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Abstract

The paper defines the architectural framework, convergence solutions and service interworking scenarios associated with SS7-TCAP/IP Interworking between applications in PSTN/IN/Wireless and IP domains.

Note

Some aspects of this contribution are the subject of a provisional patent application by Nortel Networks. The contributors hereby represent that they are not personally aware of any other proprietary or intellectual property rights in this contribution.
1.0 Introduction

Today, the telecommunications industry depends on the SS7 network for the signaling between different entities within the system. The technologies such as Internet Dial-up Access, Voice over IP (VoIP), etc. have identified the need of SS7-ISUP/IP Interworking. There are several Internet Drafts[1,2] that define how the SS7-ISUP inter-works with IP. The other aspect of the SS7 is the use of TCAP for transaction related applications as in 800/888, calling card, local number portability (LNP), wireless mobility management, Intelligent Network (IN) and CLASS services. These services are also required on VoIP convergent network. In fact, some of these service entities have been planned and/or implemented in the IP network without the standardization of the TCAP/SS7 Interworking with IP.

The explosive growth of the Internet and IP networks makes the integration of SS7 entities in the IP network more practical. The network intelligence on voice over IP network will make the use of TCAP on a more widespread basis. This paper proposes the integration of SS7 network services into IP networks via the TCAP/IP Interworking.

2.0 Terminology

Call Server/Controller (CS)
The Call Server performs signaling and call control functions for IP clients, e.g., VoIP phones and Media Gateways. CS may handle the registration and management of resources at the MG. The CS may have the ability to authorize resource usage based on local policy, for example, based on the attributes of both the end-user and the ISP.

Directory Number (DN)
Subscriber number or telephone number.

Global Title Translation (GTT)
SS7 network routing function that translates a logical address to a physical SS7 network address and possibly, a subsystem number, which identify the application that will process the message.
Internet Service Provider (ISP)
Group providing Internet service to customers

ISDN User Part (ISUP)
Integrated Services Digital Network User Part. The call control part of the SS7 protocol.

Media Gateway (MG)
A MG terminates PSTN facilities (trunks, loops), packetizes the media stream for IP, if it is not already packetized, and delivers packetized traffic to the IP network. Examples of MGs are NAS (Network Access Servers) and VoIP gateways. The NAS and VoIP functions may or may not be combined in one gateway.

Public Switched Telephone Network (PSTN)
Abbreviation used by the ITU for the public telephone network.

Service Control Point (SCP)
This is a node in an SS7 network that provides centralized service logic and data, such as call routing information.

Signaling Connection Control Part (SCCP)
The signaling layer in the SS7 protocol provides a transfer capability for circuit related and non-circuit related signaling information.

Signal Transfer Point (STP)
This is a node in an SS7 network that routes signaling messages based on their destination address in the SS7 network.

TCAP/IP Interworking Gateway (TIPG)
The network entity that provides the interface between SS7 network and IP network pertaining to TCAP messaging.

Transaction Capabilities Application Part (TCAP)
Transaction Capabilities in the SS7 protocol are functions that control non-circuit-related information transfer between two or more signaling nodes via a signaling network.

3.0 Base Configurations
SS7-TCAP/IP Interworking will provide an interface between the SS7 network TCAP messaging and IP network entities. This section presents base configurations that serve to illustrate the architectural framework of the SS7-TCAP/IP Interworking.

3.1 Reference Architecture
The SS7-TCAP/IP Interworking function will be performed on the TCAP/IP Gateway (TIPG). The Reference Architecture for the TIPG is illustrated in figure 1.

The Reference Architecture for TIPG shows the TCAP/IP interworking, including the interface between the SS7 network and the IP network. The TCAP/IP Interworking function could also be performed on any gateway that establishes an interface between the SS7 network and an IP network.

Three inter-domain scenarios are addressed:

1. SS7 entity communicating with IP server
2. IP entity (e.g. call server) communicating with SCP in SS7 network
3. IP signaling transport between two SS7 networks

To the interconnecting SS7 network, TIPG acts as a signaling endpoint. It may, of course, include STP functions and acts as a STP. To the interconnecting IP network, TIPG acts as a transit point for messaging between SS7 network and IP entities. TIPG can also be an IP entity itself, that is, a TIPG can transfer TCAP messages to a far-end TIPG for signaling transport between two SS7 networks.

By providing TCAP/IP interworking functions, the signaling transport is transparent to TCAP applications. Thus, TCAP applications must not be impacted whether the signaling message is sent over SS7 network or IP network. Within SS7 network, SCCP functions are provided for addressing and routing. Within IP network, a convergence layer is defined for addressing and routing functions.

The TIPG will perform the mapping function between IP entities and SS7 addresses, and bi-directional encapsulation/decapsulation function for the TCAP/IP Interworking.
Depending on application needs (e.g., sequence control), it may require either TCP/IP or UDP/IP to provide the transport functions for TCAP over IP. Whether using TCP, UDP, or a reliable transport is outside the scope of this document. A convergence layer named Simple TCAP Interworking Part (STIP) is defined between TCAP and UDP/IP (or TCP/IP) transport. STIP provides connectionless control for TCAP applications.

The STIP header consists of called party address and calling party address parameters as defined in SCCP.

```
+-----+               +-----+
|TCAP |               |TCAP |
+-----+               +-----+
|SCCP |               |STIP |
+-----+               +-----+
|MTP  |               |TCP/IP/Reliable transport
+-----+               +-----+
 | IP |
+-----+
```

Figure 2: TCAP messaging between SS7 network & IP network

I. SS7 network originates a TCAP message into the IP network:

```
+-----------------+-----+-----------------+
| MTP | SCCP | TCAP |
+-----+-----+-----+
Decapsulation+-----+ Encapsulation+-----+
```

Figure 3.a: TCAP messaging from SS7 network to IP network

The SS7 message is decapsulated to remove the MTP and SCCP headers. The remaining TCAP message is encapsulated with the IP header and the STIP header, which contains the required information from the MTP and SCCP headers.

II. IP network originates a TCAP message into the SS7 network:

```
+-----------------+-----+-----------------+
| IP/UDP | STIP | TCAP |
+-----+-----+-----+
Decapsulation+-----+ Encapsulation+-----+
```

Figure 3.b: TCAP messaging from IP network to SS7 network

The IP message is decapsulated to remove the IP header and the STIP header. The remaining TCAP message is encapsulated with the MTP and SCCP headers with the required information from the STIP header.

III. IP network provides TCAP message transport between two SS7 networks:
The TCAP message is originated from one SS7 network and is terminated to a far-end SS7 network. The IP network provides signaling transport functions. Each TIPG at the edge of IP network performs the encapsulation/decapsulation functions as described above.

3.2 Convergence functions

STIP convergence functions are required in both TIPG gateway and IP entity that requires the TCAP over IP function.

Note that TIPG may be deployed as a STP and thus some of IP servers, e.g. call servers, are provisioned as pseudo signaling end point to the SS7 network. The routing in this case is based on mapping between point codes and IP addresses. The STIP functions described below assume that no point codes are provisioned for IP entities except the TIPG.

3.2.1 TIPG STIP functions

TIPG acts as a signaling end point to the SS7 network and as a transit signaling point to the IP network. IP entities are TIPG’s subsystems. TIPG needs to maintain the mapping between Subsystem number (SSN) and the address of IP servers after IP servers logging in [3].

In addition to encapsulation and decapsulation functions described in section 3.1, STIP convergence layer performs SCCP addressing and routing to SS7 network and also SCCP-like addressing and routing to IP network.

3.2.1.1 Global Title Translation (GTT) function

Global Title (GT) Address in SS7 network refers E.164 DN and E.214 Mobile number. The GTT function performed by SCCP is to translate GT to find a destination node in SS7 network. Since TIPG is acting as a transit signaling point to IP entities, the GTT function may be required and extended in TIPG. Possible GTT outcomes:

- a destination node in SS7 network - DPC (+SSN or +GT)
- a destination node in IP network - IP address + port number

3.2.1.2 Incoming TCAP messages from SS7 network

STIP determines the destination IP entity based on Destination Point Code (DPC) and the called party address.
1. If DPC of the incoming message is TIPG itself, the destination is a TCAP application that may reside in one IP server or another TIPG (for signaling transport between two SS7 networks) depends on the Routing Indicator in Called Party Address (CDPA).

   - SSN routing: If SSN is available, forward the message to the IP server that has logged in with the same SSN, otherwise the SCCP message return procedure is initiated.

   - GT routing: This indicates translation is required. STIP performs GTT to obtain a far end TIPG’s IP address and forwards the message.

2. If DPC is not TIPG itself, the signaling transport function is requested. STIP retrieves the IP address of a far end TIPG based on the DPC. The mapping between DPC and IP address is described in section 3.2.1.4.

   The SCCP Called Party Address (CdPA) and Calling Party Address (CgPA) are copied into STIP CdPA and CgPA with the following exceptions:

   - CdPA: If DPC is not TIPG itself and SCCP.CdPA contains SSN only, the DPC must be added to STIP.CdPA in order for the far end TIPG to send out the message to its interconnecting SS7 network.

   - CgPA: If SCCP.CgPA contains SSN only, the OPC must be added to STIP.CgPA in order for the response message to be sent back to the originator.

3.2.1.3 Incoming TCAP messages from IP network

   If STIP.CdPA indicates GT routing, then perform GTT to obtain a destination address:
   - the destination is an IP address, forward the message to the IP entity.
   - the destination is a SS7 point code then set DPC to the SS7 point code.

   The STIP CdPA and CgPA are copied into SCCP CdPA and CgPA with the following exceptions:

   - CdPA: If STIP.CdPA contains PC and SSN, copy the SSN to SCCP.CdPA and uses the PC for DPC.

   - CgPA: If STIP.CdPA indicates GT routing, and STIP.CgPA contains SSN only, this indicates the message is originated from an IP server. STIP adds TIPG’s PC into SCCP.CgPA in order for a response message to be sent back to the TIPG.

   The OPC is set to TIPG’s PC unless the STIP.CgPA contains a different PC that indicates it is a signaling transport message. In this case, the OPC must be set to the PC from STIP.CgPA.
3.2.1.4 Mapping between point code and IP address

To provide signaling transport over IP function between two SS7 networks, it requires mapping of SS7 point codes to a TIPG’s IP address.

This mapping information is needed when a response message needs to be sent back to the originating SS7 network. STIP needs to record the DPC with incoming IP address and port number when it first sends out the query message with an OPC other than its own PC to SS7 network.

To prevent the overload with the point code mapping information, TIPG may add a ‘clean-up’ procedure to periodically delete the mapping records that are not referenced/used over a period of time.

3.2.2 STIP in IP entity (non TIPG)

STIP provides addressing and routing functions for TCAP applications in IP entities. The STIP CgPA and CdPA contain the same type of SCCP routing addresses: GT and PC/SSN. Since the IP entity is not an SS7 entity, it does not have SS7 point code nor does it utilizes any point code that may be sent to it in CgPA from the homed TIPG. The point code if any contained in CgPA in a query message is used as CdPA in a subsequent response message to the originator via TIPG.

STIP provides three primitives as described in SS7 SCCP to the TCAP user:

1. N-UNITDATA request – used by the TCAP user to request data transport to another user.
2. N-UNITDATA indication – informs the TCAP user that data is being delivered to it.
3. N-NOTICE indication – informs the TCAP user that data could not reach the final destination.

3.2.2.1 Incoming STIP TCAP Data message from TIPG

STIP TCAP Data message is defined in STIPP document [3]. The routing indicator in CdPA must be set to SSN routing. The message is passed to the application using N-UNITDATA indication primitive with parameters:
- CdPA
- CgPA
- TCAP data

3.2.2.2 Outgoing message from subsystem

STIP received the data parameters from the TCAP user via N-UNITDATA request primitive. The data parameters are:
- CdPA
- CgPA
- TCAP data
The addressing information may take the following forms:
- DPC+SSN (from the CgPA of the received message from SS7 network)
- GT

It’s optional for TCAP user to set CgPA. The CgPA is set to its own SSN. STIP sends the message via UDP/IP to the homed TIPG.

3.2.2.3 STIP TCAP Error message from TIPG

Upon receiving the TCAP Error message (defined in STIPP protocol [3]), STIP informs the TCAP user via N-NOTICE indication primitive.

3.3 Inter-domain scenarios configurations

3.3.1 Voice Over IP Services Configuration

The Voice-Over-IP (VoIP) services configuration illustrates the application of the TCAP/IP Interworking functionality. The TCAP/IP Interworking functionality will be performed within the TIPG.

![Figure 4: VoIP Services TCAP/IP Interworking Configuration](image)

Note:
1. TIPG and ISUP Gateway are two different logical entities that can physically be located on the same physical box.
2. IMT- Inter-Machine Trunk
Sample TCAP message headers:

1. Query message
   - STIP message sent by IP entity
     Dest.IP+port = TIPG’s IP+port
     Src.IP+port = IP entity’s IP+port
   - STIP.CdPA = GT + Translation Type (TT), GT routing
   - STIP.CgPA = IP entity’s SSN, SSN routing

   TIPG’s STIP sends the TCAP message with SCCP & MTP header
   - DPC = STP’s PC
   - OPC = TIPG’s PC
   - SCCP.CdPA = GT + TT, GT routing
   - SCCP.CgPA = TIPG’s PC + SSN, SSN routing

2. Response message
   - SS7 TCAP message to TIPG
     - DPC = TIPG’s PC
     - OPC = SCP’s PC
   - SCCP.CdPA = IP entity’s SSN, SSN routing
   - SCCP.CgPA = SCP’s LNP SSN, SSN routing

   TIPG’s STIP sends the TCAP message with STIP header
   - Dest.IP+port = IP entity’s IP+port
     Src.IP+port = TIPG’s IP+port
   - STIP.CdPA = IP entity’s SSN, SSN routing
   - STIP.CgPA = SCP’s PC + SCP’s LNP SSN, SSN routing

3. If a return result message is required
   - STIP message sent by IP entity
     Dest.IP+port = TIPG’s IP+port
     Src.IP+port = IP entity’s IP+port
   - STIP.CdPA = SCP’s PC + SCP’s LNP SSN, SSN routing
   - STIP.CgPA = IP entity’s SSN, SSN routing

   TIPG’s STIP sends the TCAP message with SCCP & MTP header
   - DPC = SCP’s PC
   - OPC = TIPG’s PC
   - SCCP.CdPA = SCP’s LNP SSN, SSN routing
   - SCCP.CgPA = IP entity’s SSN, SSN routing
Scenario for an VoIP phone making a call to PSTN user with LNP:

1. VoIP phone sends a "Make Call" to its carrier with PSTN number as destination DN.
2. The IP carrier CS determines the destination DN is in an interconnecting PSTN with LNP deployment, so it sends a TCAP message for LNP number translation to the TIPG over IP.
3. TIPG decapsulates the IP header, encapsulates the TCAP message with the SS7 header, and delivers to the SS7 network.
4. GTT is performed at STP to determine the destination SCP. Upon receiving the message, LNP SCP responds with a TCAP message that contains the local routing DN to the TIPG.
5. TIPG decapsulates the SS7 header, encapsulates the TCAP message with the IP header, and deliver to the CS.
6. CS acquires E.164/IP address conversion to locate a MG that has IMT to the destination PSTN. Note: for simplicity of illustration, the same CS provides media gateway control function for the identified MG.
7. CS commands MG to reserve trunk resources and sends ISUP-IAM message to the ISUP Gateway over IP.
8. ISUP Gateway decapsulates the IP header, encapsulates the ISUP message with the SS7 header, and deliver to the destination PSTN.
9. The destination CO sends back a response message to the ISUP gateway.
10. The ISUP gateway decapsulates the SS7 header, encapsulates with the IP header, and sends to the CS.
11. CS/MG completes the call setup with the VoIP phone.

The steps 2 to 5 involve the TCAP/IP interworking functionality. The other steps involve either Q.931 or ISUP functionality and are not the concern of this paper. Also note that there is the need for the mapping between IP Address/Port Number and the assigned TDM channel that is performed at the CS/MG.

3.3.2 Short Message Service TCAP/IP Interworking Configuration

The TCAP/IP Interworking function can be applied to a Short Message Service Center (SMSC) Application. Again, the TCAP/IP Interworking function will be performed within the TIPG.

```
+-------+    IP    +-------+
  | TIPG |-----------| SMSC |
  +-------+    +-------+  
    /        / ss7    
   /        /        
  +--+-    +--+-    +--+-
    | MSC |    | HLR/VLR|
    +--+-    +--+-
```

Figure 6: Short Message Service TCAP/IP Interworking Configuration
Scenario for the SS7 sending the SMS message to the SMSC:

1. SMS message arrives at the TIPG from the SS7 network destined for the SMSC.
2. TIPG decapsulates the SS7 header, encapsulates the TCAP message with the IP header, and delivers it to the SMSC.
3. SMSC saves the content of SMS message for the future delivery.

Scenario for the SMSC delivering the SMS to the SS7 network:

1. TCAP message arrives at the TIPG from the SMSC.
2. TIPG puts its PC/SSN in the originating PC/SSN field of the SS7 message. It also examines the STIP header for the destination SS7 address of the SS7 message.
3. TIPG decapsulates the IP header and encapsulates the TCAP message with the SS7 header, and then delivers it to the SS7 network.

3.3.3 IP Applications and TCAP/IP Interworking Configuration

```
+-----+    +------+    ss7    +------+
|SCP |----| STP  |-----------| TIPG |
+-----+    +------+        -- +------+
 ss7 /    /    \ 
+-----+ ----+ IP \ 
 | SP |     |IP   |
+-----+     +------+
```

Figure 7: IP Applications and TCAP/IP Interworking Configuration

Note: The IP Entity can be any IP-based application such as: Directory Service, Location Service, etc.

An important aspect of this scenario is the need for the address translation between the subsystem number and the IP address/Port Number. The TIPG must have a table that records the mapping between these two addresses.

Scenario for the SS7 originating the TCAP message into the IP network:

1. TCAP message arrives at the TIPG from the SS7 network. This TCAP message is destined for one of the IP Entities homed to the TIPG.
2. TIPG examines the destination SSN in the SS7 message and maps this SSN into IP address/port number of the destination IP Entity.
3. TIPG decapsulates the SS7 header, encapsulates the TCAP message with the IP header, and delivers it to the destination IP Entity.
Scenario for the IP Entity originating the TCAP message into the SS7 network:

1. TCAP message arrives at the TIPG from the IP Entity. This TCAP message is destined for one of the SS7 Entities within the SS7 network.

2. TIPG adds its PC in the originating PC/SSN of the SS7 message. It also examines the STIP header for the destination SS7 address of the SS7 message, which can be specified as the PC/SSN or the Global Title. The TCAP response message to a TCAP invoke message is an example of the PC/SSN specified in the STIP header. The delivery of the short message to a Short Message Entity (SME) is an example of the Global Title specified in the STIP header. In this case, the Global Title can possibly be an E.164 or E.214 number.

3. TIPG decapsulates the IP header and encapsulates the TCAP message with the SS7 header, and then delivers it to the SS7 network.

3.3.4 PSTN Signaling Transport Configuration

For VoIP services, an IP network may provide signaling transport functions for two PSTN networks. For example, a PSTN user makes a call via an interconnecting IP network to another PSTN user who has subscribed Calling Name Delivery (CNAM) service. The TCAP query message launched by the terminating switch may be transported via the IP network to the originating network to retrieve the calling name information. This intermediate signaling transport function can also support queries between the originating and terminating PSTN networks for CLASS Automatic Recall and Automatic Callback services.

Each TIPG in the edge of IP network performs the encapsulation/decapsulation functions for converting of a TCAP/SS7 message to a TCAP/IP message and of a TCAP/IP message to a TCAP/SS7 message.

```
+----+    ------------                    ------------
|SCP|--- |SS7 network|                  |SS7 network|
+----+    ------------                    ------------
   ss7 / \                           /         \
   / \ss7                           ss7/       \
  +-----+    +-----+    +-----+    +-----+
  |CO/SP|    |TIPG-2 |    |TIPG-1 |    |CO/SP|
  +-----+    +-----+    +-----+    +-----+
   |     / IP \                      / |
   | PSTN IP \ Called Pary |
   | Caller |IP network| with CNAM |

Figure 5: Signaling Transport TCAP/IP Interworking Configuration
```
Scenario for Calling Name Delivery service for a PSTN-IP-PSTN call:

1. A PSTN to PSTN call via an interconnecting IP network. This call is connected from the originating PSTN via IP carrier’s gateways such as ISUP gateway, CS & MG to the terminating PSTN switch.

2. The terminating PSTN checks the called party service profile and sends a TCAP message towards the originating carrier for CNAM information.

3. The SS7 network performs Global Title Translation (GTT) on calling party number and sends the TCAP message to TIPG-1 over SS7.

4. TIPG-1 acquires E164/IP address conversion (GTT function) based on SCCP routing information and determines the far-end TIPG-2.

5. TIPG-1 decapsulates the SS7 header, encapsulates the TCAP message with the IP header, and deliver to TIPG-2 over IP.

6. Upon receiving the TCAP message, TIPG-2 records the mapping between the originating PC and IP address of the far end TIPG-1, decapsulates the IP header, encapsulates the TCAP message with the SS7 header, and delivers to the interconnecting SS7 network.

7. The interconnecting SS7 network performs the final GTT and forwards the TCAP message to CNAME SCP.

8. SCP responds with a TCAP message that contains the requested CNAME information via the interconnecting SS7 network to TIPG-2.

9. TIPG-2 retrieves the IP address of the far end TIPG-1 based on DPC in SCCP routing information.

10. TIPG-2 decapsulates the SS7 header, encapsulates the TCAP message with the IP header, and deliver to TIPG-1.

11. Upon receiving the TCAP message, TIPG-1 decapsulates the IP header, encapsulates the TCAP message with the SS7 header, and delivers to the interconnecting SS7 network.

12. The terminating switch delivers calling name to alert called party.

4.0 Next Steps

The goal of this document is to present the importance of the SS7-TCAP/IP Interworking function in providing an interface between SS7 TCAP and IP networks. The next step is to identify the problems/issues associated with the SS7-TCAP/IP Interworking and to define a protocol for the open interface between the TIPG and the IP entity that will resolve these problems/issues.
There are a number of issues to be addressed in providing the Interworking function. The resolution of these issues will require continuing research.

* Assignment of a specific port number for the application performing the TCAP/IP Interworking function.

* Security issues involving Encryption/Decryption (at the TIPG and Endpoint Applications), Firewall Transversal, etc. at the IP interface of the TIPG will need to be addressed.

* Encapsulation, decapsulation, fragmentation and sequence control issues for multiple messages.

5.0 References and Related Work


6.0 Authors

Monling Liao
Nortel
RTP, NC
Phone: (919) 991-2704
e-mail: monling@nortelnetworks.com

Emad Qaddoura
Nortel
Richardson, TX
Phone: (972) 684-2705
e-mail: EmadQ@nortelnetworks.com

Liem Le
Nortel
Richardson, TX
Phone: (972) 684-0689
e-mail: LiemLe@nortelnetworks.com

Donald Wurch
Nortel
Richardson, TX
Phone: (972) 684-1049
e-mail: DWurch@nortelnetworks.com