모바일 IP 네트워크를 위한 액티브 라우팅 매커니즘*

박수현**, 장한이***, 이이섭****, 백두권*****

Active Routing Mechanism for Mobile IP Network

Soo-Hyun Park, Hani Jang, Lee-Sub Lee, Doo-Kwon Baik

Abstract

As mobile IP has been suggested only to support mobility of mobile station(MS) by which it dose nothing but guarantee MS's new connection to the network, it is for nothing in Quality of Service(QoS) after handoff of MS. QoS is very important factor in mobile IP network to provide multimedia applications and real-time services in mobile environment, and it is closely related to handoff delay. Therefore as a main issue in mobile IP research area, handoff delay problem is actively studied to guarantee and promote QoS. In this paper, in order to resolve such a problem, we suggest Simple Network Management Network(SNMP) information-based routing that adds keyword management method to information-based routing in active network, and then propose QoS controlled handoff by SNMP information-based routing. After setting up routing convergence time, modeling of suggested method and existing handoff method is followed in order to evaluate the simulations that are carried out with NS-2. The result of simulation show the improvement of handoff delay, and consequently it turns offthe QoS has been improved considerably.

Key Words: Active Network, Simple Network Management Network(SNMP), Information-based Routing, mobile IP, Handoff Delay, QoS(Quality of Service)

---

* 본 논문은 한국 시뮬레이션 학회 2003년 춘계학술대회에서 발표한 내용을 수정, 보완한 것임.
** School of Business IT, Kookmin University
*** LG Electronics Ltd. Core Network Team
**** Software System Lab, Dept. of Computer Science & Engineering, Korea University
***** Software System Lab, Dept. of Computer Science & Engineering, Korea University

1. Introduction

In mobile IP networks, specific QoS traits such as throughput, delay time and error rate are matters of great important factors in case of supporting real time service or multimedia streaming service at the mobile environments.[1-2] In particular, the core requirements of real time service have something to do with packet delay, especially, have a close relation to hand off delay.

Particularly, the IPv6 of next version of IPv4 adopting "binding cache" as a new routing optimization method for triangle routing problems can decrease network load and packet propagation delay as embedding the "binding cache" into a piece of protocol. Nevertheless, for applying binding cache mechanism to real Mobile IP network, all of RFC's regarding the IPv6 are all in proposed-standard status with multivendors support. This means we go first to IPv6 protocol standardization, and to make Correspond Node(CN) aware of changing of routing path to Mobile Host(MH) after CN handoff between cells, CN sends binding update message to MH. This makes multimedia application device have more heavy burden because it requires to add one more Round Trip Time(RTT) to legacy handoff delay between CN and mobile node.[3]

In this paper, to make up for these shortcomings, we begin by Simple Network Management Network (SNMP) information based routing which has been derived from information based routing in active network[4-7] adding Keyup procedure proposing keyword management methodology. By this new routing mechanism, we argue for elevating QoS to minimize handoff delay without any kind of protocol standardization.

We begin by presenting, in section 2, we explain the mechanism of SNMP information based routing. Section 3 shows minimizing scheme of handoff delay by applying new routing suggested in section 2. In section 4, we perform modeling, by example, about needed elements for proposed routing mechanism and legacy handoff technology to setup the routing convergence time. In section 5 and 6, we evaluate suggested new routing mechanism accomplishing simulation for the model of section 4 by using NS-2. Lastly in section 8, we show the anticipated result and conclude by placing our research in the context of further study.

2. SNMP Information Based Routing Mechanism

This section presents SNMP Information Based Routing Mechanism consisting of Keyup and Keyrout procedure. Suggested mechanism abides by the fundamental assumption of beacon based routing as follows.

- Beacon is a specific active node.
- Each active node should be connected to one beacon or more.
- In order to make a decision routing path, beacon broadcasts specific information to all of beacons in the network.
- The routing information of routing table existing at adjacent nodes can be transmitted by the Smart Packets[5].

As shown in Figure 1, for example, by SNMP routing mechanism, service providers(Source in Figure 1) can distribute application program patches to their customers(Destination 1 and 2 in Figure 1) needing the pache fragments. For doing this, even though service providers do not know the exact IP addresses of their customer's nodes, as service providers just send any keyword(e.g. MS_Defense) to beacon (Beacon 1 in Figure 1), the application patch can be delivered to all of customer being in need of receiving the patch program.

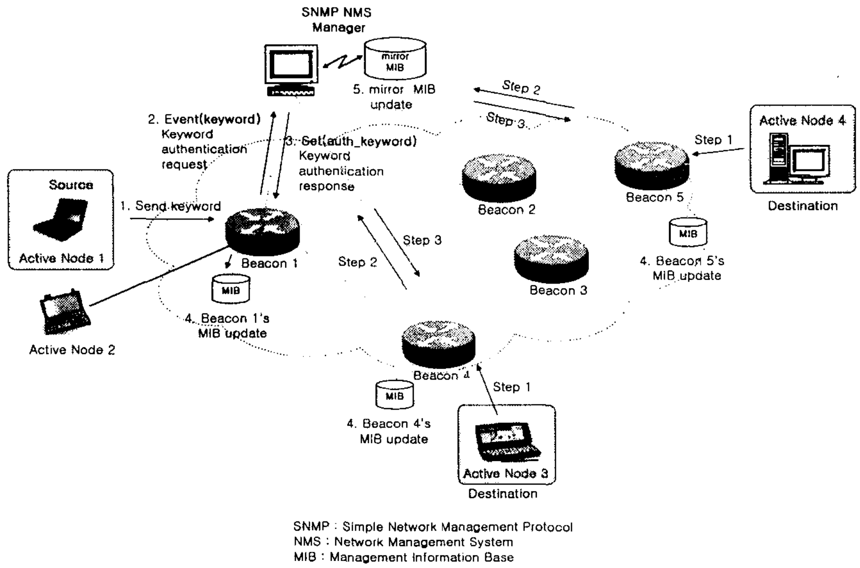


Figure 1 Keyup Procedure

2.1 Keyup Procedure (Keyword Update Procedure)

In information based routing, keyword management is very significant issue since so as to send messages correctly and accurately to destination, we should take much trouble to ensure that keyword being broadcasted to all beacons should be taken charge of keyword uniformly between source and destination node. Therefore, in this section, we suggest Keyup procedure which makes keyword information be controlled in central SNMP network management system (NMS) manager.

Keyup procedure is similar to the keyword update procedure which is applied to SNMP, legacy network management system. The access to Management Information Base(MIB), hence, is accomplished by delivering SNMP Protocol Data Unit(PDU) to manager[11] and in order to administ keyword uniformly in centralized mode, manager has mirrorMIB synchronously storing MIB informations which are changed irregularly at agent of Beacons.(Figure 1)

Next steps shows the Keyup procedure in stages.

① After active nodes(Source, Destination1, 2) create required keyword, they transmit this keyword to Beacon as a Smart Packet encapsulating this keyword.

② The agent of Beacon makes a request for keyword authentication to manager by sending *Event(keyword)* message, that is, Event (1.3.1.2.1.4. 20.1.6) as shown in Figure 2.

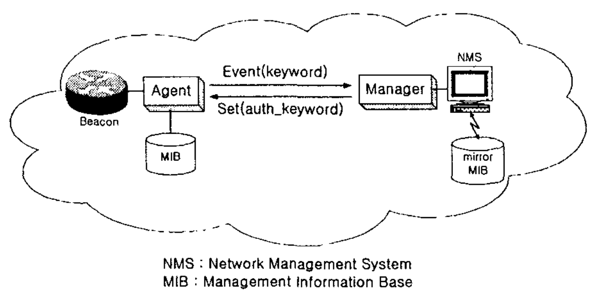
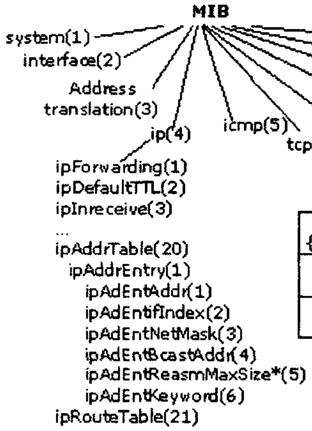


Figure 2 Authentication Procedure between Beacon's agent and Manager

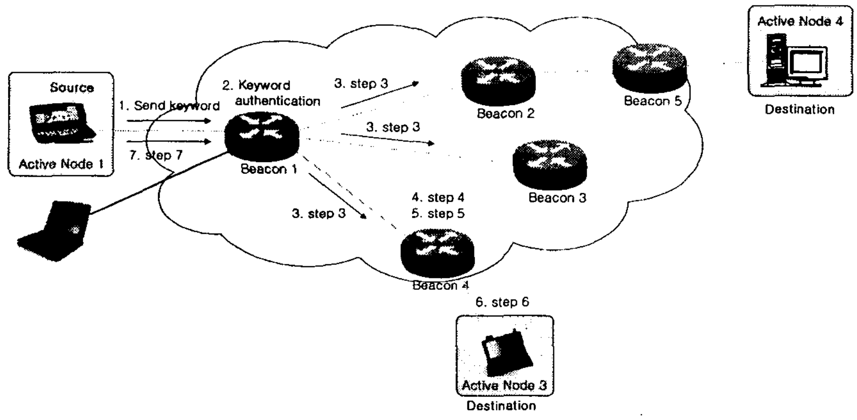


ipAddrTable {1.3.6.1.2.1.4.20}

ipAdEntAddr {1.3.6.1.2.1.4.20.1.1}	...	ipAdEntReasmMaxSize {1.3.6.1.2.1.4.20.1.5}	ipAdEntAuth_keyword {1.3.6.1.2.1.4.20.1.6}
xxx.yyy.150.2	...	12000	MS_Defense
⋮	...	⋮	⋮

Figure 3 Adding auth keyword to ipAddrTable of MIB in Beacon's agent

③ After manager authenticates the keyword coming from the Beacon's agent, it returns *Set(auth_keyword)* message, indeed, Set(1.3.1.2.1.4 .20.1.6) to the agent of Beacon like Figure 2. Also manager transmits Set(1.3.1.2.1.4.21) (Figure 3) message to the agent to update ipRouteTable at Beacon's MIB to add authenticated keyword. For keeping up consistency between manager's MIB and agent's MIB, manager updates its mirrorMIB as identical with the Beacon's MIB information (Figure 4). Every time keywords of active nodes may be changed, in order to achieve centralized administration for the keyword, Beacon informed from the active node makes its agent deliver changed keyword to the manager by Keyup procedure



[STEP Explanations]

step 3 : Broadcast the authenticated keyword to adjacent Beacons
step 4 : Recognize link information between Beacon 1 and Beacon 4
step 5 : Establish link between Beacon 1 and Beacon 4
step 6 : Full channel link is set up AN1-Beacon 1-Beacon 4-AN3
step 7 : Send packets to destination AN3

Figure 4 Keyrout procedure between Source and Destination

2.2 Keyrout Procedure(Routing procedure by Keyword)

Keyrout procedure in Figure 4 is routing path establishment procedure and in this procedure, the authenticated keyword derived from previous Keyup procedure is used. This procedure, for example, has next following steps.

(1) Link setup for the path, Active Node 1 - Beacon 1 - Beacon 4 - Active Node 3

① Beacons(e.g. Beancon 1, 4 and 5) set up links to each active node, e.g. source node(Active Node 1) and destination node(Active Node 3 and 4), which already created keyword and made an request for authentication for the keyword.

② Beacon 1 which has been received keyword from source, Active Node 1, has got authentication over the keyword from the manager through the Keyup procedure. After doing that, Beacon 1 broadcasts the authenticated keyword to all of adjacent Beacons in the network.

③ Beacon 4 obtaining the keyword from Beacon 1 recognizes link information between Active Node 3 and itself. At the following step, link between Beacon 1 and Beacon 4 is established. Accordingly, full channel link is set up for the path, Active Node 1 - Beacon 1 - Beacon 4 - Active Node 3. Through this routing path, active packets are transmitted from Source to Destination 1.

(2) Link setup for the path, Active Node 1 - Beacon 1 - Beacon 2 - Beacon 5 -Active Node 4

Beacon 2 receiving broadcasted keyword through above (1)-① ~ (1)-② steps shall exchange routing table information with adjacent Beacon 5. Consequently, Beacon 2 sets up link connection to Beacon 5 after recognizing that the keyword requested by active node 4 is supplemented to ipRouteTable in MIB of agent of Beacon 5 through the Keyup procedure. Therefore, full channel link is set up for the path, Active Node 1 - Beacon 1 - Beacon 2 - Beacon 5- Active Node 4 and through this routing path, active packets are transmitted from Source to Destination 2.

3. Scheme for Enhancement of Handoff Delay Diminution by Using SNMP Information Based Routing

In this section, by trying to extend SNMP information based routing into mobile environment, we advance a suggestion about enhancement mechanism of handoff delay reduction as follows. We assume that wire node is active node or Beacon and Foreign Agent(FA)has a connection with just one Beacon. Figure 5 shows example of network environment to explain handoff delay decreasing.

① Base Station(BS) - this may be FA or Home Agent(HA) - transmits advertisement messages to Mobile Host(MH) periodically.

② In case MH's leaving out from home network makes an enter into another foreign network, MH listens to FA in order to receive advertisement message. If MH dose not receive advertisement message in a fixed period, MH requires BS to transmit advertisement by sending solicitation message to BS.

③ Depending on network prefix of advertisement message received from FA, MH makes sense roaming of itselffrom another cell. If the network prefix is different, the mobile node assumes that it has moved.

④ If MH knows that it has moved into new network, ittransmits keyword to FA through a Smart Packet.

⑤ When FA receives the keyword from MH, FA conveys the keyword to Beacon 2 directly

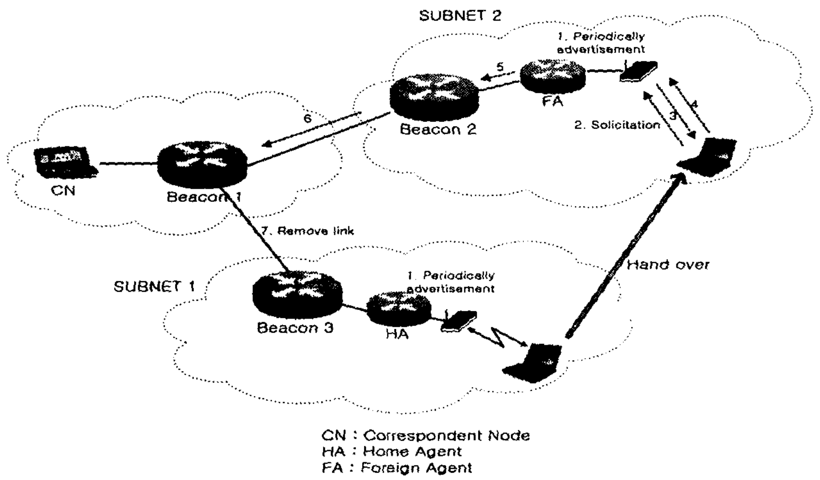


Figure 5 Handoff Delay Reduction by SNMP Information Based Routing

connected from it.

⑥ Beacon 2 delivers the keyword to adjacent Beacon 1 having the same keyword through the Keyrout procedure.

⑦ After Beacon 1 has got the keyword, it removes link to Beacon 3 from routing table and set up new link path to Beacon 2 which has delivered the Smart Packet in the previous step.

Accordingly, packets are transmitted along the newly established routing path, Correspondent Node(CN) - Beacon 1 - Beacon 2 - FA - MH. (The previous routing path was CN - Beacon 1 - Beacon 3 - HA - MH)

4. Modeling for Enhancement Mechanism of Handoff Delay Diminution by Using SNMP Information Based Routing

We can find mobile routing convergence time being a principal factor determining performance of QoS sensitive system in view of the results of performance analysis at multimedia streaming system in mobile IP environment.[3] In this section, we define routing convergence time which means the time required that all the routers throughout network get the same routing information as the elapse time from the point that MH sends solicitation message to FA till the first packet arrives at newly assigned address in MH after MH moves into visited network. Throughout this elapse time, there are a lot of considerable factors to be modeled, such as, address registration cost causing packet loss during handoff delay, cost of packet transmission to novel CoA, tunneling cost, Beacon processing cost.

- Mobile node is random walk mobility model.
- Location update is on the basis of movement-based schema
- Figure 8 and 9 shows network topology in this experiment.
- Processing cost at BS is set to C_A.
- Processing cost at Beacon is put to C_B.
- Transmission cost is be proportioned(constant proportional δ_T) to distance between source and destination.
- Assume that distances between wire and node are d equally
- d' means the distance between BS and MH.
- Mobility rate of mobile node is λ_m.
- Arrival rate of packet is λ_a.

4.1 Address Registration Cost

4.1.1 Handoff Process Model for Legacy Mobile IP Network

Base Station(BS) transmits advertisement messages to Mobile Host(MH)periodically as a polling message. In case MH dose not receive advertisement message within a fixed period, MH requires BS to transmit advertisementby sending solicitation to BS. Depending on network prefix of advertisement message received from BS, If the network prefix is different, the mobile node assumes that it has moved. If MH know that it has moved into new network, MH transmits registration request message to FA. When FA receives registration request message from MH, FA conveys registration request message to HA. HA returns registration response message to FA in order to inform that CoA has been registered. According to this mechanism, at the legacy mobile IP network(Figure 6), the cost of address registration is as follows.

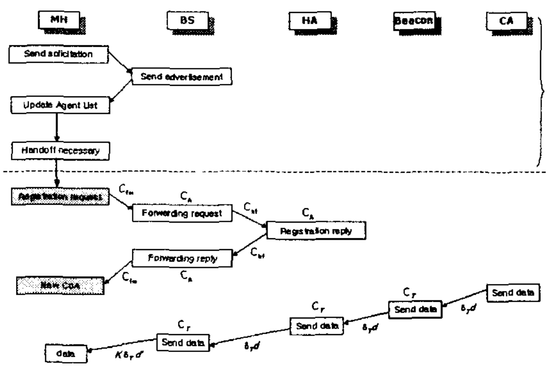


Figure 6 Handoff Process Model For Legacy Mobile IP Network

registration cost/movement = $2C_{hf} + 3C_A + 2C_{fm}$ [13] (1)

① C_{hf} : Handoff cost between HA and FA

Let d be the average distance between HA and FA. Since transmission cost is in proportion to d, C_{hf} is defined as next expression.

$C_{hf} = \delta_T d$ (2)

② C_{fm} : Handoff cost between FA and MH

On the whole, transmission cost to wireless links is higher than that of wire links. Supposing that transmission cost to wireless links is k times as high as that of wire links, C_{fm} can be defined as follows.

$C_{fm} = k\delta_T d'$ (3)

Therefore, average registration cost/movement may be defined as next expression.

$2(d+kd')T + 3C_A$ (4)

Since MH's mobility rate is m, address registration cost is determined to next expression.

$Reg_{\text{mip}} = m\,[2(d+kd')\delta_T + 3C_A]$ (5)

4.1.2 Handoff Process Model for SNMP Information based Routing

In SNMP Information based routing procedure in Figure 7, BS dose not forward registration request message to HA. Instead BS sends Smart Packet encapsulated with keyword to Beacon and the Beacon removes previous links to mobile node.

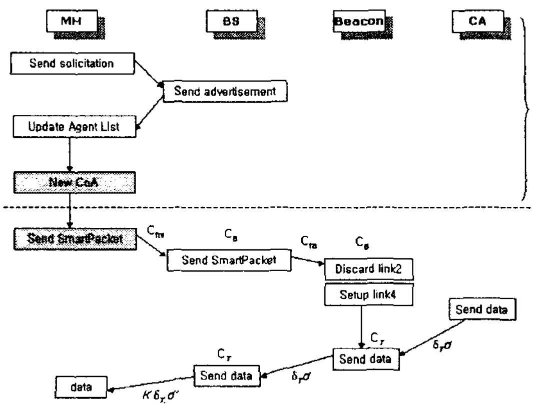


Figure 7 Handoff Process Model f or SNMP Information based Routing

Accordingly, after mobile node has moved into another network, the cost of address registration until previous step to sending data from CN to CoA is defined as follows.

$C_{fm} + 2C_B + C_{fB}$ (6)

Therefore, average registration cost/movement runs as follows.

$(d+kd')\delta_T + 2C_B$ (7)

Since MH's mobility rate is *m*, address registration cost is determined to next expression.

$Reg_{mip} = m\,[(d+kd')\delta_T + 2C_B]$ (8)

4.2. Handoff Delay and Packet Loss

Long period of handoff delay causes mobile nodes to have high packet loss and makes network utilization fall down. Let the packet's arrival rate be a and supposing that arrival of packet is regardless of MH's mobility velocity, average number of packet loss in legacy mobile IP network is defined as follows.

Average number of packet drop/unit time = $\lambda_a\lambda_m\,[2(d+kd')\delta_T + 3C_A]$ (9)

On the other hand, average number of packet drop at SNMP Information based routing procedure is shown as next expression.

Average number of packet drop/unit time = $\lambda_a\lambda_m\,[(d+kd')\delta_T + 2C_B]$ (10)

4.3 Packet Transmission to Novel CoA

In this section, we try to formulate the cost($Cost_{trans}$) for transmission packets from CN to novel CoA after mobile nodes are moved into new network. In case of legacy mobile IP network, $Cost_{trans}$ is the sum of packet transmission costs for triangle routing and tunneling. (Figure 8)

$Cost_{trans} = N(3\delta_T d + 3C_T + k\delta_T d')$, N is the number of packets (11)

However, in case of SNMP Information based

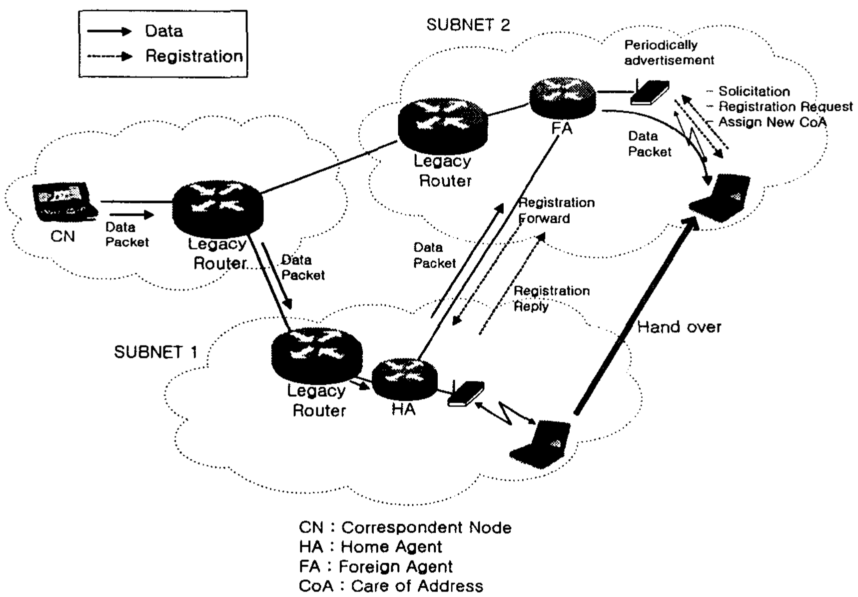


Figure 8 Packet Transmission Path after Handoff in Legacy Mobile IP network

routing procedure, $Cost_{trans}$ is total amount of Beacon processing cost for the first packet and data transmission cost for the optimized routing path.(Figure 9)

$Cost_{trans} = N(2\delta_T d + 2C_T + k\delta_T d')$, N is the number of packets

Considering transmission cost for legacy IP network, we can find the fact that $Cost_{trans}$, packet transmission cost for triangle routing is proportioned to N.

On the contrary, in case SNMP information based routing procedure, since there is just need for Beacon processing for the first packet and after doing that, packets are transmitted through optimized path for N without additional cost for tunneling, we can cut down the cost considerably in comparison with legacy mobile IP network mechanism.

5. Simulations

The NS-2 is an event driven simulator for computer networks and network protocols. Since it is widely used in the research community, a large number of network components are available for ns. In this chapter, by reusing these components, generate the scenario and simulate an existing simple handoff and proposed handoff procedure modeled in chapter 4. System environments for performance evaluation is established as shown in Table 1.

Table 1 System environments

Hardware	Pentium machine
Operating System	FreeBSD 4.5
Software	NS-2 2.1b7a(UC Berkeley wireless extension[11]), Gnuplot
Programming Language	C++, OTcl, Perl

The handoff procedure can be optimized. In proposed optimization, as soon as the Mobile Host notice that it leaves the near range of the current home agent from the network prefix of FA's periodic advertisements, it sends Smart Packet including keyword to Beacon. For enabling of this procedure,

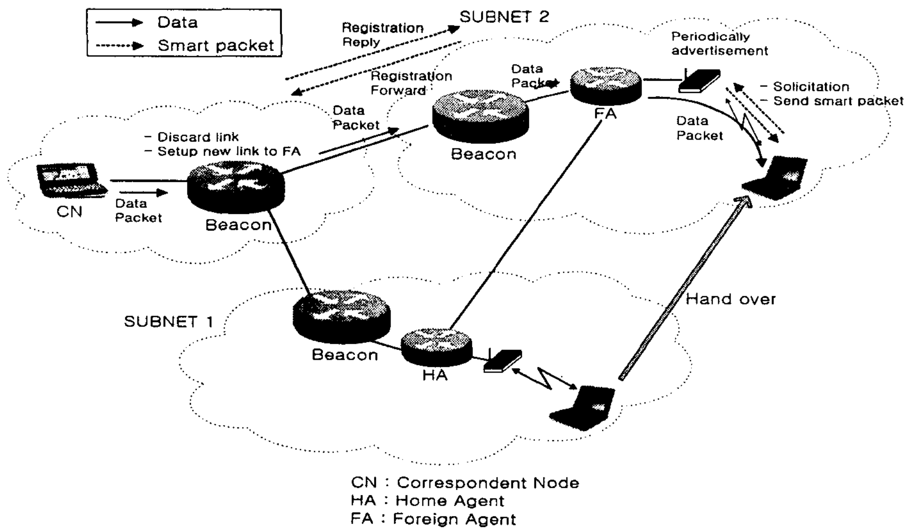


Figure 9 Packet Transmission Path after Handoff in SNMP Information Based Routing

Table 2 Four Cases for Simulation

	IP Layer Agent	Application Layer Agent	Ee Agent
Simulation Case 1	Agent/TCP	Application/FTP	N
Simulation Case 2	Agent/TCP	Application/FTP	Y
Simulation Case 3	Agent/UDP	Application/Traffic/Exponential	N
Simulation Case 4	Agent/UDP	Applica tion/Traffic/Exponential	Y

we define sender and receiver class inherited from Ee Agent to transmit "Smart Packet" among themselves after that notice.

We created several simulation scenarios for ns. The purpose of the following 4 simulations shown in Table 2 is to investigate the impact of the proposed handoff optimization on throughput and network traffic. Scenarios for proposed handoff procedure has Ee Agent for sending Smart Packet during the registration. In contrast with that, there are no Ee Agent in scenarios for simple handoff procedure.

Ns has 3 main inputs, movement pattern file called scenario file, communication pattern file, and router configuration file, to ns.

Movement pattern file describes the movement that all nodes should undergo during the simulation. The duration of the simulation we set up is 200.0 seconds. From time 100.0 on, Mobile Host moves from is original position(2, 2) toward position (640, 610) at 20m/s. (Figure 10) show the generation of topology and movement pattern in simulation scenarios 1 to 4.

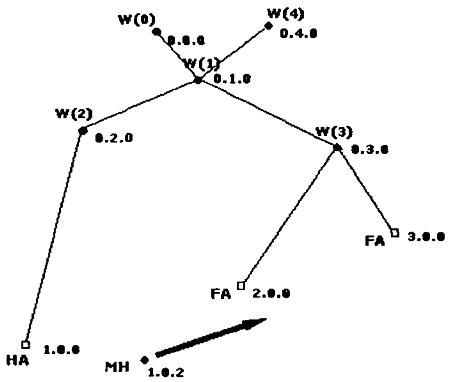


Figure 10 Generation of topology and movement pattern

Communication pattern file describes the packet workload that is offered to the network layer during the simulation. Together, the communication pattern file and movement pattern file comprise a description of simulation scenario. We use Ee agent and TCP agent as well as UDP agent as transport layer agents. As application layer agents, FTP agent and Exponential Traffic agent are sit on the top of transport agents.

Router configuration file is the router configuration file that defines which ad hoc network protocol should be used during the simulation. We use DSR(Dynamic Source Routing) protocol in router configuration file.

6. Evaluation of the optimized handoff protocol

The following graphs are generated using gnuplot for evaluation. The X axis show the simulation time and Y axis shows the throughput, packets per seconds.

6.1 Throughput comparison

Figure 11 and 12 show the throughput of the TCP connection to Mobile Host over the entire duration of the simulation. The simple handoff procedure causes the loss of packets and transmission delay that severely impair TCP throughput as shown in Figure 11. Mobile Host completely loses connectivity from time 115.00 to 132.01. After regaining connectivity, it performs a handoff. This result in a dropout until the new connection is established although the Mobile Node could still communicate with the rest of the network over its current Home Agent.

After handoff, transmission delay occurs due to the triangle routing problem as shown in Figure 11.

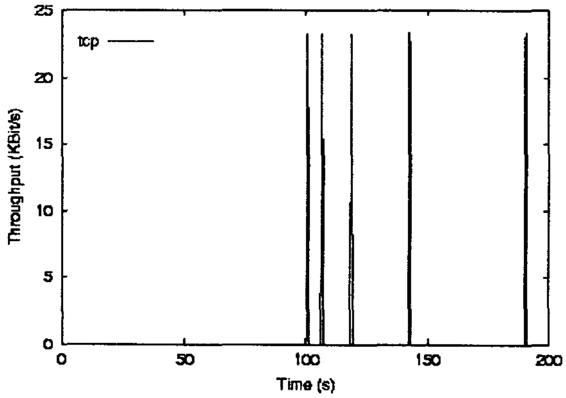


Figure 11 Result of simulation 1

Compared with simulation 1, result of simulation 2 with handoff optimization shows 40% improvement in the TCP throughput. We can infer from the improved TCP throughput that handoff optimization greatly reduced the delay by resolving the triangle routing problem.

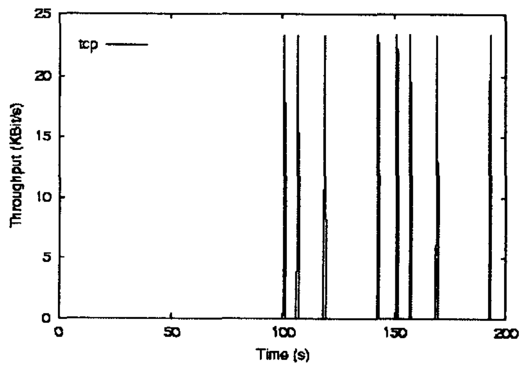


Figure 12 Result of simulation 2

6.2 Traffic Analysis

In this chapter, we analyze the network traffic generated by applications. A rapid growth of the internet and proliferation of new multimedia applications lead to an exponential growth in the volume of application traffic over IP networks. For these traffic simulations, ns provide exponential traffic object that generate the packet at a constant burst rate. Figure 13and Figure 14 are the traces of exponential application traffic agent on UDP agent during the simulations.

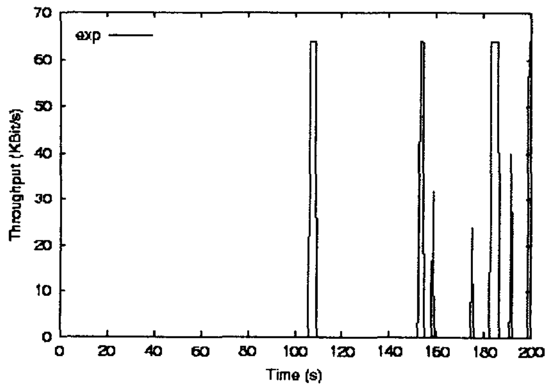


Figure 13 Result of simulation 3

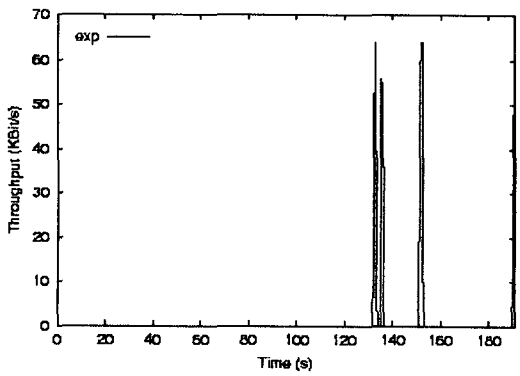


Figure 14 Result of simulation 4

Figure 13 show the application traffic that is consequence of transmission delay occurs due to the triangle routing problem.

Compared with result of simulation 3, result of simulation 4 show that our approach make the traffic have been reduced by 47.87% as reflected in Figure 14. It may be assumed that since the consequence of successive performance in handoff delay. That is, as the transmission delay due to the triangle routing problem is considerably reduced after handoff, application traffic is decreased consequently.

7. Conclusion

The point of our research is to make Quality of Service(QoS) guaranteed in Mobile IP. QoS in mobile IP is important to provide multimedia and real-time applications services in mobile environment, and it is closely related to handoff delay. Therefore handoff delay problem is actively studied to guarantee QoS in mobile IP research area. In this paper, to resolve such a problem, we suggest SNMP Information-based routing that add keyword management method to Information-based routing in actvie network, and then suggest QoS controlled handoff by SNMP Information-based routing. To prove the QoS improvement in our approach, we model the suggested handoff and simple handoff after setting up routing convergence time, then carry out simulations with NS-2.

The simulation of handoff optimization that were proposed in this paper showthat it improved throughput by 40% and reduced application traffic by 47.87% avoiding handoff delay caused by triangle routing problem. Therefore, these results of simulations proved the QoS improvement.

As a further research, we are trying to apply our handoff optimization to IPv6environments. Modeling for smooth handoff has been completed and simulations using MobiWan(NS-2 extensions to study Mobility in Wide-Area IPv6 Networks) currently under investigation.

References

[1] Ko. K.Y, Kim J.K., "Mobile IP Improvement for Micro Mobility Support", Kiss, Proceeding of 2002 Fall.

[2] Dan Chalmers, Morris sloman, "A Survey of Quality of Service in Mobile Computing Environmrnt", IEEE Communication surveys, Second Quarter 1999.

[3] Stefan Schemid, Joe Finney, Andrew Scott, Doug Shepherd, "Active Component Driven Network Handoff for Mobile Multimedia System", Proceedings of the 7th International Workshop on Interactive Distributed Multimedia Systems and Telecommunications (IDMS), October 2000.

[4] D. L. Tennenhouse, J. M. Smith, W. D. Sincoskie, D. J. Wetherall, and G. J. Minden, "A Survey of Active Network Research", IEEE Communications Magazine, Vol. 35, No. 1, pp80-86, January 1997.

[5] D. Scott Alexander, Bob Braden, Carl A. Gunter, Alden W. JacksonAngelos D. Keromytis Gary J. Minden and David Wetherall, "Active Network Encapsulation Protocol (ANEP)", RFC, ANEP documentation, April 1997.

[6] D. L.Tennehouse and D. J. Wetherall, "Toward an active network architecture", ACM Computer Communication Review, 26(2):5-18, 1996.

[7] Amit B. Kulkarni and Gary J. Minden, "Active Networking Services for Wired/Wifreless Networks", INFOCOM '99, 1999.

[8]http://www.ittc.ku.edu/~ananth/845. html," Beacon Routing in Active Network".

[9] Kevin Fall, Kannan Varadhan, "The ns Manual", The VINT Project, November 2001.

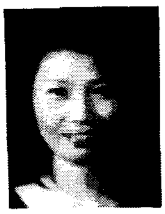
[10] Jorg Widmer, "Network Simulations for A Mobile Network Architecture for Vehicles", International Computer Science Institute Technical Report TR-00-009, May 2000.

[11] Mark A. Miller, PE, "Inside Secrets SNMP Managing Internetworks, Triangle Press, 1998.
[12] Anil K., Gopinath, "Implementing New Internet Services using an Active Network".
[13] Yu Wang, Weidong Chen, Joseph S.M.Ho, "Performance Analysis of Adaptive Location Management for Mobile IP", Technical Report 97-CSE-13, Southern Methodist University, 1997.
[14] Lidia Yamamoto, "Active Network in ns", ns-users Mailing List, October 1999.
[15] Marc Greis, "Tutorial for Network Simulator "ns".
[16] "The CMU Monarch Project's Wireless and Mobility Extension to ns", The CMU Monarch Project, August 1999.
[17] Jae Chung, Mark Claypool, "NS by Example", WPI.

주 작 성 자 : 박 수 현
논문투고일 : 2003. 9. 20
논문심사일 : 2003. 10. 22
심사판정일 : 2003. 10. 22

● 저자소개 ●

박수현(e-mail : shpark21@kookmin.ac.kr)
1988 고려대학교 컴퓨터학과 이학사
1990 고려대학교 대학원 전산학 이학석사
1998 고려대학교 대학원 컴퓨터학과 이학박사
1990~1999 (주)LG전자 중앙연구소 선임연구원
1999~2001 동의대학교 공과대학 소프트웨어공학과 교수
2002~현재 국민대학교 비즈니스IT학부 교수
2001~현재 한국SI학회 이사
관심분야 : 이동통신 시스템, Active Network, 패턴기반 소프트웨어 공학, 컴포넌트 기반 개발



장한이(e-mail : hani@software.korea.ac.kr)
2001 숙명여자대학교 컴퓨터과학과 이학사
2003 고려대학교 대학원 컴퓨터학과 이학석사
2003~현재 (주)LG전자 핵심망연구소 연구원
관심분야 : 망관리 시스템, 이동통신, 차세대 네트워크

이이섭(e-mail : eesub@software.korea.ac.kr)
1988 서강대학교 수학과 이학사
1990 서강대학교 대학원 전자계산학과 공학석사
1999 고려대학교 대학원 컴퓨터학과 이학박사 수료
1990~1992 삼성종합기술원 그룹CAE센터
1993~1995 (주)삼성SDS 정보기술연구소
1996~1999 삼성경영기술대학 정보통신학과 조교수
2000~현재 (주)삼성SDS 솔루션 사업추진실 수석연구원
관심분야 : 이동통신 네트워크, 워크플로우, 지식관리시스템, P2P 시스템

백두권(e-mail : baikdk@korea.ac.kr)
1974 고려대학교 수학과 이학사
1976 고려대학교 대학원 산업공학과 공학석사
1983 Wayne State Univ. 전산학과 공학석사
1985 Wayne State Univ. 전산학과 공학박사
1986~현재 고려대학교 컴퓨터학과 교수
1989~현재 한국정보과학회 이사/평의원
1991~현재 ISO/IEC JTC1/SC32 국내위원회 위원장
1992~현재 한국시뮬레이션학회 이사/부회장/감사/회장
2002~현재 고려대학교 정보통신대학 학장
2002~현재 과학기술정보표준위원회 위원장
관심분야 : 메타데이터, 소프트웨어 아키텍처, 시뮬레이션, 정보통합