AN END-TO-END QOS PROVISIONING ARCHITECTURE IN MOBILE NETWORK[1]

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ABSTRACT

Quality of Service (QoS) provisioning is one of critical issues in the wireless and mobile network. However, the existing works for QoS guarantee focused on only the wireless network characteristics.

In this paper, we proposed an end-to-end QoS provisioning architecture in the diverse mobility situations. This architecture consists the Differentiated Service (DiffServ) model and Integrated Service (IntServ) model. We use service level agreement and the tunneling in DiffServ region for QoS provisioning in macro mobility and proposed a multiple paths reservation scheme using Resource Reservation Protocol (RSVP) for QoS guarantee in micro mobility

The architecture can meet the end-to-end QoS specification for the mobile hosts. Furthermore, it is so flexible and scalable that it can be utilized as the QoS model in the next wireless and mobile networks.

1. INTRODUCTION

Recently, there has been much research on the provision of Quality of Service (QoS) guarantees in wireless network. These studies have focused on several features of wireless networks such as low bandwidth, high loss rate, and constraints of terminals [1]. However, due to the increase in the number of portable devices, the QoS guarantee mechanism must consider the mobility of various terminals as well as wireless network characteristics. Although some researches have been progressed for the QoS guarantee in the mobile network, they have thought about only a narrow sense of the mobility.

In this paper, we present the end-to-end QoS architecture in the mobile network. The architecture is composed of Differentiated Service (DiffServ) network and Integrated Service (IntServ) network based on Resource Reservation Protocol (RSVP). The former handles the QoS provisioning in a wired core network in which macro mobility have been occurred. On the other hand, the latter does the QoS guarantee in a wireless access network in which micro mobility have been happened. Therefore, it can guarantee the end-to-end QoS in various mobility situations.

The rest of the paper is structured as follows. Section 2 introduces the IntServ/RSVP and DiffServ models. In Section 3 we propose the end-to-end QoS provisioning architecture in the mobile network and describe the detail of QoS provisioning mechanism when micro and macro mobility occurres. Section 4 concludes our approach.

2. INTSERV/RSVP AND DIFFSERV

This section introduces IntServ/RSVP and DiffServ models.

2.1 Integrated Service/RSVP

The IntServ model based on RSVP can provide three types of services to users : (i) *Best effort services* are characterized by absence of a QoS specification and the network delivers the best possible quality, (ii) *Guaranteed services* provide users with an assured amount of bandwidth, firm end-to-end delay bounds, and no queueing loss for flows, and (iii) *Controlled load services* assure that the reserved flow will reach its destination with a minimum of interference from the best-effort traffic [2, 5].

To support IntServ capabilities, a method to inform the application's requirements of network elements along the path and to convey QoS management information between network elements and the application is needed. Also, individual network elements along the reserved path must support mechanisms to control the specified QoS requirements. This process is done using a Resource Reservation Protocol (RSVP) [3, 5].

RSVP is a signaling protocol to carry the QoS parameters from the sender to the receiver to make resource reservations along the communication path. The protocol works as follows: (i) The sender of an application sends PATH messages containing the traffic specifications to the receiver(s) of the application. (ii) The receiver received this PATH message sends RESV message to the sender

[1] This work was supported in part by the Brain Korea 21 project of Ministry of Education and in part by the National Research Laboratory project of Ministry of Science and Technology, 2001, Korea

specifying the flow it wants to receive. (iii) As the RSVP message flows back to the sender, reservations are made at every intermediate node along the path. If at any node along the path cannot support the request, that request is blocked. (iv) At every router along the way, path and reservation states are maintained for every session. For refreshment of the path and reservation states, PATH and RESV are sent periodically.

2.2 Differentiated Service

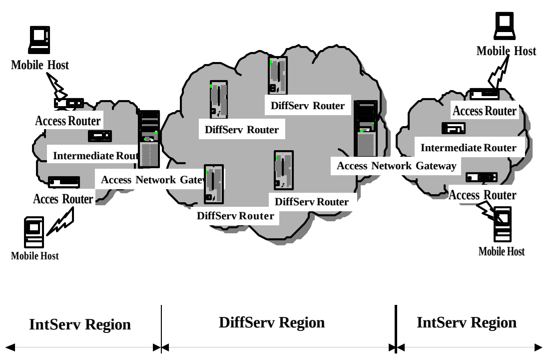
One drawback of IntServ/RSVP is that the amount of state information increases with the number of flows. Therefore it is considered a non-scalable solution for the Internet core network. On the other hand, DiffServ maps multiple flows into a few service levels. The 8-bit TOS (Type of Service) field in the IP header supports packet classification. The TOS byte is divided into 6 bit Differentiated Services Code Point (DSCP) field and a 2-bit unused field [4].

DiffServ is realized by mapping the DSCP contained in the IP packet header to a particular treatment or per-hop behavior (PHB), at each network node. There are various PHBs being defined. For example, Assured Forwarding Service gives the customer the assurance of a minimum throughput, even during periods of congestion.

DiffServ does not have any end-to-end signaling mechanism and works based on a service level agreement between the provider and the user. All packets from a user are marked in a border router to specify the service level agreement and are treated accordingly.

3. END-TO-END QOS PROVISIONING ARCHITECTURE

Figure 1 shows the proposed QoS provisioning architecture. The architecture is composed of two parts: a wired core network and wireless access networks.



[Figure 1: End-to-End QoS Architecture]

The core network uses DiffServ model for QoS provisioning. It is composed of Access Network Gateways (ANG) and DiffServ Routers (DR). ANG plays an interface role between IntServ region and DiffServ region so that it classifies packets and marks DSCP field in the packets. DR is a general DiffServ router forwarding the received packet according to PHBs.

On the other hand, the access network uses IntServ/RSVP model. The routers in an access network are organized as hierarchical structure such as Cellular IP [6] and HAWAII [7]. ANG is a root node in a wireless access network so that it administers resource management to Mobile Host (MH). Intermediate Router (IR) is a general router capable of RSVP messages and Access Router (AR) is a router that acts as Base Station (BS) for MHs.

By combining two models it might be possible to build a scalable network that would provide predictable end-to-end QoS services.

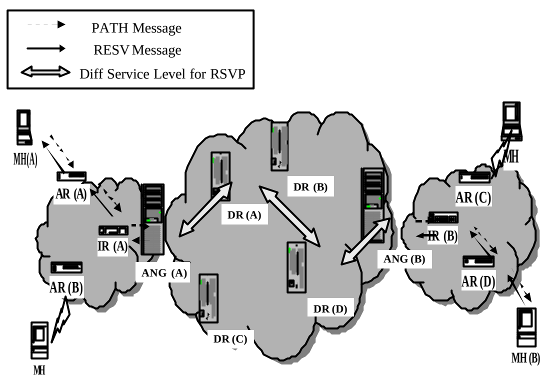
3.1 Initial QoS Negotiation Procedure

The initial signaling process to obtain end-to-end quantitative QoS starts when a MH generates an RSVP PATH message. The generated PATH message is forwarded to ANG along the AR and IRs.

Then ANG sends the received PATH message towards the DiffServ region. To forward the PATH message, ANG maps the message to the DiffServ service level. The service mapping is possible by defining a new class [8] or utilizing the existing classes. After the service mapping procedure, the PATH message is routed based on PHB.

When the PATH message gets to the destination IntServ region, the message is processed according to the standard RSVP processing rules. When the PATH message reaches the destination MH, the host generates an RSVP RESV message. And the RESV message is routed to the source MH along the reverse path.

Figure 2 shows this initial QoS negotiation procedure in the proposed architecture.



[Figure 2: Initial QoS Negotiation Procedure]

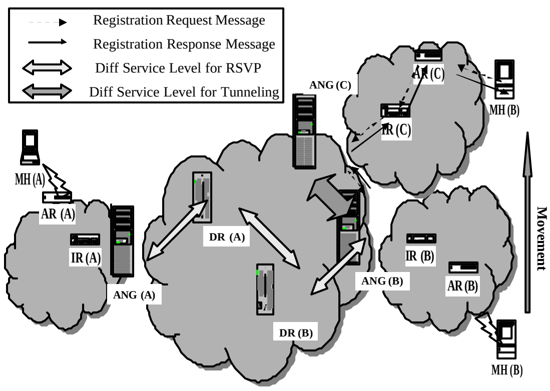
Of course, the request may be rejected at any node in the IntServ region according to IntServ admission control. Also, ANG triggers the admission control when it receives the RESV message. The ANG compares the resources requested in the RESV message to the corresponding DiffServ service level. If there are enough resources in the DiffServ region and the request fits in the customer's SLS (Service Level Specification), the request is granted. If not, the RESV message is not forwarded and the appropriate RSVP error message is sent back to the receiver.

3.2 QoS Provisioning in Macro Mobility

For the mobility management with shorter handoff latency, Caceres proposed the hierarchical mobility management [9]. According to this approach, we described the QoS handling scheme in mobile network as two categories: macro mobility and micro mobility.

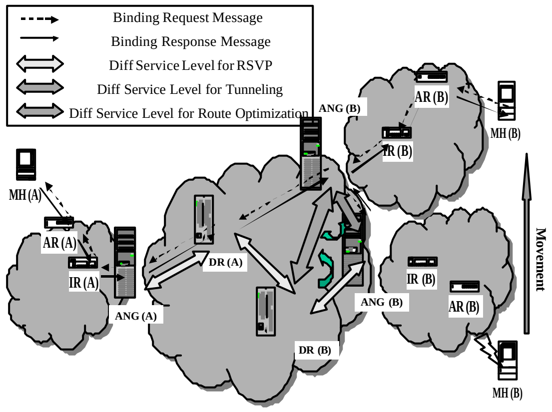
Macro mobility means that a MH moves from an access network to another access network. In such cases, it is necessary to inform the home domain of the movement because of security, billing, and other considerations. The macro mobility is generally handled by Mobile IP [10].

To negotiate QoS specification in macro mobility, the service classification and tunneling between ANGs are needed. When a MH moves to a new access network, it sends registration message to a foreign ANG in that access network. Then the ANG performs service level agreement with the previous ANG for packet tunneling. For seamless mobility, the service level for tunneling must be a service level capable of forwarding packets in the limited time bound.



[Figure 3: QoS Provisioning in macro mobility without route optimization]

Figure 3 shows the QoS negotiation procedure based on Mobile IP without route optimization. If the route optimization can be supported, the additional service level agreement between the foreign ANG and the ANG of the correspondent host is performed through Binding Update procedure. Figure 4 describes the QoS negotiation procedure based on Mobile IP with route optimization [11].



[Figure 4: QoS Provisioning in macro mobility with route optimization]

3.3 QoS Provisioning in Micro Mobility

Unlike macro mobility, micro mobility means that a terminal moves from one cell to another adjacent cell retaining IP connectivity. Since a cell size becomes smaller and smaller in the next mobile network, the micro mobility will happen more frequently. Therefore, the QoS provisioning in micro mobility is and important issue [12].

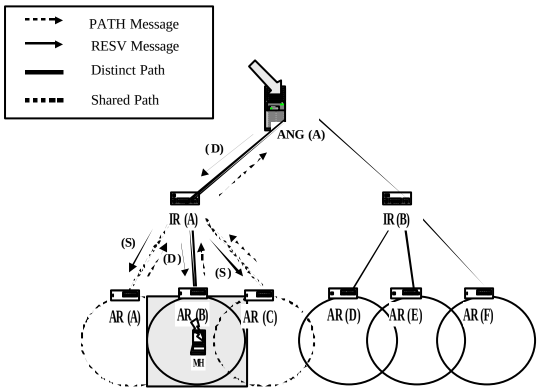
The QoS negotiation in micro mobility is based on the IntServ/RSVP model. However, the standard RSVP does not consider mobility at all. So we present modified RSVP mechanism that is more suitable to mobile environment. The modified RSVP mechanism reserves multiple paths by utilizing various reservation styles

RSVP flow reservations can be categorized into two major types: distinct and shared reservation [3]. Distinct reservations are appropriate for those applications in which multiple data sources are likely to transmit simultaneously. It requires separate admission control and queue management on the routers along its path to the receiver. On the other hand, shared reservations are appropriate for those applications in which multiple data sources are unlikely to transmit simultaneously.

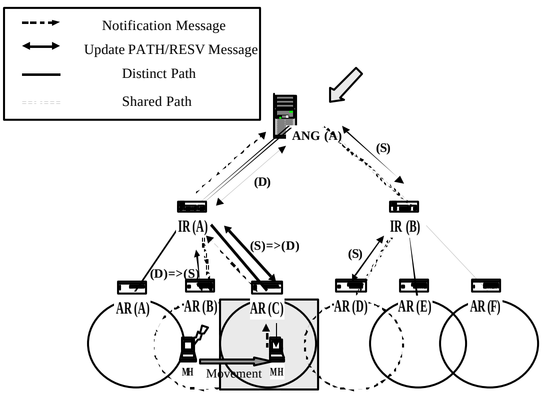
In the multiple paths reservation, when a PATH message arrives at ANG, the ANG reserves one distinct path to the AR belonging the destination MH and multiple shared paths to the ARs of the adjacent cells. Multiple shared paths are reserved by multicasting at the ANG.

Figure 4 presents the multiple path reservation mechanism. ANG(A) receiving a PATH message send the PATH messages to several ARs. First, it unicasts a PATH message to the destination MH. Then the MH sends RESV message to the ANG(B) and this RESV message reserves the distinct reservation path from the destination MH to ANG(A). In addition to unicasting, ANG(A) performs multicast to the adjacent ARs such as AR(A) and AR(C). AR(A) and AR(C) send the RESV message for the shared path reservation.

When a MH enters into a neighbor cell, the reservation update procedure is performed as described in Figure 6. MH sends the notification message to a new access router, AR(C). Then AR(C) relays the notification message to ANG(A) and ANG(A) updates the routing path and multicasts for change of the reservation styles. After then, the path styles to the AR(C) and AR(B) are changed into the distinct style and the shared style respectively.



[Figure 5: Multiple Paths Reservation Mechanism]



[Figure 6: Update Procedure after movement]

Since multiple paths are reserved in not only the specified cell but also the adjacent cells in advance, it is easy to guarantee QoS in micro mobility.

4. CONCLUSIONS

In this paper, we proposed the end-to-end QoS provisioning architecture in diverse mobility situations. It utilizes the scalable feature in DiffServ model and the per-flow resource management in IntServ model.

The architecture is able to meet the QoS requirements between two mobile hosts. In macro mobility, service level agreement and the tunneling between ANGs are required and in micro mobility multiple paths reservation scheme is used.

The most important entities in our architecture are ANGs. In macro mobility environment, it plays a role of the foreign agent or home agent and negotiates service level for packet forwarding with another ANG. Besides, in micro mobility, it is a root node in a hierarchical access network so that performs a packet routing for seamless handoff and a multicast for multiple paths reservation.

Since all nodes except ANG keep the standard DiffServ and IntServ/RSVP mechanisms, the architecture is so flexible and scalable. Therefore it will be able to be applied as the QoS model in the next wireless and mobile networks.

REFERENCES

[1] I. Mahadevan and K. Sivalingam: "Quality of Service Architecture for Wireless Networks: IntServ and DiffServ Models," I-SPAN, 1999.

[2] R. Braden, D. Clark, and S. Shenker: "Integrated Services in the Internet Architecture: an Overview," IETF RFC 1663, June 1994.

[3] R. Braden, L.Zhang et al.: "Resource ReServation Protocol (RSVP) – Version 1 Functional Specification," IETF RFC 2205, September 1997.

[4] S. Blake, D.Black, et al.: "An Architecture for Differentiated Services," IETF RFC 2475, December 1998

[5] X. Xiao and L.Ni: "Internet QoS: A Big Picture," IEEE Network, March/April 1999.

[6] A. Valk: "Cellular IP: A New Approach to Internet Host Mobility," ACM Computer Communication Review, January 1999.

[7] R. Ramjee, T. Porta, L. Salgarelli, et al.: "IP-Based Access Network Infrastructure for Next-Generation Wireless Data Networks," IEEE Personal Communications, August 2000.

[8] G. Mamais, M. Markaki, G. Politis, and I.S. Venieris: "Efficient Buffer Management and Scheduling in a Combined IntServ and DiffServ Architecture: A Performance Study," ICATM, 1999.

[9] R. Caceres and V. Padmanabhan: "Fast and Scalable Handoffs for Wireless Internetworks," MOBICOM, 1996.

[10] J. Solomon: "Mobile IP: The Internet Unplugged," Prentice Hall, September 1997

[11] D. Johnson, C. Perkins: "Route Optimization in Mobile IP," Internet Draft, November 1998.

[12] A. Campbell and J.Castellanos: "IP Micro-Mobility Protocols," Mobile Computing and Communication Review, October 2000.