IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 3, Issue 10, October 2016

Mobility Based Analysis of Horizontal Handover in Wi-Fi and WiMAX

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Abstract: Wireless networking has gained popularity being flexible in nature i.e. easy establishment and removal. First WLAN(Wireless Local Area Network) standard became available in market was WI-FI (IEEE 802.11) standards, with the increasing demand of more bandwidth and data rates new standard were developed of high frequency microwaves IEEE 802.16 standards. New networks are introducing heterogeneity among networks, for satisfying user demands of high bandwidth. Mobile users accessing internet are increasing with great pace often get less mobility feature by maintaining signal strength issues for sustainable data rates. Mobility of nodes (users) across different or homogeneous networks can overcome signal strength related issues. Mobility across networks performing handover can improve data rates and can provide all time on processing. Handover can be done with other networks like neighbor networks for connectivity. Also mobile node should handle different PHY/MAC related issues for reliable implementation of handover process. Mobility management across different networks needs to be addressed and examined for real time scenarios. In this research paper analysis of performance of horizontal handover among WI-FI and WIMAX networks considering certain parameters like packet drop and average throughput etc. in NS2 event driven simulation software. Handover among different networks evolves complexity of mobility management is discussed.

Keywords: Wireless Network, WI-FI, WIMAX, Horizontal handover, Vertical handover, NS2, Network Animator, Toolkit Command Language.

I. INTRODUCTION

Mobile user accessing internet are increasing with great pace following this new wireless technology are being developed satisfying user demands with high throughput and with small delay. There are many wireless technologies or standards which will take hold in near future improving data rates, transmission distance and lowering cost factors. In 1997 first WLAN standards developed IEEE 802.11 later known as WI-FI gained attention of users to access fast internet wirelessly with fixed mobility within the specified range. After this many business enterprises, educational institutions and airports were deployed with WI-FI routers for buffering internet and generally got popularity.

Now one can easily access Internet from many access points and handover between similar networks can be beneficial and relatively less complex to manage. As there can be more Access Point (AP) with in infrastructure so one can move from one cell to another cell doing hand off maintaining session can enhance fixed mobility to varying mobility.

In wireless networks mobile users usually get connected to the best available networks that fit best according to their service. Mobile WIMAX standard also insures mobility within large cell with high data rates. In this study an overview of WI-FI and WIMAX is performed followed by hand-off process in next section. The third section is regarding simulation and analysis. In the last conclusions &future scope is mentioned.

A. Wi-Fi

A Wireless Local Area Network (WLAN) links two or more devices over a short distance using a wireless distribution method, usually providing a connection through an access point for internet access. The 802.11 standards relentless marched through the alphabet series with various revisions address issues, such as security and mesh networking [2]. WLAN can be set in different topologies. The IEEE 802.11 standard permits devices to establish either Peer-to-Peer (P2P) networks or networks based on fixed AP with which mobile nodes can communicate [4]. It has basically two type of networking scenarios first one is infrastructure network, and other is ad hoc. This first topology is useful for providing wireless coverage of building or campus areas. By deploying multiple APs with overlapping coverage areas, organizations can achieve broad network coverage [1]. In P2P type of networks access point are not required. Client devices with in a cell communicate directly with each other. It helps up in setting up wireless networks easily and quickly.

Working of Wi-Fi is similar like talking on walkie-talkies. All wireless technologies have different PHY /MAC layers related issues. 802.11 networks are composed of three basic components; stations, access points and a distribution system [7]. Station is any device which implements the 802.11 PHY and MAC layer protocols. AP is a station which provides addressable interface among multiples stations. (Distribution System) DS is wired

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network component that connect access points to any respective Basic Service Set (BSS). The MAC layer is implemented in all 802.11 stations, and enables the station to establish a network or join a pre-existing network [5]. 802.11 standards define a number of MAC layer coordination functions to co-ordinate media access among multiple stations. The media access method used by the distributed coordination function is Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) which is contention based [2]. Sometimes degrades quality of service of link when many of users are competing for that media.

B. Wimax

WIMAX is an IP compatible, wireless broadband access technology that provides performance similar to 802.11/WI-FI networks with more coverage and Quality of Service (QOS) analogues to cellular networks. Provide fixed, nomadic, portable and eventually mobile wireless broadband without the need for direct Line Of Sight (LOS) to base station [3]. The technology has evolved through several updates of standards as 802.16a, 802.16c; the Fixed WIMAX 802.16d (802.16-2004) specification and lastly the mobile 802.16e was launched that is currently commercially available. The original version of the standard on which WI MAX is based (IEEE 802.16) specified a physical layer operating in the 10 to 66 GHz range [3]. WIMAX is generally a large cell technology with large coverage area. It works very much like cell phone technology requires reasonable proximity to a base station to establish a data link to the Internet. WIMAX can be deployed in both LOS and NLOS (Non Line of Sight) techniques [2]. A WIMAX system consists of two parts: WIMAX tower - similar in concept to a cell-phone tower- A single WIMAX tower can provide coverage to a very large area as big as 3,000 square miles while WIMAX receiver could be a small box or PCMCIA card that could be built into a laptop same way WI-FI access is today. [4] WIMAX Base Station (BS) and WIMAX Subscriber Station (SS), also referred as Customer Premise Equipment (CPE), can be built quickly keeping cost low.

WIMAX architectures use either Point to Multi-Point (PMP), Mesh, or Mobile Multi-hop Relay (MMR) mode [3]. In PMP subscriber stations connects to the base station in a single hop route. In Mesh mode subscriber stations can communicate in an ad-hoc fashion. MMR consist of three network entities BS, Relay Station (RS) and Mobile Station (MS)[3]. RSs have the functionality of playing and intermediate forwarder to forwards traffic between any MS and the BS.

C. Handover Between Networks

Handover process is the process of maintaining a user's active sessions when a mobile terminal changes its connection point to the access network. In wireless networks mobile users usually get connected to the best available networks that fit best according to their service. Actually handover is a process of changing Mobile Node's (MN) Point Of Attachment (PoA) when the Received Signal Strength (RSS) of the MN falls below a pre-defined threshold value [6]. For mobile users, handover occurs when wireless link conditions change due to the users' movement. For the stationary user, handover become reasonable when the surrounding network environment situations changes makes one network more attractive than another to use. Hand-off maintain the user's active session when it is moving. [8] Handover occurs when a mobile device move away and enter to surrounding cell coverage or to another, the connection is also transferred to the new cell[5]. Hand-off techniques works in two ways according to the radio access technologies namely 1) horizontal handover 2) vertical handover. Horizontal handover is a technique between Base Stations (BS) or AP which uses similar radio access technology, so called intra-technology handover [6]. Vertical handover is between BSs or APs which uses different radio access technologies that is why called inter-technology handover [8]. Because of the different characteristics of different access technologies which are used in the networks, the vertical hand-off seems asymmetrical while horizontal hand-off behave symmetrical due to similarity of radio accessing technologies[9].

Users can not directly hand-off between different wireless technology interfaces since the media types are incompatible [7]. Handover in wireless networks may result in performance degradation to applications because of underlying handover protocols. Handover management issues mainly concerns mobility scenarios, metrics, decision algorithms procedures and delay etc. Heterogeneous networks have different system characteristics so their performance cannot be simply compared with using the signal strength of two cells [6]. In case of horizontal handover technique, handover occurs only when the received signal strength becomes in weak position, whereas in case of vertical handover, the handover may occur depending on behalf of user decision. When hand-off occurs, packet drop is concerning issue needs to addressed. Handover policy management should be enhanced to decrease packet drop with mobility features. Vertical hand-off throughput can vary with types of standards used [5]. There are other terminologies in case of hand-off like hard handover and soft hand-off. The hard hand-off is used when the communication channel is released first and after the releasing the new channel is acquired. Simply it suffers a short disconnection or halt of communication [8]. Hard hand-off is used by the systems which use (Time Division Multiple Access) TDMA such as GSM [5]. While soft hand-off establishes multiple connections with neighboring cells. Soft hand-off is used by the (Code Division Multiple Access) CDMA systems [6].

II. SIMULATION TOOLS

Simulation creates virtual environments to analyze real world scenarios of working of underlying technologies. Simulation and modeling helps in creating and defining real time functioning of networking elements, saving time

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and money for reliable implementation. Simulation of both the technologies has been performed in NS2 simulations software version 2.35 in Ubuntu 16.04 LTS operating system. There are many software available for simulation of both the technologies these are Opnet Modeller, Omnet++, Nctuns, Qualnet and NS3 etc. most of these simulation software are paid one with relatively different working style and programming. OpnetModeller simulation software which has great graphical user interface but academic version is being available cannot simulate WIMAX technology. While Omnet++ is totally c++ based simulation software also very complex to use While Nctuns works on Fedora OS and also very difficult to install. Most of these simulation softwares are costly and license is valid for small time. There are some simulation softwares which are open source like NS2 and NS3. It is reasonable to choose NS2 simulation software for analyzing both type of networks. NS2 is famous simulation software for simulating wired and wireless networking scenarios. Modules can be added to enhance capability of version being used. NS2 is open source software. It is also simple to install. It can work on different operating systems. This study also explores the working of NS2 software for representing performance of both networks.

A. NS2 Simulator

NS-2 is an event driven packet level network simulator developed as part of the project (Virtual Internet Testbed) VINT Version 1 of NS2 was developed in 1995.Version 2 included a scripting language called Object-Oriented Tcl (Otcl). It is an open source software package available for both windows and Linux OS. NS2 has vast expanding uses including performance of existing network protocols, evaluation of new network protocols before use and runninglarge scale experiments not possible in real experiments.

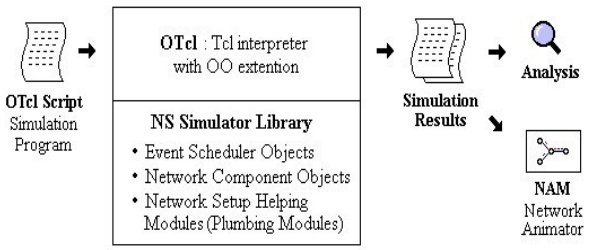

Fig.1. NS2 working

NS is an Object-Oriented Tcl (Otcl) script interpreter that has a simulation event scheduler and network component object libraries, and network set-up (plumbing) module libraries [10]. NS–2 is written in C++ with OTcl interpreter as a front end. TclCL is the language used to provide a linkage between C++ and OTcl. Toolkit Command Language (Tcl/OTcl) scripts are written to setup/configure network Command Language. New components added have to be written in C++. While NAM provides a visual interpretation of the network topology created [10]. After executing (Network Animator) NAM file generated by executing TCL scripts and trace files are generated, much software like NAM Trace and Trace Analyzer are used in representing actual data.

B. Simulation Setup

In this study two types of networking technologies are considered. In this section horizontal hand-off occurrence is discussed in following technologies. Simulation is carried using NS2 version 2.35. for which some extra modules were added including WIMAX libraries. NS2 was installed on Ubuntu 16.04 LTS operating system. A NIST mobility patch which already contains WIMAX module has been added to enhance the capability of mobile node.

1) Horizontal handover in WI-FI networks:

To illustrate the performance of WI-FI networks the scenario is created with 8 mobile nodes in which three node acts as base station or AP while other are mobile stations. Node n0, n2 and n5 are AP while other n1, n3, n4, n6 and n7 are mobile nodes connected to respective AP. Node n1 and n3 are connected to n0 AP, n4 is connected to n2 AP and n6 and n7 are connected to n5 AP. Data traffic generated for scenario is (Constant Bit Rate) CBR and routing protocol is (Adhoc On –demand Distance Vector) AODV. Node n1 is sending data to n7. When n1 starts moving from no to n5 with specific velocity through n2 then it perform handover to n2 AP first then after reaching specified destination it finally get connected to n5. Still continue to send data to n7 through AP n5 after performing hand-off decision. This was checked over different velocity and duration of simulation time. During this procedure packet drop was usual as handover occurs. Above scenario simulation has been done keeping Table1 parameters for mobile node. These were the simulation parameters for mobile node to work on modules.Table1 parameters helps in defining characteristics of networks.

Table1. Simulation Parameters of WI-FI

S.NO	SIMULATION PARAMETERS	IEEE 802.11 (Wi-Fi)
I	MODULATION	QPSK
II	NETWORK	WIRELESS NETWORK
III	NODES	8
IV	NODE SPEED	2 TO 18 M/S
V	TRAFFIC TYPE	CBR
VI	MAC LAYER	MAC/802_11
VII	BIT RATE	128KBPS
VIII	BS RADIUS	20M
IX	ROUTING PROTOCOL	AODV
X	RADIO_ PROPAGATION MODEL	PROPAGATION/ TWO RAY GROUND
XI	PACKETS SENT	300
XII	SIMULATION TIME	90SEC

DOI 10.17148/IARJSET.2016.31005

IARJSET
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2) Horizontal Handover WIMAX:
Modules used are enlisted above in simulation setup. In WIMAX simulation there are four nodes in which two are base stations n1, n2 while n3 is mobile node having WIMAX module characteristics and one sink node n0 where to send data. Mobile node is connected to BS1 initially and sending data to sink node or corresponding nodes. When n3 starts moving towards n1(BS1) then at particular moment after reaching in range of (BS2) n2, hand- off and then send data to corresponding node through BS2.

Table2. Simulation Parameters of WIMAX

S.NO	SIMULATION PARAMETERS	IEEE 802.16 (WIMAX)
I	MODULATION	16QAM
II	NETWORK	WIRELESS
III	BIT RATE	256 KBPS AND 512 KBPS
IV	NODES	4
V	BS RADIUS	100 METERS
VI	NODE SPEED	2 TO 18 M/S
VII	TRAFFIC TYPE	CBR
VIII	PACKETS TO SEND	300
IX	ROUTING PROTOCOL	AODV
X	MAC TYPE	MAC/802_16/BS
XI	SIMULATION TIME	90 SEC

The traffic type of transfer between mobile nodes is constant bit rate. Table2 contains the parameters of mobile node for WIMAX. These parameters are considered for implementing working scenarios. Now it is necessary to analyze the packet send and received in both handover processes.

III. ANALYSIS

In this simulation, analysis of the performance of horizontal hand-off between two different technologies is performed based on following parameters like end to end delay, average throughput, packet dropped and hand-off latency. Graphs depending on these parameters has been plotted to analyze objectives of performance.

A. Handover Latency
The handover latency is the duration from handover initiation to handover completion that is equal to amount of time from which, when the mobile is disconnected from the existing base station and switching over to new base station and the mobile receives the first packet service from the new BS. Since there are many nodes being taken for WI-FI simulation the hand-off

Latency is relatively less with less speed but in case of WIMAX latency increases with increase of speed of mobile node.

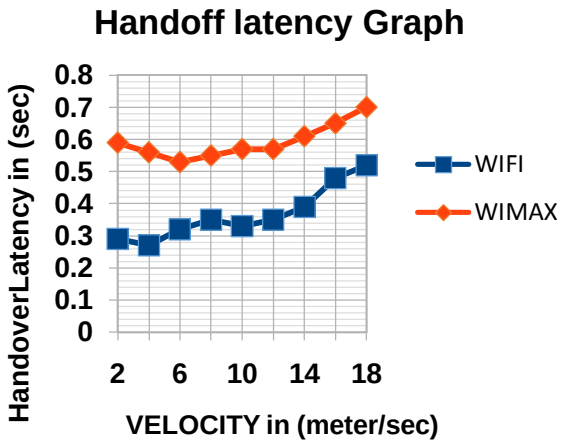

Fig.2. Hand-off latency graph

B. End To End Delay
End to end delay which can be calculated as the total time taken by the packet to reach from source network to destination network. This is also defined as a sum of transmission delay, propagation delay and processing delay. All these delays count for end to end delay.

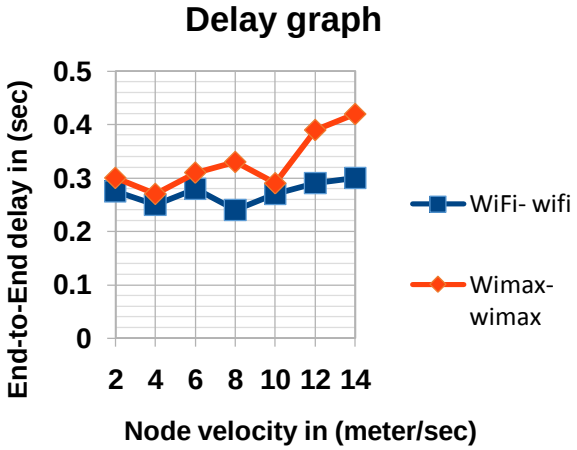

Fig.3. End to end delay graph

The graph display of end to end delay was shown in the Fig.3.As mobile node moves with different velocity from one BS to another BS end to end delay also changes. In above graph when velocity of mobile node is less delay is also small. In case of WI-FI delay changes relatively less but in case of WIMAX when velocity increases much delay has been introduced.

C. Average Throughput
Throughput is the basic average rate of successful message delivery over a communication channel. The throughput was usually measured in terms of kilobytes per second. Graph of average throughput against velocity was shown in the Fig.4. When velocity is less throughput of both technologies is comparatively high but as the velocity of mobile node increases throughput gradually decreases.

DOI 10.17148/IARJSET.2016.31005

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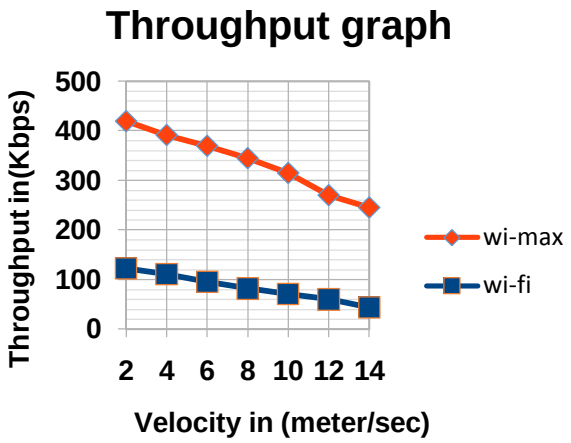

Fig.4. Average Throughput Graph

D. Packet Drop

In this simulation, packet drops were calculated versus different velocity. Packet drop usually occurs when mobile node jumps to another BS disconnecting previous BS when node speed is increasing packet drop factor also increases for both technologies. In case of WI-FI it may occur due to unnecessary hand-off while in case of WIMAX it may occur due to complexity in maintaining LOS behavior.

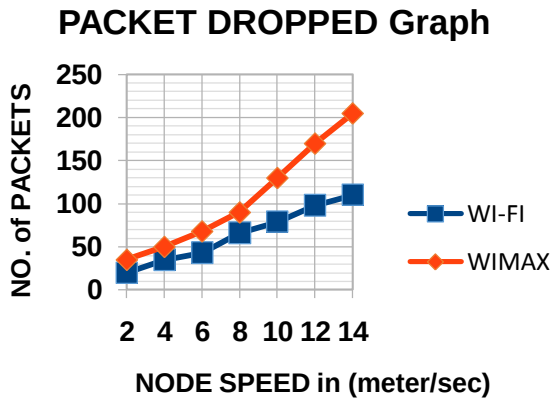

Fig.5. Packet Drop Graph

IV. CONCLUSIONS AND FUTURE SCOPE

Performance analysis of both WI-FI and WIMAX in NS2 reveals that both have varying performance accordance to mobility of the node. Handover occurs when mobile node detects other base station more influencing than connected one. Investigation shows that as hand-off occurs quality of service also get change due to certain parameters like packet drop and end to end delay etc. this study and experimentation will help to explore how mobility of nodes affect data rate and handover procedures by mean of simulation. This study reveals that if velocity increases packet drop and delay increases gradually. There is also determinable effect on throughput. There are some limitations of NS2 simulation while implementing networks scenarios. In reality it is still not possible to include two MAC ID in the same TCL file for the same mobile node. Because if it cannot give two MAC ID in the same TCL file while creating TCL animator file it only takes one MAC ID at the same time from the 802.11/802.16. In future it is necessary to create multiple interface node which will help to include MAC layer of both technologies in one mobile node. It is evident from analysis that throughput of WIMAX is much more efficient than WI-FI in term of mobility feature. But End to End delay is relatively less in WI-FI since more AP are considered in study. While WIMAX delay may be more being large cell technology. Packet drop in both technologies is lower when there was less mobility. WI-FI covers less area than WIMAX but cell overlapping can increase coverage area. It may lead to interference issue can increase packet drop. In term of hand-off WIMAX has more latency than WI-FI as we have considered more AP in study than BS in WIMAX. In end it is clear that WIMAX is technology of future with large coverage area. In future heterogeneous networks will improve data rates keeping complexity of networks manageable.

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