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A REASSEMBLY STRATEGY FOR REDUCING IN/PCS SIGNALLING TRAFFIC

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SUMMARY

This paper proposes a simple assembly/disassembly part (ADP) for the signalling system no. 7 (SS7) protocol to reduce the signalling traffic loads in intelligent networks (IN) and personal communication service (PCS) networks. The ADP combines two or more messages with the same destinations into a single message, thereby reducing signalling traffic without affecting SS7 protocol operations. The numerical results show that the proposed method can reduce traffic among signalling points 9~17%.

KEY WORDS: signalling system no. 7; disassembly; assembly

1. INTRODUCTION

Intelligent networks (IN) and personal communication service (PCS) networks use centralized databases to provide services to users. A serious problem with centralized database services is the heavy concentration of signalling traffic on the links leading to the databases. Reducing signalling traffic to centralized databases is thus an important issue in designing IN/PCS networks. Current research[1] on reducing PCS signalling traffic emphasizes redesigning signalling procedures. This method shows good results but it can be complicated and expensive. In this study, we propose a simple method for reducing signalling traffic by combining some message signal units (MSUs) that have the same destination point codes into new MSUs.

IN/PCS networks currently use the signalling system no. 7 (SS7) as their signalling protocol.[2] There are three types of signalling points in the SS7 protocol, the service switching point (SSP), signalling transfer point (STP) and service control point (SCP). The SSP generates MSUs; the STP relays MSUs; and the SCP completes the services that MSUs specify. In current IN/PCS networks, a large number of SSPs are connected to STPs, and STPs route MSUs to SCPs. Consider an IN/PCS network with SS7 protocol stacks as shown in Figure 1. The protocols in the SSP and SCP can be divided into the following layers: message transfer part (MTP),[3] signalling connection control part (SCCP),[4] transaction capability (TC) and application parts, which for IN consist of intelligent network application part (INAP), and mobile application part (MAP) for PCS. The STP has only the MTP and the SCCP.

The rest of this paper is organized as follows: in section 2, the formats of MSU and SS7 protocol operations in IN/PCS are described. Section 3 presents the proposed ADP. In Section 4, we analyse the percentage of message reduction achieved by adding the ADP. The last section presents conclusions.

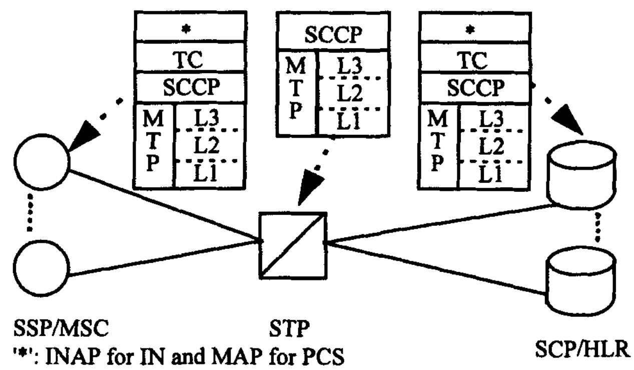

Figure 1. Reference network architecture and protocol stacks

2. MSU FORMATS AND SS7 PROTOCOL OPERATIONS

The MSUs transferred among signalling points are SCP database query messages for IN and mobility management messages for PCS. The encapsulation of an MSU is shown in Figure 2(a). Its fields are described as follows.

- Flag: a one-byte pattern used to separate signal units.
- Level 2 header and check bits: used by MTP level 2 to facilitate the reliable transfer of messages over a signalling link.
- Service information octet (SIO): composed of

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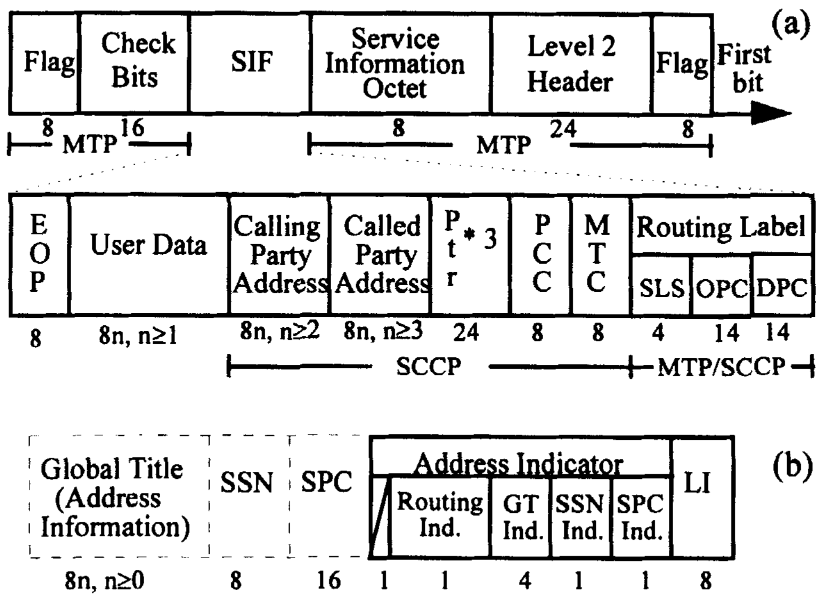

Figure 2. Message formats of (a) an MSU (b) the called/calling party address

a 4-bit service indicator and a 4-bit sub-service field. The service indicator determines the user part of the MTP level 2. The sub-service field is used to indicate that this message is for national or international use.

The signalling information field (SIF) uses more complicated formats. Its fields are:

- destination point code (DPC): indicates the point for which the MSU is intended;
- originating point code (OPC): specifies the point that sent the MSU;
- signalling link selection (SLS): informs the MTP level 3 to select a link to which to send the MSU;
- message type code (MTC): used by the SCCP to distinguish different kinds of messages;
- protocol class code (PCC): indicates which kind of service the MSU uses;
- three pointers pointing to the first octets of the called party address, calling party address and user data, respectively;
- called party address/calling party address: uniquely identify the destination/originating signalling point and the application part;
- user data: INAP data or MAP data encapsulated using the formats defined by the TC; and
- end of optional parameter (EOP): indicates the end of the MSU.

The fields of the called party address are as follows: a length indicator, an address indicator, a signalling point code (SPC), a subsystem number (SSN) and a global title (GT). The subsystem number is the identify of a process in the signalling point that provides services for MSUs. The substances of the signalling point code, subsystem number and global title depend on the signalling point code indicator, subsystem indicator and global title indicator of the address indicator. The global title includes address information to help the SCCP in routing. The calling party address has the same formats as the called party address.

The signalling process starts at the SSP when a call arrives. The TC processes the user data and passes it to the SCCP along with called/calling addresses. The SCCP appends control information forming an SIF. Each SIF is presented to the MTP for transmission. The MTP appends its own header and trailer, creating an MSU. The MSU is transmitted to the STP according to its DPC. At the STP, the MSU header and trailer are stripped off and the SIF is examined by the SCCP, which performs global title translation to decide how to route this MSU. That is, the SCCP finds the MSU's destination signalling point code and subsystem number by translating the global title contained in the called party address of this MSU. When the data are received at the SCP, the process is reversed. At each layer, the corresponding header or trailer is removed, and the remainder is passed to the next higher layer until the user data are delivered to the process identified by the subsystem number. The above procedure applies to the initial forwarding message of a call from the SSP to the SCP. When the SCP needs to reply to this call, it can recognize the originating point and subsystem from the calling party address of the initial forward message. This reply does not need to be translated by the SCCP of the STP and thus it contains *no global title*. Many applications need more than an initial forward message and a reply. There are subsequent forward messages and replies for a call which also contain *no global titles* and their DPCs are SCPs/SSPs, but not STPs. The called party addresses of the messages except for the initial forward message carry only the *subsystem numbers*. By using the DPC of the routing label and the subsystem number of the called party address, the message can be routed correctly. The calling party address usually contains the *signalling point code* and the *subsystem number*. The calling party address contains *no global title* in most cases because the use of the global title in the calling party address is an option for network interconnection security requirements.

3. PROPOSED ASSEMBLY/DISASSEMBLY PART

The ITU-T recommendation defines the maximum length of an SS7 MSU as being 272 octets. However, the average length of MSUs used in current IN/PCS networks is smaller than 272 octets. For example, the average length reported in Reference 5 for IN free-phone service is 101·6 octets. For a PCS location update message approximately 90 octets are required. We can thus combine two or more MSUs into a single MSU to reduce the signalling message overhead.

An assembly/disassembly part (ADP) is proposed in this study to reduce the signalling traffic in IN/PCS networks. The proposed ADP contains assembly and disassembly processes and it is added between the SCCP and the MTP. A DPC table that uses an array is created in the ADP. The data structure of the DPC table is shown in Figure 3. Each entry in the DPC table has three fields: the DPC code, protocol class code and a pointer field. When the ADP receives SIF data from the SCCP, it checks the DPC and protocol class code fields of the SIF data and adds this SIF to the DPC table. An assembly process periodically checks the entries in the DPC table, dequeues SIF data with the same DPCs and protocol class codes for assembly into a modified SIF. The ADP then passes the modified SIF data to the MTP.

Note that if MSUs from the same originating point have the same DPC, then these MSUs must also contain the same values in the service information octet, OPC and message type code fields. For data transfer in IN/PCS, the service indicator in the service information octet is always coded '3', specifying that the user part is SCCP. MSUs with

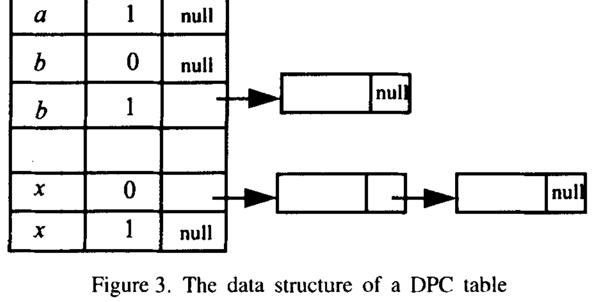

Figure 3. The data structure of a DPC table

the same destinations are coded identically in the sub-service field of the service information octet. The message type code is only the *unitdata* for current applications. Current applications use protocol class codes of 0 or 1. Signalling link selection codes may be different for class 0 MSUs. They will not be affected if re-assigned randomly by the ADP because they are assigned randomly by the SCCP. Signalling link selection codes are identical to guarantee the sequence of class 1 MSUs with the same DPCs. The fields of the modified SIF are thus defined as: DPC, OPC, signalling link selection, message type code, protocol class code, pointer 1, pointer 2, pointer 3, called party address 1, . . . , called party address *k*, calling party address 1, . . . , calling party address *k*, user date 1, . . . , user data *k* and end of option parameter. The formats of such an MSU are shown in Figure 4(i). The first, second and third pointers point to the first octets of the called party address 1, calling party address 1, and user data 1, respectively. Each called party address field (calling party address field, user data field) contains its own length indicator. Because the maximum MSU size is 272 octets, the modified SIFs cannot exceed 266 octets in length. The ADP must define a new message type code for such an assembled MSU to distinguish it from unitdata.

The disassembly process is very simple. When the ADP receives SIF data from the MTP, it checks the message type code to see if this SIF is from an assembled MSU. If the SIF is not from an assembled MSU, the ADP passes the SIF to the SCCP without additional operations. If the SIF is from an assembled MSU, the disassembly process extracts each called party address, calling party address and relevant user data from the SIF. Then the disassembly process determines pointers 1, 2 and 3, copies the DPC, OPC, signalling link selection, message type code (unitdata), protocol class code and appends an end of optional parameter to form a standard SIF format. Finally, the ADP passes these standard SIFs to the SCCP.

Note that in the modified SIF, the called/calling party addresses may have global title fields. From the discussions of SS7 protocol operations in Section 2, the reply MSU and subsequent MSUs of a call do not need global titles.[6] On the other hand, the number of SCPs and subsystems are small. For example, there are six SCPs and one subsystem per SCP for IN services in Taiwan. This means the calling party addresses are similar if they are from the same originating point. The global title field can be removed from the modified SIF if the MSU is a reply MSU or a subsequent MSU. We can thus use a 1-octet calling-party-address combination identification (CCID) to replace the calling party addresses in the modified SIF. The modified SIF formats such MSUs are shown in Figure 4(ii). The routing label, message type code, and protocol class code are not changed. The next field is a CCID that represents the combining signalling point codes and

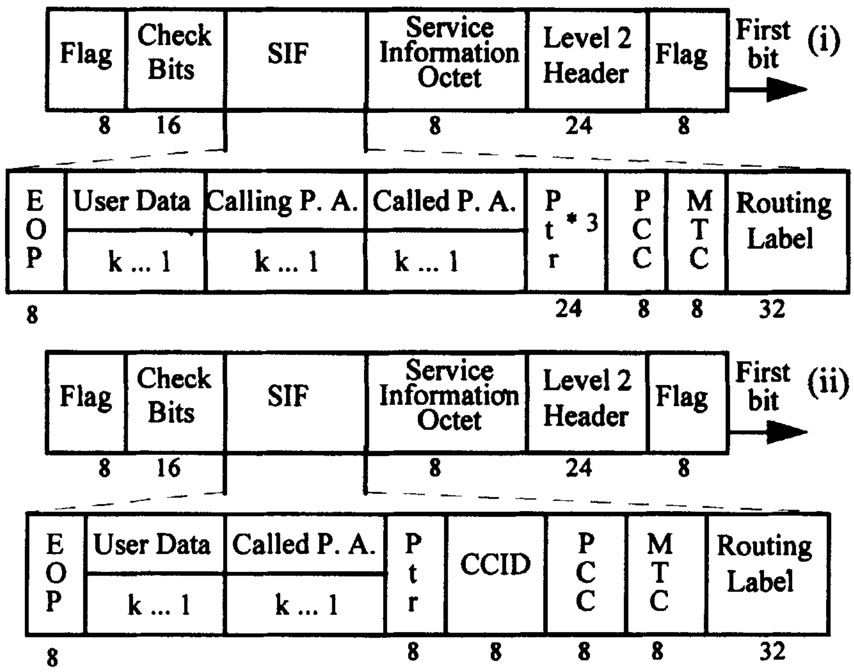

Figure 4. Formats of MSUs proposed in the reassembly strategy

subsystem numbers of calling party addresses. The ADP must define a calling-party-address combination table for each OPC. The structure of the table is shown in Figure 5. The table size is small, less than 20 entries if there are three subsystems in a signalling point, and is easily searched. The new modified SIF formats do not apply to the STP because the number of combinations of calling party addresses in a modified SIF is very large. The field next to the CCID is a 1-octet pointer that points to the first octet of the user data. Because initial forward messages usually contain called party addresses with global titles, the fields next to the pointer are called party address 1, . . . , called party address k, user data 1, . . . , user data k and EOP. The called party addresses can also be reduced and can be represented by the CCID if they contain subsystem numbers only. The user data will not be confused with called party addresses because they can be located by the pointer.

The new modified SIF should have a new message type code to distinguish it from other messages.

Table for OPC a (a is not an STP)

CCID	Combinations
1	SPC/SSN = a/g; (all calling party addresses are a/g)
2	SPC/SSN = a/h; (all calling party addresses are a/h)
m-2	SPC/SSN = a/g, a/h, a/h;
m-1	SPC/SSN = a/g, a/i, a/i;
m	SPC/SSN = a/g, a/h, a/i;

Figure 5. A calling-party-address combination table

When the ADP receives such SIF data from the MTP, the disassembly process extracts the CCID, each called party address and relevant user data from the SIF. From the CCID of the OPC table, the ADP can determine each calling party address (and if possible, the called party address). The ADP copies the DPC, OPC, signalling link selection, message type code (unitdata), protocol class code, called party address, calling party address, user data and EOP, and then determines pointers 1, 2 and 3 to form a standard SIF format. Finally, the ADP passes these standard SIFs to the SCCP.

4. NUMERICAL RESULTS

In order to analyse the signalling traffic reduction achieved by adding an ADP between the MTP and the SCCP, we assumed the following network model. There were 60 SSPs connected to an STP, each of them having four 64 Kbit/s SS7 links. The STP was connected to 10 SCPs. Each MSU generated by an SSP was routed to one of 10 SCPs with uniform distribution. The MSUs had mean lengths of 100 octets. We also assumed the called party address was 12 octets if it had a global title, and 3 octets if it had no global title. The calling party address had a signalling point code and a subsystem number and it was 5 octets in length. The service needed an initial forward message and three subsequent messages, where one subsequent message was in the forward direction and two subsequent messages were in the reverse direction, for each call. The ADP assembly process scanned the DPC list at 1 ms and 5 ms intervals during two kinds of simulations. Figure 6 shows the percentage of traffic reduction plotted against traffic loads. Signalling

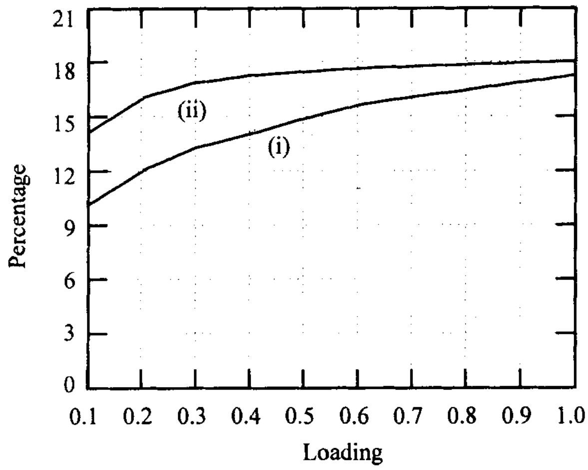

Figure 6. Percentage of traffic reduced versus loading
(i) In a cycle of 1 ms
(ii) In a cycle of 5 ms

traffic was reduced 9~17% depending on loading. Higher loading may lead to greater traffic reduction because more MSUs will be queued for transmission. Note that the shorter the messages the more the traffic is reduced.

5. CONCLUSION

We had proposed a reassembly strategy to reduce signalling traffic in IN/PCS networks that augments existing standards. MSUs of the same DPC are combined and the common network information is reduced. In current IN and PCS networks, the average MSU size is 70–110 octets. The proposed method will thus lead to significant reductions in signalling traffic among signalling points. In addition, the proposed method adds only a simple ADP between the SCCP and the MTP of SS7 protocols, which does not affect SCCP and MTP operations. The implementation effort of this ADP is very small and the cost of this strategy is the delay for processing ADP's functions. It is a tradeoff between the processing delay and the performance of this ADP. It is clear that the larger scan cycle of the assembly process can lead to better traffic reduction. However, the sum of the scan cycle time and the SS7 protocol processing time must be bounded under the transit time requirement of a relay point,[7] otherwise the quality of service will degrade. In contrast with the simulations, if a larger scan cycle is allowed then the 17% reduction will be achieved very quickly. Furthermore, the reduction rate will be increased for the network with ANSI SS7 standard. This is because the point code lengths are 24 bits in ANSI standard and 14 bits in the ITU-T recommendation. When the IN and PCS user population grows rapidly, we can use this method to reduce signalling traffic loads instead of adding new SS7 links. We believe that this method is especially useful in helping network operators save significantly on costs.

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Kuo-Ruey Wu received the BS and MS degrees in computer science from Chung Yung University and National Tsing Hua University, Taiwan, in 1988 and 1990, respectively. Since 1990, he has been with the Network planning Laboratory, Telecommunication Laboratories of Chung-Hwa Telecommunication Corporation for implementation and testing of SS7 protocols, intelligent networks and personal communication networks. He is now working toward the PhD degree in Computer and Information Science at National Chiao Tung University, Taiwan. His research interests include network architecture, communication protocol design, and wireless communication systems.

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