Incorporation of QoS in Network Mobility (NEMO) Network

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Summary
The contemporary Internet that we have been using today is based on Best-Effort (BE) service only, where packets are assigned and forwarded with the same priority. The BE service is acceptable only for traditional Internet applications like e-mail, web browsing and file transfer. However, it is not adequate for the applications like video conferencing, voice over IP (VoIP), and Video on Demand (VoD), which require high bandwidth, low delay and delay variation. Obviously, with the emergence of new real-time applications and Quality of Service (QoS) requirements, the Best Effort service becomes insufficient. Therefore, the Internet community has developed a number of new technologies to provide QoS in the Internet such as IntServ, DiffServ and MPLS. The differentiated service (DiffServ) is the most important distinct technology due to its simplicity and scalability benefits. It has been endorsed by Internet Engineering Task Force (IETF) to satisfy the requirements of new real-time applications. Internet Protocol was not designed taking into account mobility of users and terminals. In few years later, the IETF has developed protocols such as Mobile IPv4 (MIP) and Mobile IPv6 (MIPv6) for supporting seamless connectivity to mobile hosts. Mobile IPv6 is considered one of the important host mobility protocols, which was defined more in (RFC 3775 and RFC 6275). Network mobility basic support protocol (RFC 3963) is an extension of Mobile IPv6. It has been endorsed by Internet Engineering Task Force (IETF) to allow every single node in the mobile network to be reachable and connectable to the Internet while the network itself is moving around. Ultimately, this paper aims to propose and develop a new scheme to enhance QoS within NEMO environment.

Key words:
Mobile IPv6, NEMO, Quality of Service, DiffServ.

1. Introduction

Over time the needs and uses of the Internet have changed. The Internet is becoming a medium for learning, business and entertainment communications which need several types of media such as voice and video. In a few past decades, it was very difficult to assume that telecommunications services can be provided to people irrespective of their geographical location, while they are moving around. However, nowadays for many people it is very difficult to imagine life without continuous availability of communications using a mobile phone.

Mobile computers such as personal digital assistants (PDA), notebook, tablet, IPad and laptop computers with multiple network interfaces are becoming very common. Many of the emergence new applications that run on a mobile computer involve multimedia (such as teleconferencing, video-on-demand, voice-over-IP and games). Multimedia refers to the combination of different types of media elements such as text, audio, image and video in a digital form which is represented and manipulated by a single electronic device or a single computing platform for instance a personal computer PC. With the fast adoption of IP-based communications for mobile computing, users are expecting a similar service in wireless and wired networks. The Best-Effort service is not adequate for multimedia traffic. The adaption to serve these applications with acceptable quality of service (QoS) is required. Truthfully, they require a predictable and constant forwarding service from the connecting network (i.e. they can’t tolerate delay, jitter, or loss of data in transmission). QoS can be defined as the collective effect of service performance which determines the degree of satisfaction of a user of the service. The Internet Engineering Task Force (IETF) has developed new technologies and standards to provide resource assurance and service differentiation in the Internet, under the umbrella term quality of service. The best known QoS approaches are, Integrated Services (IntServ) [1], Differentiated Service (DiffServ) [2] and Multiprotocol Label Switching (MPLS) [3].

Network mobility basic support (NEMO BS) [4] protocol is an extension of Mobile IPv6 [5]. The protocol has the capability to roam as a unit and the entire network changes its point of attachment to the Internet and consequently its reachability in the network topology.

Nowadays, we are witnessing the emergence of mobile networks such as ships, submarines, buses, trains and aircrafts. Definitely, the future wireless network would be based on NEMO BS. Hence, one of main requirements of next generation IP-based networks is providing QoS for

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real-time traffic that will be transporting through NEMO networks. However, integrating QoS with NEMO is a challenging issue. This is due to the fact that QoS schemes (RFC 1633, RFC 2475 and RFC 3469) were introduced without mobility in mind.

The breakdown of this paper is as follows, related works will be introduced in the second section. After that, the third section will be deliberating the proposed framework. Lastly, the conclusion will be drawn in section four.

2. Related Work

Handover (or handoff) is a movement of mobile node (MN) between two attachment points (i.e. the process of terminating existing connectivity and obtaining new connectivity). In other words, it occurs when the MN moves away from its HA, where the transmitted signal getting more likely weak. If MN detects decreasing in the Received Signal Strength Indication (RSSI) of its attached access point, it will scan the current available access points and choose the best one with the strongest signal to connect to. Simply, MN will break the connection with the HA and establish a new connection with the foreign agent if it senses stronger signals nearby. There are different types of handover classified according to different aspects involved in the handover such as horizontal handover, vertical handover and so on so forth.

Mobility can be classified into: Host and Network mobility. Host mobility refers to an end host changing its point of attachment to the networks while the communication between the host and its correspondent node stays uninterrupted. Mobile IPv6 (RFC 3775, June 2004), Fast Mobile IPv6 (RFC 5268, June 2008), Hierarchical Mobile IPv6 (RFC 5380, October 2008) and Fast Hierarchical Mobile IPv6 are examples of host mobility protocols. On the other hand, Network mobility refers to a mobile IP subnet changing its point of attachment to an IP backbone. Network mobility basic support (RFC 3963), Nested NEMO and Multihomed network, are examples of network mobility protocols.

Few years ago, there were not many works have been covered regarding QoS in network mobility. However, recently there are noticeable efforts to study resource reservation and the performance of the NEMO BS protocol. In [6], authors proposed a resource allocation on per access point in Mobile IPv6 in DiffServ environment. DiffServ mechanism is deployed between the mobile node and access network. The policing and shaping is carried out when the traffic overloads the network exceeding its resource availability. However, a bandwidth allocation mechanism was not clearly discussed in this article which is the most important issue.

A bandwidth broker agent was proposed in [7], which is in charge of managing the DiffServ routers to supply QoS for mobile nodes. The bandwidth broker agent acts as an intermediate node for QoS signaling negotiation between the mobile node and DiffServ router. The bandwidth broker agent reconfigures the DiffServ network if sufficient resources are available to grant the mobile node requests. This approach reduces the signaling delay between the DiffServ router and mobile node. The paper in [8] 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.

Research work in [9] proposed a scheme that is known as time based bandwidth reservation to preserve resources at particular time for mobile network. This approach distributes the similar resource reservation for distinct mobile networks at various times. The first approach is an 'over-reservation' for future flows. The time based reservation approach is appropriate to deploy for a First-Come First-Served (FCFS) basis. This is unsuitable for real-time applications such as VoIP, voice on demand and video conferencing due to reserving the resources at an allocated time only. The paper in [10] presented a different approach for a bandwidth reservation scheme in network mobility. Every access router (AR) possesses proxy agent to assess the MR to do a reservation. The reservation is managed from the mobile network to its home agent. The authors have extended the concept of RSVP method, where it includes an active and passive reservation. The active reservation is set up when the mobile network connects between the current access router and its home agent, while the passive reservation is formed from neighbor access router and home agent (HA). There are three policies schemes that could be applied in order to implement efficient resource reservation. The mobile network can choose whether a static bandwidth reservation, a dynamic bandwidth reservation or a hybrid bandwidth reservation (a combination of static and dynamic). The schemes were evaluated using a mathematical analysis and simulation experiment. The analysis and results demonstrate that the probability of session dropping is decreased when the mobile network is under-loaded. The reservation utilization is higher for a dynamic policy compared to a static policy.

3. The Proposed Framework

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.

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 wire-line/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 topology depicted in Fig. 1 below, 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.

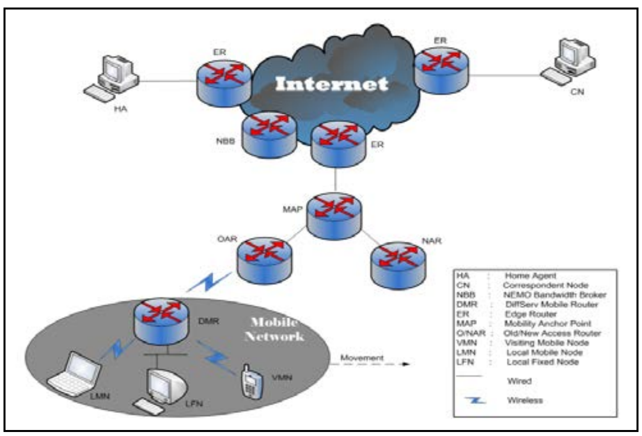

Fig. 1 The Proposed Network Topology.

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 DiffServ Access Router (DAR). 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 scheme assumes that the DMR in the proposed architecture has the functionally of the Edge Router (ER). So, it will be empower to implement the police. On the other hand, the NBB acts as 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 connects to. Once the packets pass the boundary a node into interior of the network, resource allocation is preformed based on forwarding class. The boundary nodes perform two functions, traffic classification and traffic conditioning as shown in Fig. 2.

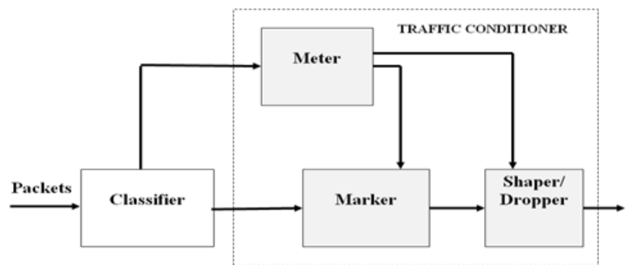

Fig. 2 Packets classifier and traffic conditioning.

Packet arrives at the classifier will be classified according to SLA. Then, the classifier forwards the packet to the traffic conditioner. The traffic conditioner may include meter, marker, shaper, and dropper. A traffic profile identifies the temporal properties of traffic stream selected by a classifier. It provides rules for determining whether a particular packet is in-profile or out-of-profile. It is specified in Service Level Specifications (SLS). A SLS is part of Service Level Agreement (a legal contract between a client and an Internet Service Provider). When the traffic stream is within the profile, the packets will be allowed to enter the network. If the user sends more than allowed packets, action will be taken to ensure that the traffic flow is fully consistent with the traffic profile.

- Classifier: classifier divides incoming packet stearm into multiple groups based on predifined rules. There are two types of classifiers:

- [ ] The BA (Behavior Aggregate) Classifier: classifies packets based on the DS codepoint only.
- [ ] The MF (Multi-Field) Classifier: which can classify packets based on the DS field and other IP header field

such as source address, destination address, DS field, protocol ID, source port and destination port numbers, and other information such as incoming interface.

• Traffic Conditioner: traffic conditioner performs traffic-policing functions to enforce the TCA between users and service providers. It may contain the four basic following elements (RFC2475, Dec 1998).

☐ Meter: it measure the temporal properties of the stream of packets selected by a classifier against a traffic profile specified in a TCA. which is either in-profile or out-of-profile.

☐ Marker: it sets the DS field of a packet to a particular codepoint, then adding the marked packet to a particular DS behavior aggregate.

☐ Shaper: it delays some or all of the packets in a traffic stream in order to bring the stream into compliance traffic profile. A shaper usually has a finite-size buffer. Packets may be discarded if there is not sufficient buffer space to hold the delayed packets.

☐ Dropper: it discards some or all of the packets in a traffic stream in order to bring the stream into compliance traffic profile. This process is known as the policer of the stream.

• Service Classes: For each packet the framwork uses two kinds of forwarding classs mechanismes (service models) besides the Best Effort. These are Expedited forwarding (EF) and Assured forwading (AF). Expedited Forwarding (EF) PHB is defined in (RFC2598, March 2002). It can be used to generate less loss, low jetter, low latency and assured bandwidth (seems as end-to-end service through DS domains). This service is usually referred to “Premium service”, “virtual leased line” or “forward me first”. It is not meant to replace the Best Effort but its purpose is to meet the emerging demand for commercial services that share the network with BE traffic. Assured Forwarding (AF) PHB does not provide bandwidth guarantee but packets are given a higher priority (RFC 2597, June 1999). These packets have a higher probability to be transmitted over the network compared to packets from the Best Effort PHB. The AF PHB uses rules semantic to “drop me last”. It is sutiable for adaptive applications that require better than Best-Effort service and reliability (e.g. one way voice).

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 as shown in fig (3). 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.

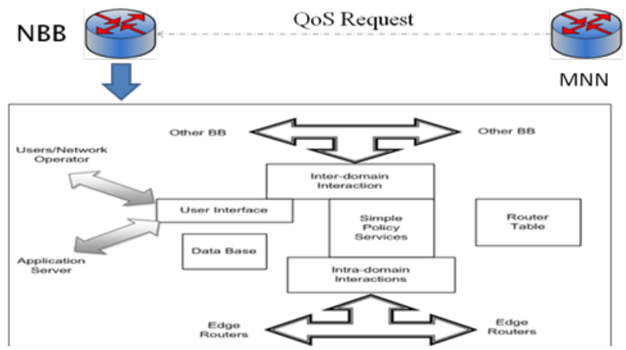

Fig. 3 NEMO Bandwidth broker.

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 Fig. 4.

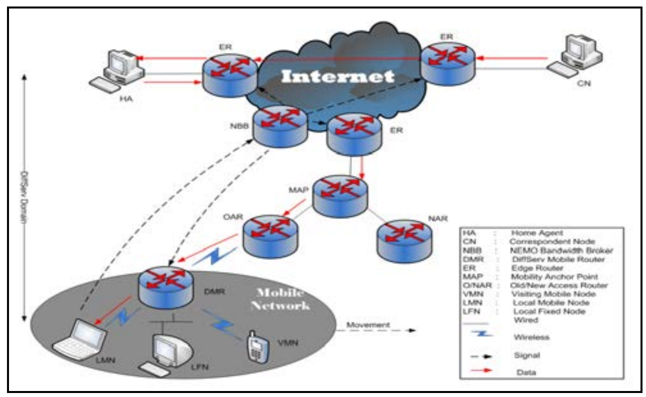

Fig. 4 Generic Signaling and Data Flow in the Proposed Scheme.

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 ER and CR 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.

4. Conclusion

In conclusion, with existing QoS mechanisms several research proposals have been introduced to ensure QoS to the moving MNs. However, less research works have been done to provide QoS for a mobile network (in case of router movement). Thus, this research work aims to propose a scheme that provides seamless connectivity as well as support resources to sustain QoS for all ongoing communications. The new proposed scheme is introduced to optimize QoS in NEMO environment. Currently, Network Simulator NS-2 [11] is been used to carried out the proposed scheme. In future work, we will further carry out the proposed scheme using analytical analysis to generate the signaling cost.

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