Scalable QoS-Aware mobility for 4G/5G Mobile Networks with Mobile IP6

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Abstract— Deploying the internet and real time applications over next generation mobile networks indicates the need to pay attention to support mobility, mobile IPv6 (MIP6) is a protocol deal with mobility for next generation mobile networks. 4G/5G networks will probably transfer data and VOIP over IPv6 due to the massive amount of the IP addresses predicted to be used around the world. Providing high QoS and efficient support for high data rates and diverse coverage areas over different RATs (Radio access technology networks) such as WiMAX and mobile Ad-Hoc environments can be achieved using mobile IPv6. In this paper, we have analyzed the performance of mobile IPv6 over mobile Adhoc/ WiMaX networks using performance metrics such as throughput and packets delay under different speeds. Comparison between mobile IPv6 and mobile IPv4 is conducted and factors that affect the QOS such as speed and network load are considered.

Keywords — QoS, MIP6, WiMaX, Ad Hoc, VOIP

I. INTRODUCTION

The next-generation wireless networks such as 4G and 5G cellular systems are targeted to support various applications such as voice, data, video conference and multimedia. Mobile Ad hoc and WiMax networks can be enhanced with higher data rates, high quality images and video, access to information and services on public and private networks with quality of service (QoS), security measures, location-awareness, energy efficiency, and new flexible communication capabilities.

In next-generation wireless networks, providing QoS guarantees to various applications is one of the important issues. Different applications can have diverse QoS requirements in terms of delay and data rates [1]. The new version of the Internet Protocol, IPv6 solves the limitations in the current IPv4 address space, and meets the future needs in the Internet. IPv6 offer enhancements such as security support embedded in the protocol’s definition, address auto-configuration, more extensibility with flexibility and no checksum at the IP header. The widespread adoption of the IP6 will support innovation and many new networking applications.

The network Address Translation solutions have been implemented in order to replace the IP version4 addresses. Solutions were developed to increasing the size of the address space and sharing IPv6 addresses [2]. Network address translation (NAT) has become common mechanism for sharing a large number of addresses among large number of hosts. Network address translation work by providing private addresses to hosts and translating them into public IPv6 address/port pairs on demand when the hosts send packets to the internet. By deploying Ad Hoc Networks mobile users can share IP-based information over an environment in which fixed network infrastructure is impossible or impractical.

Mobile nodes and network initiated handovers still survive in the same networks and being tightly integrated with other networks to provide high QoS and efficient support for resource management and handover decisions.

A. MANET

Mobile Ad-Hoc Network (MANET) is emerging wireless networking continuously self-configuring, infrastructure-less network of mobile devices which are connected without wires. MANET offer variety of services and deliver significant benefits, mobile nodes associate on ad hoc basis or extemporaneous [3]. Mobile Ad Hoc Networks are self-forming, enabling communication between mobile nodes without reliance on fixed infrastructure and centralized resources.

Mobile ad hoc networks usually has a routable networking environment on top of Link Layer and consist of peer-to-peer, self-healing and self – forming network in contrast to a mesh network has a central controller that is use to determine, distribute and optimize the routing table[4,5]. MANETs typically communicate at radio frequencies (30 MHz - 5 GH).

B. WiMAX

WiMAX is promising technology for providing last-mile wireless connectivity intended to satisfy the needs of next generation data networks (4G) due to its low cost of deployment, large coverage and high speed data rates[6].
Physical and MAC layer of the WiMaX refer to the IEEE 802.16e and IEEE 802.16d standards, which define a variety of service classes that can be used in order to satisfy Quality of Service requirements of different applications such as FTP, Web, VoIP and Video conference. The name WiMAX was introduced by WiMAX Forum in 2001. The mobile WiMAX provides data rate up to 75 Mbps and up to 1 Gbit/s for fixed stations. WiMAX system uses OFDM based on the adaptive modulation technique (AMC) in the physical layer. WiMax can support broadband wireless access (BWA) up to 30 miles (50 km) (with a single base station) in ideal conditions for Line-Of-Sight (LOS) area and the coverage range of 4-5 miles in Non-LOS and real-time traffic conditions [7].

II. MOBILE IP OVERVIEW

Mobile IP is an internet protocol that improves the existing internet protocol (IP) to allow for location-independent routing on the Internet and enable the mobile nodes to maintain its connectivity to the internet when moving from one Access Point to another. Mobile IP provides mobility support to the nodes that either have multi hops and direct connections to the internet without need to fixed infrastructure.

Mobile nodes are able to communicate with the network infrastructure after changing its point of attachment (POA) without changing its IP address. Each mobile node in the network is identified by its home address regardless the current location in the Internet. Mobile nodes are associated with care-of address while away from its home network.

Mobile IP is most often found in wireless environments where users need to roam across multiple wireless subnets such as IP over WLAN, MANET, WiMAX and LTE.

The goal of mobile IP (MIP) is to preserve the TCP connection between the mobile host and static host while reducing the effects of changing locations when the mobile nodes are moving across the networks without having to change the TCP/IP protocol.

A mobile node has a care-of address (CoA) and permanent home address, which are associated with the network when the mobile nodes are visiting.

Location and point of attachment (POA) of these nodes to the internet are changing frequently without need to change its IP address and keep communicating with other Internet nodes at any location using its fixed IP address; these devices are often a cellular phones or laptops. Mobile internet Protocol version 4 (MIPv4) specifies protocol enhancements and scalable mechanisms required for accommodating nodes mobility that allow transparent routing of IP packets to mobile nodes in the internet.

Such mechanisms enable nodes to change their point of attachment (POA) to the Internet without changing their IP address [8].

Mobile IPv6 provides the same features as mobile IPv4 besides some enhanced properties based on IPv6 protocol.

MIPv6 also provides route optimization which allow to the central node to know the position of the mobile nodes after sent its first packet. In other words, when the central node (CN) sends the first packet to the mobile node (MN), the packet will be sent to the home agent of the MN which forwards it to the foreign agent that serving the MN which forwards it to the foreign agent that serving the MN at this particular time.

III. IP QOS SUPPORT IN MOBILE NETWORK

A QoS is typically based on a hybrid architecture offer good performance but the challenge is to support end-to-end QoS architecture for end-to-end QoS signaling. QoS policy framework could be established in a QoS architecture in which the QoS Manager serves as a policy Decision Point co-ordinate resource allocation within QoS domain, and access routers as Policy Enforcement Points [9].

The maintenance and provision of QoS for mobile nodes adds more challenges (incomplete structure). Recently, IP technologies for QoS and mobility have been developed essentially independently, and little effort has been made to integrate their approaches.
As the nodes move between different IP networks, establishing QoS session across the routers in a network needs to be maintained through a different path of routing. Seamless mobility can be achieved for IP sessions with QoS requirements when the operation of QoS policy framework is accordant with seamless handover. IP QoS architecture is independent of any specific access network. Proper QoS mapping between IP QoS and access network QoS parameters is very important. Such mapping is required between all protocol layers to support multimedia application’s QoS requirements which are capable of being adaptive in its operations by changing the coding techniques. This is a particularly valuable feature to be exploited when the mobile node traverses different access networks during the course of a session [1]. Thus the application QoS interface and the QoS policy framework need to be enhanced accordingly.

IV. DUAL MIP STACK IMPLEMENTATION

Dual-stack IP implementations support both IPv4 and IPv6 addresses and provide complete protocol stacks in the same network nodes. When services are available over IPv4, hosts use native IPv4 connectivity but for services available over IPv6 only, this version will be used instead. IPv6 can be implemented to avoid the complexities of tunnelling, during the transition from IPv4 to IPv6 such as overhead management and security. Since old fashioned network equipment may not support IPv6, however, this is not always possible. Dual-stack software designed to facilitate the deployment and adoption of IPv6 [10]. However, it might introduce more security threats as the hosts could be subject to attacks from both IPv4 and IPv6. The mobile nodes which have no IPv6 dual-stack must use IPv4 infrastructure to reach IPv6 sites directly and to carry IPv6 packets, this can be done using a technique known as tunneling, tunneling encapsulates IPv6 packets within IPv4 use IPv4 as a link layer for IPv6.

V. NETWORK DESIGN

Designing an efficient network is conducted using the discrete event simulation software known as OPNET (Optimized Network Engineering Tool) Modeler as essential part to check the performance of the designed network and can provides GUI and consists of predefined models, protocols and algorithms [11].

Figure 2: Mobile IP stack model.
Different network entities are deployed to be used in the design of the MANET/WiMax network model such as mobile nodes, wireless servers, profile configuration, application configuration, IP configuration and mobility configuration. These model objects are basically a series of network components that allow attribute definition and tuning. All mobile devices are configured to use IP address version 6.

Application configuration is used to support the required application among the available applications such as VOIP, FTP, HTTP, Database, Email, etc and defines the file size, transmitted data and traffic load. In this thesis we have used VOIP and Oracle applications.

User profiles are specified on different nodes in the network to generate the application traffic by using the Profile configuration which can restrict the mobile nodes to assigned profile based on design requirement while configuring profiles applications are defined in the application configuration. In this study we have created two profiles VOIP and database based on the applications that are configured in application configuration.

Mobility configuration is used to determine the mobility model of the nodes in the network. Moreover, set the parameters that control the movement of nodes in the network such as speed, start time, stop time, pause time, etc.

Mobility configuration allows the mobile nodes to move within specific allocated area, in our network model the area size is set to 1500 square meters and a trajectory of movement to vector so the traffic generated from out of this range will not be taken into consideration. Default random waypoint mobility is configured in order to support the mobility option in the mobile nodes.

The server module is fixed WLAN server which is configured to support and control the application services such as Database and VOIP based on the user profile. The server applications are running over TCP/IP and the connection speed is set to 11 Mbps. all the mobile nodes are configured to generate data and VOIP traffic, with the ability to route the data packets to the destinations.

The trajectory is configured to support VECTOR trajectory in the network and AODV routing Protocol is assigned to the routing protocol to be used by the mobile nodes.

Meanwhile, the buffer size for the wireless LAN is set to 25,600 bits because the medium flow of application has to be generated in our network model and since the channel is important to specify the bandwidth for physical layer transmission; the channel bandwidth is configured to support 20 MHz.

The performance metrics such as, end-to-end delay, Jitter, MOS, path loss and throughput are considered to evaluate the network efficiency.

The simulation parameters used in the experimental study are shown in the following table 1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission power</td>
<td>0.005</td>
</tr>
<tr>
<td>Examined Routing Protocol</td>
<td>AODV</td>
</tr>
<tr>
<td>MAC Type</td>
<td>IEEE 802.11 DCF, IEEE 802.16</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>95</td>
</tr>
<tr>
<td>Simulation Area</td>
<td>1500x1500 Square meters</td>
</tr>
<tr>
<td>Mobility Speed</td>
<td>20,60,120 km/Hour(km/h)</td>
</tr>
<tr>
<td>Trajectory Inf.</td>
<td>MANET/WiMax mobility scenario, Vector</td>
</tr>
<tr>
<td>Reception power threshold</td>
<td>-95dBm</td>
</tr>
<tr>
<td>Data rate</td>
<td>11Mbps</td>
</tr>
<tr>
<td>Mobility Model</td>
<td>Random Way point</td>
</tr>
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<td>Buffer size</td>
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</tr>
<tr>
<td>FragmentationThreshold (bytes)</td>
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</tr>
<tr>
<td>Traffic</td>
<td>Oracle VOIP</td>
</tr>
<tr>
<td>Simulation</td>
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</tr>
<tr>
<td>Simulation Time</td>
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<tr>
<td>Seed</td>
<td>128</td>
</tr>
<tr>
<td>Update Interval</td>
<td>500000</td>
</tr>
<tr>
<td>Values per Statistic</td>
<td>100</td>
</tr>
</tbody>
</table>

VI. RESULTS ANALYSIS

The proposed network design has been simulated using OPNET modeler 14.5. In this section simulation results will be presented. At first we will define the performance metrics that will be used for the comparison.

The performance of the network is measured in terms of throughput and delay and Jitter parameters when subjected to different network topology changes and stresses. We considered total simulation to be 420 seconds over which the performance statistics are collected. All results are derived from statistics about certain performance and QoS related parameters that have been chosen. Governing metrics that significantly relate to the performance of Data and VoIP networks are jitter, MOS, packet delay variation.
The simulation results will be presented in terms of validation of implementation and values for various parameters that characterize the performance of the network.

In case of throughput we can see from Figure 4 that the network throughput is more at speed of 20 km/h but when the speed of mobile nodes is increased the network throughput decreased, the throughput is less at speed of 60 km/h and constantly decreases at speed of 80 km/h so this shows that the performance degrades as throughput is inversely proportional to the speed of Mobile nodes.

![Figure 3: Average throughput for different node speeds](image)

Delay refers to the time needed for a packet to be travelled across the network from one MN to another MN in the network. The delay typically measured in fractions of seconds. As seen from the Figure 4 that Network delay seems less at speed 20 km/h but as the speed of mobile nodes increases the network delay increases. When the speed of mobile nodes is increased to 60 km/h network delay is increased and constantly increased at speed of 80 km/h. this shows that the performance degrade as delay is directly proportional to the speed of Mobile nodes.

![Figure 4: Average Delay for different node speeds](image)

Fig illustrates the results for throughput and delay using both MIPv4 and MIPv6. MIPv6 suffers a 1.35% increase in packet size IP header [9].

It is visible that the network throughput with started to increase from 3000 bit/sec and peaked with around 12000 bit/sec while in case of using MIP4 the throughput peaked at around 4000 bit/sec. we can see from the test result, the throughput in case of using MIPv6 is larger than MIPv4 throughput due to the route optimization.

![Figure 5: Throughput through Core Network in MIPv6 case](image)
Figures 6.7 demonstrate the delay of mobile IP6 and mobile IP4 respectively. The MIP6 maintains a lower delay level of about 0.023 ms on average while MIP4 delay is found to be about 0.026. We can see that the MIPv6 suffer from less delay and it is faster than MIPv4.

From figures 5 and 6, it can be observed that the maximum value of jitter experienced for the network is close to 0.055 ms while the packet variation delay is peaked at 0.5ms.

On the other hand, the plot of the average MOS value for the network is given in figure 6 it can be seen that the MOS value is quite high as expected. The average MOS value for the network is reached 3.6 and then decreased to be stable at the 3.09 value.
Figure 10: Mean opinion score (MOS) value.

It is clear from the graph above that the download response time peaks at 0.04 seconds and gets lower from time to another, meaning that database are downloaded quicker. At 15 seconds into the network takes 0.02 seconds to respond to a query.

Figure 11: Oracle page response over IP6 Network.

VII. CONCLUSIONS

This paper presents IP-based mobility architecture presented with high scalability in both mobility and QoS support levels. Currently, Mobile IP version6 is a protocol deal with next generation mobile network and used to offer high range of addresses and make the address changes transparent to the transport and protocols layers.

The paper addresses the problems of QoS in the future mobile networks, and discusses the different entities involved in this process, for both the case of real time applications such as VOIP and database applications (such as Oracle). Several scenarios are deployed to analyze the network QoS and discussing the comparison between IP6 and IP4.

Factors that affect the QoS such as Jitter, MOS, delay and throughput are analysed in different scenarios and number of mobile nodes along the trajectory path. The results showed that the throughput in case of using IPv6 is larger than MIPv4 throughput due to Route optimization, while delay is less; MIP6 has better performance than mobile IP4. We also found that the performance of node mobility is higher when the speed of mobile node is less in the mobile Ad hoc/WIMAX networks due to the fact that ETE Delay and network load increases while the network throughput degrades when speed increases.

REFERENCES


