Evaluation of an Enhanced Scheme for High-level Nested Network Mobility

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Abstract

Recently, wireless devices have been used significantly due to the continuous and enormous services that they provide. The Mobility Support has been designed to achieve a permanent and continuing access to the Internet while the wireless devices are roaming and changing their points of attachment. One of the major challenges that arise is how to achieve seamless mobility and high network performance. The Internet Engineering Task Force (IETF) has developed Mobile IP, which allows Mobile node to be connected while it is moving as well as functioning in foreign mobile network zone using its original IP address. IETF also in order to manage mobility of an entire network as single unit, they developed NEMO Basic Support Protocol (NEMO BS), which allows Mobile Routers to move and change their point of attachment. When a Mobile Router connected to other mobile router on foreign mobile network, it makes a hierarchical structure known as nested mobile network; nested mobile network suffers from deferent problems due its complexity structure. When the level of nesting becomes high, problems of tunneling overhead are increased, which will produce high message delay and affect network performance. Many proposed schemes have been introduced to overcome nested network mobility issues. However, novel efforts are required. This research aim to present and evaluate a new scheme to support nested network mobility especially in high level of nesting. The evaluation of this proposed scheme is done using analytical approach. The proposed scheme enhancement is benchmarked with NEMO protocol and ROTIO approach witch it based on IETF standers. The result obtained had shown that the proposed scheme has better performance than the benchmark.

Key words:

Mobile Network, Mobile Router, Nested Mobile Network, Performance

1. Introduction

Wireless devices and wireless networking technologies are drastically grows recently, consequently, many electronic devices are capable to connect to the Internet using their own IP addresses, mobile networking becomes more applicable to various scenarios. So the users are expected to be connected anywhere at any time. However, network mobility is not supported as core functionality in the TCP/IP stack, so additional mechanisms are required to support network mobility. Internet Engineering Task Force (IETF) has initiated many protocols to support connectivity to these devices. This keeps the connection while the users are moving, not only to single device but also to Mobile Networks that are moving as a single unit. Mobile Network contains multiple mobile nodes and other wireless devices (routers, switches and hosts) that are capable to exchange the data between them ,the topology of network defers from network to another depending on the number and complexity of nodes. The architecture of mobile network can be Vehicular Area Network (VAN), a Personal Area Network (PAN) or a Body Area Network (BAN) which require access to the Internet. Hence, an efficient mobility management scheme is needed to provide continuous services for mobile network as it changes its point of attachment to the Internet. To provide the mobility support, IETF has proposed MIPv6 for host mobility and network mobility Basic Support Protocol (NEMO- BS) [1], for a whole network mobility. NEMO enables mobile nodes to move together as mobile network using mobile router (MR)[2]. Moreover, it allows MRs from different mobile network to connect each other in form known as nested mobile network (Nested Nemo). In NEMO [3]. Any MR is mainly designed to be connected to a particular network or home network. Then the MR is given a permanent IP address known as a home address (HoA). The MR's HoA, it is a constant address and it is not changing regardless of its attachment point in the Internet. When the MR is move from its home network, and join another network, packets addressed to the nodes of the home network are routed to the home network and a home agent (HA), a router in the home network manages all these packets. When the mobile router attached to the foreign network, it gets an address known as care-of address (CoA) in foreign mobile network. Then the mobile router sends a binding update (BU) message to its HA with the purpose of map the CoA with its HoA, after that, a bi-directional tunnel between MR and HA is established. All packets are encapsulated and transferred to the mobile node (MN) in home network through this tunnel. MR receives the encapsulated packet and extracts the original packet to MN. The main problem here is the additional IP header that are added and removed for purpose of tunneling occur between MRs and Home Agents, which may causes a lot of problems directly affects the network performance. when there are many routers connected

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together, they are create hierarchical form known as Nested Network Mobility , which is suffer from the Bi-directional tunneling overhead that are occurs multiple time depending on level of nesting.

Network mobility (NEMO) manages the movement of MR during it changes the point of attachment of the mobile network in order to be connected to the internet [1]. Therefore, it is very significant to acquire the high performance of mobility management protocol to accomplish fast and seamless handoff with lower delay and packet losses in NEMO environment [4]. Network Mobility Support protocol is based on creating bi-directional tunnel between MR and its Home Agent (HA), only MR should send the binding update message (BU) with the network prefix to provide Internet connectivity to all MNs. Following this technique MR hide the mobility of MNs and limited the repeated registration of the MNs [4]. However, establishing of bi-direction tunneling between the MR and it's HA for all communications causes on an increasing message size because it is done by (IP-in-IP) encapsulation. This increases handoff latency, packet loss, signaling cost and tunneling overhead especially when the level of nesting is becomes high.

2. Design of the Proposed Scheme for High Level Nested Network Mobility

In order to address the issues related to the nested network mobility especially in case of high level nesting, an enhanced hierarchal scheme have been proposed to overcome the overall performance issues and support seamless mobility . The proposed scheme uses Hierarchal architecture that divides the domain under MAP into multiple sub domains depending on the level of nesting. Therefore, this technique reduces the transmission cost, decreases the nested tunnels, enhances Intra domain routing perfectly; in addition to improving Message Delay, and enhancing Handoff latency and Binding Update. This scheme is simple to implement, as it requires only slight change in the implementation of mobile routers and mobile nodes, no change is required on home agents, correspondent node or any other network components. figure 1 shows the proposed scheme and its benefits.[5]

Figure 1 shows the map domain under TLMR, which is divided into multiple sub domains, so after each three levels of nesting a first arriving MR acts as sub domain TLMR (SDTLMR) that inherits all the features of original TLMR. So all the operations are done locally inside a sub domain rather than on a whole domain. This way the path in between MR and a near TLMR becomes shorter which gives an important advantage as illustrated in figure 6. Each SDTLMR sends its cache's contents to the original TLMR using suitable cache strategy technique. When correspondent node sent a message to its MR the original TLMR search its cache's contents and set which SDTLMR to receive a message, then the SDTLMR route the message to the MR.

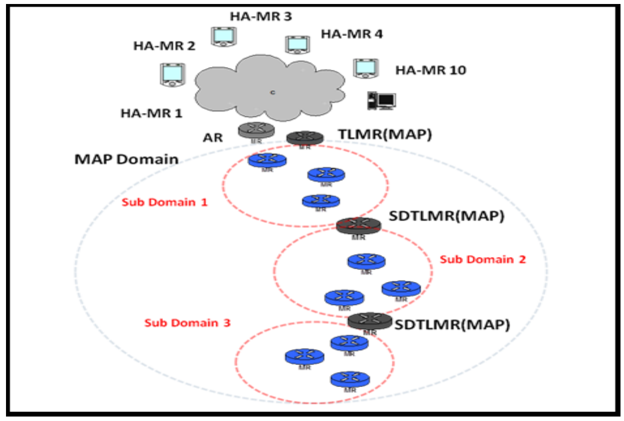

Fig. 1 the proposed scheme[43]

3. Proposed Scheme Operations

When MR visits a network, it receives a "Router Advertisement" message from AR. the Advertisement message contains MAP option of last SDTLMR to allow the MR to discover SDTLMR address. Once the MR receives Router Advertisement messages with the MAP option that contains prefix information for RCoA, it configures two addresses, RCoA and LCoA by the stateless address configuration mechanism. Rfc4041. Then As the MR builds RCoA, the MR sends Local Binding Update message to the SDTLMR. Upon receiving Local Binding Update message, SDTLMR performs Duplicate Address Detection (DAD) for RCoA. Then The SDTLMR returns a Binding Acknowledgement message to the MR, to indicate the result of the binding update to the SDTLMR. Finally The MR receives acknowledgement packet from SDTLMR containing RCoA. Once the binding update in SDTLMR is successfully completed, the SDTLMR updates the original MAP cache. Hence, the original MAP now is up to date with the sub- domain's map contents. When HA and CNs sends a message to the MR, the original MAP receives the message and searches its cache to determine which SDTLMR receives this message. The targeted SDTLMR directly routes the message to the MR. figure 2 shows the scenario of operations.

The proposed scheme provides a short path to complete these operations, so it gives low handoff latency, low transmission delay, low messaging cost, low registration overhead and low signaling cost in comparison with the previous scenarios.

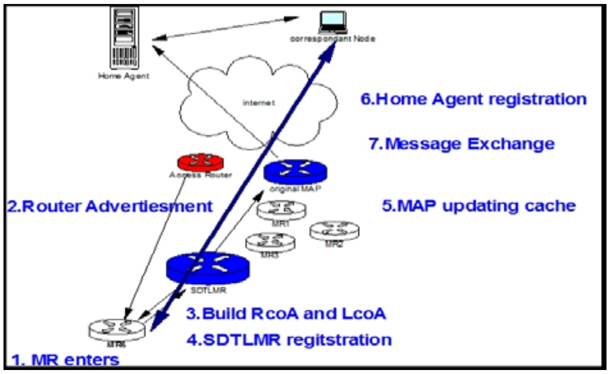

Fig. 2 the scenario of proposed scheme operations

Figure 3 shows the operation of registration on the SDTLMR and snapshot of operation in sub domain rather than a whole domain.

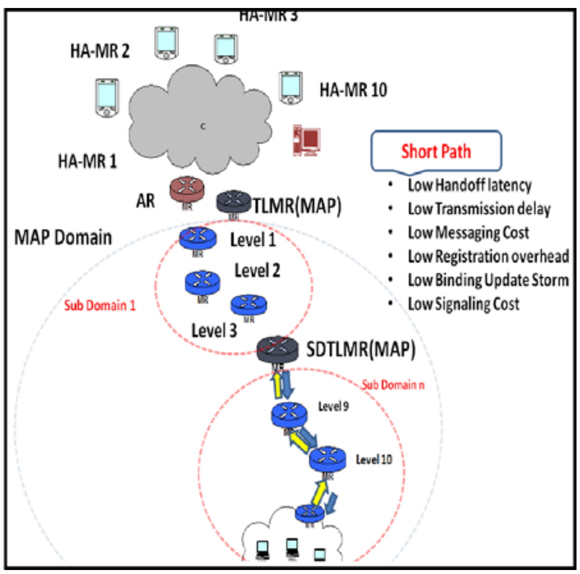

Fig. 3 the operations on the sub domain

Figure 4 shows the signaling follow of the proposed scheme.

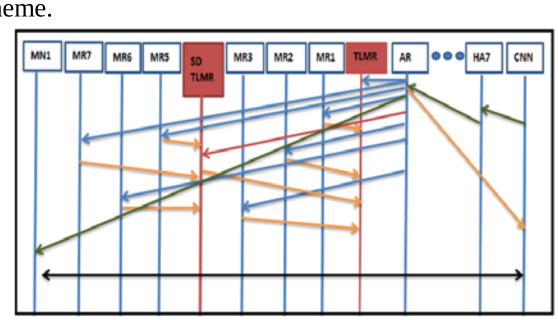

Fig . 4 the signaling follow of the proposed scheme

4. Analytical Evaluation of The Proposed Scheme

Analytical model has been developed to compare the packet transmission delay and handoff latency of the proposed scheme with selected benchmark. We have calculated the packet transmission delay by summing up the link delay between CN and MR, link delay between HA and MR, processing delay at home agents, link delay between AR and MR, link delay between AR and TLMR, link delay at each sub domain and the link delay between MR and MN. We have also calculated the handoff latency by summing up the total delay of movement detection, the total delay of duplicate address detection at each sub domain TLMR and the total processing delay at each MR and link delay between each MR.

Notations

The analytical model uses the notation shown in table 1

Table 1 the notations of the analytical model

N	The degree of nesting of whole domain
M	The degree of nesting inside sub domain
$N_{SD-TMLR}$	The number of sub domains
D^{i}_{MR}	The Processing delay of MR
$LD^{i,i+1}_{MR}$	The link delay between MR i and MR i+1
D^{i}_{HA}	The processing delay of HA
$LD_{CN-ROUTER}$	The link delay between correspondent node and MR
$D_{SD-ROUTER}$	The processing delay of SD_TLMR
$LD_{HA-ROUTER}$	The link delay between home agent and MR
LD_{MR-MN}	The link delay between MR and Mn
$LD_{AR-ROUTER}$	The link delay between AR and MR
$LD_{AR-TLMR}$	The link delay between AR and TMLR
D_{MD}	The processing delay of movement detection
D_{DAD}	The processing delay of duplicate address detection

4.1. Packet Transmission Delay

We have calculated the packet transmission delay by summing up the link delay between CN and MR, the link delay between HA and MR, and processing delay at home agents, the link delay between AR and MR, the link delay between AR and TLMR, link delay at each sub domain and link delay between MR and MN. This section shows the equation used to calculate the packet transmission delay for each approach.

4.1.1. Packet transmission delay in NEMO.

Equation (1) [6] calculates the packet transmission delay for NEMO approach as follows:

$$PD_{NEMO} = 2\,LD_{MR\text{-}MNN} + \sum_{i=1}^{N}(D^{i}_{MR} + LD^{i,i+1}_{MR} + D^{i}_{HA}) + 2\,LD_{AR\text{-}TLMR} + 2\,LD_{AR\text{-}Router} + 2\sum_{i=1}^{N} LD_{HA\text{-}Router} + \sum_{i=1}^{N} LD^{i,i+1}_{Router} + 2\sum_{j=1}^{M} LD_{HA\text{-}Router} + \sum_{j=1}^{M} LD^{j,j+1}_{Router} + \sum_{j=1}^{M}(D^{j}_{MR} + LD^{j,j+1}_{MR} + D^{j}_{HA}) \quad \ldots\ldots\ldots\ldots (1)$$

4.1.2. Packet transmission delay in ROTIO.

Equation (2) [6] calculates the packet transmission delay in ROTIO approach as follows:

$$PD_{ROTIO} = (LD_{CN\text{-}Router} + LD_{HA\text{-}Router}) + 2\sum_{i=1}^{a-1} LD_{HA\text{-}Router} + \sum_{i=1}^{a-1} LD^{i,i+1}_{Router} + \sum_{i=1}^{a-1}(D^{i}_{HA}) + LD_{AR\text{-}Router} + LD_{AR\text{-}TLMR} + \sum_{i=1}^{N}(D^{i}_{MR} + LD^{i,i+1}_{MR}) + LD_{MR\text{-}MNN} \quad \ldots\ldots (2)$$

4.1.3. Packet transmission delay in LBU+.

Equation (3) [7] calculates the packet transmission delay in LBU+ approach as follows:

$$PD_{LBU+} = (LD_{CN\text{-}Router} + LD_{HA\text{-}Router}) + \sum_{i=1}^{a}(D^{i}_{HA}) + LD_{AR\text{-}Router} + LD_{AR\text{-}TLMR} + \sum_{i=1}^{N}(D^{i}_{MR} + LD^{i,i+1}_{MR}) + LD_{MR\text{-}MNN} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

4.1.4. Packet transmission delay in proposed scheme.

Equation (4) calculates the packet transmission delay in proposed approach as follow:

$$PD_{proposed} = (LD_{CN-ROUTER} + LD_{HA-ROUTER}) + \sum_{i=0}^{a}(D^{i}_{HA}) + LD_{AR-ROUTER} + LD_{AR-TLMR} \left(\sum_{i=1}^{N}(D^{i}_{MR}) + LD^{i,i+1}_{MR}\right) / N_{SD-TMLR} + D_{SD-ROUTER} + LD_{MR-MN}$$

4.2. Handoff latency

The handoff latency is calculated by summing up the total delay of movement detection and total delay of duplicate address detection at each sub domain TLMR, the total processing delay at each MR, and the link delay between each MR. This section shows the calculation of the handoff latency for each approach.

4.2.1. Handoff latency of NEMO.

Equation (5) [7] calculates the handoff latency in NEMO approach as follow:

$$HL_{NEMO} = D_{MD} + D_{DAD} + LD_{AR\text{-}HA} + LD_{AR\text{-}MAP} + \sum_{i=1}^{n}(D^{i}_{MR}) + \sum_{i=1}^{n-1}(LD^{i,i+1}_{MR}) \quad \ldots (5)$$

4.2.2. Handoff latency of ROTIO.

Equation (6) [6] calculates the handoff latency in ROTIO approach as follow:

$$HL_{ROTIO} = D_{MD} + D_{DAD} + \sum_{i=1}^{n}(D^{i}_{MR}) + \sum_{i=1}^{n-1}(LD^{i,i+1}_{MR}) \quad \ldots (6)$$

4.2.3. Handoff latency of LBU+.

Equation (7) [7] calculates the handoff latency in LBU+ approach as follow:

$$HL_{LBU+} = D_{MD} + \sum_{i=1}^{n}(D^{i}_{MR}) + \sum_{i=1}^{n-1}(LD^{i,i+1}_{MR}) \quad \ldots\ldots (7)$$

4.2.4. Handoff latency of proposed scheme.

Equation (8) calculates the handoff latency in proposed scheme as follow:

$$HL_{proposed} = D_{MD} + D_{SD-TLMR-DAD} + \sum_{i=1}^{M} D^{i}_{MR} + \sum_{i=1}^{M-1} lD^{i,i+1}_{MR}$$

5. Result and discussion

Table 2 shows the system parameters values that are used to evaluate the proposed scheme.

Table 2 the System parameters values

Parameter	value
D^{i}_{MR}	10 ms
$LD^{i,i+1}_{MR}$	5 ms
D^{i}_{HA}	10 ms
$LD_{CN-ROUTER}$	50 ms
$D_{SD-ROUTER}$	10 ms
$LD_{HA-ROUTER}$	10-100 ms
LD_{MR-MN}	5 ms
$LD_{AR-ROUTER}$	5 ms
$LD_{AR-TLMR}$	100 ms
$LD_{CN-ROUTER}$	50 ms
D_{MD}	10 ms
D_{DAD}	10s

5.1. Packet transmission delay

Figure 5 shows that the packet transmission delay produced by the proposed scheme is less than those proposed by other approaches.

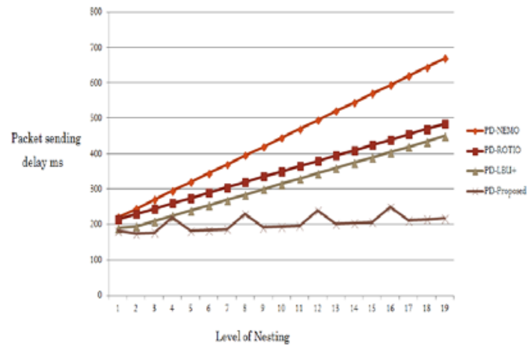

Fig 5 comparison of packet transmission delay

5.2. Handoff latency.

Figure 6 shows that the handoff latency produced by the proposed scheme is less than those proposed by the other approaches.

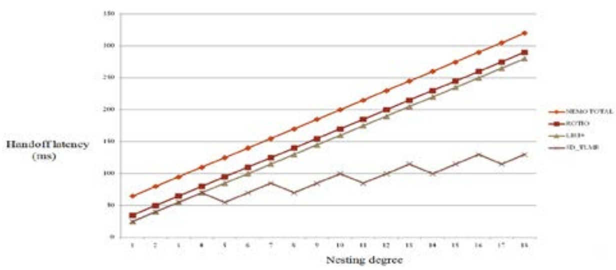

Fig. 6 comparison of handoff latency

6. Conclusion

In this paper, a novel scheme using hierarchical structure has been proposed to overcome the performance problems that occur in nested network mobility in case of high degree of nesting level. An analytical model for packet transmission delay and handoff latency are developed and evaluated compared to the benchmarks. The result obtained had shown that the proposed scheme has better performance than the benchmark.

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