delta R[t_{n-1}, t_n]} \right| \ldots\ldots 1)$$

$$t_n > t_{n-1}$$

$$\Delta R[t_{n-1}, t_n] = \left| \frac{R[t_n] - R[t_{n-1}]}{t_n - t_{n-1}} \right| \ldots\ldots 2)$$

$$I[t_{n+1}] = I[t_n]\left(1 + \frac{R[t_n] - R[t_{n-1}]}{|R[t_n]|}\right) \ldots.. 3)$$

•Formula 1) predict the time that the MS stay and leave the BS coverage= Tprep

•Formula 2) is RSS variation RATE, show how fast the MS is moving to and from BS

•If 2) >0 MS close to BS at Tn

•Is 2) <0 MS going away from BS.

•Formula 3) means the next HO trigger and prevent the RHT became small than Tprep.

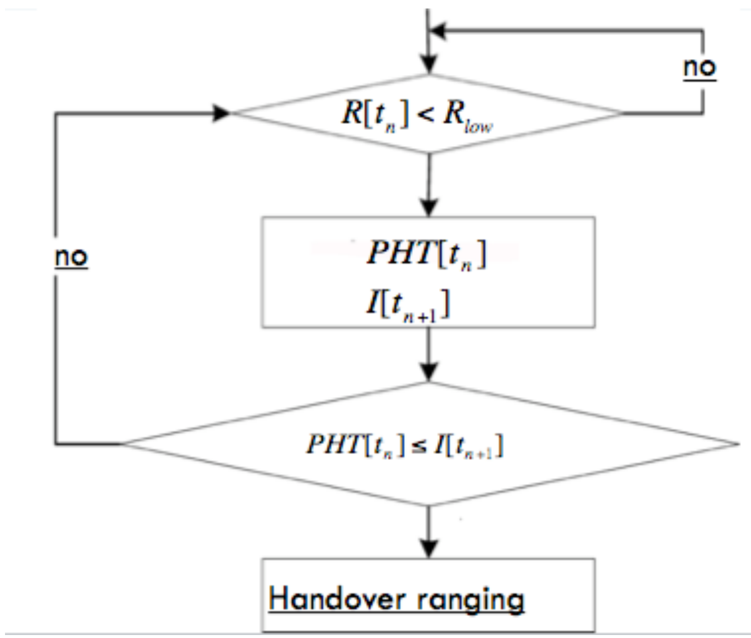

Figure 13. Predictive RSSI Trigger Algorithm (flow diagram)

•The MS periodically measures R[Tn] and compare with the given Rlow.

•Rlow is the min Treshold of stable RSS in the BS coverage.

•Then calculate RHT and I[Tn+1]

•Compare the PHT and I times and the triggers decision is made, the HO ranging began.

5.3 Proposed Scheme

The scheme that proposed in my work is shown in the figure 12, it try to explain the relation between the modulation's changes and the mobility of the MS.

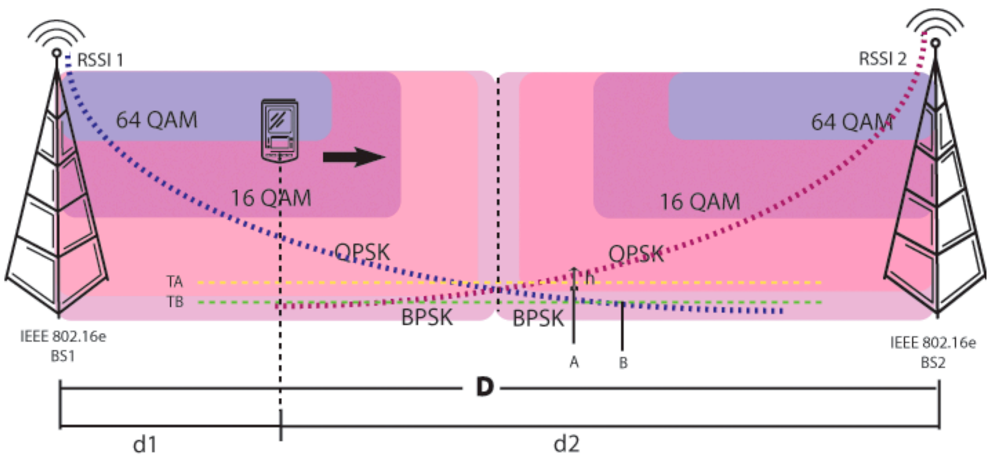

Figure 14. Proposed Scheme.

5.4 Performances and Inference

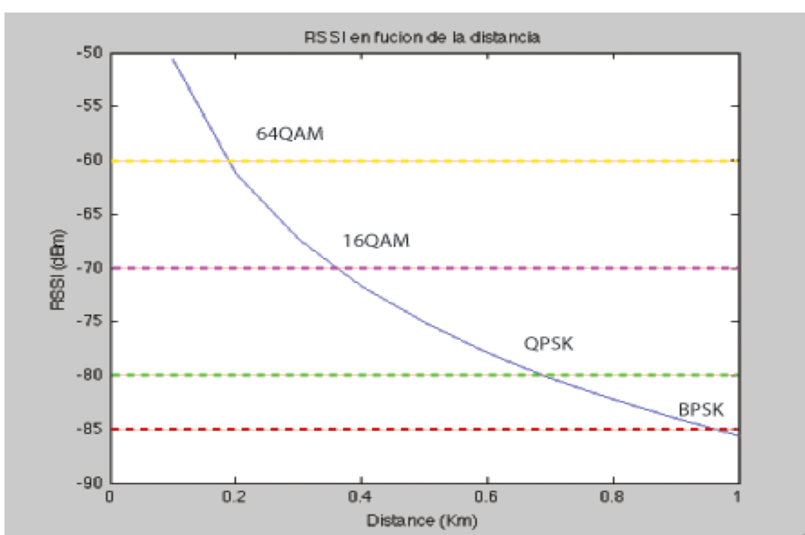

Figure 15. RSSI vs Distance (modulation's changes)

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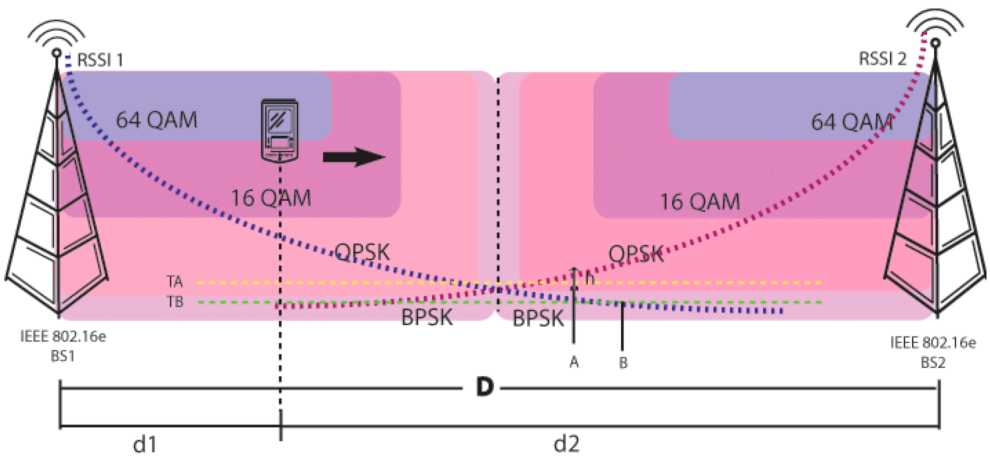

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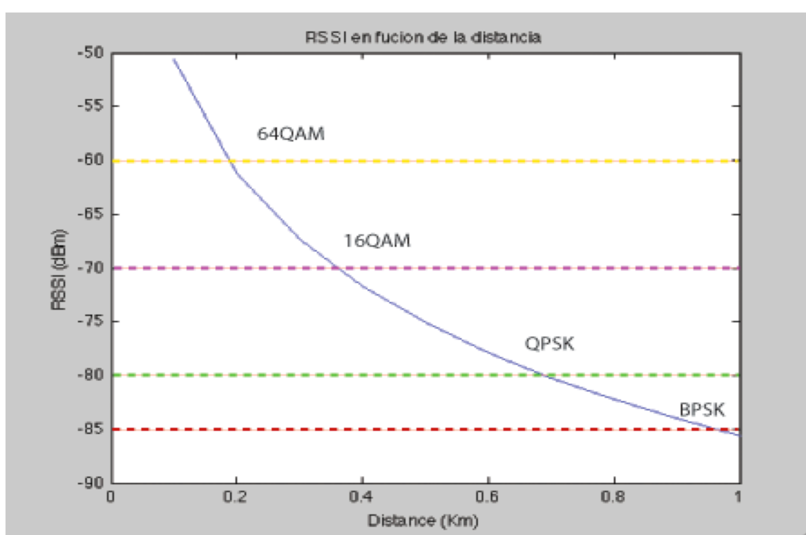

Figure 15. RSSI vs Distance (modulation's changes)

parameters	64 QAM	16 QAM	QPSK Intercellular Handover	BPSK
RSSI req	-60 dBm	-70dBm	-80 dBm	-85 dBm

Table 1. RSSI thresholds for AMC

Mobile Wimax System Parameters

Bandwidth	10MHz
FFT size or SC	1024
Subcarrier spacing	10.94 kHz
Data subcarriers	720
Pilot subcarriers	120
Guards subcarriers	184
BS power = PTX	58dBm
Propagation model	COST 231
Shadowing loss	5.56dB
Frequency	2.5 GHz
Distance	1 KM
Zona	3 (URB METRO)

Obtaining K and RSSin

- perdida1 = 46.30 + 33.90*log10(frequencia) - 13.82*log10(hte) + (44.9 - 6.55*log10(hte))*log10(distancia);
- k= perdida1 - (1.1*log10(frequencia)-0.7)*hre + (1.56*log10(frequencia)-0.8)+zona ;
- RSSIn= PTX-k+SHA

Table 2. Mobile Wimax System Parameters

5.5 Procedure and Simulation Results

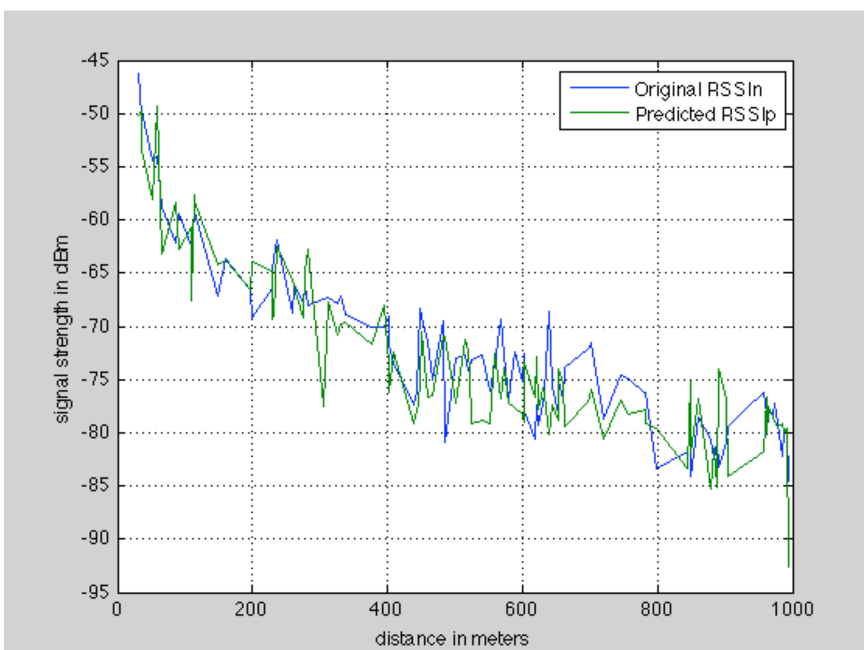

Figure 16. Original RSSI and Predicted RSSI

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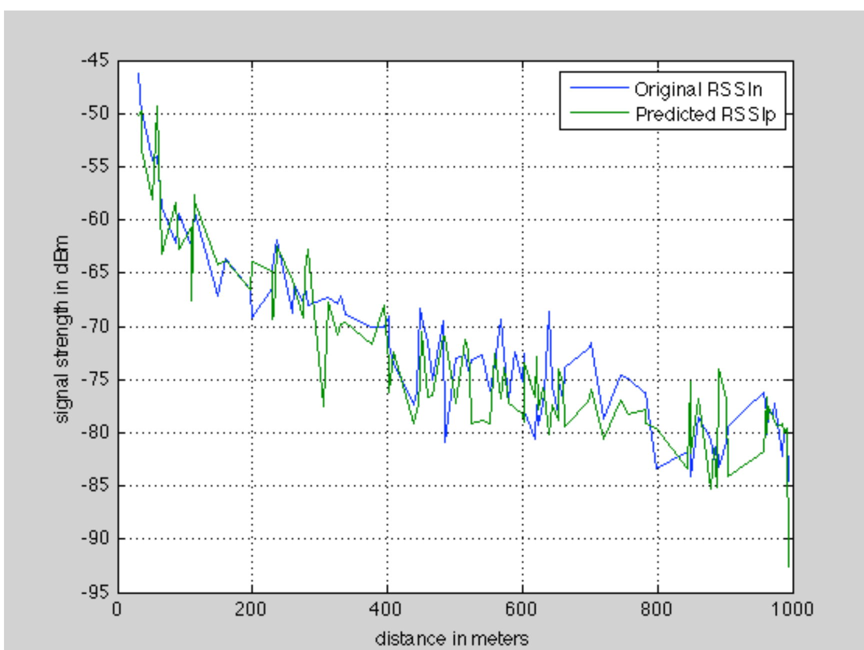

Figure 16. Original RSSI and Predicted RSSI

5.5.1 RSS when is triggered for 120 km/h

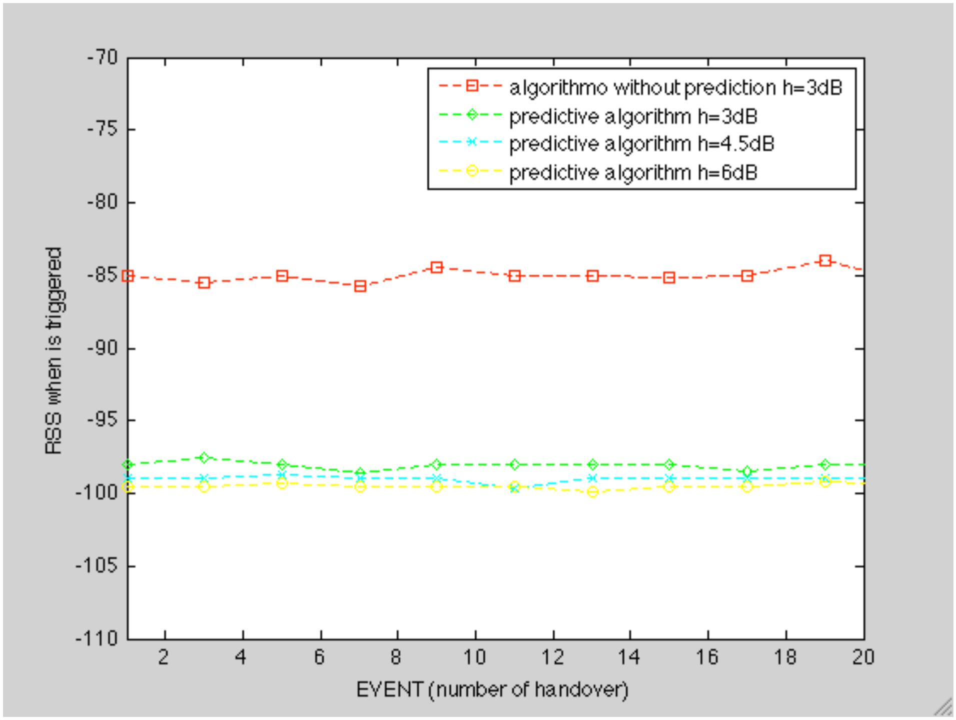

Figure 17. RSS triggered VS Numbers of Handovers

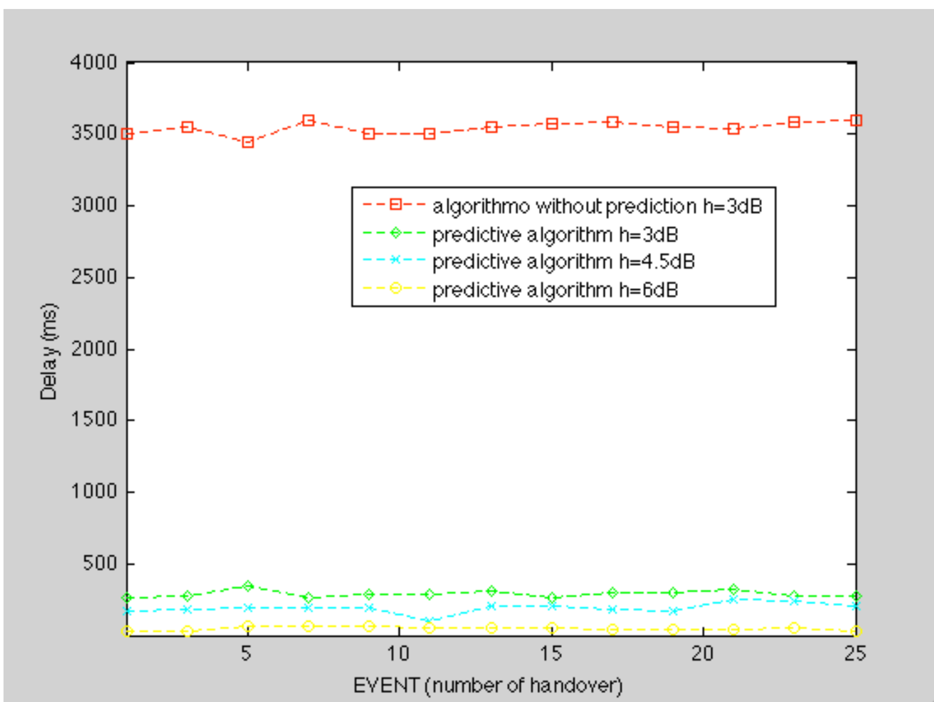

Figure 18. Delay VS Numbers of Handovers

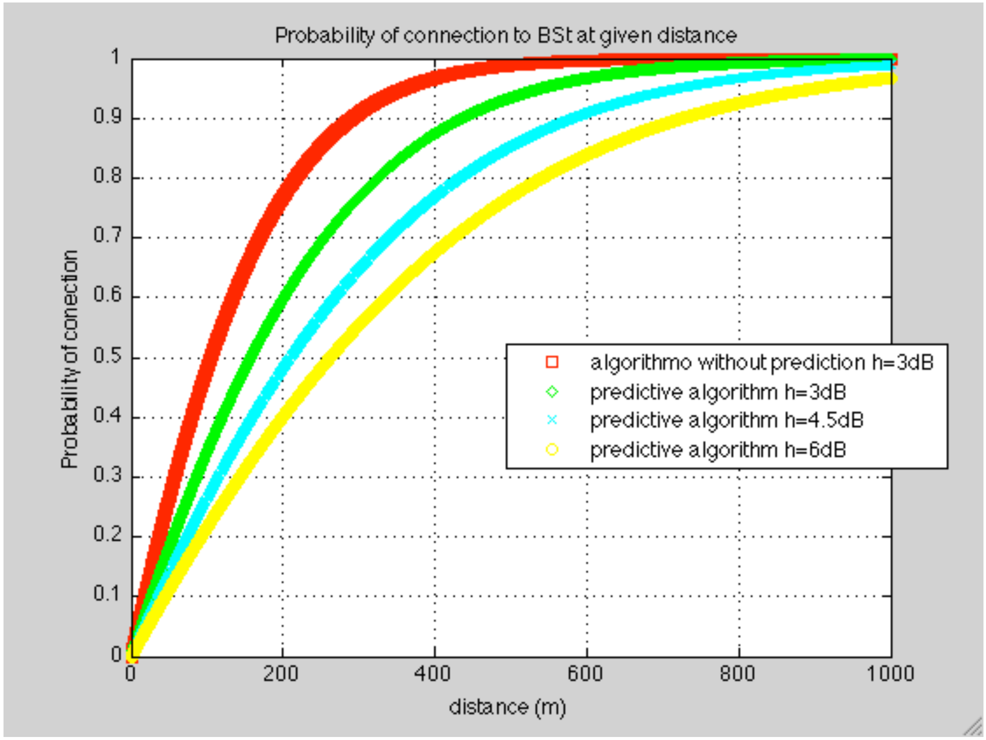

Figure 19. Probability of connection VS distance

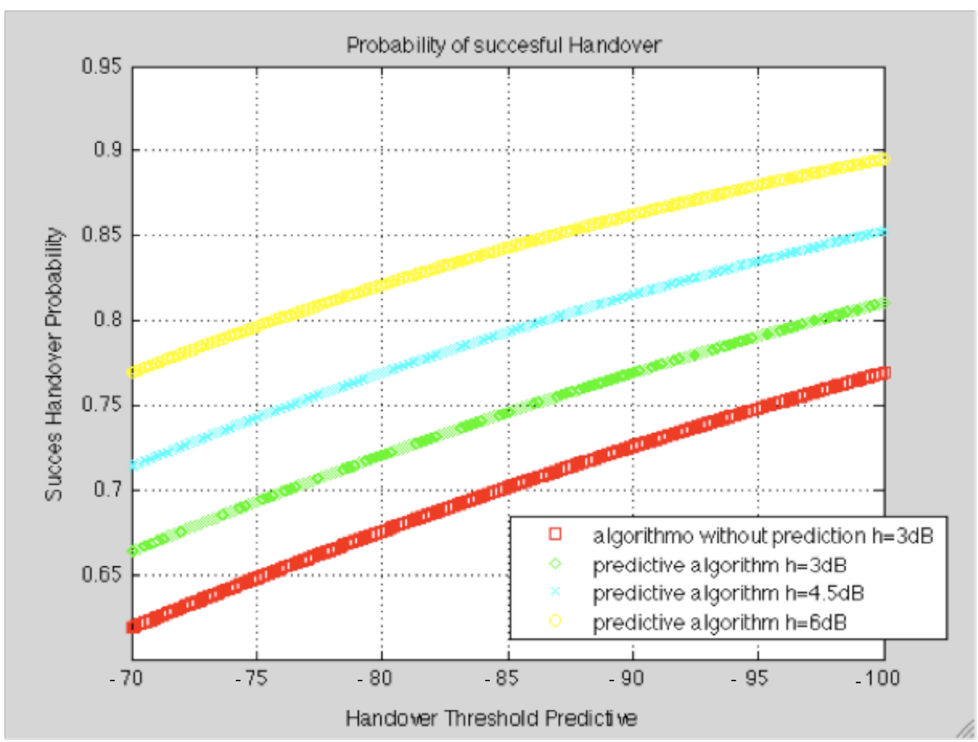

Figure 20. Probability of connection VS Handover Threshold Predictive

5.5.2 RSS when is triggered for 150 km/h

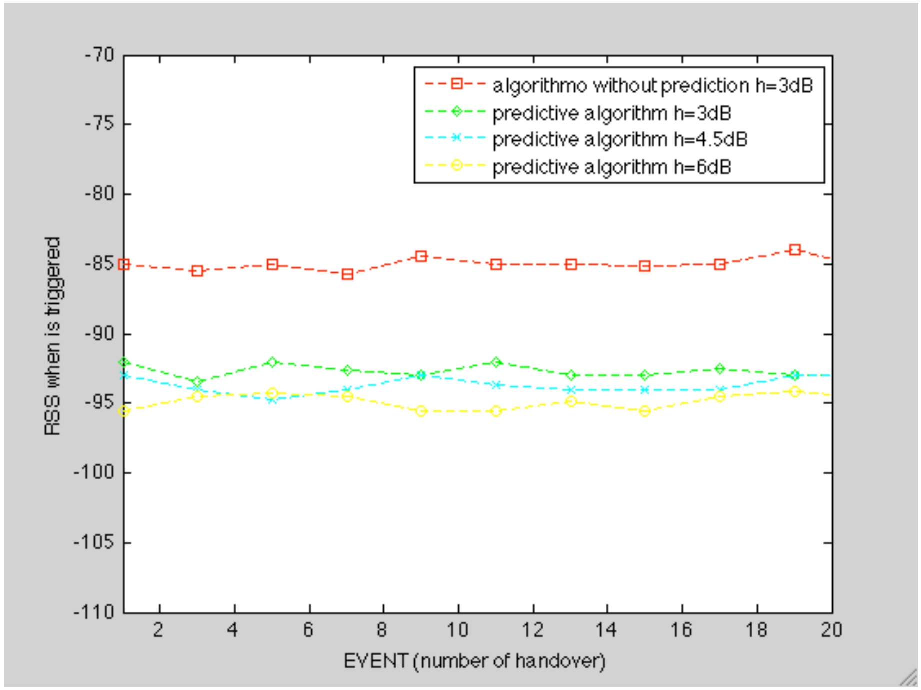

Figure 21. RSS triggered VS Numbers of Handovers

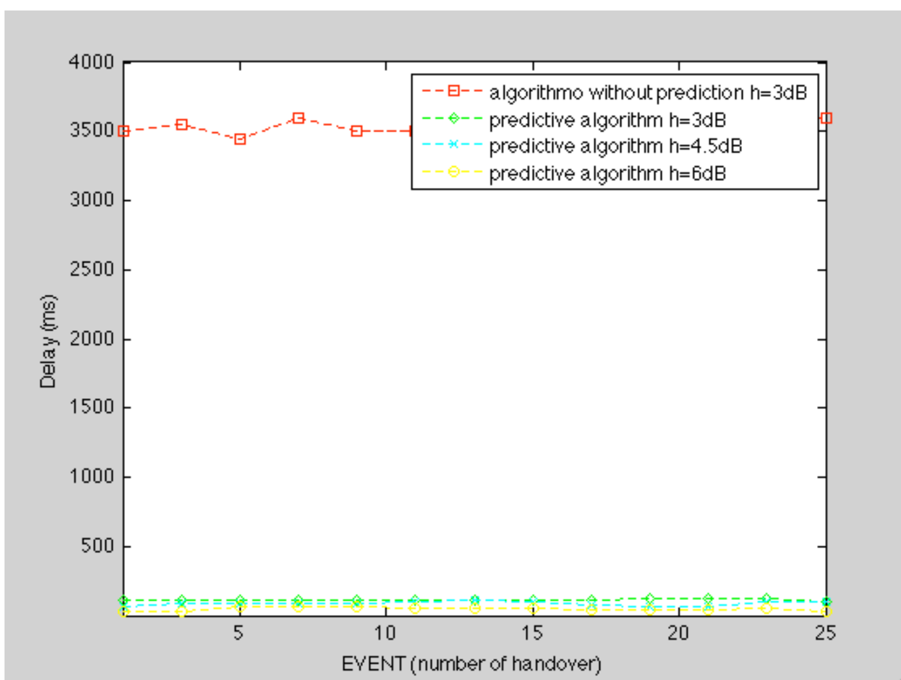

Figure 22. Delay VS Numbers of Handovers

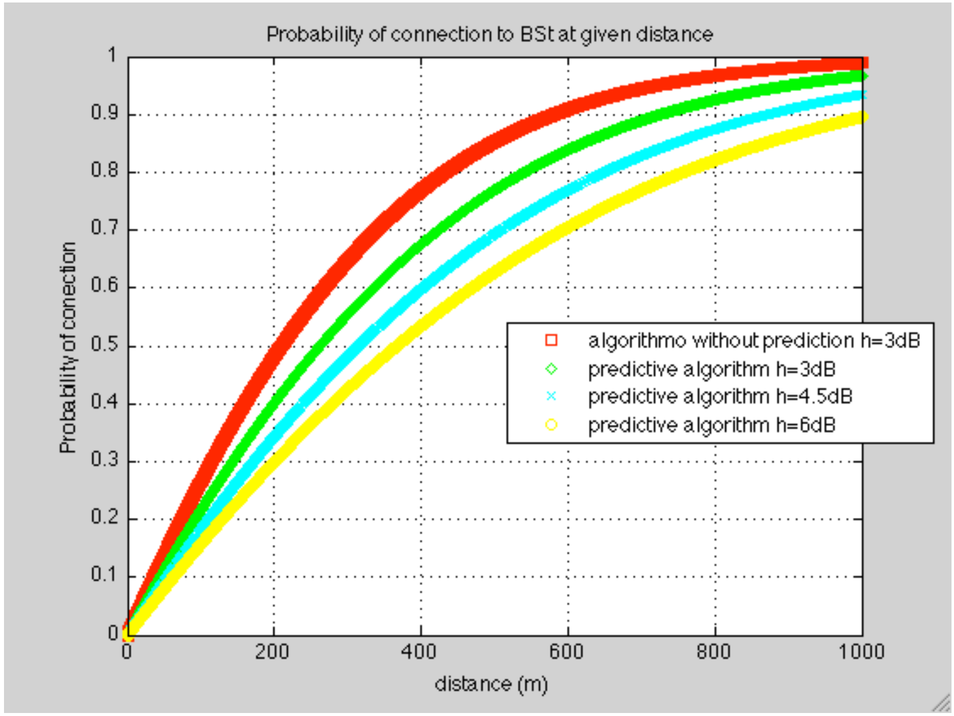

Figure 23. Probability of connection VS distance

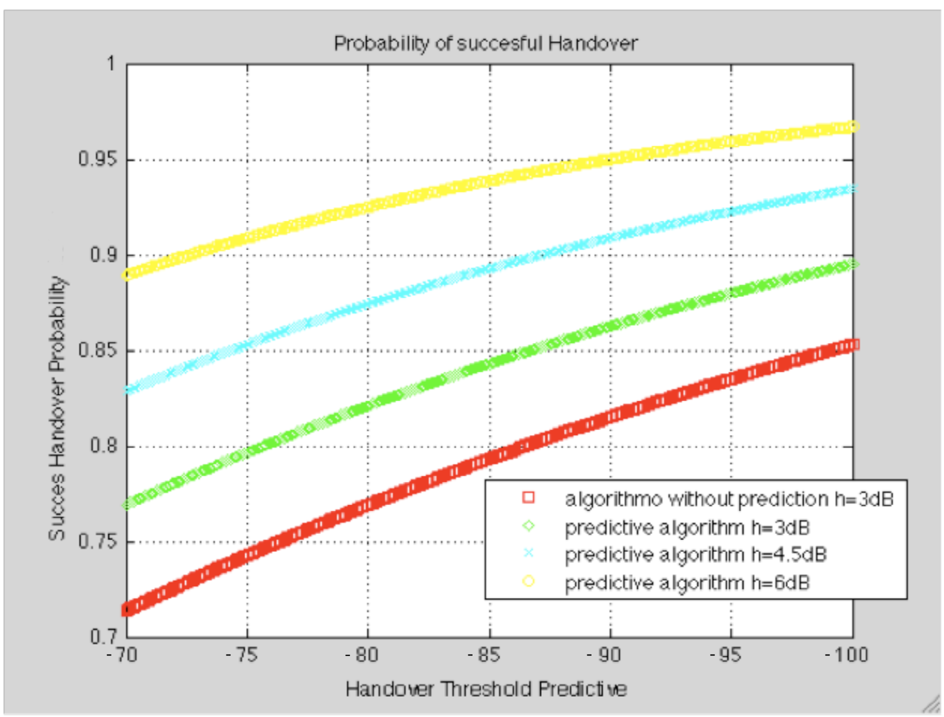

Figure 24. Probability of connection VS Handover Threshold Predictive

5.5 Conclusions and Future Work

As a conclusion, I can defined that predictive RSSI Thresholds can approach a better handover and also better performances in ways of mobile Wimax.

According to the work done in this thesis, the following ideas can be suggested for Further research:

Consider the effects of CINR threshold predictive instead of the RSSI threshold predictive that i analyzed here.

Analyze problems due to the velocity's changes on vertical handovers.

Estimate the CINR value in order to analyze the interference between neighbor's cells.

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