Design and Implementation of the ATM Handoff Subsystem Supporting Soft-Handoffs between Mobile Switching Centers

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ABSTRACT

If the service provider provides mobile service with mobile switching centers that use different handoff message format, the soft-handoff between mobile switching centers is not available and the hard-handoff scheme is used instead. When this occurs, calls are often disconnected or there is an interruption of service. This can be very annoying to a mobile user.
We propose the handoff subsystem of the ATM switch which provides the soft-handoff between wireless cells under the control of different MSCs. The proposed handoff subsystem transforms the handoff message format of the source MSC to that of the destination MSC. It also provides efficient routing scheme that distributes handoff packets to balance the traffic load.

***Keywords**: Soft-Handoff, ATM Switching, Frame Relay, Communication Protocol, Routing.*

1. INTRODUCTION

When the mobile user is within the overlapping region of two wireless cells under the control of different MSCs(mobile switching centers), the handoff is occurred to maintain the call of the mobile user. In a hard-handoff, call interruption is generated in a call process of a mobile terminal due to voice interruption in a handoff, thereby reducing quality of calls. In a worst case, call failure may occur. A soft-handoff maintains two channels by holding an original channel and connecting a new channel. The success rate of the soft-handoff is greater than that of the hard-handoff and it maintains quality of calls.
All MSCs are not compatible. For instance, two base stations which are located to each other and controlled by different MSCs, may be operate using different handoff message format.
If a handoff between these two base stations is occurred, a soft-handoff scheme is not available and only the hard-handoff scheme is used. This can be very annoying to a mobile user. Accordingly, there is a need for relatively transparent changing of base stations when the base stations use different handoff message format. In this paper, we propose the handoff subsystem of the ATM switch that can provide the soft-handoff between different MSCs. The ATM switch consists of handoff subsystem, switching subsystem, control subsystem and management subsystem. The proposed handoff subsystem performs transformation of the handoff message format of source MSC to that of destination MSC. It provides transparent changing of base stations that use different handoff message format. When the soft-handoff is occurred and the traffic is overloaded to the specific port of the handoff subsystem, the success rate of the handoff is decreased. It also suffers from the degradation of voice quality. To overcome this problem, we propose the group based fair routing scheme. The number of groups is as same as the number of MSCs connected to the handoff subsystem. The handoff packets are routed to the ports of destination group by round-robin fashion.

2. RELATED WORKS

2.1 Inter-MSC Soft-Handoffs[1]

The soft-handoffs are classified into basically following four types.

- Intra-cell handoff : This involves transferring a call between channels in the same wireless cell.
- Inter-cell handoff : This refers to transferring a call between wireless cells under the control of the same BSC(Base Station Controller).Intra-MSC handoff : This refers to handoffs between wireless cells under the control of different BSCs, but belonging to the same MSC.
- Inter-MSC handoffs : This refers to handoffs occurring between wireless cells under the control of different MSCs.

The Inter-MSC handoffs involve the transferring of handoff control from the source MSC to the destination MSC.
Figure 1 shows the flow of the soft-handoff message between MSCs. Each MSC controls the group of BSCs and each BSC

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controls the group of cells. If the soft-handoff occurs between two cells under the control of different BSCs and the same MSC, the MSC routes the handoff message between them. In figure 1, the mobile user MT2 moves to the overlapping region covered by two BSCs under the control of different MSCs. In this case, the router routes the soft-handoff message between the source MSC and the destination MSC.

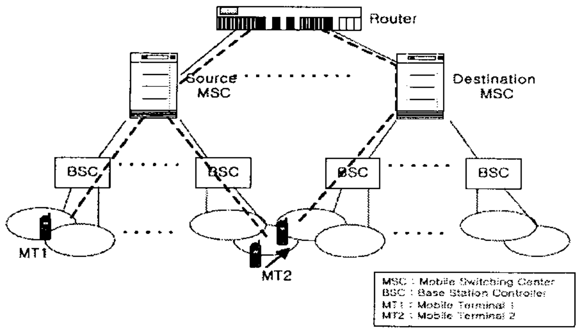

Fig. 1. The message flow of the inter-MSC soft-handoff

If two MSCs use same handoff message format, the soft-handoff scheme is available between them. But if they use different handoff message format, the destination MSC will drop the handoff packet received from the source MSC. In this case, the router in figure 1 must transform the handoff message format of the source MSC to that of the destination MSC.

2.2 Interface between the MSC and the Proposed ATM Switch

M.Cheng proposed the interworking models for supporting mobile service on an ATM switch[2]. We are interested in reference model 1[2] to implement the handoff subsystem. In reference model 1, the role of the ATM switch is transportation of mobile data between MSCs transparently[2]. There is no need to modify the existing MSCs and only the ATM access switch has interface for supporting mobile service.

Figure 2 shows the interface between the MSC and the proposed ATM switch. This interworking model is based on the reference model 1[2]. Therefore, we can provide soft-handoff between different MSCs without modifying existing MSCs. As shown in figure 2, for interworking with the MSC, the proposed handoff subsystem provides physical interface (PHY, HDLC) and service interface. In service interface, we provide transformation of the handoff message format in order to interwork with different types of MSCs. The routing block routes the handoff packet from the source MSC to the destination MSC.

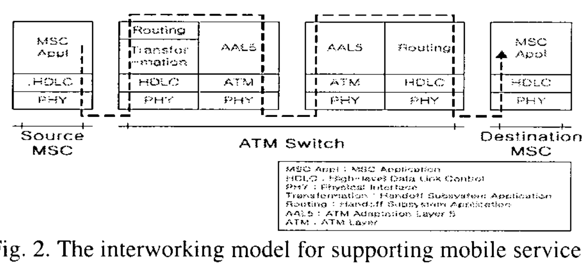

Fig. 2. The interworking model for supporting mobile service on the proposed ATM switch

3. PROPOSED ATM HANDOFF SUBSYSTEM

The proposed ATM handoff subsystem provides inter-MSC soft-handoffs, where mobile switching centers use different handoff message format. In this section, we describe subsystems of the ATM switch and the internal design of the handoff subsystem.

3.1 Subsystems of the ATM Switch

Figure 3 shows subsystems of the ATM switch. Those are handoff subsystem, switching subsystem, control subsystem and management subsystem. Each subsystem exchanges command and status messages with other subsystems through ipc (inter process communication).

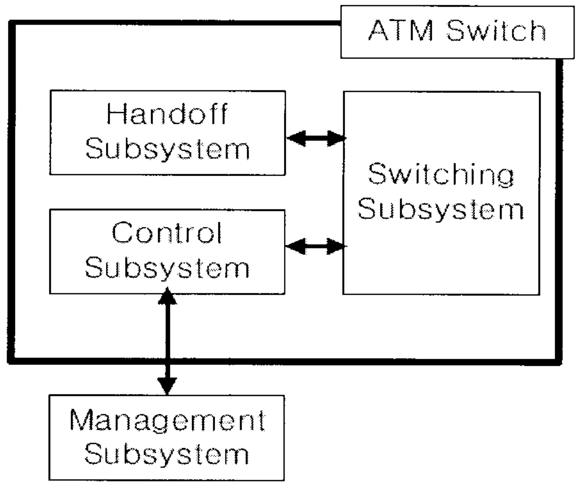

Fig. 3. Subsystems of the ATM switch

- Handoff Subsystem
  The handoff subsystem provides interface between the MSC and the ATM switch. It receives the routing table from the control subsystem. The routing table maps the physical ports of the handoff subsystem to the corresponding ATM connections. It receives the handoff message from the source MSC and transform this message format to that of the destination MSC. Then it sends this packet to the switching subsystem according to the routing table.
- Control Subsystem
  The control subsystem controls subsystems of the ATM switch. It monitors the status of each subsystem and sends command message to them. This subsystem receives the routing table from the management subsystem and sends it to the handoff subsystem. It also collects the statistics data from the handoff subsystem and reports it to the management subsystem.
- Switching Subsystem
  The switching subsystem switches ATM cells. It consists of 8*8 ports and each port can switch cell traffic up to 622M.
- Management Subsystem
  The management subsystem controls the ATM switch remotely. It provides service about configuration, performance and statistics management of the ATM switch. Operator can make routing table for the handoff

subsystem and monitor the state of all the ports in real time. This subsystem exchanges status and command messages with control subsystem.

3.2 Inside the Handoff Subsystem

The frame relay-ATM interworking assembly[3,4,5] is used to implement this subsystem to handle transformation and routing of the handoff packet by software program. Figure 4 shows the internal structure of the proposed handoff subsystem. It also shows the procedure of the handoff message processing.

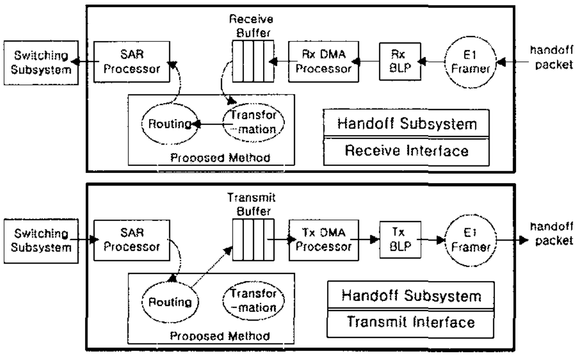

Fig. 4. The Structure of the Handoff Subsystem

As shown in figure 4, the handoff subsystem includes a packet receiving and transmission unit, a transformation unit, a routing determining unit and a SAR (Segmentation and Reassembly) processor.

- Receive Interface of the Handoff Subsystem
  The source MSC transmits the handoff message to the ATM switch. Packet receiving unit receives voice frame data and converts it into a packet according to a HDLC (high level data link controller). The HDLC stores the packet in a receiving buffer and generates an interrupt event. The transformation unit converts the handoff message format to the new one that is acknowledged by the destination MSC. The routing determining unit maps the address of the handoff packet to the corresponding ATM connection. The handoff packet is converted to ATM cells by SAR processor and goes to the switching subsystem.
- Transmit Interface of the Handoff Subsystem
  The switching subsystem transmits ATM cells to the handoff subsystem. SAR processor analyzes ATM cells and generates an handoff packet. The routing determining unit selects a transmission port for relaying a handoff packet by searching a routing table. Packet transmission unit converts the handoff packet into frame data and sends it to the transmission port.

4. IMPLEMENTATION DETAILS

Figure 5. shows the exemplary diagram of inter-MSC soft-handoffs with the proposed ATM switch. This figure is used to describe the method of transformation and the method of packet routing. As shown in figure 5, MSCs are manufactured by different companies. Each MSC is connected to the ATM switch. The ATM switch routes the handoff packet in case of inter-MSC soft-handoffs.

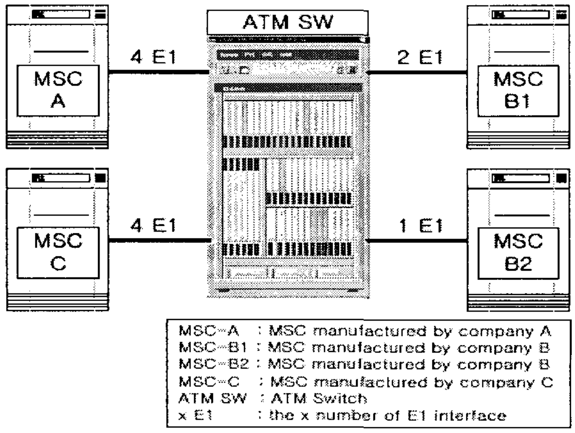

Fig. 5. The exemplary diagram of inter-MSC soft-handoffs with the ATM switch

4.1 Transformation of the Handoff Message Format

Figure 6. shows the two exemplary diagrams about the transformation of the handoff message. The first example shows the transformation of the handoff message where the MSC-A is the source and the MSC-B1 is the destination. The second example is for the transformation of the handoff message from the MSC-A to the MSC-C.

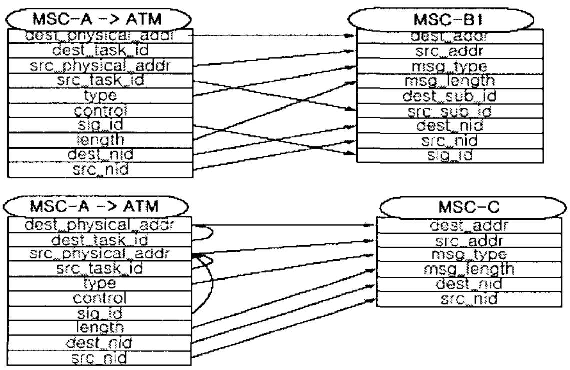

Fig. 6. The exemplary diagram of the transformation process

There are three types exist in converting the message fields. Firstly, the content of the field of the message can be directly mapped to the same field of the other one. In figure 6, destination nid (dest nid), source nid (src nid) fields of the MSC-A are directly mapped to the same field of the MSC-B1 and the MSC-C. Secondly, the content of the filed should be changed to map to the corresponding field of the other one. The destination address and the source address fields which contain BSC information should be changed according to the translation rules between different MSCs. Thirdly, the content of the field of the message is merged with the content of the other field of the same message. And it is mapped to the corresponding field of the other message. In figure 6, when the soft-handoff between MSC-A and MSC-C occurs, the signal id field, source task id field and source address field of the MSC-A are merged and mapped to the source address field of the MSC-C.

The transformation of the soft-handoff message between different MSCs is processed at the handoff subsystem of the ATM switch. Therefore, the soft-handoff between MSCs is provided transparently without modifying existing MSCs.

4.2 Routing Procedure of the Handoff Subsystem

The routing unit of the handoff subsystem decides where to route the handoff packet. We propose the group based fair routing scheme to maintain the quality of voice by distributing the handoff traffic. The number of groups is as same as that of MSCs connected to the ports of the handoff subsystem. The handoff packets are routed group by group. The handoff messages which belong to the specific group are routed to the ports of corresponding group by round-robin fashion.

1. Mapping the MSC group to the ports of the handoff subsystem
   Table 1 shows that MSC groups in figure 5 are mapped to the ports of the handoff subsystem. Network ID is the address of the MSC. The MSC-A(its role is as same as the router in figure 1) controls three MSCs numbered by 10, 11 and 12. MSC-B1 and MSC-B2 are classified into two groups by network id. MSC-C has its own Network ID 30. In this example, the handoff subsystem has four groups for routing.
2. The routing scheme
   Table 2 shows the ATM routing table of the handoff subsystem. There are four destination groups those are MA1, MB1, MB2 and MC1. MA1 has 4 ports(A1, A2, A3, A4) and MB1 has 2 ports(B1, B2). MB2 has 1 port(B3) and MC1 has 4 ports(C1, C2, C3, C4). The following steps describe how to distribute handoff message to the destination group.

   Step 1 : The handoff subsystem receives the handoff packet from the source MSC. Then, it identifies the Network ID from the destination address of the handoff message. The destination group is selected from the Table 1.

   Step 2 : The handoff subsystem transmits handoff packets to the destination group by round-robin fashion. If it transmits the handoff packet to the A2 port of the group MA1, then next time the handoff packet which has same destination address should be transmitted to the A3 port. All ports are served with equal priority. Therefore, we can distribute the handoff traffic and maintain the quality of voice by avoiding overloading of heavy traffic to the specific port.

Table 1. MSC ID and Ports

MSC Name	Network ID	Ports
MSC-A	10, 11, 12	A1, A2, A3, A4
MSC-B1	20	B1, B2
MSC-B2	21	B3
MSC-C	30	C1, C2, C3, C4

Table 2.The ATM Routing Table

Group	VPI	VCI	Port
MA1	5	30	A1
		31	A2
		32	A3
		33	A4
MB1	6	30	B1
		31	B2
MB2	7	30	B3
MC1	8	30	C1
		31	C2
		32	C3
		33	C4

5. DISCUSSION

The following issues are to be considered to implement the ATM switch which serves soft-handoff between MSCs that use different handoff message format.

5.1 Transformation

The soft-handoff message has two types. The call control message is used to make a connection of handoff call. The traffic message is used to deliver the voice of the mobile user. Each message consists of the header and the body. The header contains the routing information and the body contains the compressed voice and has some information related to the voice quality. The information of this message is varied by each MSC manufacturer.

In order to provide soft-handoff between different MSCs, the soft-handoff message format of the source MSC should be converted to that of the destination MSC. The routing information such as nid, bsc, bts ids should be considered to implement this function. Especially the information related to the voice quality such as base station power offset value cannot be directly mapped to. Because the base stations under the control of different MSCs use different power offset value. In this case, the field testing is required to find the optimal mapping formula.

5.2 Packet Processing Delay

The handoff traffic is increased very high when the number of handoff connections are many. In this case, the quality of voice is degraded due to the packet loss or packet delay. To provide high quality mobile voice service, the packet processing delay should be considered when implementing a handoff subsystem. The proposed handoff subsystem performs transformation and routing by software program. Thus, for reducing the delay of packet processing, the handoff subsystem process packets by interrupt basis. If the handoff packet arrives at the HDLC controller (BLP in figure 4), the controller generates the packet arrival event. Then, the interrupt service routine (Transformation, Routing in figure 4) processes the packet and sends it to the switching subsystem.

6. CONCLUSION

In this paper, we design and implement the handoff subsystem of the ATM switch. It provides the inter-MSC soft-handoffs transparently without modifying existing MSCs that use different handoff message format. It increases success rate of handoff and minimize the degradation of voice quality.

To provide soft-handoff between MSCs, the proposed handoff subsystem performs the transformation of the handoff message format. It also uses the group based fair routing scheme to maintain the quality of voice by distributing the small traffic messages to the ports of the destination group.

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