An Efficient Resource Reservation and QoS Provisioning Mechanism Based on mSCTP for Next Generation Network

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Abstract

The next generation network (NGN) must provide mobility and multiple interfaces to enable the seamless delivery of packets, in IP mobility environments, with the best possible quality of service (QoS) guarantee. This paper proposes an efficient resource reservation and QoS provisioning mechanism based on mobile SCTP (mSCTP) with network mobility and multi-homing for NGN. To do this, the proposed mechanism does not refresh the reserved resources on the common path through the path management at the time of mSCTP-based handover. The path management is accomplished by maintaining the common path and common routers on the path. To show the validity of the proposed mechanisms, the ns-2 simulator was used. it can provide the end-to-end seamless QoS and resources management in IP mobility environments more efficiently.

1 Introduction

Next generation network (NGN) has been discussed in ITU-T and other standard committee meetings very well. This network is expected to integrate legacy phone service and data service networks using IP technologies. Moreover, NGN should accommodate traffic by new applications and services in addition to one by these legacy networks. To do this, NGN must integrate wireless access, user mobility and IP technology into a seamless whole.

IETF (Internet Engineering Task Force) provides a concept on mobile IP (MIP) which was born due to the needs of mobility in Internet. Although MIP is widely accepted in both industry and research, MIP has several problems, such as high handover latency, high packet loss rate and inefficient routing [1] [2] [3]. Therefore, the several shortcomings of MIP could be worse with the sophisticated managements, in particular, for the resource management for improving QoS.

In order to provide the truly seamless service and soft performance guarantees, NGN must provide mobility and multiple interfaces to enable the seamless delivery of packets, in IP mobility environments, with the best possible QoS guarantee. The use of multiple interfaces is foreseen to provide ubiquitous, permanent and fault-tolerant access to internet, particularly on mobile nodes which are more prone to failure or sudden lack of connectivity. It seems that the transport layer (such as SCTP) is needed so that the several IP addresses in the upper layer can be accepted at the same time, to provide mobility management in end-to-end level.

This paper therefore proposes an efficient resource reservation mechanism with network mobility and multi-homing for NGN. The proposed mechanism uses the mSCTP architecture as mobility management and applies RSVP model for provisioning the resource reservation in end-to-end fashion. However, the RSVP mechanism based on mSCTP can make a waste of resources with the re-reservation of resources on the common path. The proposed mechanism allows the path management at the time of mSCTP-based handover to do not reserve resources on the common path again. Therefore, the proposed mechanism is able to provide an efficient resource reservation for seamless services without termination over different wireless networks.

This paper is structured as followed. Section 2 discusses related work. Section 3 proposes common path mechanism and QoS path management reservation mechanism. Section 4 analyzes resource reservation cost and simulate QoS provisioning mechanism. Finally, section 5 concludes the paper.

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2 Related Work

2.1 Providing end-to-end QoS over MIP

Over the past several years there has been a considerable number of researches to provide QoS to MIP : particularly IntServ, DiffServ and MPLS. However, they are designed in the context of a static environments(fixed hosts and networks). Therefore, these mechanisms are not fully adapted to mobile environments. In the case of applying RSVP based on IntServ to mobile communication environments, there are four problems: the resource pre-reservation, RSVP tunneling, common path identification and the mobile proxy problems [2].

2.2 mSCTP (mobile SCTP)

2.2.1 Motivation of SCTP

Until late 2000, the TCP and UDP have been the only available standard transport layer protocols in the TCP/IP protocol suite. Like TCP and UDP, SCTP resides in the transport layer of the Internet protocol stack and also illustrates an SCTP association using multi-homing and multi-streaming.

- Multi-homing allows two endpoints to set up an association with multiple IP addresses for each endpoint (In SCTP, ”association” is the name for the communication relationship between end points; it is loosely comparable to ”connection” in TCP). These multi-homed endpoints can utilize the redundancy in network, and make high-availability applications perform switchovers during link failure situations without interrupting the data transfer.

- Multi-streaming is used to alleviate the Head-of-Line (HOL) blocking effect resulting from TCP's strict byte-order delivery policy. Each stream is a ”sub-flow” within the overall data flow, and the delivery of ”sub-flow” is independent each other.

The Multi-homing of the SCTP allows an association between two end points span across multiple IP addresses or network interface cards. The Multi-streaming allows data from the upper layer application to be multiplexed onto one channel (called association in SCTP). It is noted that the multi-homing feature of SCTP enables SCTP to be used for IP handover support [5].

2.2.2 SCTP for Mobility

Unlike MIP, mSCTP is motivated to support as transport protocol for seamless handover to be able to apply to IP mobility management, especially using the multi-homing function of SCTP. Here ”seamless” means low latency and low packet loss. [5] and [6] proposed the concept of the mSCTP architecture and evaluated the performance. mSCTP is expected to solve several problems of MIP and steps of mSCTP are as follows :

1. Step 1 : an MN obtains a new IP address.
   While MN moves from old location to new location, obtains a new IP address from new location using DHCP or IPv6 Stateless auto-configuration. The MN is dual-homing while it is in Overlapping Region.

2. Step 2 : the MN adds the new IP address to association.
   MN adds the new IP address to the SCTP association by sending SCTP ASCONF (Address Configuration Change) chunk to the CN. Then, MN sets primary address to new IP address.

3. Step 3 : the CN redirects data packets to an interface card with the new IP address.
   When MN moves further into the coverage area of new location, new data path becomes increasingly more reliable than old data path. CN can then redirect data traffic to the new IP address. This task can be accomplished by the MN sending an ASCONF chunk.

4. Step 4 : mSCTP updates a location manager.
   mSCTP employs and updates a location manager that maintains a database which records the correspondence between MN's identity and current primary IP address.

5. Step 5 : obsolete IP address is deleted or deactivated.
   Deleting the old IP address from the SCTP association is done by sending SCTP ASCONF Chunk to the CN.

Therefore, these steps are exploit multi-homing to keep the old data path alive until the new data path is ready to take over the data transfer, thus achieve a low latency, low loss handover between adjacent subnets [5] [6].

3 Efficient Resource Reservation Mechanism Based on mSCTP

This section proposes the mechanism that can provide an efficient resource reservation on mSCTP. We considered following points for an efficient resource reservation.

(a) The problem of applying IntServ/RSVP to mSCTP.

(b) The mechanism for finding common path.

(c) The problem of applying (a) and (b) to mSCTP.

Finally, we present an end-to-end QoS service mechanism that enables QoS for seamless services on NGN.

3.1 Mechanism of applying Resource Reservation to mSCTP

Table 1 shows the differences focused on RSVP problems about the QoS mechanism in the MIP-based handover environment and those of SCTP-based handover environment.

Table 1. Solutions and Problems of MIP and mSCTP for support RSVP

Problems of RSVP on MIP	Resolutions with MIP	Resolutions with mSCTP
resource pre-reservation	-MRSVP -HMRSVP	No need solutions
RSVP tunneling	-IP encapsulation -RSVP tunneling	No need solutions
common path identification	-using flow labels	Need solutions

First, the decision of resource reservation before handover is closely related to which handover mechanism is used for mobility. SCTP can easily support resource reservation because SCTP-based handover mechanism has the muti-homing functionality for resource reservation. Namely, the resource reservation can be possible to use end-to-end connectivity for handover after the mobile node informs the corresponding node of its mobility.

Secondly, if MIP uses RSVP for resource reservation, the RSVP has tunnelling problem when mobile node moves. Techniques are suggested to solve the tunnelling problem of MIP by encapsulating IP packet into additional IP packet or using additional RSVP tunnelling for mobile node. But these two ways can make the router overloaded for data processing. However, SCTP-based QoS Mechanism doesn't care about tunnelling because the tunnelling is not created when mobile node moves.

Thirdly, the common path search problem according to mobile node's frequent movement from place to place is a very challenging one to be solved. If the end-to-end resource reservation is done every time when mobile nodes moves, the delay for re-reservation or the cost of frequent signalling can make problems to support seamless end-to-end connectivity. So, the new more efficient technique is needed to make resource reservation for new route except previously searched common route.

Until now, we discussed and studied to survey the interworking between RSVP and Mobility, especially MIP to find out the way how to be able to apply RSVP to mobile SCTP. Following steps introduce new brief mechanism with RSVP signals added in mSCTP architecture.

In Figure 1, we draw a timing step for the proposed QoS mechanism based on mSCTP in overlapping area between subnet A and subnet B.

- RSVP-1 : After computed new IP address in mobile SCTP, CN can send Path message along with new IP added.
- RSVP-2 : This step receives Resv message from MN along with new path. According to Path message from CN, MN can send RESV message to intermediate routers along with new path. Intermediate routers which received RESV message will prepare and reserve resources needed to meet a required QoS.
- RSVP-3 : Register requests CN to refresh QoS resource reservation, RSVP protocol belongs to the functions to refresh the resources previously reserved.
- RSVP-4 : Resource reservation in old path is terminated to reduce a blocking rate of new call.

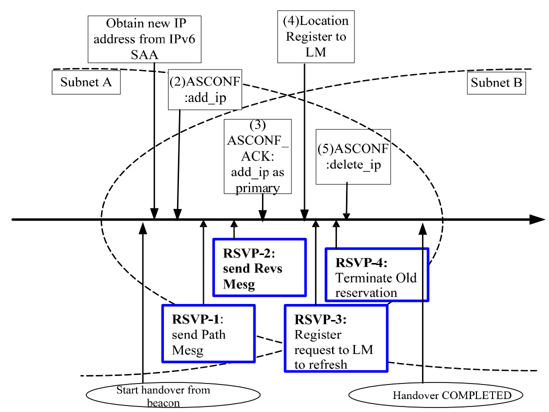


Figure 1. Behavior steps in mSCTP with RSVP messages in overlapped area

The proposed mechanism is big picture to support resource management based on mSCTP as an efficient path management mechanism on NGN.

3.2 The mechanism for finding common path

In Figure 2, when mobile nodes are in the access router (AR) 1 area, it is supposed that the route from correspondent node (CN) to mobile node is CN → router 1 → AR 1 → mobile node (MN). If mobile node moves into AR 2 area, the route from CN to mobile node is CN → router 1 → AR 2 → MN.

The common route is from CN to router 1 and it means that the route is not changed. The end-to-end routers of a

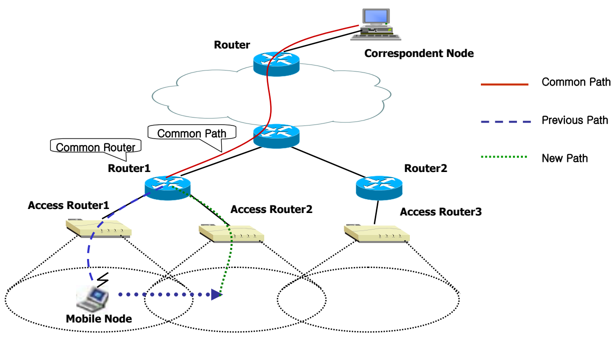
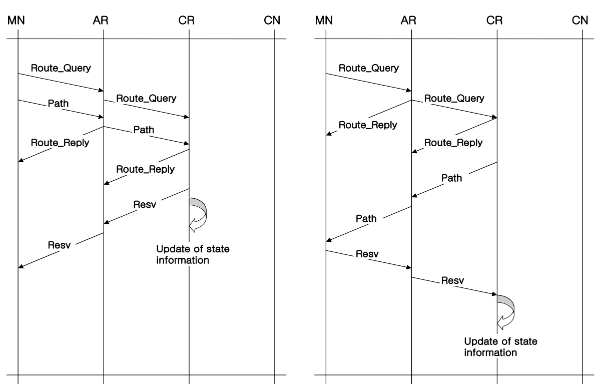


Figure 2. Common Path and Common Router

common route are called the common router (CR). In this paper, we use the Route_Query and Route_Reply message. They are used to search CR and validate the RSVP's state information and request the changed information. The CR can be searched by using at least session ID, destination IP address from the state information. Because of the characteristics of RSVP with unidirectional protocol, it should be considered whether the mobile node is the sender or the receiver. Thus, we considere the CR searching mechanism when mobile node is the sender or receiver shown figure 3.



(a) Mobile node is the sender (b) Mobile node is the receiver

Figure 3. Procedure for finding Common Router

Figure 3 (a) shows the CR searching mechanism when mobile node is the sender. When the mobile node moves into AR 2 area, the mobile node tries to make a resource reservation by sending Route_Query message to the validate state information for the path and sends the path message at the same time to AR in the network. AR checks the session ID and the destination IP address from the message to verify whether they correspond to the its information, and if they do not correspond to the information, AR just let the mobile node know the result using Route_Reply message and sends Route_Query and Path message to the superior router to validate state information for path and try to make a resource reservation in the network topologies same as described figure 2. If the state information from AR corresponds to MN's one, the router will become CR and the AR approves the request of MN's resource reservation. After finishing these procedures, previous common path (e.g., from CN to AR1) and the new established one are annexed to new common path.

Also, figure 3 (b) shows the CR searching mechanism when MN is the receiver. it sends Route_Query to AR to validate state information for path like figure 3 (a). In this case if there is corresponding information, AR becomes CR and response by sending Route_Reply to MN. However, if there is no corresponding information, AR sends Route_Query message to the superior router to validate information and if the information is in accord, the router becomes the CR. Thus, this mechanism used to find common path and make reservation only new path instead of end-to-end re-reservation for NGN and we implements this mechanism using Network Simulator 2(ns-2) simulator in the section 4.2.

3.3 An Efficient Resource Reservation Mechanism

The resource reservation should be made to support seamless connectivity service before MN completely moves into. It should be decided to make a resource reservation previously during procedures of transport-layer handover. When MN moves into overlapping area, MN notifies its new assigned IP address to correspondent node and start to search CR for making a resource reservation on new path after MN got the new assigned IP address. It is very important to make a resource reservation to support seamless end-to-end connectivity before 3-level handover starts.

Figure 4 shows a solution to search CR and to solve a problem of resource pre-reservation. when a mobile node enters new area, receive the beacon from new AR, then mobile node requests new IP from DHCP server of that network and assign new IP. The next, mobile node informs new IP to CN and simultaneously send Route_Query message to find CR for a resource reservation. After it finds CR, the resource reservation between CR and mobile node is achieved. After the reservation is complete, MN sends ASCONF message again to CN to inform of the thing to communicate by using new IP. After the handover finished, the obsolete IP and resources are deleted or deactivated for seamless resource reservation.

Until now, we proposes the mechanism searching a new

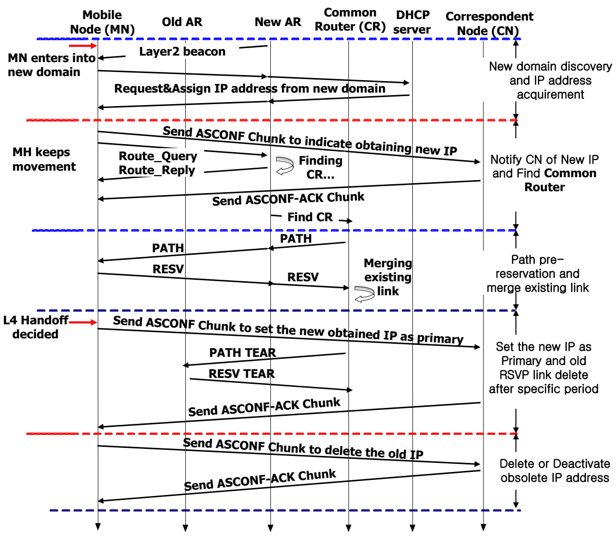


Figure 4. Steps in overlapped area for handover and QoS provision preparing

path during movement of mobile node and making reservation only new path instead of end-to-end re-reservation on the path for providing seamless QoS service based on mSCTP in NGN. In the next section, we analyze the reservation cost in order to verify the proposed mechanism through the experiment on resource reservation while handover using ns-2 simulator.

4 Evaluation

In this section, the resource reservation cost for new searched path and common routers (CRs) is analyzed. In addition, how efficiently seamless connectivity service can be provisioned is shown and analyzed by simulating QoS provisioning through SCTP-based handover during MN's mobility.

4.1 Analysis of Resource Reservation Cost

The resource reservation cost is analyzed using Marcov chain to verify the propriety of SCTP-based QoS mechanism proposed in this paper through comparing the resource reservation cost by new CR search to that by HMRSVP. And the network structure is supposed to be complete the binary tree, which is that GW is a root of the tree. In addition, MN moves only along a leaf node of the tree which is access router (AR). In this case, if the height of complete binary tree is h, the number of leafs is 2^{h-1}. So, Marcov chain is used by modeling MN's irregular mobility because MN moves along leaf nodes, namely AR.

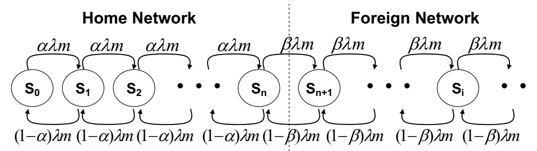


Figure 5. The state transition diagram for behavior modeling of an MN

For simplicity, we model the mobility behaviors of an MN among leaf nodes in the lowest level of the tree hierarchy as Markov chain, as shown in figure 5.

Parameters to be defined here are as follows :

S_i : It means the state whether MN belong to any AR.

$P(i)$: It means the Steady-state probability, which is that an MN stays in a AR with the state S_i.

α : It means probability, which is that an MN may move right which belongs to the home network, gateway namely.

β : It means probability, which is that an MN may move right to its foreign network

λ_m : It means mobility rate of an MN.

We distinguished a home network and foreign network in this model. Because of the better than the probability which moving of home network better than moving of foreign network, when $\alpha > \beta$ and $\beta < \frac{1}{2}$, we can get the expressions following :

$$P(i)\alpha\lambda_m = P(i+1)(i-\alpha)\lambda_m \ , \quad 0 \le i \le n-1 \quad (1)$$
$$P(i)\beta\lambda_m = P(i+1)(i-\beta)\lambda_m \ , \quad i \ge n \quad (2)$$
$$\sum_{i=0}^{\infty} P(i) = 1 \quad (3)$$

From the above equation, when $A = \frac{\alpha}{1-\alpha}$, $B = \frac{\beta}{1-\beta}$, the steady state probability $P(i)$ for all i can get the expressions following :

$$P(i) = A^i \frac{(A-1)(1-B)}{(A^{n+1}-1)(1-B)+A^n(A-1)}, \quad 0 \le i \le n \quad (4)$$
$$P(i) = A^n B^{i-n} \frac{(A-1)(1-B)}{(A^{n+1}-1)(1-B)+A^n(A-1)}, \quad i \le n+1 \quad (5)$$

Equation (4) and (5) are used when an average of resource reservation cost is calculated whenever a handover occurs. The next equation calculates an average reservation cost for only new path whenever a handover occurs.

$Cost_{CR}$ = *average cost which finds CR in a home network + average cost to reserve new region in a home network + average reservation cost in the case to move to a foreign network*

The next equation calculates an average cost for resource reservation from GW to mobile node.

$Cost_{GW}$ = *average reservation cost of a local network + average reservation cost in the case to move to an foreign network*

Some values must be defined to calculate $Cost_{CR}$ and $Cost_{GW}$.

l : It defines the number of hops of CR. Namely, if depth of tree as the number of hops for newly reservation is h, the number of hops become 1 to $h-1$ in the worst case.

ρ : It means the cost of reservation for a hop.

σ : It means cost for query between a hop when search CR.

τ : It represents the cost for the re-establishment path and the moving cost to a foreign network.

S_l : when $i > 0, i \subseteq n$ and $n < (2^{l-1}-1)+2^l$, S_l become element of S_i.

In case the MN moves only in home network by using these values, $Cost_{CR}$ and $Cost_{GW}$ can be calculated following :

$$\begin{aligned} Cost_{CR} &= \rho \sum_{l=i}^{h-1} \sum_{i \in S_l} l(\alpha P(i) + (1-\alpha)P(i+1)) + \\ &\quad \sigma \sum_{l=i}^{h-1} \sum_{i \in S_l} l(\alpha P(i) + (1-\alpha)P(i+1)) \\ &= (\rho+\sigma) \sum_{l=i}^{h-1} \sum_{i \in S_l} l(\alpha P(i) + (1-\alpha) \\ &\quad P(i+1)) \qquad (6) \\ Cost_{GW} &= \rho(h-1) \qquad (7) \end{aligned}$$

When the value of l is from 1 to $h-1$ and $i \subset S_l$, $Cost_{CR}$ is calculated with probability through the expression (6). $Cost_{GW}$ becomes $\rho(h-1)$ because the reservation cost from gateway to mobile node is always reserved whenever a handover occurs.

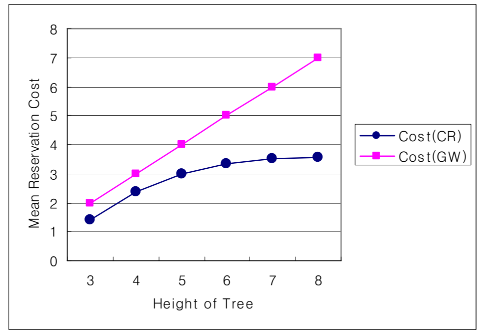


Figure 6. Average reservation cost at handover in local network

Figure 6 shows relations between the cost of reservation and the depth of tree using expression (6) and (7). The reservation cost increases in proportion to the height of tree because $Cost_{GW}$ reserves resources as much as $h-1$ whenever a handover occurs. On the other side, $Cost_{CR}$ can get the result which is that the average cost is not over 4 although the height of the tree increases because it reserves resources for just new route. The method, which searches a common path and reserves new path, consumes less reservation cost than the existing method in mobile environment.

4.2 Evaluation of QoS Provisioning

Figure 7 shows topology for the experiment to evaluate the QoS provisioning.

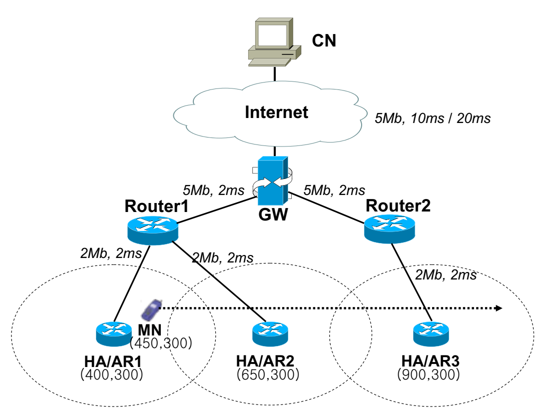


Figure 7. Simulation topology

The CN communicates with a mobile node. A experiment was conducted under the condition which had bandwidth of 5Mb between CN and a gateway and time delay of 10ms and 20ms. We supposed that a mobile node was in the area of AR1(HA) at the first time and made it move to right side. As the figure 7 has illustrated, after 10 seconds, the mobile node started to move from the coordinate(450,300) to another coordinate (1050,300) with 10m/s.

In table 2, compared targets which provide QoS in SCTP-based handover technology are listed. There are two compared targets. One of them is the MIP-based handover technology and the other one is the SCTP-based handover technology. Through three cases, it was tested that how many disconnections are occurred during the data communication. All transport layers use SCTP and traffic uses FTP.

Table 2: Comparison of simulation to handover on mobile environment

	MIP	mSCTP	mSCTP + QoS
IP layer protocol	MIP	IP	IP
Transport layer protocol	SCTP (single homing)	SCTP (multi-homing)	SCTP (multi-homing)
QoS	not used	not used	RSVP

Figure 8 shows the result of measuring transmission amount per a second when handover occurs twice at 12.5 seconds and 25seconds in case the speed of mobile node is 20m/s and the time delay between gateway and CN is 10ms.

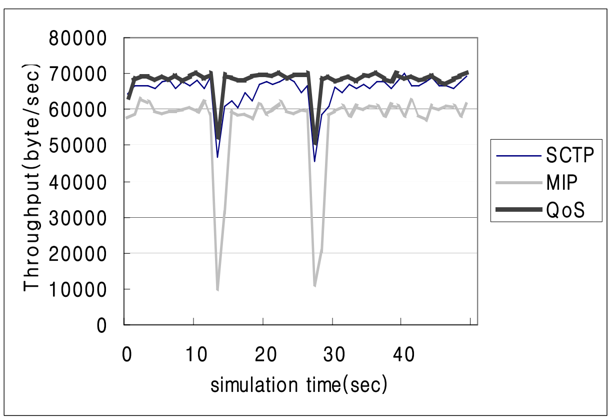


Figure 8. Throughput when speed is 10m/s and delay is 10ms between GW and CN

In Figure 8, the amount of transmission of the MIP-based handover is remarkably dropped the same as when the speed is 10m/s. On the other hand, in case of the SCTP-based handover, it is illustrated that the speed is increased to 20m/s and the amount of transmission is dropped slightly by losing data when the handover occurs. In the case QoS based on SCTP is provided, although amount of data transmission is dropped slightly by losing data, the amount of data transmission is recovered more quickly when resources are reserved previously than not reserved.

5 Conclusion

This paper presented an efficient resource reservation and QoS provisioning mechanism based on mSCTP with network mobility and multi-homing for NGN. The proposed mechanism can make a reservation of resources without the re-reservation of resources on common path. It is because the proposed mechanism searches the common path and common routers on the path, and does not refresh the reserved resources on the path. In the experiments conducted in this research, the proposed mechanism was proven that it consumes less reservation cost than the existing mechanisms. It was also proven that the proposed mechanism recovers more quickly than when the pure RSVP model is used on mSCTP at the time of handover in mobile environments. The proposed mechanism therefore is an useful method to provide QoS and mobility in NGN.

References

[1] Kan Zhigang, Ma Jian, LuoJun, Hu Jianping. : Mobile IPv6 and some issues for QoS, INET2001, Stockholm, Sweden, 5-8 June 2001

[2] Shing-Jiuan Leu, Ruay-Shiung Chang. : Integrated Service Mobile Internet: RSVP over Mobile IPv4&6, Mobile Networks and Applications 8(6), (2003) pp. 635.

[3] C. Andreoli, N. Blefari-Melazzi, M. Listanti and M. Palermo. : Mobility management in IP networks providing real-time services, in: 5th IEEE International Conference, Vol. 2 (1996) pp. 774-777.

[4] R.-S. Chang and A. Chu, : Supporting quality of service communications for mobile hosts with advanced resource reservations, Journal of Internet Technology 1(1), (2000) pp. 1-10.

[5] S. J. Koh, et al., : Mobile SCTP for Transport Layer Mobility, IETF Internet Draft, draft-reigel-sjkoh-sctp-mobility-04.txt, Jun. 2004.

[6] S. Fu and M. Atiquzzaman, : TraSH: A Transport Layer Seamless Handover for Mobile Networks, Technical Report TR-OU-TNRL-04-100.

[7] Weijia Jia, Bo Han, Ji Shen, Haohuan Fu, : Next Generation Networks Architecture and Layered End-to-End QoS Control, ISPA 2005: 1055-1064.

[8] Lee, K.O., Kim, S.Y., and Park, K.C, : QoS evaluation of KT-NGN, 9th Asia-Pacific Conference on Communications, Proc. of APCC 2003, pp.900.903.

[9] Pavlou, G, : Traffic engineering and quality of service management for IP-based next generation networks, IEEE/IFIP Network Operations and Management Symposium, 19.23 April 2004.

[10] J. Hillebrand, C. Prehofer, R. Bless, M. Zitterbart, : Quality-of-Service Signaling for Next-Generation IP-based Mobile Networks, IEEE Communications Magazine, Vol. 42 No. 6, June 2004 pp. 72-79

[11] G. Schollmeier and C. Winkler, ”Providing sustainable QoS in next-generation networks”, IEEE Communications Magazine, vol.42, no.6, June 2004 pp.102-107.