A Survey of Performance metrics for Vertical Handover between Wi-Fi and WiMAX

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Abstract

Mobile communication technology evolved rapidly over the last few years due to increasing demands such as accessing Internet services on mobile phones with a better quality of the offered services. The most important issues in this technology are to provide seamless handover when a mobile node (MN) moves between different access networks.The present communication reveals a survey of Vertical Handover Performance metrics within WiMAX and WiFi and describes two techniques Wi-Fi (Wireless Fidelity) & WiMAX(Worldwide Interoperability for Microwave Access) used in wireless communication along with their comparison. The aim of this paper is to study these two techniques and describe the basic Performance metric used for doing vertical handover procedure

Keywords:
IEEE 802.11, IEEE 802.16, Vertical Handover, Wi-Fi, WiMAX

1. Introduction

In the recent years, there has been huge development in wireless access technologies, to fulfil the need of people to be "Always Best Connected". There are numerous technologies, networks, systems, applications and devices. These varieties of technology bring a well-known issue to the field of wireless access networks: seamless handover services. Among several candidate technologies for the numerous wireless broadband networks, Worldwide Interoperability for Microwave Access (WiMAX, IEEE 802.16 [1] [2]) shows promising potentials, where Wireless Local Area Network (WLAN, IEEE 802.11 [3]) is one of the most used wireless. The IEEE 802.11 WiFi have been deployed widely and 802.11 access point can cover area of few hundred meters ,making them suitable for enterprise networks and public hotspot networks. Recently 802.16 standards (WiMAX) can provide high data rate and wide area of coverage. Integration of these two technologies raises several challenges

When MN changes its current point of access technology handoff occurs. There can be two different types of handoff: horizontal handoff and vertical handoff. Horizontal handoff refers to switching between point of attachment or base station that belongs to same network. Vertical handoff refers to switching between stations that belong to different networks. Process of vertical handoff can be divided into three steps, namely system discovery, handoff decision and handoff execution. During system discovery phase MN search networks and what are the available services in each network. During handoff decision phase MN determines which network it should connect to. Handoff decision may depend on various parameters such as bandwidth, delay, access cost, and transmission power, current battery status of mobile node and user preferences. During handoff execution phase connections are transferred from existing network to new network in seamless manner. This involves authentication, authorization as well as transfer of user's context information.

Among several candidate technologies for the numerous wireless broadband networks, IEEE 802.16-operated WiMAX shows promising potentials. IEEE 802.16 Fixed WiMAX has been developed by the IEEE 802.16 standard activities. Because it cannot support the mobility of terminals, IEEE802.16 Fixed WiMAX is not suitable for mobile computing environments. Thus, to support mobility on terminal stations, IEEE 802.16e Mobile WiMAX standard is proposed [4][5]. This paper describe the basic Performance metric used for doing vertical handover procedure and addresses basic vertical handover algorithm for interworking between IEEE 802.11 WiFi and IEEE 802.16e Mobile WiMAX.

2. Wi-MAX TECHNOLOGY

The fiber optic transport services providing the high bandwidth and data rates is replaced by WiMAX wireless technology all across the world. WiMAX is emerging technology to fulfil the high data rate and QoS requirements of the customers, also it is the cheap deployment of voice services with no need of line of sight wireless channel.

WiMAX signals have the property to adopt the atmospheric conditions everywhere. WiMAX electromagnetic waves also offer the support of adoptive coding and different operation modes, so voice and data services can easily be transported by WIMAX network platform.

More familiar terms for these standards are Fixed WiMAX (802.16-2004 [1]) and Mobile WiMAX (802.16e [2]). By definition, Fixed WiMAX does not support mobility and is therefore not useful for this research. That is why in this paper, the term WiMAX used, is for Mobile WiMAX (802.16e). It provides mobility support at frequency bands between 2 and 6 GHz. Mobile WiMAX introduces OFDMA and supports several key features necessary for delivering mobile broad band services at vehicular speeds greater than 120 km/hr1[6].

2.1. Architecture

The WiMAX Network Architecture defines a framework consisting of several functional entities and interconnections. Figure1 shows this framework in simplified manner, followed by a description of each entity [7].

- **NAP**: Network Access Provider A business entity that provides WiMAX radio infrastructure.
- **NSP**: Network Service Provider Just like the NAP, the NSP is a business entity. It provides IP connectivity and WiMAX services. The level of services is legally binded through contractual agreements with one or more NAPs.

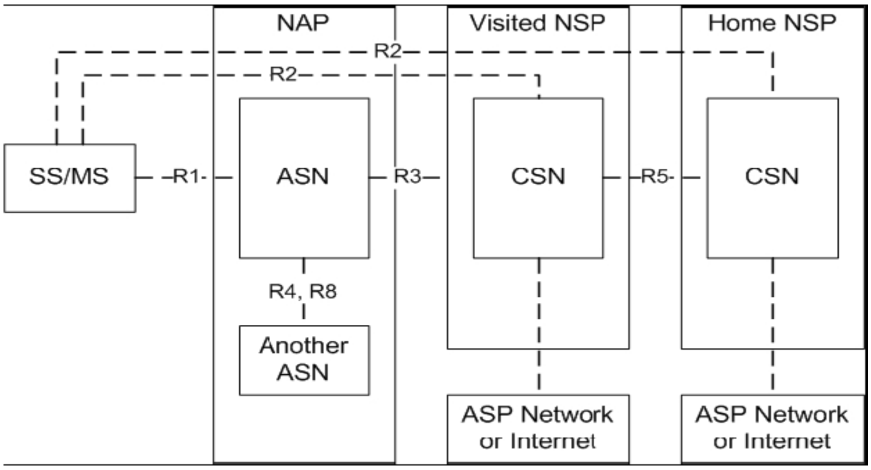

Figure 1. WiMAX Network Architecture

- **SS/MS**: Subscriber Station/Mobile Station Entity which wants to make a connection to the network.
- **ASN**: Access Service Network This is the point of entry for the SS/MS into the WiMAX network. This entity must support a complete set of functions required to connect a client to the network: authorization, authentication, session management, network discovery, IP-address allocation, QoS etc.
- **CSN**: Connectivity Service Network The CSN is the part of the network which provides IP connectivity services. It consists typically of routers, servers, proxies, and gateways etc. providing functions like Internet access and peer-topper services.

Besides these entities the architecture also contains a number of interconnections or reference points. The most important and relevant ones are summarized here.

- **R1**: Protocols between SS/MS and ASN including PHY and MAC layers as specified by the 802.16 standard.
- **R2**: Protocols/procedures between SS/MS and CSN concerning authentication, authorization and IPconfiguration management.
- **R3**: Control procedures between ASN and CSN. Provides tunnelling of user data between the two entities.
- **R4**: Control procedures between ANSs like MS mobility between different ASNs.
- **R5**: Control procedures for supporting roaming from a home NSP to a visited NSP.
- **R8**: When switching between different BSs within the same ASN or between different ANSs (which most likely will also involve a switch between BSs) this is an optional reference point to ensure fast and seamless handover through direct transfer of MAC context and data.

Together, the technology and network architecture give a summarized and simplified view of WiMAX networks.

3. Wi-Fi Technology

Wireless Fidelity (Wi-Fi) is a wireless technology which provides internet connectivity or connectivity among the users. In 1997 IEEE provide a set of specification and standards for Wi-Fi which is under the title 802.11 that explains the structure of the comparatively short range radio signal for Wi-Fi service. After that several specifications came and most commonly used specifications today are 802.11b, 802.11g and 802.11a [8]. Out of these three, 802.11a can provide higher speeds within the various radio frequencies. IEEE is now working for a new standard 802.11n which is more reliable, secure and faster than the other standard .Originally Wi-Fi was created for wireless extension for the wired LAN. That's why the distance between the Wi-Fi access point and user equipment is limited to around 100 feet indoor and up to 300 feet outdoors [9]. So if a user moves its computer to a new location, he/she should find a new access point for continuing the communication.

Due to the cheap availability of the equipment and its maintenance and servicing cost, Wi-Fi is widely accepted throughout the world and it is widely used in a restaurants, hotels, airports and school campuses. It is also work well in the auditoriums, meeting rooms and small businesses. Internet service providers also use it for individual home connectivity and connectivity to the commercial complexes. All wireless devices that join a Wi-Fi network, whether mobile, portable or fixed, are called wireless stations (STAs). A wireless station might be a PC, a laptop, a PDA or a phone. When two or more STAs are wirelessly connected, they form a basic service set (BSS). This is the basic building block of a Wi-Fi network. The BSS is an example of the simplest Wi-Fi network possible: two wireless stations. A common distribution system (DS) and two or more BSSs create what is called an extended service set (ESS). An ESS is a Wi-Fi network of arbitrary size and complexity. Fig 2 is a representation of an ESS comprised of BSS 1, 2 and 3. The distribution system is not part of the ESS. The distribution system enables mobility in a Wi-Fi network by a method of tracking the physical

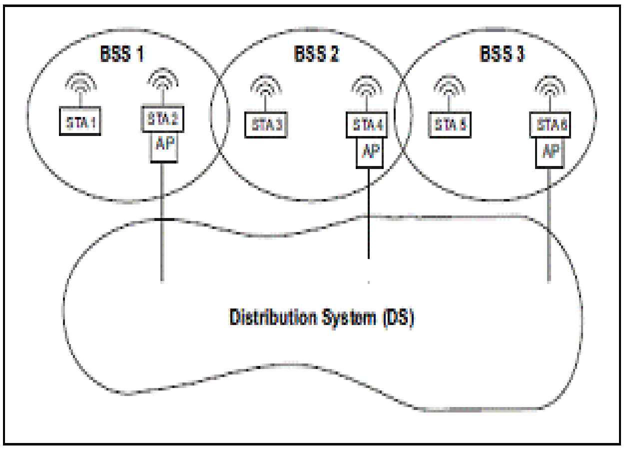

Fig 2. ESS (Extended Service Set)[11]

location of STAs, thus ensuring that frames are delivered to the AP associated with the destination STA. Mobility means a wireless client can move anywhere within the coverage area of the ESS and keep an uninterrupted connection.

These two wireless technologies have common components in their operations with a major difference in the communication range. The following table below gives the detailed comparative analysis of the two broadband wireless access networks (Wi-Fi and WiMAX):

Table 1. Comparison between WiMAX and Wi-Fi [10]

Feature	WiMAX(IEEE 802.16a)	Wi-Fi(IEEE 802.11b)	Wi-Fi(IEEE 802.11a/g)
Primary Application	Broadband Wireless Access	Wireless LAN	Wireless LAN

Frequency Band	Licensed/Unlicensed 2GHZ to 11GHz	2.4 GHz ISM	2.4 GHz ISM(g) 5 GHz U-NII(a)
Bandwidth Efficiency	<=5 bps/Hz	<=0.44 bps/Hz	<=2.7 bps/Hz
Modulation FEC	BPSK,QPSK,16,64 ,256-QAM Convolution Code Reed-Solomon	QPSK None	BPSK,QPSK Convolution Code
Encryption	Mandatory-3DES	Optional-RC4	Optional- RC4
Mobility	Mobile WiMAX(802.16e)	in development	In development
Mesh	Yes	Vendor Proprietary	Vendor Proprietary
Access Protocol	Request Grant	CSMA/CA	CSMA/CA

4. Vertical Handover

- Diverse processes are required in order to perform a Vertical Handover (VHO).VHO process into three phases: i) Handover information gathering, ii) Handover decision, and iii) Handover execution [12][13]. The information gathering phase is in charge of collecting relevant information from diverse context sources such as network capabilities, access points, user equipments, and user preferences. The most critical process in a VHO process is the decision phase since, depending on the
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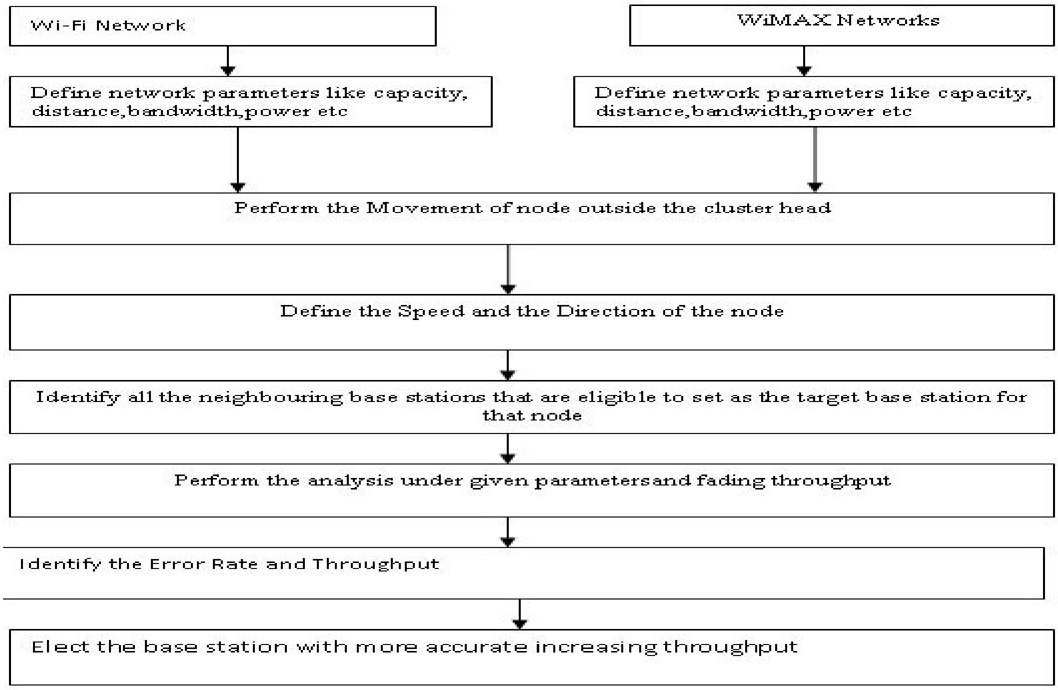

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Fig 3. Flow Chart of Vertical Handover

- network candidate chosen, the performance of the system could improve or decrease. This decision should consider several parameters in order to choose the best candidate network to handover to [9]. The execution phase is in charge of committing the VHO itself. In this process the UE (User Equipment) leaves the current network and gets attached to a new network in a seamless manner, experiencing low latencies and minimal packet loss.
- This flow chart [Fig. 3] is about the selection of the next target cell as a node move outside its coverage area. As it moves outside, number of possible base stations that are having the coverage to that node will poll to get the access. The coverage will be decided under the distance coverage. The presented flow chart is about to select this target base station. In flow chart we have defined multiple parameters. In this flow chart to compare the Wi-Fi and WI-Max network and first of all define the network parameters such as capacity, distance, bandwidth and diameters of the network after that to check the movement of the nodes i.e. either randomly or behalf of the cluster head. Cluster head define the speeds and the direction of movement in the network area and cluster head also identifying all the base station that are lies in these network area or to the target of particular node. Base station perform the analysis of the nodes or the cluster head and to

find the throughput of the nodes i.e. the number of the cycle to complete the execution. Identify the error rate according to time frame schedule these are depends on time division multiplexing. Elect the base station with accurate data to increasing throughput and calculate the speeds, diameters and to the target of the node.

5. Performance Matrices for Handoff Mechanism

5.1 Bandwidth

Bandwidth is a measure of the width of a range of frequencies. It is the difference between the upper and lower frequencies in a contiguous set of frequencies. In order to provide seamless handoff for Quality of service (Qos) in wireless environment, there is a need to manage bandwidth requirement of mobile node during movement. Bandwidth is generally known as the link capacity in a network. Higher offered bandwidth ensures lower call dropping and call blocking probabilities; hence higher throughput [14].Bandwidth handling should be an integral part of any of the handoff technique.

5.2 Handoff Latency

Handover of calls between two BS is encountered frequently and the delay can occur during the process of handoffs. This delay is known as handoff latency. A good handoff decision model should consider Handoff latency factor and the handoff latency should be minimized. Many proposed handoff decision models have tried to minimize the handoff latency by incorporating this factor in their handoff decision models. Handoff Latencies affect the service quality of many applications of mobile users. It is essential to consider handoff latency while designing any handoff technique.

5.3 Power Consumption

In 4G networks, we need to find ways to improve energy efficiency. Power is not only consumed by user terminal but also attributed to base station equipments. Power is also consumed during mobile switching or handoffs. During handoff, frequent interface activation can cause considerable battery drainage. The issue of power saving also arises in network discovery because unnecessary interface activation can increase power consumption. It is also important to incorporate power consumption factor during handoff decision.

5.4 Network Cost

A multi criteria algorithm for handoff should also consider the network cost factor. The cost is to be minimized during VHO in wireless networks. The new call arrival rates and handoff call arrival rates can be analyzed using cost function. Next Generation heterogeneous networks can combine their respective advantages on coverage and data rates, offering a high Quality of Service (QoS) to mobile users. In such environment, multi-interface terminals should seamlessly switch from one network to another in order to obtain improved performance or at least to maintain a continuous wireless connection. Therefore, network selection cost is important in handoff decisions.

5.5 User Preferences

When handover happens, the users have more options for heterogeneous networks according to their preferences and network performance parameters. The user preferences could be preferred networks, user application requirements (real time, non-real time), service types (Voice, data, video), Quality of service (It is a set of technologies for managing network traffic in a cost effective manner to enhance user experiences for wireless environments) etc. User Preferences can also be considered for VHO in 4G wireless networks.

5.6 Throughput:

Throughput or network throughput is the average rate of successful message delivery over a communication channel. These data may be delivered over a physical or logical link, or pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.

Throughput = [(Total Bytes Sent * 8) / (Time Last Packet Sent - Time First Packet Sent)] where 'time' is in seconds.[15]

5.7 End-to-End Delay:

End-to-end delay indicates the length of time taken for a packet to travel from the CBR (Constant Bit Rate) source to the destination. It represents the average data delay an application or a user experiences when transmitting data. The delay is usually measured in seconds.

Average end-to-end delay = (Total of Transmission Delays of All Received Packets)/ (Number of Packets Received)[15]
Where,
Transmission Delay of a Packet = (Time Pkt. Rxvd. at Server – Time Pkt Txd. at Client)
Where 'time' is in seconds.

5.8SNR-- Signal to Noise Ratio[15]:

Signal-to-noise ratio is defined as the power ratio between a signal (meaningful information) and the background noise (unwanted signal):

$$\mathbf{SNR= [P_{signal}/P_{Noise}]}$$

Where P is average power. Both signal and noise power must be measured at the same and equivalent points in a system, and within the same system bandwidth. If the signal and the noise are measured across the same impedance, then the SNR can be obtained by calculating the square of the amplitude ratio:

$$\mathbf{SNR= [P_{signal}/P_{Noise}] = (A_{signal}/ A_{Noise})^2}$$

where A is root mean square (RMS) amplitude (for example, RMS voltage). Because many signals have a very wide dynamic range, SNRs are often expressed using the logarithmic decibel scale. In decibels, the SNR is defined as

$$\mathbf{SNR_{dB} = 10 \log_{10} (P_{signal}/P_{Noise}) = 20 \log_{10} (A_{signal}/ A_{Noise})}$$

6. Conclusion

When connections need to migrate between heterogeneous networks for performance and high-availability reasons, seamless vertical handoff is necessary. Handoff occurs when mobile node changes its point of access technology. This paper describe two of the most prominent developing wireless access networks and detailed comparative analysis between the 802.11 (Wi-Fi) and 802.16 (WiMAX) wireless networks. As we have studied above one of the major problems of the mobile networks is the degradation of the throughput during the handover mechanism. The presented work provides different performance metrics that need to consider during handover and the basic operation of a seamless vertical handover process that can takes place under hybrid networks in order to reduce the error rate, improve throughput over the wireless communication.

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