EVALUATING USER CLASS APPROACH FOR NETWORK MOBILITY PROTOCOL

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ABSTRACT

This paper highlights the importance of the Quality of Service in mobile network by introducing a user class approach for traffic management between a mobile router and the mobile network nodes. The approach scheme encompasses the application of mobile user (e.g. public transport user) while they are moving to optimize the network resource utilization. Experiments are conducted using a Network Simulator 2 to measure the performance of user class in different scenarios; off peak hours and peak hours. Based on this information, traffic from mobile network nodes has significant improvement where it provides high throughput, low end-to-end delay and low packet loss rate.

Keywords: Mobile Network, User Class, Quality of Service, WLAN, Mobile WiMAX, Simulation

1. INTRODUCTION

There are large scale deployment of wireless hotspots in public areas such as cafes, airports, libraries, campus areas, schools and train stations, that offer free surfing for their customers. However, some offer the service with charges. Most personal user devices such as laptops, PDAs and mobile phones are built-in with an IEEE 802.11b/g. Furthermore, users are able to access the Internet anytime and anywhere. A user who is able to access the Internet at public areas may want to continue accessing the services whilst on the move. The NEtwork MObility Basic Support (NEMO BS) protocol [1] allows IPv6-enabled devices access to the Internet whilst on the move, because the devices have the mobility functions to stay connected to the Internet. A mobile network node (MNN) can be moved within its administrative domain or different administrative domains. When the MNN 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 registration process, binding update, and configuration are increased.

In recent years, the Internet Engineering Task Force (IETF) [2] has developed protocols to support mobility, which are Mobile IPv4 (MIPv4) [3], Mobile IPv6 (MIPv6) [4] and NEMO BS. MIPv4 and MIPv6 are protocols that support node movement whilst roaming. MIPv6 was introduced to improve several weaknesses in MIPv4 and offers more addresses to use. An extension to MIPv6 is the NEMO BS protocol where it supports movement of an entire network rather than mobile devices. Frequent mobility of the user is accompanied by more difficult challenges to provide Quality of Service (QoS) guarantees. Therefore, resources should be provisioned before the handover is performed to eliminate packet drops if insufficient resources exist in a wireless link. Using a QoS provisioning mechanism in a dynamic mobile network environment may improve the mobile network performance however the challenge is to maintain the originally requested level of service by the mobile users. Issues related to QoS in mobile networks are areas of open research.

The outline of the paper is as follows. In Section 2, background and related works are presented. Section 3 discusses about the network mobility implementation where it consists of the user approach, the architecture, method and configuration. In section 4, the experiment results are discussed. Section 5 presents the conclusion.

2. BACKGROUND & RELATED WORK

Figure 1 shows an overview of the network mobility model. Multiple mobile network nodes (MNNs) are connected to the mobile router (MR) to communicate with the correspondent node (CN). This protocol provides transparency of mobility to the MNNs. The MNN may be a local fixed node (LFN) or a local mobile node (LMN). When the mobile network moves from its home network to a foreign network, the MR obtains a temporary address which is called a Care-of-Address (CoA). Then the MR sends a binding update (BU) message which contains its CoA to the HA. When the BU process is completed, a bi-directional tunnel is established between the MR and the HA. Any packets from the CN destined to the MNN on the mobile network are intercepted by the HA before forwarding to the MNN. In the opposite direction, the MNN sends the packets to the MR to be tunneled to the HA before sending it to the CN.

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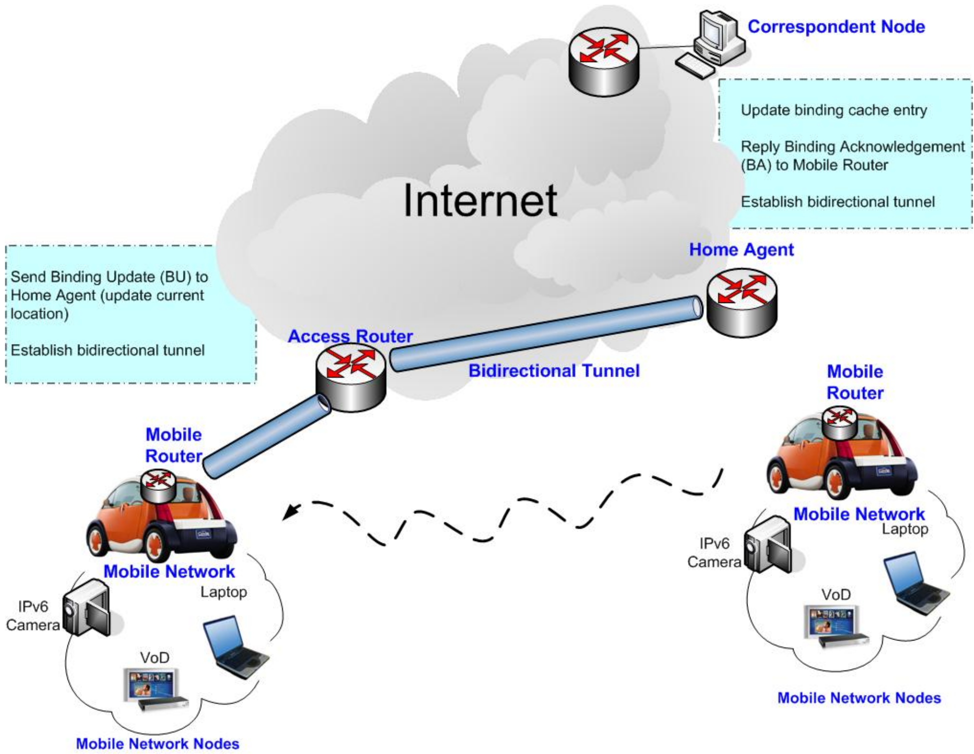

Fig.1 NEMO BS Protocol

In network mobility, a MNN can act as a mobile host and MR. If the MNN acts as the mobile host, the HA is not required to maintain any prefix information related to the mobile host's home address. If the MNN acts as a mobile router, the information about its home address is maintained in a binding cache. In the NEMO BS protocol message format, this is distinguished by the value in the MR flag (R) (see Figure 2). If the value is set to 0, the HA assumes that the MR is in a state of being the MNN. If the value is set to 1, the packets are from the MR. A mobility option field includes the binding update, type, length, reserved, prefix length and mobile network prefix.

When the MR is attached at its home network, the MR needs to be reconfigured to prevent other nodes from configuring the mobile router as the default router. The configuration involves the sending of the Router Advertisement (RA), replying with the Router Solicitation (RS) on the home network interface and setting a lifetime field to 0 (zero). In the foreign network, the MR should not send unsolicited RA and should not reply to the RS. However, the MR should reply with the Neighbor Advertisement (NA) when it receives the Neighbor Solicitation (NS) on the egress interface.

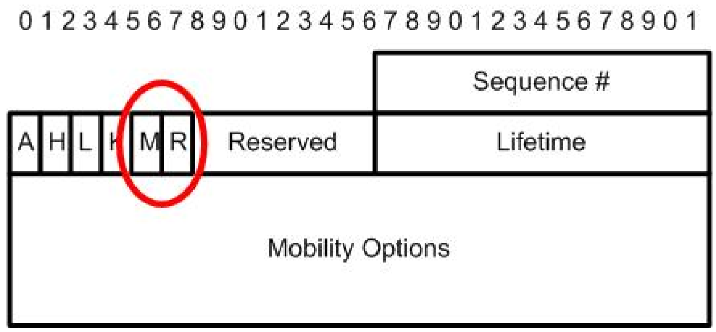

Fig.2 NEMO BS Protocol Message Format

Gurpal and Sohi [8] show that QoS provisioning in 802.11 wireless networks is important especially with regard to access delay, packet loss, round trip time and traffic throughput. The authors reconfigured the queue mechanisms in 802.11e EDCA methods. A dynamic queuing strategy was assigned to an appropriate queue to achieve QoS. The queue was configured based on various parameter settings such as minimum congestion window, maximum congestion window, transmission opportunity and arbitrary interframe spacing. A testbed was set-up to analyze a First In First Out (FIFO) queue and priority queue. The throughput results showed some improvements in the priority queue compared to the FIFO queue. Not much work has been completed regarding QoS in network mobility. However recently, there are efforts to study resource reservation and the performance of the NEMO BS protocol. The process of handover occurs when the mobile network moves to a new point of attachment because of QoS degradation, loss of signal, or the service terminated when there is not enough resources in the mobile network [9]. Tlais and Labiod [10] 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. The authors studied the handover process in handling the resource reservation, where the mobile node searches a good level of QoS before joining the mobile network. Tlais and Labiod proposed a protocol that could support RSVP signaling, NEMO Reservation (NEMOR). The protocol reserved the resources according to aggregated flows. The implementation involved two phases: the MR and HA, and HA and CN. However, the NEMOR protocol was written as an Internet draft and has not been extended for further work.

Han [11] has defined two new Mobility Option (MO) headers to exchange 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 first MO header is a priority negotiation request that contains the priority and the address information for the destination. The second header is a priority negotiation reply that contains a return value that is either a simple success or failure. If the MR and the HA receive a request for a priority from their ingress network, they initiate the MO header for the negotiation signal and send it to their respective MR or HA. The technique separates the traffic between the highest and normal priority. A NetFilter software is used as a test bed by [12] to validate a packet marking, classifying, scheduling and queuing. A test on a multihomed NEMO network was performed too. The QoS functionalities are performed in GNU/Linux system and the results are analyzed to see the implication on mobile routing.

Network mobility can be divided into two domains: a wireless domain and wired domain. This is how Wang et. al [13] 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 collects the QoS requests and aggregates them into a single Service Level Specification (SLS) [14] 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 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 [15] which offers signaling control between the MR and the access network. Three policies are proposed which are temporal, cardinal and resource-threshold. Details of these policies are explained in. Wang et al. [16] also proposed a feasible solution for a 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), that has shown QoS guarantees for the higher priorities and maintains the reasonable throughput for the lower priorities.

As the mobile network roams, its traffic path changes and path re-establishment is required to avoid a service disruption. Not much research work on QoS provisioning in network mobility has been done. Hamida and Boukhatem [17] proposed a time-based bandwidth reservation scheme to reserve resources at a certain time for the mobile network. The approach allocates the same resource reservation for the different mobile networks at different times. The first approach is an 'over-reservation' for future flows. The time-based reservation approach is suitable to apply for a First-Come First-Served (FCFS) basis. This is unsuitable for real time traffic such as voice or video conferencing because the approach reserves the resources at an allocated time only. There is another approach [18] for a bandwidth reservation scheme in network mobility. Each access router has a proxy agent to help the MR to make a reservation. The reservation is made from the mobile network to its home agent. The authors extended the idea of an RSVP mechanism, where it contains an active and passive reservation. The active reservation is established when the mobile network attaches between the current access router and its home agent. At the same time, the passive reservation is established from the mobile network's access router neighbor and the home agent. To implement the resource sharing reservation efficiently, there are three policies schemes to apply. The mobile network has an option either to make a static bandwidth reservation, dynamic bandwidth reservation or hybrid bandwidth reservation (combination of static and dynamic). The schemes were analyzed using a mathematical analysis and simulation experiment. The analysis and results show that the probability of session dropping is decreased when the mobile network is underloaded. The reservation utilization is higher for a dynamic policy compared to a static policy.

3. NETWORK MOBILITY IMPLEMENTATION

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

3.1 User Class Approach

The service-based approach [19] deals with the traffic types, 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 levels 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.

The mobile network nodes (MNNs), mobile router (MR) and home agent (HA) control the QoS functionalities of IPv6 and MIPv6 packets. The IPv6 packet format consists of two fields that support QoS functionality, i.e. the traffic class and flow label. The MNNs use these two fields to perform traffic classification and marking. When the MR receives an IPv6 packet, resources are provisioned according to QoS requirements that are defined in both fields. Then, the IPv6 packet is queued based on the classification process. All packets from the same class receive the same treatment from a scheduler. The MR will re-mark the packet before forwarding to the HA through the bi-directional tunnel.

A packet scheduling algorithm can differentiate the service class and user class. There are many types of scheduling algorithms such as Priority Queue (PQ) [20], Class Based Queue (CBQ) with Weighted Round Robin (WRR) [21], Weighted Fair Queuing (WFQ) [22], Dynamic Weighted Fair Scheduling [23] and First Come First Served (FCFS) [24]. In a mobile network, the simplest scheduling, FCFS is applied for the default service and lower user class. For the other service and user classes, the scheduling algorithm used is PQ. The difference between PQ and FCFS is that PQ gives high priority to the defined traffic and controls it, whereas FCFS processes the traffic according to their arrival time. PQ is implemented in a non-preemptive manner where the ongoing traffic (e.g. lower priority class) is not interrupted when there is incoming traffic (e.g. higher priority class or other priority classes). This is because the resources have been reserved for the higher priority traffic before transmitting.

The user class is proposed to differentiate the level of users when accessing the network resources. Three user groups (high level, medium level and low level) are categorized as a user profile 1, user profile 2 and user profile 3, respectively. Figure 3 illustrates the user profiles. To achieve this, the groups must be defined first. A group consists of three set of streams that 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 user group pseudo code is shown in Figure 4.

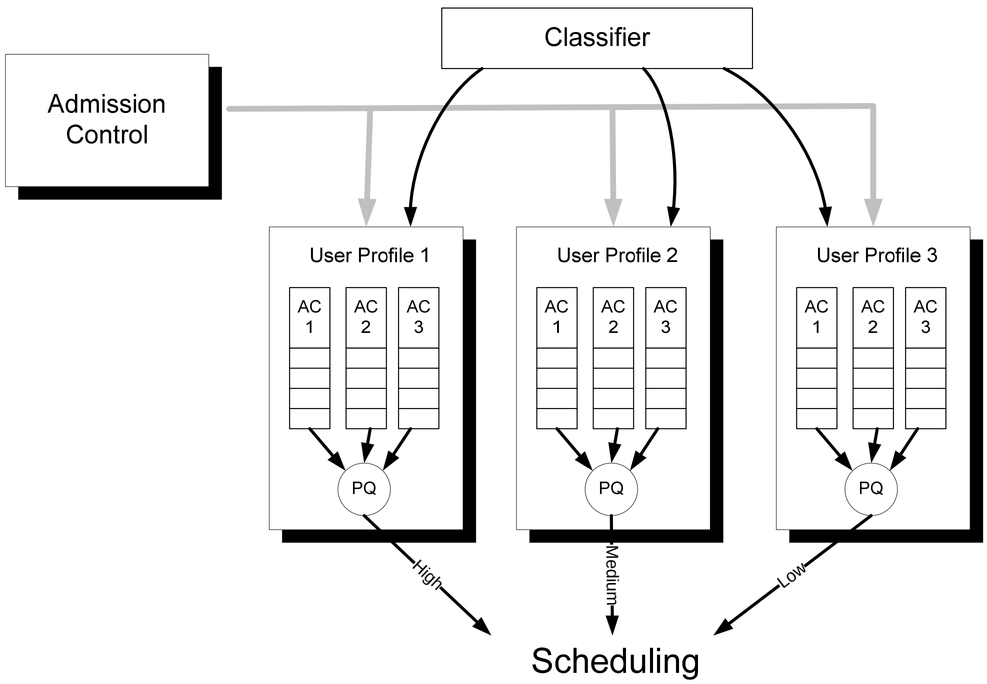

Fig.3 User Profile Model

```
begin
G: Max Group Size
UserProfile1: a group with the highest level user
UserProfile2: a group with the medium level user
UserProfile3: a group with the lowest level user
if Count(UserProfile1)< G
  if premium { add flow to PremiumGroup }
  else if intermediate { add flow to IntermediateGroup }
  else if default { add flow to DefaultGroup }
    else { Remove }
if Count(UserProfile2)< G
  if premium { add flow to PremiumGroup }
    else if intermediate { add flow to IntermediateGroup }
    else if default { add flow to DefaultGroup }
  else { Remove }
if Count(UserProfile3)< G
  if premium { add flow to PremiumGroup }
    else if intermediate { add flow to IntermediateGroup }
    else if default { add flow to DefaultGroup }
  else { Remove }
end
```

Fig.4 User Class Pseudo Code

3.2 The Architecture

Figure 5 shows the relationship components in the mobile network. The mobile network consists of four important entities, which are the mobile network nodes, the mobile router, the home agent and the correspondent node. The mobile network nodes do not need to know about mobility and they simply send and receive packets. The packets are sent and received to and from the mobile router using a default routing protocol. When the mobile router is moved and attached to a new point of attachment, the mobile router's operations involve sending a new binding update to its home agent. A mobile network prefix option is included in the binding update message to indicate the prefix information for the mobile network to the home agent. An error processing component interprets any error message received in the binding acknowledgement from the home agent. Examples of error messages operations are the mobile router is not permitted to send packets, forwarding setup failed, invalid prefix and many more.

The NEMO BS protocol is an extension of Mobile IPv6. Therefore, the mobile network transmits all the IPv6 traffic. There are two fields in IPv6 packet format that support QoS, i.e. a traffic class (8 bits) and a flow label (20 bits). The dynamic QoS provisioning model is mapped with the network mobility entity. The dynamic QoS provisioning consists of classification, marking, admission control, queuing 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, i.e. 00100000 and 01000000, where the 00100000 is for a premium service class and 01000000 is for a high priority user. Figure 6 shows the traffic class bits.

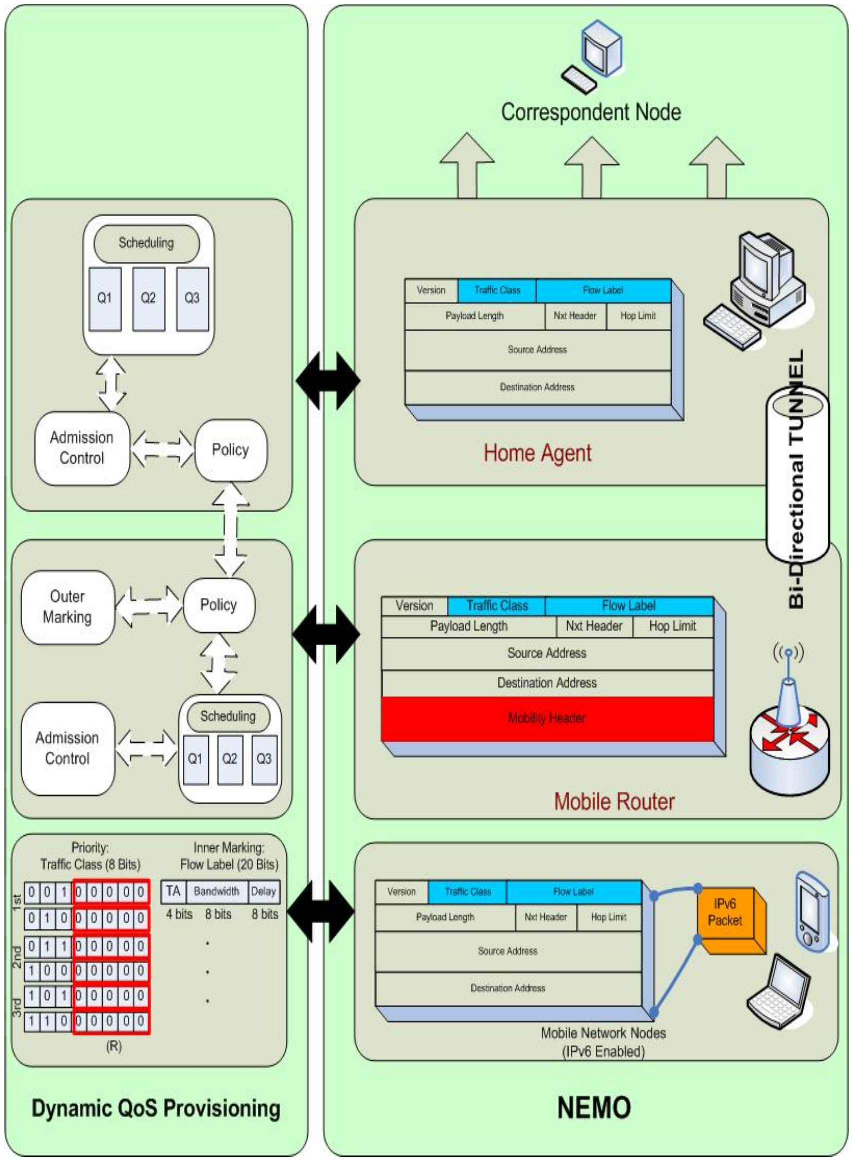

Fig.5 QoS and NEMO Component Architecture

Fig.6 Three User Classes

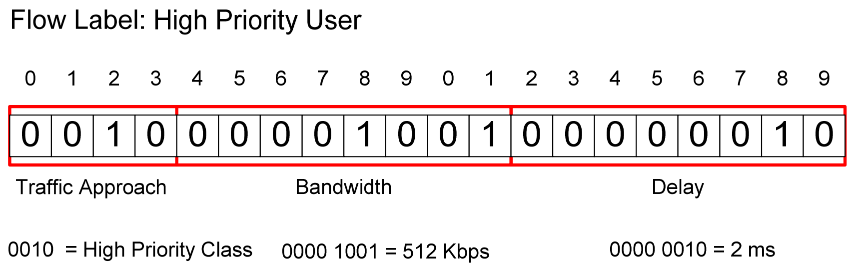

Fig.7 Example of Flow Label for High Priority User

The flow label in the IPv6 packet format is divided into three groups: 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 `No QoS' is marked. If the TA bit is 0010, the packet is marked as high priority user. Figure 7 shows an example of the flow label bits for the high priority user.

After the IPv6 packet has been classified and marked, it is forwarded to the mobile router (see Figure 8). Dynamic QoS provisioning [25] is controlled by the mobile network nodes, mobile router and home agent. To enable dynamic QoS provisioning in the mobile network, five processing functions are performed:

- **Classification.** A packet is classified using the traffic class in the IPv6 packet. The first 3 bits are used to define the classes, i.e. service and user classes.
- **Marking.** The second process is to mark the packet if it matches 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 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 technique used are the priority queue (PQ) and First-Come and First-Served (FCFS). Packets are treated differently according to their classification and marking.

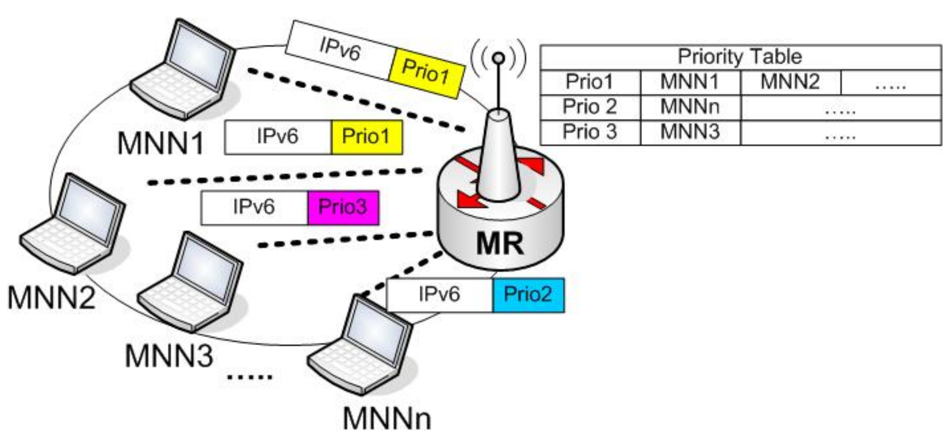

Fig.8. Traffic Classification and Forwarding between Mobile Network Nodes and Mobile Router

3.3 The Method

If bandwidth guarantees have been defined, bandwidth is allocated first to the highest priority user. Once all guarantees have been met, the excess bandwidth is divided between the various traffic classes using the following formulas. To calculate the percentage of excess bandwidth allocated to a traffic class for the specific mobile network nodes (since priorities start with zero, they must be incremented by one for this calculation), use the following formulas:

$$\text{High Priority} = \frac{CP^{High} + 1}{\sum_{i=m}^{n} \text{active\_class\_priority}_i + 1}$$

$$\text{Secondary Priority} = \frac{CP^{\text{Secondary}} + 1}{\sum_{i=m}^{n} \text{active\_class\_priority}_i + 1}$$

$$\text{Low Priority} = \frac{CP^{Low} + 1}{\sum_{i=m}^{n} \text{active\_class\_priority}_i + 1}$$

NS-2 simulator [26] is used to measure the performance of the mobile network. Figure 9 illustrates a simulation setup when the mobile network handover between different administrative domains. The mobile network is attached to 802.11e access point in a foreign network. It consists of multiple mobile network nodes (MNNs) and is managed by a WLAN administrative network. The mobile network's CoA is 2.2.254. When the mobile network moves from the WLAN administrative domain to a Mobile WiMAX administrative domain, the mobile router will register its new location to its home network. The CoA received from the foreign access router is 3.3.254. A detailed registration process is explained in the NEMO Basic Support protocol's document, RFC3963 [1]. Table 1 shows the simulation parameters and values used in this experiment.

Table.1. Simulation Parameters

Parameter	Value
Simulation Time	150 s
Simulation Area	2,000 x 2,000m
802.11 Transmission Range	100 m
802.16e Transmission Range	500 m
Mobile Router Speed	15 m/s
Wired Link	100 Mbps
802.11 WLAN Link	11 Mbps
802.16e Mobile WiMAX Link (64 QAM ¾)	22.44 Mbps

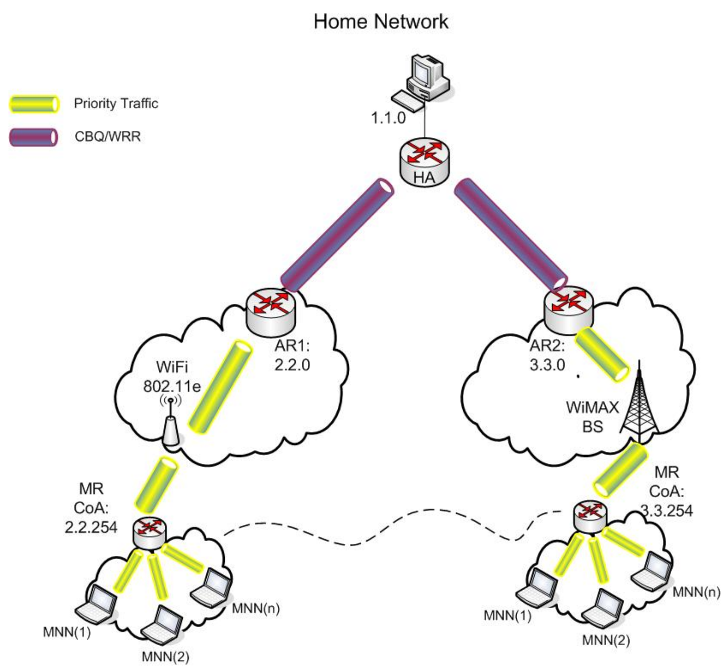

Fig.9. Simulation Topology

The user class was categorized into a higher level, secondary level and lower level. The user class is not dependent on the types of application access as in the service class. A user who wants to be treated higher than other user levels will register as a higher level user. Therefore, if the packets come from a higher level user, it is prioritized first compared to the other level users. In this experiment, the medium CBR packet size, 500 Bytes and the data rate, 200 Kbps were used. The simulation time was 150 seconds. The set of experiments for the user class is listed as follows.

3.3.1 Off Peak Hours

The mobile network is suitable to be implemented in a vehicular environment. Therefore, the evaluation is conducted two scenarios, which are off peak hours and peak hours. The off peak hours experiments are divided into four set of experiments.

Experiment 1: There were 18 passengers equipped with their mobile devices. The first 6 passengers were categorized as the higher user class passengers, the next 6 passengers were categorized as the secondary user class and the last 6 passengers were the lower user class. From the 6 passengers in each user class 2 passengers transmitted 2 premium traffic, the next 2 passengers transmitted 2 intermediate traffic and the last 2 passengers transmitted 2 default traffic.

Experiment 2: This was conducted by increasing the number of passengers. There were 12 passengers for each user class. Therefore the train was loaded with 36 passengers. The three service classes were divided equally between the passengers in the user class.

Experiment 3: The numbers of passengers were increased to 45; 15 passengers for each user class.

Experiment 4: 21 passengers for each user class. The total numbers of passenger was 63.

3.3.2 Peak Hours

The peak hours experiments are divided into three experiments. A set of experiment in the user class is listed as follows.

Experiment 1: The train was loaded with 90 passengers, where each 30 passengers were categorized as higher level user, secondary level user and lower level user. In each user class, the 30 passengers were divided into three service classes, i.e. the first 10 passengers transmitted in the premium class, the next 10 passengers transmitted in the intermediate class and the last 10 passengers transmitted in the default class.

Experiment 2: In this experiment, the passengers were increased to 135. The number of passengers was distributed equally, i.e. 45, and each 15 service class traffic was transmitted by the passengers.

Experiment 3: The maximum number of passengers for this experiment was increased to 153.

During these experiments, the average throughput, average end-to-end delay and packet loss rate were calculated. The results for the user class off peak hours and peak hours are compared and discussed in the results section.

4. RESULTS AND DISCUSSION

In this evaluation, the numbers of users during off peak hours were increased from 16 to 63. In peak hours, the number was increased to 150 at its maximum. To simplify the evaluation for this scenario, each user class (profile) transmitted multiple traffic for the classes equally, i.e. premium, intermediate and default. Traffic differentiation is implemented in each user class to provide bandwidth fairness for the traffic classes. Therefore, the bandwidth allocation for premium class is guaranteed in each user profile.

4.1 Average Throughput

Figure 10 shows the results for the off peak hours and peak hours. Figure 10(a) shows the off peak results for the average throughput for all traffic classes. At the beginning of the evaluation process, the user profile 1 shows a-higher average throughput, i.e. 144.33 Kbps. However, the average throughput decreased as the number of users increased. The results for the user profile 2 and the user profile 3 showed similar impact. At 21 passengers for each class, the user profile 1 average throughput was 80.29 Kbps, whilst the user profile 2 was 19.21 Kbps and 16.65 Kbps for user profile 3. During the peak hours (Figure 10(b)), the average throughput for three user profiles did not show much difference from off peak hours at the beginning of the experiment. The average throughput for the user profile 1 decreased from its maximum throughput, from 144.44 Kbps to 58.26 Kbps. However, at 51 passengers, the average throughput for user profile 2 and user profile 3 were 9.23 Kbps and 3.45 Kbps respectively. The average throughput decreased extremely in user profile 2 and user profile 3 because the bandwidth was first allocated for the user profile 1.

4.2 Average End-to-End Delay

Figure 11(a) shows the average end-to-end delay results for off peak hours. During the off peak hours, as the number of users increased, the average end-to-end delay increased too. At 21 passengers, the average end-to-end delay for user profile 3 was 321.99 ms. When the number of user profile 2 increased to 21, the average end-to-end delay increased from 164.22 ms to 287.99 ms. However, for user profile 1, the average end-to-end delay was 210.87 ms. The average end-to-end delay values for each user profile were from different traffic types. Each user profile contained the real time traffic, non real time traffic and best effort traffic. Figure 11(b) depicts the average end-to-end delay for peak hours in each user profile. When the number of users were increased to 51 each, the average end-to-end delay for user profile 1, user profile 2 and user profile 3 were 336.66 ms, 406.90 ms and 461.12 ms respectively. The results were higher because the traffic from each user struggled to gain the network bandwidth. Each user profile contained the same traffic types, i.e. premium, intermediate and default class.

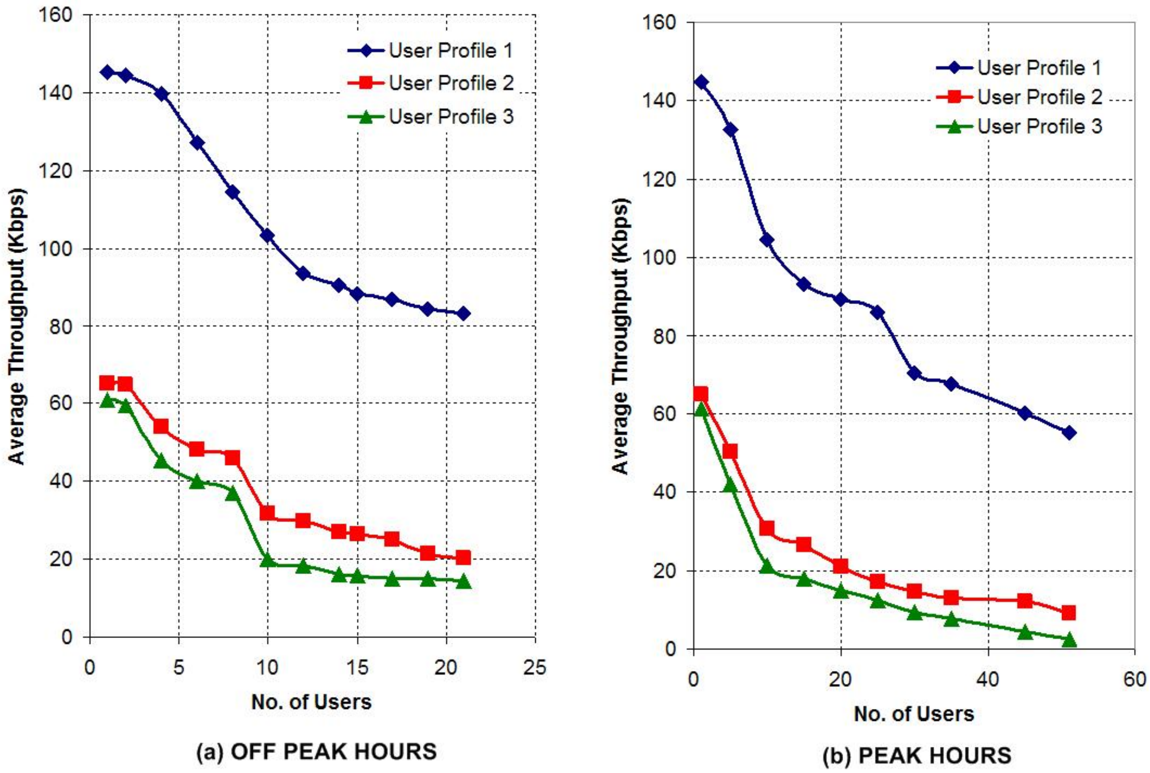

Fig.10. Average Throughput

4.3 Packet Loss Rate

Figures 12 illustrates the packet loss rate for off peak hours and peak hours. During off peak hours (Figure 12(a)), the average packet loss rate for user profile 1 was slightly less than the other two user profiles, i.e. 39.98% at 21 maximum numbers of users. The user profile 2 and 3 generated 57.62% and 59.31% average packet loss rate respectively. During the peak hours (Figure 12(b)), the average packet loss rate in each user profile was higher. The average packet loss rate for user profile 1 was 53.21% at the maximum number of users, 51. Whilst, the average packet loss rate was 91.22% and 100% for the user profile 2 and user profile 3 respectively. The results show a higher loss rate because the traffic types carried by each user profile contains higher delay sensitive applications and required bandwidth guaranteed (e.g. real time).

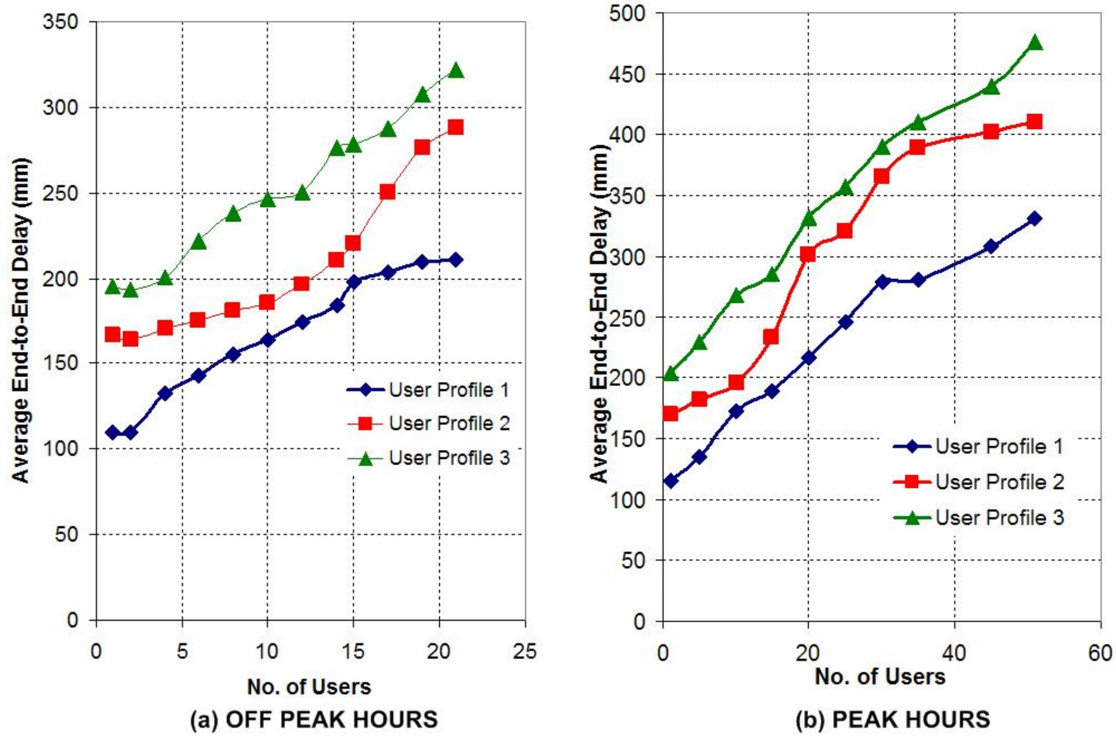

Fig.11. Average End-to-End Delay

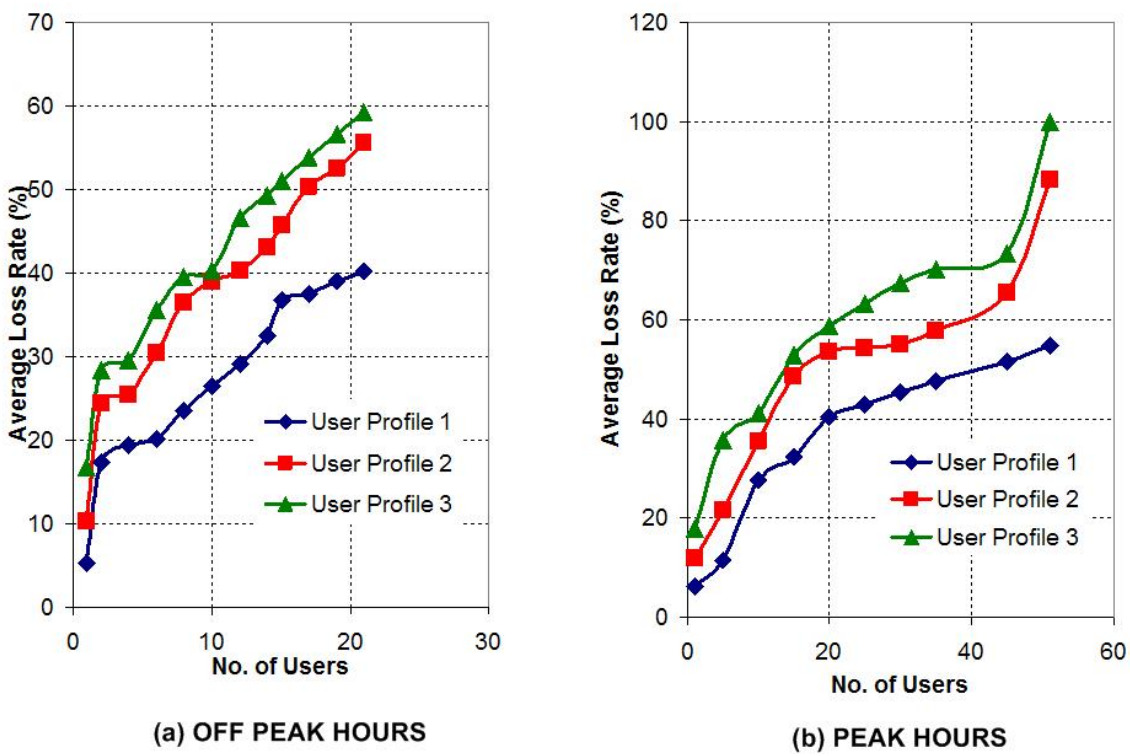

Fig.12. Packet Loss Rate

5. CONCLUSION

User class approach in mobile network was performed to meet the objective of the experiments which is to optimize the traffic according to the user classes. The evaluation was divided into two scenarios, the off peak hours and peak hours train journey. Each case scenario was divided into several separated experiments as the number of passengers increased. The results for the average throughput, end-to-end delay and packet loss rate were presented. The user class approach mechanism provided bandwidth guarantee for selected traffic classes even though there were worse link bandwidth utilization. The simulation results have shown an optimal bandwidth allocation for the high priority user from each scenario. In addition, the evaluation results from the experiments conducted in this article has shown the promising results compared to the results presented in [19] where, the network resources are monopolized by the premium class in the service class approach. Meanwhile, in user class approach the network resources are not monopolized by one particular class. This is because traffic accessed by the user class approach may vary depending on the user needs regardless the user class (or profile). It is clear that none of the works introduced in previous works as discussed in section 2 (as of writing) conducted user class approach experiment to provide QoS in network mobility basic support protocol. Further, this approach enables the integration of varies traffic supported by all level of user classes.

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