[ICT02] Qos-Aware Handover Scheme Using Context Transfer With Link Layer Trigger For Hierarchical Mobile IP

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Introduction

New applications such as VoIP, video on demand and video conferencing, are gaining popularity in the Internet. Although the Internet is based on a best effort delivery mechanism, the introduction of these applications has placed a new demand on the Internet to provide guaranteed Quality of Service (QoS). To date considerable research has been directed towards achieving this goal. With the rapid growth of mobile cellular services in the form of 2.5G and 3G networks, the Internet evolution is facing many new challenges, requiring the QoS provision mechanisms to be extended to the wireless networks.This is because traditionally, IP protocols developed by the Internet Engineering Task Force (IETF) have mainly been designed for fixed networks. In wireless environment their behavior and performance are often affected. One major requirement in wireless networks is the support of user mobility in a seamless manner.

Different strategies have been proposed to support QoS in wireless networks, although they lack key elements to support mobility with effective QoS support. The provision of QoS in wireless access networks is very challenging because of movement of the hosts, the characteristics and unpredictable nature of wireless links. The number of different transmission services and the requirement of multimedia application further complicate the provision of QoS in a mobile access network. Mobile IP suffers several drawbacks that further cause QoS to detoriate while handoff occurs in an intra domain. This has led to the study of micro-mobility schemes, among the important few that can be cited are Hierarchical Mobile IP(C.Castelluccia,1998), Cellular IP (A. Valko,1999) and Handoff Aware Wireless Access Internet Infrastructure (R.Ramjee et al.,1999). These micro-mobility schemes aim to reduce latency required for handover signalling and therefore minimizing overall service interruption.

Making handover seamless is one of the key issues in mobility management for the next generation of all-IP networks. It is important to note that in the next few years the majority of terminals will be mobile and the majority of traffic will originate from IP-based applications offering more and more real-time services. The quality of real-time services like IP telephony and video-on-demand will depend greatly on the ability to minimize the impact of the handover, hence traffic redirection of ongoing sessions.

This paper presents the integration of the elements of link layer trigger and context transfer into the QoS-aware handover scheme proposed by (X. Fu et al.,2002). We present a performance analysis of the QoS-aware handover scheme with and without the integration of link layer trigger and context transfer. This paper is organized as follows: Firstly the problem statements regarding QoS in general are emphasised. Secondly a brief review of existing QoS schemes are presented. Next the proposed enhanced QoS aware handover scheme is introduced. This is followed by the simulation results, discussion and conclusion.

Quality of service (QoS) support for mobile IP

In IP networks that support host mobility, routing paths often change leaving behind routing related services such as Authentication, Authorization, and Accounting (AAA), header compression and QoS. A host needs to re-establish these services from scratch everytime a handoff occurs. This causes services distruption, undesirable latency and definitely a waste of scarce wireless bandwidth for signalling to reestablish those services. To overcome these problems the IETF is actively looking into

Context transfer as a solution (J.Kempf, 2002; J.Loughney et al.,2004; Syed H et al., 2002).

Context Transfer aims to contribute to the enhancement in handover performance by minimizing the time needed to associate a mobile node (MN) to a new access router. The process of context transfer is achieved by transferring information about the current state of a MN, known as context, from its previous to its new access router. Context transfer is important because, when a MN moves to a new subnet it needs to continue certain transport or routing-related services that have already been established at the previous subnet. Re-establishing these services at the new subnet will require a considerable amount of time for the protocol exchanges and as a result time-sensitive real-time traffic will suffer during this time

Another critical factor in achieving good performance for IP mobility protocols is the ability to use layer two trigger mechanisms. Using solely a layer three detection has proved to cause further latency depending on time interval used by a system (A.Festag, 2002) .Several protocol designs have been advanced for mobile IP that seek to reduce the amount of handover latency at layer three (R. Koodli et al.,2000) (R.Koodli el at., 2003)(H.Soliman,2003).These protocols depend on obtaining timely information from layer two about the progress of handover. Link-layer information such as signal strength allows a mobile node to detect the loss of connectivity more quickly than a layer-3 advertisement-based algorithm. Apart from this, link-layer information may be used to detect a decaying wireless link before the link is broken. This facilitates the execution of the handover and the elimination of the time to detect handover

There are a few QoS-aware handover schemes presently that make use of newly defined QoS object for IPv6. (H.Caskar et al.,2001) proposed a new IPv6 option called "QoS Object Option which triggers certain QoS procedures at the intermediate network domains for the cases of best-effort, MPLS, DiffServ and IntServ domains. Its drawback is that the mobile node (MN) does not receive any feedback on whether the desired QoS is available at all along the new path and that a handover always takes place, irrespective of available QoS resources.

The problem of handover taking place irrespective of availability of QoS resources was solved in (X. Fu et al., 2002), where a handover occurs only upon the ability of providing the required QoS along the new path. Here micro mobility solution namely HMIPv6 was added to further enhance the performance. However this scheme has several drawbacks such as high signaling overhead over the wireless link and also the higher latency because the scheme relies solely on layer 3 notifications to initiate and start the handover. The drawbacks of above scheme are the main motivation of this paper and our proposed scheme presented in the next section basically aims to overcome it.

Proposed enhanced QoS-aware handover scheme

The overall processes involved are shown in Figure 1.

The processes are as follows:-

1. Link layer trigger is received by the new access router (nAR).
2. Two events take place here, nAR sends Router Advertisement to mobile node
   and sends context transfer request (CTR) to old access router (OAR).
3. oAR then send context transfer data (CTD) which is the requested information by nAR.
4. The MN then sends the context transfer activate request (CTAR) message to the nAR to activate the context.
5. The nAR will than send the binding update plus QoS (BU + QoS) through intermediate nodes till it reaches the mobility anchor point (MAP).
6. MAP then sends binding acknowledgement plus QoS (BA + QoS) through the AR's , and sheds the QoS part before it is sent to MN. If it is a positive BA, a release message will be sent through the old path to release resource

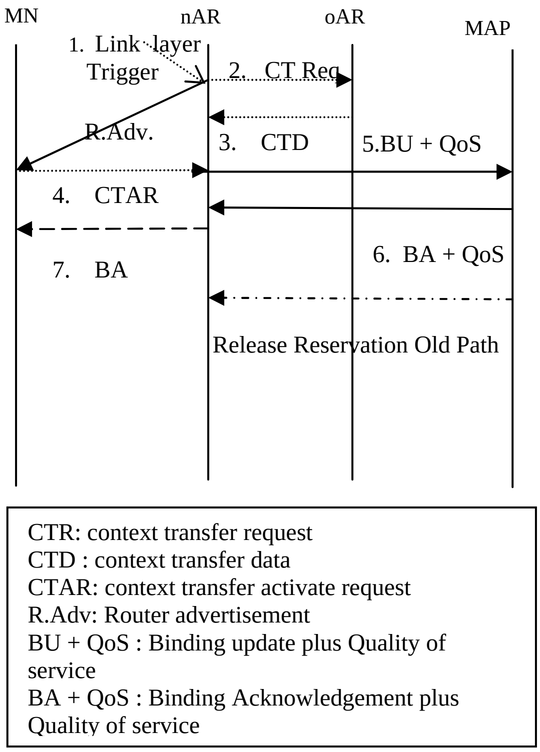

FIGURE 1 Signaling Diagram of Proposed Scheme

Simulation setup

For HMIPv6, handover delay is directly proportional to the round-trip time for a binding update from MN to the MAP. For the proposed scheme, the handover delay is taken to be the time AP sends BU + QoS till the time BA is received by the MN. Based on the time required for each sequence of the handover operation (time duration for BU send and BA received), the handover delay is calculated.

In order to study the performance of the enhanced QoS-aware handover scheme, a simulation model of the Hierarchical architecture implementing the QoS-aware handover scheme is built with features of context transfer and link layer trigger using Visual Fortran 6.5.

The simulation scenario used for the proposed scheme is shown in (Figure 2). The simulation makes use of six nodes, AP1 to AP6, and on top of the hierarchy of access network, resides a MAP that works as gateway router to the Internet. It is assumed that the MN moves in a straight line from left to right, (i.e AP3 to AP6) assuming that the MN is currently using the path of AP3 (Figure 2). The links between the AP's and MAP have a bandwidth of 10 Mbit/s.

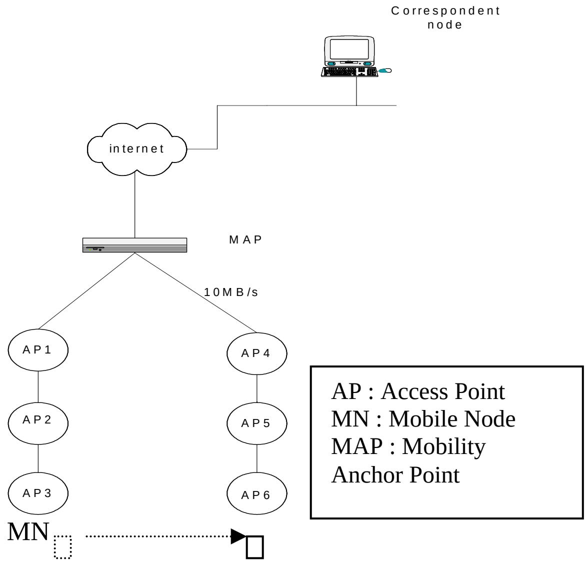

FIGURE 2 Hierarchical Mobile IP Topology Scheme for Simulation

The simulation assumes that an application sends packets at a constant length between MN and CN. For example, to send 50 packets/second with 8000 bits/packet is equivalent to a bandwidth of 400KBit/s. Because of the IP header added to each packet the required bandwidth grows to 425 Kbit/s. This is the value used for reservation when the binding update is sent.

Results and discussion

For the proposed scheme the simulation assumes that the MN waits for a router advertisement after receiving a link layer trigger or rather a triggered router advertisement. For the simulation the mean waiting time amounts to 50ms. Using this waiting time the system managed to complete the signaling required for the transfer of QoS information.

Depending on the variation of the number of binding updates from 100 to 2000, the average delay was calculated. (Figure 3) shows the average delay for a binding update for the proposed scheme is about 0.05061 seconds or 50.61ms.

For the scheme without context transfer and link layer trigger (Figure 4), an inter advertisement time of 100 ms for router advertisement is used assuming that it takes two intervals for a detection. The average delay for a binding update is about 0.21362 seconds or 213.6 ms in this case.

It was noticed that using a link layer trigger mechanism with context transfer decreases handover delay about 163 ms (213.60ms-50.61ms); this is an improvement of about 76.3% (Figures 3 and 4). It clearly shows that the time to detect handover contributes significantly to the overall service interruption.

For the proposed scheme, a link layer trigger is used to trigger a router advertisement, thus eliminating the usual detection time. Additionally, the proposed system uses context transfer, unlike the basic scheme that needs additional time to reinitiate and send signaling messages through the MN across the access point. Therefore, a considerable delay was introduced in the basic scheme compared with the proposed scheme, thus producing a longer average delay as seen in (Figure 4).

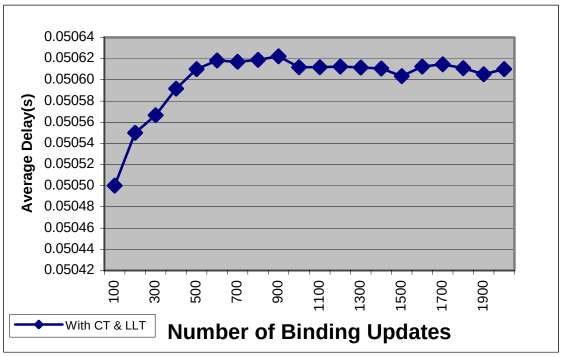

FIGURE 3 Average Handover Delay With Context Transfer and Link Layer Trigger

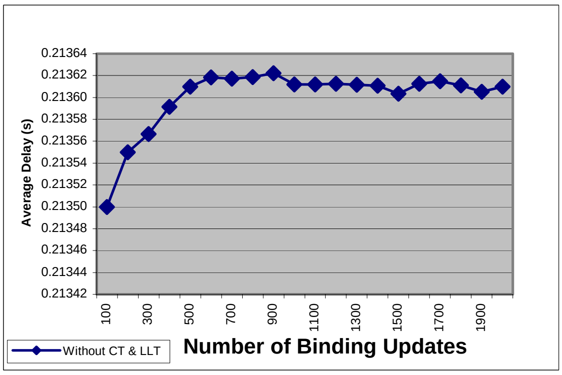

FIGURE 4 Average Handover Delay Without Context Transfer and Link Layer Trigger

To examine the handover delay for QoS-aware handover scheme with and without context transfer and link layer trigger, the number of binding updates sent in each scheme was varied from 100 to1000 and the delay was calculated. Figure 5 shows the combined results with and without context transfer.

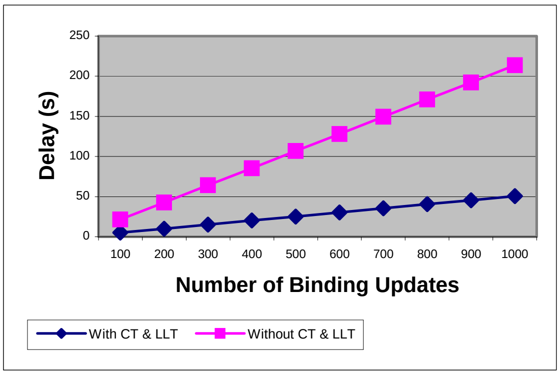

FIGURE 5 Comparison of Handover Delay For QoS Aware Handover Scheme With and Without Context Transfer & Link Layer Trigger

The handover delay ranges from 5.05 to 50.6 seconds for binding updates for QoS-aware handover scheme with context transfer and link layer trigger. As for the scheme without context transfer and link layer trigger the delay ranges from 21.4 to 213.6 seconds. The handover delay increases for both the schemes as shown in Figure 5 as the load increases; the rate of increase is about 0.20 for the scheme without enhancement and about 0.05 with enhancement. The delay increases noticeably higher (75 %) without using link layer and context transfer. Thus it can be concluded that the enhanced scheme causes less handover delay when the load increases in a system.

The packet loss rate is directly proportional to the accumulated link transmission time for the registration operation (P. D. Silva et al., 2001)(A. G. Valko, 1999). During this period, the MN is unreachable. If any correspondent node (CN) sends packets to MN, the packet will be lost. For the proposed scheme, the packet loss rate is taken to be the amount of packets sent by CN during the period in which the AP sends binding update + QoS, until the time when the MN receives BA message. To test the performance of packet loss, the packet service rate transmitted by the CN was varied. The variations of packet service are from 10 packets/second to 100 packets/second.

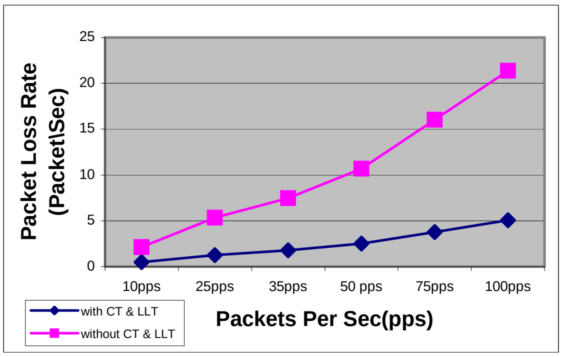

FIGURE 6 Comparison Packet Loss Rate for QoS Aware handover With and Without Context Transfer and Link Layer Trigger

The performances are plotted in (Figure 6) for both the schemes, with and without the enhancements. The packet loss rate is about 5.1% for the proposed scheme and for the scheme without enhancement, the packet loss rate is about 21.4%. The proposed scheme outperforms the basic scheme by 16.3%, clearly showing it has enhanced the performance of the basic QoS-aware handover scheme.

Conclusion

In this paper the performance of handover operation for the basic QoS-aware handover scheme and the proposed scheme with its integration of link layer trigger and context transfer have been described and tested.

The main idea for using context transfer is to reap the benefits from not reinitiating certain information, so timing is curial, thus early notification of handovers is essential to having sufficient time to complete the required protocol signaling. The link layer trigger proposed plays an important role in initiating the context transfer, whereby it uses the precious time before the layer three handover to complete the signaling required for the transfer of QoS information to take place.

The basic scheme experiences longer handover delay and higher packet loss. Relying on a layer three trigger, which is the router advertisement, mainly causes this. On the other hand, the proposed scheme uses a link layer trigger to trigger a router advertisement or rather a triggered router advertisement was used. This method has proven to be very effective in reducing the movement detection phase and resulted in a shortened handover delay. Apart from this factor, the main idea of context transfer has proven to shorten delay and reduce packet loss. This is because; the scheme has transferred established information between access points rather than reinitiating and sending over a wireless link, which introduces additional delay into a system.

From results in this paper, it can be said that the proposed scheme has improved the performance of the basic QoS-aware handover scheme. It has managed to reduce the handover delay and packet loss rate with the appropriate integration of context transfer and link layer trigger that provides an overall improved, feasible and scalable scheme.

Acknowledgements

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