Transport of (Legacy) Signaling over IP

SCTP

SIGTRAN architecture
(http://www.ietf.org/html.charters/sigtran-charter.html)

Summary of course scope
Stream Control Transmission Protocol – SCTP - features

RFC - Request for Comments: 2960 defines SCTP (Oct 2000)

- Reliable transport of messages across a possibly unreliable network service such as IP
  - checksums, acknowledgements and message numbering (in streams)
  - detection of lost, corrupted and duplicated packets
  - selective retransmission
  - congestion control for associations
- Many streams (of packets) within an association
- Multihoming (hosts with $n$ IP addresses)

More SCTP features

- Data segmentation to MTU size at end systems
- Multiplexing of user messages to SCTP datagrams: chunks in messages.
- Resistance to flooding (denial of service) and masquerade attacks
What’s wrong with TCP for transport of signaling?

- **HOL blocking**: Two network nodes signal at the same time about many independent calls. TCP ties them together – one lost message concerning a single call causes signaling of other calls to halt until retransmission recovers the lost message.
- TCP is **byte stream** oriented – application needs to add its own message delimiters and push operations.
- TCP does not allow multihoming → does not reach the required level of reliability (UDP is even more unreliable).
- Nrof simultaneous TCP connections determined by the OS Kernel
- Application can not control TCP timers – signaling delay requirements are difficult to meet when TCP uses retransmission.
- TCP is vulnerable to DOS attacks (e.g. the **SYN attack**).

A use case: Signaling Gateway

- **M3UA** – MTP3 User Adaptation layer extends MTP3 primitive i/f to remote user.
An SCTP association looks like this

- Association is identified by:
  - IP addresses,
  - Port numbers
  - Verification tags
  - Checksums in msgs

Only one association at any time between a pair of EPs!

One or more IP addresses (IPv4 or IPv6)
In each EP one IP address is primary others are backup addresses → reliability

SCTP packets have a common header + control and data chunks

<table>
<thead>
<tr>
<th>SCTP Common Header</th>
<th>32 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Port</td>
<td>Destination Port</td>
</tr>
<tr>
<td>Verification tag</td>
<td>Checksum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chunk 1</th>
<th>Type</th>
<th>Flags</th>
<th>Chunk Length</th>
<th>User data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Flags</td>
<td>Length</td>
<td>User data</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chunk N</th>
<th>Type</th>
<th>Flags</th>
<th>Length</th>
<th>User data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Flags</td>
<td>Length</td>
<td>User data</td>
<td></td>
</tr>
</tbody>
</table>
### Chunk types are:

<table>
<thead>
<tr>
<th>ID Value</th>
<th>Chunk Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Payload Data (DATA)</td>
</tr>
<tr>
<td>1</td>
<td>Initiation (INIT)</td>
</tr>
<tr>
<td>2</td>
<td>Initiation Acknowledgement (INIT ACK)</td>
</tr>
<tr>
<td>3</td>
<td>Selective Acknowledgement (SACK)</td>
</tr>
<tr>
<td>4</td>
<td>Heartbeat Request (HEARTBEAT)</td>
</tr>
<tr>
<td>5</td>
<td>Heartbeat Acknowledgement (HEARTBEAT ACK)</td>
</tr>
<tr>
<td>6</td>
<td>Abort (ABORT)</td>
</tr>
<tr>
<td>7</td>
<td>Shutdown (SHUTDOWN)</td>
</tr>
<tr>
<td>8</td>
<td>Shutdown Acknowledgement (SHUTDOWN ACK)</td>
</tr>
<tr>
<td>9</td>
<td>Operation Error (ERROR)</td>
</tr>
<tr>
<td>10</td>
<td>State Cookie (COOKIE ECHO)</td>
</tr>
<tr>
<td>11</td>
<td>Cookie Acknowledgement (COOKIE ACK)</td>
</tr>
<tr>
<td>12</td>
<td>Reserved for Explicit Congestion Notification Echo (ECNE)</td>
</tr>
<tr>
<td>13</td>
<td>Reserved for Congestion Window Reduced (CWR)</td>
</tr>
<tr>
<td>14</td>
<td>Shutdown Complete (SHUTDOWN COMPLETE)</td>
</tr>
<tr>
<td>15 to 255</td>
<td>reserved by IETF</td>
</tr>
<tr>
<td>63, 127,191,255</td>
<td>IETF-defined Chunk Extensions</td>
</tr>
</tbody>
</table>

Chunk types are:

SCTP association establishment 1

<table>
<thead>
<tr>
<th>Type=01</th>
<th>Flags</th>
<th>Chunk Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiate Tag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advertised Receiver Window Credit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nrof outbound streams</td>
<td>Nrof inbound streams</td>
<td></td>
</tr>
<tr>
<td>Initial TSN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Optional/Variable length parameters

Initiate Tag gives the value for the verification tag the destination must use in this association in future msgs.

init. a-rwnd = buffer space in bytes reserved by Initiator for this association

TSN = transmission sequence number (msg number)

Optional: backup addresses, Host name, Increase state cookie time …
### SCTP association establishment 2

![Diagram of SCTP association establishment 2]

- **INIT ACK**
  - Type=02
  - Flags
  - Chunk Length
  - Initiate Tag
  - Advertised Receiver Window Credit
  - Nrof outbound streams
  - Nrof inbound streams
  - Initial TSN
  - Optional/Variable length parameters

  The same optional parameters as in INIT
  One MANDATORY variable length parameter: **State Cookie**
  - contains all information for the destination to create this association

- **COOKIE ECHO**
  - Type=10
  - Flags
  - Chunk Length
  - Cookie

### SCTP association establishment 3

![Diagram of SCTP association establishment 3]

- **COOKIE ECHO**
  - Type=10
  - Flags
  - Chunk Length
  - Cookie
  - Possible data chunks...

- **COOKIE ACK**
  - Type=11
  - Flags
  - Chunk Length
  - Possible data chunks...

*The Destination can now rely on that the Initiator is who it claims to be*

*4-way handshake prevents DOS attacks like the SYN attack in TCP*

**Data transfer**

**TCB – transmission control block contains association state**
SCTP Data Transfer

Established

DATA

Type=0 Flags: UBE Chunk Length
Transmission Sequence Nr
Stream Identifier Stream Seq Nr
Payload protocol Identifier

User Data

B – beginning fragment, E – ending fragment, U - unordered
TSN – sequence number of data chunk within an association
SACK (selective acknowledgement)

Type=3 Flags Chunk Length
Cumulative TSN Acknowledgement
Advertised Receiver Window Credit
Nrof Gap Ack blocks(G) Nrof Duplicate TSNs (D)
Gap Ack Block #1 start Gap Ack block #1 End
Gap Ack Block #G start Gap Ack block #G End
Duplicate TSN #1
Duplicate TSN #D

The path heartbeat gives information about secondary IP address state

Established

HEARTBEAT CHUNK

Type=4 Flags Chunk Length
Heartbeat info type=1 Heartbeat info length

Sender specific Heartbeat Info

HEARTBEAT ACK

Type=5 Flags Chunk Length
Heartbeat info type=1 Heartbeat info length

Sender specific Heartbeat Info

Not defined: usually IP address, time when sent etc…
You can even find out MTU using this procedure…
SCTP Shutdown procedure

SCTP can be easily extended

• ABORT and ERROR Chunks are used in exceptional cases – still part of the base specification
• New Chunk types are easy to add
• Example ideas: dynamic addition of IP addresses into an association, per-stream flow control …
SUA supports the following

- Transfer of SCCP-User Part messages (TCAP, RANAP, etc.)
- Emulation of SCCP connectionless and connection oriented service.
- Seamless operation of SCCP-User protocol peers.
- Management of SCTP transport associations between an SG and one or more IP-based signalling nodes.
- Distributed IP-based signalling nodes.
- Asynchronous reporting of status changes to management.
SUA Routing context ties the IP entities to SS7 address parameters

Routing key = set of SS7 address parameters or parameter ranges: PC, SSN, SIO, Global title

Routing context = 1:1 Exchanged with the AS

Application Server (AS) - A logical entity serving a specific Routing Key.
An example of an Application Server is a SCP handling all requests for a SCCP-user. The AS contains a set of one or more unique Application Server Processes, of which one or more is normally actively processing traffic.

SIGTRAN components can be used also in the All IP network

SUAP - SCCP/SUA Application Protocol (e.g. - RANAP/RNSAP in 3G)

IP Server Process (IPSP) - A process instance of an IP-based application. An IPSP is essentially the same as an AS Process, except that it uses SUA in a peer-to-peer fashion. An IPSP does not use the services of a Signalling Gateway.

IP based telephony network elements

This might be useful for carrying an existing originally for ISDN designed application into an IP environment.
Signaling Gateway can use M3UA

- M3UA – MTP3 User Adaptation layer extends MTP3 primitive interface to remote user.

M3UA extends MTP3 services to a remote AS in an IP network

- Routing key = set of SS7 address parameters or parameter ranges: CIC, OPC, DPC, SLS, SSN, SIO
- 1:1 Routing context
- Exchanged with the AS
- "Index to Routing key"
- Application Server
  - e.g. MGC or IP-based HLR
  - Failover AS
- SCTP association
- Host-name, IP address

M3UA Supports
- the transfer of all SS7 MTP3-User Part messages (e.g. ISUP, SCCP, TUP etc.)
- seamless operation of MTP3-User protocol peers
- management of SCTP transport associations and traffic between an SG and one or more MGCs or IP-resident Databases
- MGC or IP-resident Database process failover and load sharing
- asynchronous reporting of status changes to management
Alternative for SCP connectivity using SCTP

M2PA – MTP2 User Peer-to-Peer Adaptation layer makes IP network look like a signaling channel (including network management features) for MTP3. Carries all the CCS7 signaling network legacy to the IP environment. SCP is an SS7 signaling point. SG = STP in SS7 terms...

An alternative for MGC connectivity using SCTP

M2UA – MTP2 User Adaptation layer extends MTP2 primitive interface to the IP network: MTP3 of MGC uses SG MTP2 as its layer 2 protocol.

Raimo Kantola –S- 2003  Signaling Protocols  15 - 23
M2UA extends MTP2 primitive interface to a remote system

Each signaling link has IID – Interface Identifier

Messages from many signaling links can be sent to one AS

M2UA manages AS fail over.

Each signaling link is mapped to its own stream in one association, thus messages from different links can be treated in different sequences.

M2UA extends primitive interface to IP

M2PA creates an SS7 signaling link

Differences between M2PA and M2UA include:

M2UA: MGC transports MTP3/MTP2 primitives between the SG’s MTP2 and the MGC’s MTP3 (via the NIF) for processing.

b. M2PA: SG-IPSP connection is an SS7 link.
M2UA: SG-MGC connection is not an SS7 link. It is an extension of MTP to a remote entity.

c. M2PA: SG is an SS7 node with a point code (SG = STP).
M2UA: SG is not an SS7 node and has no point code.

d. M2PA: SG can have upper SS7 layers, e.g., SCCP.
M2UA: SG does not have upper SS7 layers since it has no MTP3.

e. M2PA: relies on MTP3 for management procedures.
M2UA: uses M2UA management procedures.

Source: draft-ietf-sigtran-m2pa-04.txt
SIGTRAN summary

- Has produced 3 RFCs and 11 Internet drafts
- SIGTRAN intends to create a comprehensive signaling architecture for integrating SCN and IP telephony
- SCTP is a generic new transport protocol not only for signaling — OS kernel implementations are available and under way
- These protocols are used in 3G, modernization of IN and IP Telephony

SIGTRAN Internet-Drafts: Status of Spring-2002
according to http://www.ietf.org/html.charters/sigtran-charter.html

- Signaling System 7 (SS7) Message Transfer Part (MTP)2 - User Adaptation Layer (200731 bytes)
- SS7 MTP3-User Adaptation Layer (M3UA) (255043 bytes)
- Stream Control Transmission Protocol Management Information Base using SMIv2 (91359 bytes)
- Stream Control Transmission Protocol Applicability Statement (26493 bytes)
- Signalling Connection Control Part User Adaptation Layer (SUA) (304792 bytes)
- Telephony Signalling Transport over SCTP applicability statement (41358 bytes)
- SS7 MTP2-User Peer-to-Peer Adaptation Layer (90752 bytes)
- SS7 MTP3-User Adaptation Layer (M3UA) Management Information Base using SMIv2 (129205 bytes)
- V5.2-User Adaptation Layer (V5UA) (41441 bytes)
- DPNSS/DASS 2 extensions to the IUA protocol (21903 bytes)
- M3UA Implementor’s Guide (31462 bytes)

SIGTRAN Request For Comments:

- Architectural Framework for Signalling Transport (RFC 2719) (48646 bytes)
- Stream Control Transmission Protocol (RFC 2960) (207757 bytes)
- ISDN Q.921-User Adaptation Layer (RFC 3057) (140327 bytes)
SIGTRAN latest doc’s/04-2003

Internet-Drafts:
Stream Control Transmission Protocol Management Information Base (81420 bytes)
Signalling Connection Control Part User Adaptation Layer (SUA) (313013 bytes)
Telephony Signalling Transport over SCTP applicability statement (65919 bytes)
SS7 MTP2-User Peer-to-Peer Adaptation Layer (110191 bytes)
SS7 MTP3-User Adaptation Layer (M3UA) Management Information Base using SMIV2 (130389 bytes)
V5.2-User Adaptation Layer (V5UA) (43810 bytes)
DPNSS/DASS 2 extensions to the IUA protocol (25509 bytes)
M3UA Implementor’s Guide (151875 bytes)
IUA (RFC 3057) Outstanding Issues (94923 bytes)
Security Considerations for SIGTRAN Protocols (25730 bytes)
GR-303 extensions to the IUA protocol (20644 bytes)

Request For Comments:
Architectural Framework for Signaling Transport (RFC 2719) (48646 bytes)
Stream Control Transmission Protocol (RFC 2960) (297757 bytes)
ISDN Q.921-User Adaptation Layer (RFC 3057) (140327 bytes)
Stream Control Transmission Protocol Applicability Statement (RFC 3257) (24198 bytes)
Signaling System 7 (SS7), Message Transfer Part (MTP) - User Adaptation Layer (RFC 3331) (210807 bytes)
SS7 MTP3-User Adaptation Layer (M3UA) (RFC 3332) (265055 bytes)