A HMRSVP Approach to Support QoS Challenges in Mobile Environment

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Summary
The current Internet architecture with its best effort service model is inadequate for real time applications that need certain Quality of Service (QoS) assurances. Several QoS models are proposed, however, these models were proposed for static environment. The main aim of this paper is to propose a set of protocols that enable the support of seamless mobility with the required QoS. To achieve this, first, the current static environment QoS models are studied, evaluated and compared. Their limitations to support mobility are identified and discussed. Second Mobile RSVP (MRSVP) and its extensions Hierarchal Mobile RSVP (HMRSVP) and Resource Reservation with Pointer Forwarding (HMRSVPpf) approaches are also studied and evaluated. It was shown that the main drawback of these approaches is the scalability issue. Lastly, this paper proposes an extension to the HMRSVP approach to overcome its drawbacks.

Key words:
QoS, HMRSVP, MIP.

1. Introduction

Mobile IP [1] as an extension of Internet Protocol (IP) [2] has solved the mobility issues for the current best effort internet services. This protocol gives the node the freedom to roam in different networks. Mobile IP version 6 (MIPv6) [3] was proposed as enhancement of Mobile IP, it solves the problem of triangle routes in Mobile IP by using the route optimization [4]. Beside the added security feature, MIPv6 gives the advantage of increasing addresses that can be used by different networks.

To support real time applications, different QoS models were proposed. QoS deals with different parameters that required to be achieved by the network. These parameters are the bandwidth, delay, delay variance (jitter) and reliability. The main QoS models are Integrated Services (IntServ) [5] and Differentiated Services (DiffServ) [6] models. DiffServ uses per aggregate technique, where each packet is classified and marked by the edge router. IntServ uses a per flow technique. IntServ uses Resource ReSerVation Protocol (RSVP) [7] for resource reservation, which is done end to end. It has one main draw back which is the scalability.

However, these models when designed were for static environment, in which IP address of the host doesn't change. So the mobility issue was out of mind. Hence the current QoS models don't support mobility. Mobility created more than one issue to be addressed and solved. In order for QoS to be supported an extension was required to be done.

This paper is organized as follows, QoS for mobile IP are going to be reviewed in section two. Section three describes the limitations of DiffServ and IntServ. Section four presents RSVP Extensions,. In section fiv, the proposed Hierarchical MRSVP with Optimal Routing is explained (HMReSVPor). Section six covers the numerical analysis used to compare MRSVP and its extension, with our proposed protocol. Section sen contains results and discussion. This paper ends with the conclusion.

2. Related work

Previous works on simulative analysis of hybrid QoS models were done greatly on extending WLAN IEEE 802.11 with DiffServ. It did not include the RSVP signaling for the wireless network [8][9]. Other works were presented on QoS of IntServ over DiffServ but lacked simulation and comparison with the non-QoS wireless networks [10][11]. Extending DiffServ with

Manuscript received January 5, 2009
Manuscript revised January 20, 2009

MPLS is active work in the network community, but it lacks the QoS for the wireless networks since it assumes it uses the standard protocols [12]. Araniti, Iera and Pulitano has discussed the hybrid model of IntServ over DiffServ using MIPv4, hence work to evaluate QoS with MIPv6 is needed. Hybrid model was introduced by Sangheon Pack and Yanghee Choi [13]. But that model studied the effect if the wireless network is in Hierarchal structure, such as Cellular [14] and HAWAII [I5], they didn't study the effect of using 802.11e for their mac layer, and they lacked the simulation.

3. Limitation of DiffServ and IntServ to face mobility challenges

There are several of limitations of QoS models in their static environment, but the limitations which face mobile environment are different and face different challenges.

3.1 Limitation of DiffServ in mobile environment

It is impossible to guarantee a good service to a mobile node in foreign networks. The edge router of the foreign domain will have the full authority to decide weather to let a flow through based upon its current capacity. Thus, an ISP (Internet Service Provider) cannot guarantee its mobile customers a guaranteed premium service.

There is another important issue that arises. That is, the mobility agent and the DiffServ boundary router have, till now, been considered as separate devices. But it may be the same node performing both the functions. So we must figure out, how the functionality of such a node is to be characterized [16].

The service level agreements that a user makes with its service provider are static and have to be manually configured leading to delays. There is a need for dynamic SLA renegotiation mechanisms like the bandwidth broker (BB) protocol as given in [17]. Also, there is a need for a signaling protocol to support SLA negotiation among different networks that the mobile visits.

3.2 Limitations of IntServ in mobile environment

RSVP got different limitation when it comes to mobile environments. For instance, RSVP has no mechanisms to reserve resources in advance from a location where the mobile is "likely" to visit next. In traditional RSVP, reservation can be initiated only from a location where the mobile is currently located.

RSVP does not support reservation over IP-IP tunnels, even though the routers in the tunnel may be RSVP capable. This will cause the routers in the tunnel to be transparent to the quality of service that was guaranteed by the receiver for the application.

There is no provision for passive reservation. A passive reservation is from a location specified in the Mobile Specification file (MSPEC) that the mobile will move to in the future. This file contains the information about the locations and duration that the mobile is likely to visit next [16].

In summary, IntServ provides more powerful service but has serious limitations with respect to network scalability and robustness. DiffServ is more scalable, but cannot provide services that are comparable to IntServ. In addition, scalable and robust admission control for DiffServ is still an open research problem.

4. RSVP Extensions

Previous work has been focused on minimizing handoff time by making advance passive reservations. The following subsection describes the extensions of RSVP to meet the mobility challenges and requirements.

4.1 MRSVP

Mobile RSVP (MRSVP) was proposed by Anup Kumar Talukdar *et al* [18]. MRSVP introduced the concept of passive and active reservations. Proxy agents are required to monitor these reservations. The model assumed a mobile node can determine where it may move and had a data structure named Mobility Specification "MSPEC" which holds this mobility information. Also, passive RSVP messages (PATH and RESV) are introduced. The proxy agent at the current location is called a local proxy agent and the remaining proxy agents in the MSPEC file are called remote proxy agents. An active reservation is made to/from the current location of the Mobile Node (MN) and passive reservations are set up to/from the remote proxy agents. A reservation is activated when the mobile node moves to its respective link and the previously active reservation is toggled to passive state. This should provide seamless handoffs to real-time Internet application, however, causes the model to be too costly to implement as scalability – which is a big problem for RSVP in general – is aggravated by the multiple passive reservations over the Internet.

4.2 Hierarchical MRSVP with Pointer Forwarding

Later, Chien-Chao Tseng *et al.* have proposed Hierarchical MRSVP which exploits Mobile IP regional registration [19], and makes fewer advance resource – only when inter-domain handoff is expected. Passive reservations are not required within a domain as establishing a new reservation from MN to its Mobility Anchor Point (MAP) only requires a trivial amount of time. An extension of HMRSVP was HMRSVP with Pointer Forwarding ($HMRSVP_{pf}$) which was proposed by Chien-Chao Tseng *et al* [20]. In this extension, a direct link to neighbouring leaves is required and passive reservation is only through this direct, one-hop link. This model was a realistic approach to serve real-time traffic as the already reserved path is simply extended; quality of service is not compromised even during a handoff. However, the main limitation of this model is that it does not use optimal routes. In most cases, a triangular route is created because of the chain and hence the reservation cost increases.

The main aim of this work is to propose an extension to $HMRSVP_{pf}$ to overcome the non-optimal routing problem. Section 4 explains our proposed protocol, namely; Hierarchal Mobile RSVP with Optimal Routing ($HMRSVP_{or}$).

5. Hierarchical MRSVP with Optimal Routing

Setting up an optimal path is very useful in minimizing the reservation cost. $HMRSVP_{pf}$ provides better support for both intra and inter domain mobility. However, when the mobile node moves several hops away from the access router from which the chain was initiated, the length of the chain will increase and consequently, the overall reservation cost will increase. The aim of this protocol is to reduce the length of the chain. This is achieved by resetting the chain of active reservation periodically, say every Δt. However, the chain should not be reset frequently as this would cause extra overhead. Current chain length can be determined by simply counting the number of handoffs a mobile node has carried out. A router is assumed to have some technique of knowing its current distance from the Mobility Anchor Point (MAP). This is normally (H-1) where H is the hierarchy level of the visited network tree as shown in figure 1.

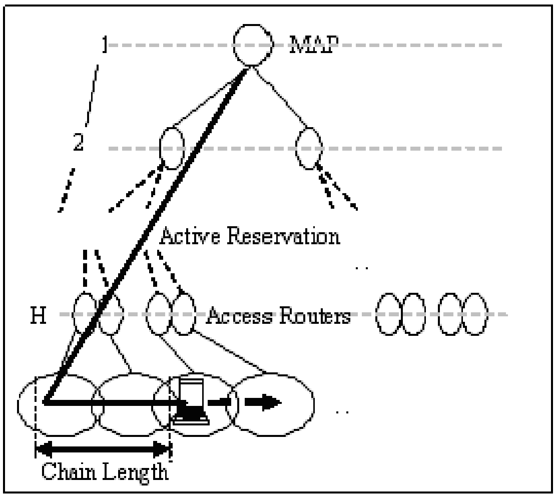

Figure 1: $HMRSVP_{or}$ architecture

The current chain length can periodically be checked against the access router's distance from the MAP. This overhead should be very small because information is retrieved right from the local access router. Different levels of hierarchy cause different optimal chain lengths. The condition to set up a direct reservation to the MAP is that the length of current forwarding chain is equal (or grater than) the distance mentioned above.

6. Reservation cost analysis

Parameters required to measure the reservation cost of the three protocols are:

- Cost of an active reservation of a single-hop, C_a.
- Cost of a passive reservation of a single-hop, C_p.
- The ratio C_p / C_a , which should be less than 1.

For MRSVP*:*

- Depending on the receiver/sender anchor, the length of a reservation path is a relatively large number, we denote it by L.
- Number of proxy agents, remote and local: N

Reservation Cost = Active reservation cost + Passive reservations cost

$$= L\, C_a + \sum_{2}^{N} L_n\, C_p \qquad (1)$$

L_n: Path length from CN to the n^{th} MSPEC proxy agent.

For HMRSVP:

- The active reservation cost should be the same as that of MRSVP. The difference lies in the fact that HMRSVP does not always reserve resources in advance.
- We denote the probability of making inter-domain handoff by μ; this value is normally less than 0.5.

Cost = Active reservation cost + Passive reservation cost

$$= L\,C_a + \mu L\,C_p \quad (2)$$

For $HMRSVP_{or}$:

- Passive resource reservation is one-hop, regardless of length of reserved path to the CN through the Internet.
- We denote the chain's average length by χ.

Cost = Active reservation cost + Passive reservation cost

$$= L\,C_a + \chi\,C_a + (1)\,C_p \quad (3)$$

Figure 2 shows the reservation cost of the different protocols.

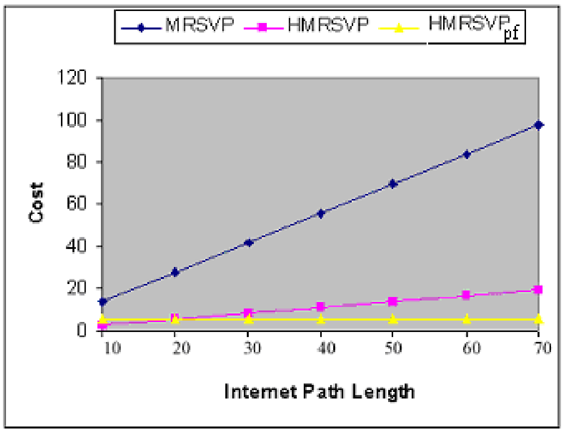

Figure 2: Reservation cost vs. distance from corresponding node.

From the figure above, it can be seen that MRSVP has very high reservation cost compared to HMRSVP and $HMRSVP_{pf}$,.

From equations 2 and 3, we get

- $C_{HMRSVP} \propto 0.4\,L\,C_p$ $\quad \mu$ assumed to be 0.4 $\quad$ (4)
- $C_{PtFwd} \propto \chi\,C_a + C_p$ $\quad C_p / C_a < 1$ $\quad$ (5)

Figure 3 shows the effect of increasing the chain length on the reservation cost.

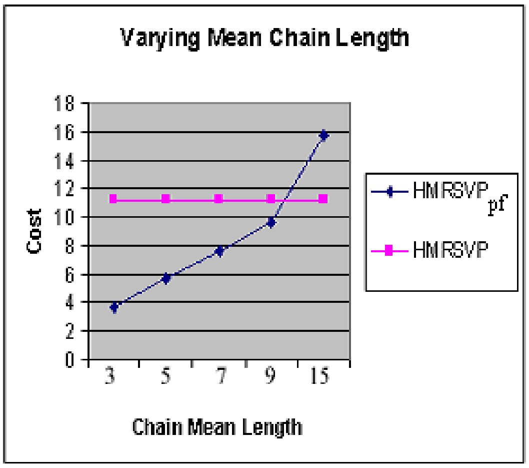

Figure 3: Reservation cost vs. chain length

The following part focuses on the extension made to optimize the reservation length in $HMRSVP_{pf}$,.

HMRSVP:

$Cost_{handof}$ (after intra domain handoff) = $(H-1)\,C_a$ $\quad$ (6)

$HMRSVP_{or}$:

$Cost_{handoff} = C_p + \alpha\,(H-1)\,C_a \qquad \alpha = P\,(\chi \geq H-1)$ $\quad$ (7)

Figure 4, shows the reservation cost after intra domain handoff. It compare HMRSVP and $HMRSVP_{or}$

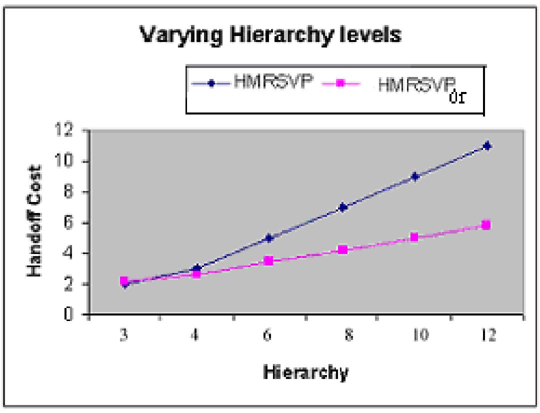

Figure 4: Reservation cost vs. hierarchy level

7. Discussion

Figure 2 shows the suitability of HMRSVP and the Pointer Forwarding schemes. Unlike MRSVP, the two protocols perform better, regardless of the location of the Correspondent Node (CN). The pointer forwarding approach performs better than HMRSVP especially when the CN is located far from the MN.

Figure 3 reveals the need of route optimization in the pointer forwarding scheme. When the chain length is not monitored at all, cost spirals to lofty values.

As anticipated, figure 4 has demonstrated that the addition of optimal routing to pointer forwarding reduces the reservation cost compared to the HMRSVP.

8. Conclusions

RSVP as a QoS module fails to meet the mobility challenges. MRSVP and its extensions support QoS for mobile users. However it was shown that these protocols experience high reservation cost. It was shown that our proposed Hierarchical MRSVP with route optimization protocol can be considered as a practical solution to provide better QoS with less reservation cost.

Acknowledgment

We would to acknowledge the support of the School of Computer Technology, Sunway University College, Malaysia and the Research Management Centre at the International Islamic University Malaysia.

References

[1] C. Perkins, “IP Mobility Support”, RFC2002, October 1996
[2] Information Sciences Institute, “INTERNET PROTOCOL”, RFC791, September, 1981.
[3] D. Johnson, C. Perkins, J. Arkko,” Mobility Support in IPv6”, RFC3775, June 2004.
[4] D. Johnson et al., "Route Optimization in Mobile IP," Internet Draft, Nov. 1998.
[5] R. Braden, D. Clark, S. Shenker, “Integrated Services in the Internet Architecture an Overview”, RFC 1633, June 1994
[6] S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang, W. Weiss, "An Architecture for Differentiated Services", RFC 3260, Dec. 1998.
[7]R. Braden, Ed., L. Zhang, S. BersonS, Herzog, S Jamin, “Resource ReSerVation Protocol (RSVP)”, RFC 2205, September, 1997.
[8] Seyong Park, Kyungtae Kim, Doug C. Kim, Sunghyun Choi, Sangjin Hong, “Collaborative QoS Architecture between DiffServ and 802.11e Wireless LAN”, February, 2003.
[9] Sai Shankar and Sunghyun Choi, "QoS Signaling for Parameterized Traffic in IEEE 802.11e Wireless LANS," LectureNotes in Computer Science, vol. 2402, pp. 67-84, August 2002.
[10] Shahrokh Valaee, “Call Admission Control and Class Assignment in Hybrid IntServ/DiffServ Networks”, proceeding of IASTED Int Conf. on wireless and optical comm., pp.410-415, 2002.
[11] Li Zheng, Arek Dadej, Steven Gordon, ”Hybrid Quality of Service Architecture for Wireless/Mobile Environment”, September, 2003.
[12] Thomas Pliakas and George Kormentzas, “End-to-End QoS Management over Heterogeneous Wireless/Wired Networks”, May, 2004.
[13] Sangheon Pack, Yanghee Choi, “Seamless QoS Handling Mechanism for Macro and Micro Mobility”, Feb, 2003.
[14] A. Valk, "Cellular IP: A New Approach to Internet Host Mobility," ACM Computer Communication Review, January 1999.
[15] R. Ramjee et al., "IP-Based Access Network Infrastructure for Next-Generation Wireless Data Networks," IEEE Personal Communications, Aug. 2000.
[16] Sarabjeet Singh Chugh,” Supporting Quality of Service in Mobile Networks”, project report, April 24, 2000.
[17] K. Nicholas, V. Jacobson, and L. Zhang. A two-bit differentiated services architecture for the internet. ftp://ftp.ee.lbl.gov/papers/dsarch.pdf, November 1997.
[18] Anup K. Talukdar *et al*, “MRSVP: A Resource Reservation Protocol for an Integrated Services Network with Mobile Hosts”, 1997.
[19] H. Soliman *et al., “*Hierarchical Mobile IPv6 Mobility Management (HMIPv6)”, RFC 4140, August 2005.
[20] Chien-Chao Tseng *et al*, “HMRSVP: A Hierarchical Mobile RSVP Protocol”, 2001.

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