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Full Length Research Paper

User class mechanisms for quality of service in network mobility

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Network mobility basic support (NEMO BS) protocol was introduced by the IETF and allows a mobile network to move and maintain internet sessions. NEMO BS is an extension of mobile IPv6 where the network keeps its home address whilst it is moving. In crowded environments such as trains, the bottleneck is often between the access link and the mobile network. Prioritizing the traffic and allocating a minimum bandwidth guarantee for each user is crucial in this environment. Due to the limited and variable wireless link bandwidth the resource management in mobile network is a challenging problem. A dynamic QoS provisioning framework is designed to provide traffic differentiation according to a user class. Network Simulator, Ns-2 is used to validate the framework and to understand how the mobile network behaves on varies types of applications.

Key words: Network mobility, user class, QoS differentiation, wireless network, Ns-2.

INTRODUCTION

Recently there has been a large scale deployment of wireless hotspots in public areas such as cafes, airports, libraries, campus areas, schools and train stations. Wireless hotspot implementation is less expensive; therefore it provides free surfing for their customers. However, some offer with charges. Most of personal user devices such as laptops, PDAs and mobile phones are built-in with an IEEE 802.11b/g. Furthermore, the users are able to access the internet at anytime and anywhere. A public user who is able to access the internet at public areas may want to continue accessing the services whilst on the move. As a matter of fact, the network mobility basic support (NEMO BS) (Devarapalli et al., 2004) protocol allows IPv6 enabled devices access to the internet whilst on the move. Consequently, devices espousing the mobility functions of Mobile IP, 3G card, satellite detection can stay connected to the internet. The mobile network can be moved within its administrative domain or different administrative domains. When the mobile network is moving within its administrative domain, it is called a localized movement. Hence, the process of registration and binding update are reduced. When the mobile network is moving among different administrative domains, the process of registration, binding update, configuration, etc. are increased.

Mechanisms for traffic prioritizing and scheduling are needed to determine the traffic limits and to keep the channel non-saturated. The QoS differentiation approach is to provide a consistent level of QoS to the mobile network nodes (MNNs). Traffic is aggregated into different QoS classes so that sufficient capacities of resources are provided. The mobile network is responsible for determining the maximum bandwidth dedicated for each QoS class. A priority mechanism for network mobility is where a packet with a priority class is

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Abbreviations: AF, Assured forwarding; **AR,** Access router; **BE,** best effort; **CBR,** constant bit rate; **CN,** correspondent node; **DiffServ,** differentiated services; EF, expediated forwarding; **HA,** home agent; **LFN,** local fixed node; **LMN,** local mobile node; **MNN,** mobile network node; **MR,** mobile router; **NEMO BS,** network mobility basic support; **QoS,** quality of service; SLS, service level specification; VMN, visited mobile node**; WF2Q,** fair weighted fair queuing.

queued differently to one with a different class or no class at all. The queues of the same priority level are handled equally in the scheduler. In the simplest example, the priority packets may have different QoS requirements for certain applications. A real-time application may assign at a higher priority level compared to something like web browsing. The priority levels may also be controlled by a service level agreement defining the user requirements. QoS provisioning can be achieved and guaranteed with a proper configuration, reservation and allocation of resources.

Related work

Traffic scheduling and shaping mechanisms were used based on DiffServ model to limit the traffic sources (Heusse et al., 2003). The approach is to reduce the wireless channel (802.11b) saturated. Traffic is grouped from a high priority to a low priority. The EF class has the higher priority than AF and BE. Worst-case fair weighted fair queuing (WF2Q) mechanism is configured to allocate the bandwidth for AF and BE traffic. The approach focuses on constraining the traffic rate rather than allocating the bandwidth for each class. Similar to Heusse et al. (2003), an admission control is required to limit the amount of EF traffic to avoid the wireless channel being saturated (Banch et al., 2002). When there is no EF traffic transmitted over the wireless channel, the bandwidth is given to the AF and BE traffic. However, BE traffic competes to use the channel bandwidth with the AF traffic. Patil and Hota (2006) 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 performed when the traffic is overloaded and when it exceeds the resource availability. However, a bandwidth allocation mechanism was not clearly discussed in this article which is the most important issue. Torsten and Gunther (2001) proposed a bandwidth broker agent which is responsible for managing the DiffServ routers to provide 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 reconfigured the DiffServ network if sufficient resources are available to grant the mobile node requests. This reduced the signaling delay between the DiffServ router and mobile node.

The network mobility can be divided into two domains; a wireless domain and wired domain. This is how Wang et al. (2005) have proposed a two-level aggregation-based QoS architecture to provide QoS in NEMO. The architecture is divided into two levels, a node level and a network level. The QoS requirements for each flow are collected at the mobile network nodes, whilst the MR at the network level collected the QoS requests and aggregated them into a single service level specification (SLS) (Bard et al. 2009) request for the entire NEMO subnet. The MNNs send the resource requests for several flows or applications and distribute the resources to these flows. On top of that, they also proposed that a universal signaling protocol to exchange the SLS between MNNs and the MR, and MR and the visited networks. The SLS is introduced to carry QoS information for traffic aggregations. Another QoS aggregation approach has been proposed by Kamel et al. (2009) which offers signaling control between the MR and the access network. Three different policies are proposed which are temporal, cardinal and resource-threshold. Details of these policies are explained in Kamel et al. (2009).

In different article, Wang et al. (2008) proposed a feasible solution of scheduling algorithm in network mobility. The authors compared the performance of priority scheduling and fair scheduling. They proposed a scheduling algorithm, adaptive rotating priority queue (ARPQ). This algorithm has shown QoS guarantees for the higher priorities and maintains the reasonable throughput for the lower priorities.

METHODS

Differentiated Services (DiffServ) model is suitable to apply into the mobile network because of its characteristic that provides QoS differentiation between a higher level class and lower level class. QoS Differentiation allows packet to be sent according to its requirements, such as delay, bandwidth, response time, etc. The mobile network should support a variety of traffic types which are significantly present in mobility environments. The mobile network should satisfy the requirements of high data rate, delay sensitive applications, low data rate and bursty traffic over the internet. Real-time streaming applications such as Voice over IP (VoIP) and video conferencing have very strict QoS delay requirements. Non real-time applications, such File Transfer Protocol (FTP) and web browsing support less QoS delay requirements. Therefore, various QoS classes should be defined according to their traffic types.

The service based approach deals with the traffic types (Mdnoor et al., 2009), whereas the class based approach intervenes at the user level. A mobile network technology is suitable for public transport environments; therefore the public transport users (with mobility devices) are part of the mobile network. Which user is given the priority to access the resources in the mobile network regardless of the traffic types is an important issue. The user class based approach is proposed to solve this issue. There are three level of user classes; higher level user, secondary level user and lower level user. Resources are reserved according to the user classes regardless of the traffic types accessed.

Figure 1 illustrates a user class model. To achieve this, the groups must be defined first. A group consists of three set of streams which are defined in the service classes; premium, intermediate and default. Traffic differentiation is applied in the three sets of streams because each stream requires different level of resources. The MAC parameter tuning is applied in each set of streams. Consequently, the user with a real-time application receives appropriate bandwidth compared to the user with non-real time or best effort requirements.

The mobile network nodes (MNNs), mobile router (MR) and home agent (HA) control the QoS functionalities in IPv6 and MIPv6 packets. There are two fields in IPv6 packet format that support QoS, that is a traffic class (8 bits) and a flow label (20 bits). The dynamic QoS provisioning model (Mdnoor et al. 2006) is mapped with the network mobility's entity. The dynamic QoS provisioning consists of classification, marking, admission control, queueing and scheduling. At the mobile network nodes, the packet is classified according to the classes that have been defined either as a service class or a user class. In the IPv6 traffic class field, the first 3 bits are used to classify the traffic according to its priority class and 5 bits are reserved for future use.

For example, the first priority class consists of two groups of bits, 00100000 and 01000000, where the 00100000 is for a premium service class and 01000000 is for a higher level user. Figure 2 shows the traffic class bits. The flow label in IPv6 packet format is divided into three groups which are; the traffic approach (TA) which contains 4 bits to determine the QoS classes, bandwidth and delay contain 8 bits each. This field is to mark the packet according to its traffic classes (service or user). As for the service class, each traffic requires its own QoS requirements (bandwidth and delay). For example, if the TA bits are 0000 (all 4 bits zero) the "No QoS" are marked. If the TA bits are 0001, the packet is marked as premium service. Figure 3 shows an example of flow label bits for the premium service.

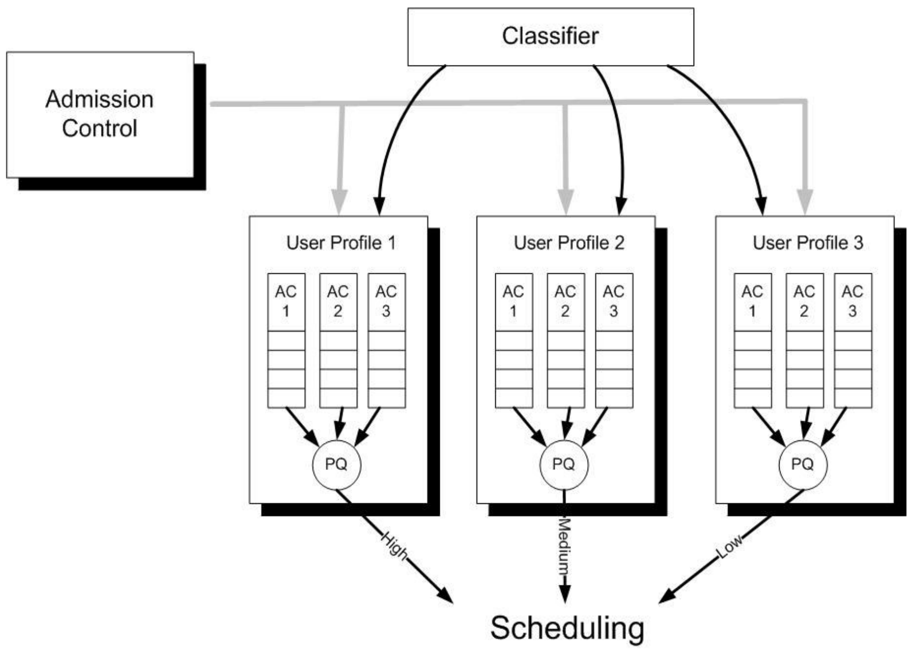

Figure 1. User class model.

Figure 2. Traffic class bits.

After the IPv6 packet has been classified and marked, it is forwarded to the mobile router. The dynamic QoS provisioning is controlled by the mobile network nodes, mobile router and home agent. To enable the dynamic QoS provisioning in the mobile network, five processing functions are performed:

- *Classification:* Packet is classified using the traffic class in the IPv6 packet. The first 3 bits are used to define the classes, that is service and user classes.
- *Marking*: The second process is to mark the packet if it is matched with a particular classification profile.
- *Admission Control:* The appropriate marked packet is admitted with the amount of resources and forwarded into a particular queue.
- *Queuing:* The packets are queued into three different queues; first priority, second priority and third priority before transmitting.
- *Scheduling:* In the context of QoS, the scheduling process defines the way packets are removed from the queue. The simplest queue scheduling used are a priority queue (PQ) and First-Come and First-Served (FCFS). Packets are treated differently according to their classification and marking.

EXPERIMENT

NEMO BS protocol package was successfully installed in Linux machine (Ns-2, 2007). The package is an extension from a MobiWan package built by the MOTOROLA Labs, Paris, in collaboration with INRIA PLANETE team (MobiWan, 2002). The package is built to simulate the Mobile IPv6 (MIPv6) under the large Wide Area Networks (WAN). An all-in-one Ns-2 version 2.29 is installed under the Linux operating systems. Figure 4 shows a logical view of a mobile network when it is attached to its home agent (home network) and moves to a base station (foreign network) over the internet. The mobile network consists of a Local Fixed Node (LFN), Local Mobile Node (LMN) and Visited Mobile Node (VMN). In situation (1), the mobile network is attached to its home agent. The traffic from the mobile network is forwarded to the correspondent node via the home agent. Whilst in situation (2), when the mobile network is moved away from its home agent and attached to the base station in a foreign network, the traffic to the correspondent node is intercepted by the home agent.

NS-2 SIMULATION

The topology model is divided into two parts which are a wired network and mobile network. The wired network consists of a correspondent node (CN), an access router (AR) and four base stations (BS1-BS4). The mobile network consists of a mobile router (MR) and mobile network node (MNN). The hierarchical address for each node is shown in Figure 5. The CN is linked to the AR via an Ethernet link, that is 100 Mbps. Each base station is configured as IEEE 802.11b access point and is connected to the AR. The links are configured with 100 Mbps. A Constant Bit Rate (CBR) packet

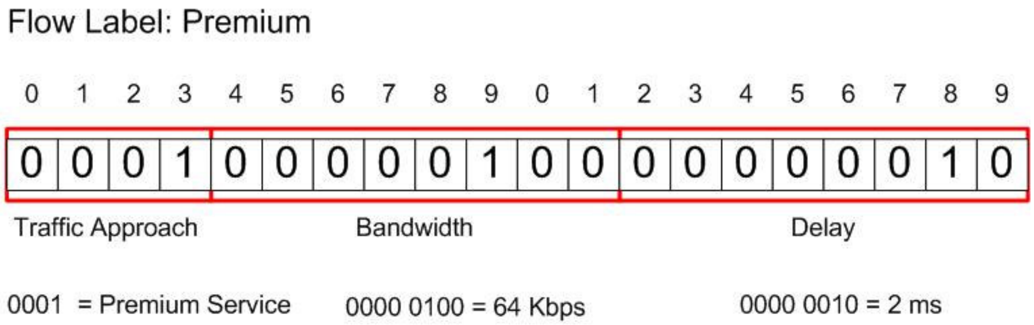

Figure 3. Flow label for premium class.

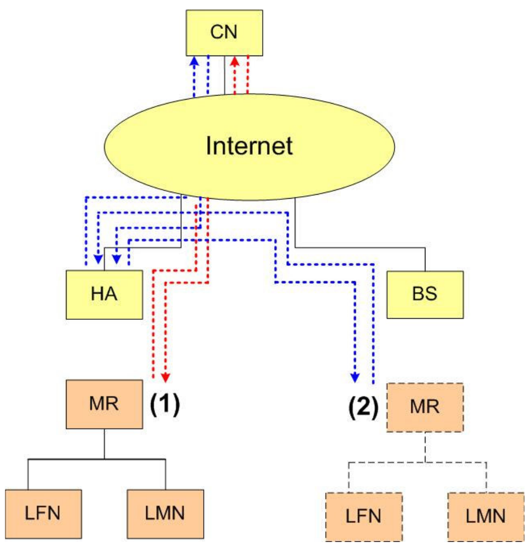

Figure 4. Network mobility components.

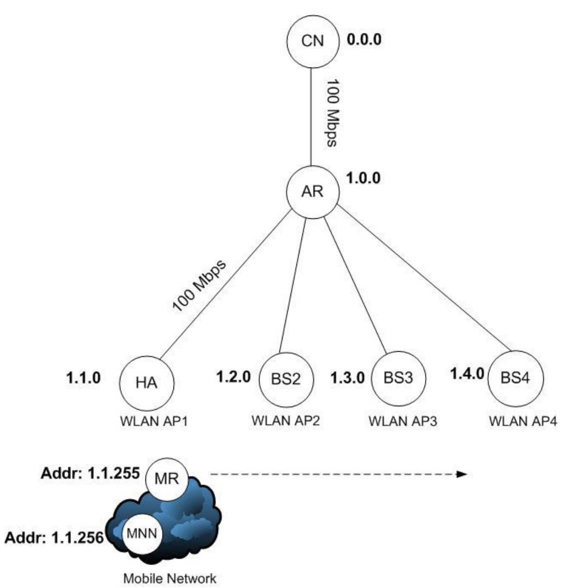

Figure 5. Network topology.

type is used throughout the experiments. The CBR packet size and data rate vary, according to the experiments conducted. The model is created over a square field of 20,000 m x 20,000 m.

RESULTS

In this experiment, nine users (mobile network nodes) were created and attached to the mobile router. The users were divided into three user profiles, which are a high level user, a secondary level user and a low level user. Each user profile transmitted different types of traffic, involving real-time, non-real time and best effort. The experiment was to determine bandwidth allocation according to the user differentiation. Tables 1, 2 and 3 show the results for each user level. In Table 1 High Level User, there were three users who transmitted different traffic each. The MAC parameter tuning in EDCA algorithm was implemented in this experiment. The user who transmitted premium class traffic received a bandwidth guarantee with an average throughput of 64.00 Kbps, 0.001% average loss rate and 0.0013 s average delay. Although, the users were in a same group, that is high level user, the user with a premium traffic class was given a priority and bandwidth guarantee compared to the users who accessed the intermediate or default traffic class. The average throughput for intermediate and default classes users were 4.07 Mbps and 812.00 Kbps, respectively. The average packet loss for intermediate and default classes were 6.23 and 8.33% respectively. The default class has a lower delay compared to the intermediate class which was 0.00317 s. This is because, the intermediate traffic required a higher bandwidth (i.e. 5 Mbps) to transmit a large video traffic compared to the best effort which only required 1 Mbps to transmit its traffic. The observation has shown that even though the users were in the same group level, traffic was differentiated to provide bandwidth guarantee and fairness among each user traffic.

Table 2 shows the results for the secondary level user. The performance for the three classes has reduced compared to the high level user. As expected, the

Table 1. High level user.

	Premium	Intermediate	Default
Average throughput	64.00 Kbps	4.07 Mbps	812.00 Kbps
Average loss rate (%)	0.001	6.23	8.33
Average delay (s)	0.0013	0.00432	0.00317

Table 2. Secondary level user.

	Premium	Intermediate	Default
Average throughput	62.31 Kbps	3.83 Mbps	515.87 Kbps
Average loss rate (%)	0.021	12.94	31.56
Average delay (s)	0.0266	0.674	0.592

Table 3. Low level user.

	Premium	Intermediate	Default
Average throughput	35.19 Kbps	288.98 Mbps	92.55 Kbps
Average loss rate (%)	46.12	58.13	78.05
Average delay (s)	2.23	2.78	1.04

premium class traffic received bandwidth guarantee in this group. However, the premium class average throughput was slightly reduced to 62.31 Kbps. The throughput for the intermediate and default classes was 3.83 and 515.87 Kbps, respectively. The delay for all the traffic has increased to 0.0266 (2.66 ms), 0.674 (67.4 ms) and 0.592 (59.2 ms). The results for the low level user were worst compared to the high and medium level users (see Table 3). The low level user was treated like the best effort traffic in traffic differentiation. The throughput for the premium class was reduced to 35.19 Kbps compared to the high level user, 64.00 Kbps and secondary level user, 62.31 Kbps. The loss rates have increased to 46.12% for the premium traffic, 58.13% for the intermediate traffic and 78.05% for the default traffic. The average delay has increased and it was not acceptable for the quality of the traffic. This poor performance has shown that the bandwidth is not guaranteed for the low level user regardless of their traffic types.

DISCUSSION

The model has a great flexibility and could be applied not only for the network mobility but for the fixed network as well. The NEMO BS protocol supports packet exchange between the correspondent node (CN) and the mobile network node (MNN) without passing through the home agent (HA). This concept is called `route optimization'.

The model developed on the existing NEMO BS package did not support route optimization techniques. By applying route optimization in the model, this will help to reduce the mobility handover delay and increase the overall performance. The mobile network is considered multihomed when either the mobile network is simultaneously connected to the internet via more than one mobile router, or a mobile router has more than one egress interface. The dynamic QoS provisioning model was developed to solve the bottleneck issues between the mobile router's egress interface and access network, and the mobile router's ingress interface and the mobile network nodes.

Conclusion

QoS requirements in network mobility were identified and a dynamic QoS provisioning architecture was designed. The dynamic topology and insufficient resources which degraded the quality of service of the mobile network were highlighted. During the study, the mobility problem could be solved by several means where the most common means is QoS provisioning. The resources were provisioned between the mobile router and the mobile network nodes. The traffic was prioritized according to the user classes. The results for average throughput, delay and packet loss rate are presented. The user class mechanism provided bandwidth guaranteed for selected traffic classes even though there were worse link bandwidth utilization. The simulation results have shown an optimal bandwidth allocation for a premium class in the high level user.

REFERENCES

Albert B, Markys R, Xavier P (2002). Assured and Expedited Forwarding Extensions for IEEE 802.11 Wireless LAN. Tenth IEEE Int. Workshop on Quality of Serv., pp. 237-246.

Badr B, Zeina J, Francine K (2009). QoS management in Mobile IP Networks using a Terminal Assistant. Int. J. Network Manage., 9(1): 1-24.

Torsten B, Gunther S (2001). Providing Differentiated Services to Mobile IP Users. IEEE Conf. Local Comput. Networks, pp. 89-90.

Vijay D, Ryuji W, Pascal T (2004). NEMO Basic Support Protocol. Network Working Group, RFC3963.

Martin H, Paul S, Frank R, Gilles BS, Andrzej D (2003). Bandwidth Allocation for DiffServ based Quality of Service over 802.11. IEEE GLOBECOM, 2(1): 992-997.

George K, Mihailovic A, Hamid AA (2009). A Cost-Optimal QoS Aggregation Policy for Network Mobility: Analysis and Performance Comparisons. IEEE Tran. Vehicul. Technol., 58(7): 3547-3557.

Prabhu P, Chittaranjan H (2006). DiffServ QoS Provisioning for Real Time Traffic in Frequent Handoff Mobile IPv6 Networks. Int. J. Comput. Sci. Network Secur., 6(4): 151-155.

Md NR, Edwards C (2006). A Dynamic QoS Provisioning Model for Network Mobility. The 7th Annual PostGraduate Symposium on The Convergence of Telecommunications, Networking and Broadcasting. Liverpool. United Kingdom.

Md NR, Edwards C (2009). Using NEMO to support Network Mobility within Railway Infrastructures. The 9th International Conference on ITS Telecommunication Lille, France.

Yaning W, Linghang F, Nadeem A, Kar AC, Rahim T (2005). An Aggregation-based QoS Architecture for Network Mobility. 4th IST Mobile Summit Conference.

Yaning W, Linghang F, Dan H, Rahim T (2008). Performance Comparison of Scheduling Algorithms in Network Mobility Environment. J. Comput. Comm., 31(9): 1727-1738.

Ns-2: Simulation for Network Mobility (NEMO). (2007). Available at http://www.arcst.whu.edu.cn/center/kongrs/nemo_sim.htm.

MobiWan: NS-2 extensions to study mobility in Wide-Area IPv6 Networks. (2002). Available at http://www.inrialpes.fr/planete/mobiwan.