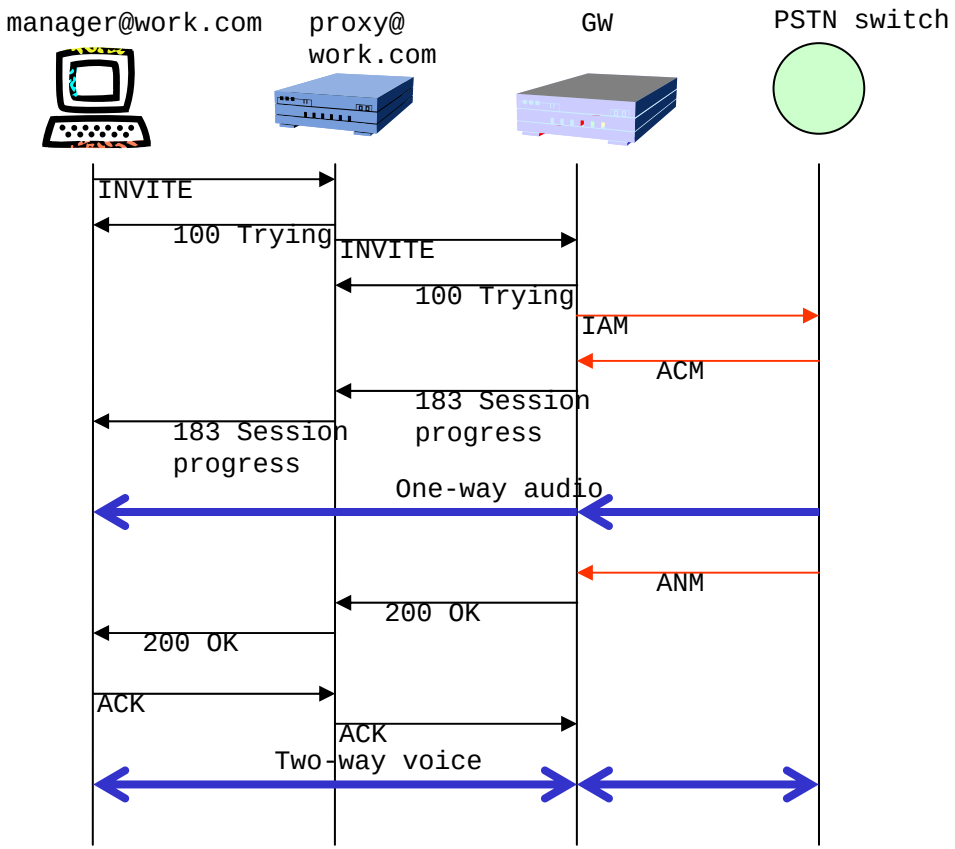
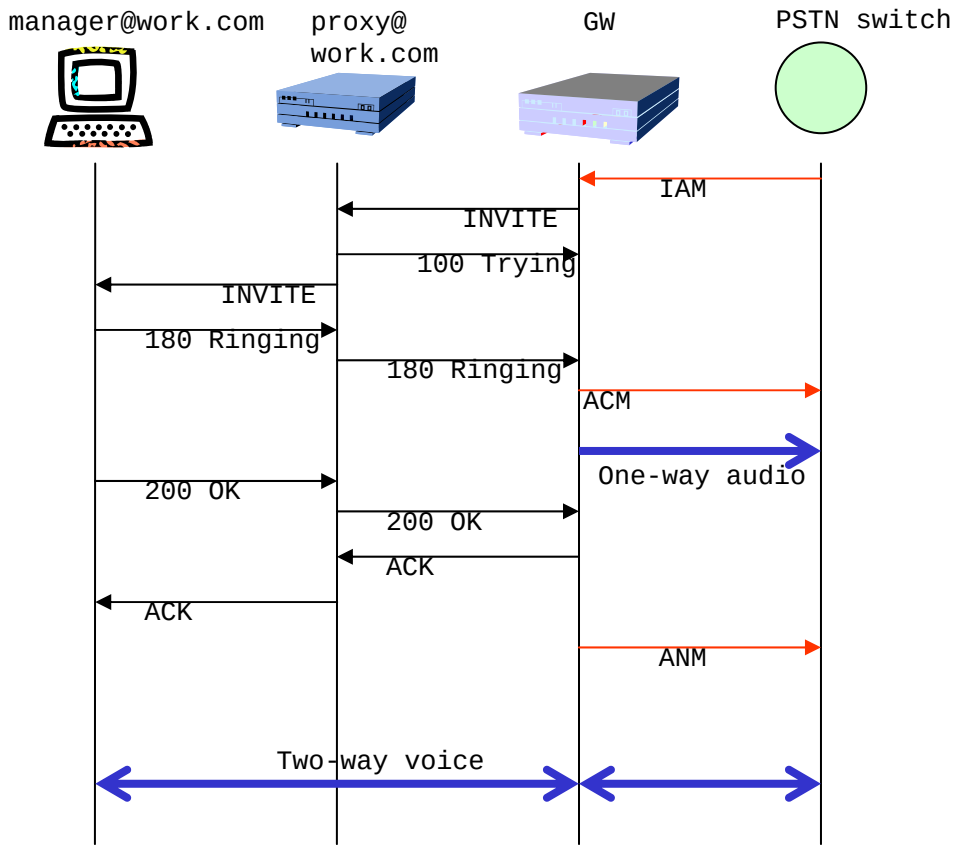
Interworking telephone signaling

- Interworking different signaling systems is one of the most complex problems of telephony

Simplified example of interworking SIP/PSTN



Simplified example of interworking SIP/PSTN



Interworking

- In the interworking of telephone networks both media and signaling must be managed correctly
- We may have separated devices (gateways) for the translation of signaling and media

Interworking

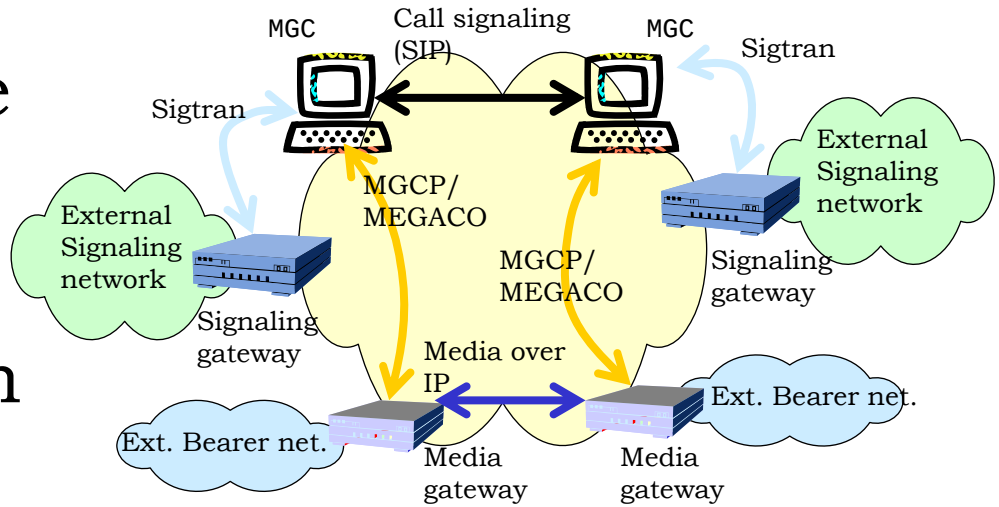
- A logical and physical separation of media and signaling translation can provide multiple benefits
  - Optimization of device location
  - Gateways can be organized hierachically, with few gateway controllers managing a large number of peripheral gateways
- However, is such a distributed architecture an additional signaling protocol is needed to allow communications among gateways and gateway controllers

Media gateway and signaling gateway

- Media gateways translate media, while signaling gateways interwork signaling
- Media gateways are controlled by Media Gateway Controllers (MGC) and they communicate using a specialized signaling protocol such as the Media Gateway Control Protocol (MCGP)
- Clearly, also MGCs and signaling gateways need to intercommunicate and, in this way, a gateway architecture is created
- This distributed architecture is usually referred to as “softswitch”
- Softswitch manages separately media and signaling

Softswitch

- MGCs intercommunicate through SIP
- MGCs communicate with media gateways with MGCP or MEGACO

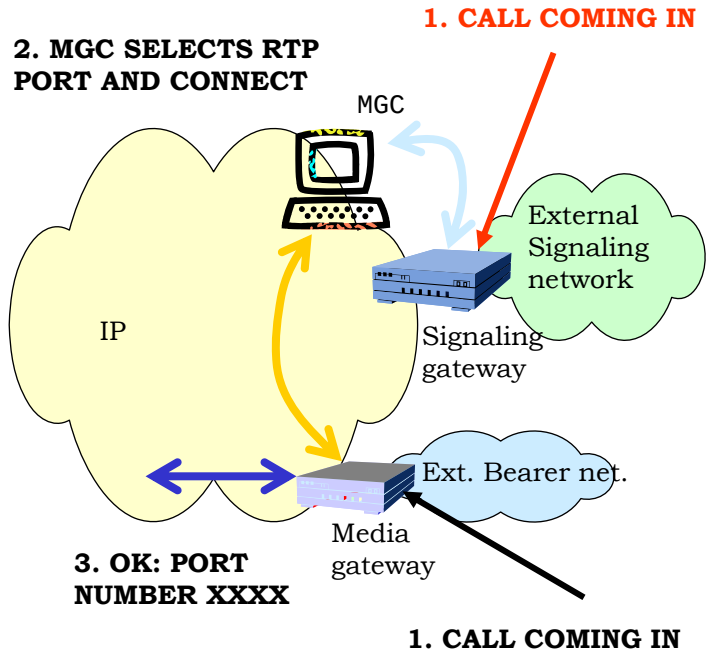


MGC

- Specifies how a media gateway (MG) must translate media
- Manages in-band signaling (DTMF)
- Can require dynamic change of media format
- Deve poter intevenire nei report di qualita'
- Manage multiple MGs in a reliable way

Protocols in the softswitch architecture

- The MG, after the MGC's request, sets up a connection between a PCM stream in the circuit-switched network and a RTP port in the IP network

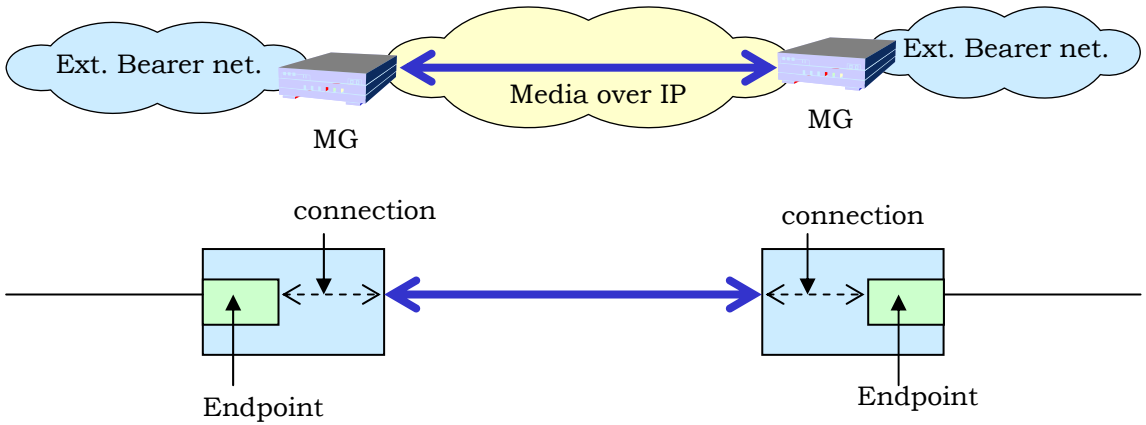


MGCP

- The basic objects managed by MGCP are the *endpoints*, for example:
  - 64 kbps PCM flows
  - Analog telephone lines
  - Authomatic announcement generators (one way)
  - IVR units
  - …

MGCP

- MGCP connections are logical mappings between endpoints and RTP/UDP/IP streams



MGCP commands

- MGCP provides textual commands with the following form
  - Command line:
    - **CommandVerb TransactionID EndpointID MGCP 1.0**
  - Some lines with additional parameters
  - A void line
  - SDP description, if needed

MGCP commands

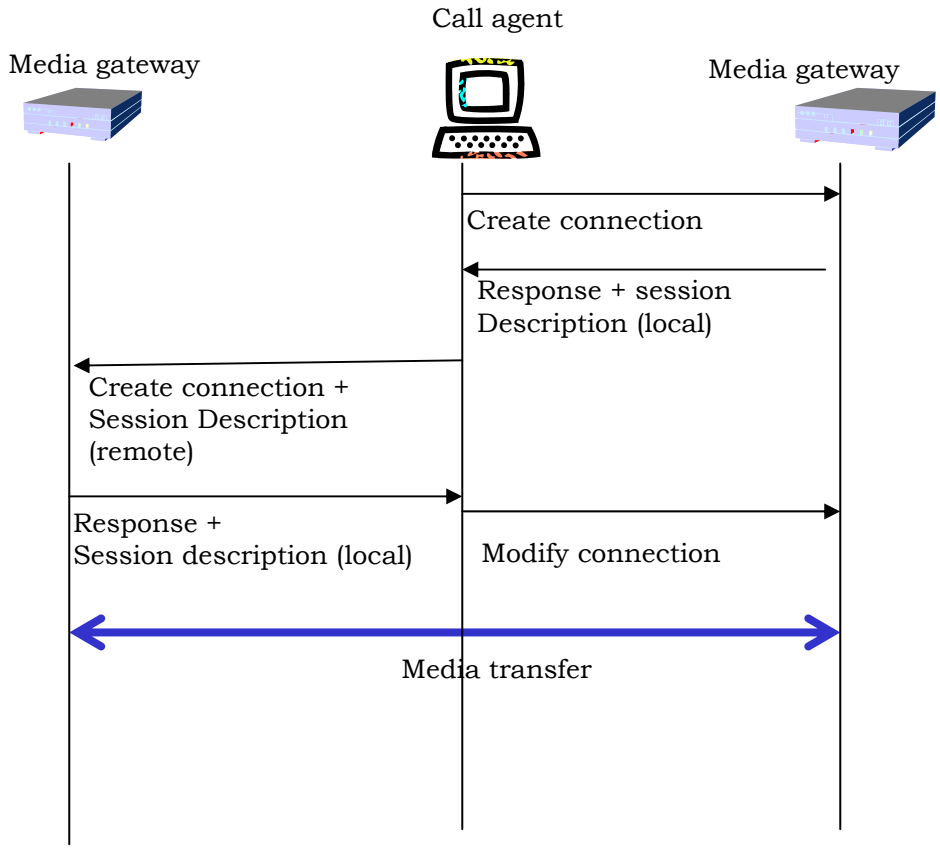
- Some MCGP commands
  - **EndpointConfiguration (EPCF):**
    - Set configuration parameters of endpoints (for example, PCM law A or μ)
  - **CreateConnection (CRCX):**
    - Create a connection inside the MG (from MGC to MG)
  - **ModifyConnection (MDCX):**
    - Modify a connection (from MGC to NG)
  - **DeleteConnection (DLCX):**
    - Tear down a connection (from MGC to MG)
  - **NotificationRequest (RQNT):**
    - Request for information (from MGC to MG)
  - **Notify (NTFY):**
    - Transmission of information (from MG to MGC)

MGCP rsponses

- 0XX
  - ACK
- 1XX
  - provisional
- 2XX
  - OK
- 4XX
  - failure (transient)
- 5XX
  - failure (permanent)
- 8XX
  - ...

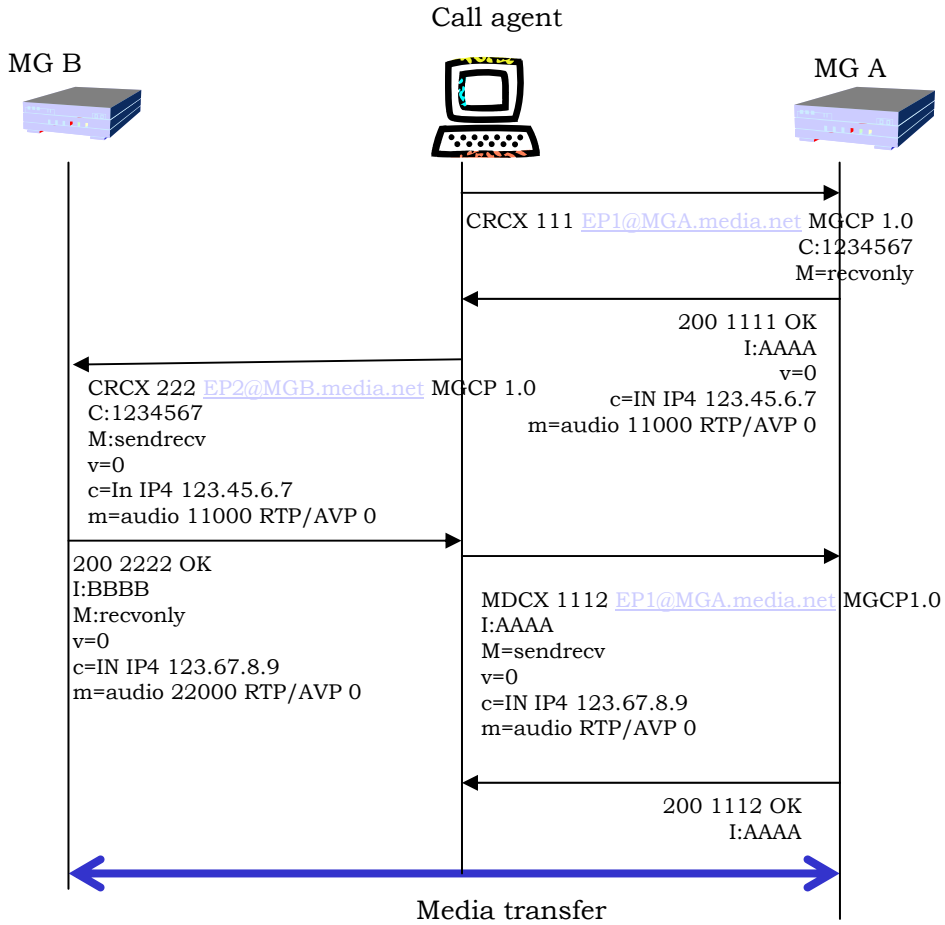
Setup example MGCP

- The figure shown the creation of a media channel between a couple of MGs

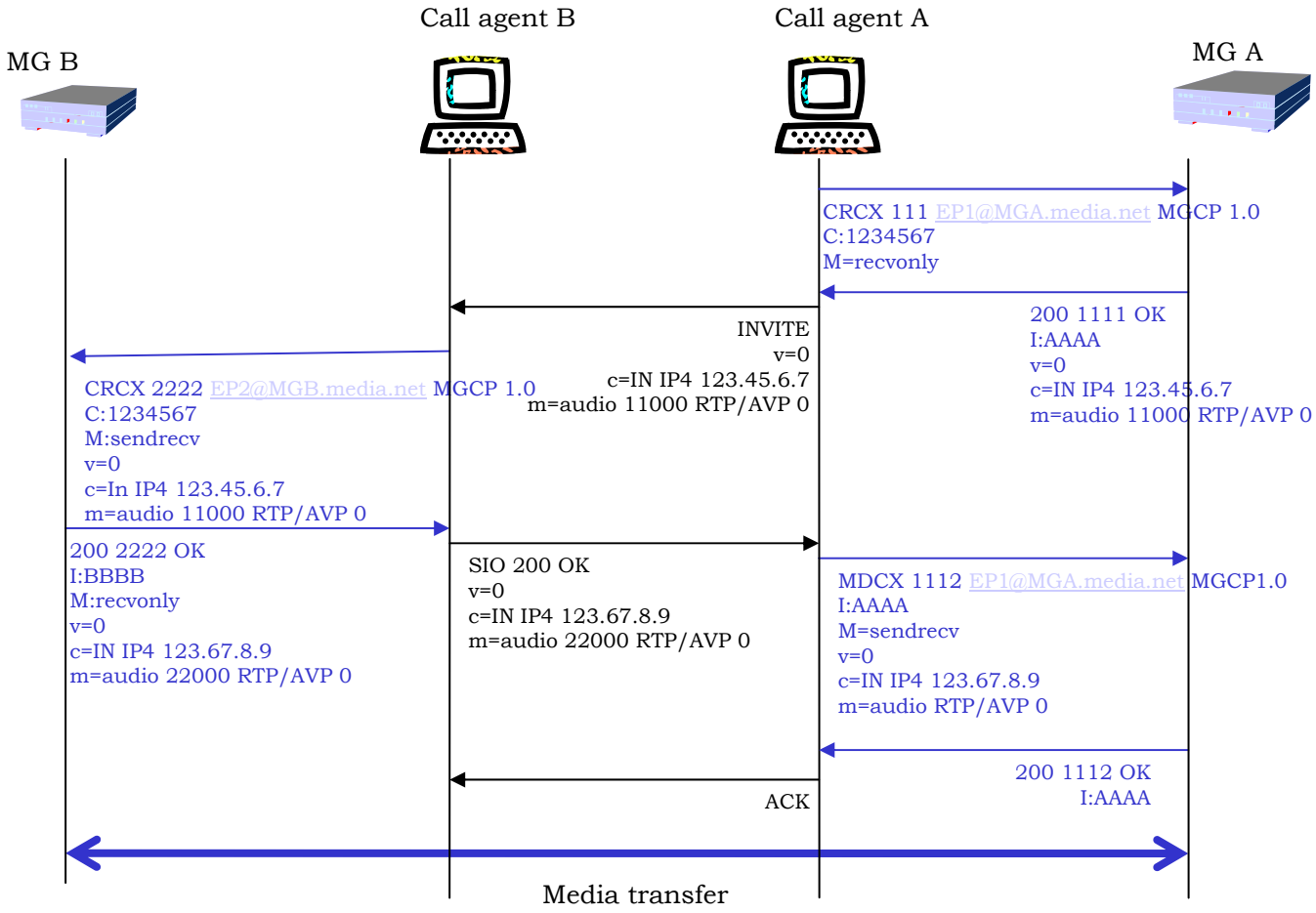


Setup example MGCP

- The same example, with additional details



Setup example MGCP + SIP



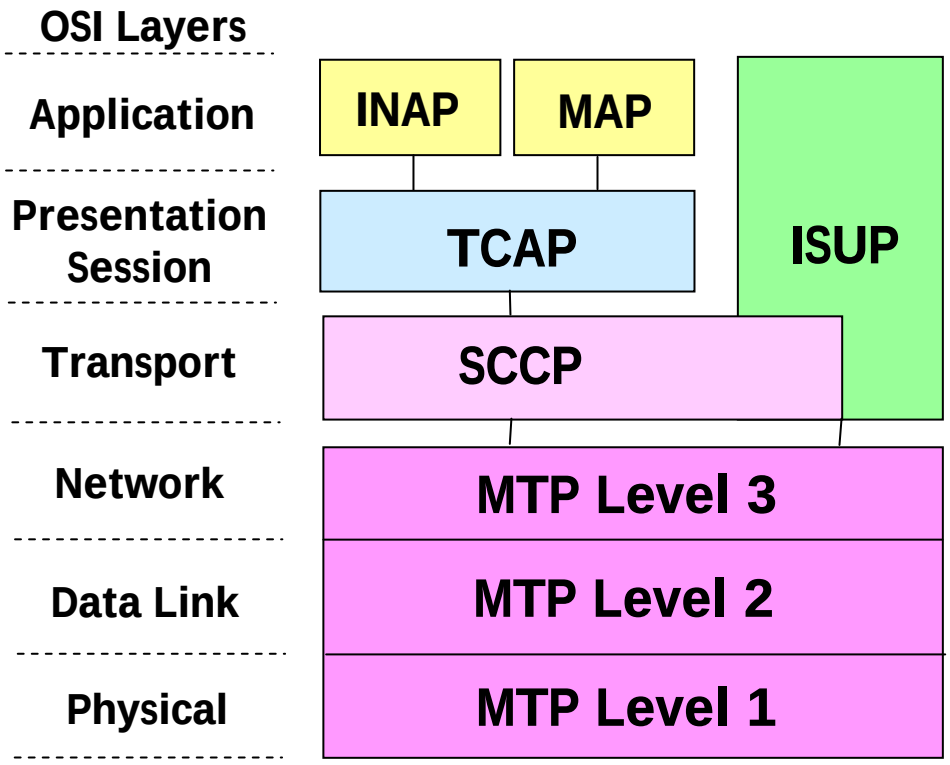
SS7: brief overview

- SS7 is the traditional Common Channel Signaling protocol
- The nodes of the SS7 network are referred to as Signaling Points (SP)
- The address of a SP is the "signaling point code" (SPC)
- A linkset is a group of links connecting two SPs

SS7: brief overview

- The SS7 has 5 basic
- SSP/Service Switching Point
  - Voice switching, service invocation
- STP/Service Transfer Point
  - Signaling routing
- SCP/Service Control Point
  - Intelligent network services
- SDP/Service Data Point
  - Usually manages user and service data
- IP/Intelligent Peripheral
  - Common resources such as announcements, IVR, DTMF handling

SS7 Protocol Suite



- MTP: Message Transfer Part
- SCCP: Signalink Connection Control Part
- TCAP: Transaction Capabilities Applications Part
- ISUP: ISDN User Part
- INAP: Intelligent Network Applications User Part
- MAP: Mobile User Part

MTP (Message Transfer Part)

- Level 1
  - Physical layer, usually 64 kbps channels
- Level 2
  - Standard highly reliable layer-2 protocol handling the transmission of Signaling Units (SU) on signaling links
- MTP Level 3
  - Routing of SS7 messages among SPs

ISUP (ISDN User Part)

- Application protocol to setup and tear down connections
  - The path of a connection can differ from the path of signaling
- SS7 ISUP messages
  - Initial Address Message (IAM)
    - To start the setup of a connection
  - Answer Message (ANM)
    - The call has been accepted
  - Release Message (REL)
    - To release a call

TCAP (Transaction Capabilities Applications Part)

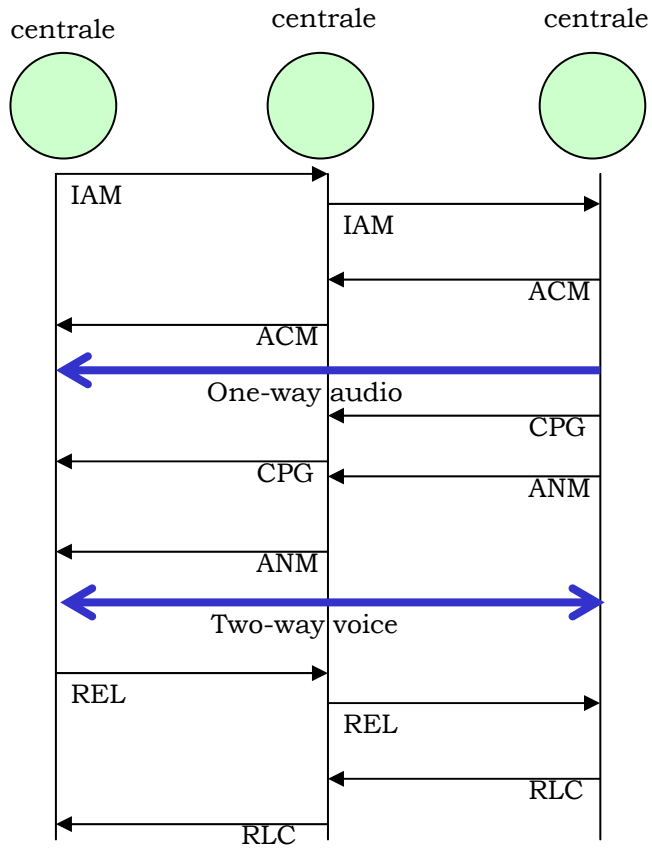
- TCAP
  - supports transactions among SS7 applications
- Provides services to
  - INAP (IN Application Part)
  - MAP (Mobile Application Part)

Service Control Point (SCP)

- Offers added value (intelligent network) services, such as 800 numbers

ISDN User Part (ISUP) - basic call

- IAM, Initial Address Message
- ACM, Address Complete
- CPG, Call Progress
- ANM, Answer Message
- REL, Release
- RLC, Release Complete



Performance requirements of SS7

- From Bellcore spec. GR-246-Core
  - MTP
    - $< 10^{-7}$ message loss rate
    - $< 10^{-10}$ out of sequence rate
    - It is very difficult to obtain this kind of performance through a Best-Effort IP network
  - ISUP
    - A large number of timers at the ISUP layer

SS7 Point Codes (PC)

- Each SS7 signaling end point has a Point Code (PC)
- In exceptional cases (SPs at national boundaries) mora than one PC can be assigned to one device
- PCs are usually 14 bit codes

SS7 circuits for telephony

- PSTN telephony is transported through 64 kbit/s, circuits (one time slot of a E1/T1 frame)
- Telephone exchanges are connected through groups of such circuits
- Circuits are identified by the CIC (circuit identification code, 12 bits)

MTP1

- It is the physical layer of the MTP, the basic channel is a 64 kbit/s link

MTP2

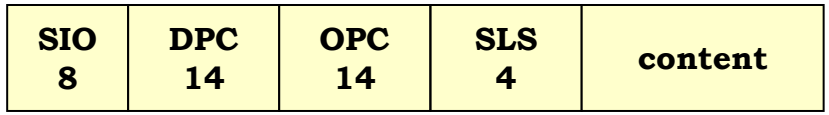
- MTP2 is the dala link layer of SS7, its frames are the Signaling Units (SU)
- MTP2 implements:
  - **numeration of SUs**,
  - **acknowledge of SUs**,
  - **aetransmission of SUs**,
- The required performance of a SS7 signaling link is:
  - Errors in SUs < 10^{-10}
  - Loss of SUs < 10^{-7}
  - Out-of-sequence SUs < 10^{-10}

MTP2

- MTP2 also implements:
  - Flow control
  - Congestion control

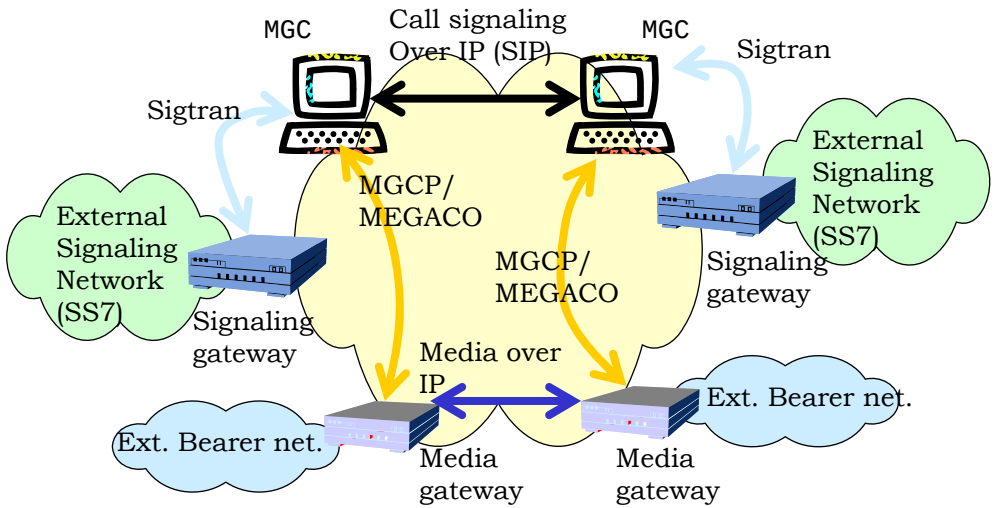
MTP3

- MTP3 is the network layer of the SS7 architecture, thus, it routes messages among SS7 entities
- A MTP packet is called MTU (message Transfer Unit)
- Source and Destination addresses are OPC e DPC
- The Signaling Link Selection (SLS) field is used to guarantee that for a given call all signaling packet use the same physical link in every phyisical link group they cross



Softswitch architecture

MGCs must implement SS7. SS7 messages are enveloped into IP Packets and are delivered to MGCs



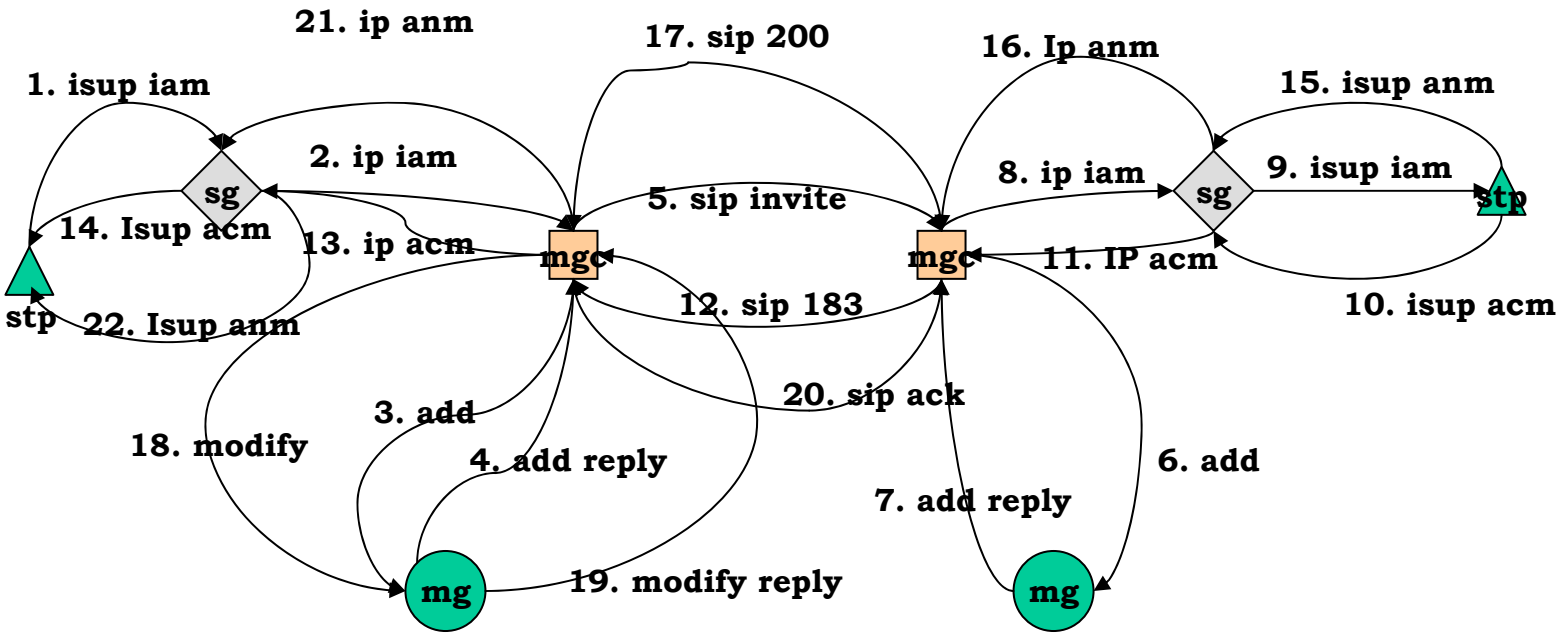
Signaling Transport (SIGTRAN)

- The SigTran architecture has been defined by the IETF and has the objective of transporting SS7 signaling over IP
- SigTran allows the interaction among SIP, MEGACO, MGCP, ISUP

Signaling Transport (SIGTRAN)

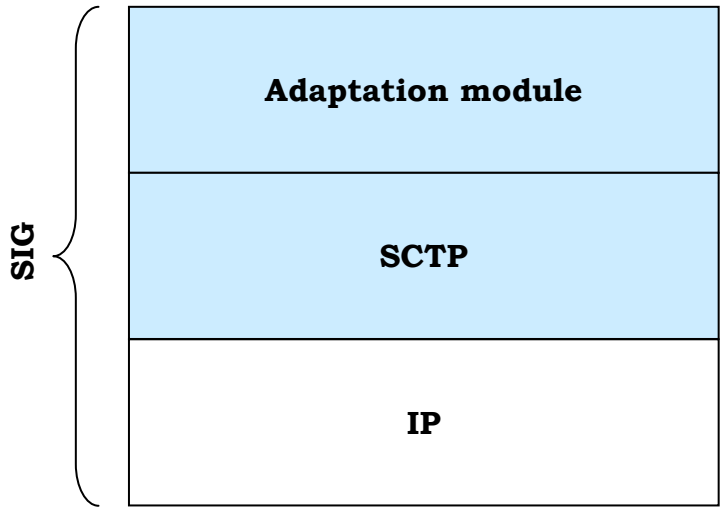
- Basic problems coped with by SIGTRAN
  - Address translation (PointCode-IP)
  - Message encapsulation
  - Transport over IP (both UDP and TCP are not good solutions for the transport of SS7 over IP)
  - Interworking MGC/SG

Basic call ISUP/SIP/MEGACO



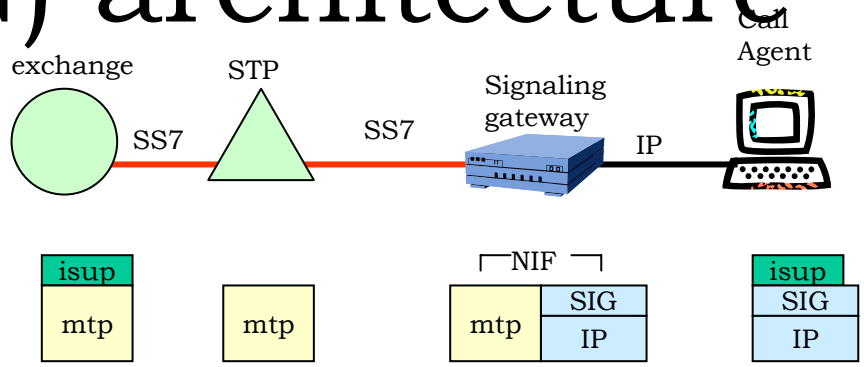
SIGTRAN (SIG) architecture

- Adaptation modules allow a correct interworking SS7/IP
- The transport layer SCTP (Stream Control Transmission Protocol) is designed specifically for the transport of SS7 over IP



SIGTRAN (SIG) architecture

- The translation function between SS7 and IP is performed by the NIF



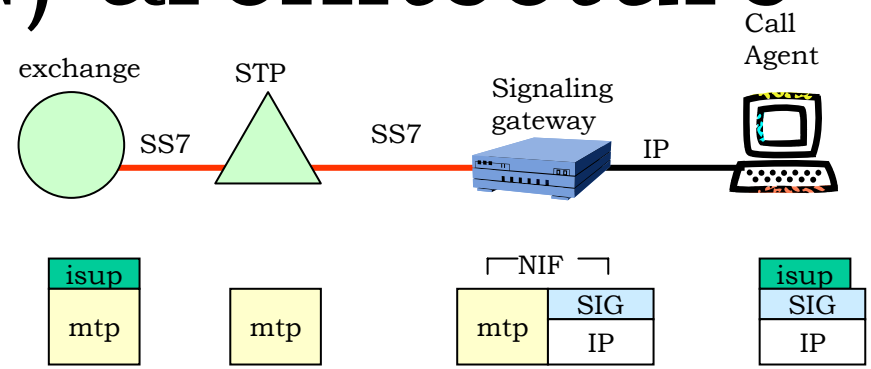
NIF=nodal interworking function

End-to-end transaction: ISUP

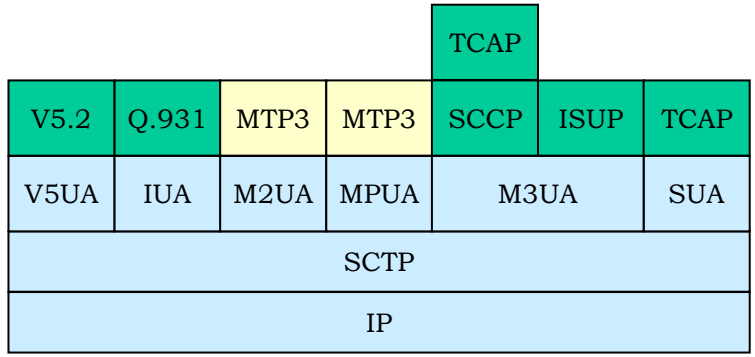
The exchange colloquiates with the Call Agent as if it were just another SS7 exchange

SIGTRAN (SIG) architecture

- Each signaling application has one or more adaptation modules
- SCTP is a commen trasnport layer guaranteeing error-free and fast transport of SS7 messages over IP

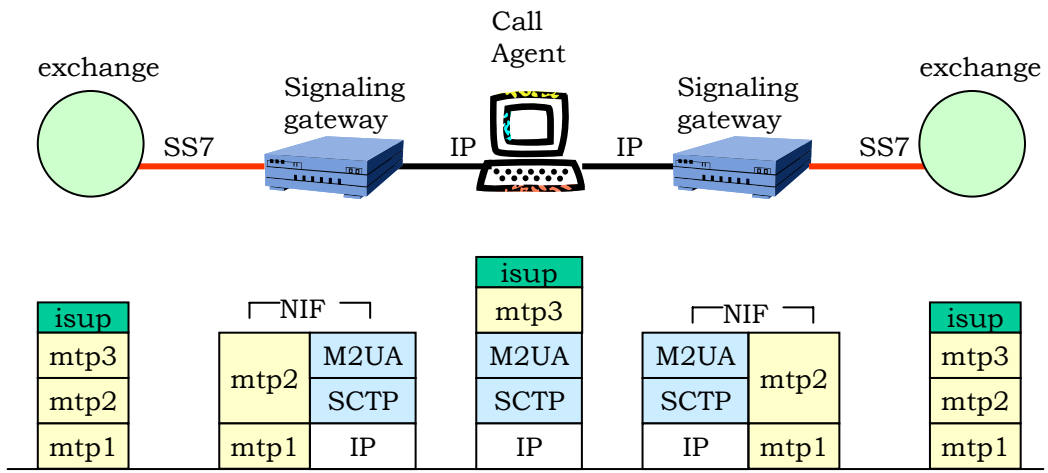


NIF=nodal interworking function



Adaptation Layer
M2UA (MTP-2 User Adaptation Layer)

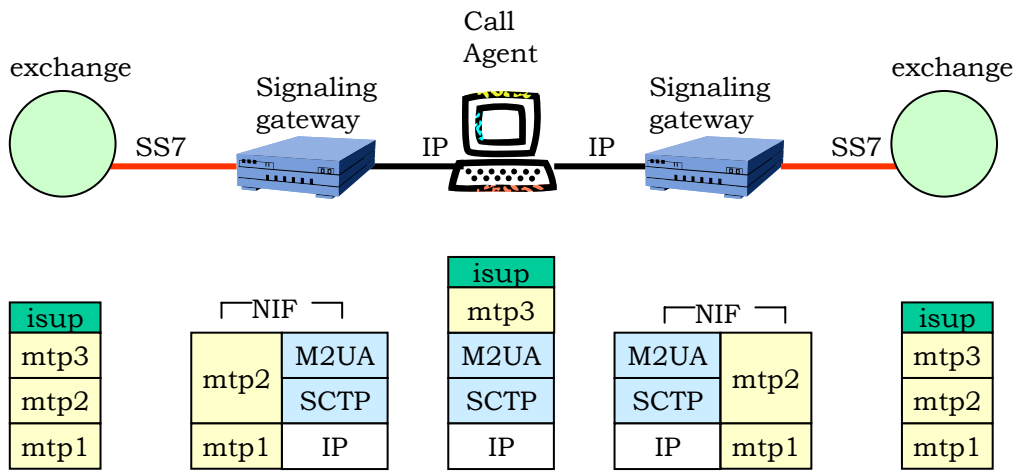
- M2UA provides adaptation between MTP3 and SCTP
- It is possible to transport MTP3 across SIG
- In practice, MTP3 entities work over IP as if it were an MPP2 data link



NIF=nodal interworking function

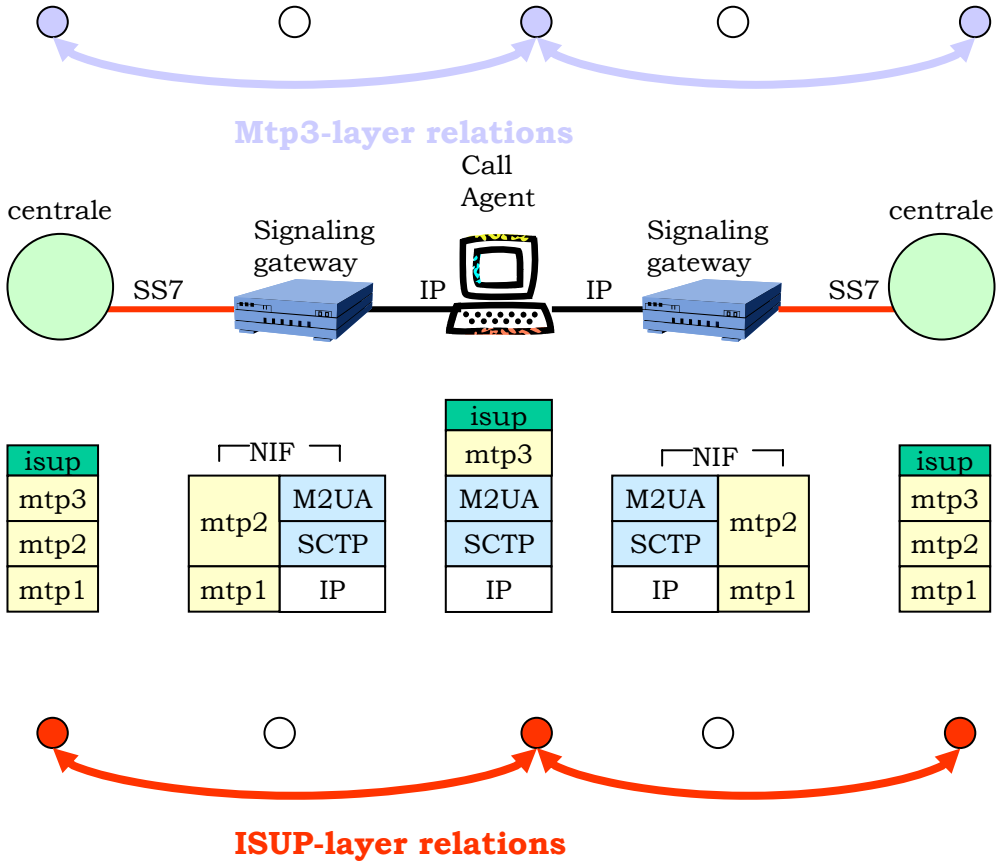
Adaptation Layer
M2UA (MTP-2 User Adaptation Layer)

- Note that the real MTP2 used by the CA is remote (it is implemented by the signaling gateway)
- However, the signaling gateway does not have a local MTP3, thus, it has no Point Code
- SG is not exactly a standard SS7 node, thus, total transparency is not obtained



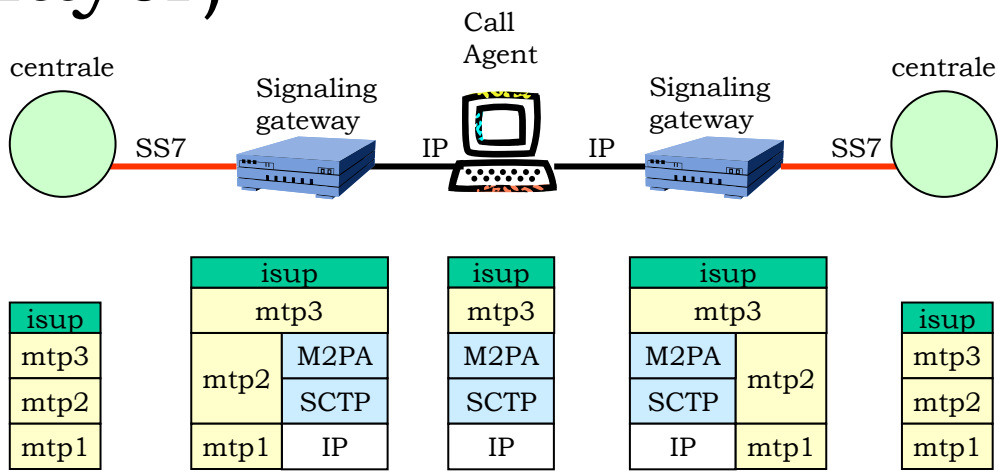
NIF=nodal interworking function

Adaptation Layer
M2UA (MTP-2 User Adaptation Layer)

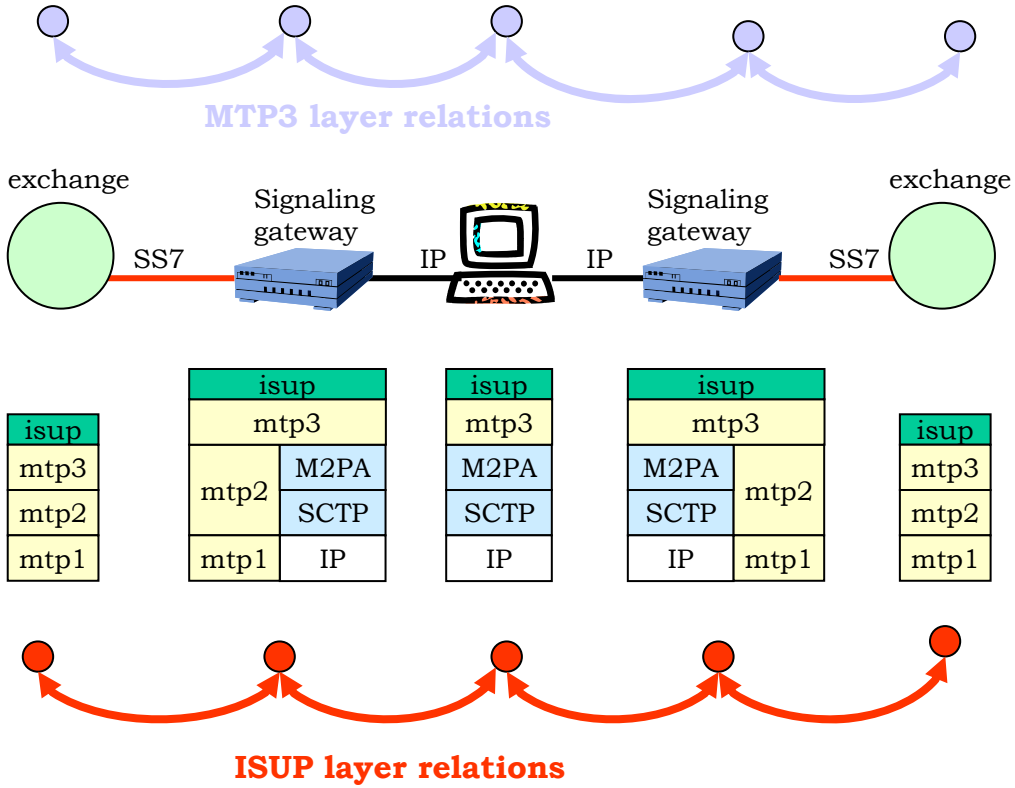


Adaptation Layer
M2PA (MTP-2 Peer-to-Peer Adapt. Layer)

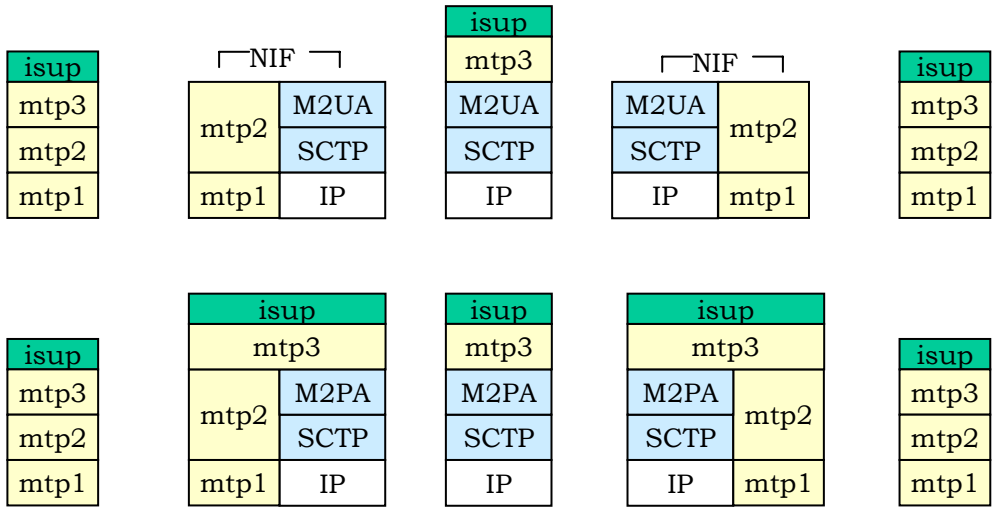
- M2PA is a fully transparent adaptation layer
- MGCs and SGs are fully equivalent to SS7 nodes
- Links connecting SGs and MGCs are equivalent to SS7 links
- The SG has a point Code



Adaptation Layer
M2PA (MTP-2 Peer-to-Peer Adapt. Layer)

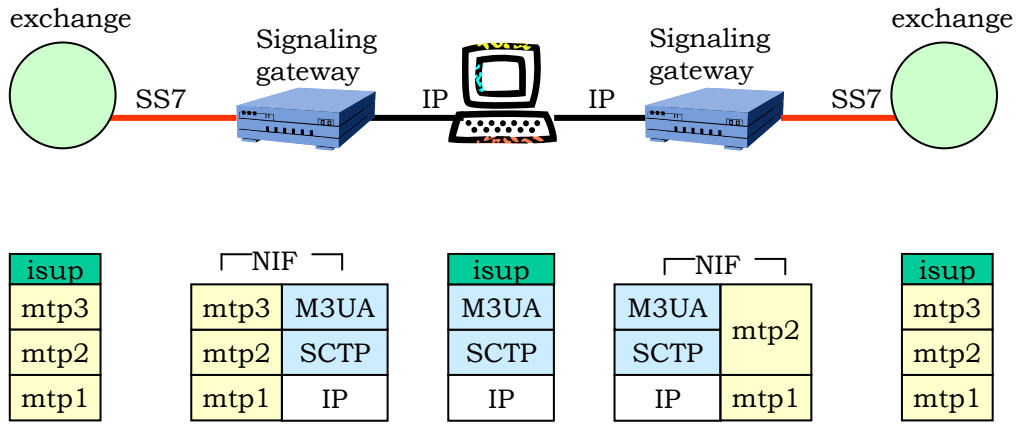


Adaptation Layer
M2PA and M2UA



Adaptation Layer
M3UA (MTP3-User Adaptation Layer)

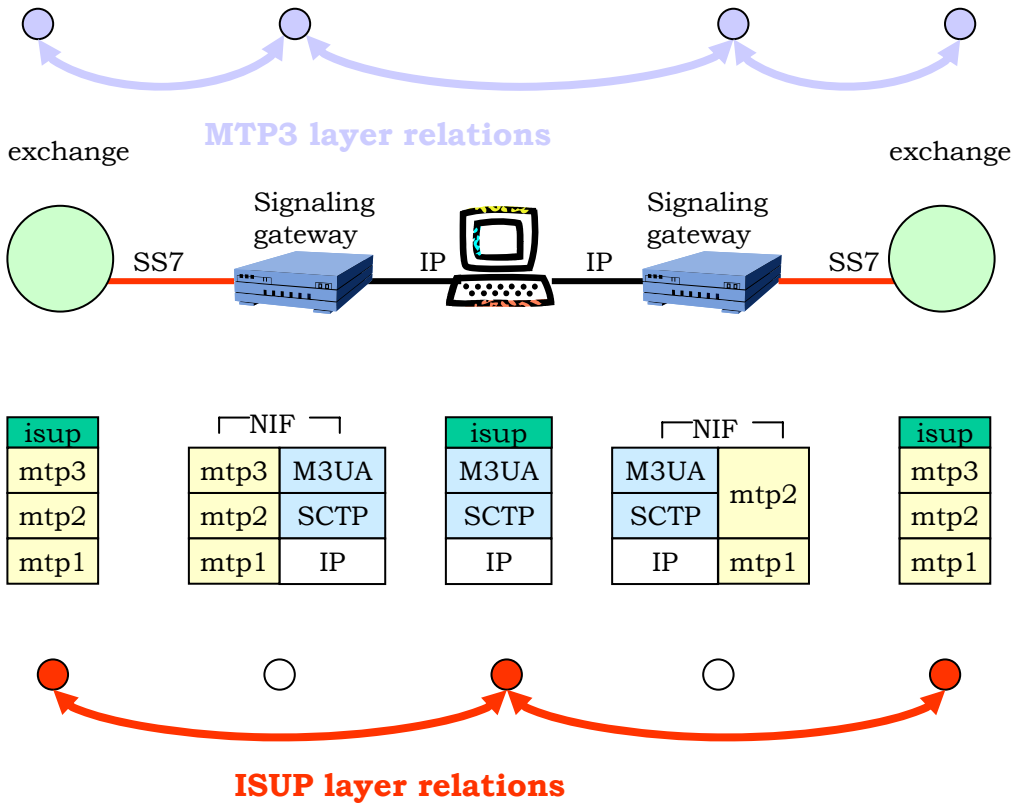
- It provides a MTP3 interface: ISUP and SCCP can be transported
- SGs are proper STPs
- The MGC does not behave fully as a SS7 node (no physical instance of MTP3)



Adaptation Layer
M3UA (MTP3-User Adaptation Layer)

- MGC can provide ISUP services in the followinf ways:
  - ISUP/MTP3/M2UA/SCTP
  - ISUP/MTP3/M2PA/SCTP
  - ISUP/M3UA/SCTP
- The main difference is where MTP3 is actually implemented
- With M2UA and M2PA, MTP3 is in the MGC, while with M3UA, MTP3 is in the SG
- This is why with M3UA, MGC is not exactly equivalent to a standard MTP3 node

Adaptation Layer
M3UA (MTP3-User Adaptation Layer)



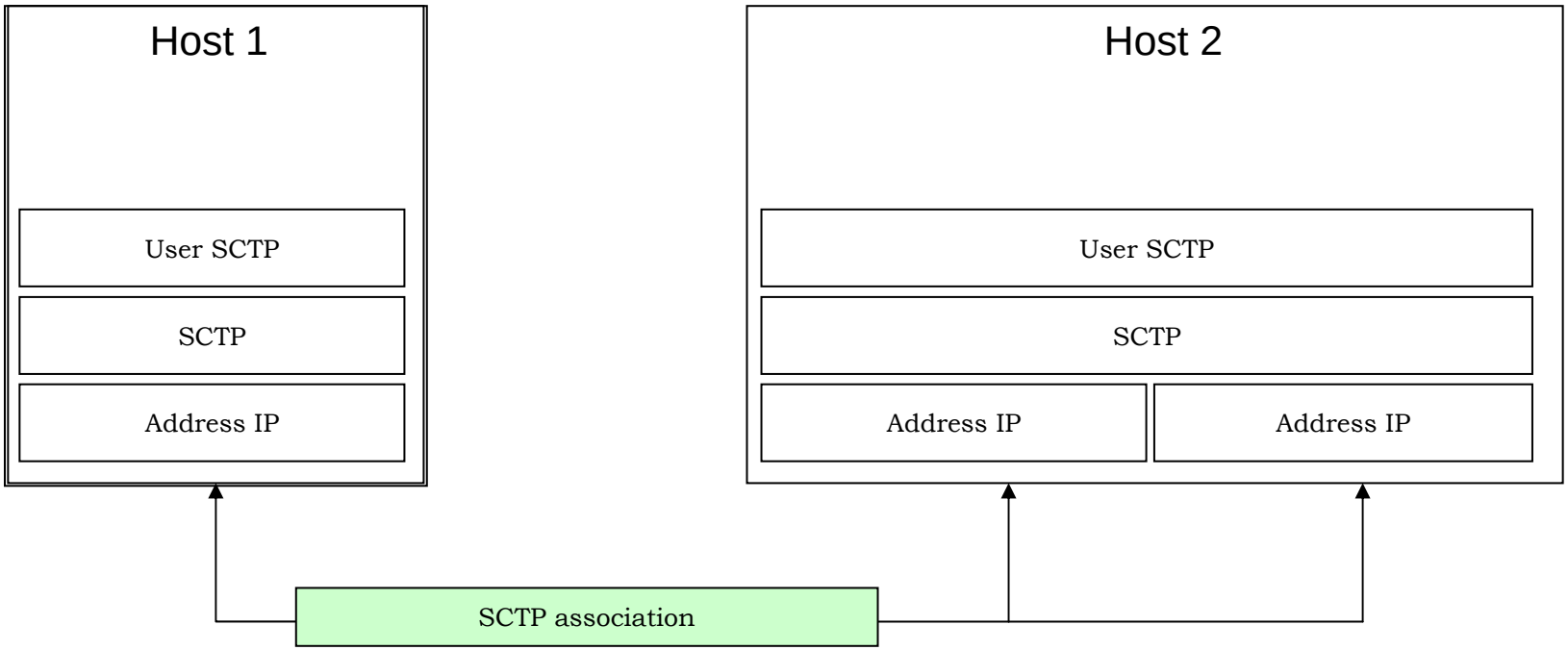
SCTP

- SCTP (Stream Control Transport Protocol) provides a reliable trasnport for signaling interworking
- It has a 4-way handshake, it supports multihoming
- It has been conceived with the purpose of meeting the requirements of SIGTRAN
- It is better than TCP, fr this purpose, because
  - Multihoming increases reliability, and TCP does not support it
  - TPC is more vulnerable to DOS attaks such as SYN flooding
  - It has a more efficient retransmission algorithm

SCTP

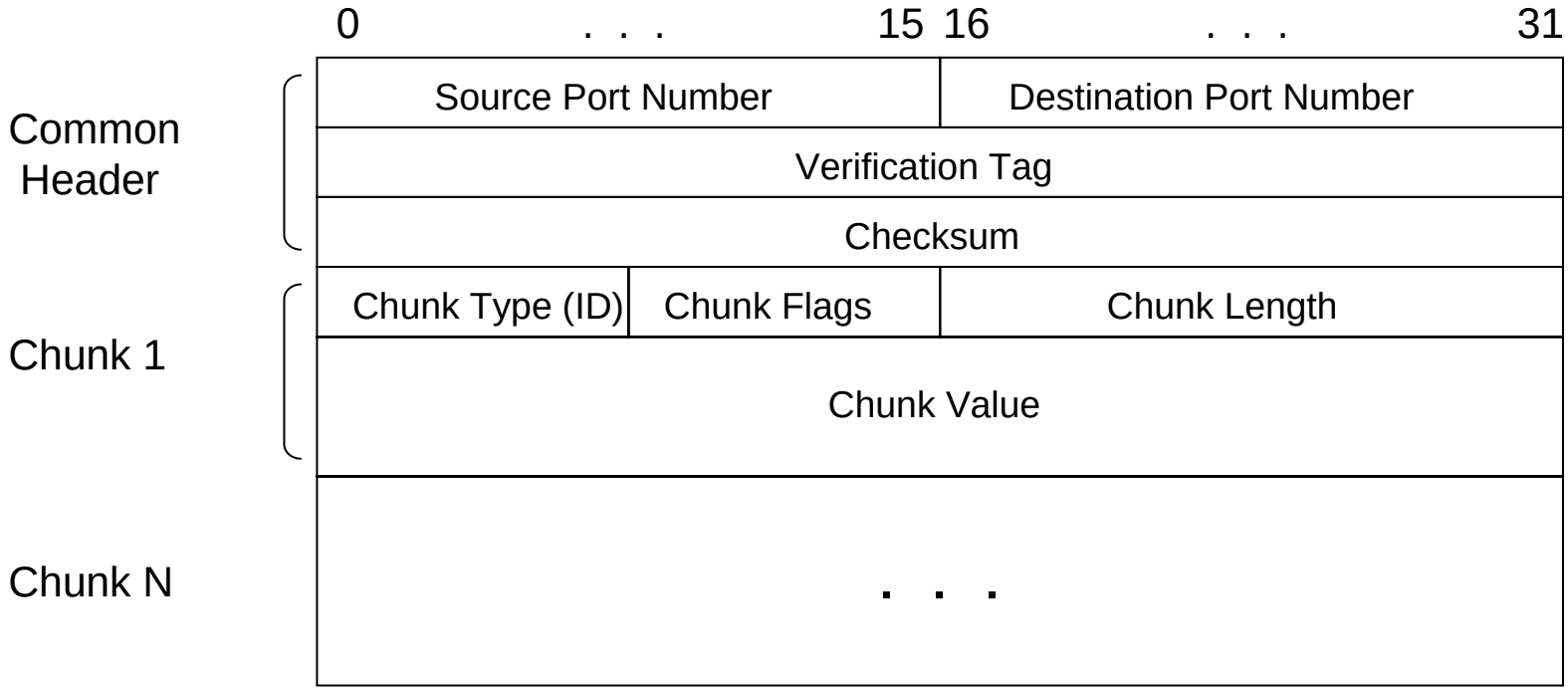
- Endpoint
  - The sender/receiver of SCTP packets
  - Transport address = IP address + SCTP port number
  - Multihoming: each endpoint can have multiple transport addresses
- Association
  - A relation between two SCTP endpoints
  - Two endpoints can have at most one association
- Stream
  - Unidirectional logical channel between two endpoints
  - An association can support multiple streams
  - a stream delivers packets with the correct sequence

Multi-Homed Host

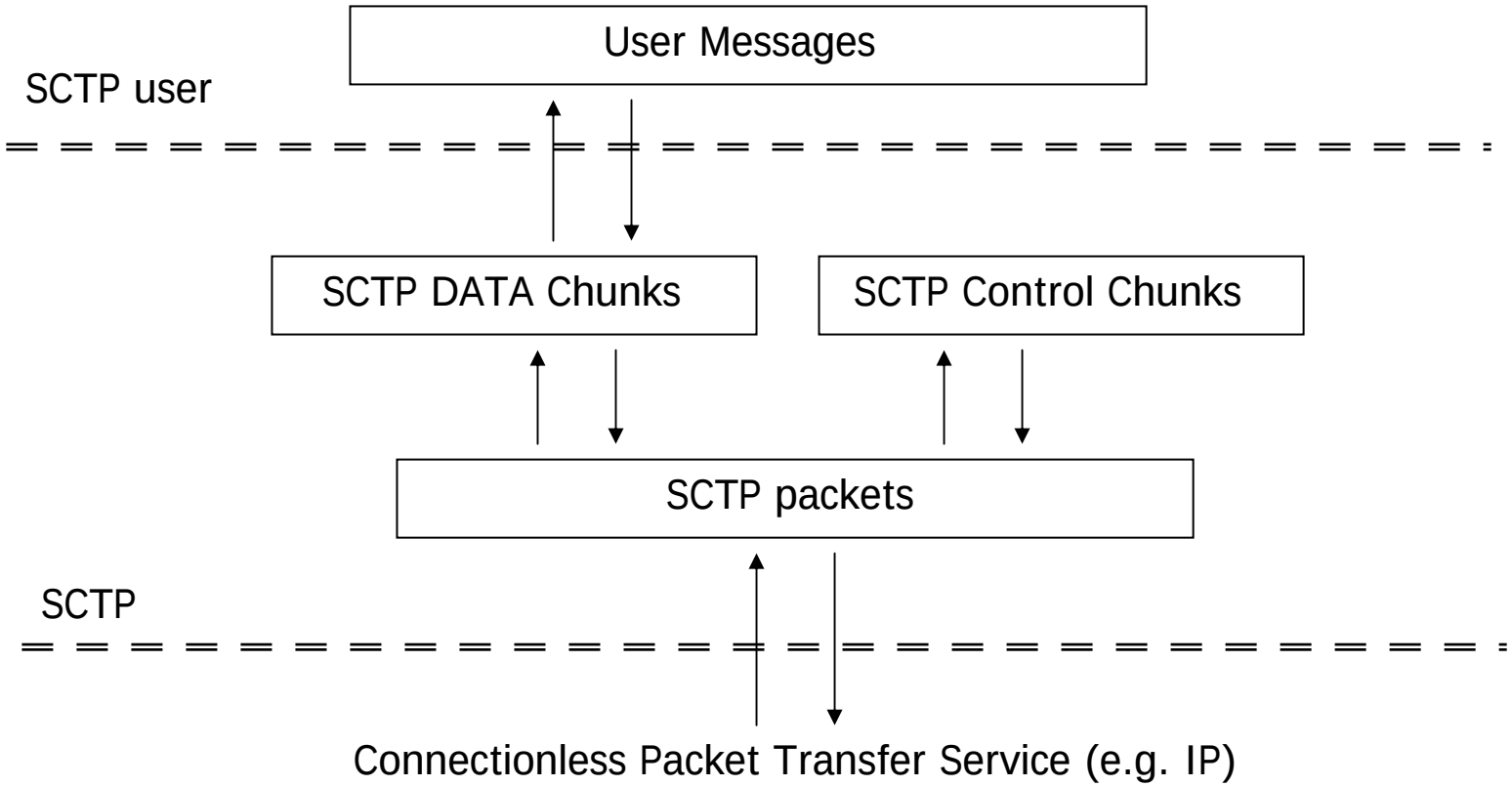


SCTP

- Packets are composed by *chunk*
- A *chunk* can contain user data or control information



SCTP


User Messages
SCTP user
SCTP DATA Chunks
SCTP Control Chunks
SCTP packets
SCTP
Connectionless Packet Transfer Service (e.g. IP)

SCTP control chunks

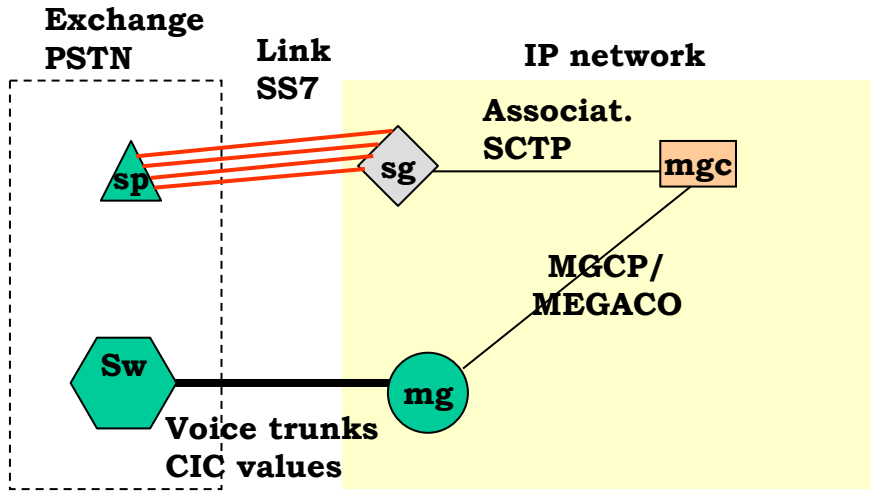
- INIT / INIT ACK
  - They initiate an association
- COOKIE ECHO / COOKIE ACK
  - They initiate an association
  - INIT ACK contains a “cookie”, a block of information regarding the association, timestamp, lifetime ...

SCTP control chunks

- SACK (selective acknowledge)
  - Acknowledges a DATA chunk
  - Selective Repeat is adopted
- HEARTBEAT / HEARTBEAT ACK
  - Sent periodically when no data are transmitted
- ERROR
  - To signal errors
- ABORT
  - Aborts an association
- SHUTDOWN/ SHUTDOWN ACK / SHUTDOWN COMPLETE
  - graceful termination of an association

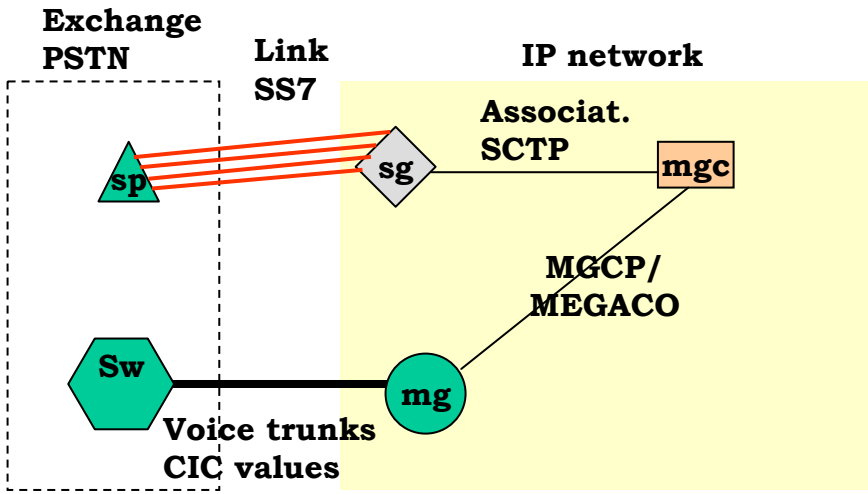
SCTP streams

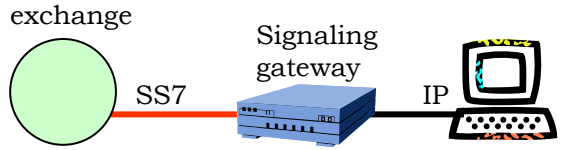
- A call agent call agent (mgc) uses ISUP to communicate with the PSTN through a signaling gateway (sg)
- With M2UA, the MTP3 layer of the call agent transmits SS7 signaling messages to the signaling point (sp) through a specific signaling link (always the same, through the SLS selection field)

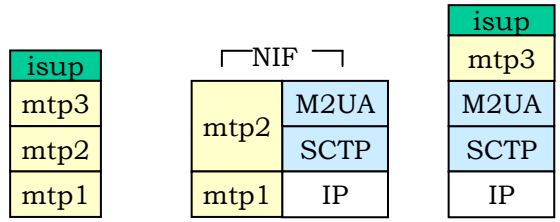


SCTP streams

- The usage of SCTP can create problems, since sg is not provided with MTP3 and ISUP
- No standard way of communicating is available

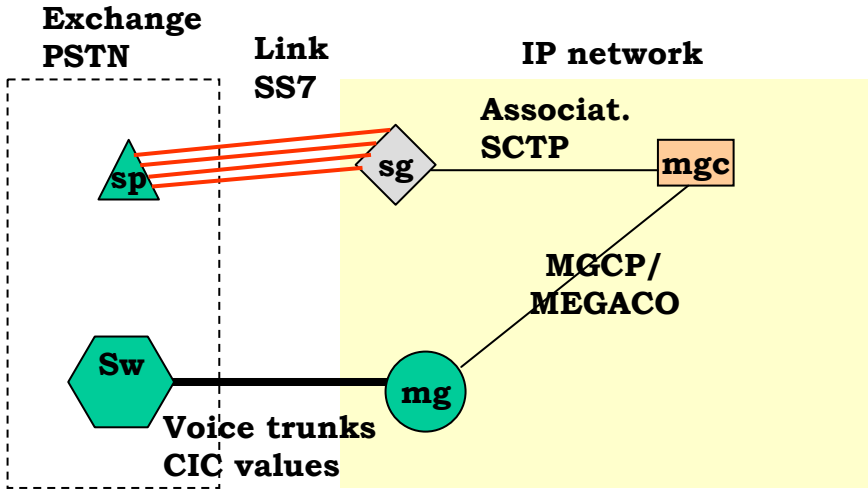


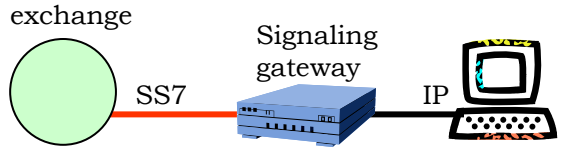


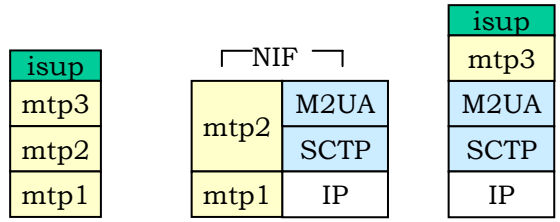


SCTP streams

- The problem is solved by NIF in this way:
- The SCTP association between mgc and sg must have N streams, with N equal to the number of physical signaling links between sg and sp
- NIF creates a 1:1 map between SCTP streams and signaling links, in such a way that all packets of each signaling relation follow exactly the same path
- In this way, a standard SS7 communication is simulated

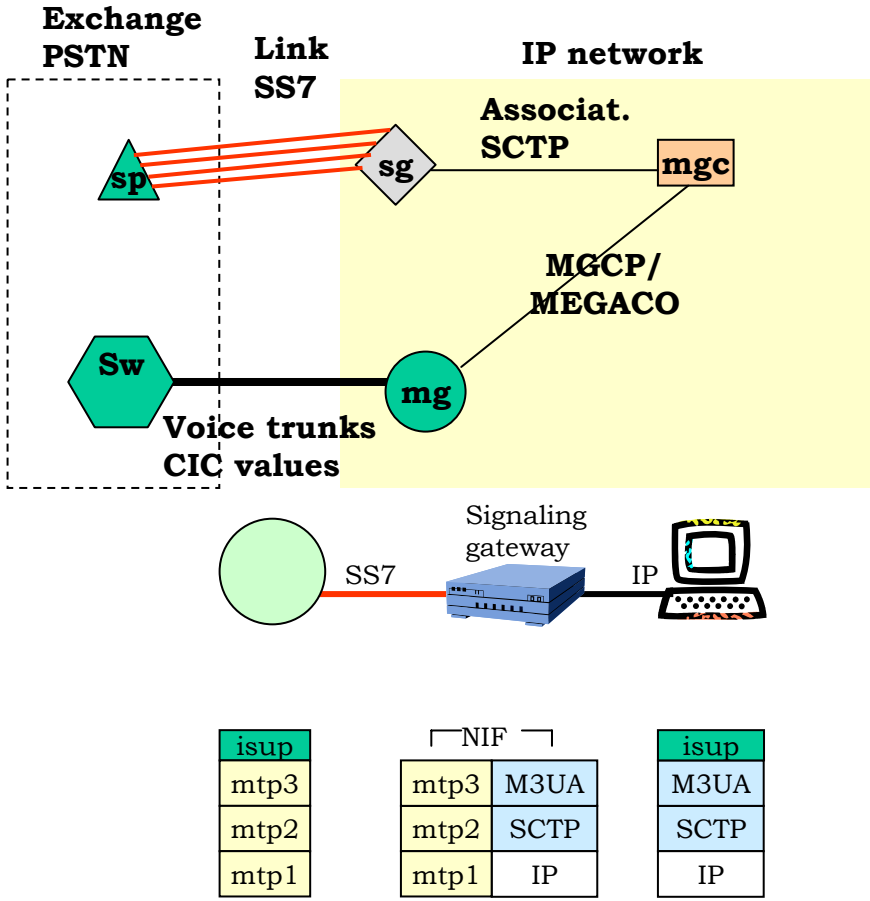






SCTP streams

- With M3UA the same problem is present
- It is possible to solve it more in general, as not only SLS, but also (DPC, OPC) or (DPC, OPC, CIC) can be used for the mapping



M3UA

- M3UA provides an interface to ISUP
- The interface allows ISUP to use the remote MTP3 services of the SG
- M3UA must provide transparency for some critical MTP3 services, for example
  - MTP-Transfer-Request: ISUP uses this primitive to ask MTP3 to transfer a message
  - MTP-Status-Indication: MTP3 signals to ISUP problems related to the transport of signaling messages

M3UA

- For example, assume that ISUP must send a signaling message
- ISUP issues a MTP-Transfer-Request to M3UA
- M3UA envelopes the message in a SCTP data chunk and it sends the message through the correct association/stream
- In the SG, NIF hands the message to MTP3 and from now on the delivery is standard