Evaluation of QoS supported in Network Mobility NEMO environments

To cite this article: L F Hussien et al 2013 IOP Conf. Ser.: Mater. Sci. Eng. 53 012032

View the article online for updates and enhancements.

Related content
- A comparative signaling cost analysis of Macro Mobility scheme in NEMO (MM-NEMO) with mobility management protocol Shayla Islam, Aisha H Abdalla, Mohamed H Habaebi et al.
- Fuzzy Logic based Handoff Latency Reduction Mechanism in Layer 2 of Heterogeneous Mobile IPv6 Networks Farhat Anwar, Mosharrof H Masud and Suhaimi A Latif
Evaluation of QoS supported in Network Mobility NEMO environments

L F Hussien1*, A H Abdalla1, M H Habaebi1, O O Khalifa1 and W H Hassan2

1Department of Electrical and Computer Engineering, Faculty of Engineering International Islamic University Malaysia, 50728 Kuala Lumpur, Malaysia

2Malaysia Japan International Institute of Technology, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia

*E-mail: lolo_cts1@yahoo.com

Abstract. Network mobility basic support (NEMO BS) protocol is an entire network, roaming as a unit which changes its point of attachment to the Internet and consequently its reachability in the network topology. NEMO BS doesn’t provide QoS guarantees to its users same as traditional Internet IP and Mobile IPv6 as well. Typically, all the users will have same level of services without considering about their application requirements. This poses a problem to real-time applications that required QoS guarantees. To gain more effective control of the network, incorporated QoS is needed. Within QoS-enabled network the traffic flow can be distributed to various priorities. Also, the network bandwidth and resources can be allocated to different applications and users. Internet Engineering Task Force (IETF) working group has proposed several QoS solutions for static network such as IntServ, DiffServ and MPLS. These QoS solutions are designed in the context of a static environment (i.e. fixed hosts and networks). However, they are not fully adapted to mobile environments. They essentially demands to be extended and adjusted to meet up various challenges involved in mobile environments. With existing QoS mechanisms many proposals have been developed to provide QoS for individual mobile nodes (i.e. host mobility). In contrary, research based on the movement of the whole mobile network in IPv6 is still undertaking by the IETF working groups (i.e. network mobility). Few researches have been done in the area of providing QoS for roaming networks. Therefore, this paper aims to review and investigate (previous /and current) related works that have been developed to provide QoS in mobile network. Consequently, a new proposed scheme will be introduced to enhance QoS within NEMO environment, achieving by which seamless mobility to users of mobile network node (MNN).

1. Introduction

The emergence and success of cellular communication networks indicate that there are wide users’ demands to mobility. Actually, such networks are developed to grant not only the traditional voice
service but also data services as well. Internet Protocol (IP) seems to be the base technology of future networks to provide all kind of services to both (fixed and mobile) users via different access technologies. Nowadays, there are multiple technologies existing such as Wireless Local Area Network (WLANs), Bluetooth, Satellite communications, Microwaves, Wireless Metropolitan Area Networks (WiMAX) and cellular networks. However, IP was not designed taking into account the mobility of both users and their own terminals. In few years, the Internet Engineering Task Force (IETF) has developed protocols such as Mobile IPv4 (MIP) [1] and Mobile IPv6 (MIPv6) [2] for supporting seamless connectivity to mobile hosts. Mobile IPv4 protocol was more defined in (RFC 3344) and the updates were added in (RFC 4721). The protocol Mobile IPv6 was examined well in (RFC 3775 and RFC 6275).

Nevertheless, these protocols do not support the movement of a complete network that changes its point of attachment from fixed infrastructure, while still maintaining sessions of every device belong to the network. For the time being, we are witnessing the emergence of mobile networks, namely a set of hosts that move collectively as a whole unit for instance: ships, submarines, buses, trains and aircrafts as illustrated in Figure 1. The IETF has created a working group known as: Network Mobility (NEMO) (RFC 3963), with the aim of extending existing host mobility solutions (i.e. an individual mobile device) to enable the movement of an entire mobile network in IPv6 [3].

![Figure 1. NEMO applications usage scenarios](image)

Quality of Service (QoS) can be characterized in more than one way. In the field of computer networking it is the ability of the network element (e.g. application, host or router) to provide some level of assurance for consistent network data delivery. In other words, QoS is a set of technologies that enables network administrators to manage the effects of congestion on applications traffic flows by using network resource optimally rather than conditionally adding extra capacity.

The various QoS characteristics are divided in two groups, technology-based and user-based QoS parameters. Technology-based parameters contain superior performance in terms of delay, response time, jitter, data rate and loss rate. On the other hand, user-based QoS parameters are more likely subjective. They include categories such as perceived QoS, the visual quality of a streaming video, cost per unit time or per unit of data and the security. As an example, a user browsing the web and watching public news broadcast would be more interested in the quality of the picture rather than its security. A user who is remotely connecting to a corporate network would be most interested in the security of the connection and less interested in costs.

Within a few past decades, QoS is certainly not supported over the IP-based networks. Working on QoS support in IP networks, has led to three distinct approaches namely, Integrated Services (IntServ) [4], Differentiated Service (DiffServ) [5] and Multiprotocol Label Switching (MPLS) [6]. Unfortunately, these approaches were initially designed for static networks without mobility in-mind. Thus, they are not fully adapted to mobile environments yet. In fact, it is anticipated that more mobile
users will be connected to the Internet rather than PCs users. These mobile users are interested to get similar QoS in mobile terminals as in fixed terminals (i.e. wired networks) in order to run real-time applications properly. Above all QoS models, the most promising approach due to its simplicity and scalability advantages, is DiffServ. Therefore, integrating QoS with mobility support seems to be needed to fulfil the necessity of users.

The essential goal of the NEMO working group is to specify a solution to provide continuous Internet connectivity to nodes in a mobile network at all times while the mobile network changes its point of attachment [3]. NEMO networks might lead to frequent handovers while mobile networks roam among different Access Routers (ARs) and still staying connected to the fixed network. Quality of Service degradation or enforced service termination may arise when there are insufficient resources required for handover requests in NEMO networks. In fact, users inside a NEMO require QoS guarantee while accessing the Internet via a mobile. Therefore, resources should be ideally provisioned before the handover process to eliminate or minimize the packet drops due to insufficient resources.

The rest of the paper is structured as follows. Section 2 & 3 will explore literature review and the related works that gather the integration of QoS within NEMO area. Section 4 will deliberate the open issues. After that, Section 5 will present the proposed scheme. Finally, the conclusion and future work are given in Section 6.

2. Literature review

NEMO basic support protocol introduces several advantages, such as reduced signalling, increased manageability, reduced power consumption and conservation of bandwidth when it is compared with individual host mobility. However, it inherits all the drawbacks of Mobile IPv6-based, such as inefficient routing path, single point bottleneck, increased handover latency and packet loss rates, increased packet overhead and so on so forth. To overcome these drawbacks of NEMO, one must perform an extensive research works investigation. Therefore, a new yet novel break-through with a new proposed scheme could be achieved.

Beside NEMO BS protocol basic support, the IETF has developed and extended two more complex versions: nested network mobility and multi-homed network mobility.

2.1. Nested network mobility (NEMO)

A Mobile networks can encompass a very complex hierarchy, e.g. individual mobile networks operating within a larger mobile network, the visiting mobile nodes (VMNs) in a mobile network is actually a mobile router that has its own mobile network nodes, and so on. Thus, NEMO model that supports the connectivity of one entire mobile network through another mobile network resulting in topologies referred to as Nested NEMO networks. In other words, Nested mobile networks occur when the VMN with different home address from a MR is attached to the mobile network, or a mobile network is attached to another mobile network. The Nested NEMO scenarios quickly become extremely inefficient and are not suitable for real life deployment solutions. The inefficient routing model that occurs in Nested NEMO Networks is commonly known as “pinball routing problem”.

Each mobile router (MR) and mobile network node (MNN) has its own home agent (HA). So, if the correspondent nodes (CNs) desire to send data to the leaf MNN which is located at the bottom of the nested mobile network, the packets have to travel to all home agents that are mapped to the MRs of the nested mobile networks. Therefore, the mobile network will become more complicated. The process of the nested mobile network is depicted in Figure 2.
2.2. Multihomed network NEMO

In the NEMO terminology, Multihomed network mobility consists of:

- Multiple egress interfaces on a MR as shown in Figure 3. Egress interface is an interface that connected to access router from the MR, where the packets from the mobile MNNs routed their ways out), or

- Multiple MRs in a mobile network as illustrated in Figure 4, by which the mobile network is simultaneously connected to the Internet via more than one mobile router, or
Multiple global prefixes are available on the mobile network or mobile networks associated with multiple HAs as shown in Figure 5. This situation exists when the MNN/ MR has different home addresses.

Multihomed NEMO yields many benefits such as:

1. Fault-Tolerance/Redundancy.
2. Load-Sharing.

3. Related work
Several aggregation policies have been proposed in the literature by [7], [8] to control and manage the buffering duration at the MR. All of these use a static parameter upon which to make the aggregation decision. However, they might handle the cost inefficiency when the request rate unpredictably fluctuates over time. In the work done in [9], [10], a dynamic cost-driven QoS aggregation policy was proposed and analyzed. It is able to cost-efficiently operate under burst QoS requests, while at the same time not disadvantaging the user with long waiting time. The process of handover happens when the mobile network roams to a new point of attachment. Resources might not be enough in the mobile network due to loss of signal, QoS degradation or service termination [11]. Authors in this paper [12] defined an IntServ and DiffServ model to propose an alternative approach which combines the
advantages of IntServ and DiffServ protocols to provide QoS guarantees in NEMO networks. They studied the handover process in handling the resource reservation, where the mobile node searches a good level of QoS before joining the mobile network. This work proposes a protocol that could support RSVP signaling, called NEMO Reservation (NEMOR). The protocol reserved the resources according to aggregated flows. The implementation comprised two phases: the MR and HA, and the HA and CN. However, the NEMOR protocol was written as an Internet draft and has not been extended for further work. No performance evaluation study was conducted in order to appreciate the benefits and gauge their associated overhead.

The binding cache of Home Agent (HA) only contains home address of mobile router. The addresses of mobile network nodes are not binded with current CoA of mobile router. As a result, packets cannot be tunneled to the mobile router correctly. To solve this issue, the idea of Prefix Scope Binding Update (PSBU) [13] is proposed to support advanced network mobility in IPv6. It suggests that an MR advertise its mobility through both the classic Mobile IPv6 binding update and PSBU. A PSBU binds the mobile network prefix with the COA of the MR rather than HoA with CoA of the MN. With this approach, upon reception of a packet from MR’s HA, the MR will send a PSBU to the CN which enables the CN to bind the mobile network prefix to the MR’s COA. Thus, all the subsequent packets addressed to the nodes in the mobile network will be sent toward the MR’s COA to achieve route optimization.

The work in [14] has proposed the use of two new Mobility Option (MO) headers to trade priority information between a MR and its respective HA. A negotiation signal is exchanged between the MR and HA. This signal is a mobility option header carried in Mobile IPv6. The former MO header is a priority negotiation request that holds the priority and the address information for the destination. The latter header is a priority negotiation reply that includes a return value that is either a simple success or failure. If the MR and the HA obtain a request for a priority from their ingress network, they set off the MO header for the negotiation signal and send it to their respective MR or HA. The technique splits up the traffic between the highest and normal priority.

In NEMO BS, the binding update traffics are minimized at the cost of tunneling overhead. To reduce the tunneling overhead, an adaptive NEMO support protocol based on hierarchical mobile IPv6 (HMIPv6) was proposed in [15]. The general idea is a trade-off between adaptive binding update traffic and tunneling overhead. An adaptive binding update strategy was adopted based on the session to mobility ratio (SMR). This SMR with predefined threshold was compared with different binding update procedures. An optimal threshold for adaptive binding updates was also derived in [16].

Network mobility could be split up into two domains, a wireless domain and wired domain. Authors in [17] have proposed a two-level aggregation-based QoS architecture to offer QoS support in NEMO. The architecture is divided into two levels, a node level and a network level. The QoS requirements for each flow are assembled at the mobile network nodes, while the MR at the network level gathers the QoS requests and aggregates them into a single Service Level Specification (SLS) [18] request for the entire NEMO subnet. The MNNs forward the resource requests for several flows or applications and allocate the resources to these flows. Moreover, they also proposed a universal signaling protocol to exchange the SLS between MNNs and the MR, and MR and the visited networks. The SLS is presented to carry QoS information for traffic aggregations. Another QoS aggregation approach has been proposed in [19] to provide for signaling control between the MR and the access network. Three policies were proposed which are temporal, cardinal and resource-threshold. The paper in [20] proposed a reasonable solution for a scheduling algorithm in network mobility. The authors assessed the performance of priority scheduling and fair scheduling. They proposed a scheduling algorithm Adaptive Rotating Priority Queue (ARPQP) that has exposed QoS guarantees for the higher priorities and maintains the reasonable throughput for the lower priorities.

Traffic scheduling and shaping mechanisms were utilized based on DiffServ model in [21] to constrain the traffic sources. The approach is to reduce the 802.11b wireless channel of saturation. Traffic is grouped from a high priority to a low priority. The EF (Expedited forwarding) class has the higher priority than AF (Assured Forwarding) and BE. Worst-case fair weighted fair queuing (WF2Q)
mechanism is configured to distribute the bandwidth for AF and BE traffic. The technique concentrates on constraining the traffic rate rather than allocating the bandwidth for each class. In the same way, an admission control is required to control the amount of EF traffic to avoid the wireless channel being saturated. When there is no EF traffic transmitted over the wireless channel, the bandwidth is given to the AF and BE traffic. However, BE traffic carries on utilizing the channel bandwidth with the AF traffic.

A couple of attempts have been done to analyze the signaling cost for mobility protocols. This framework [22] performed cost analysis of Mobile IP to minimize the signaling cost while introducing a novel regional location management scheme. The research work in [23] analyzed the signaling costs of SIGMA [45] and HMIPv6. In [24] an analytical model for the performance and cost analysis of IPv6-based mobility protocols were presented. Authors of [25] performed the signaling cost analysis of Seamless IP diversity based Network Mobility (SINEMO) [26]. Though, these analyses overlooked all possible costs (e.g. costs for sending query message by CN, securing location updates, obtaining IP address by MH, etc.), they failed to consider computing the signaling costs on various mobility entities. The work in [27] analyzes the total cost (including data delivery cost) of various mobility entities of NEMO basic protocol and figures out how those costs are affected by various network parameters, such as network size, mobility rate, traffic rate, and data volume. However, more optimizations are needed.

4. Open issues

From the previous related works that have been conducted, obviously there are a lot of opportunities to improve Quality of Service in network mobility. Some proposals have succeeded to tackle some issues in network mobility. However, certain research areas are still having open issues and they need to be highlighted:-

- **Performance Issues (Delay, Packet loss):** The handover process results in increased latency due to the multiple levels of indirection involved. The chances of packet loss are also more significant as a result of increase in latency. Research is required to adapt mechanisms such as Fast handover, Hierarchical handover or DiffServ to support QoS in mobile networks.

- **Increase in Packet Size:** Each added level of nested mobility requires an additional tunnel encapsulation, and these extra IPv6 headers increase the packet size and the associated overheads. Solutions that optimize the routes and reduce the levels of indirection are needed.

- **Sub-Optimal Routing:** the NEMO basic protocol uses bidirectional tunnelling between the MR and HA to achieve global connectivity to nodes within the mobile network. In case of nested NEMO network, several tunnelling occurs and this leads to several complexities. One of the significant problems regarding the nested NEMO is the pinball routing problem. Packets will flow via the Home Agents of all the Mobile Routers on their paths within the mobile network. When the mobile network moves to a new location, the new location has to be informed to the home agent of the mobile network. This binding update and binding acknowledgement has to pass through several MR-HA tunnels. This process is called as pinball routing. This is highly undesirable because it would incur delays, more bandwidth usage and increase the packet size at each level of nested mobility.

- **Multi-Homing Issues:** Support for multi-homing in a network mobility environment is crucial since if a MR fails to maintain session continuity this would affect the session preservation of the entire network. Also multi-homing support would enhance the load sharing and fault tolerant capabilities of mobile networks. However, NEMO Basic Support protocol neither prevents nor explicitly specifies mechanisms to handle multi-homing issues. Providing QoS for mobile network nodes by exploiting the redundancy provided in multi-homed mobile networks is a research area that needs further research.

- **Scalability Issues:** how to grow mobile network (i.e. by increasing the number of MNNs, MRs, Nested NEMO or Multihomed NEMO) while maintaining the performance is a challenge need to be taken under consideration.
• Signalling cost Issues: the cost analysis of network mobility and the underlying mobility management entities have become essential to avoid their performance degradation. However, there have been a few comprehensive cost analyses of NEMO protocol that considers all possible costs. Thus, developing analytical framework to measure network mobility costs and comparative analysis of the schemes based on the network mobility costs require more investigations.

5. The proposed scheme
The most important intention of studying QoS support in mobile environment lies in two aspects: One concentrates on how the mobility node affects end-to-end QoS guarantees. While the second concentrates on how to apply the existing QoS technologies in wired networks to wireless networks, namely how to append mobility support to these solutions and how these solutions suit the wireless link characteristics [28].

The topology depicted below in Figure 6, it based on an IPv6 network with mobility support and DiffServ model composite within the network to offer privilege QoS guaranteed service. The whole network literally moves as single unit.

![Figure 6. The proposed network topology](image)

This topology allows the nodes to simply connect as if they were on a fixed point of attachment, hiding all the complexity of handling mobility into three devices called DiffServ Mobile Router (DMR), Home Agent (HA) and MAP (mobility anchor point). The HA is a fixed device responsible for transmitting data from correspondent nodes to mobile nodes through the DMR. The DMR is located in a mobile environment. It can utilize any available access technology (e.g. 3G, 4G, WLAN or WiFi) to ensure proper routing functions between the mobile nodes and the Internet. Furthermore, it the DMR can also use more than one access technologies at the same time for load sharing and facilitating the vertical handover to the MNNs.

The proposed framework integrates the existing QoS over IP architecture with NEMO BS protocol. The aim is to suit the needs of both QoS guaranteed and mobility in communication. Taking the advantages of Differentiated Service (DiffServ) approach into a count, our focus is to propose the necessary modification in NEMO to ensure that the seamless mobility with the required QoS parameters can be achieved. Differentiated Service (DiffServ) has been proposed by Internet Engineering Task Force (IETF) to extend the Internet to be a QoS-capable, efficient and scalable network supportive. The Differentiated Services (DS) network architecture provides QoS guarantees in a scalable and least complex manner. Service differentiation is desirable to accommodate
heterogeneous application requirements and user expectations. It interconnects heterogeneous wireline/wireless networks with the Internet backbone to provide end-to-end QoS and seamless roaming to mobile users. It also permits differentiated pricing of Internet service.

The proposed scheme assumes that the DMR in the proposed architecture has the functionality of the Edge Router (ER). So, it will be empowered to implement the police. On the other hand, the NBB acts as a bandwidth broker to manage and monitor the network resource. By allocating resources to forwarding classes and controlling the amount of traffic for these classes, the framework will create different levels of services and resource assurance but not absolute bandwidth guarantees or delay bounds for individual flows.

Precisely, NEMO Bandwidth Broker is responsible for mapping packets to one of forwarding classes supported in the network. It must ensure that the traffic conforms to SLA for particular users. The SLA specifies packet classification, re-marking rules, traffic profiles and actions to traffic streams which are In/Out-of-profile. The TCA between the domains is derived (explicitly or implicitly) from this SLA. The boundary nodes translate the TCA into traffic profile for each user connected to. Once the packets pass the boundary nodes into the interior of the network, resource allocation is performed based on forwarding class.

Mobile network node (MNN) defines its requirements using SLA to request resources. In contrary, NBB agent has to perform admission control task by accepting or rejecting bandwidth requests. It maintains a database of parameters, in accordance with which reservations are made and then the DSCP for those services are going to be assigned. The negotiations for bandwidth allocation will initially occur between the MNN and NBB. After which, if the NBB accepts the QoS request to grant the resources, it will configure the edge routers and DMR to help optimizing the existing resources (i.e. controlling the network load) as shown in Figure 7.

As we know that Network Mobility is an extension of Mobile IPv6 (MIPv6). In conjunction with MIPv6, the MN performs binding update to HA/CNs regardless of its movements to other subnets. This induces unnecessary signaling overhead and latency. Therefore, the proposed scheme makes the use of F-HMIPv6 protocol. This is due to the fact that F-HMIPv6 protocol intends to combine the Fast Handovers for Mobile IPv6 (FMIPv6) protocol with the Hierarchical Mobile IPv6 Mobility Management protocol (HMIPv6). It means that the fast handover mechanism will be deployed over the HMIPv6 networks using the F-HMIPv6 protocol. Therefore, the protocol provides the advantages of both schemes (i.e., a seamless handover scheme with less signaling overhead and lower handover latencies). Hierarchical topology hides the network mobility form internet. Moreover, the overall
handover latency achieved by FMIPv6 will be further reduced because of local location updating in HMIPv6, while in the original FMIPv6, the Home Agent (HA) and CNs are usually far away. Priority Queue algorithm (PRI) has been chosen as a scheduler at all of edge and core routers to provide service differentiation by classifying the arriving data to different priority classes. The PRI scheduler at the output link should ensure that EF always receives a better QoS than AF and while the AF class receives better service than BE class. It also has the advantage of being simple and easy to implement for scheduling of the traffic at each output link in a DiffServ network.

6. Conclusions
In conclusion, Quality of Service is a set of service requirements (performance guarantees) to be met by the network while transporting a flow. Obviously, mobile users need to achieve QoS similar to wired users. However, the current QoS approaches are designed without mobility in mind. Therefore, there is a need to come up with a set of protocols to ensure that mobile users along with their terminals can obtain feasible required QoS. This paper reviewed (the previous and current) works that have been adopted different techniques to provide QoS in mobile network context. Then, the main fundamental open issues are presented and discussed in general. A new proposed scheme is introduced in this paper to optimize QoS in NEMO environment. Currently, Network Simulator NS-2 is been used to carry out the proposed scheme. In future work, we will further carry out the proposed scheme using analytical analysis to generate the signaling cost. Moreover, we plan to extend the model to investigate a detailed analysis of different techniques with certain performance metrics to check how the proposed scheme is working in a complex network such as nested or multihomed network mobility.

References
[3] T. Ernst 2005 Network Mobility Support Goals and Requirements IETF Internet draft <draft-ietf-nemo-requirements-05>


[20] Martin Heusse, Paul Starzetz, Franck Rousseau, Gilles Berger-Sabbatel, Andrzei Duda 2003 Bandwidth Allocation for DiffServ based Quality of Service over 802.11


[27] Md. Shohrab Hossain and Mohammed Atiquzzaman 2011 Cost and Scalability Analysis of Mobility Management Entities of NEMO