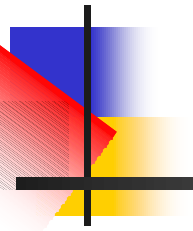
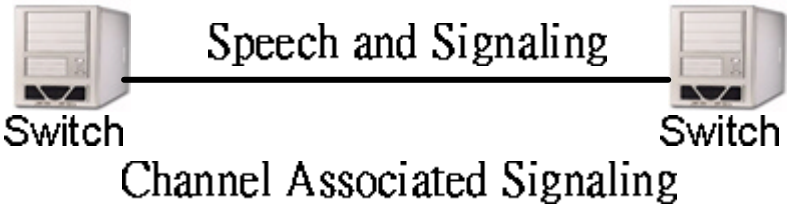


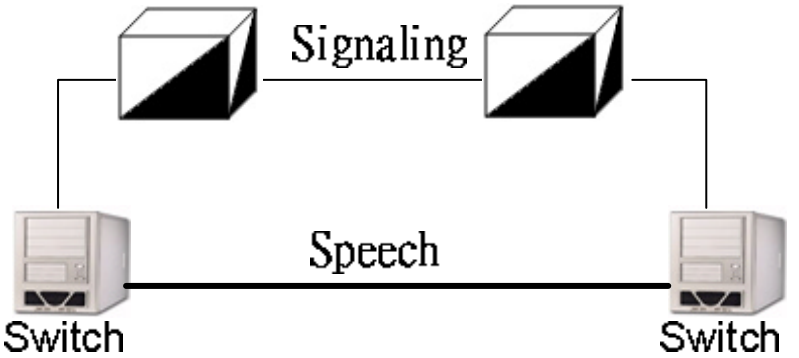
VoIP and SS7

Introduction

- Channel Associated Signaling (CAS)
  - Still widely deployed today
  - Considered as old technology
- Common Channel Signaling (CCS)
  - Separation of signaling and call paths
  - Signaling System 7 (SS7)
    - To enable a wide range of services to be provided to the end-user
    - Caller ID, toll-free calling, call screening, number portability, etc.
    - SS7 is the foundation for Intelligent Network (IN) services.

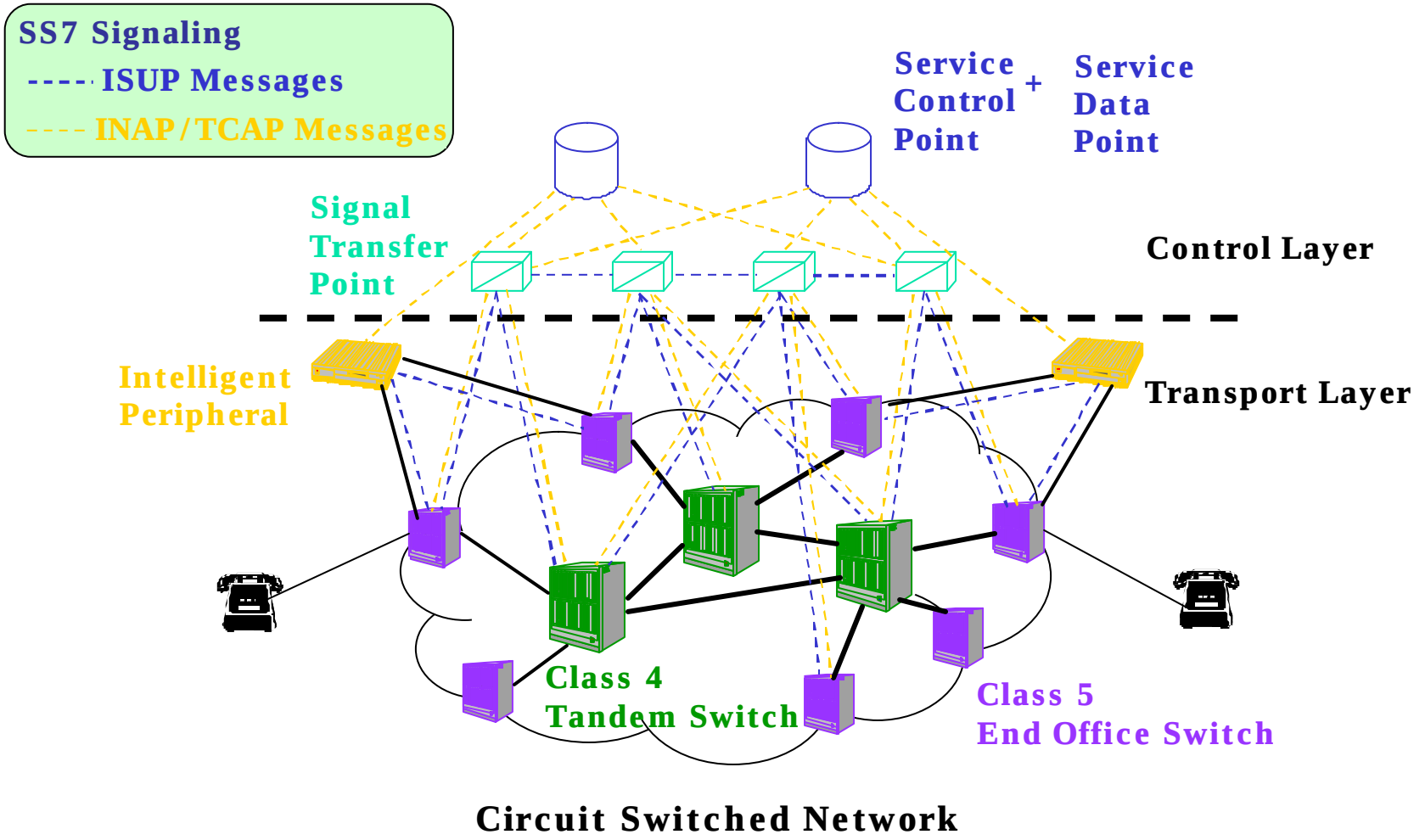


Channel Associated Signaling



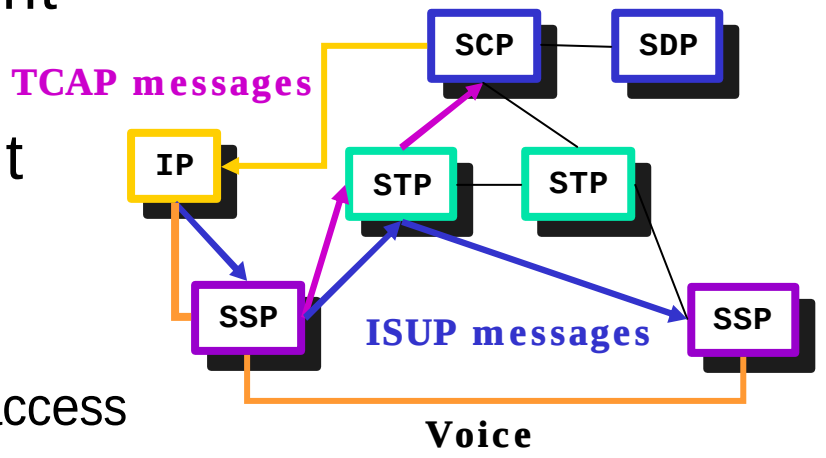
Common Channel Signaling

The Telephone Network [1/2]



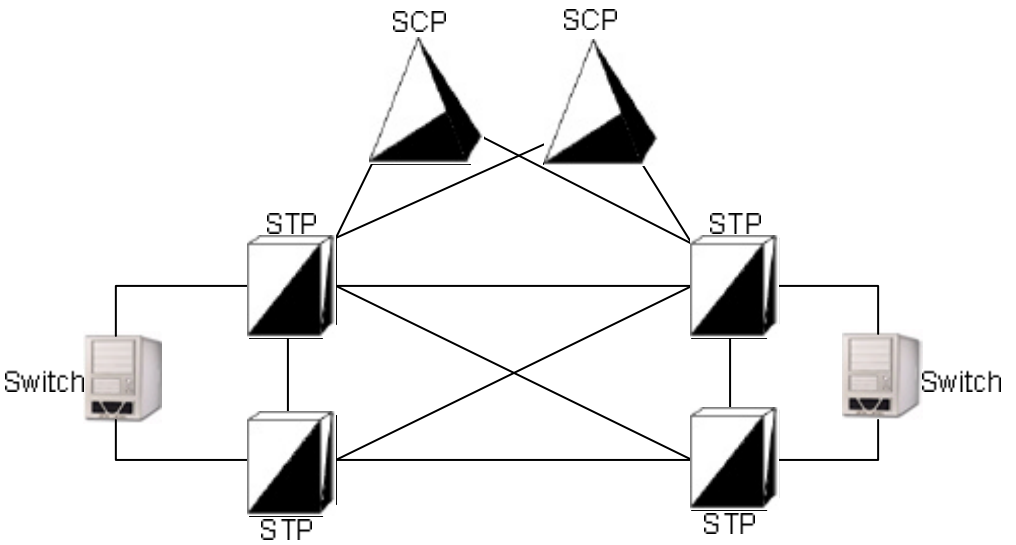
The Telephone Network [2/2]

- 5 Basic Components in Intelligent Networks
  - SSP/Service Switching Point
    - switching, service invocation
  - STP/Service Transfer Point
    - signal routing
  - SCP/Service Control Point
    - service logic execution
  - SDP/Service Data Point
    - subscriber data storage, access
  - IP/Intelligent Peripheral
    - resources such as customized voice announcement, voice recognition, DTMF digit collection



SS7 Network Architecture

- A typical SS7 network arrangement
- This configuration serves several purposes.
  - A fully meshed signaling network is not required.
  - The quad arrangement ensures great robustness.

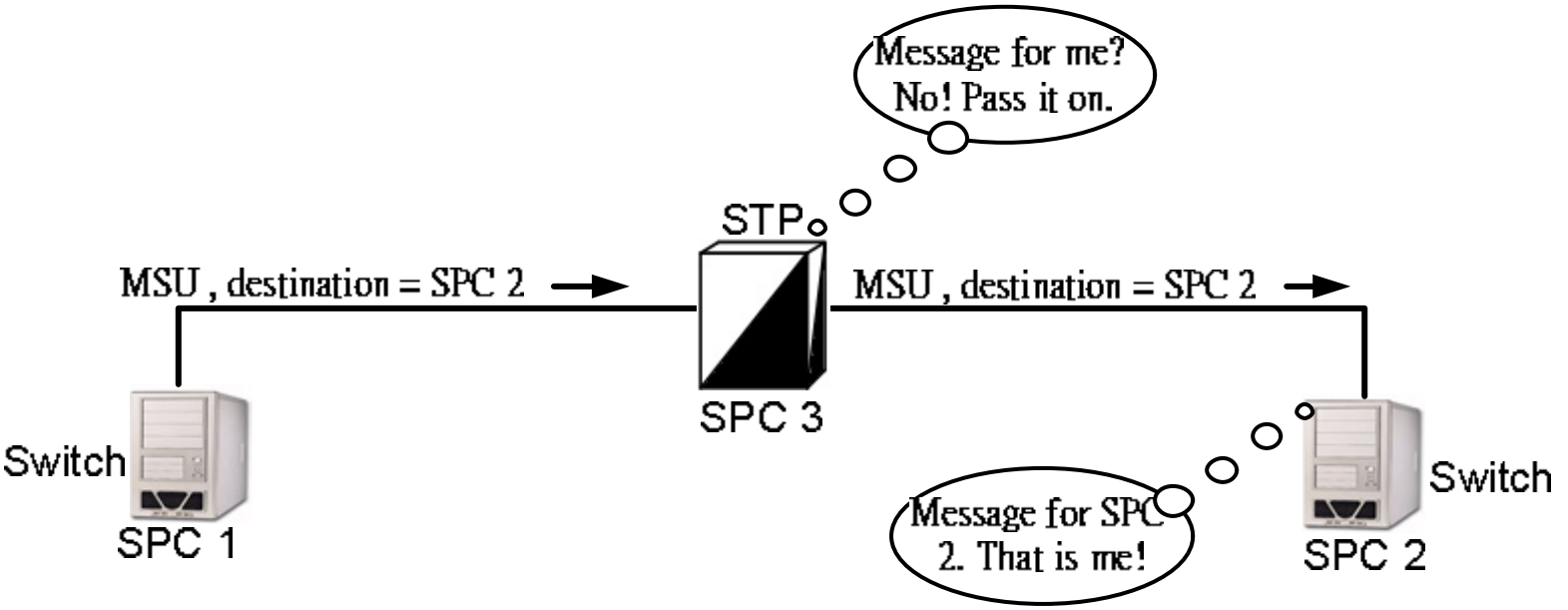


Signaling Point (SP)

- Each node in an SS7 network is an SP.
- The signaling address of the SP is known as a signaling point code (SPC).
- Linkset
  - Group of signaling links directly connecting two SPCs
  - For capability and security reasons

Signal Transfer Point (STP)

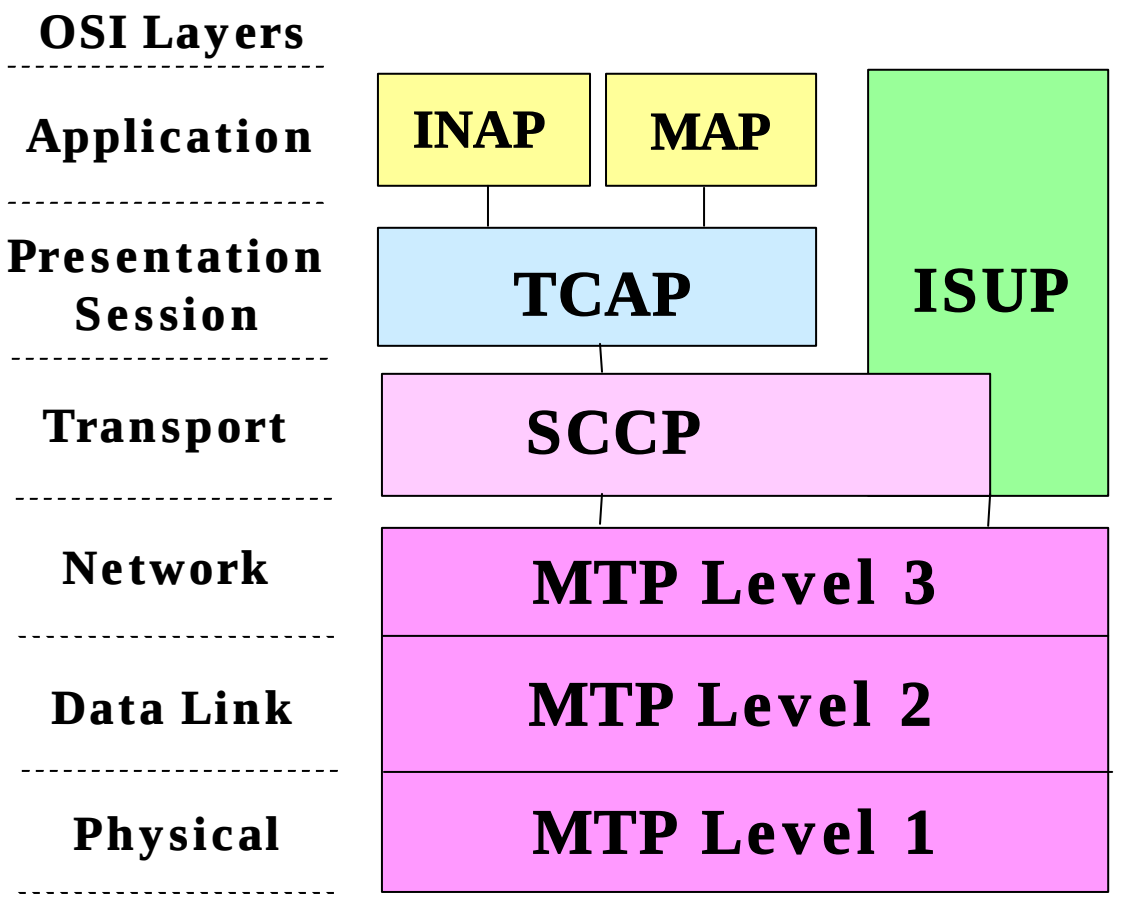
- To transfer messages from one SPC to another



Service Control Point (SCP)

- A network entity that contains additional logic and that can be used to offer advanced services
- The switch sends a message to the SCP asking for instructions.
  - The SCP, based upon data and service logic that is available, will tell the switch which actions need to be taken.
- An good example – toll-free 800 number

SS7 Protocol Suite



MTP Levels 1 & 2

- Message Transfer Part
  - Responsible for getting a particular message from the source to the destination
- Level 1
  - Handling the issues related to the signals on the physical links between one signaling node and another
- Level 2
  - Dealing with the transfer of messages on a given link from one node to another
  - Providing error detection/correction and sequenced delivery of the SS7 messages

MTP Level 3

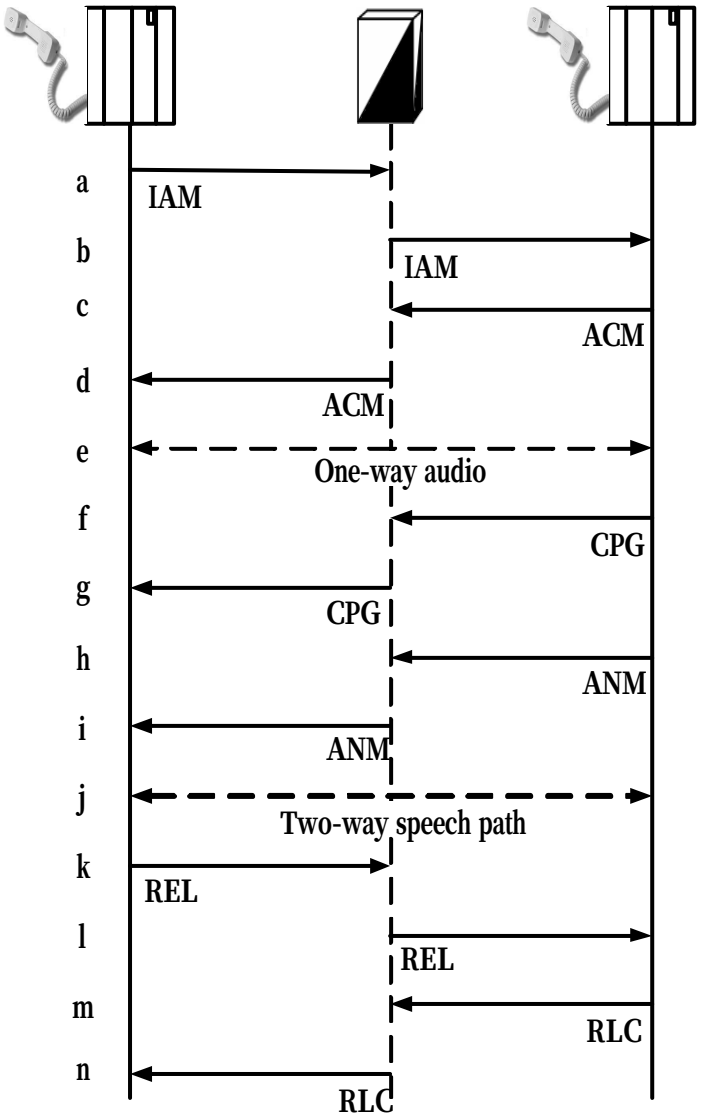
- Signaling message handling
  - Providing message routing between signaling points in the SS7 network
- Signaling network management
  - Rerouting traffic to other SS7 signaling links in the case of link failure, congestion or node failure
  - Load-sharing

ISDN User Part (ISUP)

- Used as the protocol for setting up and tearing down phone calls between switches
- Initial Address Message (IAM)
  - To initiate a call between two switches
- Address Complete Message (ACM) - Optinal
  - To cause a one-way audio path opened from the destination switch to the originating switch (the caller can hear a ring-back tone)
- Call Progress Message (CPG) – Optional
  - To provide additional information to the calling switch regarding the handling of the call
- Answer Message (ANM)
  - To indicate that a call has been accepted by the called party
- Release Message (REL)
  - To initiate call disconnection

ISUP Call Establishment and Release

- A given circuit between two switches is identified by OPC, DPC and CIC.



SCCP

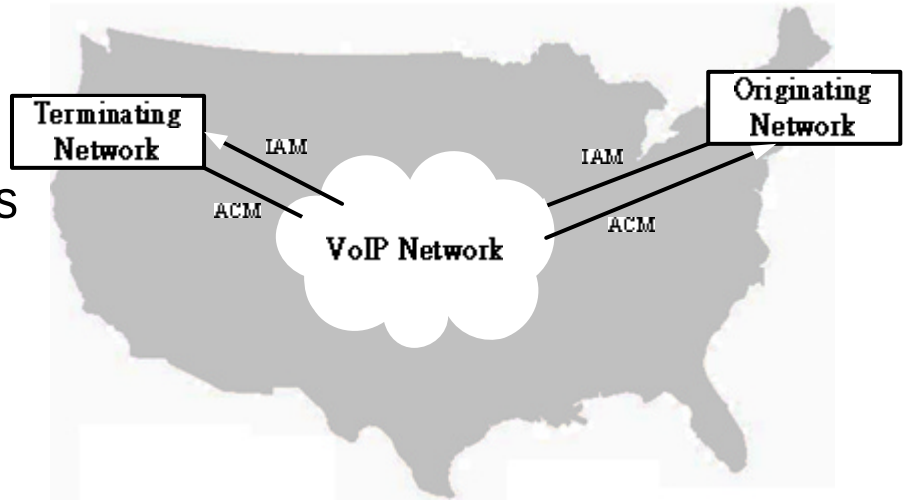
- Signaling Connection Control Part
- Used as the transport layer for TCAP-based services
  - freephone (800/888), calling card, wireless roaming
- Both connection-oriented and connectionless
  - Mostly connectionless signaling
- Global title translation (GTT) capabilities
  - The destination signaling point and subsystem number is determined from the *global title*

TCAP, MAP and INAP

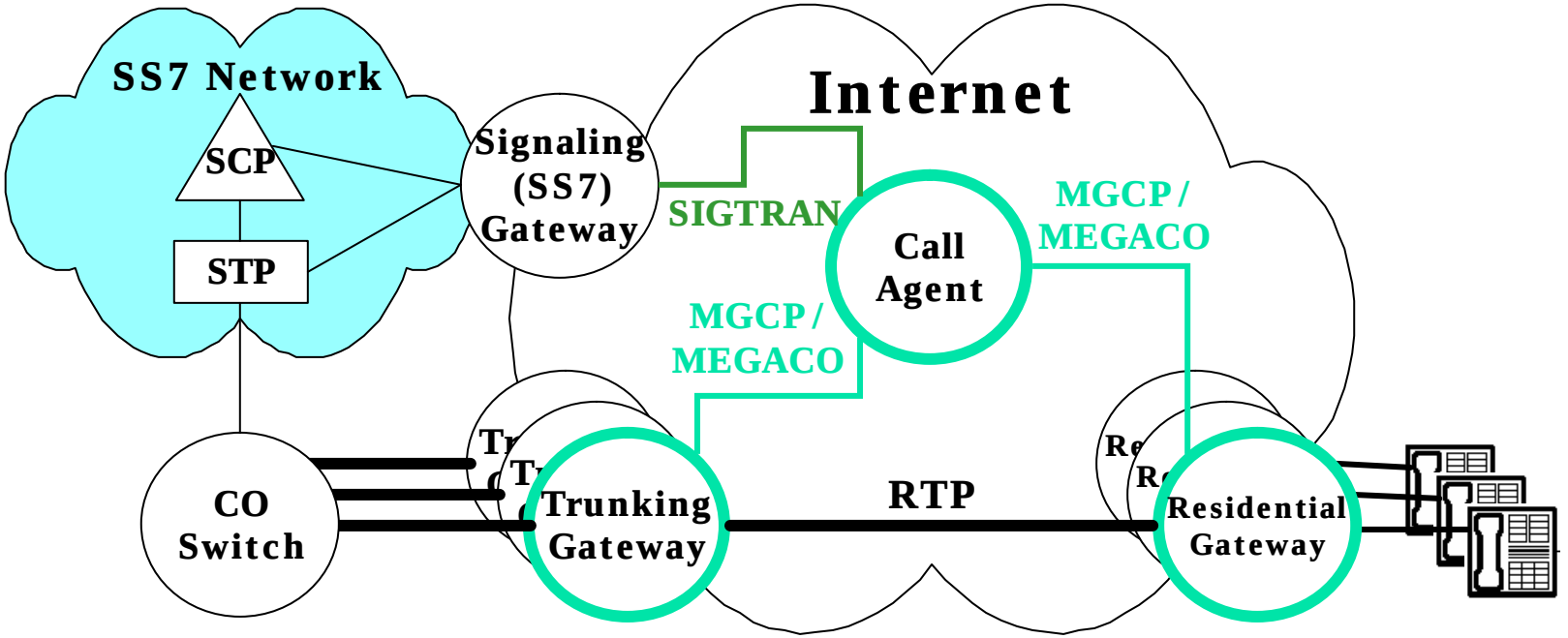
- TCAP (Transaction Capabilities Applications Part)
  - Supporting the exchange of non-circuit related information between signaling points
  - Queries and responses sent between SSPs and SCPs are carried in TCAP messages
- INAP (IN Application Part)
- MAP (Mobile Application Part)

Performance Requirements for SS7

- VoIP networks should support the performance requirements specified for SS7.
- A given route set should not be out of service for more than 10 minutes per year.
- No more than $1x10^{-7}$ messages should be lost.
- No more than $1x10^{-10}$ messages should be delivered out of sequence.
- In ISUP, numerous timing requirements must be met.
- How to make sure that VoIP networks can emulate the signaling performance of SS7.
  - SIGTRAN (Signaling Transport) group of IETF

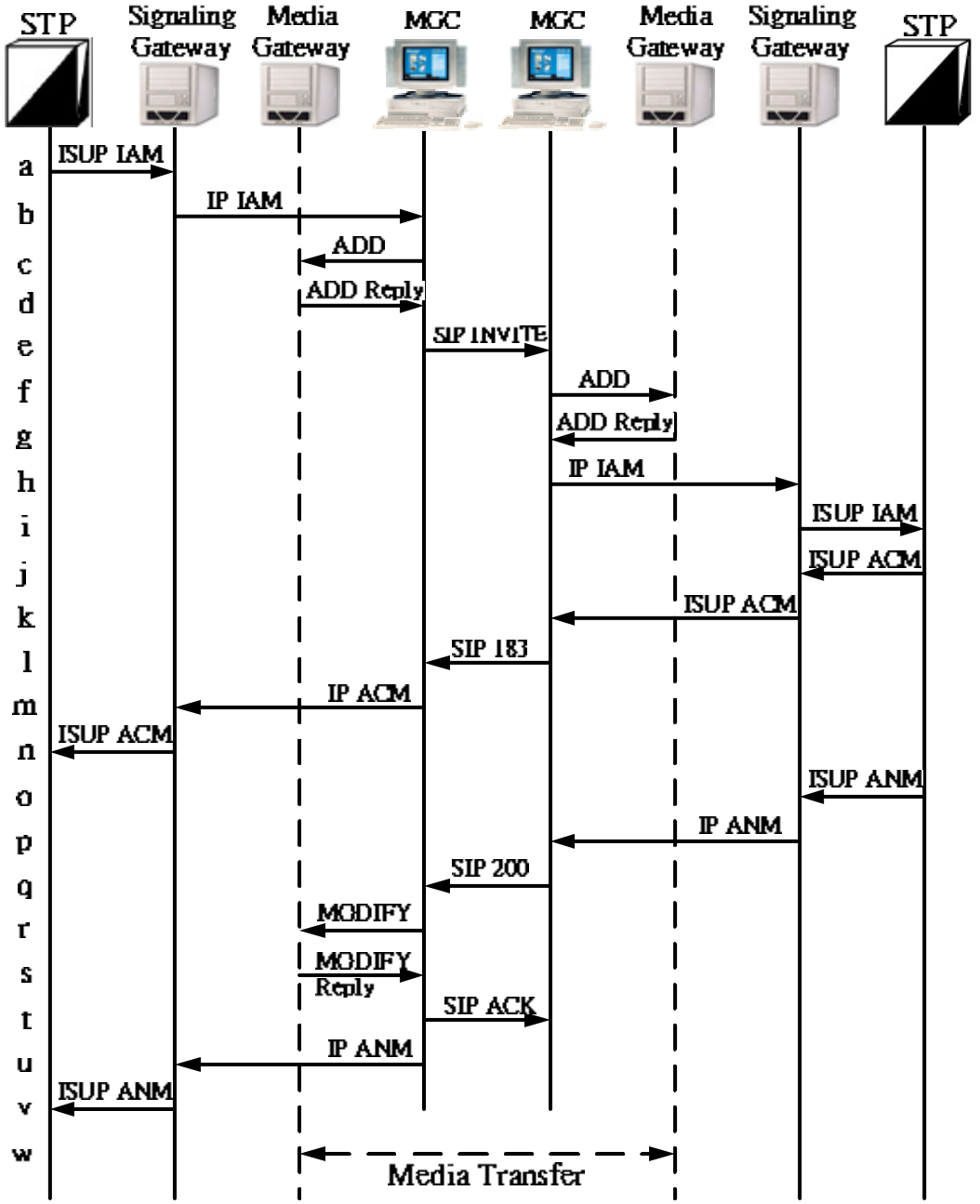


Softswitch Architecture



Signaling Transport (SIGTRAN)

- Addressing the issues regarding the transport of signaling within IP networks
  - The issues related to signaling performance within IP networks and the interworking with PSTN
- SIP/MEGACO/ISUP Interworking
  - Translating the MTP-based SS7 message (e.g., IAM) to IP-based message (e.g., IP IAM)
  - Just a simple translation from point code to IP address ???

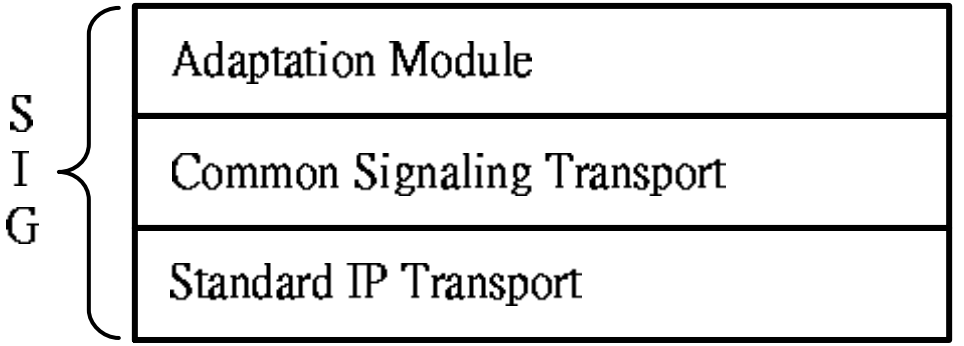

STP
Signaling Gateway
Media Gateway
MGC
MGC
Media Gateway
Signaling Gateway
STP
a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w
ISUP IAM
IP IAM
ADD
ADD Reply
SIP INVITE
ADD
ADD Reply
IP IAM
ISUP IAM
ISUP ACM
ISUP ACM
SIP 183
IP ACM
ISUP ACM
ISUP ANM
IP ANM
SIP 200
MODIFY
MODIFY Reply
SIP ACK
IP ANM
ISUP ANM
Media Transfer

SIGTRAN

- Issues discussed in SIGTRAN
  - Address translation
  - How can we deploy an SS7 application (e.g., ISUP) that expects certain services from lower layers such as MTP when lower layers do not exist in the IP network?
  - For transport layer, the ISUP message must be carried in the IP network with the same speed and reliability as in the SS7.
    - UDP x
    - TCP x
- RFC 2719, “Framework Architecture for Signaling Transport”
  - To describe an overall approach and methodology for signaling transport within IP networks

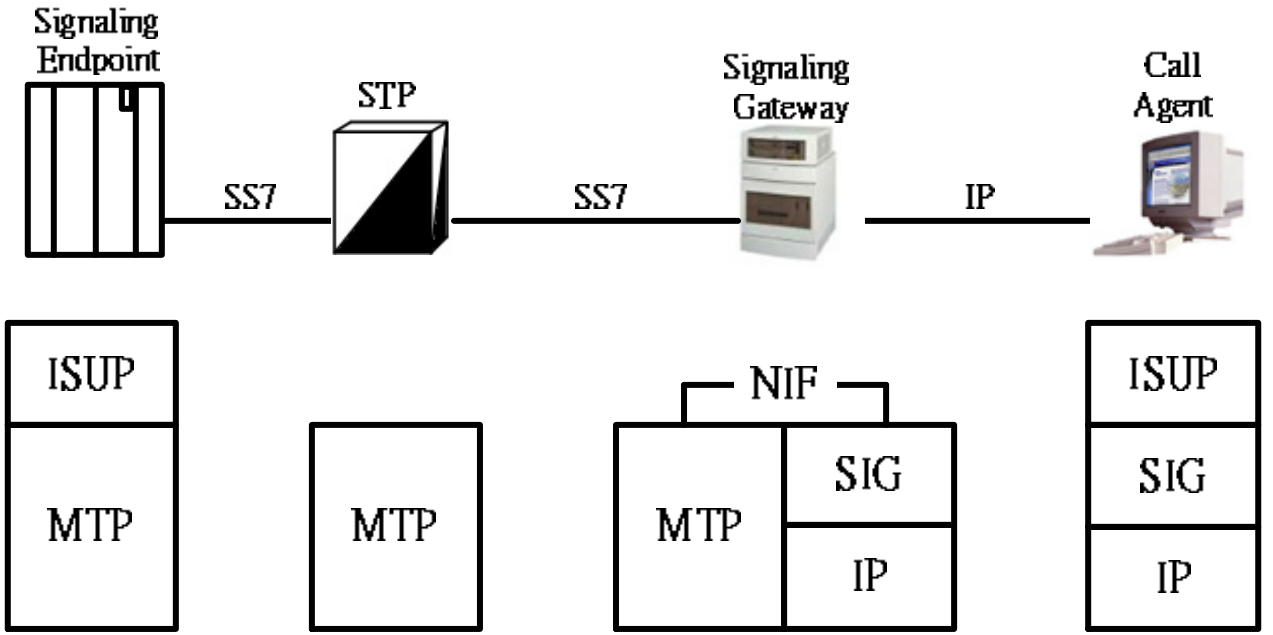
SIGTRAN Architecture

- Signaling over standard IP uses a common transport protocol that ensures reliable signaling delivery.
  - Error-free and in-sequence
  - Stream Control Transmission Protocol (SCTP)
- An adaptation layer is used to support specific primitives as required by a particular signaling application.
  - The standard SS7 applications (e.g., ISUP) do not realize that the underlying transport is IP.



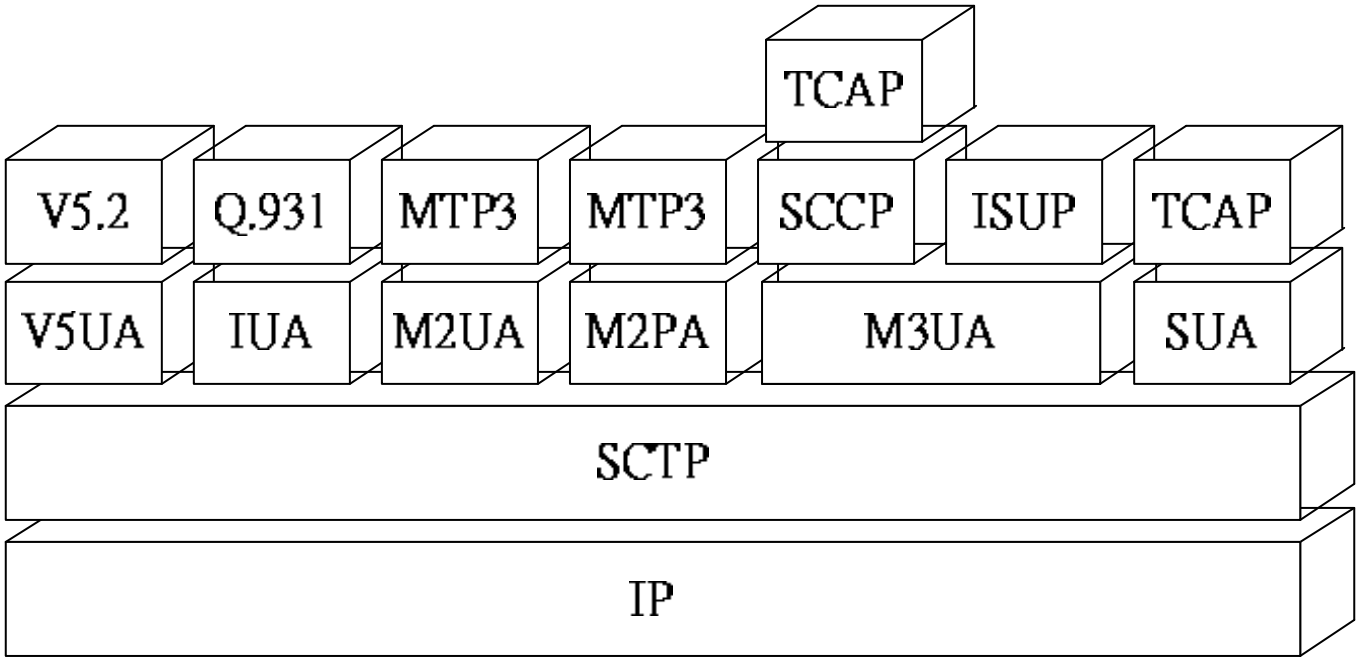
ISUP Transport to MGC

- NIF (Nodal Interworking Function) is responsible for inetworking between the SS7 and IP networks



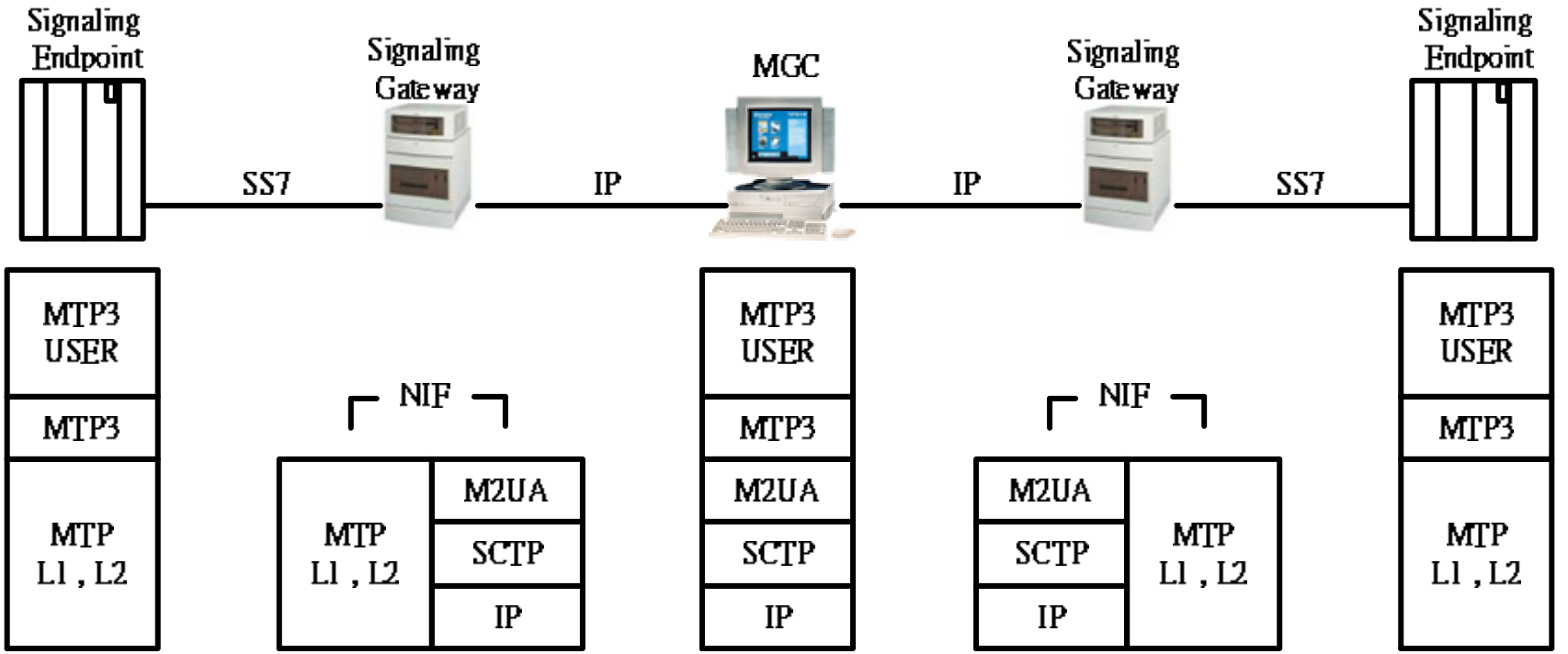
SIGTRAN Protocol Stack

- SCTP: fast delivery of messages (error-free, in sequence delivery), network-level fault tolerance



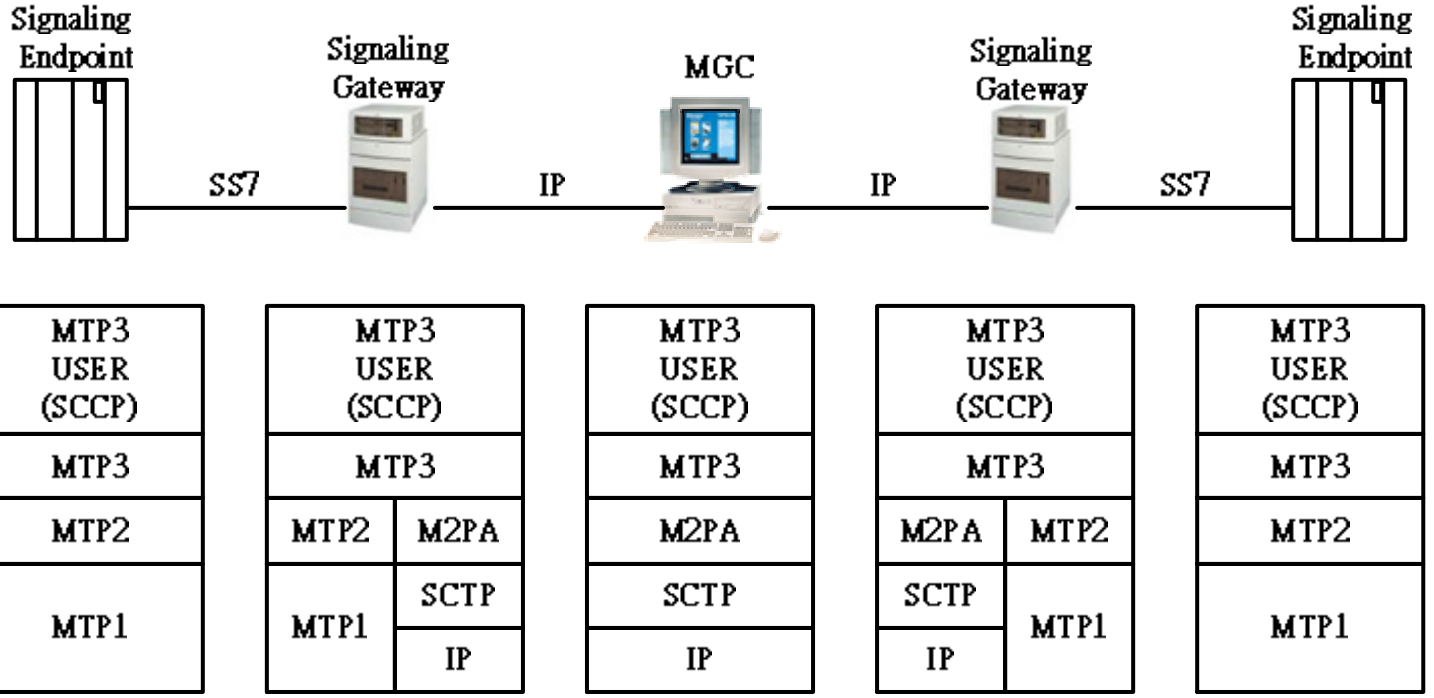
Adaptation Layer [1/3]

- M2UA (MTP-2 User Adaptation Layer)



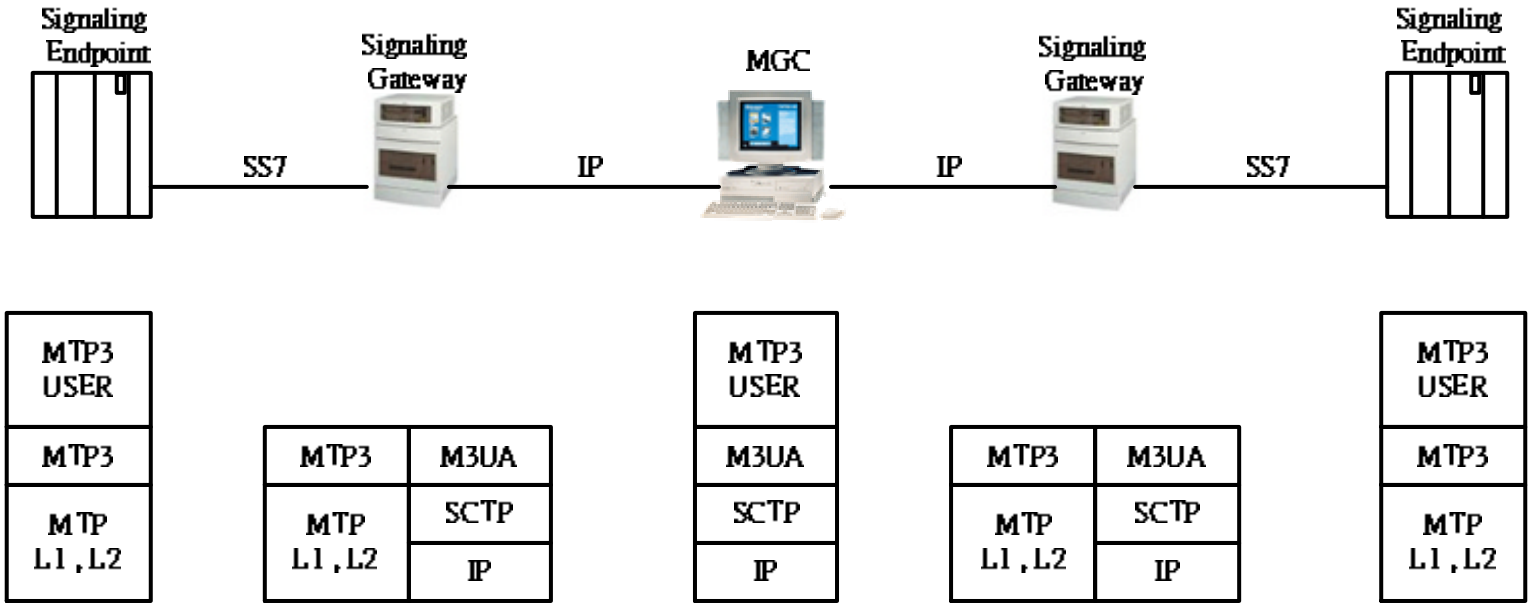
Adaptation Layer [2/3]

- M2PA (MTP-2 Peer-to-Peer Adaptation Layer)
  - An SG that utilizes M2PA is a signaling node for the MGC.
    - It is effectively an IP-based STP.
  - SG can processing higher-layer signaling functions, such as SCCP GTT.



Adaptation Layer [3/3]

- M3UA (MTP3-User Adaptation Layer)
- SUA (SCCP-User Adaptation Layer)
  - Applications such as TCAP use the services of SUA.
- IUA (ISDN Q.921-User Adaptation Layer)
- V5UA (V5.2-User Adaptation Layer)



SCTP

- To offer the fast transmission and reliability required for signaling carrying.
- SCTP provides a number of functions that are critical for telephony signaling transport.
  - It can potentially benefit other applications needing transport with additional performance and reliability.
- SCTP must meet the Functional Requirements of SIGTRAN.

Why not use TCP?

- TCP provides both reliable data transfer and strict order-of-transmission, but SS7 may not need ordering.
  - TCP will cause delay for supporting order-of-transmission.
    - Head-of-line Blocking
- The limited scope of TCP sockets complicates the task of data transmission using multi-homed hosts.
- TCP is relatively vulnerable to DoS attack, such as SYN attacks.

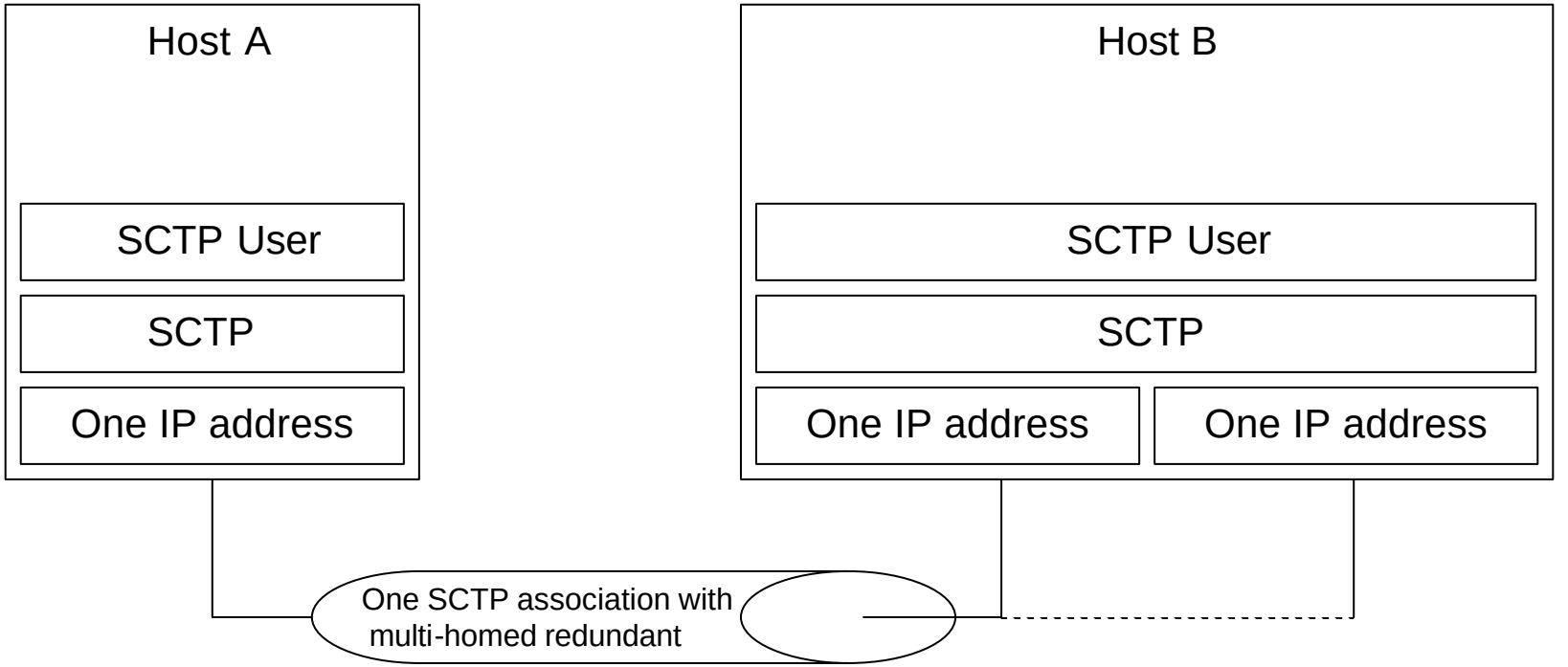
What Supported By Using SCTP?

- To ensure reliable, error-free, in-sequence delivery of user messages (optional).
- To support fast delivery of messages and avoid head-of-line blocking.
- To support network-level fault tolerance that is critical for carrier-grade network performance by using multi-home hosts.
- To provide protection against DoS attack by using 4-way handshake and cookies.

SCTP Endpoint & Association

- Endpoint
  - The logical sender/receiver of SCTP packets.
  - Transport address = IP address + SCTP port number
  - An endpoint may have multiple transport addresses (for multi-homed host).
- Association
  - A protocol relationship between SCTP endpoints.
    - Before applications at two endpoints can communicate, an association must be established.
  - Two SCTP endpoints MUST NOT have more than one SCTP association.
  - The task of instigating an SCTP association falls to the applicable adaptation layer.

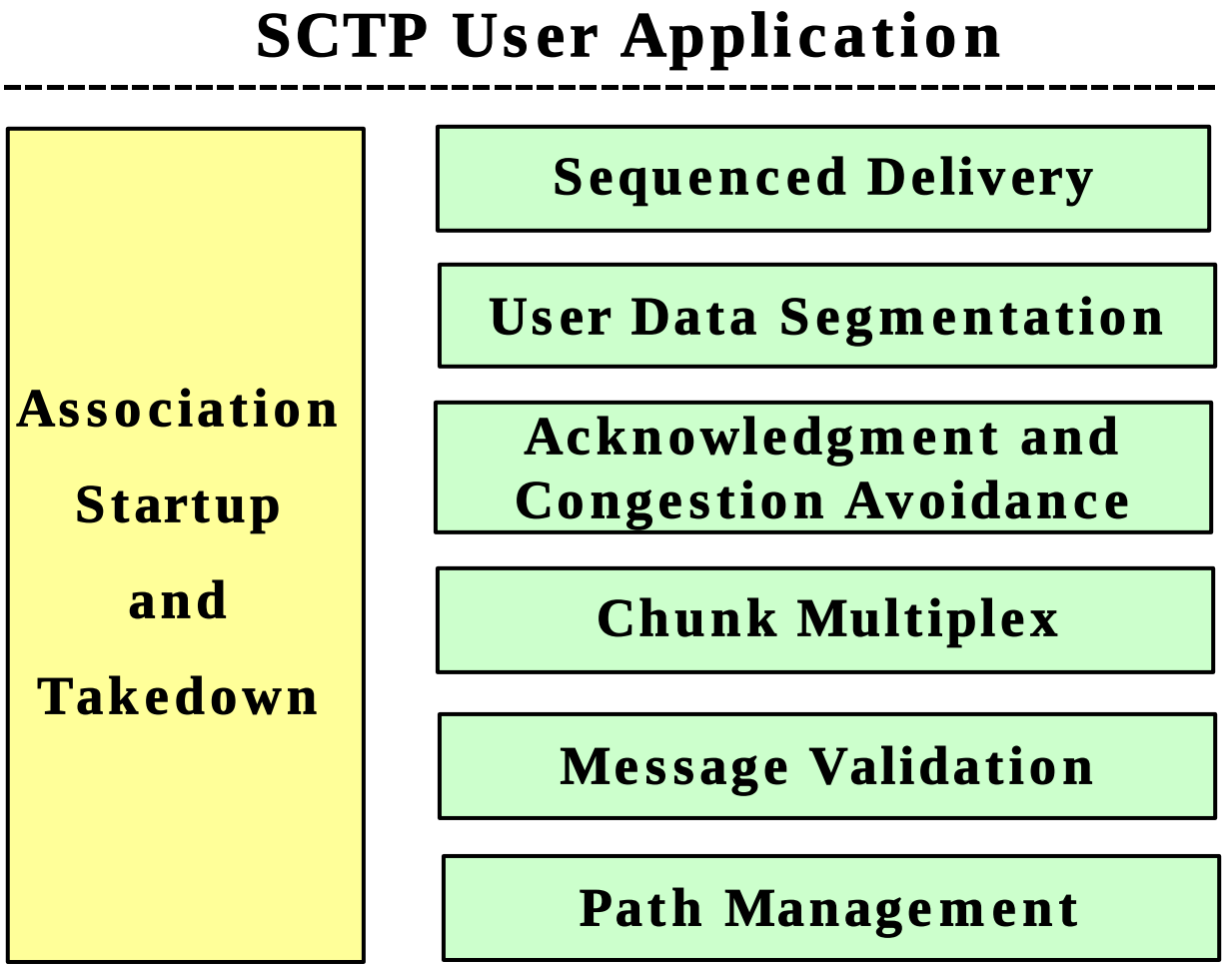
Multi-Homed Host



SCTP Streams

- A stream is a one-way logical channel between SCTP endpoints.
  - The number of streams supported in an association is specified during the establishment of the association.
- To avoid head-of-line blocking and to ensure in-sequence delivery
  - In-sequence delivery is ensured within a single stream.

SCTP Functional View [1/5]



Functional View [2/5]

- Association Startup and Takedown
  - An association is initiated by a request from the SCTP user.
  - SCTP provides for graceful close of an active association.
    - On request from the SCTP user
  - SCTP allows ungraceful close.
    - On request from the user (ABORT primitive) or as a result of an error condition detected within the SCTP layer

Functional View [3/5]

- Sequenced Delivery within Streams
  - Stream is used to refer to a sequence of user messages that are to be delivered to the ULP.
  - SCTP ensures that messages are delivered to the SCTP user in sequence within a given stream.
  - SCTP provides a mechanism for bypassing the sequenced delivery service.

Functional View [4/5]

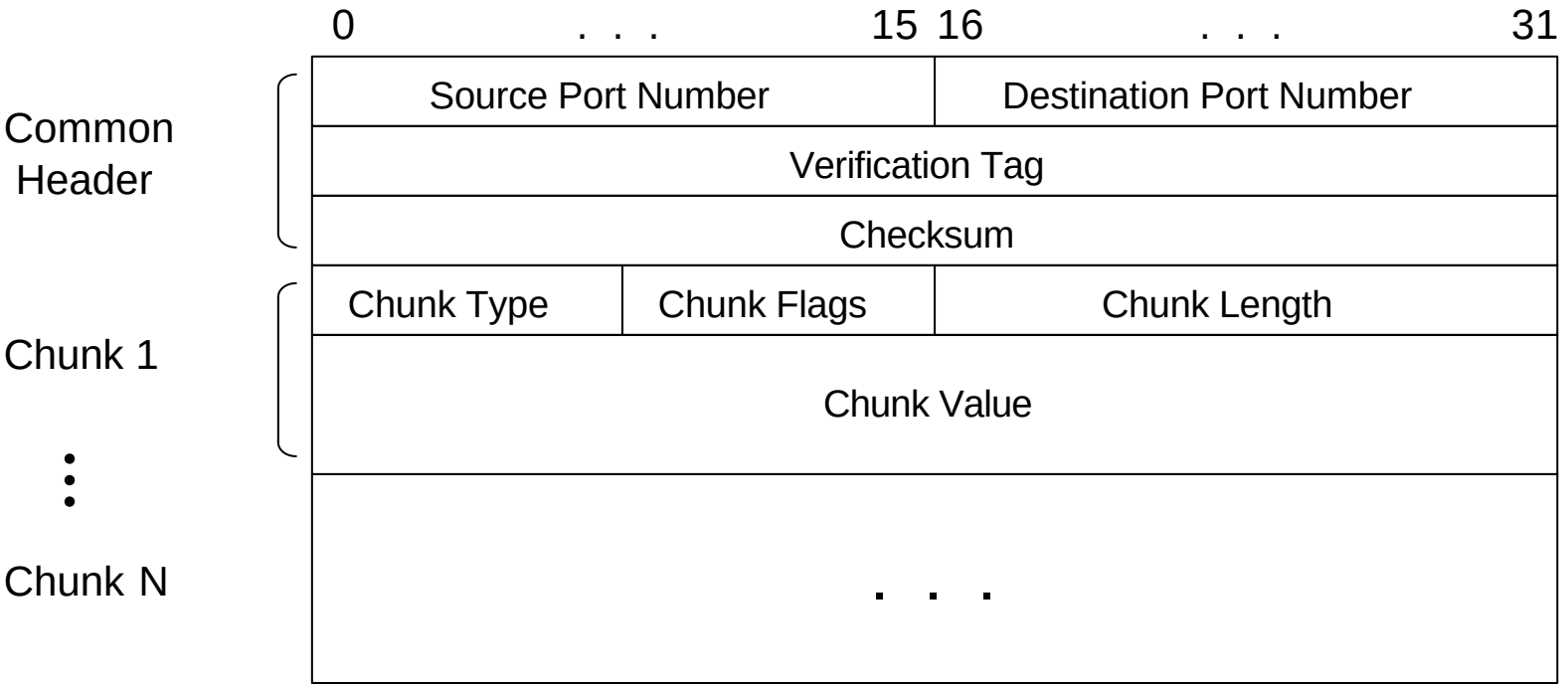
- User Data Fragmentation
  - Fragmenting user messages to conform the lower layer MTU
- Acknowledgement and Congestion Avoidance
  - Responsible for packet retransmission when timely acknowledgement has not been received
- Packet Validation
  - Verification Tag
  - Checksum

Functional View [5/5]

- Chunk Bundling
  - The SCTP user has the option to request bundling of more than one user message into a single SCTP packet.
- Path Management
  - To monitor reachability of the far-end endpoint through heartbeats

SCTP Packets & Chunks

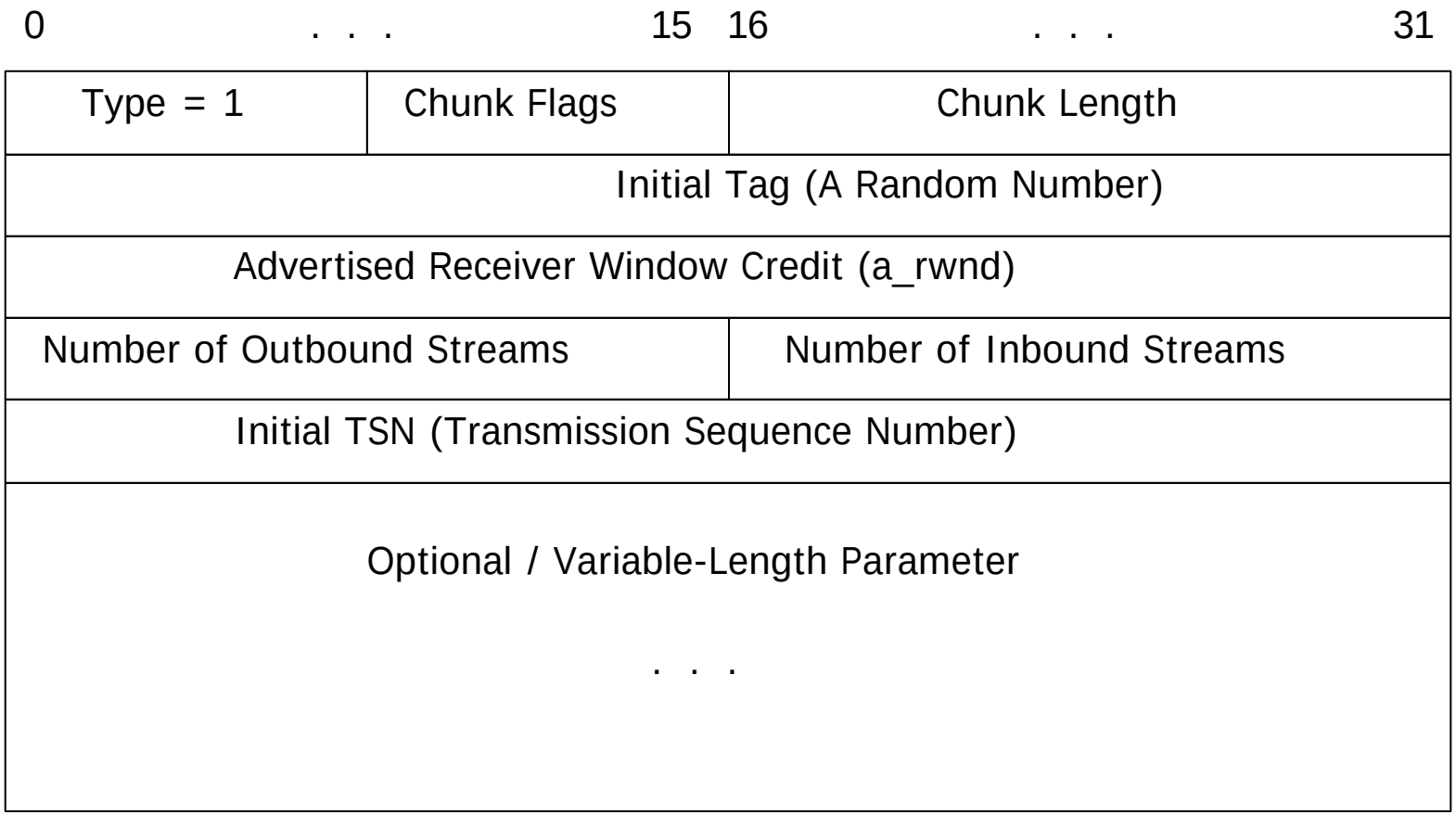
- A SCTP packet can comprise several chunks.
- Chunk
  - Data or control



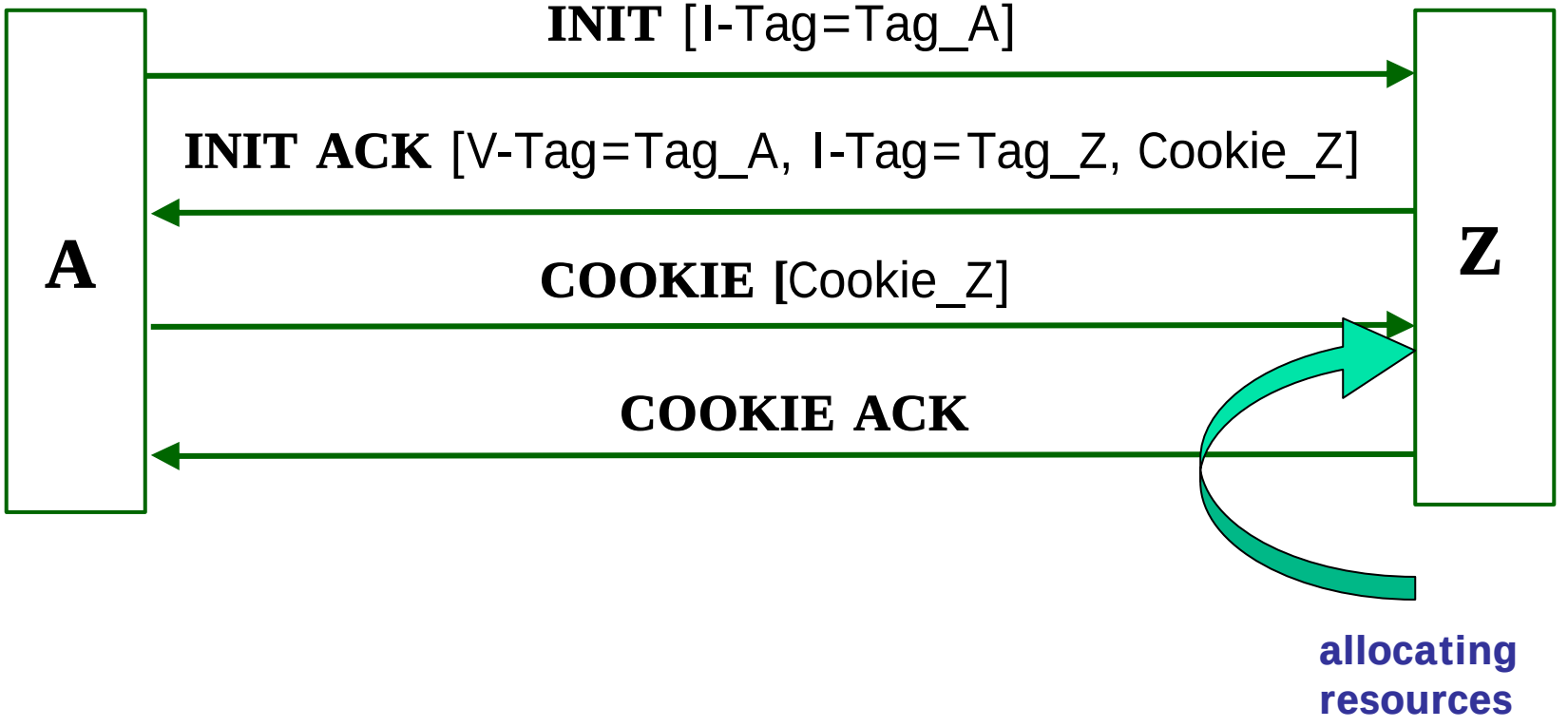
Chunk Type

ID Value	Chunk Type
--------	---------------
0	- Payload Data (**DATA**)
1	- Initiation (**INIT**)
2	- Initiation Acknowledgement **(INIT ACK**)
3	- Selective Acknowledgement (**SACK**)
4	- Heartbeat Request (**HEARTBEAT**)
5	- Heartbeat Acknowledgement **(HEARTBEAT ACK**)
6	- Abort (**ABORT**)
7	- Shutdown (**SHUTDOWN**)
8	- Shutdown Acknowledgement **(SHUTDOWN ACK**)
9	- Operation Error (**ERROR**)
10	- State Cookie (**COOKIE ECHO**)
11	- Cookie Acknowledgement **(COOKIE ACK**)
12	- Reserved for Explicit Congestion Notification Echo (**ECNE**)
13	- Reserved for Congestion Window Reduced (**CWR**)
14	- Shutdown Complete (**SHUTDOWN COMPLETE**)
…	- Reserved for IETF

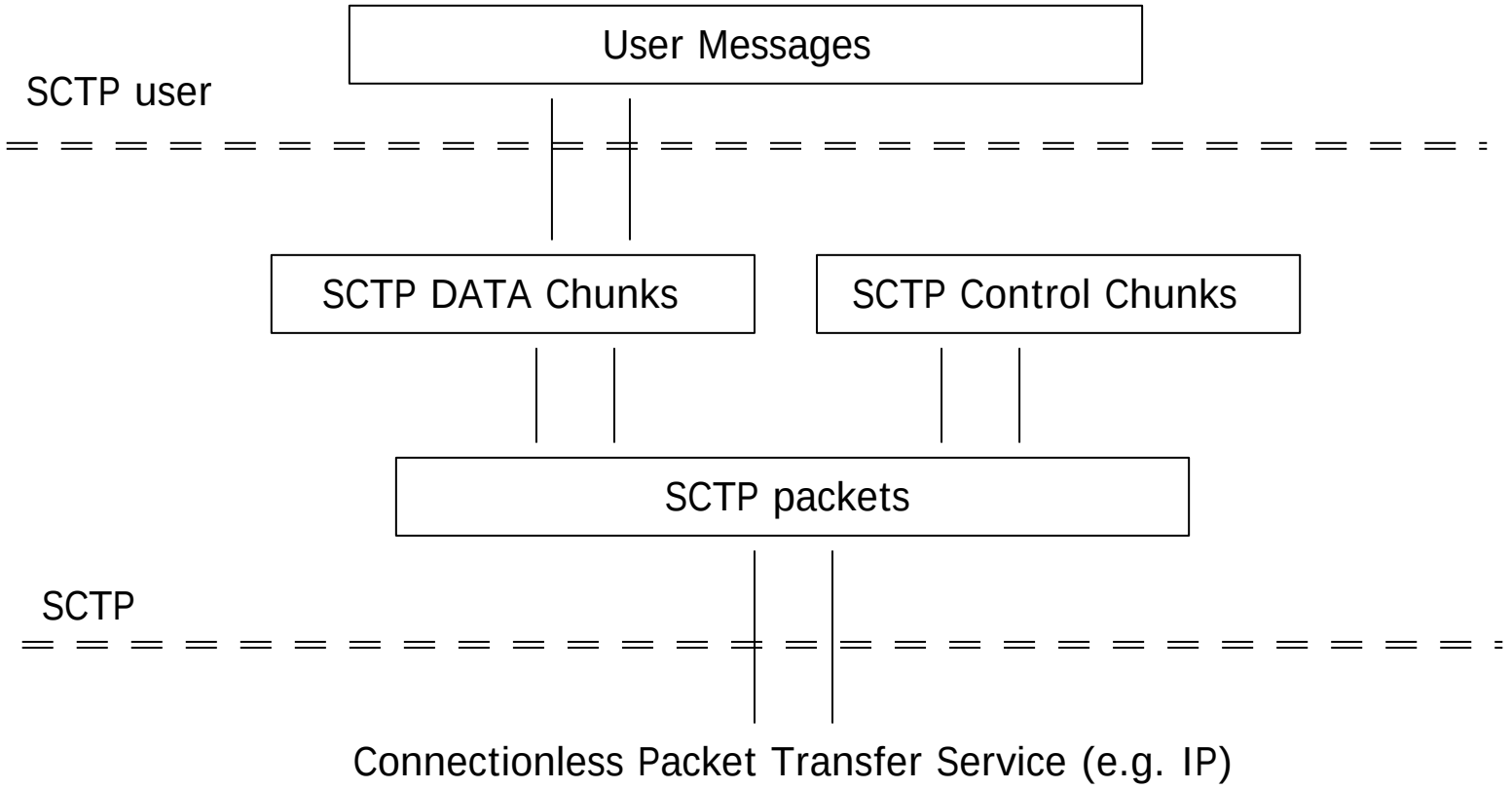
INIT Chunk


0 . . . 15 16 . . . 31
Type = 1
Chunk Flags
Chunk Length
Initial Tag (A Random Number)
Advertised Receiver Window Credit (a_rwnd)
Number of Outbound Streams
Number of Inbound Streams
Initial TSN (Transmission Sequence Number)
Optional / Variable-Length Parameter
. . .

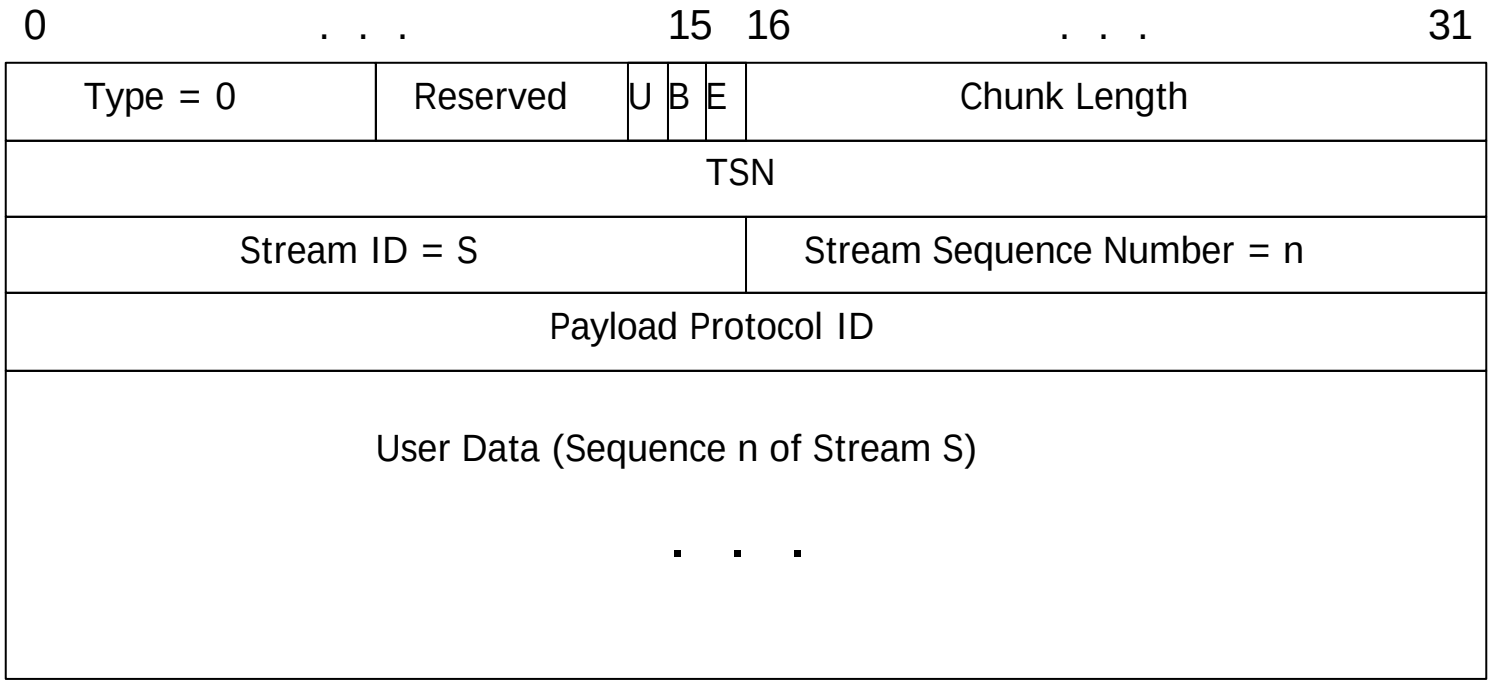
Association Establishment



User Data Transfer

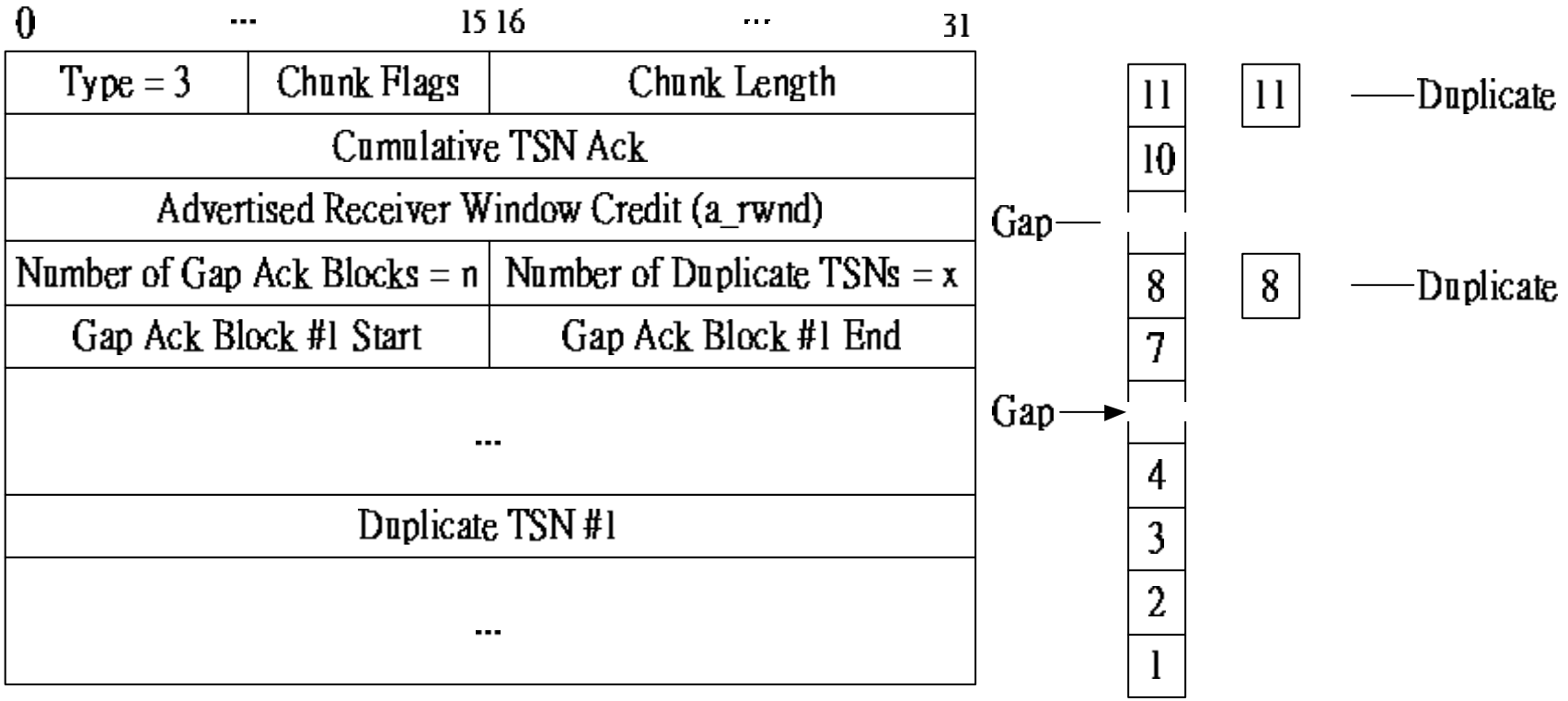


DATA Chunk



U : unordered
B : begin
E : end

SACK Chunk


0 ... 15 16 ... 31
Type = 3
Chunk Flags
Chunk Length
Cumulative TSN Ack
Advertised Receiver Window Credit (a_rwnd)
Number of Gap Ack Blocks = n
Number of Duplicate TSNs = x
Gap Ack Block #1 Start
Gap Ack Block #1 End
...
Duplicate TSN #1
...
Gap
Gap
11
10
8
7
4
3
2
1
11
Duplicate
8
Duplicate

SCTP Robustness

- Robustness is a key characteristic of any carrier-grade network.
  - To handle a certain amount of failure in the network without a significant reduction in quality
  - The network should provide a graceful rather than a drastic degradation in the event of failures or overload.
- Congestion Control Mechanism and PathMTU Delivery
- INIT and INIT ACK chunks may optionally include one or more IP addresses (a primary address + several secondary addresses).
  - Multi-homes hosts
- SCTP ensures that endpoint is aware of the reachability of another endpoint through the following mechanisms.
  - SACK chunks if DATA chunk have been sent
  - HEARTBEAT chunks if an association is idle