Problem Statement for Sigtran Network Management

draft-cui-tsvwg-snm-ps-00.txt

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Abstract

Sigtran is widely applied in the telecommunication network but there are still some issues. This document briefly describes some concerned scenarios and presents the association changeover and Sigtran routing management problems. The goal of this document is to analyse the existing shortage of Sigtran and discuss the desirable improvements.

Conventions used in this document

In examples, "C:" and "S:" indicate lines sent by the client and server respectively.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

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1. Introduction

Sigtran is designed to provide IP based signaling bearer for the existing switched circuit network signaling protocols. Sigtran typically consists of three components: adaptation sub-layer, common signaling transport protocol (i.e., SCTP) and standard IP transport. Sometimes application signaling protocol can be directly combined with SCTP transport protocol. Sigtran enabled application signaling to be transported in the IP network and in some scenarios Sigtran can also compress the original protocol stack. Sigtran provides an important way to migrate the TDM based circuit-switched network to the IP based packet-switched network.

But in some aspects the functionality and performance provided by Sigtran can not meet the same criterion as SS7 or TDM based circuit-switched network. However, these aspects are crucial in the telecommunication.

For example, [ITU-T-Q.704] specifies "in the case of a link failure, the traffic conveyed over the faulty link should be diverted to one or more alternative links" (section 3.1) and [ITU-T-Q.704] also introduces changeover mechanism to "ensure that signaling traffic carried by the unavailable signaling link is diverted to the alternative signaling link(s) as quickly as possible while avoiding message loss, duplication or mis-sequencing" (section 5.1.1). This requirement is very important to telecommunication network but this functionality is not inherited in Sigtran solutions.

On the other hand, Sigtran provides a new manner for signaling transport. But in the Sigtran network some SS7 network management functions are affected and the existing Sigtran network management can not meet the requirements of telecommunication network.

Some analyses are provided and some problems are also stated in this document. Section 3 is about SCTP association changeover and section 4 is about routing management in Sigtran network. Conclusion and recommendation are provided at last.

2. Terminology

All the Sigtran related terms used in this document are to be interpreted as defined in Stream Control Transmission Protocol [RFC4960] and Signaling System 7 (SS7) Message Transfer Part 3 (MTP3) - User Adaptation Layer (M3UA) [RFC4666].
This document also provides the following context-specific explanation to the following terms used in this document. These terms are defined in 3GPP specifications.

**eNodeB (eNB)**

The eNodeB is the radio station of 3GPP’s future LTE wireless communication standard.

**Evolved Packet Core (EPC)**

EPC is the core network architecture of 3GPP’s future LTE wireless communication standard.

**E-UTRAN**


**LTE**

LTE is the project name of a new high performance air interface for cellular mobile communication systems in 3GPP standard. It is the last step toward the 4th generation (4G) of radio technologies designed to increase the capacity and speed of mobile telephone networks.

**Mobility Management Entity (MME)**

MME is the key control plane entity within Evolved Packet Core. MME functions include Non-Access-Stratum signaling, mobility management, Bearer management, etc.

**S1**

Interface between an eNB and an EPC, providing an interconnection point between the E-UTRAN and the EPC.

**S1-MME interface**

The S1-MME is a reference point for the control plane protocol between E-UTRAN and MME in 3GPP standard.
3. SCTP Association Changeover Problem

3.1. SCTP Message Retrieval Problem

In SCTP specification [RFC4960], some primitives are defined to provide SCTP transport service to the ULP. The ULP can use "Receive Unsent Message" and "Receive Unacknowledged Message" primitives to retrieve the data that need retransmission or other disposal. The ULP can get the related information from SCTP layer by "Status" or "COMMUNICATION LOST notification" primitives. But in fact, in most scenarios the ULP can not get the accurate information related to the acknowledged/unacknowledged data. For example, in the flowing scenario:

```
Endpoint A         IP network             Endpoint B
ULP    SCTP       SCTP           ULP
<table>
<thead>
<tr>
<th>SEND</th>
<th>&gt;</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>data #1</td>
<td>\</td>
<td>data #2</td>
</tr>
<tr>
<td>----&gt;-------------</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>data #3</td>
<td>\</td>
<td>sack #1 sucker</td>
</tr>
<tr>
<td></td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>data #3</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td></td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>data #3</td>
<td>&gt;</td>
<td>&gt;</td>
</tr>
<tr>
<td>T1 T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>/</td>
<td>\</td>
<td>\</td>
</tr>
<tr>
<td>/</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>sack #2</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>/</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>sack #3</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>T:</td>
<td></td>
<td>T3</td>
</tr>
<tr>
<td>broken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td>&lt;</td>
<td>&lt;</td>
</tr>
<tr>
<td>LOST</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>RETRIEVAL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Figure 1  SCTP Message Retrieval Issue
In such an assumption, endpoint A sends data to endpoint B. At time T1 endpoint A receives the first sack for data #1, at time T2 endpoint B receives all data #1, #2 and #3, and responds sack #1, #2 and #3. Endpoint A receives sack #2 and #3 respectively at time T3 and T4. In this flow the time sequence is T1 < T2 < T3 < T4.

If the IP network that connecting endpoint A and endpoint B is interrupted at time T which is between T2 and T3, endpoint B should receive data #1, #2 and #3, but endpoint A should only receive sack for data #1. When the SCTP layer in endpoint A sends COMMUNICATION LOST notification to the ULP layer, SCTP indicates ULP that data #2 and #3 are not acknowledged, so if the ULP layer retrieves unacknowledged data and retransmits the data in some other manner, the endpoint B would receives the duplicated data #2 and #3, which is explicitly a wrong result.

If the IP network that connecting endpoint A and endpoint B is interrupted at the time between T3 and T4, endpoint B should receive data #1, #2 and #3, but endpoint A should only receive sack for data #1 and data #2. When the SCTP layer in endpoint A sends COMMUNICATION LOST notification to the ULP layer, SCTP indicates ULP that data #3 are not acknowledged, so if the ULP layer retrieves unacknowledged data and retransmits the data in some other manner, the endpoint B would receives the duplicated data #3, which is also a wrong result.

Analyzing these cases, we can find that the key issue is the floating sack packets. The amount of floating sack packets depends on the throughput, the trip time from the receiver to the sender and other reasons. The amount, which is related to the network condition, may be small, middle or large. Because of these floating sack packets, ULP can’t get the accurate unacknowledged information via the existing primitives.

3.2. SS7 Adapter over SCTP Problem

M3UA specified in [RFC4666] is the most popular SS7 adapter in current network. M3UA can provide service not only to IPSP-IPSP communication but also to Signalling Gateway.

The failover mechanism in M3UA layer is "n+k" redundancy model, where "n" ASPs are active and "k" ASPs are inactive. When the active ASP(s) lost communication (association interrupted), the inactive ASPs may takeover the active ASP role. But during the failover procedure the traffic is affected. Some signaling messages that have been sent to the interrupted association are not successfully transported to the receiver, so the failover mechanism M3UA provided is a "lossful" solution.
3.3. Application Signalling over SCTP Problem

Signalling layer may use the SCTP layer directly without adapter layer, such as S1-MME interface in 3GPP network. In the control plane of 3GPP LTE/EPC network the E-UTRAN accesses EPC network by S1-MME interface, and the protocol stack specified in section 5.1.1.2 of [3GPP-TS-23401] is as below:

```
+-----------+            |            +-----------+
|   S1-AP   |  ---------------------  |   S1-AP   |
|-----------|            |            |-----------|
|   SCTP    |  ---------------------  |   SCTP    |
|-----------|            |            |-----------|
|    IP     |  ---------------------  |    IP     |
|-----------|            |            |-----------|
|    L2     |  ---------------------  |    L2     |
|-----------|            |            |-----------|
|    L1     |  ---------------------  |    L1     |
+-----------+            |            +-----------+
```

Figure 2 eNodeB/MME Architecture

SCTP is adopted as the signaling transport protocol in LTE/EPC network. Section 4.1 of [3GPP-TS-36412] additionally specifies that "Provision of redundancy in the signaling network" is provided by the S1 signaling bearer. But, because SCTP can’t support inter-association changeover function now, which means SCTP can only provide inner-association level redundancy mechanism but can not provide end-to-end level redundancy mechanism, 3GPP has to specify in section 7 of [3GPP-TS-36412] that "There shall be only one SCTP association established between one MME and eNB pair". In fact, there is no distributed SCTP TCB implement, so in the actual device, any association MUST be implemented in single host or single board. Also because of the high speed data transmission, TCB synchronization and buffered data reproduction are almost can’t be achieved in practice. So the "single board/single association" mechanism can’t meet the redundancy requirement of telecommunication network. On the other hand, one association can only provide limited throughput for ULP, because of the hardware capability, so the multi-association solution SHOULD be provided for the telecommunication network and the association changeover mechanism SHOULD also be provided.

4. Routing Management Problem

Routing management is a very important functionality in the signaling network. When the source node wants to send a signaling message to
the destination node, the source node MUST know some address
information of the destination node. The destination may be
identified by Signalling Point Code, IP address, User identity or
other identifiers. The source node encapsulates the signaling message
and transmits the message to the network. In SS7 network the
destination of the signaling message may be a node (Layer3 node,
Layer3 identifier) or a specific part in a specific node (User part
of a node, Layer3 identifier + User Identity). The routing of user
part falls into the scope of signaling routing management, too.

But current Sigtran specifications don’t provide complete solution
for some scenarios. [I-D.sigtran-m3ua-ext] and
[Liaison-sigtran-to-3gpp] have presented some discussion on this
topic.

In the basic scenario where IPSEP communicates with No.7 SP, some
problems on routing management would appear. For example,

```
+----+ +----+ +----+
| IPSP 2 | SG1 | SG2 |
+----+ +----+ +----+
|    |    |    |
| +----+ +----+ +----+
|    |    |    |
|    |    |    |
+----+ +----+ +----+
```

Figure 3 Sigtran Routing Management Issue

In this case, SP1 is No.7 Signalling Point, SG1 and SG2 are
Signalling Gateways. 7#SP1 may use TDM based or IP based signaling
connection to access the SGs. IPSP2 is an IP based No.7 Signalling
Point and two User Parts are running in this node. Additionally there
are four ASPs connecting to SG1 and SG2 respectively (ASP1 and ASP2
to SG1, ASP3 and ASP4 to SG2). ASP1 and ASP3 both provide service to
User1 in IPSP2. ASP2 and ASP4 both provide service to User4 in IPSP2.
The routing table in IPSP2 is as below:

<table>
<thead>
<tr>
<th>Source</th>
<th>ASP</th>
<th>Association</th>
<th>Destination</th>
<th>7#SP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>User1</td>
<td>ASP1</td>
<td>Association1</td>
<td>SG1</td>
<td>7#SP1</td>
</tr>
<tr>
<td>User1</td>
<td>ASP3</td>
<td>Association3</td>
<td>SG2</td>
<td>7#SP1</td>
</tr>
<tr>
<td>User2</td>
<td>ASP2</td>
<td>Association2</td>
<td>SG1</td>
<td>7#SP1</td>
</tr>
<tr>
<td>User2</td>
<td>ASP4</td>
<td>Association4</td>
<td>SG2</td>
<td>7#SP1</td>
</tr>
</tbody>
</table>

In this scenario, if Association #1 loses communication to SG1 (too heavy traffic from User1, board crashes down or other reasons) while association #2 is active, SG1 SHOULD detects that IPSP2 is an available node and User1 in IPSP2 is unavailable, SG1 SHOULD send a Destination User Part Unavailable (DUPU) message to 7#SP1 at this moment. However, SG2 and all connections of SG2 work well.

7#SP1 would meet the confusing situation in this scenario. Because MTP and Sigtran don’t maintain status information of remote User Part and MTP/Sigtran would send unavailable indication by MTP-STATUS primitive to User Part. But the other path (7#SP1-SG2-IPSP2 User1) for the User Part is active, so the User part of 7#SP1 can’t proceed correctly.

In other scenarios where multiple IPSPs or No.7 SPs share same Sigtran connections (e.g. M3UA ASPs and SCTP associations), more routing management issues would happen. The existing management solutions on status of destination (i.e., SP status and User Part status) and Routing Context cannot meet the requirements of some telcom environments.

The origin of these troubles is that Sigtran splits MTP into multiple units, which are indexed by Routing Context. Traditional SS7 protocol stack consists of User Part and Message Transfer Part, so SP status and User Part status is simple. While Sigtran divides Message Transfer Part, which leads to the SP status and User Part status depend on the status of the sub-units and the combination. Existing mechanism can’t deal the "partly-available" status.
5. Conclusion and Recommendations

The problems about changeover (traffic management) and routing management are introduced in this document. The existing model of application signaling plus Sigtran can not meet the requirements of telecommunication network. So for the IP migration of telecommunication, Sigtran needs some extensions and enhancements.

6. Security Considerations

Security considerations regarding traffic management and routing management are needed. The security solution SHOULD fulfill the requirements of all involved nodes and the signaling traffic.

7. IANA Considerations

This document doesn’t request any assignment from IANA.

8. Acknowledgments

TBD.
9. References

9.1. Normative References


9.2. Informative References


[I-D.sigtran-m3ua-ext] Xu, C., Xinyan, L., Hao, Z. And X. Duan, "The proposal of extenting RFC4666 for the M3UA deployment", draft-chen-sigtran-m3ua-ext-00.txt, (expired), November 2007.

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