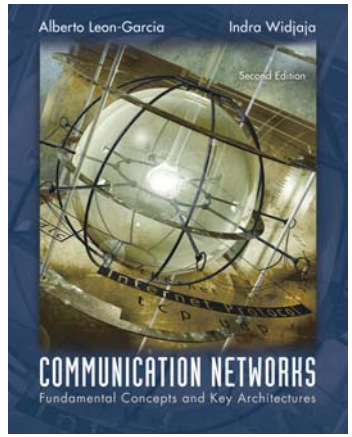
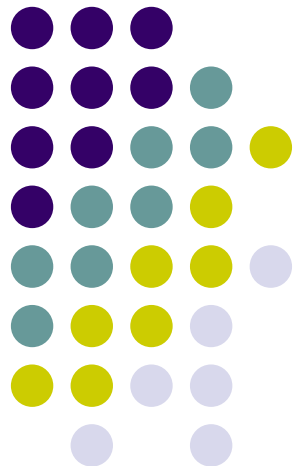
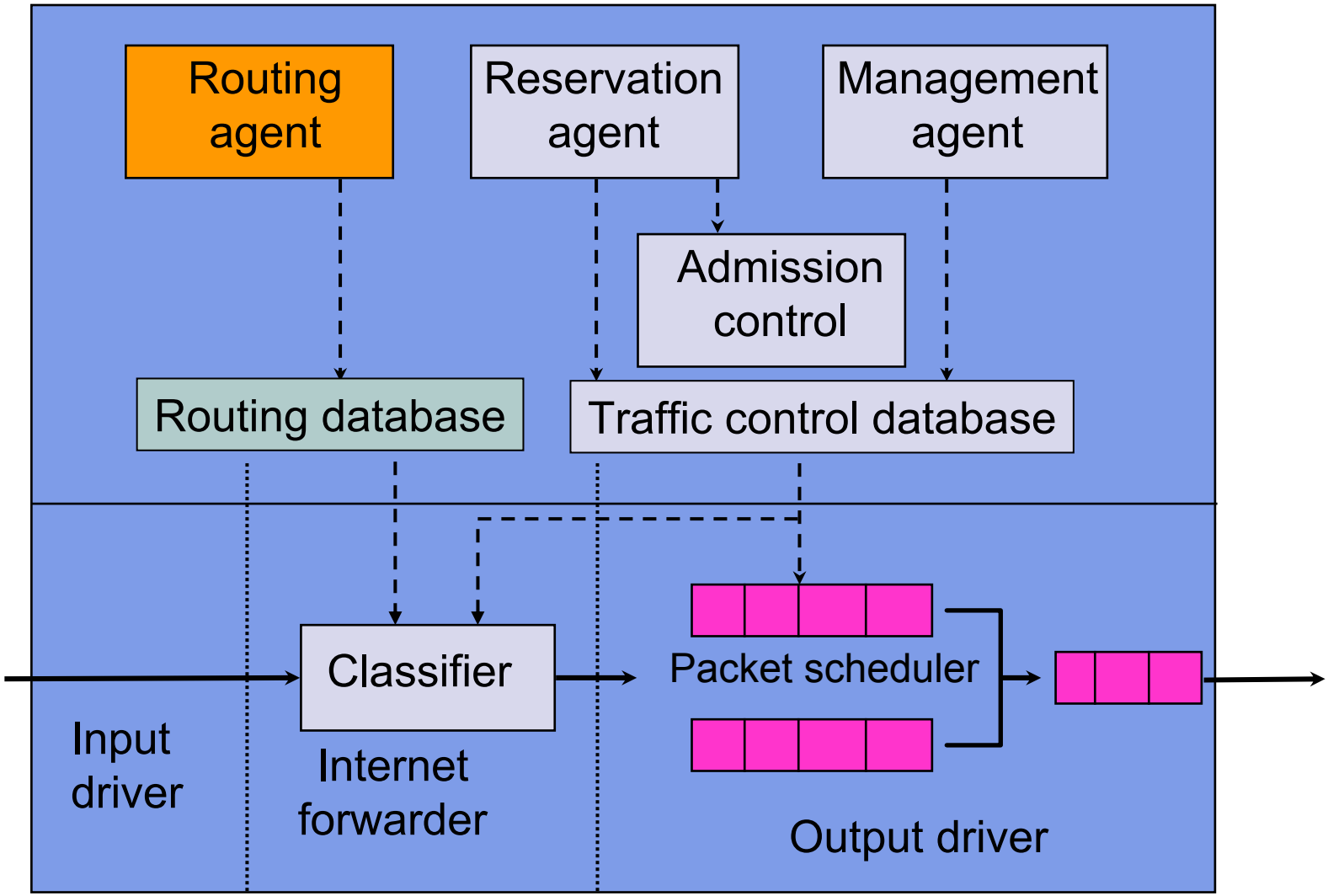
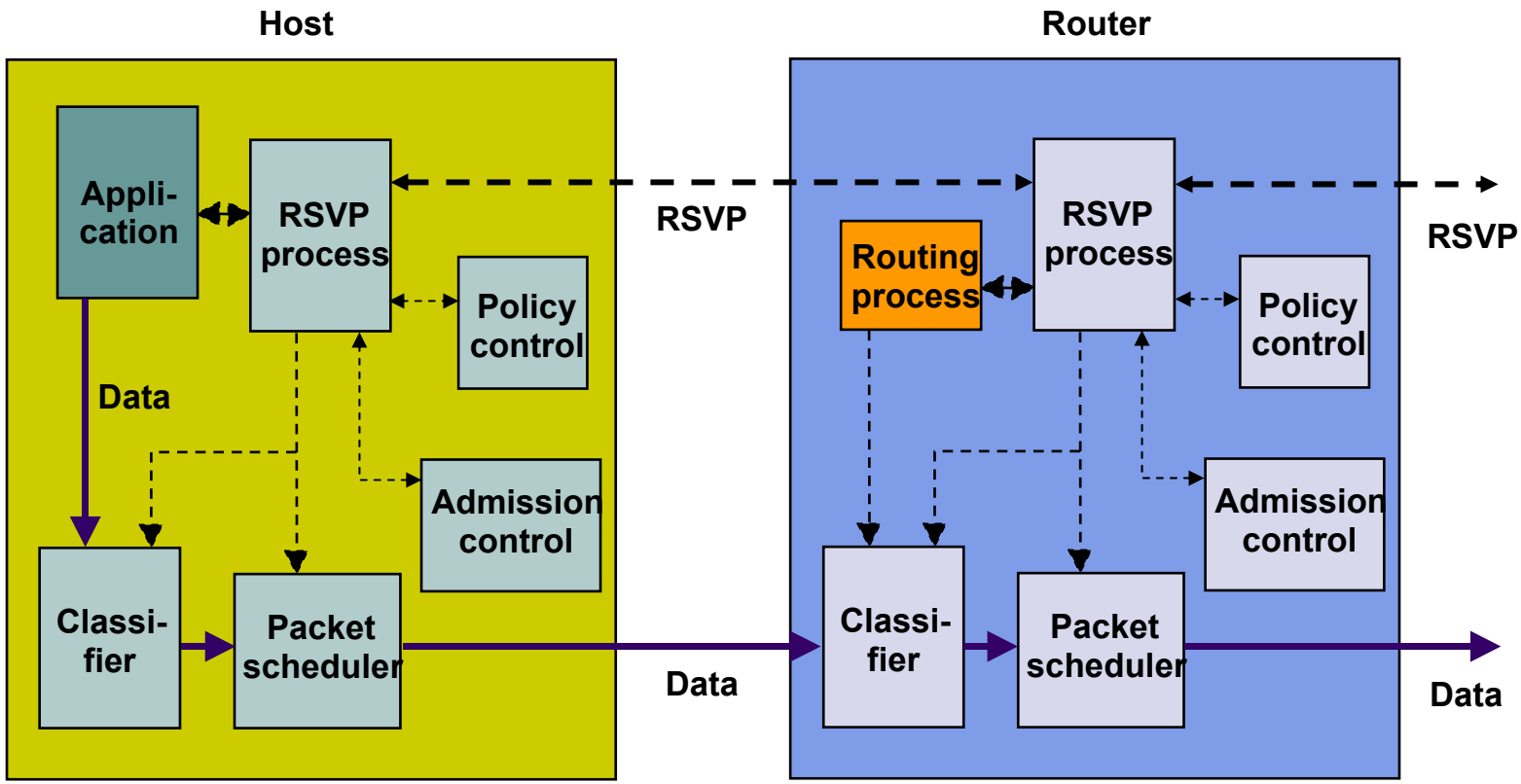
Chapter 10
Advanced Network Architectures

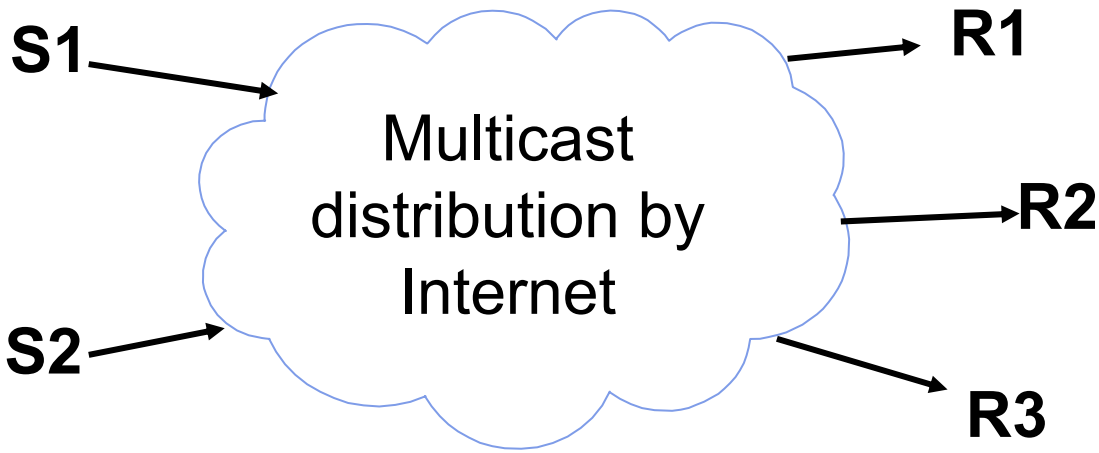


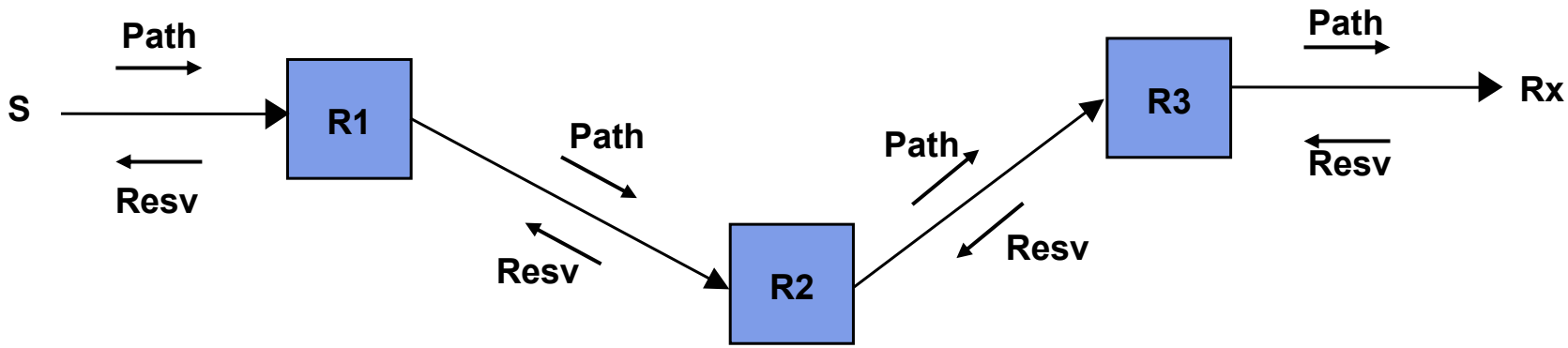
Chapter Figures

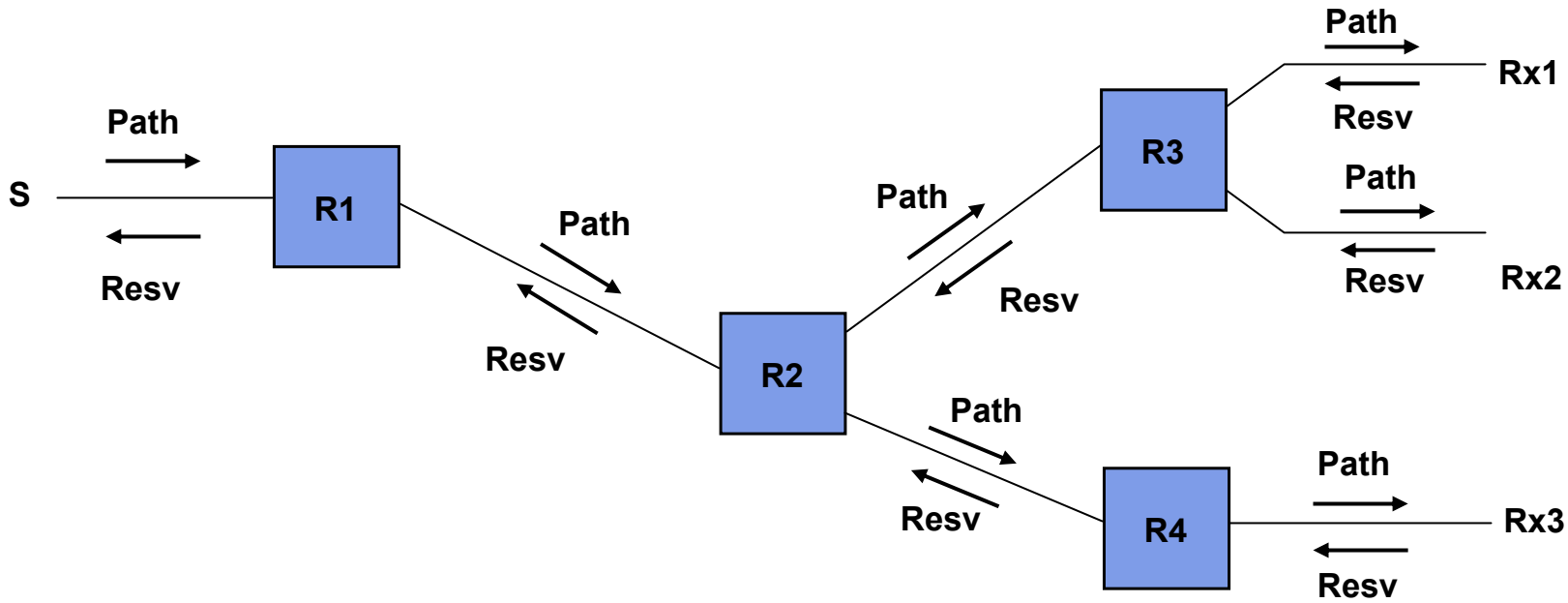


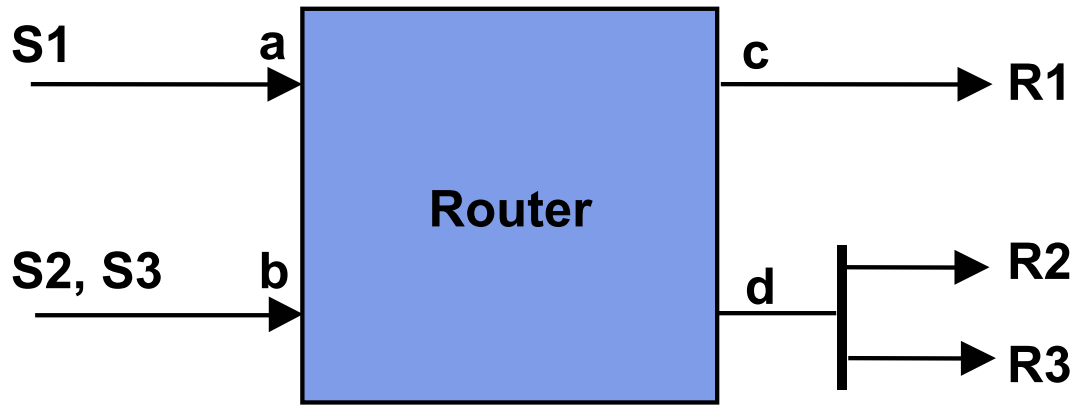

Routing agent
Reservation agent
Management agent
Admission control
Routing database
Traffic control database
Classifier
Packet scheduler
Input driver
Internet forwarder
Output driver

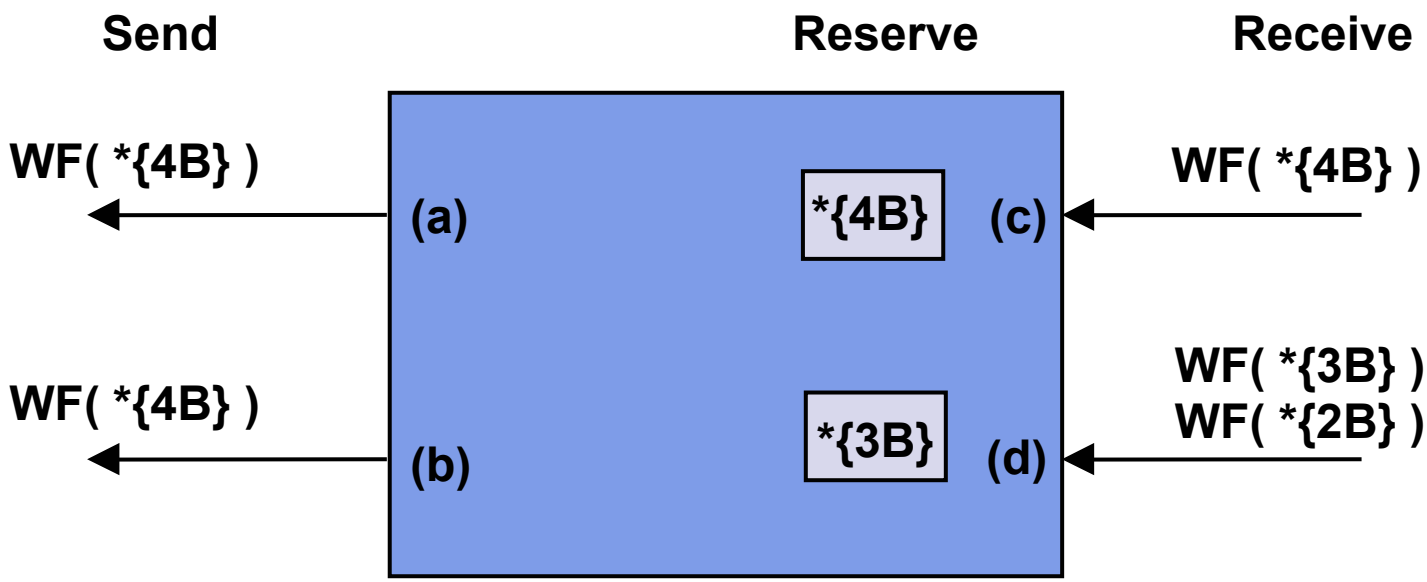

Host
Router
Appli-
cation
RSVP
process
Policy
control
Data
Admission
control
Classi-
fier
Packet
scheduler
RSVP
RSVP
Routing
process
RSVP
process
Policy
control
Admission
control
Classi-
fier
Packet
scheduler
Data
Data

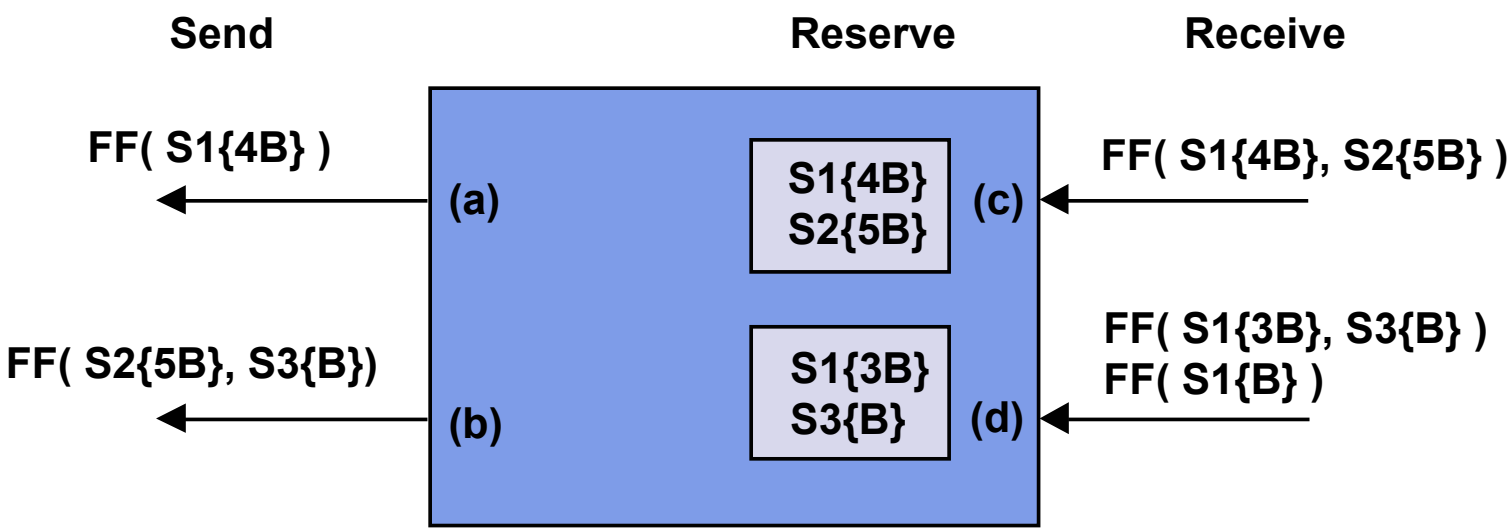

S1
S2
Multicast
distribution by
Internet
R1
R2
R3

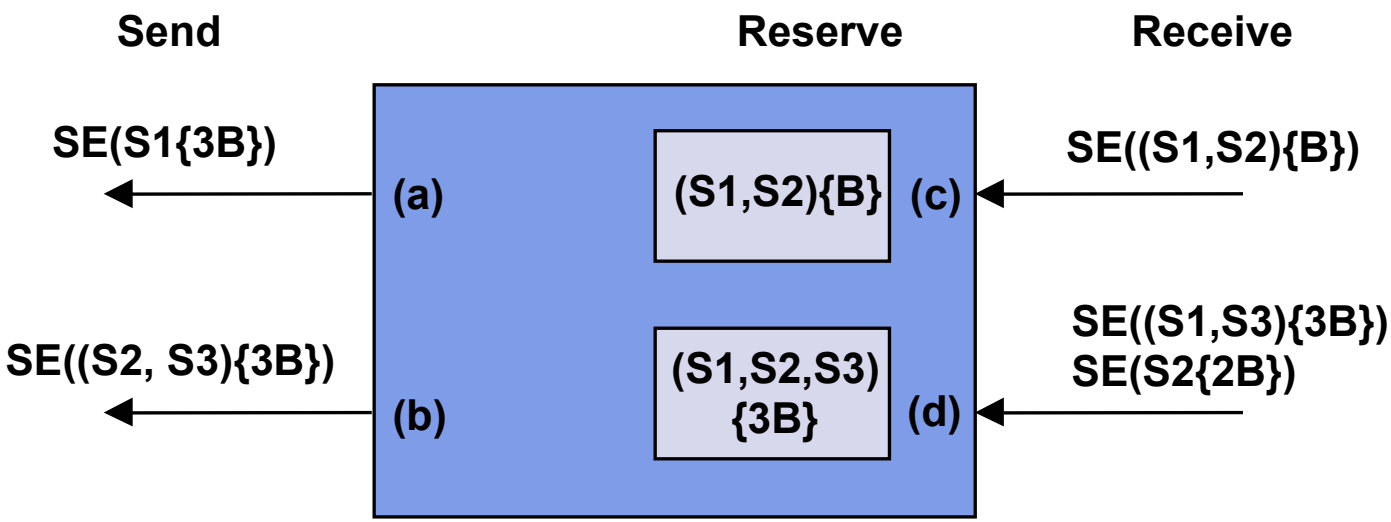

Path
S
R1
Resv
Path
Resv
R2
Path
Resv
R3
Path
Rx
Resv

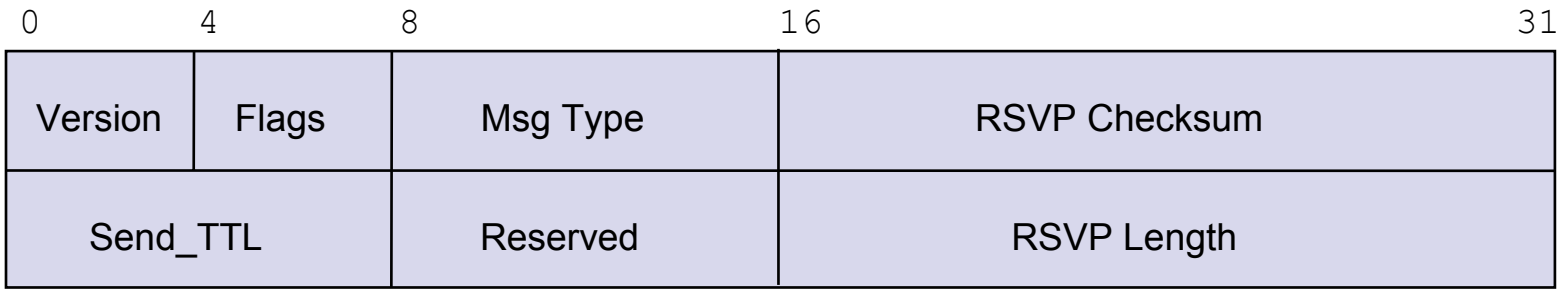

S
Path
Resv
R1
Path
Resv
R2
Path
Resv
R3
Path
Resv
Rx1
Path
Resv
Rx2
Path
Resv
R4
Path
Resv
Rx3

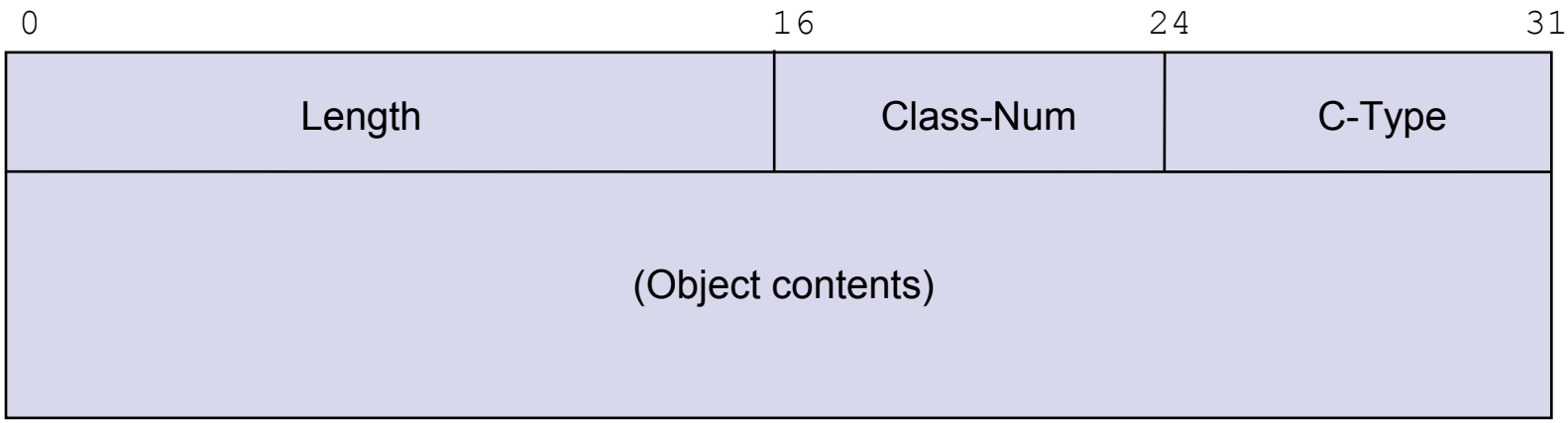

S1
a
Router
c
R1
S2, S3
b
d
R2
R3

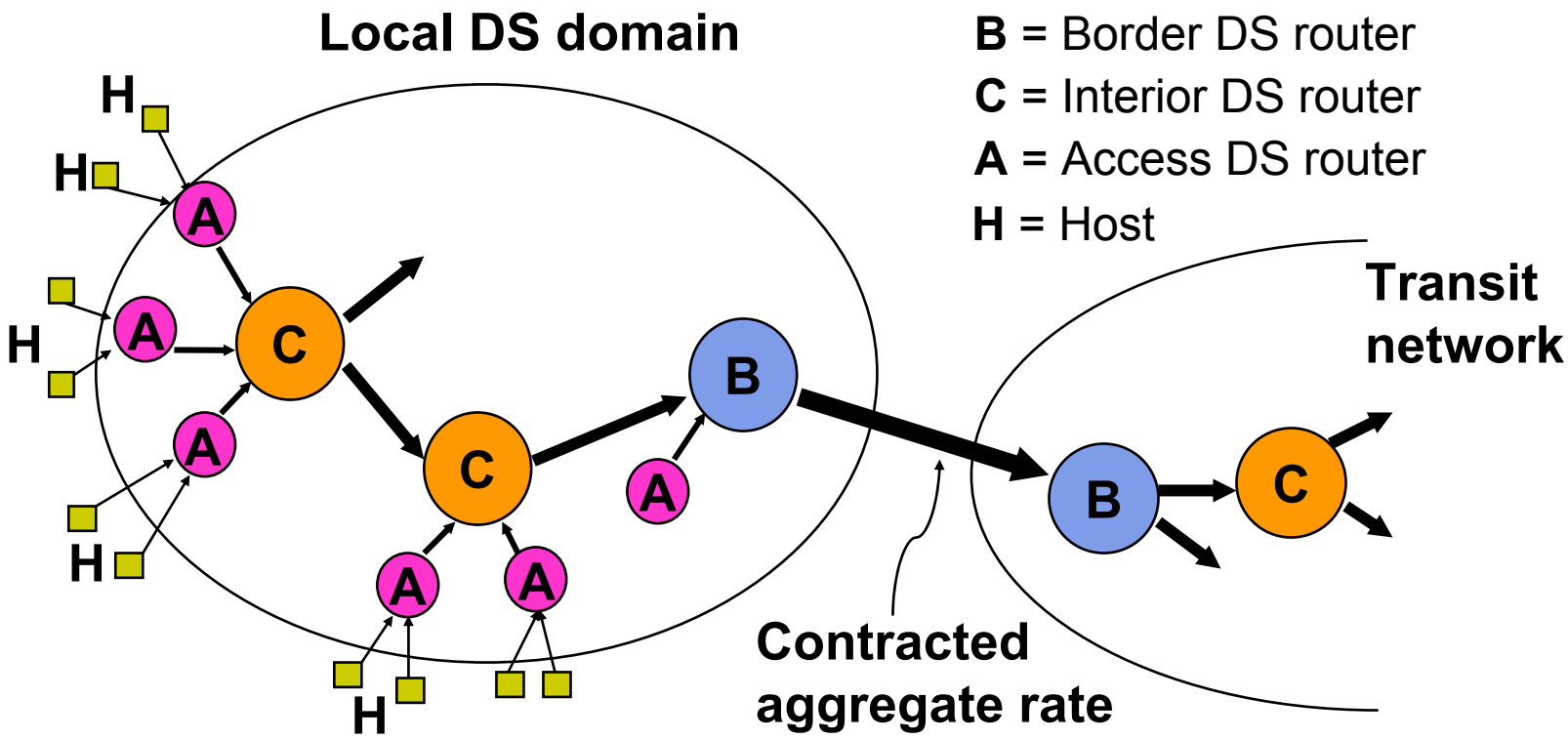

Send
Reserve
Receive
WF(*{4B})
(a)
*{4B}
(c)
WF(*{4B})
WF(*{4B})
WF(*{3B})
WF(*{2B})
(b)
*{3B}
(d)

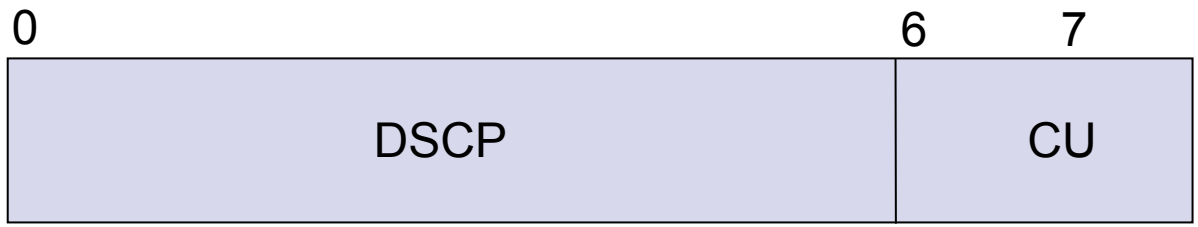

Send
Reserve
Receive
FF(S1{4B})
(a)
S1{4B}
S2{5B}
(c)
FF(S1{4B}, S2{5B})
FF(S2{5B}, S3{B})
(b)
S1{3B}
S3{B}
(d)
FF(S1{3B}, S3{B})
FF(S1{B})

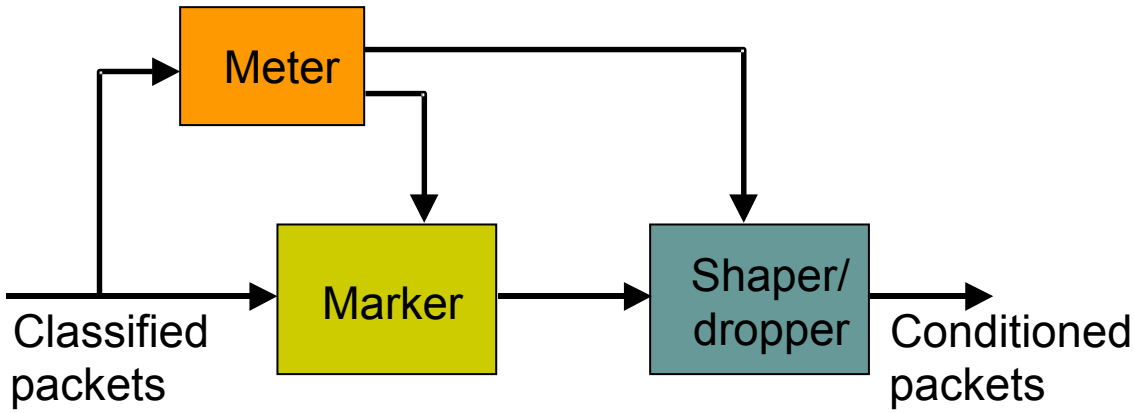

Send
Reserve
Receive
SE(S1{3B})
(a)
(S1,S2){B}
(c)
SE((S1,S2){B})
SE((S2, S3){3B})
(b)
(S1,S2,S3)
{3B}
(d)
SE((S1,S3){3B})
SE(S2{2B})

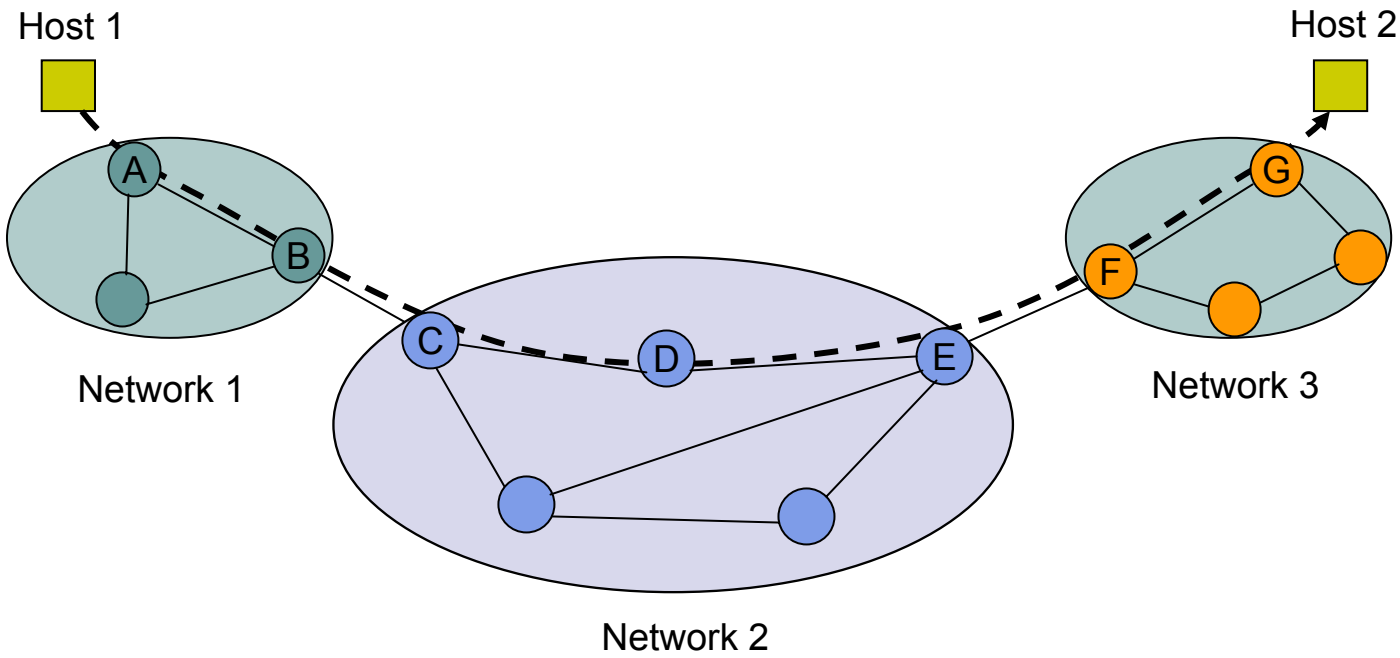

0
4
8
16
31
Version
Flags
Msg Type
RSVP Checksum
Send_TTL
Reserved
RSVP Length

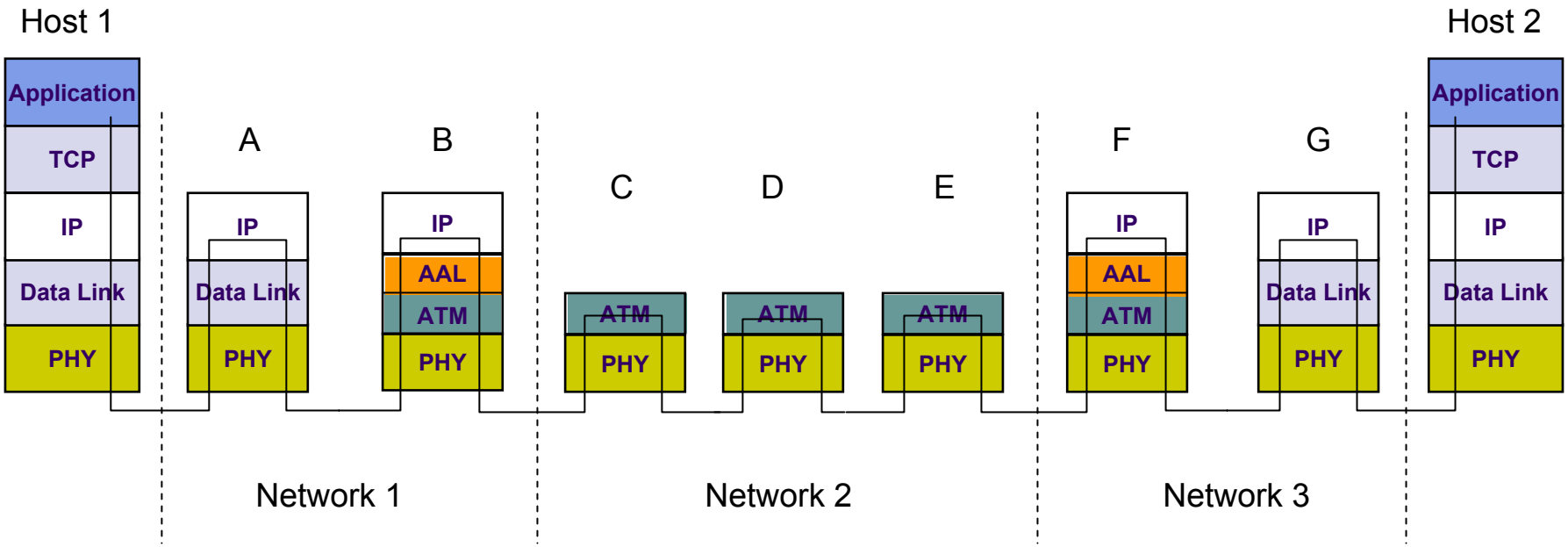

0
16
24
31
Length
Class-Num
C-Type
(Object contents)

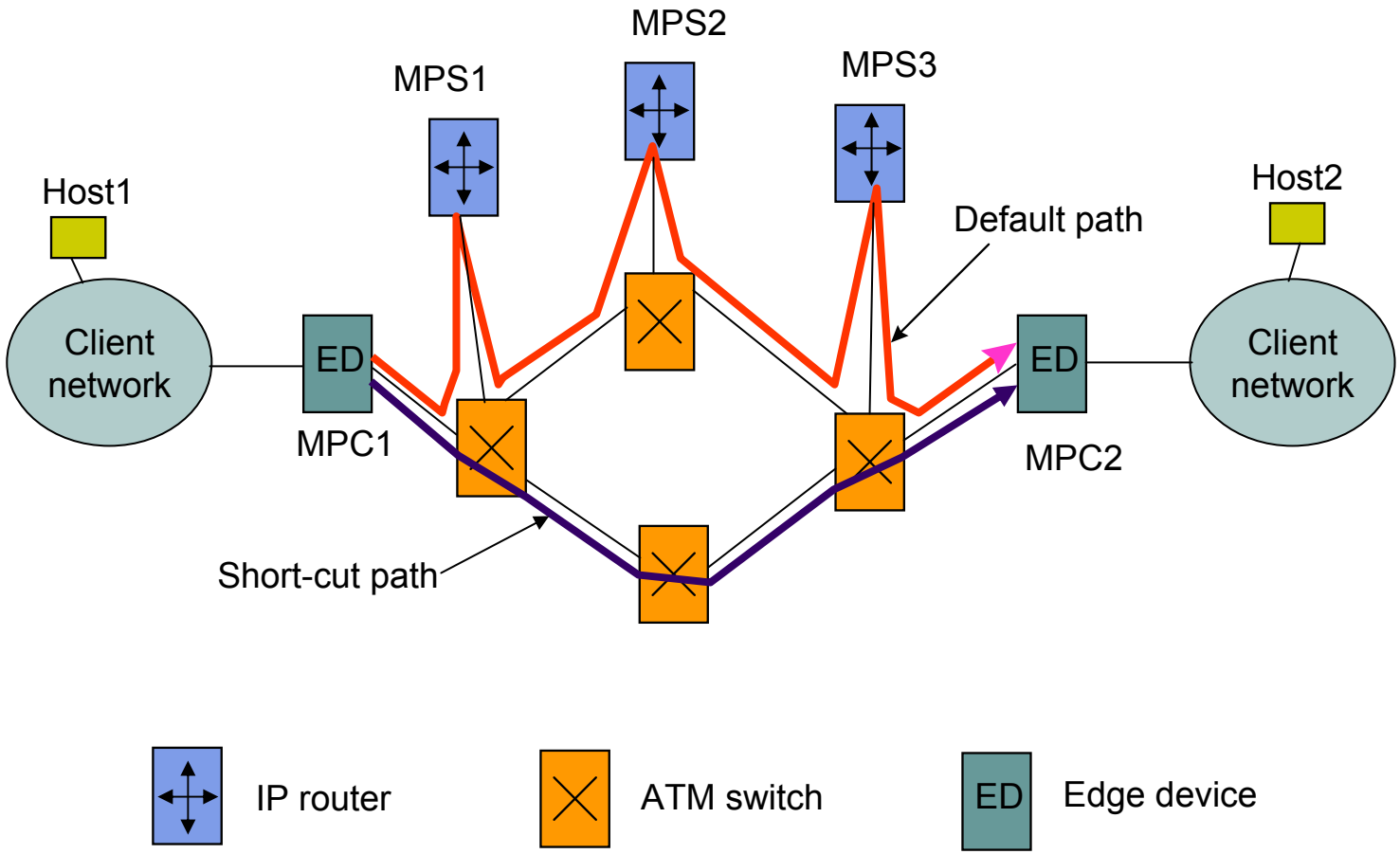

Local DS domain
B = Border DS router
C = Interior DS router
A = Access DS router
H = Host
Transit network
Contracted aggregate rate
H
A
C
B

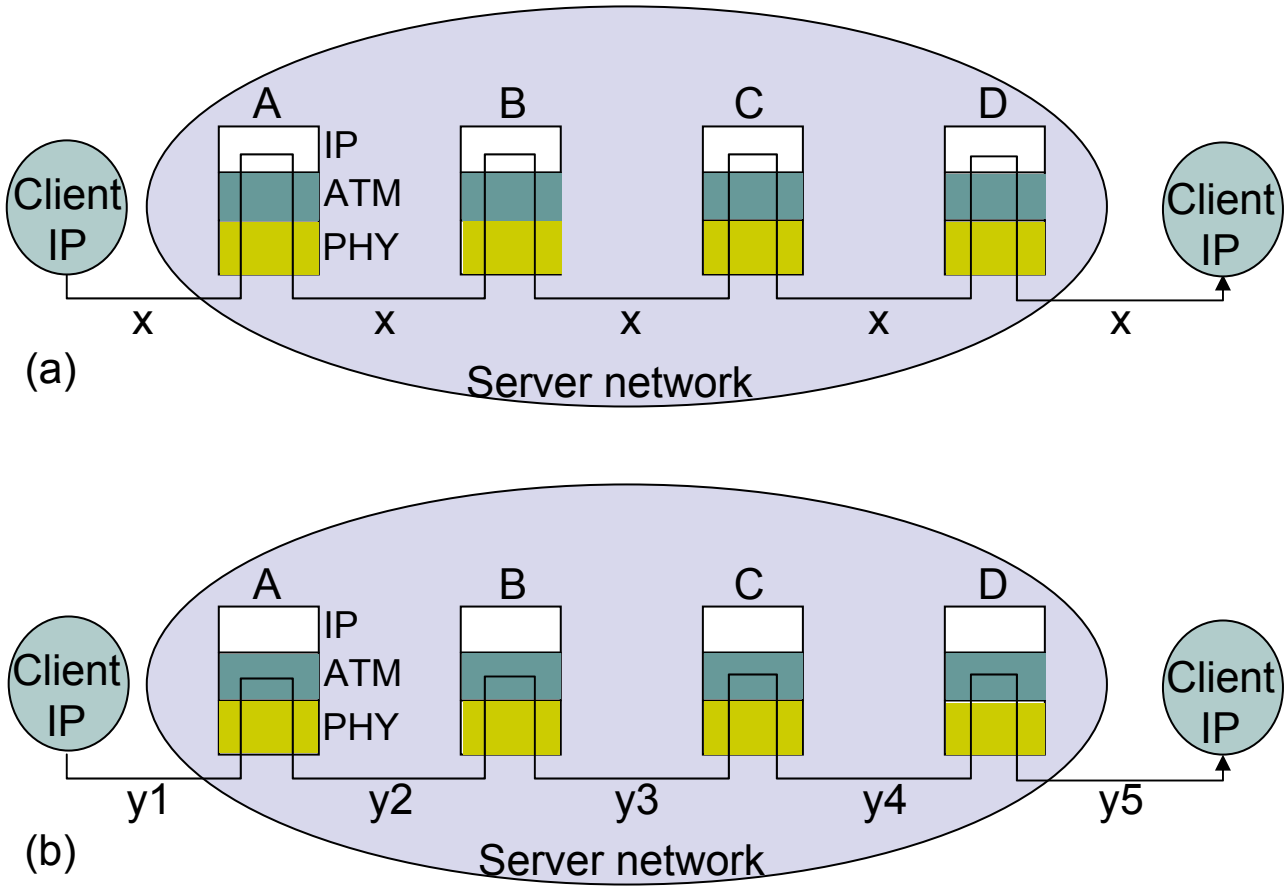

0
6
7
DSCP
CU

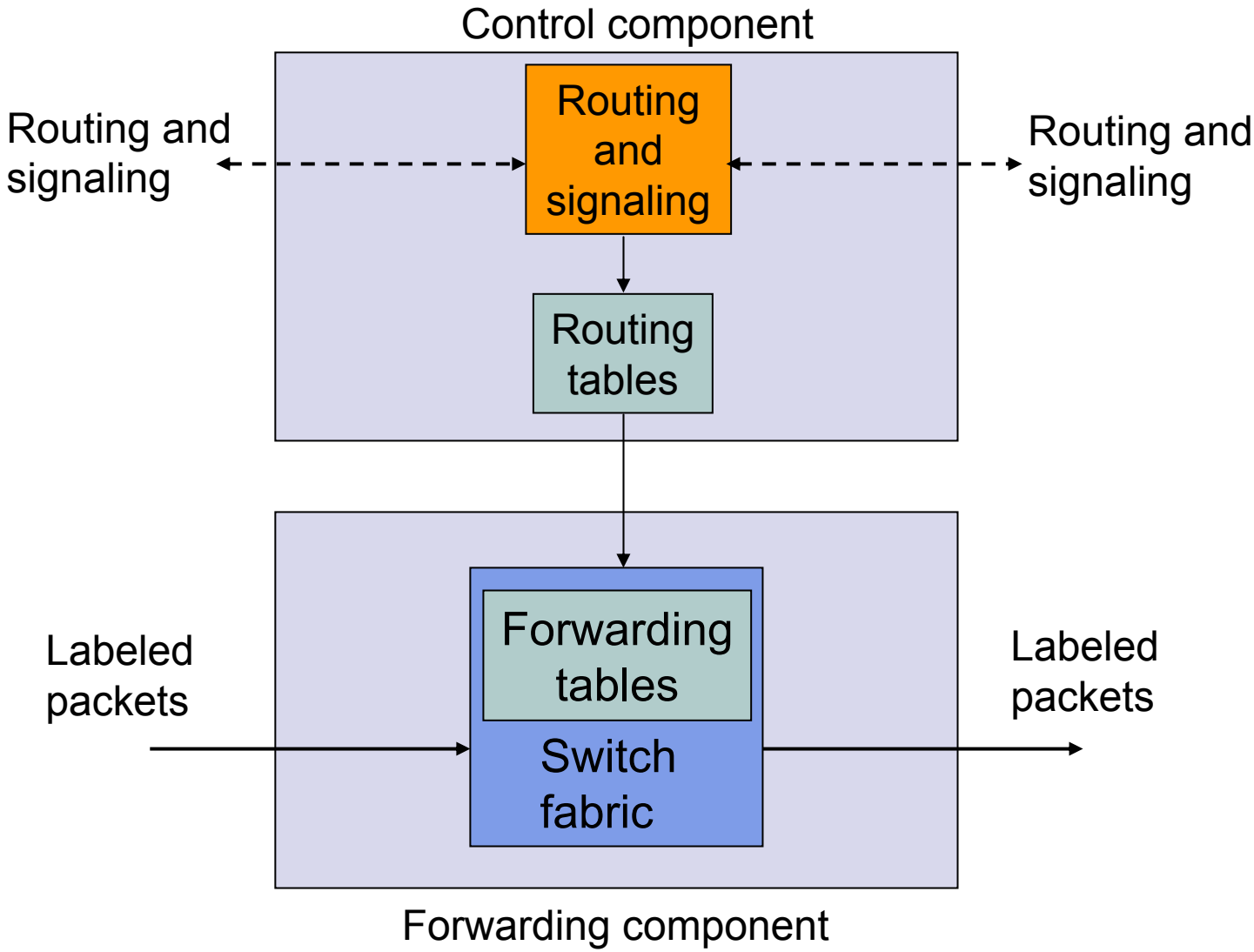

Meter
Marker
Shaper/
dropper
Classified
packets
Conditioned
packets

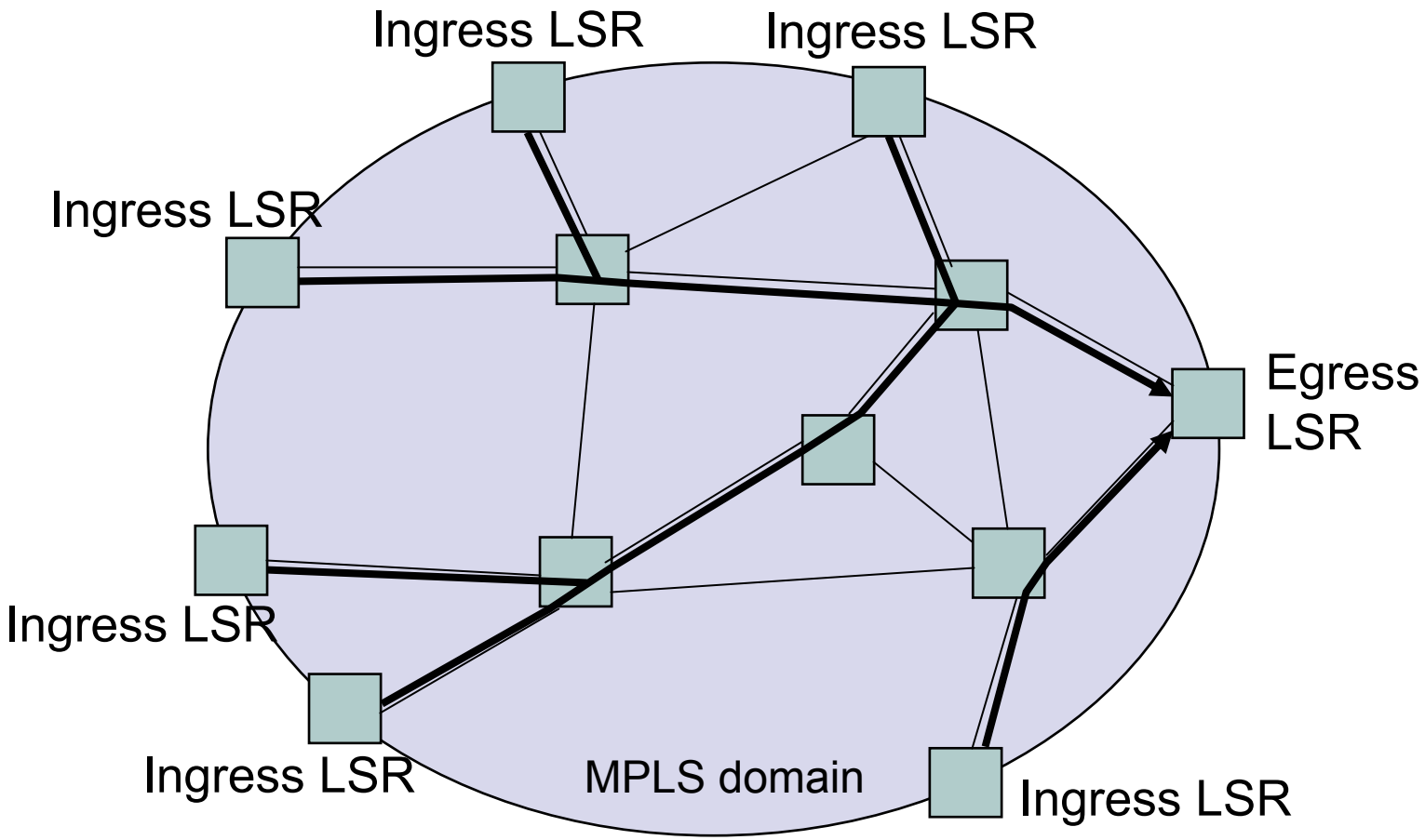

Host 1
Host 2
A
B
C
D
E
F
G
Network 1
Network 2
Network 3

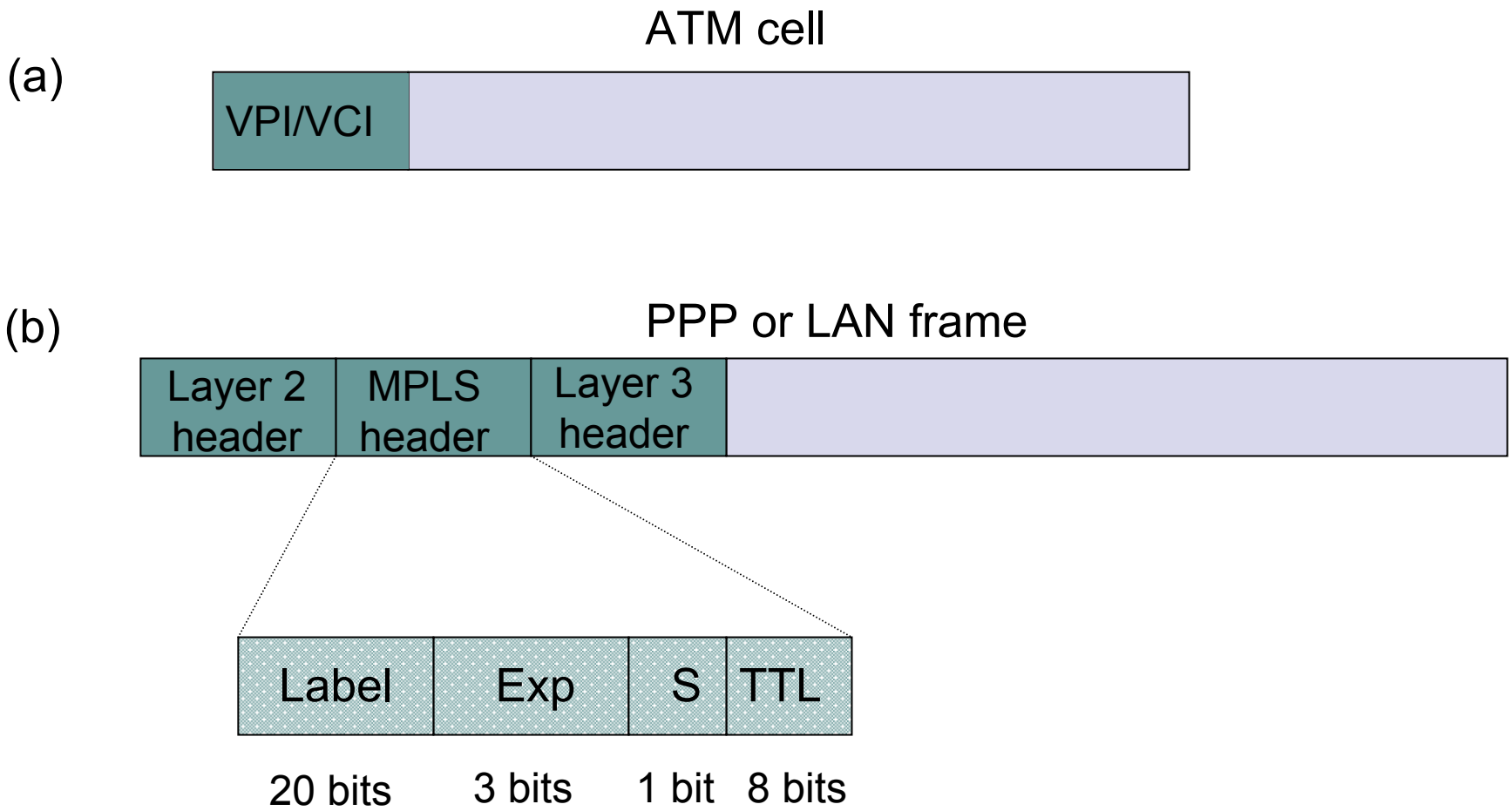

Host 1
Host 2
Application
TCP
IP
Data Link
PHY
A
B
C
D
E
F
G
IP
Data Link
PHY
AAL
ATM
Network 1
Network 2
Network 3

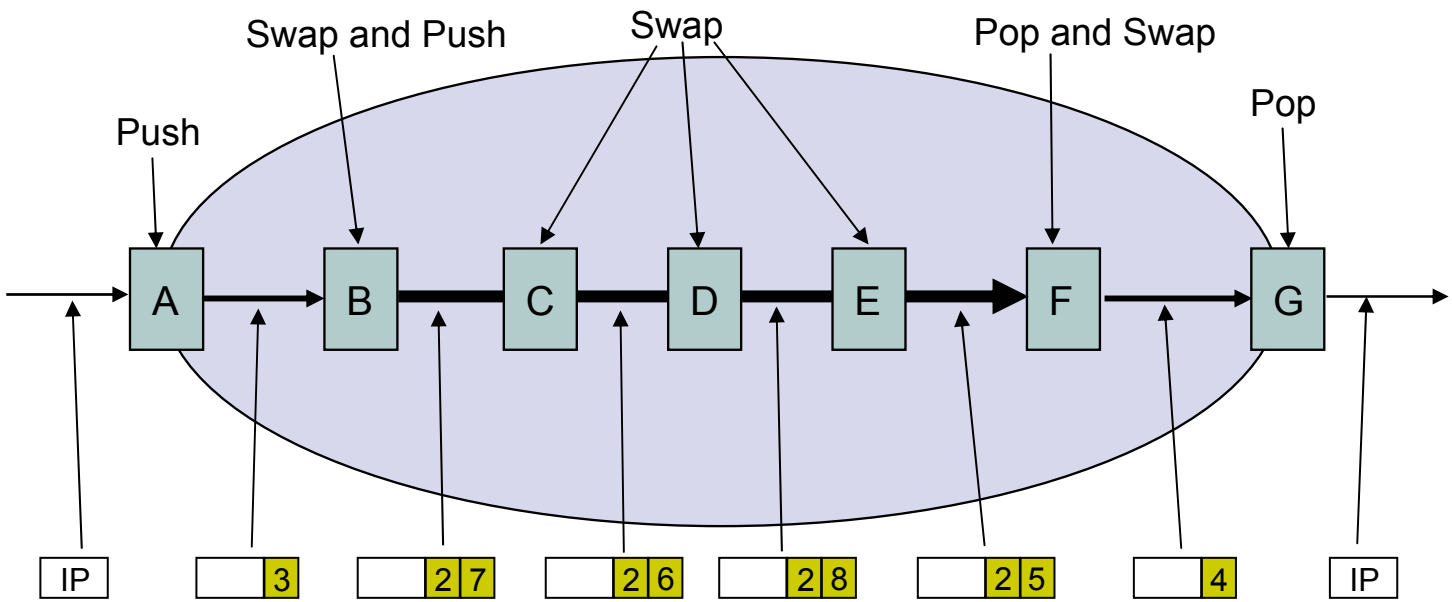

MPS2
MPS1
MPS3
Host1
Host2
Default path
Client network
ED
ED
Client network
MPC1
MPC2
Short-cut path
IP router
ATM switch
ED
Edge device

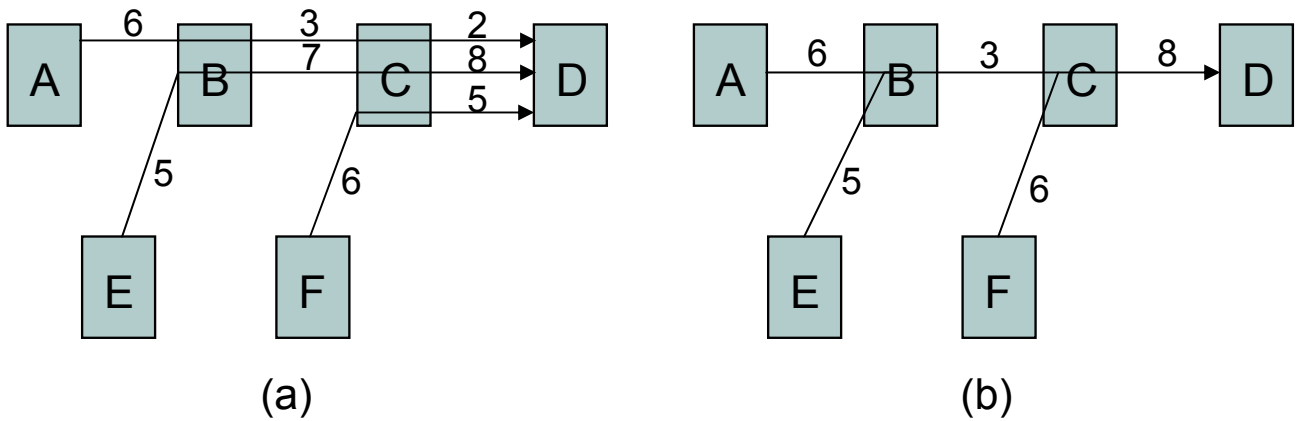

A
B
C
D
IP
ATM
PHY
Client IP
Client IP
x
x
x
x
x
(a)
Server network
A
B
C
D
IP
ATM
PHY
Client IP
Client IP
y1
y2
y3
y4
y5
(b)
Server network

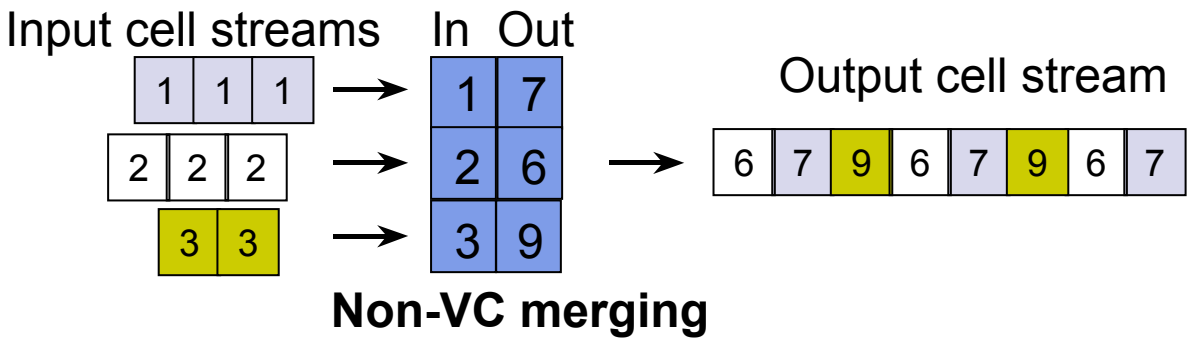

Control component
Routing and signaling
Routing and signaling
Routing and signaling
Routing tables
Forwarding tables
Switch fabric
Labeled packets
Labeled packets
Forwarding component

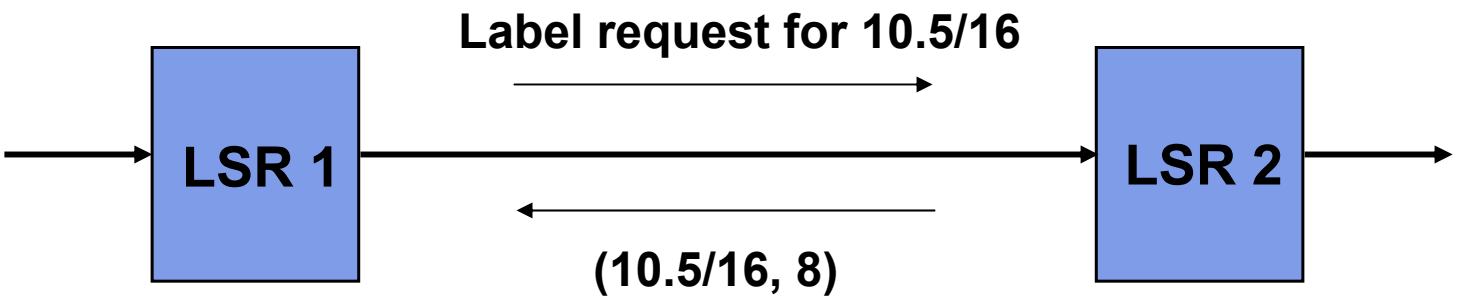

Ingress LSR
Ingress LSR
Ingress LSR
Egress
LSR
Ingress LSR
Ingress LSR
MPLS domain
Ingress LSR

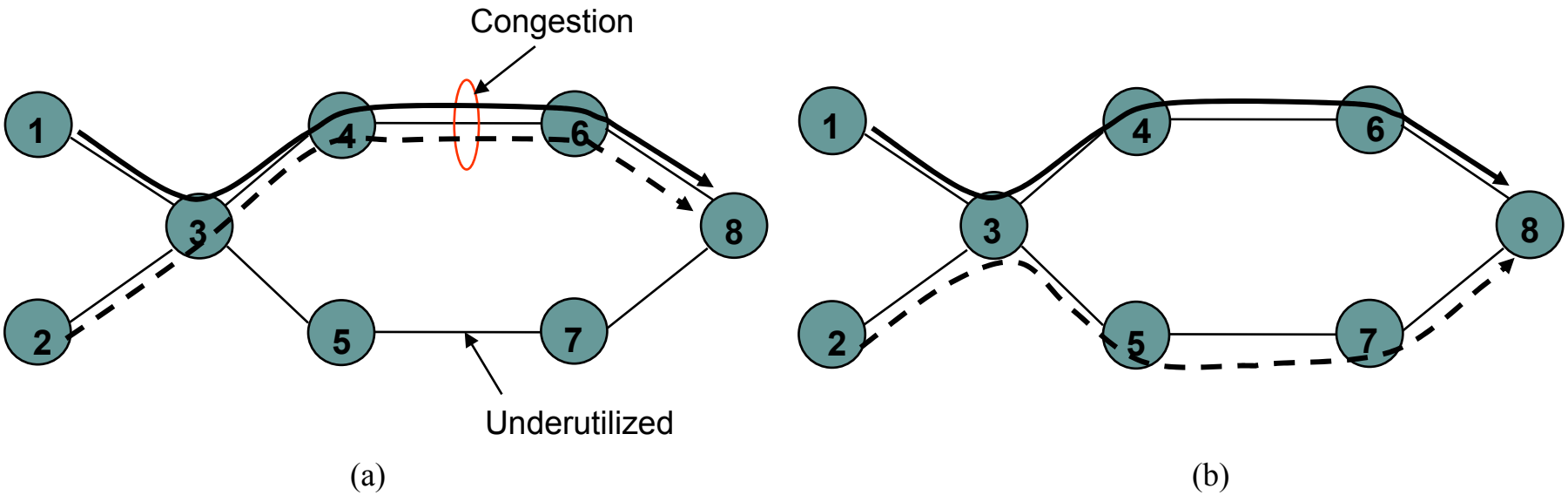

(a)
ATM cell
VPI/VCI
(b)
PPP or LAN frame
Layer 2 header
MPLS header
Layer 3 header
Label
Exp
S
TTL
20 bits
3 bits
1 bit
8 bits

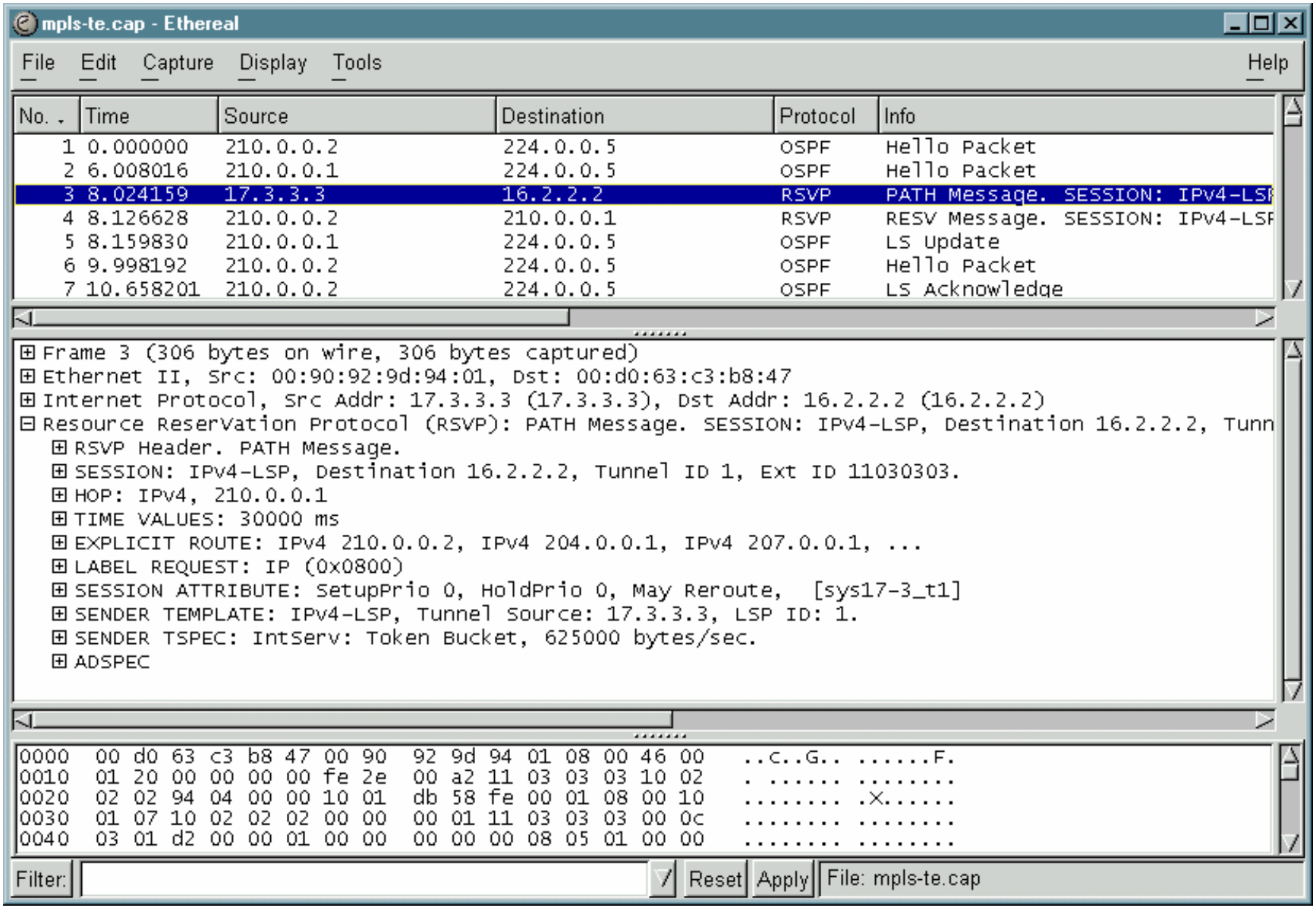

Swap and Push
Swap
Pop and Swap
Push
Pop
A
B
C
D
E
F
G
IP
3
2 7
2 6
2 8
2 5
4
IP

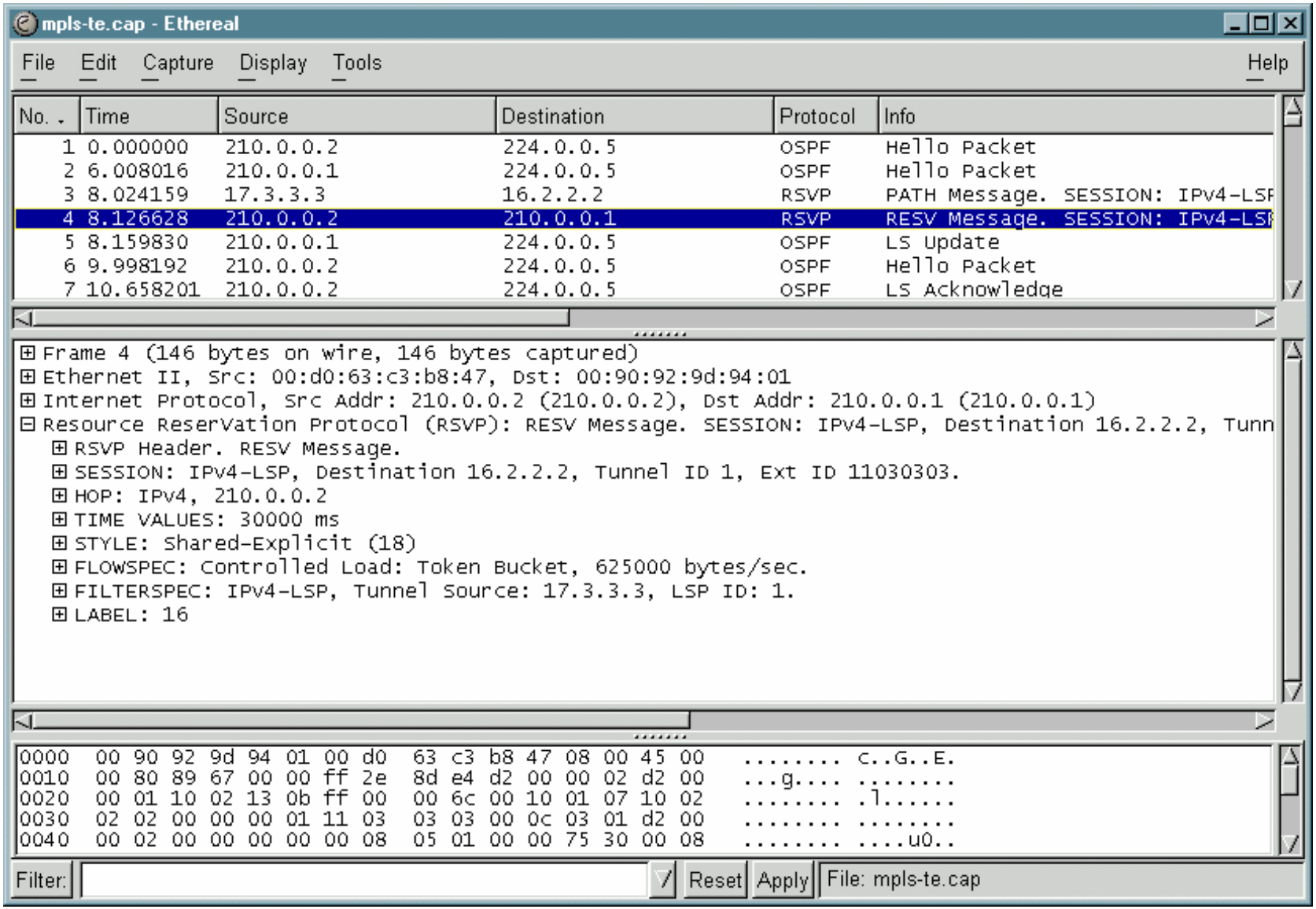

A
B
C
D
E
F
6
3
7
2
8
5
5
6
(a)
A
B
C
D
E
F
6
3
8
5
6
(b)

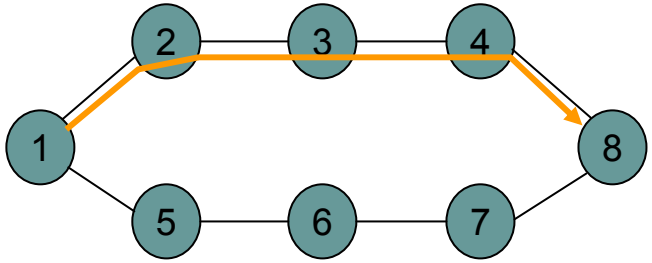

Input cell streams
In Out
1 1 1
2 2 2
3 3
1 7
2 6
3 9
Output cell stream
6 7 9 6 7 9 6 7
Non-VC merging
Input cell streams
In Out
1 1 1
2 2 2
3 3
1 7
2 7
3 7
Output cell stream
7 7 7 7 7 7 7 7
Packet 3
Packet 2
Packet 1
VC merging


Label request for 10.5/16
LSR 1
LSR 2
(10.5/16, 8)

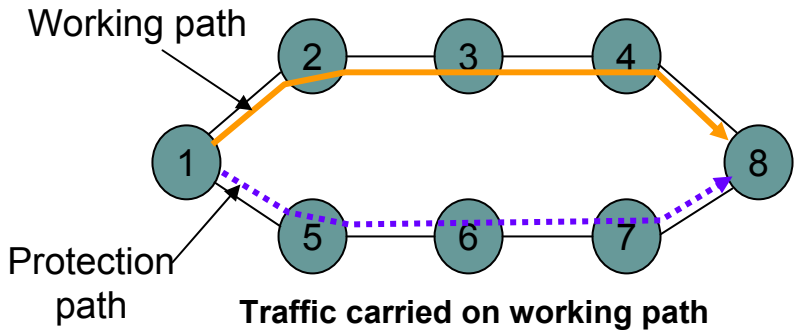

Congestion
1
2
3
4
5
6
7
8
Underutilized
(a)
1
2
3
4
5
6
7
8
(b)


mpls-te.cap - Ethereal
File Edit Capture Display Tools Help
No. Time Source Destination Protocol Info
1 0.000000 210.0.0.2 224.0.0.5 OSPF Hello Packet
2 6.008016 210.0.0.1 224.0.0.5 OSPF Hello Packet
3 8.024159 17.3.3.3 16.2.2.2 RSVP PATH Message. SESSION: IPv4-LSP
4 8.126628 210.0.0.2 210.0.0.1 RSVP RESV Message. SESSION: IPv4-LSP
5 8.159830 210.0.0.1 224.0.0.5 OSPF LS Update
6 9.998192 210.0.0.2 224.0.0.5 OSPF Hello Packet
7 10.658201 210.0.0.2 224.0.0.5 OSPF LS Acknowledge
Frame 3 (306 bytes on wire, 306 bytes captured)
Ethernet II, Src: 00:90:92:9d:94:01, Dst: 00:d0:63:c3:b8:47
Internet Protocol, Src Addr: 17.3.3.3 (17.3.3.3), Dst Addr: 16.2.2.2 (16.2.2.2)
Resource ReserVation Protocol (RSVP): PATH Message. SESSION: IPv4-LSP, Destination 16.2.2.2, Tunn
RSVP Header. PATH Message.
SESSION: IPv4-LSP, Destination 16.2.2.2, Tunnel ID 1, Ext ID 11030303.
HOP: IPv4, 210.0.0.1
TIME VALUES: 30000 ms
EXPLICIT ROUTE: IPv4 210.0.0.2, IPv4 204.0.0.1, IPv4 207.0.0.1, ...
LABEL REQUEST: IP (0x0800)
SESSION ATTRIBUTE: SetupPrio 0, HoldPrio 0, May Reroute, [sys17-3_t1]
SENDER TEMPLATE: IPv4-LSP, Tunnel Source: 17.3.3.3, LSP ID: 1.
SENDER TSPEC: IntServ: Token Bucket, 625000 bytes/sec.
ADSPEC
0000 00 d0 63 c3 b8 47 00 90 92 9d 94 01 08 00 46 00 ..c..G.. ......F.
0010 01 20 00 00 00 00 fe 2e 00 a2 11 03 03 03 10 02 . ...
0020 02 02 94 04 00 00 10 01 db 58 fe 00 01 08 00 10 .... .X......
0030 01 07 10 02 02 02 00 00 00 01 11 03 03 03 00 0c ....
0040 03 01 d2 00 00 01 00 00 00 00 00 08 05 01 00 00 ....
Filter: Reset Apply File: mpls-te.cap

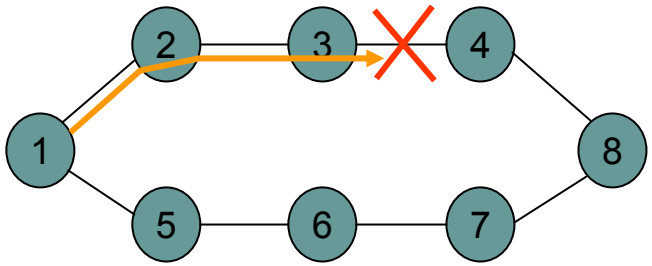

mpls-te.cap - Ethereal
File Edit Capture Display Tools Help
No. Time Source Destination Protocol Info
1 0.000000 210.0.0.2 224.0.0.5 OSPF Hello Packet
2 6.008016 210.0.0.1 224.0.0.5 OSPF Hello Packet
3 8.024159 17.3.3.3 16.2.2.2 RSVP PATH Message. SESSION: IPv4-LSP
4 8.126628 210.0.0.2 210.0.0.1 RSVP RESV Message. SESSION: IPv4-LSP
5 8.159830 210.0.0.1 224.0.0.5 OSPF LS Update
6 9.998192 210.0.0.2 224.0.0.5 OSPF Hello Packet
7 10.658201 210.0.0.2 224.0.0.5 OSPF LS Acknowledge
Frame 4 (146 bytes on wire, 146 bytes captured)
Ethernet II, Src: 00:d0:63:c3:b8:47, Dst: 00:90:92:9d:94:01
Internet Protocol, Src Addr: 210.0.0.2 (210.0.0.2), Dst Addr: 210.0.0.1 (210.0.0.1)
Resource ReserVation Protocol (RSVP): RESV Message. SESSION: IPv4-LSP, Destination 16.2.2.2, Tunn
RSVP Header. RESV Message.
SESSION: IPv4-LSP, Destination 16.2.2.2, Tunnel ID 1, Ext ID 11030303.
HOP: IPv4, 210.0.0.2
TIME VALUES: 30000 ms
STYLE: Shared-Explicit (18)
FLOWSPEC: Controlled Load: Token Bucket, 625000 bytes/sec.
FILTERSPEC: IPv4-LSP, Tunnel Source: 17.3.3.3, LSP ID: 1.
LABEL: 16
0000 00 90 92 9d 94 01 00 d0 63 c3 b8 47 08 00 45 00 .... c..G..E.
0010 00 80 89 67 00 00 ff 2e 8d e4 d2 00 00 02 d2 00 ...g.... ....
0020 00 01 10 02 13 0b ff 00 00 6c 00 10 01 07 10 02 .... .l......
0030 02 02 00 00 00 01 11 03 03 03 00 0c 03 01 d2 00 ....
0040 00 02 00 00 00 00 00 08 05 01 00 00 75 30 00 08 ....u0..
Filter: Reset Apply File: mpls-te.cap



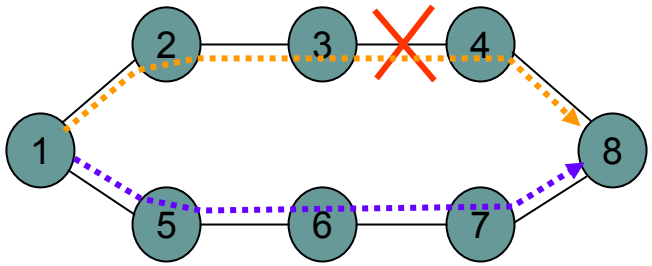
Normal operation



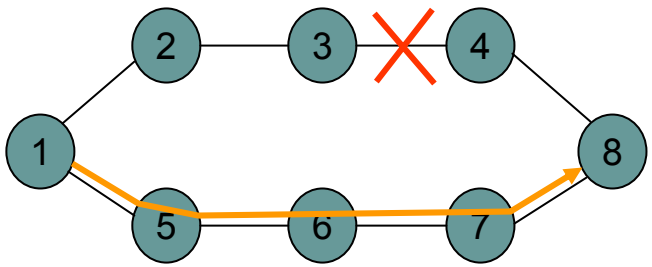
Traffic carried on working path



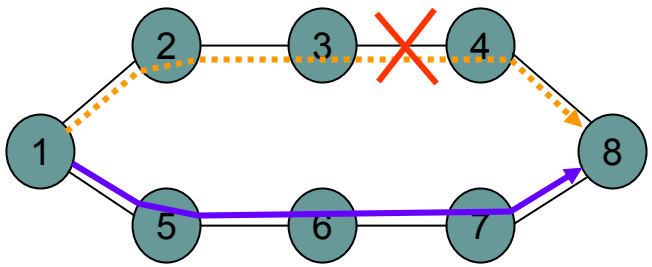
Failure occurs and is detected



Failure on working path is detected



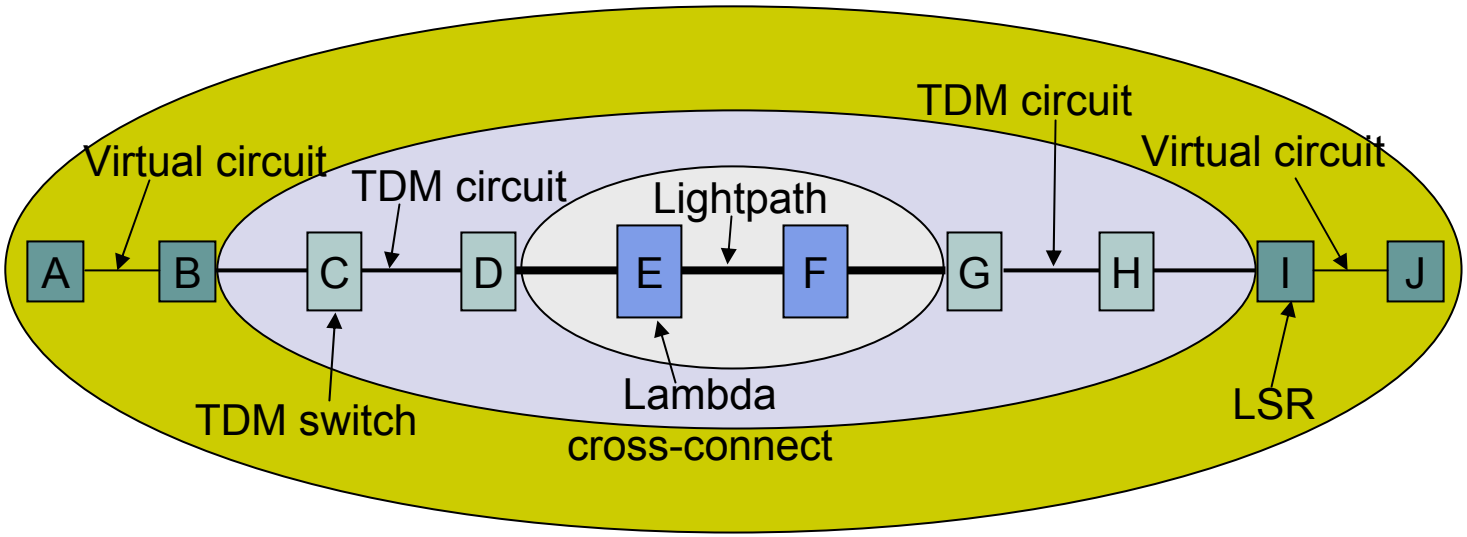
Alternate path is established, and traffic is re-routed

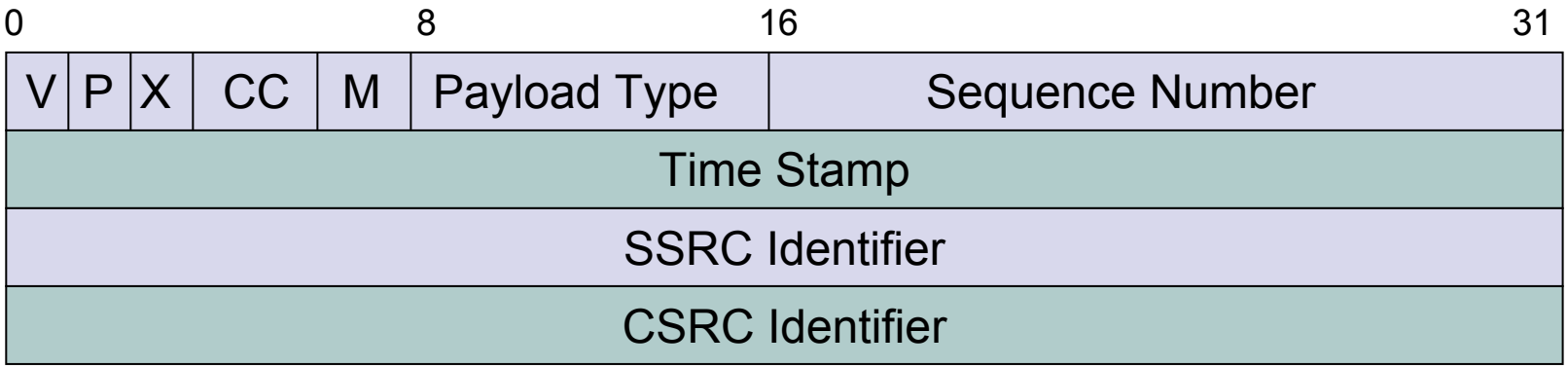


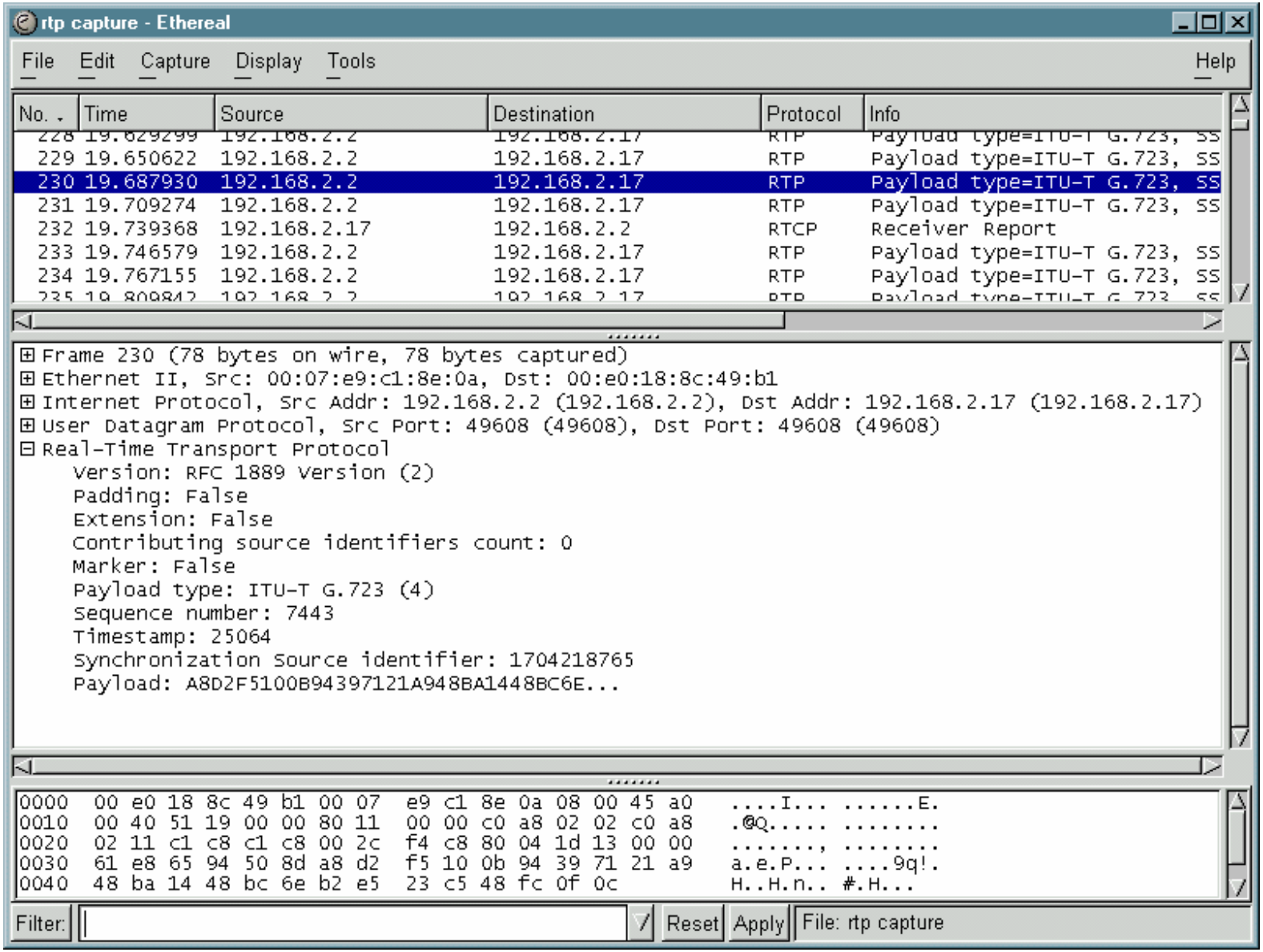
Traffic is switched to the protection path

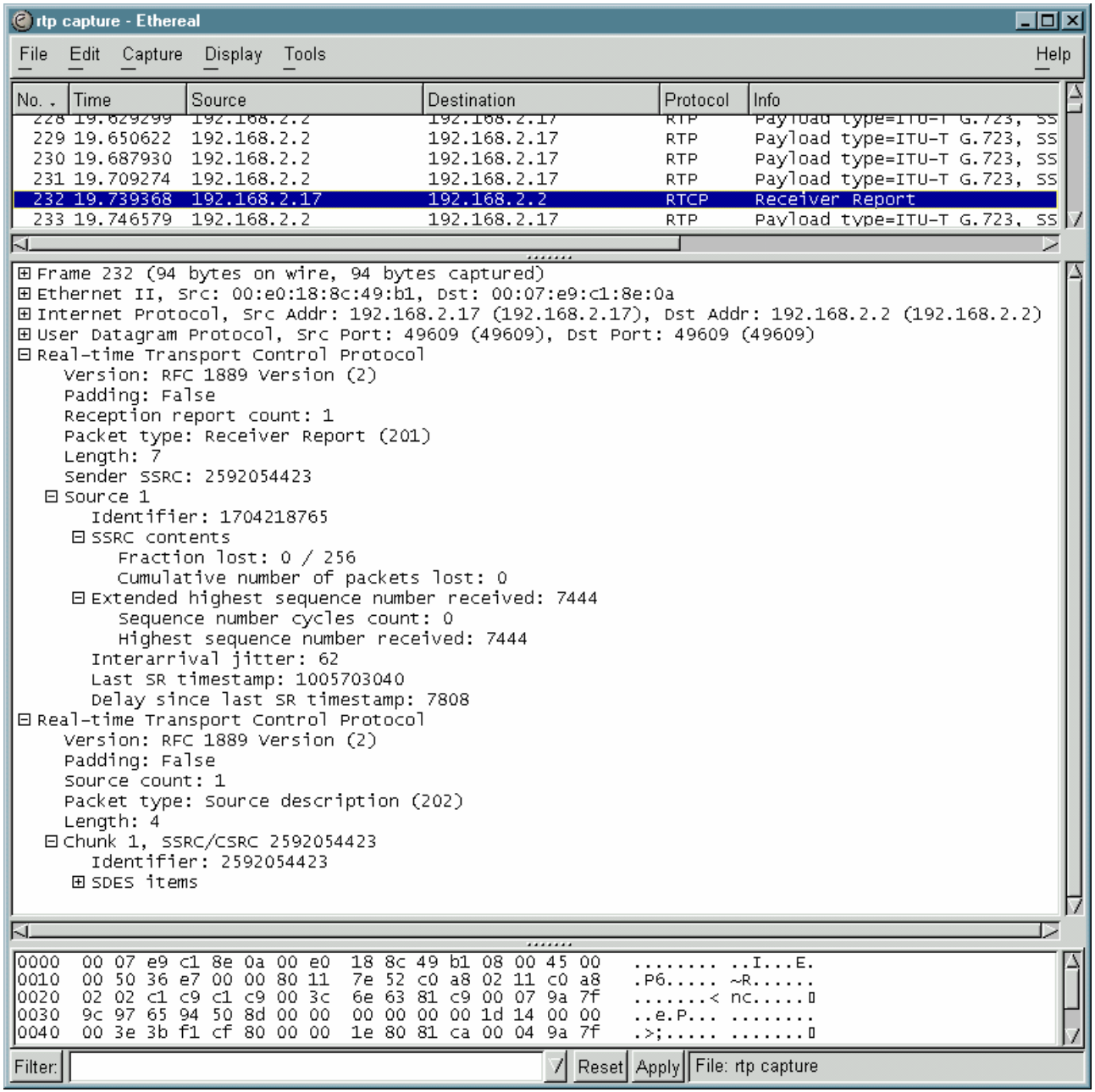
(a)

(b)


TDM circuit
Virtual circuit
Virtual circuit
TDM circuit
Lightpath
A
B
C
D
E
F
G
H
I
J
TDM switch
Lambda
cross-connect
LSR


0
8
16
31
V
P
X
CC
M
Payload Type
Sequence Number
Time Stamp
SSRC Identifier
CSRC Identifier


rtp capture - Ethereal
File Edit Capture Display Tools Help
No. Time Source Destination Protocol Info
229 19.650622 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
230 19.687930 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
231 19.709274 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
232 19.739368 192.168.2.17 192.168.2.2 RTCP Receiver Report
233 19.746579 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
234 19.767155 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
Frame 230 (78 bytes on wire, 78 bytes captured)
Ethernet II, Src: 00:07:e9:c1:8e:0a, Dst: 00:e0:18:8c:49:b1
Internet Protocol, Src Addr: 192.168.2.2 (192.168.2.2), Dst Addr: 192.168.2.17 (192.168.2.17)
User Datagram Protocol, Src Port: 49608 (49608), Dst Port: 49608 (49608)
Real-Time Transport Protocol
Version: RFC 1889 Version (2)
Padding: False
Extension: False
Contributing source identifiers count: 0
Marker: False
Payload type: ITU-T G.723 (4)
Sequence number: 7443
Timestamp: 25064
Synchronization Source identifier: 1704218765
Payload: A8D2F5100B94397121A948BA1448BC6E...
0000 00 e0 18 8c 49 b1 00 07 e9 c1 8e 0a 08 00 45 a0 ....I... ......E.
0010 00 40 51 19 00 00 80 11 00 00 c0 a8 02 02 c0 a8 .@Q..... ....
0020 02 11 c1 c8 c1 c8 00 2c f4 c8 80 04 1d 13 00 00 ...., ...
0030 61 e8 65 94 50 8d a8 d2 f5 10 0b 94 39 71 21 a9 a.e.P... ....9q!.
0040 48 ba 14 48 bc 6e b2 e5 23 c5 48 fc 0f 0c H..H.n.. #.H...
Filter: Reset Apply File: rtp capture


rtp capture - Ethereal
File Edit Capture Display Tools Help
No. Time Source Destination Protocol Info
228 19.629299 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
229 19.650622 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
230 19.687930 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
231 19.709274 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
232 19.739368 192.168.2.17 192.168.2.2 RTCP Receiver Report
233 19.746579 192.168.2.2 192.168.2.17 RTP Payload type=ITU-T G.723, SS
Frame 232 (94 bytes on wire, 94 bytes captured)
Ethernet II, Src: 00:e0:18:8c:49:b1, Dst: 00:07:e9:c1:8e:0a
Internet Protocol, Src Addr: 192.168.2.17 (192.168.2.17), Dst Addr: 192.168.2.2 (192.168.2.2)
User Datagram Protocol, Src Port: 49609 (49609), Dst Port: 49609 (49609)
Real-time Transport Control Protocol
Version: RFC 1889 Version (2)
Padding: False
Reception report count: 1
Packet type: Receiver Report (201)
Length: 7
Sender SSRC: 2592054423
Source 1
Identifier: 1704218765
SSRC contents
Fraction lost: 0 / 256
Cumulative number of packets lost: 0
Extended highest sequence number received: 7444
Sequence number cycles count: 0
Highest sequence number received: 7444
Interarrival jitter: 62
Last SR timestamp: 1005703040
Delay since last SR timestamp: 7808
Real-time Transport Control Protocol
Version: RFC 1889 Version (2)
Padding: False
Source count: 1
Packet type: Source description (202)
Length: 4
Chunk 1, SSRC/CSRC 2592054423
Identifier: 2592054423
SDES items
0000 00 07 e9 c1 8e 0a 00 e0 18 8c 49 b1 08 00 45 00 ....I...E.
0010 00 50 36 e7 00 00 80 11 7e 52 c0 a8 02 11 c0 a8 .P6..... ~R.....
0020 02 02 c1 c9 c1 c9 00 3c 6e 63 81 c9 00 07 9a 7f ..... nc.....
0030 9c 97 65 94 50 8d 00 00 00 00 00 00 1d 14 00 00 ..e.P... .....
0040 00 3e 3b f1 cf 80 00 00 1e 80 81 ca 00 04 9a 7f .>;..... .....
Filter: Reset Apply File: rtp capture

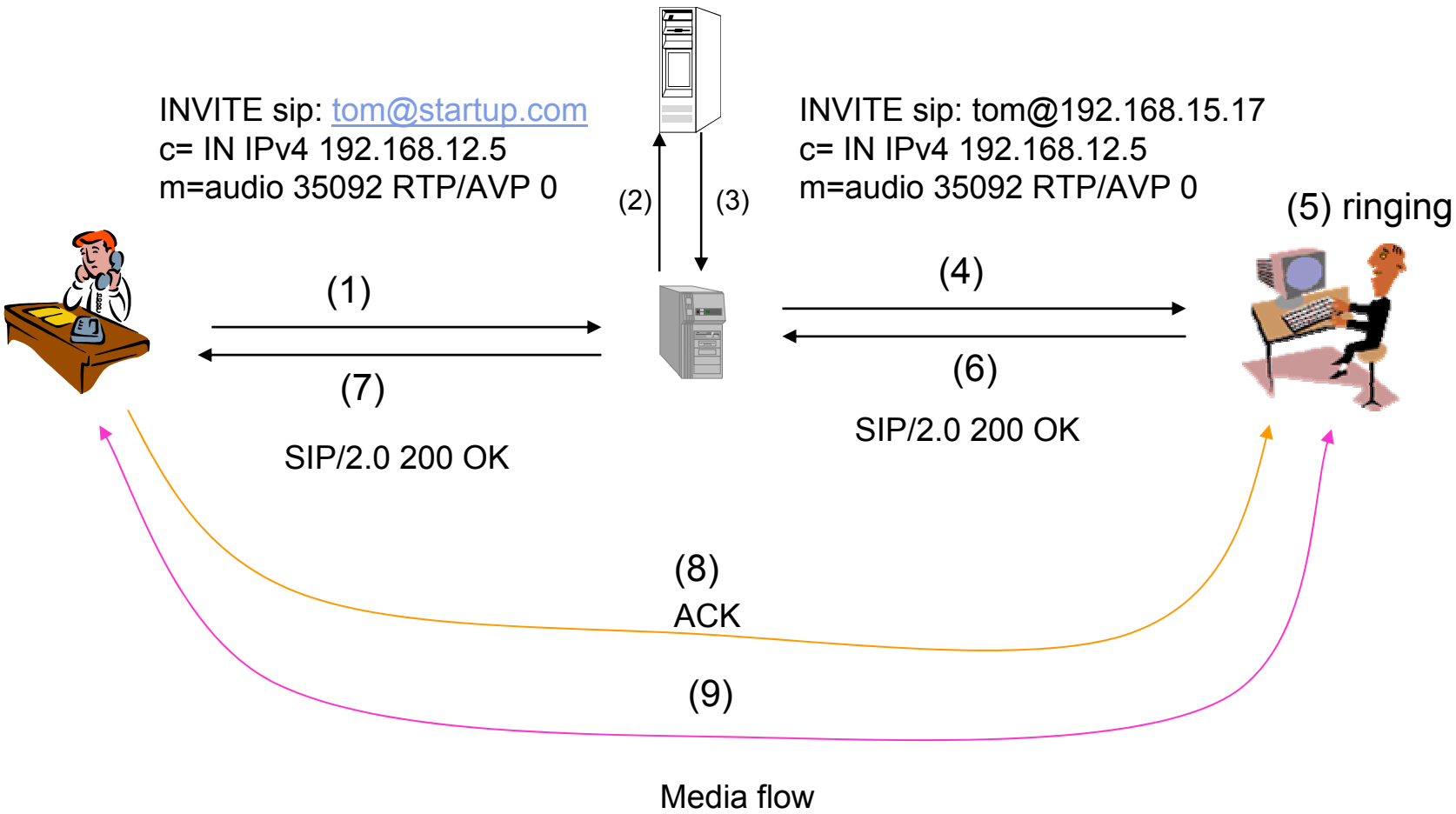
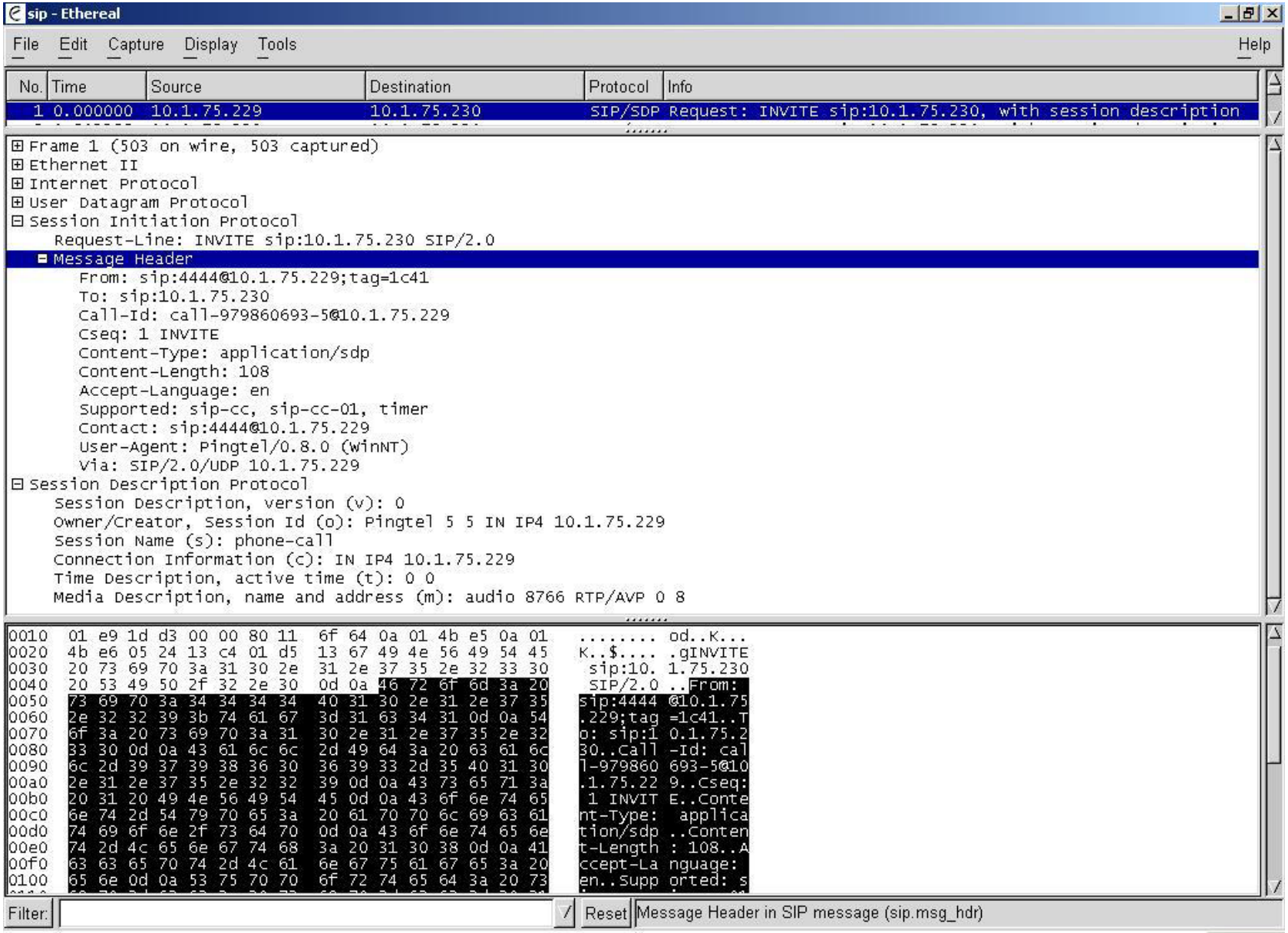
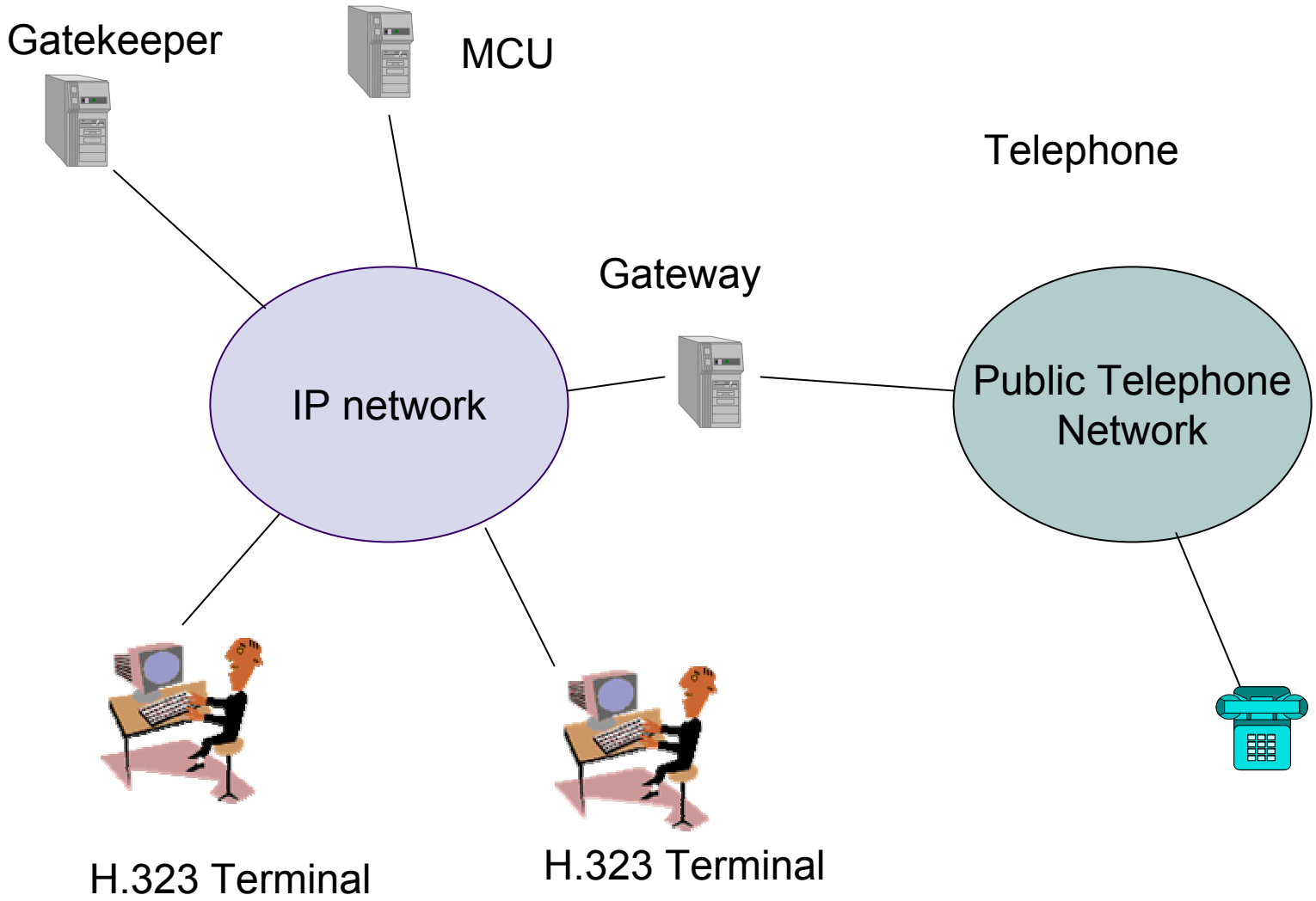
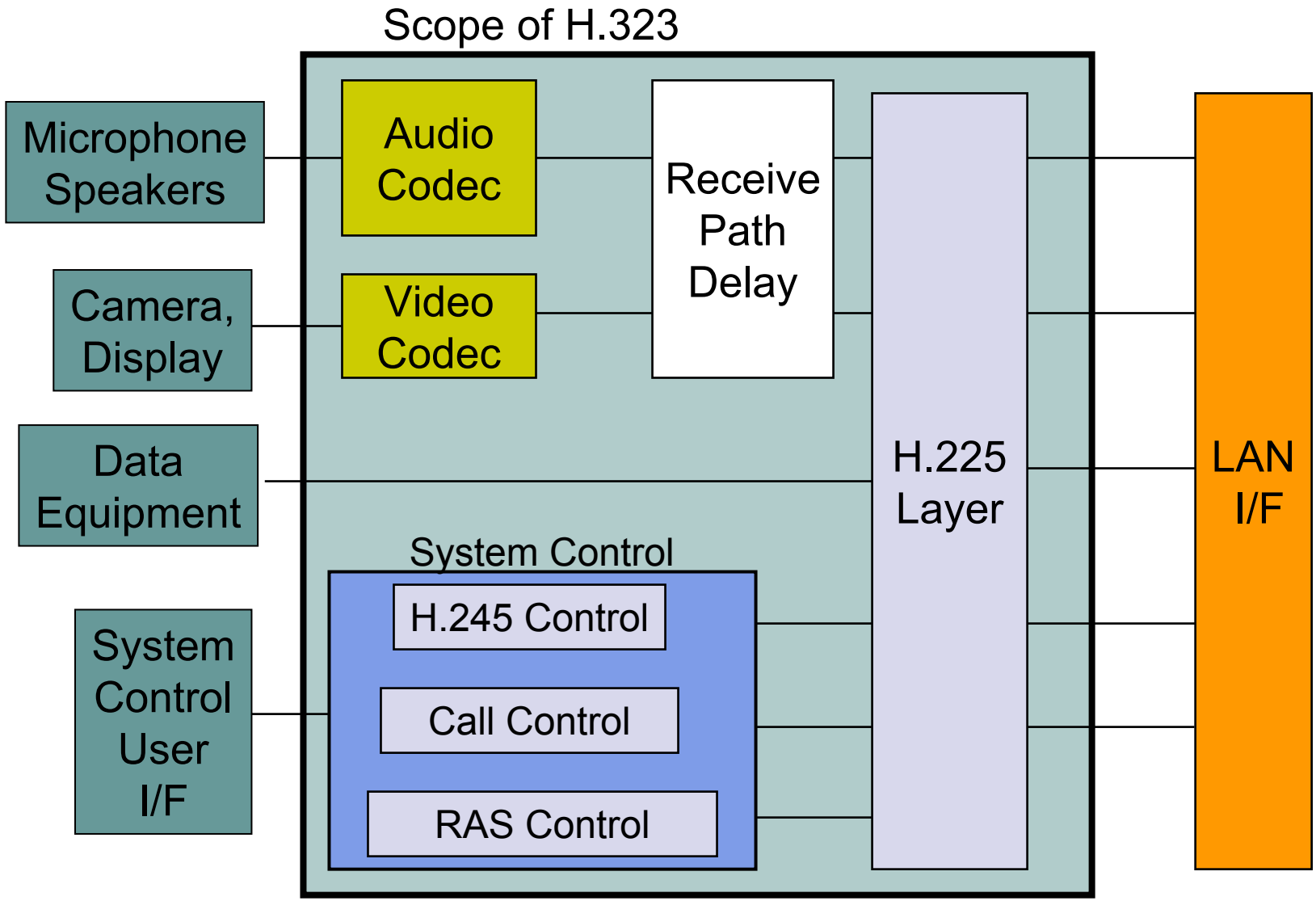
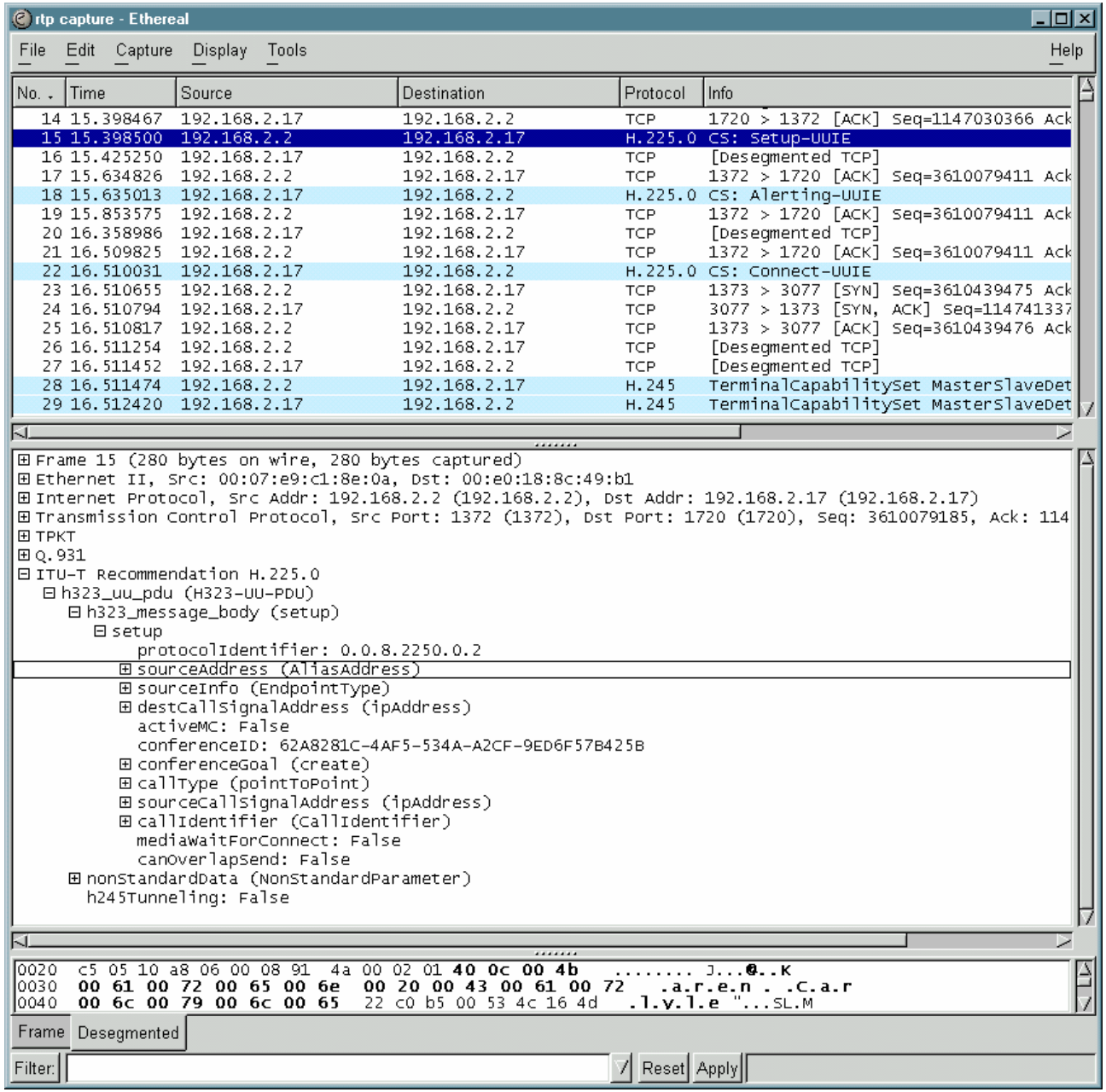

INVITE sip: tom@startup.com
c= IN IPv4 192.168.12.5
m=audio 35092 RTP/AVP 0
(2)
(3)
INVITE sip: tom@192.168.15.17
c= IN IPv4 192.168.12.5
m=audio 35092 RTP/AVP 0
(5) ringing
(1)
(4)
(7)
(6)
SIP/2.0 200 OK
SIP/2.0 200 OK
(8)
ACK
(9)
Media flow

Figure 10.34


sip - Ethereal
File Edit Capture Display Tools Help
No. Time Source Destination Protocol Info
1 0.000000 10.1.75.229 10.1.75.230 SIP/SDP Request: INVITE sip:10.1.75.230, with session description
Frame 1 (503 on wire, 503 captured)
Ethernet II
Internet Protocol
User Datagram Protocol
Session Initiation Protocol
Request-Line: INVITE sip:10.1.75.230 SIP/2.0
Message Header
From: sip:4444@10.1.75.229;tag=1c41
To: sip:10.1.75.230
Call-Id: call-979860693-5@10.1.75.229
Cseq: 1 INVITE
Content-Type: application/sdp
Content-Length: 108
Accept-Language: en
Supported: sip-cc, sip-cc-01, timer
Contact: sip:4444@10.1.75.229
User-Agent: Pingtel/0.8.0 (WinNT)
Via: SIP/2.0/UDP 10.1.75.229
Session Description Protocol
Session Description, version (v): 0
Owner/Creator, Session Id (o): Pingtel 5 5 IN IP4 10.1.75.229
Session Name (s): phone-call
Connection Information (c): IN IP4 10.1.75.229
Time Description, active time (t): 0 0
Media Description, name and address (m): audio 8766 RTP/AVP 0 8
0010 01 e9 1d d3 00 00 80 11 6f 64 0a 01 4b e5 0a 01 ..... od..K...
0020 4b e6 05 24 13 c4 01 d5 13 67 49 4e 56 49 54 45 K..$.... .gINVITE
0030 20 73 69 70 3a 31 30 2e 31 2e 37 35 2e 32 33 30 sip:10. 1.75.230
0040 20 53 49 50 2f 32 2e 30 0d 0a 46 72 6f 6d 3a 20 SIP/2.0 ..From:
0050 73 69 70 3a 34 34 34 34 40 31 30 2e 31 2e 37 35 sip:4444 @10.1.75
0060 2e 32 32 39 3b 74 61 67 3d 31 63 34 31 0d 0a 54 .229;tag =1c41..T
0070 6f 3a 20 73 69 70 3a 31 30 2e 31 2e 37 35 2e 32 o: sip:1 0.1.75.2
0080 33 30 0d 0a 43 61 6c 6c 2d 49 64 3a 20 63 61 6c 30..Call -Id: cal
0090 6c 2d 39 37 39 38 36 30 36 39 33 2d 35 40 31 30 l-979860 693-5@10
00a0 2e 31 2e 37 35 2e 32 32 39 0d 0a 43 73 65 71 3a .1.75.22 9..Cseq:
00b0 20 31 20 49 4e 56 49 54 45 0d 0a 43 6f 6e 74 65 1 INVIT E..Conte
00c0 6e 74 2d 54 79 70 65 3a 20 61 70 70 6c 69 63 61 nt-Type: applica
00d0 74 69 6f 6e 2f 73 64 70 0d 0a 43 6f 6e 74 65 6e tion/sdp ..Conten
00e0 74 2d 4c 65 6e 67 74 68 3a 20 31 30 38 0d 0a 41 t-Length : 108..A
00f0 63 63 65 70 74 2d 4c 61 6e 67 75 61 67 65 3a 20 ccept-La nguage:
0100 65 6e 0d 0a 53 75 70 70 6f 72 74 65 64 3a 20 73 en..Supp orted: s
Filter:
Reset
Message Header in SIP message (sip.msg_hdr)
captured by jfmule@packetizer.com


Gatekeeper
MCU
Telephone
Gateway
IP network
Public Telephone Network
H.323 Terminal
H.323 Terminal


Scope of H.323
Microphone Speakers
Camera, Display
Data Equipment
System Control User I/F
Audio Codec
Video Codec
Receive Path Delay
H.225 Layer
LAN I/F
System Control
H.245 Control
Call Control
RAS Control


rtp capture - Ethereal
File Edit Capture Display Tools Help
No. Time Source Destination Protocol Info
14 15.398467 192.168.2.17 192.168.2.2 TCP 1720 > 1372 [ACK] Seq=1147030366 Ack
15 15.398500 192.168.2.2 192.168.2.17 H.225.0 CS: Setup-UUIE
16 15.425250 192.168.2.17 192.168.2.2 TCP [Desegmented TCP]
17 15.634826 192.168.2.2 192.168.2.17 TCP 1372 > 1720 [ACK] Seq=3610079411 Ack
18 15.635013 192.168.2.17 192.168.2.2 H.225.0 CS: Alerting-UUIE
19 15.853575 192.168.2.2 192.168.2.17 TCP 1372 > 1720 [ACK] Seq=3610079411 Ack
20 16.358986 192.168.2.17 192.168.2.2 TCP [Desegmented TCP]
21 16.509825 192.168.2.2 192.168.2.17 TCP 1372 > 1720 [ACK] Seq=3610079411 Ack
22 16.510031 192.168.2.17 192.168.2.2 H.225.0 CS: Connect-UUIE
23 16.510655 192.168.2.2 192.168.2.17 TCP 1373 > 3077 [SYN] Seq=3610439475 Ack
24 16.510794 192.168.2.17 192.168.2.2 TCP 3077 > 1373 [SYN, ACK] Seq=114741337
25 16.510817 192.168.2.2 192.168.2.17 TCP 1373 > 3077 [ACK] Seq=3610439476 Ack
26 16.511254 192.168.2.2 192.168.2.17 TCP [Desegmented TCP]
27 16.511452 192.168.2.17 192.168.2.2 TCP [Desegmented TCP]
28 16.511474 192.168.2.2 192.168.2.17 H.245 TerminalCapabilitySet MasterSlaveDet
29 16.512420 192.168.2.17 192.168.2.2 H.245 TerminalCapabilitySet MasterSlaveDet
Frame 15 (280 bytes on wire, 280 bytes captured)
Ethernet II, Src: 00:07:e9:c1:8e:0a, Dst: 00:e0:18:8c:49:b1
Internet Protocol, Src Addr: 192.168.2.2 (192.168.2.2), Dst Addr: 192.168.2.17 (192.168.2.17)
Transmission Control Protocol, Src Port: 1372 (1372), Dst Port: 1720 (1720), Seq: 3610079185, Ack: 114
TPKT
Q.931
ITU-T Recommendation H.225.0
h323_uu_pdu (H323-UU-PDU)
h323_message_body (setup)
setup
protocolIdentifier: 0.0.8.2250.0.2
sourceAddress (AliasAddress)
sourceInfo (EndpointType)
destCallSignalAddress (ipAddress)
activeMC: False
conferenceID: 62A8281C-4AF5-534A-A2CF-9ED6F57B425B
conferenceGoal (create)
callType (pointToPoint)
sourceCallSignalAddress (ipAddress)
callIdentifier (CallIdentifier)
mediaWaitForConnect: False
canOverlapSend: False
nonStandardData (NonStandardParameter)
h245Tunneling: False
0020 c5 05 10 a8 06 00 08 91 4a 00 02 01 40 0c 00 4b .... J...@..K
0030 00 61 00 72 00 65 00 6e 00 20 00 43 00 61 00 72 .a.r.e.n . .C.a.r
0040 00 6c 00 79 00 6c 00 65 22 c0 b5 00 53 4c 16 4d .l.y.l.e "...SL.M
Frame Desegmented
Filter: Reset Apply