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Comparision study of MobileIPv4 and MobileIPv6

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Abstract: IPv4 is being replaced by IPv6 due to the increased demand from mobility devices. However, it is necessary that there is a lack of research on what change actually means for the performance of mobility. This research aims at comparing Mobile IPv4 and Mobile IPv6 in terms of performance on latency, TCP/UDP throughput, and connectivity loss while roaming. Thus the study will explore the effects of the future implementation of Mobile IPv6 for mobile devices.

***Keywords**: MobileIPv4, MobileIPv6, Mobile node, Home address, Care of Address etc...*

*****

I. Introduction

With standard IPv4 and IPv6 routing protocols, the IP address changes when a node connects to a new point of access to the network. This will break the on-going TCP, UDP sessions. The internet traffic used today is TCP which is defined by the combination of port number and IP address on both sides of the established connection. When one of these four parts changes the connection will be lost and needs to be re-established. In order to avoid disruption and keep on-going TCP connection, the IP addresses and ports used during the TCP session should not be changed. Mobile IP protocol was chosen by IETF to solve this problem. Mobile IP provides the nodes with two IP addresses, the first is the home address and the second address is known as care-of address that changes depending on the network it is connected to. Mobile IP is designed to work for IPv4 and IPv6. So far almost all mobile devices use Mobile IPv4. Today as the number of Mobile devices increase with PDA's, laptops, cellular phones, etc. the demands on internet are growing and the capacity of Mobile IPv4 is not enough. In order to satisfy the increasing demands Mobile IPv6 is meant to take over after Mobile IPv4. As it does so Mobile IPv6 is designed to be more efficient with a built in support for mobility. A lot of literature has described how to implement a mobility network for IPv4 and IPv6 in Linux/Unix environment. For Microsoft OS there is some information how to implement Mobile IPv6 using Windows XP with SP1. This study will use the physical deployments of Cisco equipments and Microsoft Windows 7 Professional OS to study the differences in performance between Mobile IPv4 and Mobile IPv6.

II. Mobile IP Operation

Mobile IP has two different identifiers for the Mobile hosts, a routing identifier and an endpoint identifier. The original IP address assigned for the Mobile host when it is at home network is known as endpoint identifier. The endpoint identifier is called the mobile host's home address (HoA). On the home network a HA is responsible for storing information about the MNs that has a permanent home address in its network. When the MN moves to a foreign network a special last hop router, known as a foreign agent in MIPv4 and Access Router in MIPv6, informs about the visiting mobile nodes in its network. However, it is still the MN's home agent that maintains its CoA and recognizes its movements in a foreign network.

2.1 Basic Operation of Mobile IPv4

Mobile IPv4 has three main parts that handle the mobility, a Home Agent, a Foreign Agent, and a Mobile Node. Every MN in Mobile IPv4 has two IP addresses, a static home address that is used to identify higher layer connections (e.g., TCP) and a care-of address which is used for routing purposes.

When the MN is moving to a different foreign network, CoA changes at every new foreign network. This is because the CoA is located at the FA. When moving the MN sends a message to its HA which contains the binding between the new CoA and the HoA. This procedure is known as home-agent registration. During home agent registration the MN maintains the binding between the HoA and the CoA at the home agent. Since the MN is registered with its home network even when away from home, a correspondent node (CN) that sends packets to the MN will do so by sending them to the mobile node's home address. Then the HA forwards the packets to the mobile node's CoA, which is registered with the home agent.

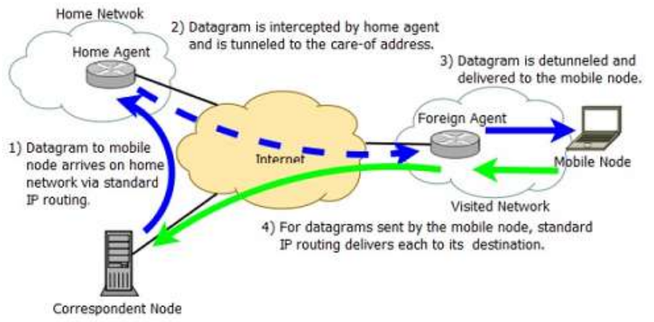

Figure 1: Operation of Mobile IPv4 Datagram Route.

2.2 Basic Operation of Mobile IPv6

Similar to Mobile IPv4, Mobile IPv6 has three main parts that handles the mobility, a Home Agent (HA), an Access Router (AR), and a Mobile Node (MN). When the mobile node is within its home network, it is counted as a normal host when receiving and sending packets and communicates via standard IP routing mechanisms. If the mobile node changes location to a new network, it will have an additional IP address, a CoA that can be obtained through mechanisms such as Stateless auto-configuration or DHCPv6 (Dynamic Host Configuration Protocol for IPv6). The communication process between HoA and CoA is called home-agent binding update. When in a foreign network, the MN sends a binding update message to the home agent to register its CoA. The HA answer with a binding acknowledgment. In this process all the nodes communicating with a MN are called Correspondent Node. When communicating with CN the MN sends the registration directly to CN, which is called correspondent registration. However if CN wants to communicate with MN it can be done by one of two ways; Bidirectional Tunneling or Route Optimization.

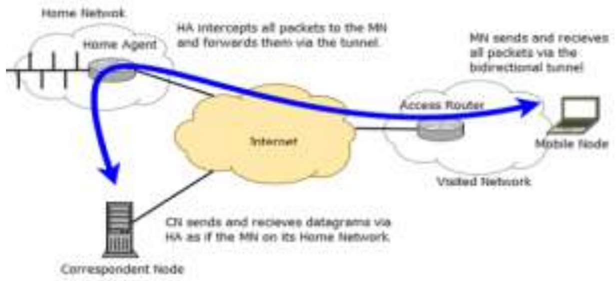

Figure 2: Operation of Mobile IPv6 with Bidirectional tunneling.

III. Methodology

The method that will be employed to study and compare the performance of MIPv4 and MIPv6 will be based on the creation of two different scenarios, one with MIPv4 configuration and another with MIPv6 configuration. The tests will then consist of latency test, TCP and UDP tests to measure throughput, loss, and delay as well checking the connectivity between CN and MN while roaming from foreign network to another.

Test Environment: The Mobile IP topology that was used in the test process consists of a HA, FA, CN and a MN in MIPv4 and a HA, AR, CN and a MN in MIPv6

Topology: The physical topology uses a Mobile network model, with four Cisco 2811 routers, Three routers are connected through a switch and a fourth router acts as a MN and MR at the same time enabling mobility access to all its connected hosts. Figure 3.5 shows the topology for MIPv4.

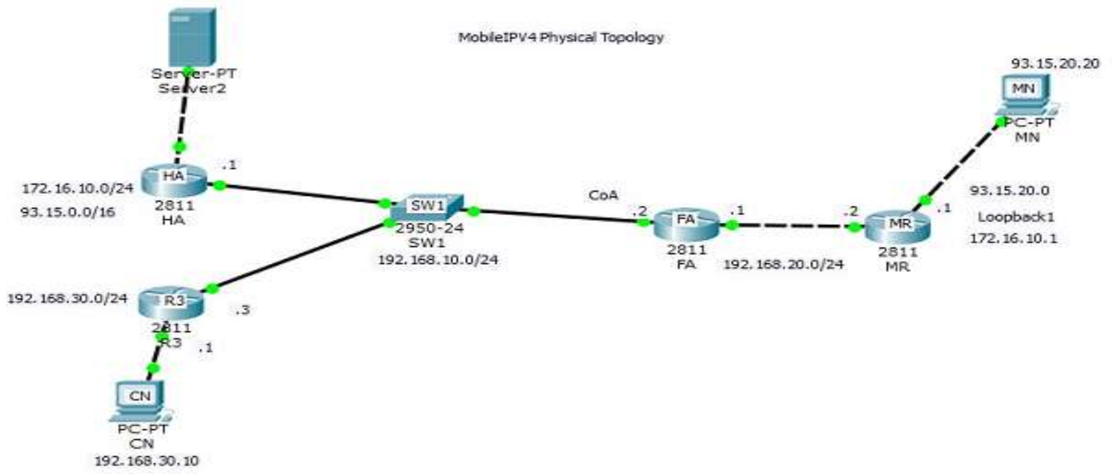

Figure 3: MIPv4 physical topology.

Figure 4 shows the route between CN and MN in MIPv4 topology.

```
C:\>tracert 93.15.20.20

Tracing route to MN [93.15.20.20]
over a maximum of 30 hops:

  1    <1 ms    <1 ms    <1 ms   192.168.30.1
  2     1 ms    <1 ms    <1 ms   192.168.10.1
  3     1 ms     1 ms     1 ms   172.16.10.1
  4     1 ms    <1 ms    <1 ms   MN [93.15.20.20]
```

Figure 4: MIPv4 traffic path from CN to MN.

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The topology will look the same when testing MIPv4 and MIPv6, only the Foreign Agent (FA) in MIPv4 is replaced with an Access Router (AR) in MIPv6. This is illustrated below in Figure 5.

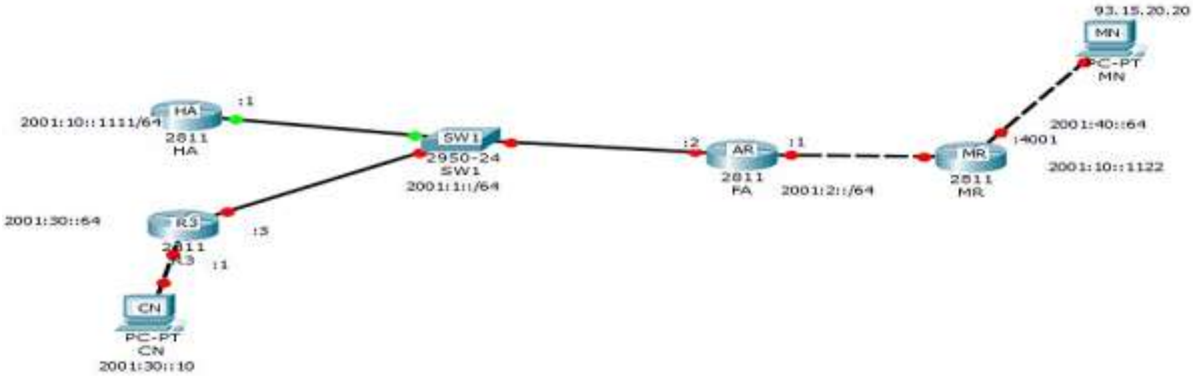

Figure 5: MIPv6 physical topology.

Figure 6 shows the route between CN and MN in MIPv6 topology

```
C:\>tracert 2001:40::4015

Tracing route to 2001:40::4015 over a maximum of 30 hops

  1    <1 ms    <1 ms    <1 ms  2001:30::1
  2     1 ms     1 ms     1 ms  2001:1::1
  3     2 ms     1 ms     1 ms  2001:2::ea04:62ff:fe25:1850
  4     6 ms     1 ms     1 ms  2001:40::4015
```

Figure 6: MIPv6 traffic path from MN to CN.

In addition, when doing the connectivity tests while roaming a new router was added to work as a second FA in MIPv4, and as a second AR in MIPv6, as shown in Figure 7. To test the connectivity loss while roaming the handover took place between FA and FA2 in MIPv4, and between AR and AR2 in MIPv6.

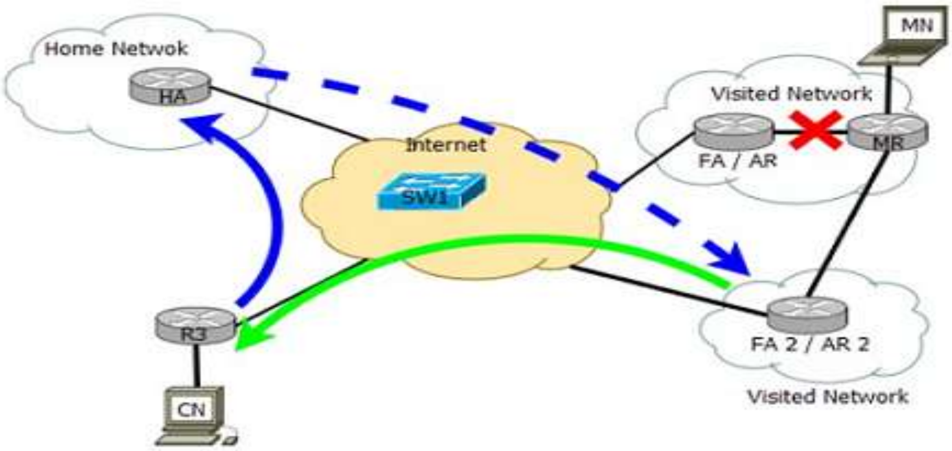

Figure 7: MIPv4 and MIPv6 physical roaming topology

Router mobile configurations were used in both scenarios with MIPv4 and MIPv6 respectively. For the different devices on the topology, the following configurations have been used for MIPv4:

- HA Router with Home Agent configuration (Cisco 2811).
- FA Router with Foreign Agent configuration (Cisco 2811).
- CN-Rtr (R3) with Basic IPv4 configuration (Cisco 2811).
- MR Router with Mobile Router configuration which acts as a MN and MR at the same time (Cisco 2811).

For MIPv6 the following configurations were used (see appendix 2):

- HA Router with Home Agent NEMO configuration (Cisco 2811).
- CN-Rtr (R3) and AR Routers with basic IPv6 configuration (Cisco 2811).
- MR Router with Mobile Router NEMO configuration which acts as a MN and MR at the same time (Cisco 2811).

Since the tests are carried out in Microsoft Windows 7 environment the MNs are not MIPv4 and MIPv6 capable. This is the reason for the fourth router acting as a MR as well as MN, as seen in Figure 3 and Figure 5 above. One of the particularities of MIPv4 on Cisco Routers is that the configuration will create a dual tunnel, one between the HA and FA as well as another one inside the first one between the HA and MR. The dual tunnel is necessary because in MIPv4 on Cisco routers there is a route only to the home address on the FA which, if no second tunnel was in place, would create a routing loop as packets destined to the mobile network would follow the standard routing and return to the HA. To simplify the understanding of the process, Figure 8 shows the output of show ip mobile tunnel, where the IP 192.168.9.1 is the HA address.

```
Total mobile ip tunnels 2
Tunnel0:
    src 192.168.9.1, dest 192.168.10.2
    encap IP/IP, mode reverse-allowed, tunnel-users 1
    Input ACL users 0, Output ACL users 0
    IP MTU 1480 bytes
    Path MTU Discovery, mtu: 0, ager: 10 mins, expires: never
    outbound interface FastEthernet0/0
    HA created, CEF switching enabled, ICMP unreachable enabled
    5 minute input rate 0 bits/sec, 0 packets/sec
    5 minute output rate 4676000 bits/sec, 674 packets/sec
    0 packets input, 0 bytes, 0 drops
    4828784 packets output, 1185618217 bytes
Tunnel1:
    src 192.168.9.1, dest 172.16.10.1
    encap IP/IP, mode reverse-allowed, tunnel-users 1
    Input ACL users 0, Output ACL users 0
    IP MTU 1460 bytes
    Path MTU Discovery, mtu: 0, ager: 10 mins, expires: never
    outbound interface Tunnel0
    HA created, CEF switching enabled, ICMP unreachable enabled
```

Figure 8: Dual tunnel on MIPv4.

Route optimization in MIPv6, which above has been described as the feature that makes MIPv6 more efficient than MIPv4, requires a MIPv6 capable CN. This is currently not possible in a Microsoft Windows 7 environment as the one used for the tests in this paper. Only in Windows XP with service pack one, Windows CE .NET v4.2, or Windows Mobile™ 2003-based embedded devices is the route optimization possible. However, it requires the access to the MS MIPv6 Tech Preview Network Protocol which is not available for public download. In addition, as Cisco routers for MIPv6 require NEMO configuration to redistribute the Mobile Network, route optimization is not supported. Thus, in this research, MIPv6 datagram have been routed via HA which is also the case in MIPv4. The route process for MIPv6 is shown above in Figure 5.

IV. Results

The tests that have been carried out aim at measuring the performance of the MIPv4 and MIPv6 networks in Cisco Router environment. The tests measure the latency, TCP throughput, UDP throughput, loss, and delay and the connectivity loss between CN and MN while roaming from foreign network to another foreign network.

The latency tests were done by using Ping utility between CN and the MN. The tests were carried out 5 times in both MIPv4 and MIPv6 scenarios in order to measure packets sent, received and loss as well as approximate round trip time.

Different TCP tests were carried out between CN and MN to measure data transfer and bandwidth in MIPv4 and MIPv6. The tests were done by using iperf. The tests that were performed were the following:

- TCP default test where the TCP default test has a window size of 8 Kbytes (depends on OS, 8 Kbytes in Windows 7 OS) and runs for 10 seconds.
- TCP with tuned window size of 24 Kbytes and default time of 10 seconds.
- TCP with tuned windows size of 64 Kbytes, 3 minutes and a buffer length of 16000 Kbytes.

During these tests the MN acted as a server and the CN acted as a client. The iperf TCP tests measure data transfer and throughput. The following tests were used:

4.1 TCP Throughput

Three different TCP tests were carried out between CN and MN to measure data transfer and throughput in MIPv4 and MIPv6. The test results for MIPv4 and MIPv6 are show below in tables 2 and 3 starting with the results for the TCP default test

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MIPv4	Mbytes Transferred	Throughput
Test1	29.6	24.9
Test2	35.8	30.0
Test3	29.5	24.7
Test4	31.4	26.3
Test5	33.2	27.9
Average	31.9	26.7

Table 2: MIPv4 TCP default tests

MIPv6	Mbytes Transferred	Throughput
Test1	47.1	39.4
Test2	60.9	50.9
Test3	55.4	46.4
Test4	52.9	44.3
Test5	56.5	47.3
Average	54.5	45.6

Table 3: MIPv6 TCP default tests

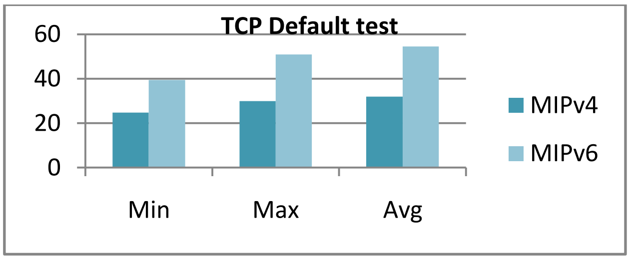

Figure 9: TCP Default test

The second test of the TCP throughput with tuned window size 24 Kbytes is shown in Tables 4 and 5 below.

MIPv4	Mbytes Transferred	Throughput
Test1	59.6	50.1
Test2	62.1	51.9
Test3	62.4	52.4
Test4	62.1	52.1
Test5	62.3	52.3
Average	**61.7**	**51.7**

MIPv6	Mbytes Transferred	Throughput
Test1	92.9	78.0
Test2	91.9	77.0
Test3	107.0	89.6
Test4	107.0	89.3
Test5	104.0	87.3
Average	**100.5**	**84.2**

Table 4: MIPv4 TCP test with tuned window size 24Kbytes. Table 5: MIPv6 TCP test with tuned window size 24Kbytes

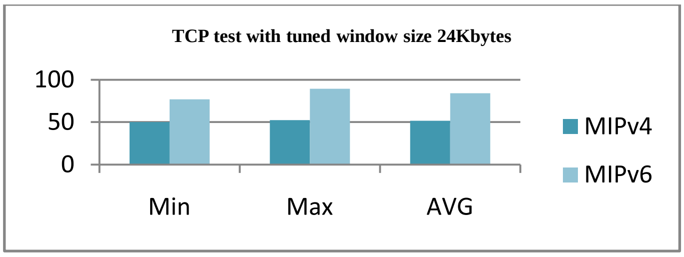

Figure 10: TCP test with tuned window size 24Kbytes

Table 6 and Table 7 show the results of the third TCP test running for 3 minutes with 64 Kbytes window size and buffer length of 16000 Kbytes.

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MIPv4	Gbytes Transferred	Throughput
Test1	1.19	56.8
Test2	1.19	56.5
Test3	1.19	56.9
Test4	1.19	56.8
Test5	1.20	56.9
Average	**1.19**	**56.9**

Table 6: MIPv4 TCP test.

MIPv6	Gbytes Transferred	Throughput
Test1	1.85	88.4
Test2	1.89	89.9
Test3	1.89	90.0
Test4	1.92	91.3
Test5	1.92	91.3
Average	**1.89**	**91.3**

Table 7: MIPv6 TCP test

When comparing MIPv4 with MIPv6 in each of the three different tests, the results showed that MIPv6 performed better in all tests. For this reason, only the results for the last test are presented here to compare MIPv4 and MIPv6 (Figure 10 and Figure 11 below). The results for the TCP tests show that MIPv6 transfers 1.89 Gbytes of data and MIPv4 1.19 Gbytes during three minutes. When it comes to throughput, MIPv6 had 91.3 Mbits/sec and MIPv4 56.9 Mbits/sec. Thus, as both of these comparisons illustrate, MIPv6 transferred more data and at faster speed.

Figure 10: Data transfer with tuned TCP window size 64kbytes during 3 minutes.

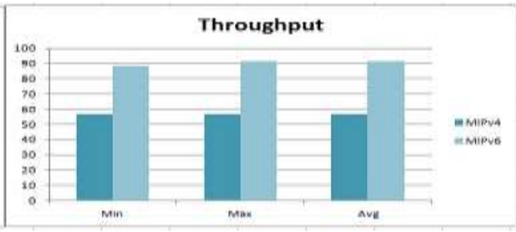

Figure 11: Throughput with tuned TCP TCP window size 64kbytes during 3 minutes.

4.2 Ping Tests

Ping tests showed that, in both scenarios the packet sent and received were equal and thus there was no packet loss. When it comes to approximate round trip time, MIPv4 had 1ms minimum and maximum and thus the average was 1ms as well. The Table 8 below shows the results of MIPv4 round trip time.

MIPv4 Ping tests	Minimum	Maximum	Average
Test1	1.0	4.0	2.0
Test2	1.0	2.0	1.0
Test3	1.0	1.0	1.0
Test4	1.0	1.0	1.0
Test5	1.0	2.0	1.0
Average	**1.0**	**2.0**	**1.2**

Table 8: MIPv4 Ping tests round trip times in mili seconds.

MIPv6 Ping tests	Minimum	Maximum	Average
Test1	1.0	1.0	1.0
Test2	1.0	1.0	1.0
Test3	1.0	1.0	1.0
Test4	1.0	1.0	1.0
Test5	1.0	1.0	1.0
Average	**1.0**	**1.0**	**1.0**

Table 9**:** MIPv6 Ping tests round trip times in mili seconds.

MIPv4 had 1ms minimum and maximum and thus the average was 1ms as well, shown in Table 9.

The Figure 12 shows a comparison between MIPv4 and MIPv6 of the approximate round trip time in ms. notice, that time taken for round trip which is based on the five tests showed that the difference was not so big but MIPv6 was faster than MIPv4.

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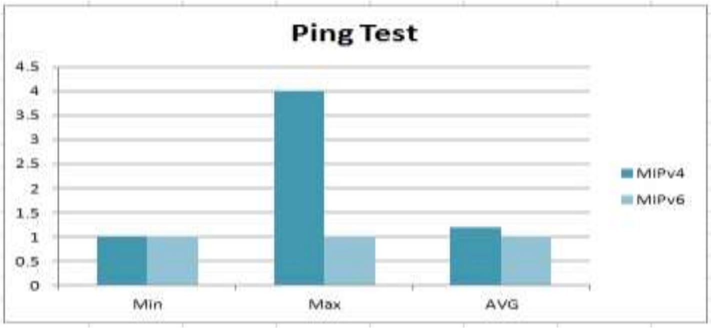

Figure 12: MIPv4 and MIPv6 round trip times in milli-seconds.

V. Conclusion

After all tests were done and reviewed, the results showed that the MIPv6 had better performance than MIPv6. When it comes to latency, MIPv4 had less latency than MIPv6. In TCP tests, we can notice a big difference between MIPv4 and MIPv6 in the datagram transferred. In addition the UDP tests showed that MIPv6 had better performance than MIPv4 in particular concerning jitter and packet loss.

An advantage with MIPv6 is that it has mobility built in not in extensions as with MIPv4. MIPv6 does not require a special router to act as foreign agent which is needed for MIPv4. The most important advantage of MIPv6 is that it has route optimization which allows the traffic to travel directly between CN and MN without passing through HA. This comparative study of MIPv4 and MIPv6 has shown that MIPv6 performs better than MIPv4 in latency, TCP/UDP throughput The TCP tests showed that MIPv6 performed better than MIPv4. This can be illustrated by the TCP default test where MIPv6 had a throughput of 45,6 Mbits/sec compared to 26,7 Mbits/sec for MIPv4. In the tests of UDP datagram loss MIPv6 had 1,58 percent datagram loss while MIPv4 had 6,68 percent, thus again demonstrating MIPv6 superiority in this study.

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