VOL 2 (2018) NO 4 - 2

e-ISSN : 2549-9904
ISSN : 2549-9610

INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION

Network Quality Assesment of Wireless Communication Based on Mobility Issue

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Abstract*— Up-gradation of wireless communication system is mainly based on some critical attributes like speed, coverage, interoperability, reliability, cost, security etc. This paper looks potential approaches to network quality analysis based on mobility. In this paper, focus is given to determine handover latency, vital property of mobility. This paper presents simulation to investigate handover effects-handover latency in homogeneous and heterogeneous environment using network simulator NCTUns 6.0 and simulator version 2 (NS-2) respectively for different generations of wireless communication. Also simulation is performed to find out the handover latency with respect to mobile node's speed and then the results are compared with each other for performance analysis. *The obtained results show that advanced generations of wireless communication provides low handover latency as well as higher mobility support which leads to better network performance and seamless connectivity.

***Keywords*— Interoperability, Mobility, Handover, Handover Latency, Mobile Node speed.**

I. INTRODUCTION

Next generation wireless communication systems feel the necessity of high speed, ubiquitous and seamless user roaming with end-to-end connectivity and interoperability. Interoperability can offer network providers with a possibility to switch between alternative wireless access networks [1]. Interoperability between different generations of wireless communication system lead to higher data rate, higher mobility support and QoS guarantees. Mobility and hand over latency are the two most important parameters of interoperability as well as wireless communication.

Mobility is the most important feature of a wireless cellular communication system. Mobility is closely related to mobile users and mobile nodes (MN) when they are roaming between previous wireless access network and new wireless access network. Mobility management deals with mobility. Generally, mobility management allows mobile communication systems to locate roaming nodes for voice/data delivery as well as maintaining network connectivity when the node moves into a new service area. This transfer of an ongoing call or data session from core network to visited network is known as handover. Handover has become an essential criterion in wireless communication system. During handover procedure, for a time period, mobile node (MN) cannot send or receive packets, because of the link switching delay. This period of time is known as handover latency. Handover Latency is an important factor for seamless connectivity, smooth migration and mobility. Handover latency affects the service quality of real time applications of mobile users. Long handover latency causes loss of packet, delayed transmission and dropped call. Low handover latency provides better mobility performance. Handover latency highly depends on different factors like delay between Home Agent (HA) and Foreign Agent (FA), mobile node's speed, etc. [2,3].

In this paper, focus is given mainly to mobility issue as well as handover latency of different generations of wireless communication in homogenous and heterogeneous environment, and the effect of MN's speed on mobile node's speed. Simulation is done for handover in homogeneous and heterogeneous environment by network simulator NCTUns 6.0 and simulator version 2 (NS-2) respectively. The analyzed simulation scenario investigates handover effects-handover latency for different generations of wireless communications such as GPRS (for 2G), IEEE 802.11b (WiFi for 3G) and IEEE 802.16e, j (WiMAX for 4G). The design network is then evaluated in terms of parameters handover latency. Simulation is also done to find out the handover latency with respect to mobile node's speed and then the results are compared with each other for network performance analysis. The variation of handover latency with respect to mobile node's speed is found out by simulation. The results are analyzed for 2G, 3G, and 4G. Then the obtained results are compared with each other and network performance is analyzed.

II. MATERIAL AND METHOD

1. *Quality Assessment Parameters*

Network quality assessment parameters measure network performance. There are many different ways to measure the performance of a network, as each network is different in nature and design. The following parameters listed in Table I are often considered.

TABLE I
ESSETIAL PARAMETERS FOR NETWORK QUALITY ASSESMENT

Parameter	Description
1. Band-width	the maximum rate that information can be transferred.
2. Throughput	the actual rate that information is transferred.
3. Latency	the delay between the sender and the receiver decoding it, this is mainly a function of the signals travel time, and processing time at any nodes the information traverses.
4. Jitter	variation in packet delay at the receiver of the information.
5. Error rate	the number of corrupted bits expressed as a percentage or fraction of the total sent.

Bandwidth: The available channel bandwidth and achievable signal-to-noise ratio determine the maximum possible throughput. It is not generally possible to send more data than dictated by the Shannon-Hartley Theorem. The higher the bandwidth, the higher the data rate [4].

Throughput: Throughput is controlled by available bandwidth, as well as the available signal-to-noise ratio and hardware limitations.

Latency: The speed of light imposes a minimum propagation time on all electromagnetic signals. It is not possible to reduce the latency below $t= s/c_m$ where s is the distance and c_m is the speed of light in the medium. In general, this measure should not exceed 150ms (where internal network latency< 150 ms) in one direction to prevent deterioration of call quality.

Jitter: Jitter that exceeds 40ms will cause severe deterioration in call quality. High levels of jitter are usually a consequence of slow speeds or congested networks or dropouts [5].

Error rate: Too high a BER may indicate that a slower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be resent [6].

High speed of wireless communication, one of the pre-requisites of high performance network, is driven by mobility issues, handover latency and mobile node's speed. In this paper the characteristics of these three factors are highlighted.

A. *Mobility Issues*

Mobility is important aspect in wireless and very much connected to mobility management communication [1–3]. The aim of mobility management is to track location update (where the subscribers are), allowing calls, SMS and other mobile phone service to be delivered to them. Mobility management depends on mobility and its category. Mobility management is based on two issues, namely Handover management and Location management.

Handover mechanism is extremely important in mobile network. Handover management is the way to improve the cellular network performance by using efficient handover prioritization schemes i.e. by keeping a mobile node keeps its connection active when it moves from one access point to another when user is switching between the cells. If handover does not occur at right time the QoS may be drop below an adequate level and connection will be dropped. Each handover requires network resources to route the call to next base station. There are several different reasons needed to be known to determine whether a handover is required such as the signal strength of the base station, signal strengths of the surrounding stations, the availability of the channels, and the strength of the base stations. Considering these issues, the network makes the decision about the handover.

There are three stages involved in a handoff process, such as

- The initiation of handoff is triggered by either the mobile device, or a network agent, or the changing network conditions.
- A new connection generation, where the network must find new resources for the handoff connection and perform any additional routing operations.
- Data-flow control needs to maintain the delivery of the data from the old connection path to the new connection path according to the agreed-upon QoS guarantees.

Also the following design factors should be considered for the handoff management techniques in all IP based next-generation wireless networks: (i) Signaling overhead should be minimized, (ii) Power requirement should be minimized for processing handoff messages, (iii) QoS guarantees must be made, (iv) Network resources should be efficiently used, (v) The handoff mechanism should be scalable, reliable and robust.

On the other hand, location management scheme is a major and crucial component of any wireless communication network to effectively deliver network services to mobile users. There are two essential tasks in location management, namely, location update (location registration) and terminal paging (call delivery). Location update periodically notifies mobile terminal's current location to a network to update the mobile terminal's location profile in a location database. Terminal paging searches a mobile terminal by sending polling signals based on the information of its previous reported location for directing an incoming phone call to the mobile terminal [7, 8]. Mobility can be categorized as network mobility and radio mobility.

Network Mobility: Network mobility mainly deals with mobile management. The aim of mobility management is to track location update (where the subscribers are), allowing calls, SMS and other mobile phone service to be delivered to them. Each mobile device is required to regularly report about its periodic location update and random location update is required. Managing mobility is also required to reselect coverage from a cell in a different location area, because of signal fade. Thus a subscriber has reliable access to the network and may be reached with a call, while enjoying the freedom of mobility within the whole coverage area [9,10].

Network mobility is categorized in to two groups namely, Horizontal mobility and Vertical mobility. Horizontal mobility is the mobility on the same layer. Generally, it is referred to as the mobility within the same access technology i.e. homogeneous environment. Conversely, the vertical mobility is the mobility between different layers. It is referred to as the mobility between different access technologies i.e. heterogeneous environment. To measure a mobility pattern one needs to track a large number of nodes for a long period of time. In fact, this is the perfect application area for wireless sensor networks specialized in localization. Localization can be solved by measuring ranging information from signal strength, time of arrival or the time difference of arrival, or angle of arrival. Mobility can be classified as follows: pedestrians, vehicles, aerial, dynamic medium, robot, and outer space motion.

Radio Mobility: Radio mobility is mainly concerned with the handoff process. Handover is one of the essential features that guarantee the subscriber mobility in a mobile network, where the subscriber can move around. Maintaining connection with a moving subscriber is possible with the help of the handoff function. When the mobile user moves out of his coverage area, handover is required to enjoy continuation of services. Controlling the handover mechanism is, however, quite a complicated issue in cellular systems. As the viewpoint of handover management, the characteristic that NGN is related to two types of environment such as Homogeneous environment where handover is occurred within same access networks, which is known as horizontal handover. Generally, it is referred to as the Intra-AN handover. Heterogeneous environment where handover is occurred across heterogeneous access networks, which is known as vertical handover. Generally, it is referred to as the Inter-AN handover [11].

The aim of mobility is to continue the communication of the mobile node and the networks during movement without disrupting of the connections. When a mobile node moves from one place to another, the prime and foremost requirement is seamless connectivity and continuous reach ability. The following factors affect the mobility issue [12,13].

Efficient Handover: Efficient Handover is the performance of a mobility scheme. Handover should be handled efficiently in order to reduce or avoid the loss and delay of packets

Location Management: The location management performs location update, location look up and paging to obtain the current location of the mobile unit and through paging the system informs the caller the location of the called unit in terms of its current location.

Efficient Routing: Efficient routing is the process of selecting a path for traffic in a network or between or multiple access networks to enhance network lifetime and its ability to forward packets.

Security: Wireless security is the prevention of unauthorized access or damage.

Scalability: Scalability is one of the major deciding factors for any new networking technology. A scalable network system starts with just a few nodes but can easily expands to thousands of nodes to be accepted, deployed and to evolve continuously. A new user can be added by issuing a password and updating it in the server. [14].

Fault Tolerance: Fault tolerance is the ability of maintaining functionality when a portion of a system breaks down. If its operating quality decreases at all, the decrease is proportional to the severity of the failure, leading yo total breakdown

Simultaneous Mobility: Both end hosts can move simultaneously without interruption.

Link Layer Independence: Designing communications protocol to allow mobile device users to move from one network to another while maintaining a permanent IP address for with location-*independent* routing of IP datagrams .

Compatibility between Routing: This is successfully used to verify the *compatibility* between routing.

Transparency: It allows an operating system or other service a user to access a resource without the user needing to know, and usually not being aware of, whether the resource is located on the local machine [14-15].

B. Handover Latency

Wireless network deals geographically selective network. As a result, a wireless communication terminal is to maintain connection among multiple points and perhaps multiple networks as it moves from one location to another. The connection may be intra-technology, inter-technology, heterogeneous, or homogeneous networking. The process of supporting the change from one wireless point of connection to another is referred to as handover. Handover is a frequent operation in mobility management. Handoff affects the quality of service directly. Handoff occurs if the signal quality falls below a predefined threshold level. The Quality of service (QoS) and capacity of the network may be affected due to handoff [12-14].

Efficient handover mechanism is essential for ensuring seamless connectivity and uninterrupted service delivery. A network performs properly if handoff occurs smoothly, without gaps in communications and without confusion about selecting active base station. The First Generation wireless communication was based on analog system transmissions, and less heavy and expensive. Second Generation uses digital modulation to improve voice quality but the network offers limited data service. The third Generation revolution allowed customer to use audio, graphics and video applications. Instead of developing a new uniform standard for all wireless communications systems, 4G communication networks introduces seamlessly integrate various existing wireless communication technologies when comparing to 2G, 3G networks. The aim of this migration is to provide seamless handover among various communications systems with small handoff latency and packet loss [15-16].

The success of handover mechanism depends mostly on handover latency, the time interval between last reception of data on the current network and the moment when mobile unit starts receiving packets at the new point of attachment in the complete handoff process. Handover latency is one of the most important concerns in mobility issue of wireless communication. Hanover latency plays very important role in many IP based applications like games, VOIP, mail & file sync, application sharing, video & voice conference over IP. For successful handover, handover latency must be as low as possible and the total number of handoff should be minima [15]. Long handover latency results in high packet losses and severely degrades its end-to-end TCP performance. Delay sensitive real-time applications demands packet lossless and low latency Quality-of-Service (QoS) guarantee during handover. At present, users aim to allow a seamless connectivity to enjoy global roaming across multiple networks and support for high quality multimedia at lower cost. So, low handover latency is very much required for enhanced network performance. This demand is fulfilled by an interoperable system. An interoperable system is continuous and consumes low latency period for hand over and 4G wireless system facilitates these opportunities. Interoperability ensures smooth and easy migration between different generations of wireless communication system [7, 11, 17].

C. Mobile Node's Speed

The perceptible growth of subscriber and their elevated demands bring forth the next generation wireless communication. As the number of mobile and vehicular network user is rapidly increasing, there is a need for supporting highly speedy mobility. Mobility aims to maintain the seamless connection between a mobile host and a static host while reducing the effects of location changes in case of moving mobile host without having to change the underlying connection. This kind of communication can be efficiently implemented using Mobile IP (MIP) which is an Internet Engineering Task Force (IETF) standard communications protocol that allows mobile device users to move from one network to another while maintaining a permanent IP address. *Mobile IP* is related to mobile node very closely and directly [18].

Mobile nodes are devices that are capable of connecting to the Internet from a variety of different points of entry. This kind of node is often a cellular telephone or handheld or laptop computer, although a mobile node can also be a router. The benefit of this type of Internet-connected device is that persons who are on the go may establish a connection to the Internet from a wide range of locations. Special support is required to maintain Internet connections for a mobile node as it moves from one network or subnet to another, because traditional Internet routing assumes a device will always have the same IP address. Therefore, using standard routing procedures, a mobile user would have to change the device's IP address each time they connected through another network or subnet. Mobile IP specifies how a *mobile node* registers with its home agent and how the home agent routes datagrams to the *mobile node* through the tunnel. Network size, control overhead, and traffic intensity will have a considerable impact on mobile node. Node mobility has a greater impact on average control overhead than any other factor. Mobile IP would encompass all the technologies for seamless mobility depending on some important issues like latency, security, triangulation, reliability [19, 20].

2. Quality Assessment by Simulation

The simulation experiments were carried out for the followings cases.

Case-1: Simulation for handover in homogeneous environment by network simulator NCTUns 6.0 and investigate handover latency for different generations of wireless communications such as GPRS (for 2G), IEEE 802.11b (WiFi for 3G) and IEEE 802.16e, j (WiMAX for 4G). In this simulation, the following considerations are made.

- A parameter of interest was the experienced handover latency.
- In homogeneous environments the handover behavior is analyzed. In this environment, both the base station is of same access network.
- In this scenario, MS will break the connection with the original BS before making a new the connection with the original BS before making a new connection with another BS.
- The analyzed simulation scenario investigates handover effects between different generations of wireless communications such as GPRS (for 2G), IEEE 802.11b (WiFi for 3G) and IEEE 802.16e, j (WiMAX for 4G). It consists of a (i) Corresponding Node (CN) generating traffic towards a Mobile Node (MN) (ii) intermediate routers, IEEE 802.11. (iii) Access Point (AP), (iv) IEEE 802.16 Base Station (BS) and (v) a GPRS node. All are placed in a simulated area of 2000 m x 2000 m.

The whole simulation area has GPRS coverage, whereas the IEEE 802.16 and the IEEE 802.11 technologies cover a circular area with a radius of 500 m and 40 m inside, respectively. The MN moves freely throughout the simulation area performing various vertical handover. The assumed channel model is ideal. The obtained result is given in Table 1 and shown in Fig.1 (a-d).

Case-2: Simulation for handover in heterogeneous environment simulator version 2 (NS-2). In this simulation, the following considerations are made.

- The all-in-one package of the Network Simulator, version 2.29 (NS-2) [101] was used.
- But Network Simulator, version 2.29 (NS-2) does not include full support for Mobile WiMAX and therefore additional components are required. Two packages, the WiMAX and the Mobility module, from NIST [102] were installed to achieve simulations of proposed mobile scenarios.
- This section highlights simulation for handover in heterogeneous environment simulator version 2 (NS-2).
- In this scenario, the vertical handover is performed between 2 wireless technologies: 802.11 (WiFi) and 802.16(WiMAX).
- Simulation is performed for the proposed network scenario for visualizing vertical handover with Network Animator in NS-2 system .

Case-3: Simulation to find out the handover latency with respect to mobile nodes' various speed. For seamless connection in a network for moving terminals i.e. MN, the decision to initiate handover should be taken before the user moves out of the coverage area of its current access point. So the relation between handover latency and MN's speed is also very important. In this section followings are done.

- Simulation is done on handover latency (HOL) vs. MN's speed.
- *H*and over latency is checked for different speeds of MN like 10, 20, 30 ms and for different generations like 2G(802.11b), 3G(802.16e), 4G (802.16j) and finally compared the result in Table 3 and Figure 2.

III. RESULT AND DISCUSSION

The simulation results for handover latency at different generations in homogeneous environment are shown in Table-II and Figure 1.

TABLE II
HANDOVER LATENCY FOR DIFFERENT GENERATIONS IN HOMOGENEOUS ENVIRONMENT

Handover	**Handover Latency (HOL)**
GPRS (2G) to GPRS (2G)	4s
802.11b (3G) to 802.11(b)	4s
Mobile WiMAX802.16e(3.5 G) to Mobile WiMAX802.16e(3.5 G)	3s
Mobile WiMAX802.16j (4G) to Mobile WiMAX802.16j (4G)	1s

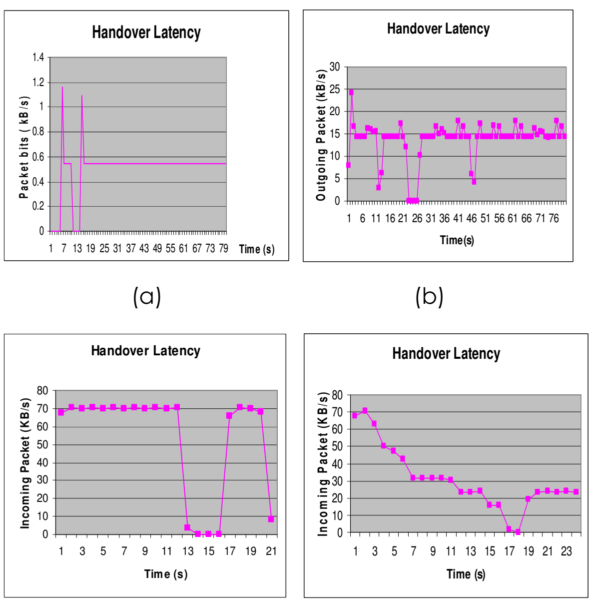


Fig. 1 Handover Latency in (a) GPRS system (b) 802.11b (c) Mobile WiMAX 802.16e (d) Mobile WiMAX 802.16j

This result shows that the handover latency of GPRS (2G) and IEEE 802.11b (3G) are the highest while that of IEEE 802.16j (4G) is the lowest. Thus the handover latency is gradually decreasing from 2G to 3G to 4G and hence supporting the analysis that 4G wireless communication system is more interoperable.

The simulation results for handover in heterogeneous environment are shown in Table-III.

TABLE III
RESULT ANALYSIS FOR HETEROGENOUS ENVIRONMENT

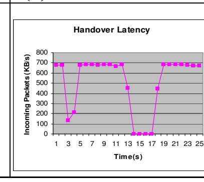
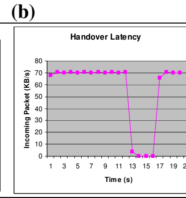
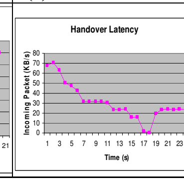
Handover Timeline			
Handover 802.16-802.11: at 28s, due to detection of new AP, Link UP			
Handover 802.11-802.16: at 59.8s, due to Link Going Down 802.11: Pt=0.0134W, RxThreshold: 5.25089e-10 W, Going Down Threshold: 6.301068e-10 W, F= 2.4Ghz			
Handover 802.16-802.16: at 173.27s, due to Link Going Down 802.16: Rx Threshold: 2.96631e-09W, Going Down Threshold: 3.559572We-9, Pt = 15W, F=3.5 GHz			
Handover 802.16-802.11: at 210.70s, due to detection of new AP, Link UP **Handover 802.11-802.16**: at 243.26s, due to Link Going Down			
Handover 802.16-802.11 latency			
Link Detect at	Link UP at		Handover Latency
28.244389s	28.245614s		1.22ms
Handover 802.11-802.16 latency			
Link going down at	Link down at	Link up at	Handover Latency
58.517s	59.744389 ms	59.844160 ms	99.77 ms

This result presents that the handover latency HOL is low for 802.16 (3G) to 802.11 (2G) than that of 2G (WiFi) to 3G (WiMAX) which indicates that 3G is providing better mobility and connectivity than previous generations.

Finally, the simulation results for the handover latency with respect to mobile nodes' various speed are shown in Table IV and in Figure 2.

TABLE IV
HANDOVER LATENCY(HOL) FOR DIFFERENT MN'S SPEED IN CASE OF 2G,3G AND 4G

MN's speed	**2G (802.11b)**	**3G (802.16e)**	**4G (802.16j)**
10m/s	4s	3s	1s
20m/s	6s	5s	1s
30m/s	9s	7s	1s

m/s	**For 2G (802.11b) (a)**	**For 3G (802.16e) (b)**	**For 4G (802.16j) (c)**
10			

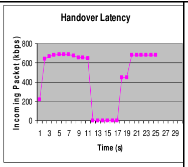
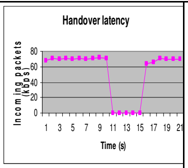
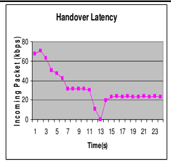
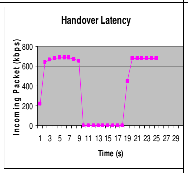
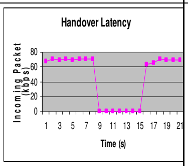
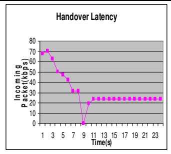
20			
30			

Fig. 2 Handover Latency (HOL) for different MN's speed in case of 2G,3G and 4G

In case of 2G (802.11b) HOL is found 4s, 6s and 9s for MN's speed 10m/s, 20m/s and 30 m/s respectively. Similarly, HOL is 3s, 5s, 7s for 3G (802.16e) and 1s, 1s, 1s for 4G (802.16j) with respect to MN's speed 10m/s, 20m/s and 30ms.

The same situation occurs for 3G (802.16e) and 4G (802.16j). Thus HOL starts earlier with the increase of MN's speed. Similar results are obtained in case of 3G (802.16e) and 4G (802.16j).

Therefore, we can say that HOL is gradually increasing with the MN's speed. Again, when MN's speed is 10m/s, HOL starts at 14th second, for 20m/s HOL *starts at* 12th second and for 30m /s, it is 10th second in case of 2G (802.11b).

IV. CONCLUSIONS

To keep the demand of up gradation the best way is to keep existing wireless network systems as they are and apply some techniques. So that different systems can work together as if they are a single unit. That means data from different standards can be exchanged without any interruption. In this research, parameter of interest is the experienced handover latency (HOL). The handover behavior is analyzed in both homogeneous and heterogeneous environments using network simulator NCTUNs6 and NS2. The analyzed simulation scenario investigates handover effects between different generations of wireless communications. In addition, the effect of mobile node's speed on handover latency for different generations of wireless communication is observed through simulation. The analyzed simulation scenario investigates handover effects between different generations of wireless communications. In addition, the effect of mobile node's speed on handover latency for different generations of wireless communication is observed through simulation. The observed value of handover latency for three different situations (homogeneous, heterogeneous environment and with MN speed) reflects that advanced generations of wireless communication shows better performance provides better mobility and is very similar to the theoretical conception. Thus, 4G network shows better performance than other generations of wireless communication.

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