DiffServ QoS Provisioning for Real Time Traffic in Frequent Handoff MobileIPv6 Networks

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Summary
The next-generation mobile networks are evolving towards a versatile IP-based network that can provide various real-time multimedia services to mobile users. Two major challenges in establishing such a wireless mobile Internet are support of fast handoff and provision of quality of service (QoS) over IP-based wireless access networks. In this article, DiffServ resource allocation architecture is proposed for the evolving next generation mobile IPv6 networks. The use of DiffServ eliminates the signaling overhead on mobile node during frequent handoff scenario. The IPv6 networks are made to communicate via currently most popular IPv4 Internet through tunneling. Testbed has been set up to support the architecture and evaluate the performance of real time traffic in frequent handoffs of mobile hosts.

Key words: *IntServ, DiffServ, MobileIPv6, handoff, MIPL*

1. Introduction

One of main requirements of next generation IP based networks is providing Quality of Service for real time traffic. The services like video conferencing, audio/video streaming require guaranteed QoS provisioning. QoS for real time traffic is mainly characterized by bandwidth, packet loss rate, delay and jitter. The main scheme by IETF to provide QoS in wired networks is IntServ/RSVP in local networks and DiffServ in core network [3]. With increasing deployment of mobile networks, new mobile devices and emergence of new real time services, there is an increasing need for providing QoS for mobile hosts and mobile networks. Mobility management for mobile hosts is provided by MobileIP [1]. The next generation IPv6 protocol has built-in support to IP-level mobility with MobileIPv6 [2]. There are several issues about providing QoS in MobileIPv6. These include frequent handoffs, roaming in heterogeneous QoS domains, no advance resource reservation in visited networks, packet loss, and delay and duplicated signaling for IntServ MobileIP during handoff [4]. So, for fast moving mobile hosts the increased handoff rate affects QoS in a greater way. When a mobile host moves from one location to another with an active flow, the data flow path changes. As a result, the QoS parameters may change due to changes in the path length and different congestion levels at the routers along the new path. So RSVP renegotiation has to be performed. Before this RSVP renegotiation completes, service degradation could occur due to lack of QoS guarantee in the newly added portion of the path between the correspondent nodes (CN) and mobile node (MN). In case of Intelligent Transportation Systems (ITS) the mobile node/network handoff is frequent during high speed and the signaling overhead will be heavy. In such cases, RSVP renegotiation may be failed. So the handoff delay and dropping should be fatal factors. To provide flexibility and fewer overheads we use DiffServ aggregate packet handling for fast moving mobile hosts.

The rest of the paper is structured as follows. Section 2 describes IntServ/RSVP and DiffServ models in brief and introduces related works. In Section 3 we propose the overall architecture based on these models. Section 4 describes the QoS aware MobileIPv6 testbed setup in our lab and Section 5 evaluates the performance of the proposed mechanism for real time traffic. Finally, Section 6 concludes our approach and suggests further improvements.

2. Background and Related Work

In IntServ model, the path between sender and receiver has to be reserved before the establishment of session. RSVP is employed in this model as a method of conveying QoS information and path setup. It is receiver oriented. The basic RSVP signaling process for a data flow involves the exchange of Path and Resv messages. RSVP is better suited for the services having constant bandwidth requirements for longer period of time but not to the mobile host which has frequent '*handoffs*'. Many schemes have been proposed to minimize the overhead due to Path and Resv messages every time when mobile host moves to new network. MRSVP [5] [6] suggests making reservations to all locations where the mobile host is expected to visit during the lifetime of its connection. It provides mechanism for active and passive reservations. [7] Allows the mobile host to setup and maintain the reservations along the path to its current location. This protocol uses the pre-provisioned RSVP-Tunnels with

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MobileIP. But these proposals for providing QoS based on RSVP have severe scalability problem inherited from RSVP. So IP mobility with RSVP incurs frequent overheads in fast moving mobile hosts.

DiffServ [8] approach provides more flexibility than IntServ/RSVP. It divides the packets in to smaller number of service classes at the network edge. The packets are marked for each class and conditioned at the edge routers according to Service Level Agreement (SLA). For each of the core router in the visited network, QoS for different classes are differentiated by different per-hop behaviors (PHB) [9]. Different types of media can adopt various DiffServ types. For example Expedited Forwarding (EF) class of DiffServ can be used for stream video media and Assured Forwarding (AF) can be used for voice media. DiffServ reduces the heavy signaling overhead of RSVP receiver when the mobile host encounters frequent '*handoffs*'. By employing fast handoff techniques [10] and thereby minimizing the handoff time for the mobile host, QoS guarantee for real-time services and keep the handoff call no dropping.

3. Proposed Architecture

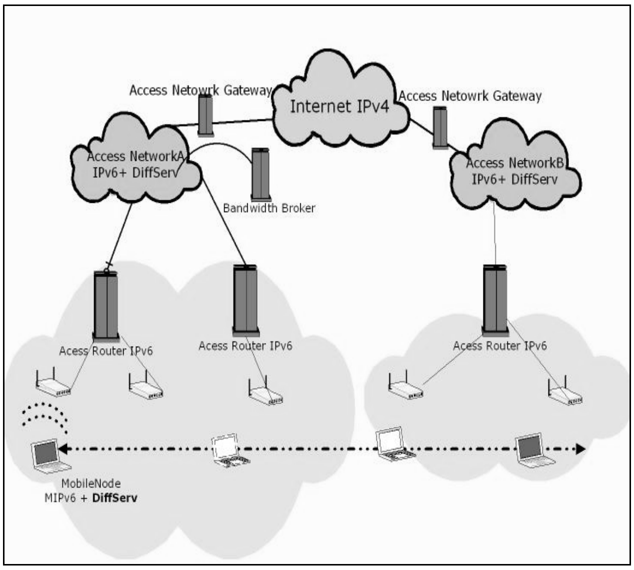

Fig 1 QoS architecture for Mobile IPv6

The network nodes proposed in the architecture are presented in Figure 1. The Access Router (AR) is the IPv6 router delivering packets to and from a Mobile Node (MN) in the visited networks. The access router is responsible for resource co-ordination for access points attached to it. Each AR has separate interfaces for each of its access points and therefore can perform per access point resource allocation. The visited networks are IPv6 enabled and MN is capable for MobileIPv6. This eliminates the requirement for foreign agents. AR can be simple IPv6 router with routing advertisement daemon running in it. AR has same functionality as DiffServ border router upgraded to support RSVP signaling and optionally Service Level agreement (SLA) management with Bandwidth Broker (BB). AR is responsible for service negotiation and setting up proper DiffServ Code Point (DSCP) to IP packets in order to produce a proper forwarding behavior in network routers. The IPv6-in-IPv4 tunnels have to be created between the all IPv6 networks in order to route the IPv6 packets in public IPv4 Internet. Dynamic Tunnel Management can be employed for the same. DiffServ policing and shaping is performed if load exceeds the amount of resources allocated to different Per-Hop-Behavior (PHB) aggregates. The access router has static mapping of SLA or gets the information from Bandwidth Broker (BB) using the COPS protocol.

Mobile Node with MIPv6 capabilities has DiffServ QoS provisioning and thereby eliminating the overhead of RSVP signaling overhead when MN encounters frequent handoffs. This minimizes the packet delay and loss for the MN while changing its point of attachment too frequently. The architecture supports deployment of IPv6 networks in to currently well established IPv4 Internet. When many nodes are connected within the MobileIPv6 network RSVP (IntServ) can be employed between mobile node and MIPv6 enabled mobile router. The following diagram shows deployment of QoS in the architecture.

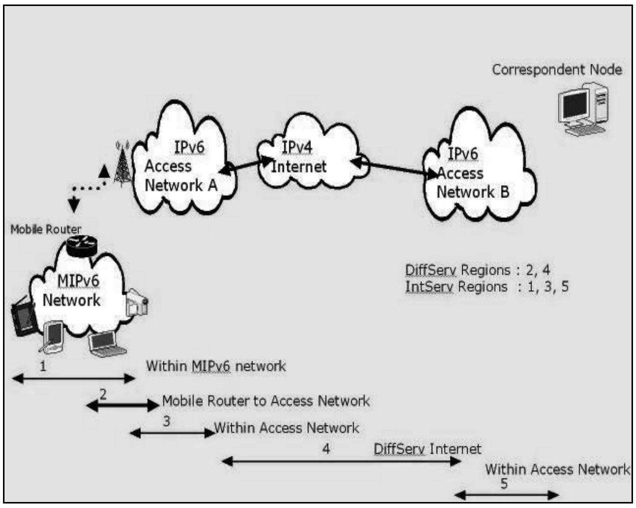

Fig 2 MobileIPv6 QoS provisioning

4. TestBed Setup

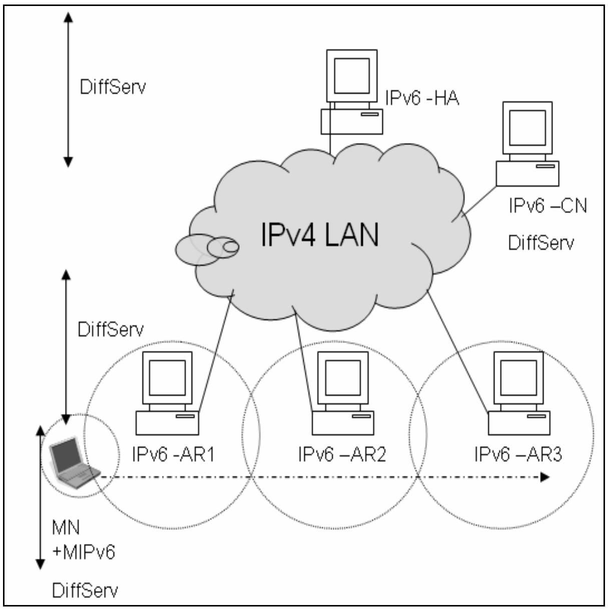

Fig 3 MobileIPv6 testbed setup with QoS support

We have setup the DiffServ enabled MobileIPv6 testbed in the lab to conduct experiments with real-time applications. We have used MIPL1.0 [11] to provide MobileIPv6 feature in both HA and MN. All of the HA, AR1, AR2, AR3 are IPv6 routers and represent the IPv6 network. Correspondent Node (CN) is IPv6 enabled. IPv6-in-IPv4 tunnel are made operational between Home Agent (HA) and all Access Routers (AR*n*) via IPv4 Network. This has been done because the normal public Internet mainly consists of IPv4 domain. The dominant routing is still IPv4 based in Internet. The intermediate IPv4 LAN routes the IPv4 traffic between HA and AR. This adds additional overhead on both HA and AR because of IPv6-in-IPv4 tunneling. DiffServ has been configured in AR*n*, HA and MN.

5. Results and Analysis

We have used MGEN packet generator tool [12] to generate the real-time traffic at CN directed towards MN. Route Optimization (RO) [13] has been enabled to overcome the problem of triangular routing. OpenIMP tool [14] is used to measure end-to-end QoS parameters between CN and MN. We have taken care that MN gets required bandwidth in all access router domains and thus eliminating the need for Bandwidth Broker for simplicity of testbed setup.

MN is registered with HA and moved between different AR with high speed and making frequent handoffs. We carried out different tests in two different cases to measure the one-way delay, average throughput, and packet-loss and delay distribution for real time traffic between CN and MN. Case 1) MN as sender. Case 2) MN as receiver. In both the cases the results were collected for different values of total number of handoffs per minute. The UDP IPv6 packet stream 256 packets/sec of 1472 bytes each was made to flow between MN and CN. In the second case CN was made aware of Route Optimization so that the communication can be done without HA interfering. There is an added delay due to IPv6-in-Ipv4 tunneling.

The figure 4, figure 5 and figure 6 show the packet loss fraction, one-way-delay and delay distribution for MN as sender. MN makes 8 handoffs in 3 minutes between AR1, AR2 and AR3. Average delay varies from 15ms-20ms during handoffs. Average loss fraction ranges from 0.2 to 0.5 during handoffs. The Figure 7, figure 8 and figure 9 show the delay distribution, packet loss rate and one-way delay for MN as receiver. The MN makes 4 handoffs in 1 minute between AR1, AR2 and AR3. The average delay varies between 12ms-14ms for the UDP IPv6 stream and packet loss fraction ranges from 0.2 to 0.5. The one-way delay between CN and MN has little breaks when the MN moves to Route Optimized AR. The delay decreases because the packets need not travel via HA to reach MN. CN tunnels the packets directly to MN through AR. UDP IPv6 stream between CN and MN is encapsulated in double Tunnel. The inner tunnel is IPv6-in-IPv6 and outer tunnel is IPv6-in-IPv4 for normal routing in IPv4 Internet. This decapsulation of tunneled stream adds for delay in communication.

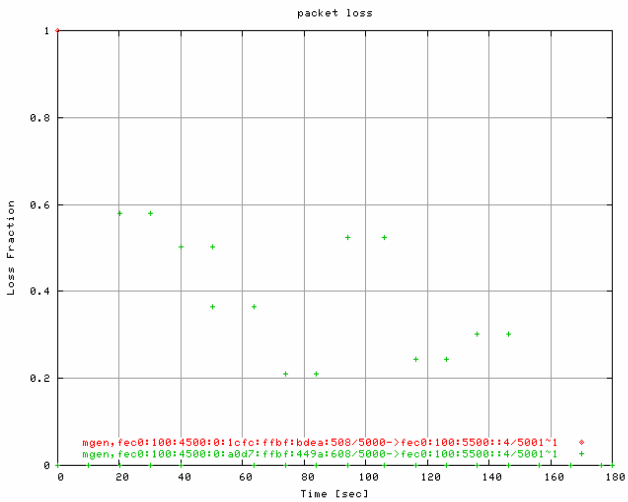

Fig 4. Packet Loss (MN to CN)

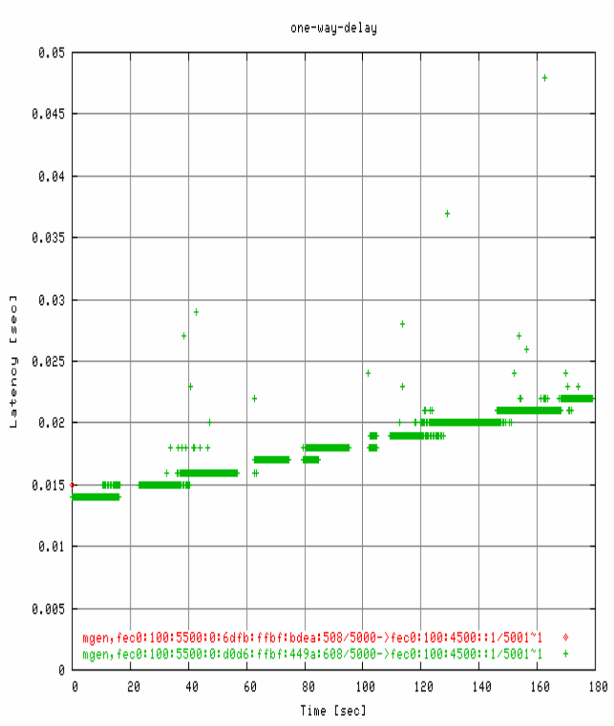

Fig5. One-way-delay (MN to CN)

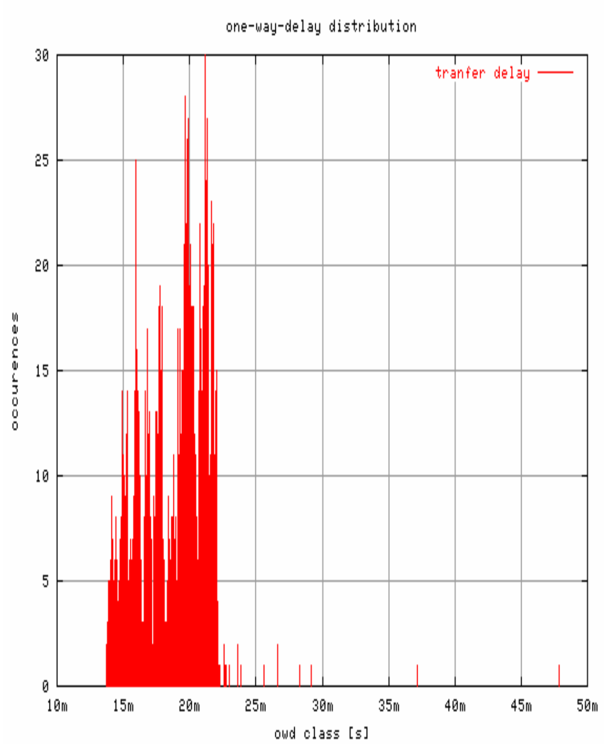

Fig 6. Delay Distribution (MN to CN)

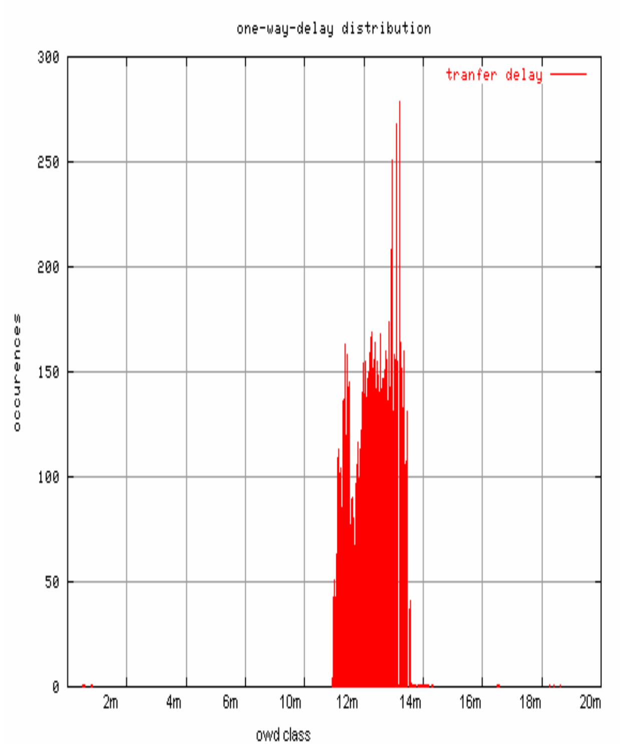

Fig 7. Delay Distribution (CN to MN)

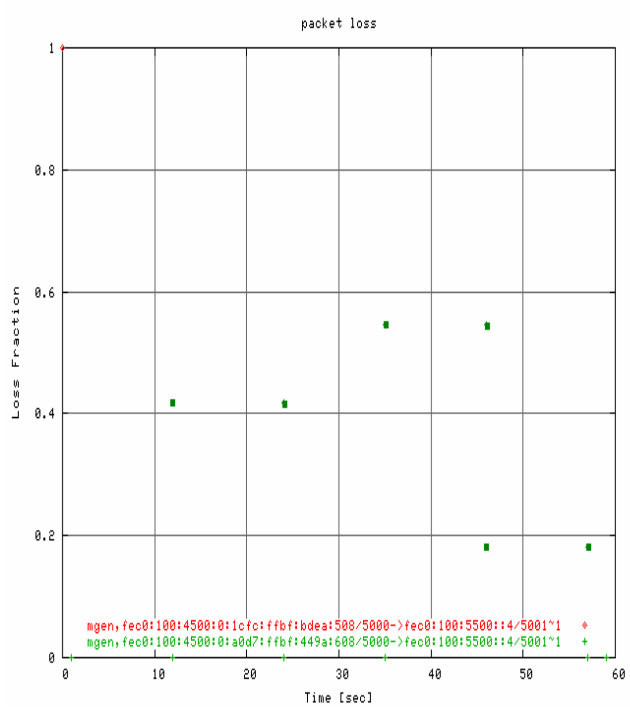

Fig 8 Packet Loss fraction (CN to MN)

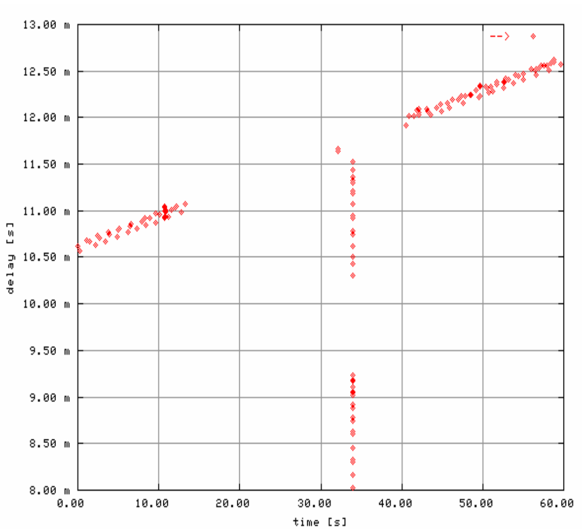

Fig 9. One-Way-Delay (CN to MN)

6. Future Work and Conclusion

The proposed QoS architecture for Mobile Node is independent of mobility issues since we keep the resource states on the edge IPv6 routers and MobileIPv6 node and police the flows according to the resource availability. This minimizes the signaling burden on mobile node when involved in frequent handoff. DSCP mappings are done for the flows. The network architecture is based on the integration of IPv6 in IPv4 networks. This depicted the real IPv6 network deployment. The use of IPv6 provides support for large mobile hosts and next generation mobile networks.

Future work includes use of fast handoff methods to reduce the packet loss ratio, layer 2 signaling for handoff detection or use of SNMP traps. The dynamic DiffServ resource reservation in Access Network can also be incorporated in the proposed architecture and use of dynamic SLA for mobile node with bandwidth brokers.

References

[1] C.E. Perkins, "IP Mobility Support", IETF RFC 2002, Oct 1996. Proposed Standard.
[2] RFC 3775 (rfc3775): Mobility Support in IPv6.
[3] Sangheon Pack and Yanghee Choi, "Seamless QoS handling mechanism for macro and micro mobility", 2002.
[4] Kan Zhigang, Ma Jian, LuoJun and Hu Jianping "Mobile IPv6 and some issues for QoS", The 11th Annual Internet Society Conference (INET2001), Stockholm, Sweden, 5-8 June 2001.
[5] A. Terzis, M. Srivastava, and L. Zhang, "A simple QoS signaling protocol for mobile hosts in the integrated services Internet", Proceedings of the IEEE INFOCOM '99, New York, NY, March 1999.
[6] A.Talukdar and B.R.Badrinath, "MRSVP: A Reservation Protocol for an Integrated Services Network with Mobile Hosts", Wireless Network, 22(7), 2001, pp.5-19.
[7] A. Terzis, M. Srivastava, and L. Zhang. "A simple QoS signaling protocol for mobile hosts in the integrated services Internet", Proceedings of the IEEE INFOCOM '99, New York, NY, March 1999.
[8] S. Blake et al., "An Architecture for Differentiated Services", RFC 2475, Dec. 1998.
[9] V. Jacobson, K. Nichols and K. Poduri, "An Expedited Forwarding PHB", RFC2598, June 1999.
[10] Hidetoshi Yokota, Akira Idoue, and Toru Hasegawa, "Link Layer Assisted Mobile IP Fast Handoff Method over Wireless LAN Networks", MOBICOM'02, September 23–28, 2002, Atlanta, Georgia, and USA.
[11] www.mobile-ipv6.org
[12] MGEN The Multi-Generator Toolset, http://pf.itd.nrl.navy.mil/mgen/
[13] D. Johnson et al., "Route Optimization in Mobile IP", Internet Draft, Nov. 1998.
[14] OpenIMP, http://www.ip-measurement.org /openimp/
[15] Jaehoon Jeong, Jungsoo Park and Hyoungjun Kim, "Dynamic Tunnel Management Protocol for IPv4 Traversal of IPv6 Mobile Network", 2003.
[16] Shou-Chih Lo1, Guanling Lee, Wen-Tsuen and Chen1 Jen-Chi Liu, "Architecture for Mobility and QoS Support in All-IP Wireless Networks", 2003.
[17] Shamini Pillay, Sabira Khatun and Borhanuddin Mohd. Ali, "Handover Delay For QoS-Aware Handover Scheme Using Context Transfer With Link Layer Trigger", M^{2}USIC 2004.
[18] Edwin Hernandez and Abdelsalam helal, "Examining MobileIP performance in rapidly mobile environments: Case of a commuter train", IEEE 2001.

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