Handoff Performances of SIGMA using mSCTP and MIP

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Abstract

To make sure of a continuous media communication when the MN moves between wireless networks. It is a challenging task to ensure uninterrupted media transmission during Handoff (HO), as the MN is getting media from the wireless network to which it is linked already; when it changes into the new wireless network, it is required to interrupt the linking with the old wireless network and create a link with the new wireless network. TCP/IP does not support hand off during MN's mobility. Mobile IP (Perkins C. *et al.*, 1998) presented HO management scheme at the network layer (layer 3) and Seamless IP diversity based Generalised Mobility Architecture (SIGMA) using mSCTP uses HO management scheme at the transport layer (layer 4) . SIGMA (Atiquzzaman S. *et al.*, 2005) was based on IP diversity and its objective is to improve the HO performances over MIP by decreasing the HO latency. In this paper work the performance of the HO schemes using the NS-2 Simulator was analysed. Results indicated that SIGMA architecture gives lower HO latency compared with the MIP. Furthermore, SIGMA using mSCTP can attain an uninterrupted HO between two wireless networks.

Keyword: SIGMA,SCTP,mSCTP,MIP

1. Introduction

The SIGMA's signaling procedure involved in the mobile handover process is discussed. The whole procedure can be divided into five parts, which will be described below. The main idea of SIGMA is trying to keep the old data path alive until the new data path is ready to take over the data transfer by exploiting the IP diversity at MH, thus achieve a low latency, low loss handover between adjacent subnets. An example of SCTP multihoming is shown in Figure 1.1, where both endpoints A and B have two interfaces bound to an SCTP association. The two end points are connected through two types of links: satellite at the top and ATM at the bottom. One of the addresses is designated as the primary while the other can be used as a backup in the case of failure of the primary address, or when the upper layer application explicitly requests the use of the backup. A typical mobile handover in SIGMA using SCTP as an illustration is shown in Figure 1.2, where MH is a multihomed node connected to two wireless access networks. Correspondent node (CN) is a node sending traffic to MH, corresponding to the services like file download or web browsing by mobile users.

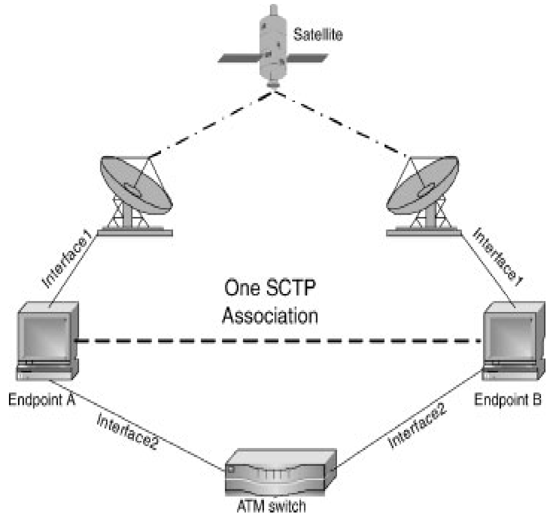

Fig. 1.1 Stream Control Transmission Protocol (SCTP) multihoming.

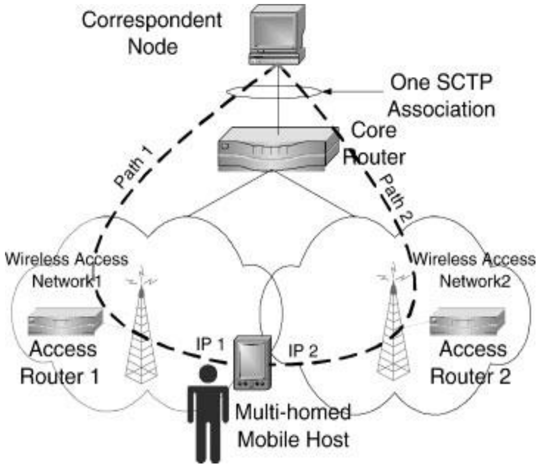

Fig. 1.2. An SCTP association with multihomed mobile host.

2. Survivability comparison of SIGMA and MIP

In this Paper we discuss the survivability of MIP and SIGMA. We highlight the disadvantages of MIP in terms of survivability, and then discuss how those issues are taken care of in SIGMA.

A. Survivability of MIP

In MIP, the location database of all the mobile nodes are distributed across all the HAs that are scattered at different locations (home networks). According to principles of distributed computing, this approach appears to have good survivability. However, there are two major drawbacks to this distributed nature of location management as given below:

- If we examine the actual distribution of the mobile users' location information in the system, we can see that each user's location and account information can only be accessible through its HA; these information are not truly distributed to increase the survivability of the system. The transparent replication of the HA, if not impossible, is not an easy task as it involves extra signaling support as proposed in [2].
- Even if we replicate HA to another agent, these HAs have to be located in the home network of an MH in order to intercept the packets sent to the MH. The complete home network could be located in a hostile environment, such as a battlefield, where the possibility of all HAs being destroyed is still relatively high. In the case of failure of the home networks, all the MHs belonging to the home network would no longer be accessible.

MOBILE IP

Mobile IP , proposed by the Internet Engineering Task Force working group, is a modification to IP that enables nodes to change their points of attachments to the Internet without changing their IP addresses. Mobile IP is essentially a network layer solution which is intended to be transparent to all upper layer protocols. Mobile IP accomplishes its task by setting up IP routing tables in appropriate nodes so that IP packets destined to mobile hosts can be reachable. Control messages, defined in Mobile IP, allow IP nodes involved to manage their IP routing tables reliably. The primary purpose of Mobile IP is to allow IP packets to be routed to mobile nodes which could potentially change their location continuously.

B. Centralized Location Management of **SIGMA** *offers Higher Survivability*

The location management and data traffic forwarding functions in SIGMA are decoupled, allowing it to overcome many of the drawbacks of MIP in terms of survivability as given below:

- The LM uses a structure which is similar to a DNS server, or can be directly combined with a DNS server. It is, therefore, easy to replicate the Location Manager of SIGMA at distributed secure locations to improve survivability.
- Only location updates/queries need to be directed to the LM. Data traffic do not need to be intercepted and forwarded by the LM to the MH. Thus, the LM does not have to be located in a specific network to intercept data packets destined to a particular MH. It is possible to avoid physically locating the LM in a hostile environment; it can be located in a secure environment, making it highly available in the network.

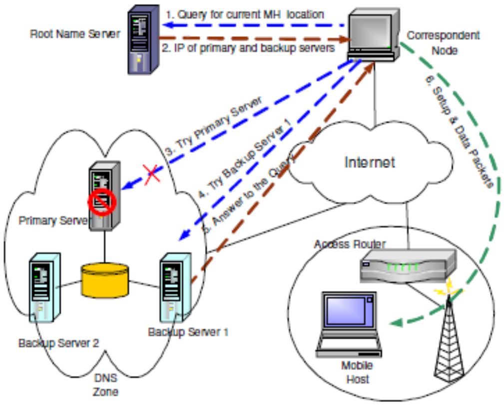

Fig. 2.1. Survivability of SIGMA's location management.

Fig.2.1 illustrates the survivability of SIGMA's location management, implemented using DNS servers as location servers. Currently, there are 13 servers in the Internet [12] which constitute the root of the DNS name space hierarchy. There are also several delegated name servers in the DNS zone [13], one of which is primary and the others are for backup and they share a common location database. If an MH's domain name belongs to this DNS zone, the MH is managed by the name servers in that zone. When the CN wishes to establish a connection with the MH, it first sends a request to one of the root name servers, which will direct the CN to query the intermediate name servers in the hierarchy. At last, CN obtains the IP addresses of the name servers in the DNS zone to which the MH belongs. The CN then tries to contact the primary name server to obtain MH's current location. If the primary server is down, CN drops the previous request and retries backup name server 1, and so on. When a backup server replies with the MH's current location, the CN sends a connection setup message to MH. There is an important difference between the concept of MH's DNS zone in SIGMA and MH's home network in MIP. The former is a logical or soft boundary defined by domain names while the latter is a hard boundary determined by IP routing infrastructure.

If special software is installed in the primary/backup name servers to constitute a high-availability cluster, the location lookup latency can be further reduced. During normal operation, heart beat signals are exchanged within the cluster. When the primary name server goes down, a backup name server automatically takes over the IP address of the primary server. A query requests from a CN is thus transparently routed to the backup server without any need for retransmission of the request from the CN.

Other benefits SIGMA's centralized location management over MIP's location management can be summarized as follows:

- *Security*: Storing user location information in a central secure database is much more secure than being scattered over various Home Agents located at different sub-networks (in the case of Mobile IP).
- *Scalability*: Location servers do not intervene with data forwarding task, which helps in adapting to the growth in the number of mobile users gracefully.
- *Manageability*: Centralized location management provides a mechanism for an organization/service provider to control user accesses from a single server.

3. Motivation of SIGMA

As the amount of real-time traffic over wireless net-works keeps growing, the deficiencies of the network layer based Mobile IP, in terms of latency and packet loss, becomes more obvious. The question that naturally arises is: Can we find an alternative approach to network layer based solution for mobility support? Since most of the applications in the Internet are end-to-end, a transport layer mobility solution would be a natural candidate for an alternative approach. A number of transport layer mobility protocols have been proposed in the context of TCP, for example, MSOCKS [5] and connection migration solution [7]. These protocols implement mobility as an end-to-end service without the requirement to change the network layer infrastructures; they, however, do not aim to reduce the high latency and packet loss resulting from handovers. As a result, the handover latency for these schemes is in the scale of seconds.Traditionally, various *diversity* techniques have been used extensively in wireless communications to combat channel fadings by finding independent communication paths at physical layer. Common diversity techniques include: space (or antenna) diversity, polarization di-versity, frequency diversity, time diversity, and code diversity [2], [4]. Recently, increasing number of mobile nodes are equipped with multiple interfaces to take advantage of overlay networks (such as WLAN and GPRS) [12]. The development of Software Radio technology also enables integration of multiple interfaces into a single network interface card. With the support of multiple IP addresses in one mobile host, a new form of diversity: *IP diversity* can be achieved. On the other hand, A new transport protocol proposed by IETF, called Stream Control Transmission Protocol (SCTP), has recently received much attention from the research community. In the field of mobile and wireless communications, the performance of SCTP over wireless links, satellite networks, and mo-bile ad-hoc networks is being studied. Multihoming is a built-in feature of SCTP, which can be very useful in supporting IP diversity in mobile computing environ-ments. Mobility protocols should be able to utilize these new hardware/software advances to improve handover performance.

The *objective* of this paper is to describe the ar-chitecture, survivability, and security of a new scheme for supporting low latency, low packet loss mobility management scheme called Transport Layer Seamless Handover (SIGMA). We also show the applicability of SIGMA to mange handoffs in space networks. Similar in principle to a number of recent transport layer han-dover schemes the basic idea of SIGMA is to decouple location management from data transfer, and achieve seamless handover by exploiting IP diversity to keep the old path alive during the process of setting up the new path during handover. Although we illustrate SIGMA using SCTP, it is important to note that SIGMA can be used with other transport layer protocols that support multihoming. It can also cooperate with IPv4 or IPv6 infrastructure without any support from Mobile IP.

4. Handover Process

The handover process of SIGMA (Shaojian Fu et al, 2005) can be described by the following five steps.

Step 1: Layer 2 Handover and Obtain New IP Address: Refer to Figure 1.2 as an example; the handover preparation procedure begins when MH moves into the overlapping radio coverage area of two adjacent subnets. In the state of the art mobile system technologies, when a mobile host changes its point of attachment to the network, it needs to perform a layer 2 (data link layer) handover to cutoff the association with the old access point and re-associate with a new one. For example, in IEEE 802.11 WLAN infrastructure mode, this layer 2 handover will require several steps: detection, probe, and authentication and reassociation with new AP. Only after these procedures have been finished, higher layer protocols can proceed with their signaling procedure, such as layer 3 router advertisements. Once the MH finishes layer 2 handover and receives the router advertisement from the new access router (AR2), it should begin to obtain a new IP address. This can be accomplished through several methods: DHCP, DHCPv6, or IPv6 stateless address auto-configuration (SAA)]. We call the time required for MH to acquire the new IP address as address resolution time.

Step 2: Add IP Addresses Into the Association: Initially, when the SCTP association is setup, only CN’s IP address and MH’s first IP address (IP1) are exchanged between CN and MH. After the MH obtained the IP address IP2 in STEP 1, MH should bind IP2 also into the association (in addition to IP1) and notify CN about the availability of the new IP address through SCTP address dynamic reconfiguration option [9]. This option defines two new chunk types (ASCONF and ASCONF-ACK) and several parameter types (Add IP Address, Delete IP address, and Set Primary Address, etc.).

Step 3: Redirect Data Packets to new IP Address: When MH moves further into the coverage area of wireless access network2, CN can redirect data traffic to new IP address IP2 to increase the possibility that data can be delivered successfully to the MH. This task can be accomplished by sending an ASCONF from MH to CN, through which CN set its primary destination address to MH’s IP2. At the same time, MH needs to modify its local routing table to make sure the future outgoing packets to CN using new path through AR2. If MH can utilize the information from layer 2, such as radio link Signal/Noise Ratio (SNR), Bit Error Rate (BER), or available bandwidth, MH has much more accurate information about when the primary data path should be switched over to the new path. One disadvantage of this method is that it requires cross layer communication in the protocol stack, which may result in difficulties in protocol deployment.

Step 4: Update Location Manager (LM): SIGMA supports location management by employing a location manager which maintains a database recording the correspondence between MH’s identity and MH’s current primary IP address. MH can use any unique information as its identity, such as home address (like MIP), or domain name, or a public key defined in public key infrastructure (PKI).Following our example, once MH decides to handover, it should update the LM’s relevant entry with the new IP address, IP2. The purpose of this procedure is to ensure that after MH moves from wireless access network1 into network2, subsequent new association setup requests can be routed to MH’s new IP address (IP2). Note that this update has no impact on the existing active associations. We can observe an important difference between SIGMA and MIP: the location management and data traffic forwarding functions are coupled together in MIP, while in SIGMA they are decoupled to speedup handover and make the deployment more flexible.

Step 5: Delete or Deactivate Obsolete IP Address: When MH moves out of the coverage of wireless access network1, no new or retransmitted data should be directed to address IP1. In SIGMA, MH notifies CN that IP1 is out of service for data transmission by sending an ASCONF chunk to CN to delete IP1 from CN's available destination IP list. A less aggressive way to prevent CN from sending data to IP1 is to let MH advertise a zero receiver window (corresponding to IP1) to CN. This will give CN an impression that the interface (on which IP1 is bound) buffer is full and cannot receive data any more. By deactivating, instead of deleting, the IP address, SIGMA can adapt more gracefully to MH's zigzag movement patterns and reuse the previous obtained IP address (IP1) as long as the IP1's lifetime is not expired. This will reduce the latency and signaling traffic caused by obtaining a new IP

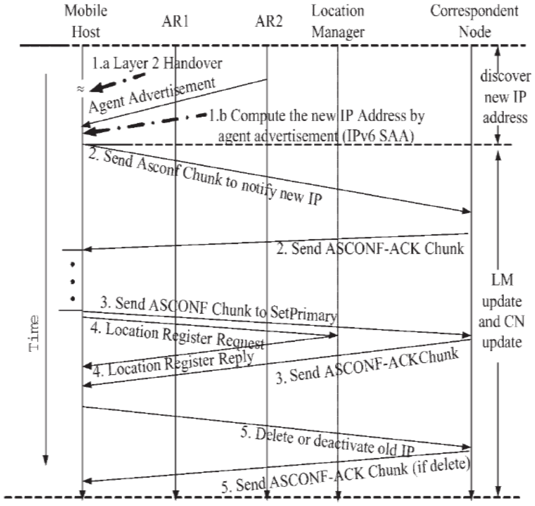

Fig. 4.1. Timing diagram of SIGMA

A)Timing Diagram of SIGMA

Figure 4.1 summarizes the signaling sequences involved in SIGMA, assuming IPv6 SAA is used for MH to get new IP address, the timing diagrams for using other methods can be drawn similarly. It should also be noted that until the old IP is deleted at CN(including the time for discovering new IP address), MH can always receive data packets from old IP in parallel with the exchange of signaling packets.

B) Low layer 2 setup latency

Fig. 4.2 shows the packet trace observed at the CN during one typical handover for SIGMA with layer 2 setup latency of 200ms. From Fig. 5 we can observe that SCTP data segments .are sent to MH's IP1 until time 8.16 sec (point t1), then the IP2 almost immediately (point t2), and all these packets are successfully delivered to MH. Therefore, SIGMA still experienced a seamless and over because it can prepare the new path in parallel with data forwarding over the old path. This is the basic reason that explains why SIGMA can achieve a low handover latency, low packet loss rate and high throughput.

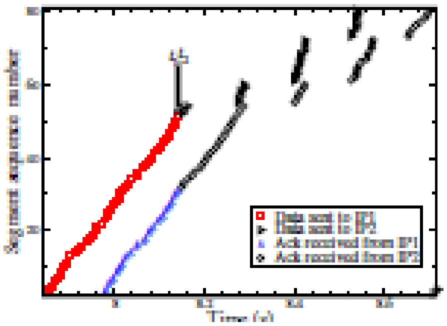

Fig. 4.2. Segment sequence of SIGMA during one handover with layer 2 setup latency of 200ms (Shaojian Fu et al,2005).

5. Conclusion

In this paper, we show that the location management scheme used in SIGMA can enhance the survivabil-ity of the mobile network. We developed an analytical model based Markov Reward Process to evaluate the survivability of location management schemes. Through the model, the survivability of SIGMA as compared to that of Mobile IP. Numerical results have shown the improvement system response time and service blocking probability of SIGMA over Mobile IP in practical environments under the risk of hardware failures and distributed DoS attacks.

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