Preparing your campus for AV/IT convergence

Technical Audio Group

If you **fall asleep** – (or found this useful) you can find the slides at

go.tag.com.au/aetm19

Ewan McDonald

System Sales Manager

Michael Goodyear

Special Projects Engineer

AETM

tag Technical Audio Group

Questions during the presentation?

sli.do/aetm

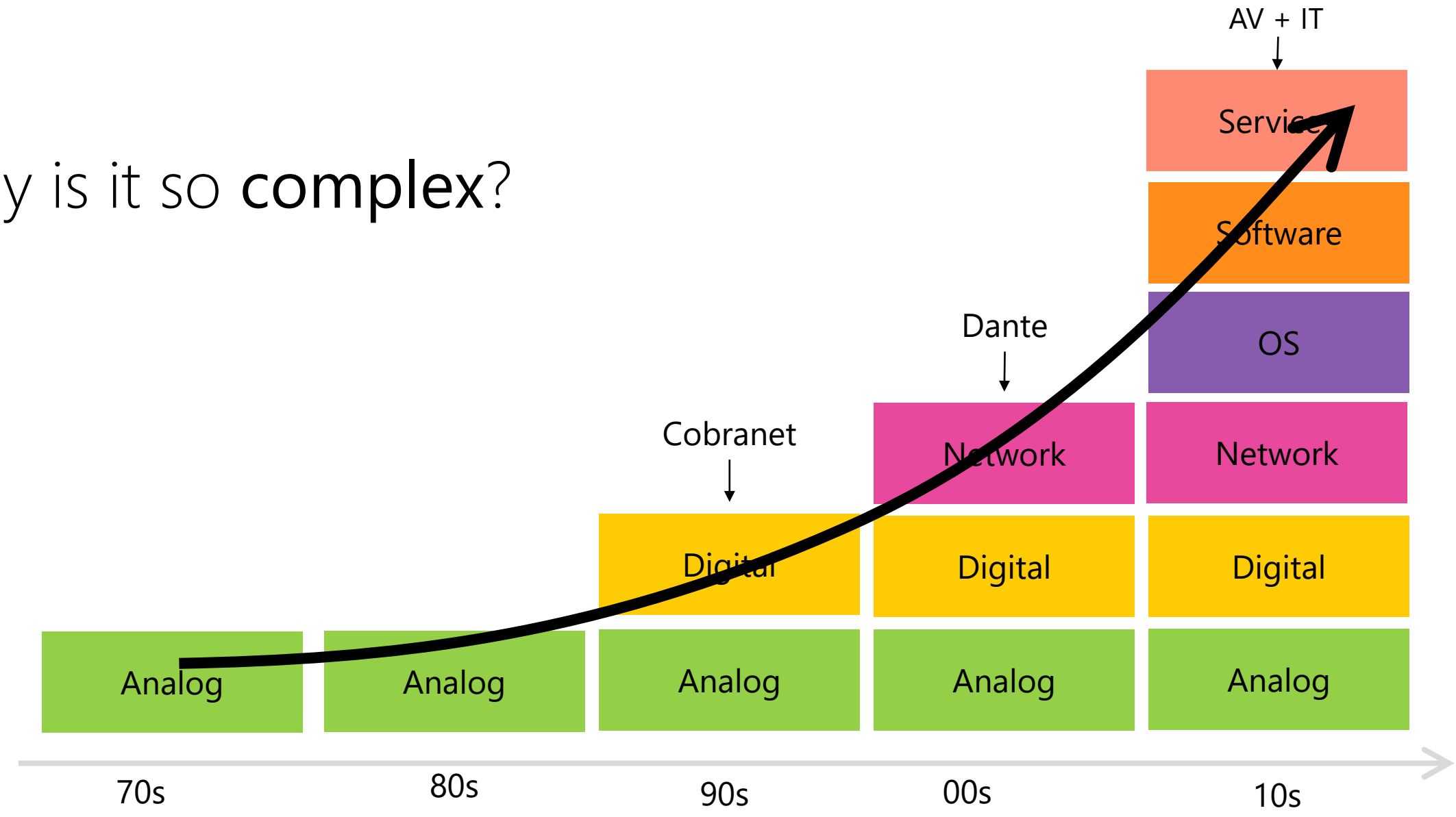
Definitions

Technology

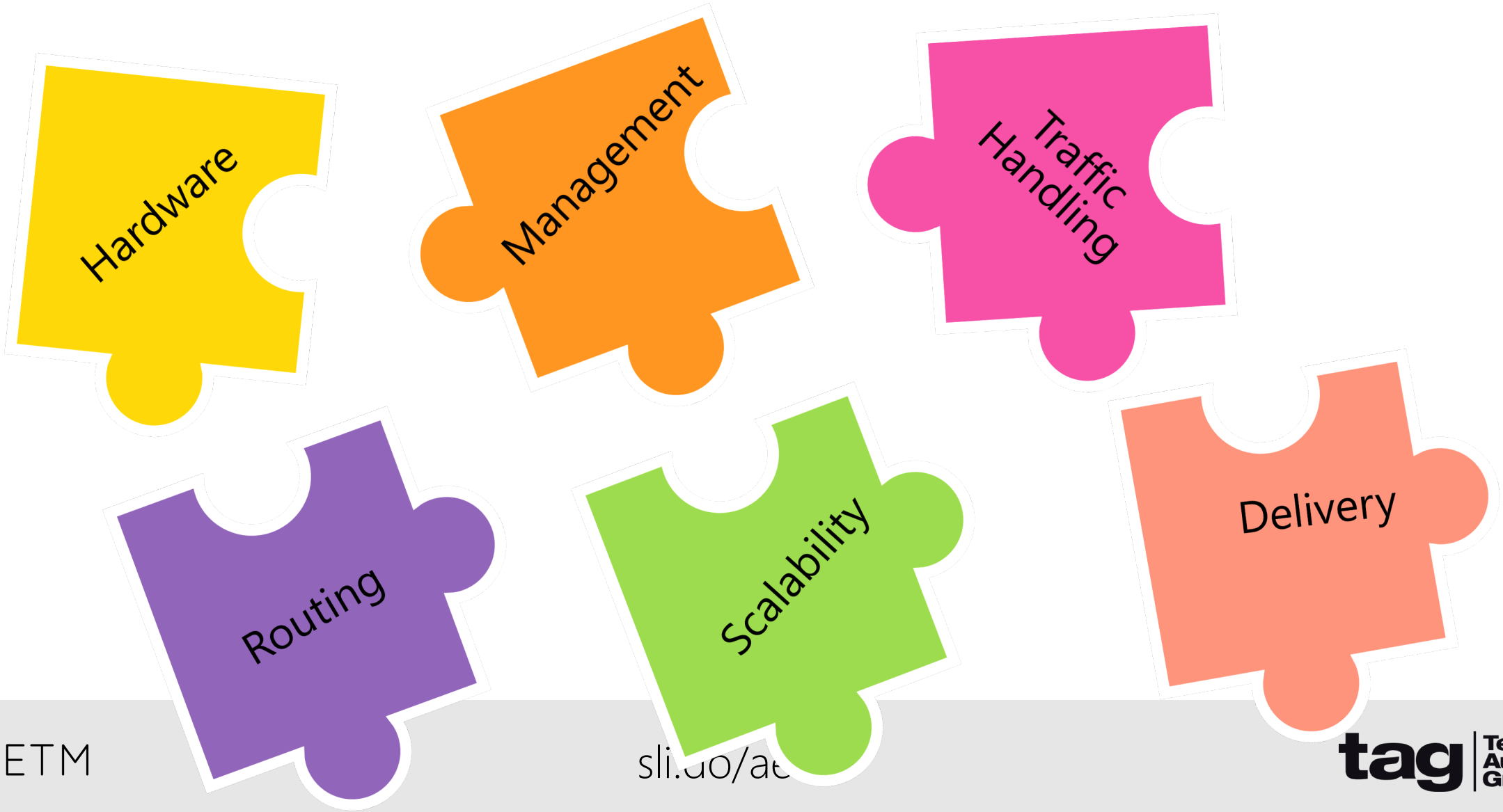
Systems

People

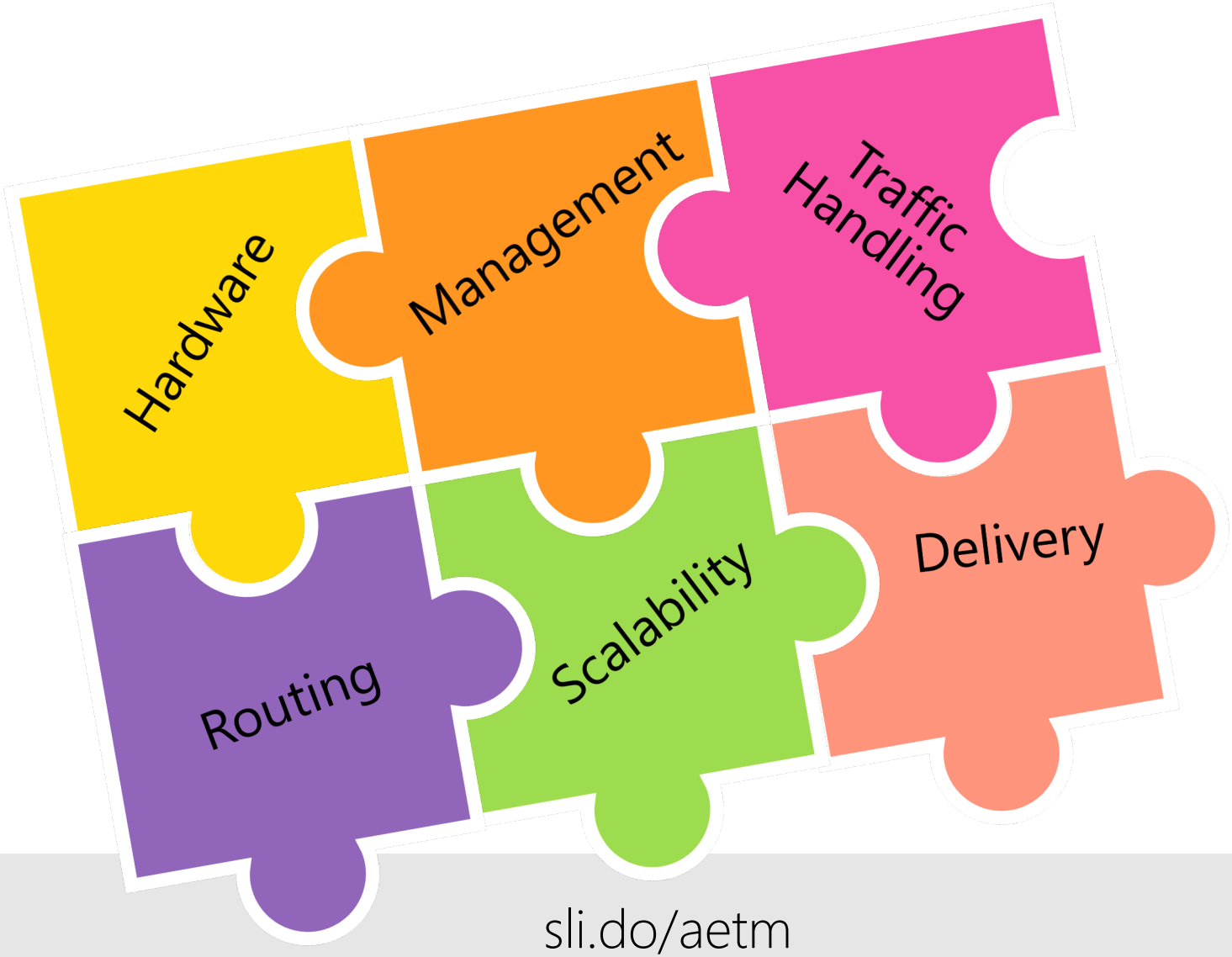
Why is it so **complex**?



IT Ready?


Hardware
Management
Traffic Handling
Routing
Scalability
Delivery

A Real IT System



Networking

Networking

Basics

Data Flow

Addressing

Packet Structure

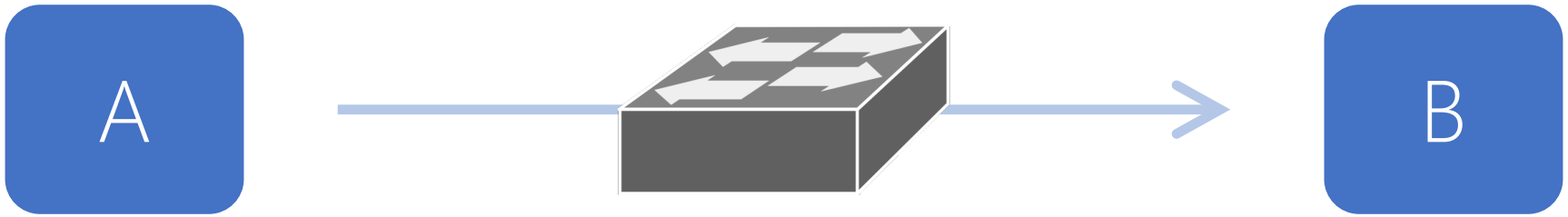
AV Essentials

Multicasting

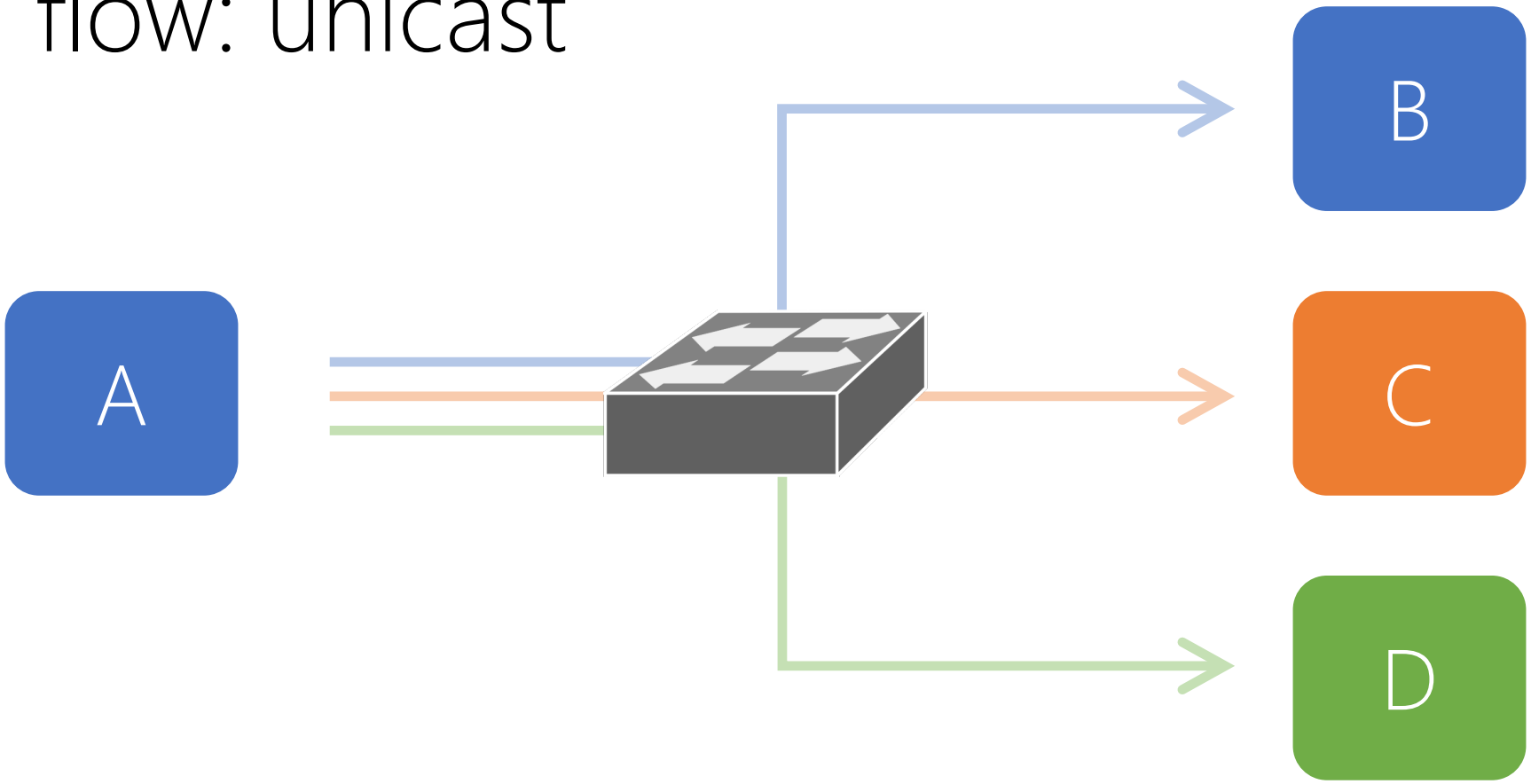
Latency & Jitter

Clocking

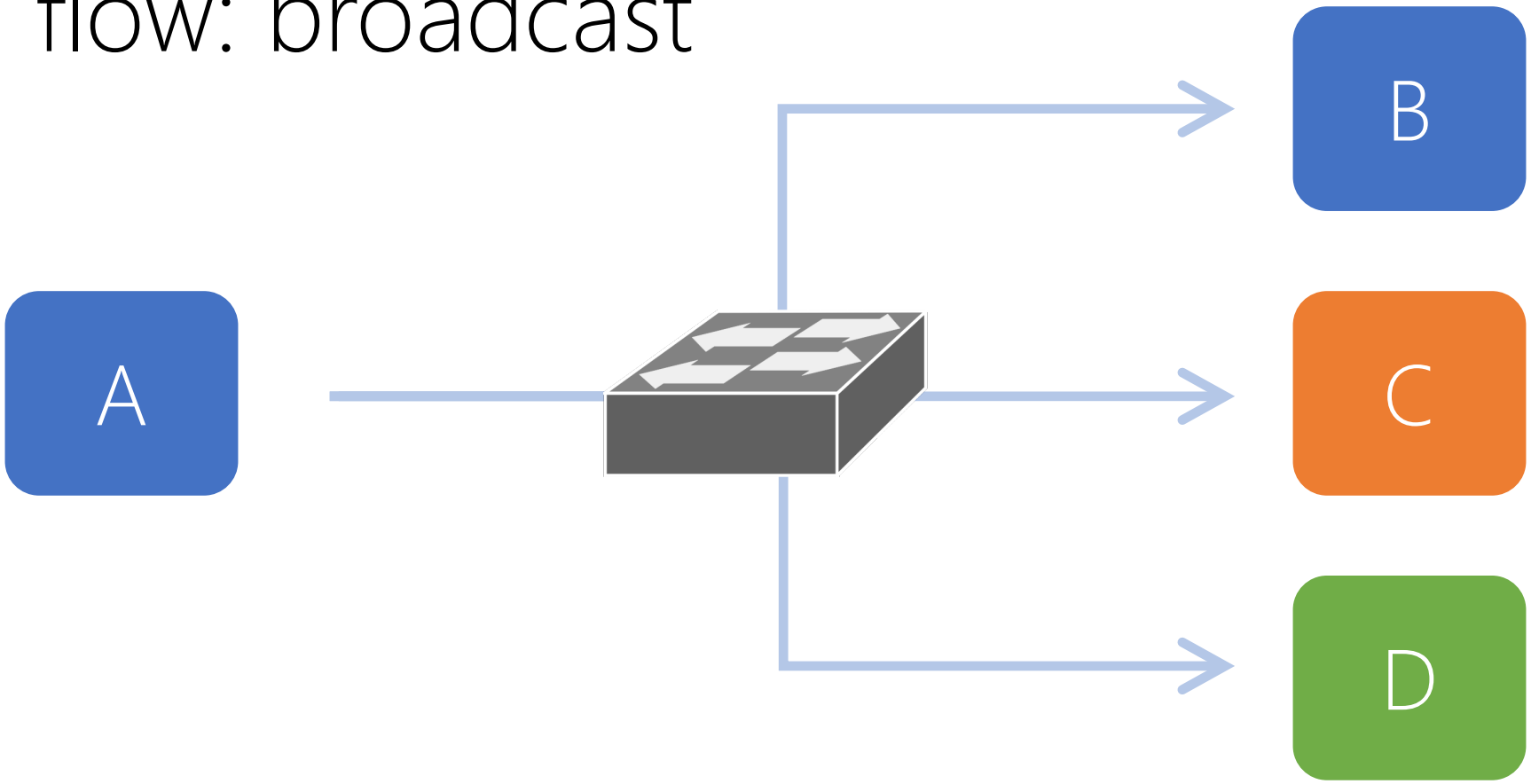
Data flow



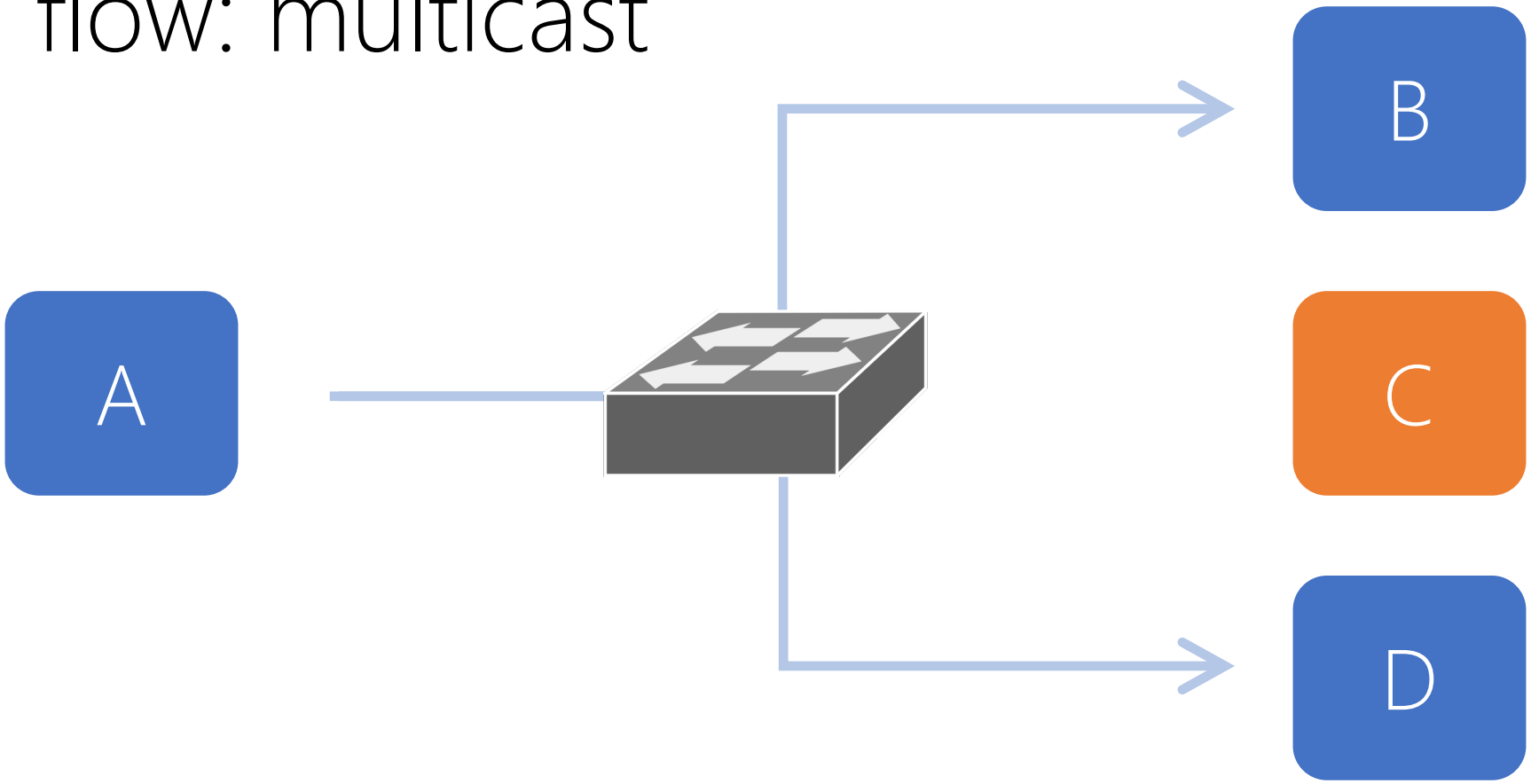
Data flow: unicast



Data flow: broadcast



Data flow: multicast



Addressing

MAC

0A:BD:1C:6E:CA:FE

IP

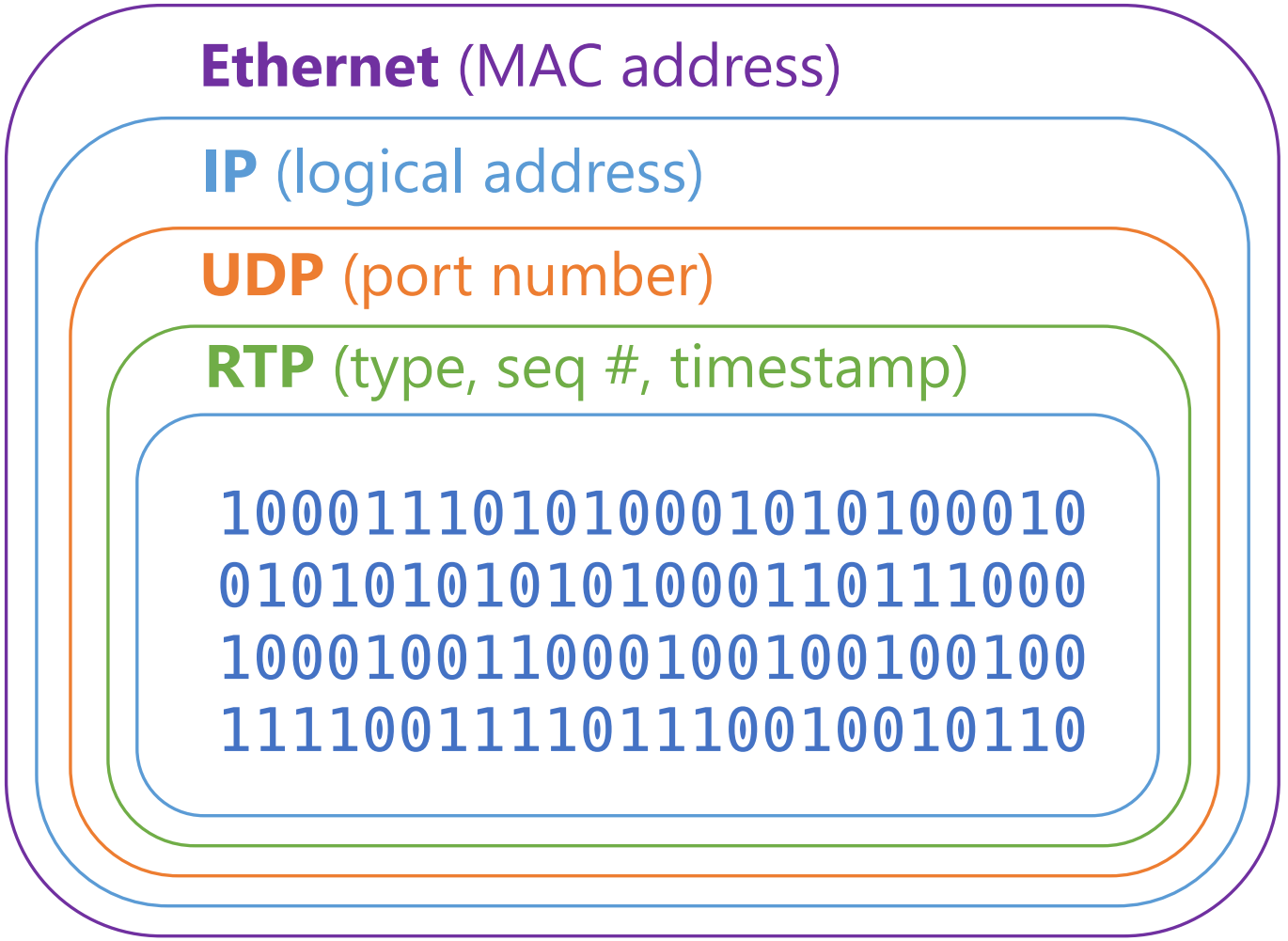
192.168.0.1

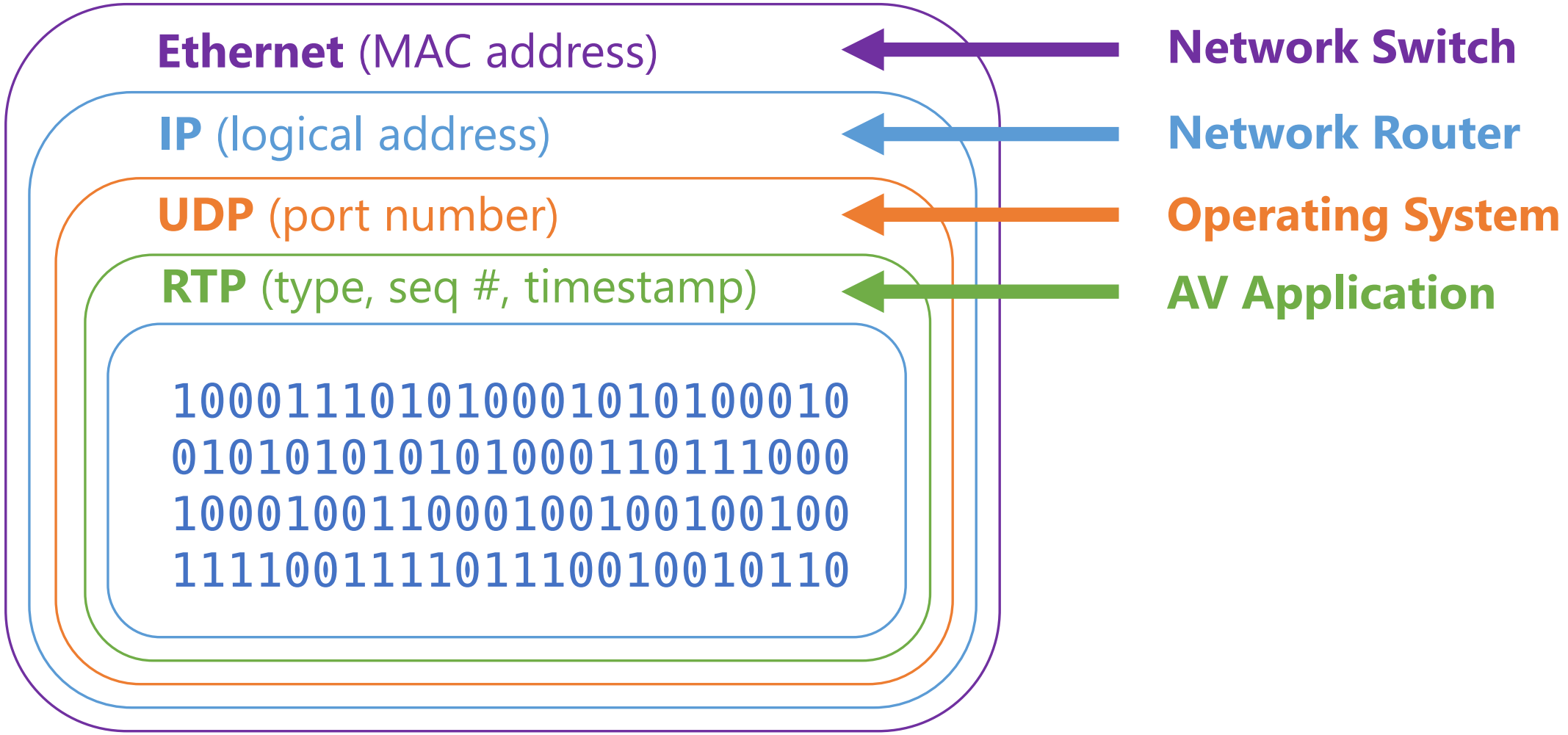
Port

8080

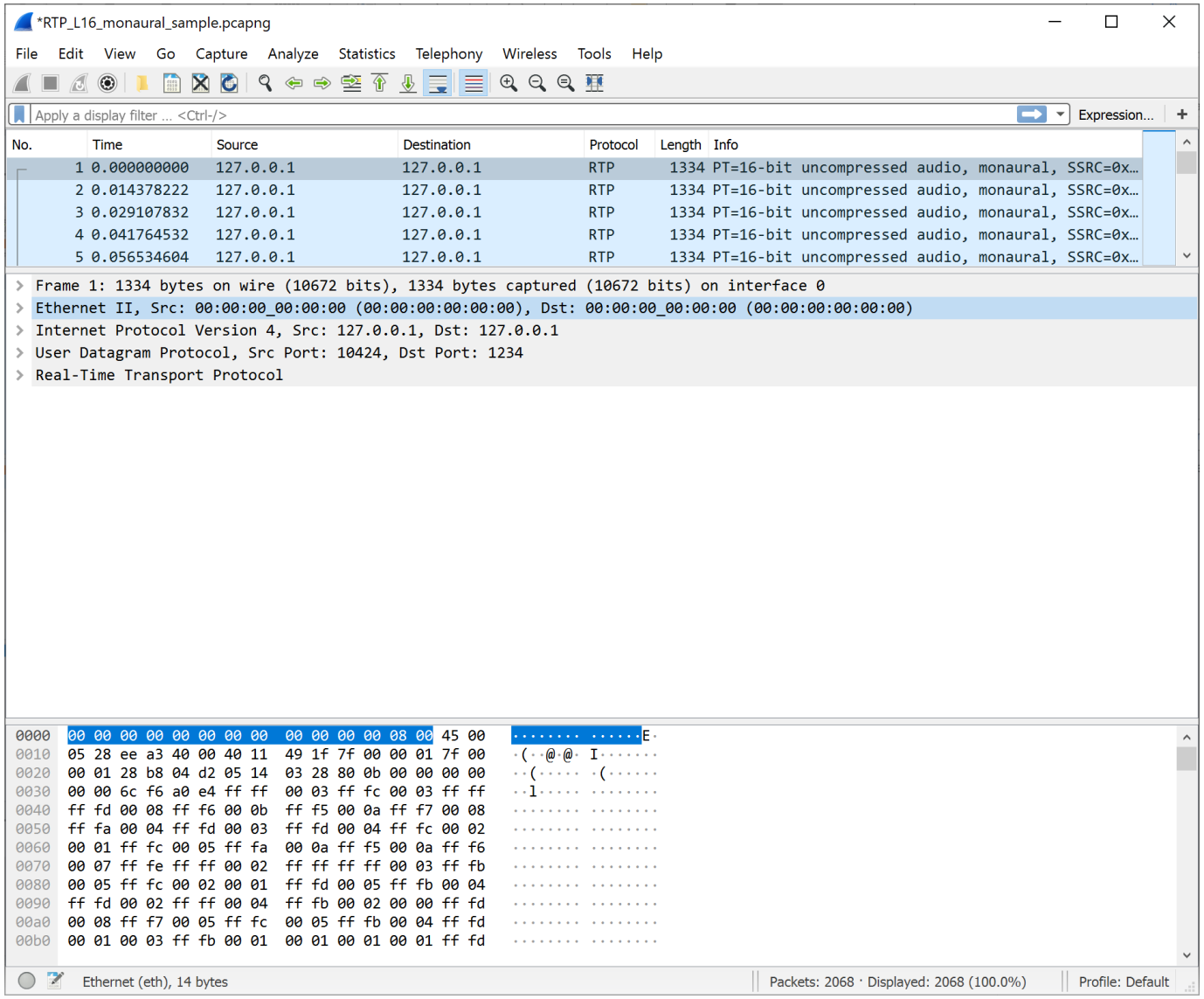
Packet Structure

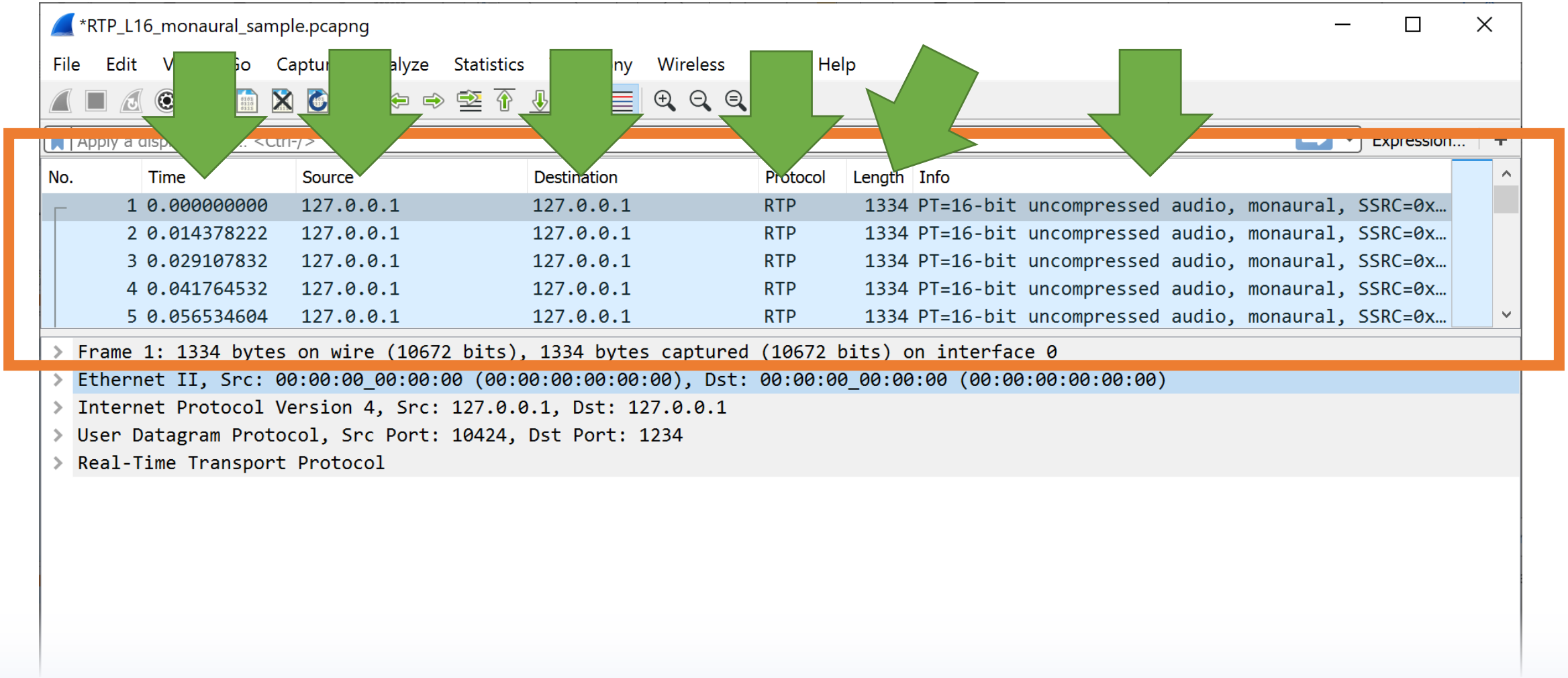

10001110101000101010001


Ethernet (MAC address)
IP (logical address)
UDP (port number)
RTP (type, seq #, timestamp)
10001110101000101010001001010101010100011011100010001001100010010010010011111001111011100100101110


Ethernet (MAC address)
IP (logical address)
UDP (port number)
RTP (type, seq #, timestamp)
10001110101000101010001001010101010100011011100010001001100010010010010011111001111011100100101 10
Network Switch
Network Router
Operating System
AV Application

Wireshark


*RTP_L16_monaural_sample.pcapng
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...
No. Time Source Destination Protocol Length Info
1 0.000000000 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
2 0.014378222 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
3 0.029107832 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
4 0.041764532 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
5 0.056534604 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
Frame 1: 1334 bytes on wire (10672 bits), 1334 bytes captured (10672 bits) on interface 0
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
User Datagram Protocol, Src Port: 10424, Dst Port: 1234
Real-Time Transport Protocol
0000 00 00 00 00 00 00 00 00 00 00 00 00 08 00 45 00
0010 05 28 ee a3 40 00 40 11 49 1f 7f 00 00 01 7f 00
0020 00 01 28 b8 04 d2 05 14 03 28 80 0b 00 00 00 00
0030 00 00 6c f6 a0 e4 ff ff 00 03 ff fc 00 03 ff ff
0040 ff fd 00 08 ff f6 00 0b ff f5 00 0a ff f7 00 08
0050 ff fa 00 04 ff fd 00 03 ff fd 00 04 ff fc 00 02
0060 00 01 ff fc 00 05 ff fa 00 0a ff f5 00 0a ff f6
0070 00 07 ff fe ff ff 00 02 ff ff ff ff 00 03 ff fb
0080 00 05 ff fc 00 02 00 01 ff fd 00 05 ff fb 00 04
0090 ff fd 00 02 ff ff 00 04 ff fb 00 02 00 00 ff fd
00a0 00 08 ff f7 00 05 ff fc 00 05 ff fb 00 04 ff fd
00b0 00 01 00 03 ff fb 00 01 00 01 00 01 00 01 ff fd
Ethernet (eth), 14 bytes
Packets: 2068 · Displayed: 2068 (100.0%)
Profile: Default


*RTP_L16_monaural_sample.pcapng
File Edit Statistics Wireless Help
No. Time Source Destination Protocol Length Info
1 0.000000000 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
2 0.014378222 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
3 0.029107832 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
4 0.041764532 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
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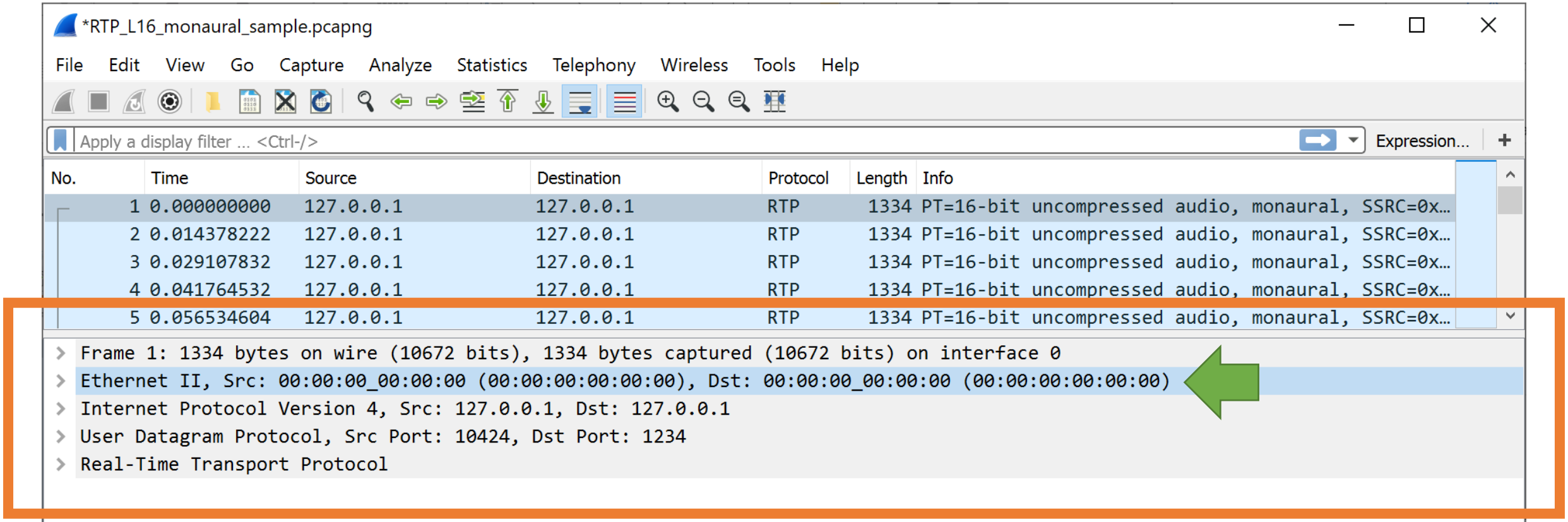
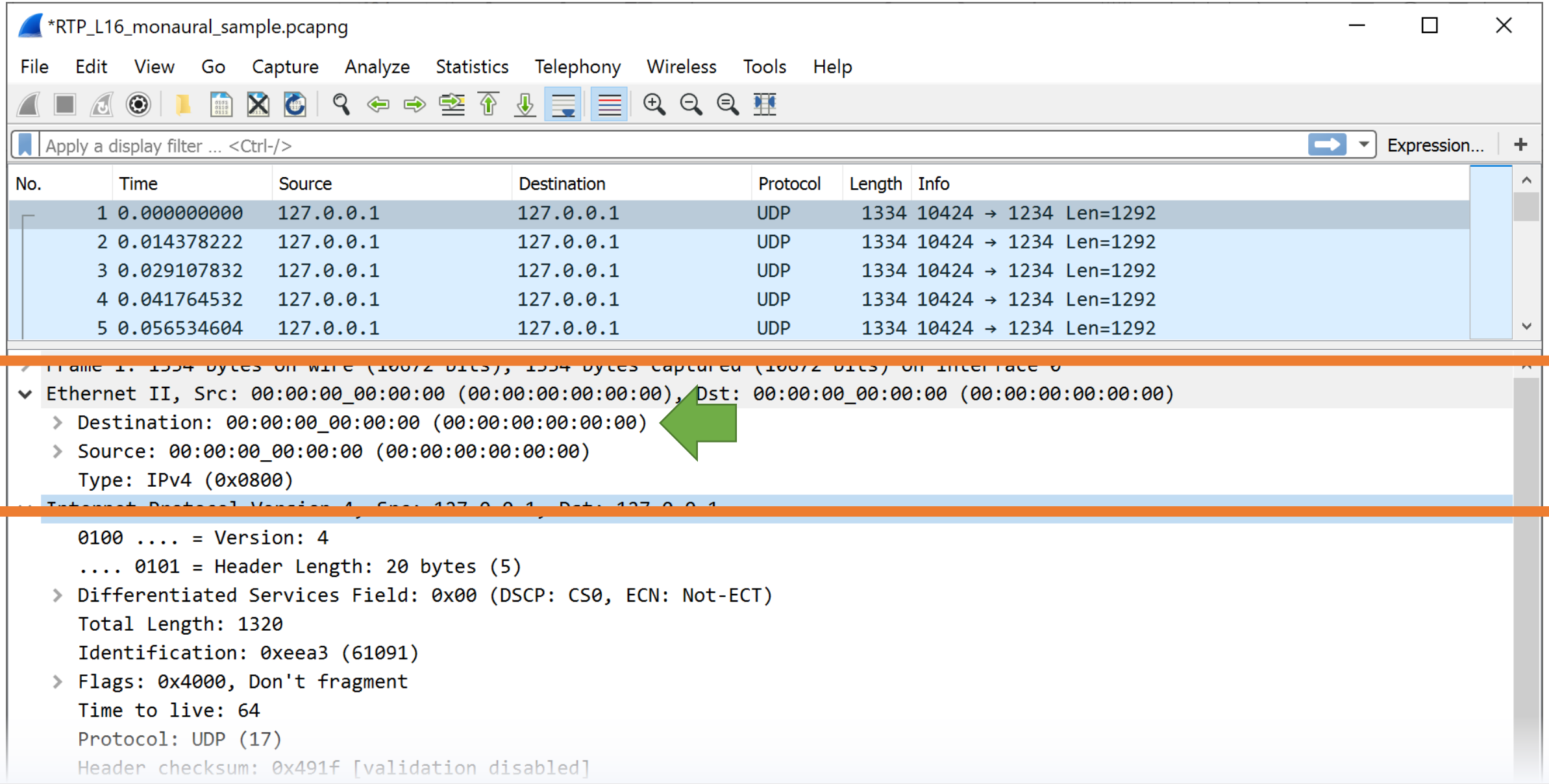
Frame 1: 1334 bytes on wire (10672 bits), 1334 bytes captured (10672 bits) on interface 0
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
User Datagram Protocol, Src Port: 10424, Dst Port: 1234
Real-Time Transport Protocol

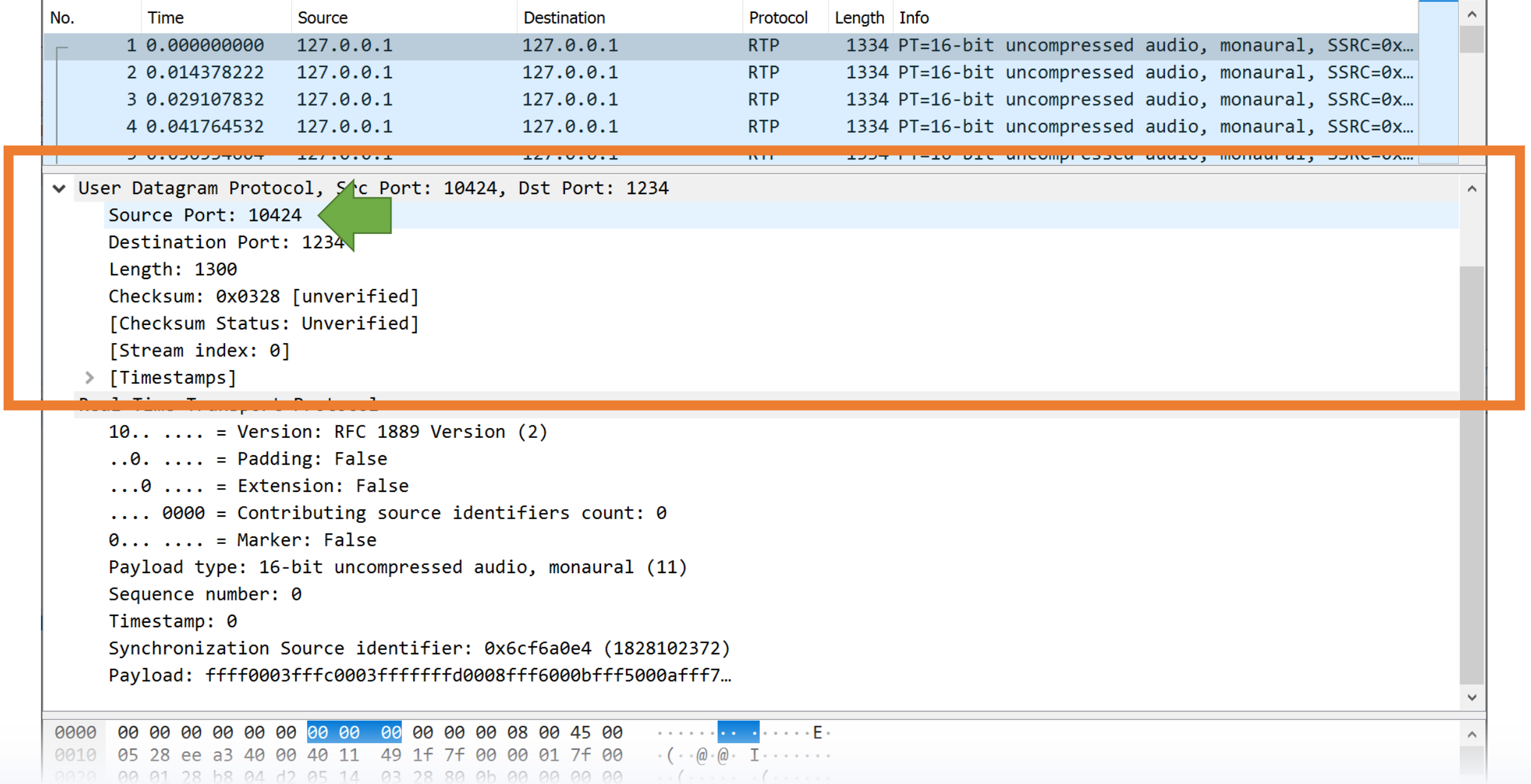

*RTP_L16_monaural_sample.pcapng
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...
No. Time Source Destination Protocol Length Info
1 0.000000000 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
2 0.014378222 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
3 0.029107832 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
4 0.041764532 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
5 0.056534604 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x...
Frame 1: 1334 bytes on wire (10672 bits), 1334 bytes captured (10672 bits) on interface 0
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
User Datagram Protocol, Src Port: 10424, Dst Port: 1234
Real-Time Transport Protocol


*RTP_L16_monaural_sample.pcapng
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...
No. Time Source Destination Protocol Length Info
1 0.000000000 127.0.0.1 127.0.0.1 UDP 1334 10424 → 1234 Len=1292
2 0.014378222 127.0.0.1 127.0.0.1 UDP 1334 10424 → 1234 Len=1292
3 0.029107832 127.0.0.1 127.0.0.1 UDP 1334 10424 → 1234 Len=1292
4 0.041764532 127.0.0.1 127.0.0.1 UDP 1334 10424 → 1234 Len=1292
5 0.056534604 127.0.0.1 127.0.0.1 UDP 1334 10424 → 1234 Len=1292
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
Destination: 00:00:00_00:00:00 (00:00:00:00:00:00)
Source: 00:00:00_00:00:00 (00:00:00:00:00:00)
Type: IPv4 (0x0800)
0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 1320
Identification: 0xeea3 (61091)
Flags: 0x4000, Don't fragment
Time to live: 64
Protocol: UDP (17)
Header checksum: 0x491f [validation disabled]

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
2	0.014378222	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
3	0.029107832	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
4	0.041764532	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
5	0.056534604	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292

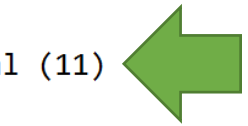
```
> Frame 1: 1334 bytes on wire (10672 bits), 1334 bytes captured (10672 bits) on interface 0
v Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
    > Destination: 00:00:00_00:00:00 (00:00:00:00:00:00)
    > Source: 00:00:00_00:00:00 (00:00:00:00:00:00)
v Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
      0100 .... = Version: 4
      .... 0101 = Header Length: 20 bytes (5)
    > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      Total Length: 1320
      Identification: 0xeea3 (61091)
    > Flags: 0x4000, Don't fragment
      Time to live: 64
      Protocol: UDP (17)
      Header checksum: 0x491f [validation disabled]
      [Header checksum status: Unverified]
      Source: 127.0.0.1
      Destination: 127.0.0.1
> Data (1292 bytes)
```

```
0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 00   ........ ......E.
0010  05 28 ee a3 40 00 40 11  49 1f 7f 00 00 01 7f 00   .(..@.@. I.......
```


No. Time Source Destination Protocol Length Info
1 0.000000000 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x…
2 0.014378222 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x…
3 0.029107832 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x…
4 0.041764532 127.0.0.1 127.0.0.1 RTP 1334 PT=16-bit uncompressed audio, monaural, SSRC=0x…
User Datagram Protocol, Src Port: 10424, Dst Port: 1234
Source Port: 10424
Destination Port: 1234
Length: 1300
Checksum: 0x0328 [unverified]
[Checksum Status: Unverified]
[Stream index: 0]
[Timestamps]
10.. .... = Version: RFC 1889 Version (2)
..0. .... = Padding: False
...0 .... = Extension: False
.... 0000 = Contributing source identifiers count: 0
0... .... = Marker: False
Payload type: 16-bit uncompressed audio, monaural (11)
Sequence number: 0
Timestamp: 0
Synchronization Source identifier: 0x6cf6a0e4 (1828102372)
Payload: ffff0003fffc0003ffffffd0008fff6000bfff5000afff7…
0000 00 00 00 00 00 00 00 00 00 00 00 00 08 00 45 00
0010 05 28 ee a3 40 00 40 11 49 1f 7f 00 00 01 7f 00

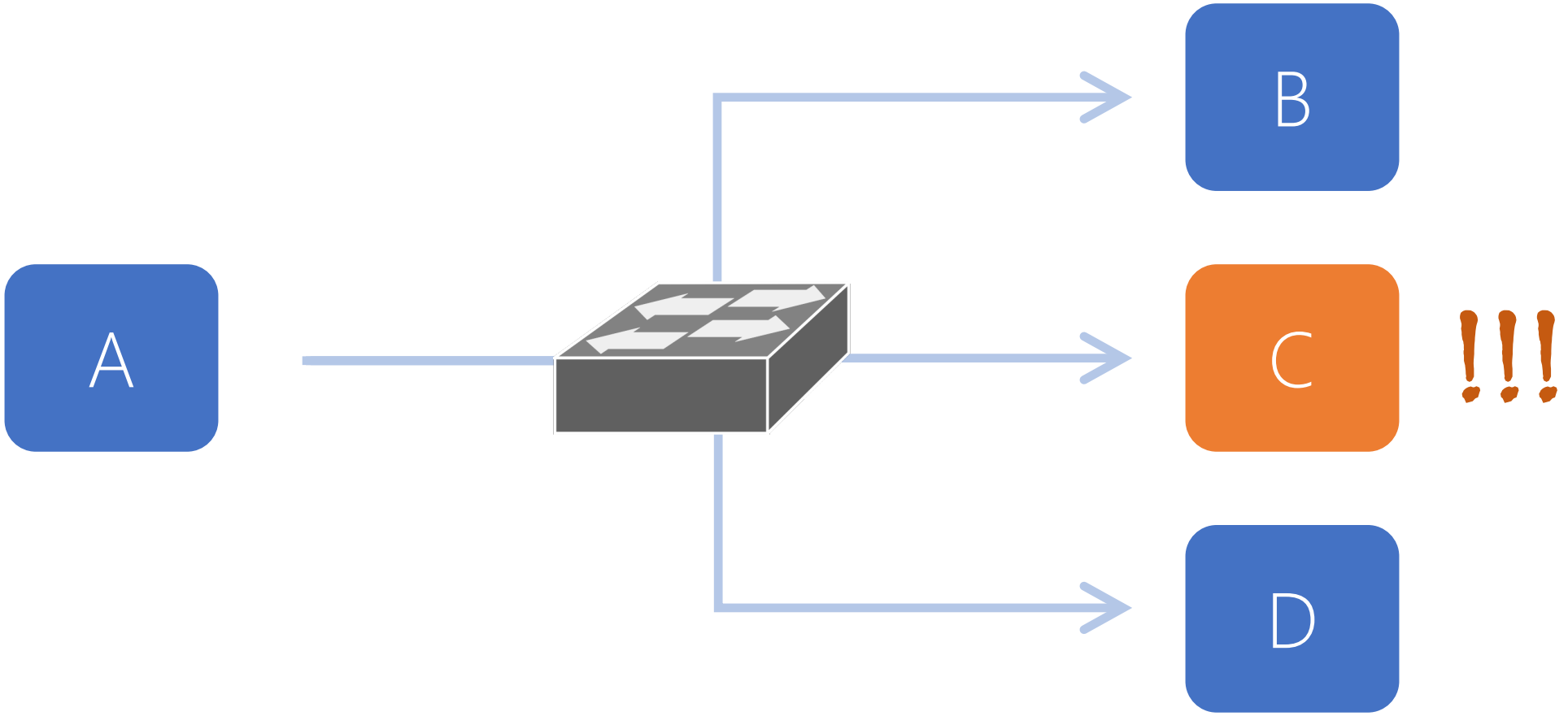
```
5 0.056534604   127.0.0.1   127.0.0.1   RTP   1334 PT=16-bit uncompressed audio, monaural, SSRC=0x…
```

```
User Datagram Protocol, Src Port: 10424, Dst Port: 1234
    Source Port: 10424
    Destination Port: 1234
    Length: 1300
    Checksum: 0x0328 [unverified]
    [Checksum Status: Unverified]
    [Stream index: 0]
  > [Timestamps]
Real-Time Transport Protocol
    10.. .... = Version: RFC 1889 Version (2)
    ..0. .... = Padding: False
    ...0 .... = Extension: False
    .... 0000 = Contributing source identifiers count: 0
    0... .... = Marker: False
    Payload type: 16-bit uncompressed audio, monaural (11)
    Sequence number: 0
    Timestamp: 0
    Synchronization Source identifier: 0x6cf6a0e4 (1828102372)
    Payload: ffff0003fffc0003ffffffd0008fff6000bfff5000afff7…
```

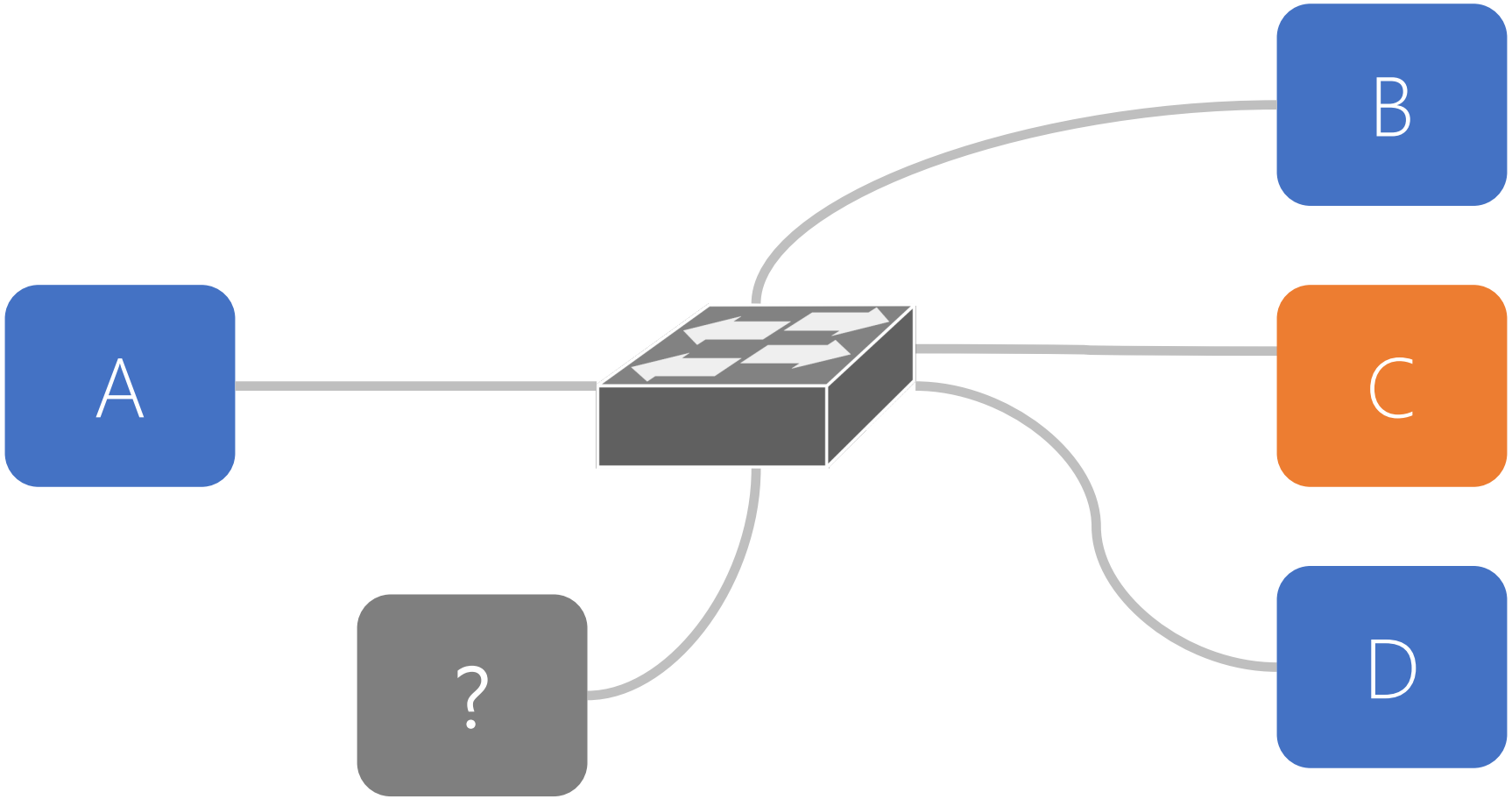


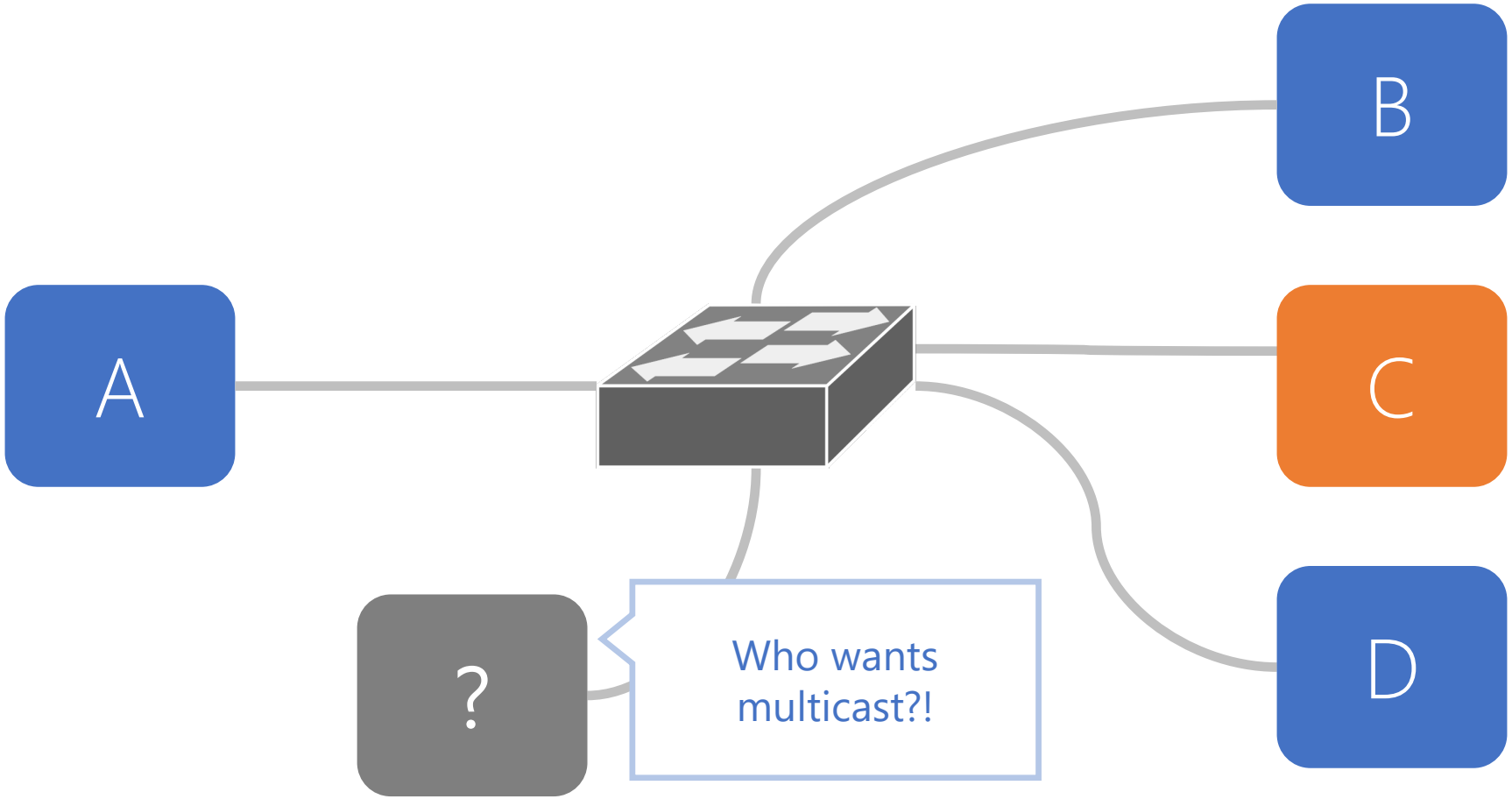
```
0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 00   ······ ·· ·····E·
0010  05 28 ee a3 40 00 40 11  49 1f 7f 00 00 01 7f 00   ·(··@·@· I·····
0020  00 01 28 b8 04 d2 05 14  03 28 80 0b 00 00 00 00   ··(····· ·(····
0030  00 00 6c f6 a0 e4 ff ff  00 03 ff fc 00 03 ff ff   ··l····· ····
0040  ff fd 00 08 ff f6 00 0b  ff f5 00 0a ff f7 00 08   ···· ···· ····
0050  ff fa 00 04 ff fd 00 03  ff fd 00 04 ff fc 00 02   ···· ···· ····
0060  00 01 ff fc 00 05 ff fa  00 0a ff f5 00 0a ff f6   ···· ···· ····
0070  00 07 ff fe ff ff 00 02  ff ff ff ff 00 03 ff fb   ···· ···· ····
```

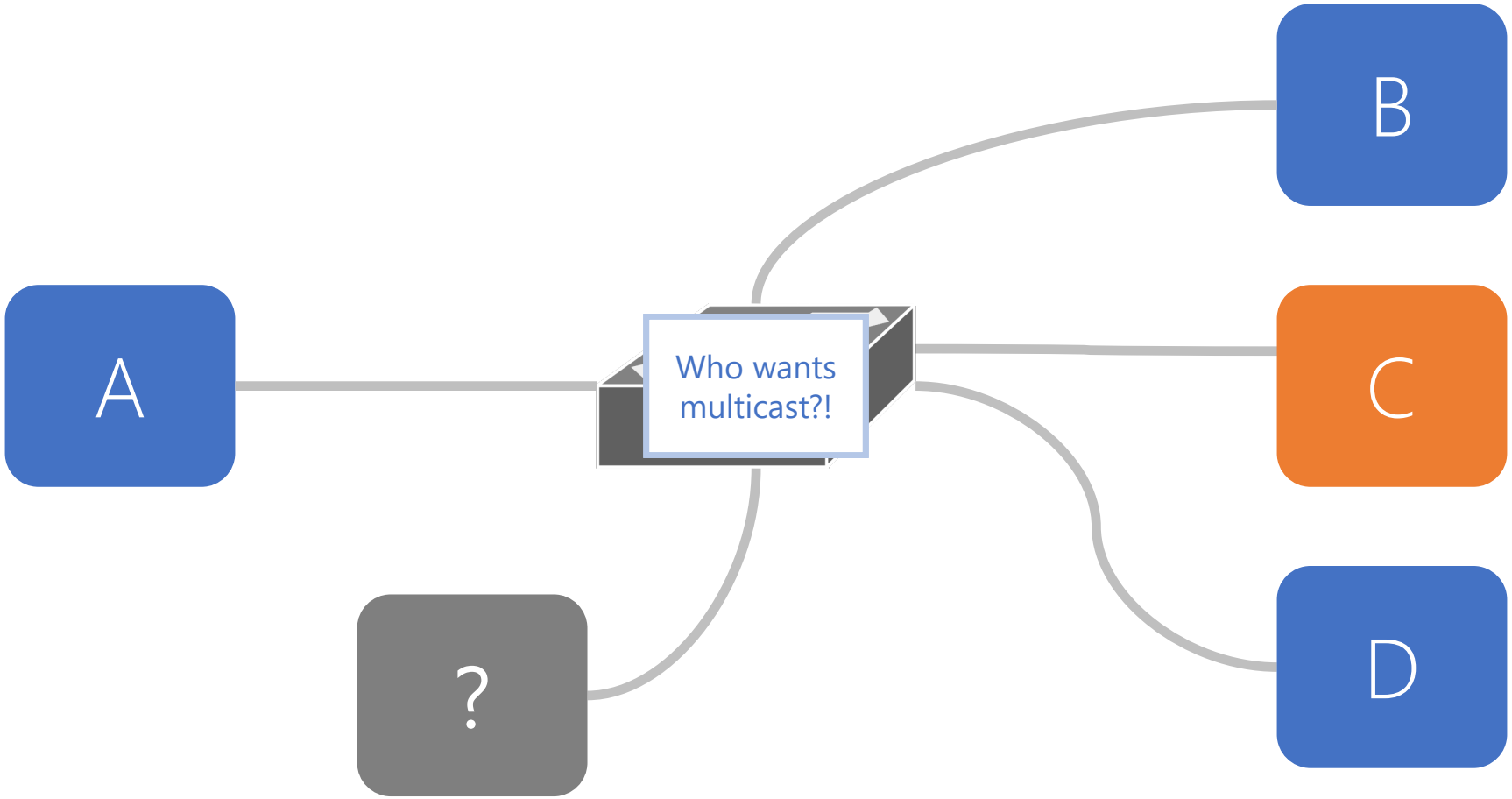
AV Essentials

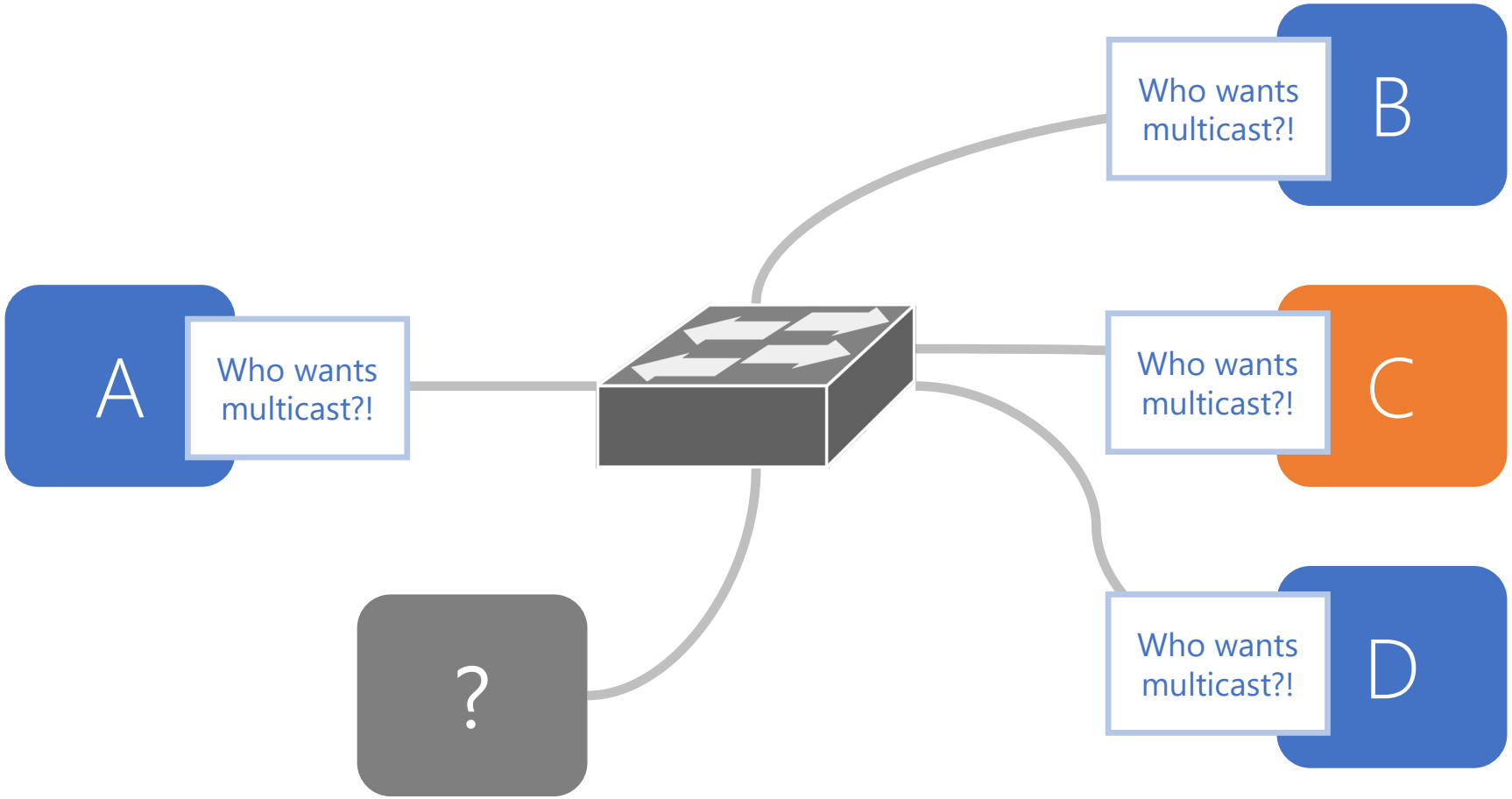

A
B
C
D
!!!

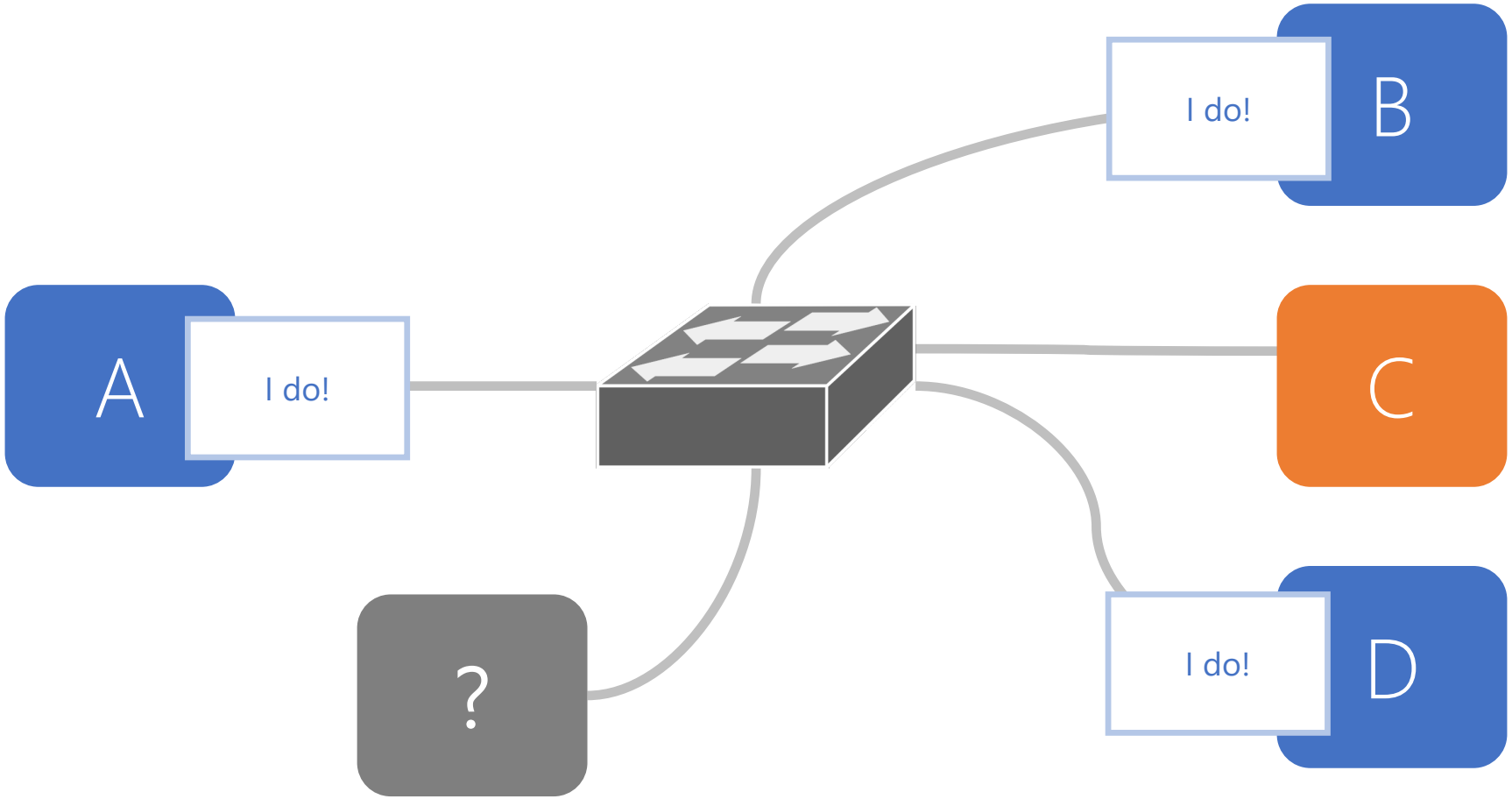
IGMP Snooping

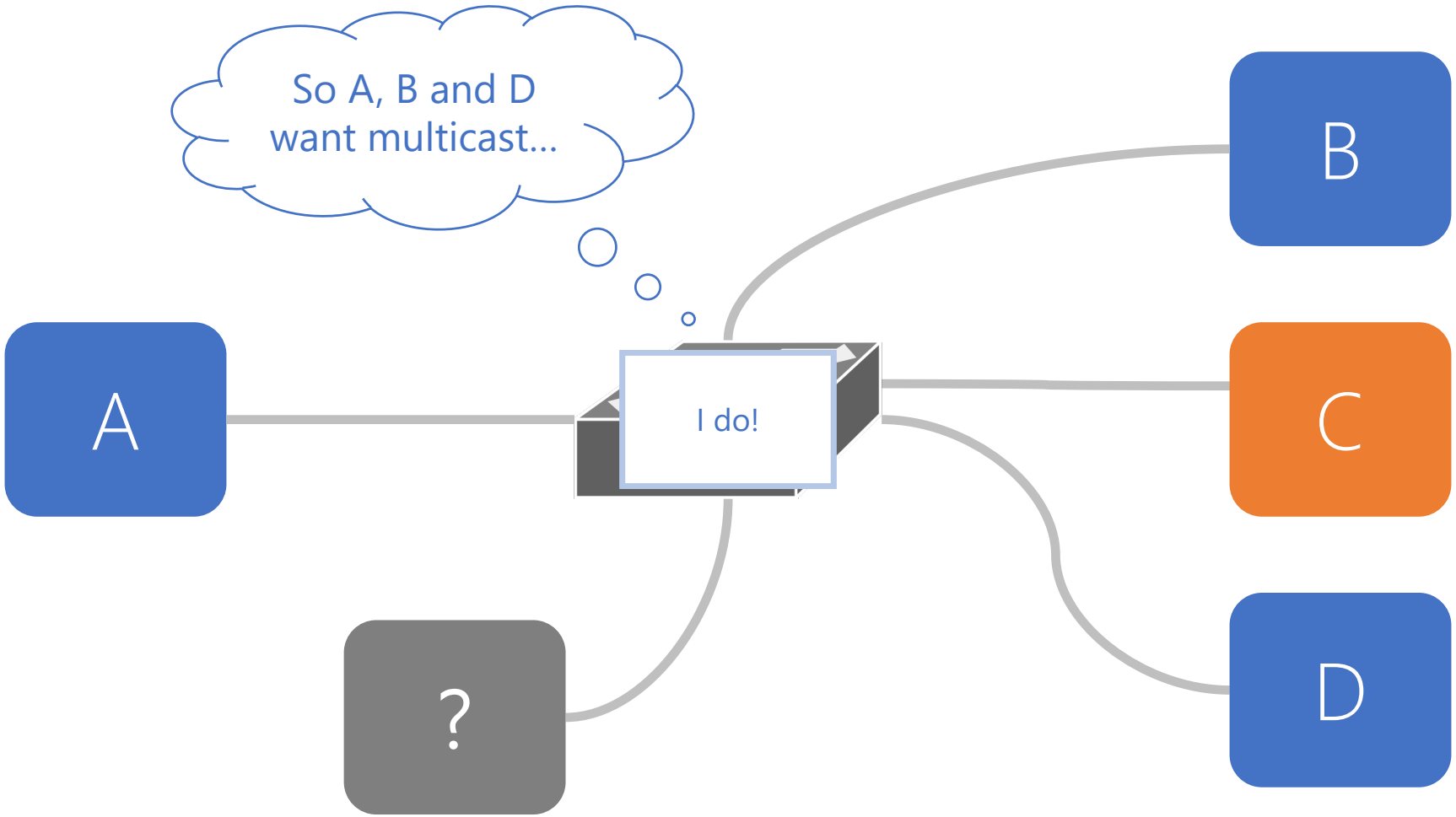

B
A
C
?
D

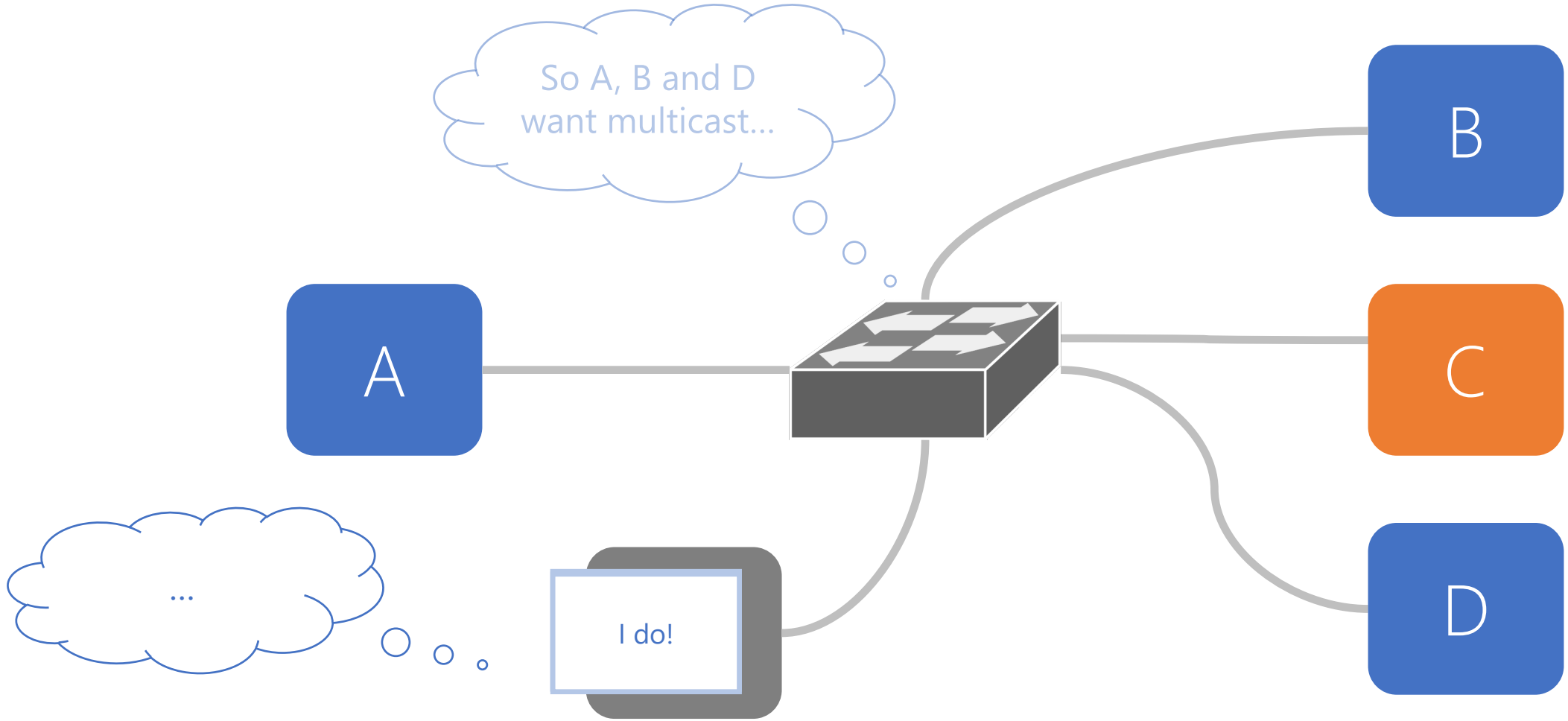

B
A
C
?
Who wants multicast?!
D

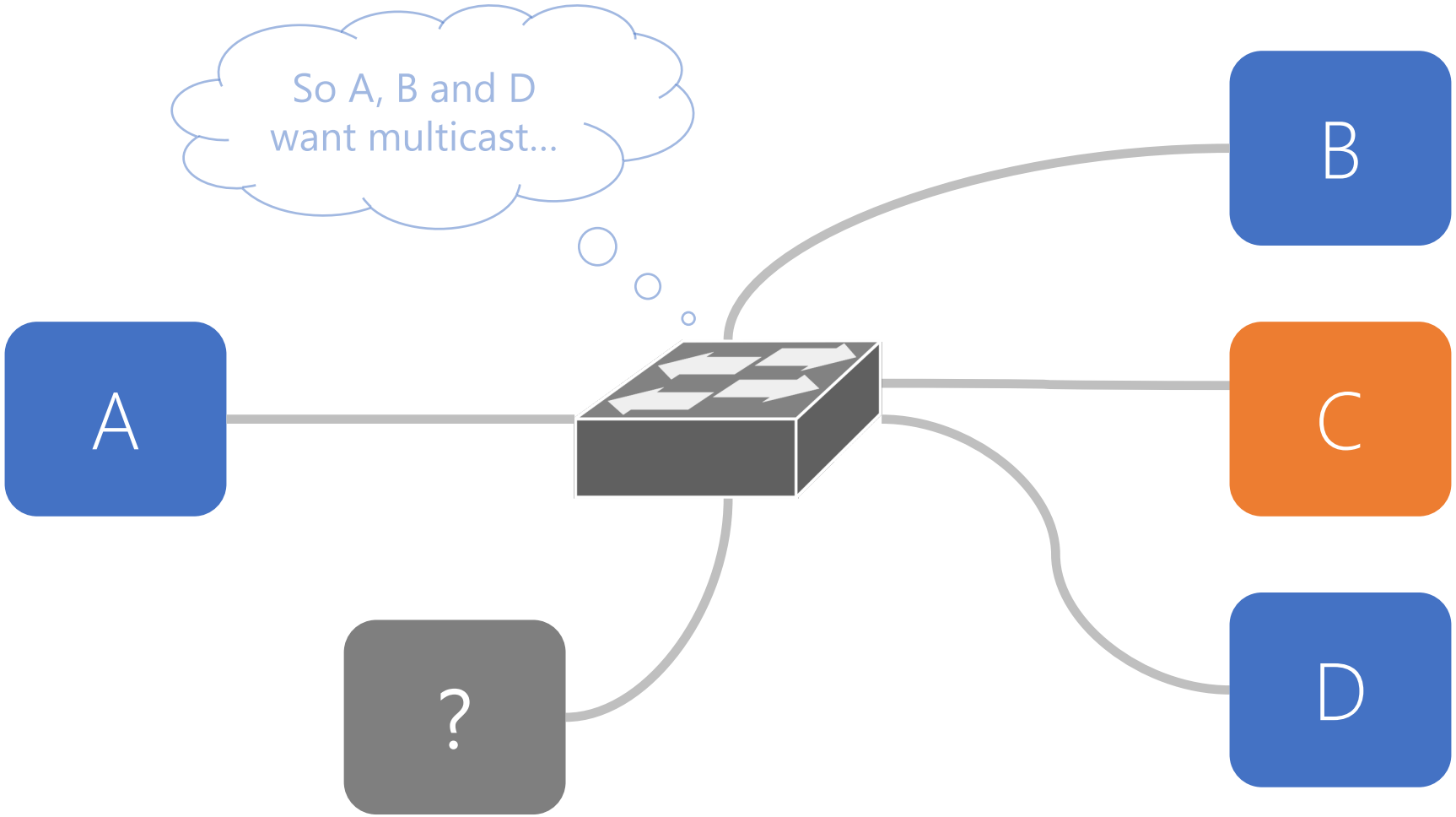

A
Who wants multicast?!
B
C
D
?

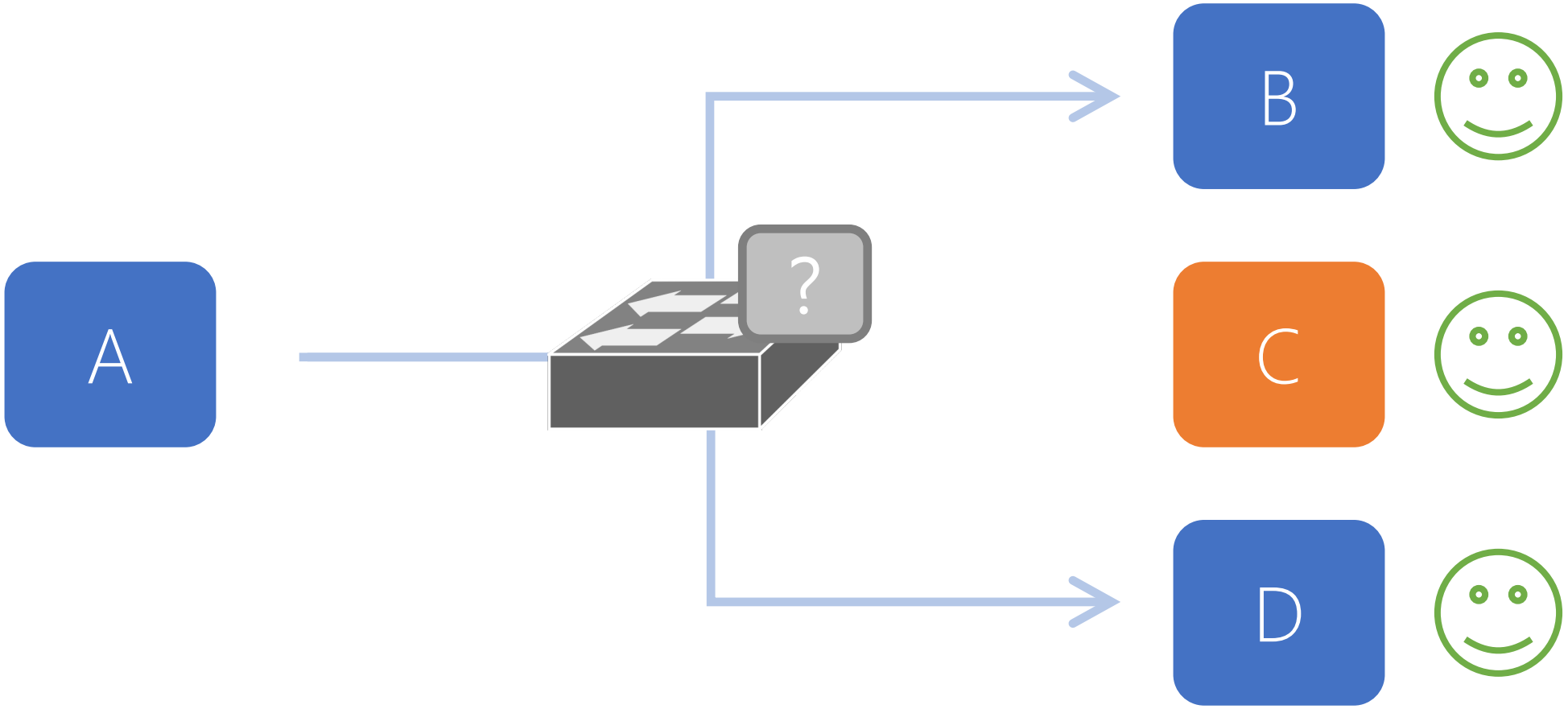

A
Who wants multicast?!
Who wants multicast?! B
Who wants multicast?! C
Who wants multicast?! D
?


I do!
B
A
I do!
C
?
I do!
D


So A, B and D
want multicast…
B
A
I do!
C
?
D


So A, B and D
want multicast...
B
A
C
...
I do!
D


So A, B and D
want multicast...
A
B
C
D
?


A
?
B
C
D

Larger Networks

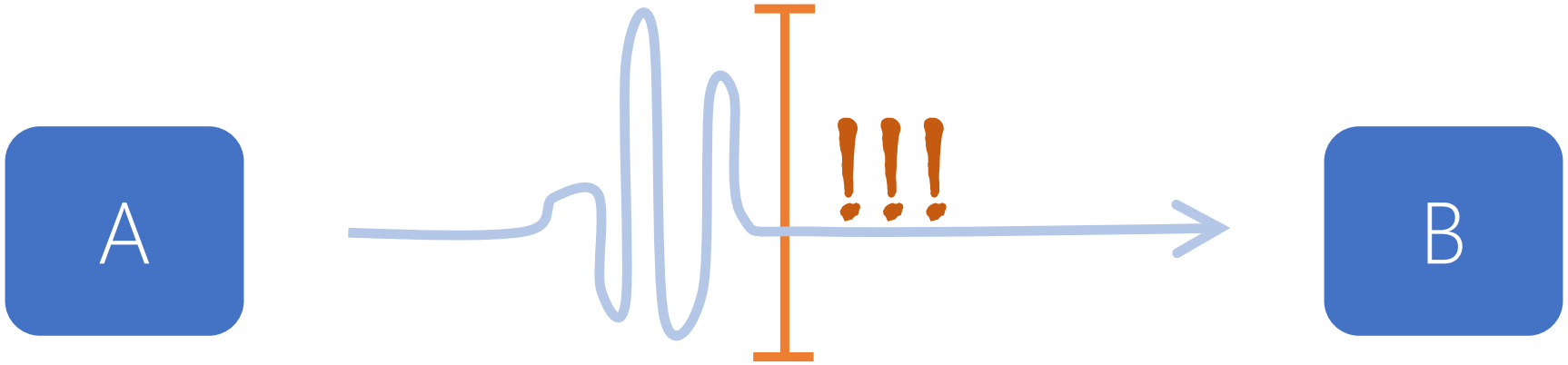
PIM-SM

Realtime Networking

Networking where timing matters!

Latency

Jitter



What affects timing?

What affects timing?

Topology

Topology

Network size

Topology

Network complexity

Topology

Link speed

What affects timing?

Topology

Other Traffic

Other Traffic

QoS

QoS Classification

Port Numbers

Tagging

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
2	0.014378222	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
3	0.029107832	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
4	0.041764532	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292
5	0.056534604	127.0.0.1	127.0.0.1	UDP	1334	10424 → 1234 Len=1292

```
> Frame 1: 1334 bytes on wire (10672 bits), 1334 bytes captured (10672 bits) on interface 0
v Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
    > Destination: 00:00:00_00:00:00 (00:00:00:00:00:00)
    > Source: 00:00:00_00:00:00 (00:00:00:00:00:00)
v Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1
      0100 .... = Version: 4
      .... 0101 = Header Length: 20 bytes (5)
    > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      Total Length: 1320
      Identification: 0xeea3 (61091)
    > Flags: 0x4000, Don't fragment
      Time to live: 64
      Protocol: UDP (17)
      Header checksum: 0x491f [validation disabled]
      [Header checksum status: Unverified]
      Source: 127.0.0.1
      Destination: 127.0.0.1
> Data (1292 bytes)
```

```
0000  00 00 00 00 00 00 00 00  00 00 00 00 08 00 45 00   ........ ......E.
0010  05 28 ee a3 40 00 40 11  49 1f 7f 00 00 01 7f 00   .(..@.@. I.......
```

AETM

sli.do/aetm

tag Technical Audio Group

QoS Classification

Port Numbers

Tagging

DSCP

AV	**IT**
56 - Clock	56 - Zoom Audio
46 - Audio	46 – Cisco Phones
34 - Video	34 – Cisco VC

Other Traffic

Jumbo Packets

What affects timing?

Topology – Size, complexity and link speed

Other Traffic – QoS, Jumbo Packets

Timing Measurements

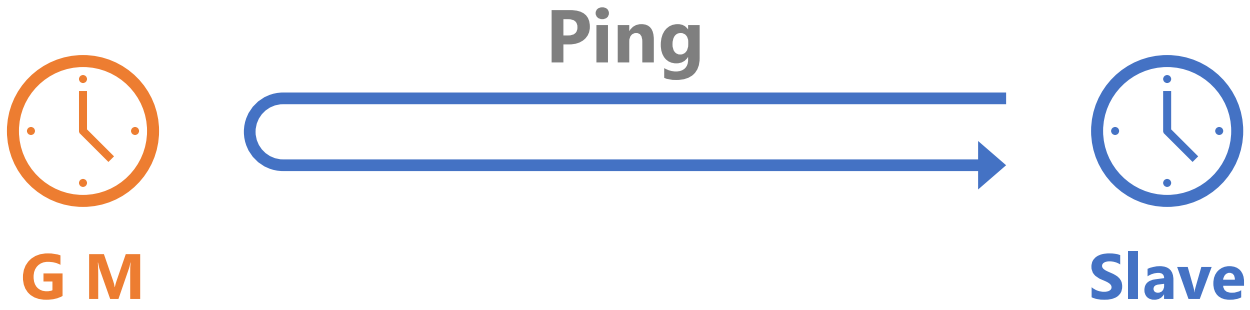

XENA
NETWORKS
XenaCompact
C1-M6SFP+


MAIN MENU
E1
T1
DATACOM
VoIP
ETHERNET
WIFI
G.729
IP Tools
HOME
NeT
RESEARCH
NetProbe 2000
TELECOM AND IP NETWORK ANALYZER
POWER
CHARGE

PTP

G M


The time is... X
G M
Slave


Ping
G M
Slave

The time must be:
X + (ping time / 2)

G M

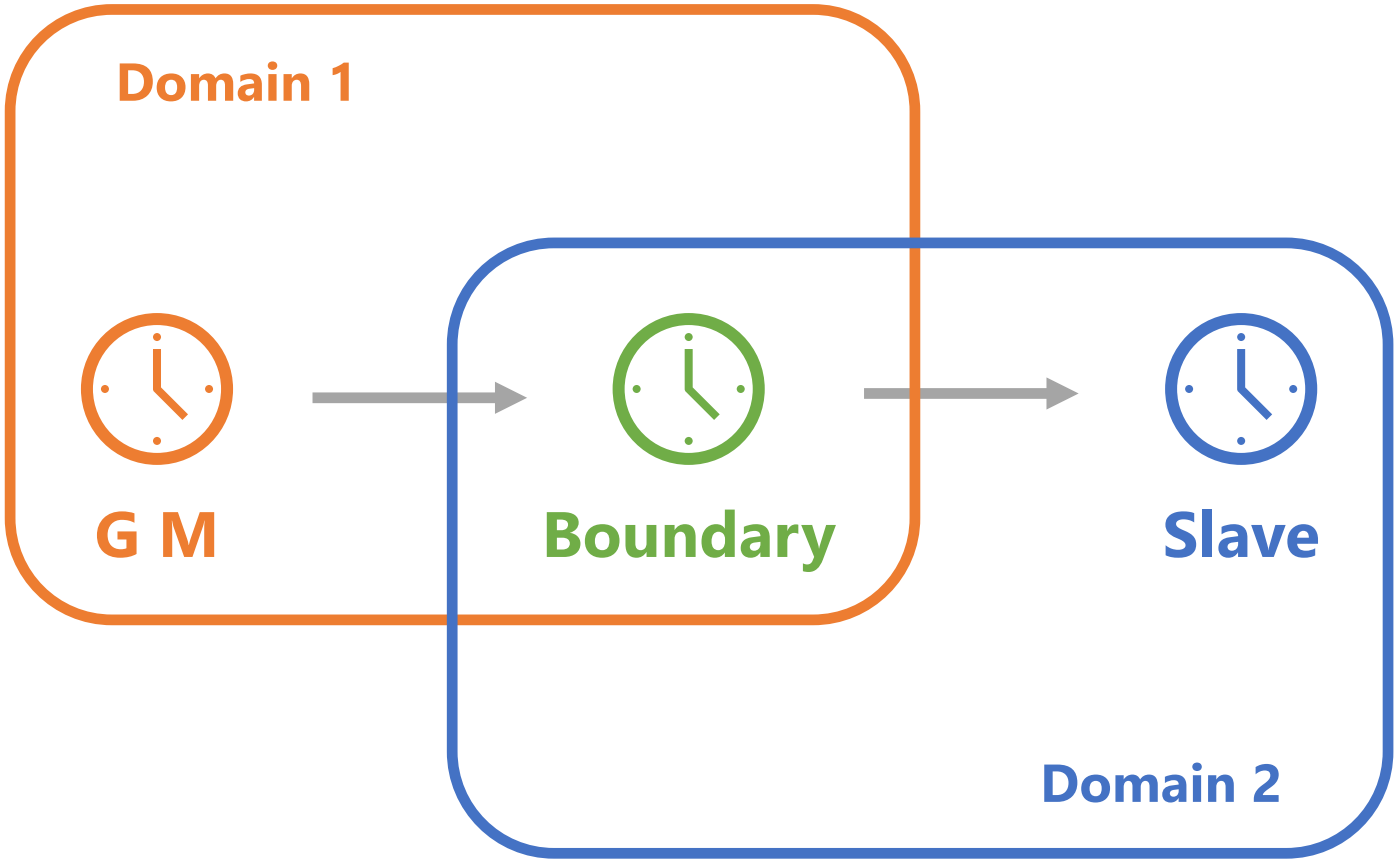
Slave

PTP Elections

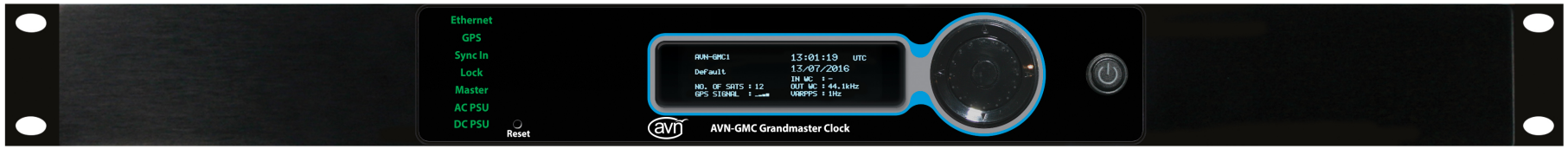
PTP Domains

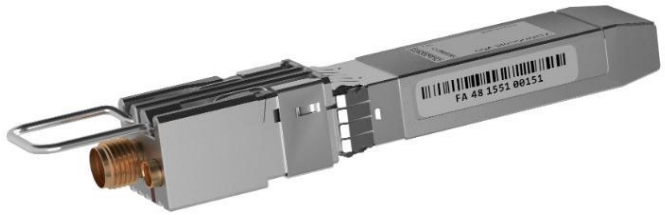
Groups of synchronised PTP devices

PTP Roles


Domain 1
G M
Boundary
Slave
Domain 2

PTP Infrastructure


Ethernet
GPS
Sync In
Lock
Master
AC PSU
DC PSU
Reset
AVN-GMC1
13:01:19 UTC
Default
13/07/2016
NO. OF SATS : 12
GPS SIGNAL :
IN WC :-
OUT WC : 44.1kHz
VARPPS : 1Hz
avn
AVN-GMC Grandmaster Clock


FA 48 1551 00151


SHURE

Common Protocols

Audio

Dante	Q-LAN	AVB	AES67
RTP PCM	RTP PCM	RTP PCM	RTP PCM
PTPv1	Routable	Deterministic	No Discovery
More Latency Options	QSC-proprietary	Requires specific switches	Lowest Common Denominator

Video

Compression

Unicast / multicast

Synchronisation

Bandwidth

What about VLAN's?

Isolation

Requires routing

Peace of mind

Security

People

People

"I am your worst nightmare"

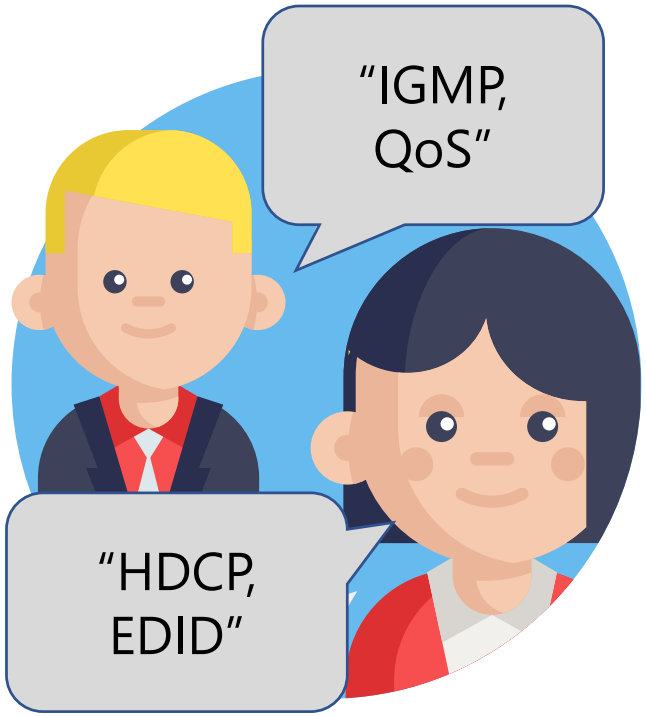
-Actual IT Guy on a Uni Job

People – Demarcation

Distil requirements down

Make interfaces measurable

People – Domain Specific Knowledge



*Create a **learning** culture*

IT aren't used to having stuff on their network they don't manage.

AV aren't used to having someone else managing their stuff.


(Remove the probe and insert to the opposing pin)
LG
RHYTHM CITY
ATLANTA, GA 30305
Mfg. By RAPCO CABLE & LIGHTING
Jackson, Ms. USA
(Pin 1)

Blame-free culture

Try offering fault!

Strategies

Strategies

The dilemma of effort vs risk

Strategies

"Let's Wing it!"

- Low effort. Fast to implement. High risk
- Plug it all in and see if it works
- If it doesn't make incremental changes
- Quick Wins..
  - IGMP
  - QoS
  - VLAN

Strategies

The Pragmatic Approach

- Balanced effort vs speed of implementation vs Risk
- Best effort approach
- Apply all manufacturer recommendations
- Give traffic the best chance of success
- If it doesn't work, start taking measurements

Strategies

The GOLD Standard

- Maximum Effort with Maximum time of implementation but Minimum Risk
- Measure Latency and Jitter of each network device under load with site specific configurations
- Allocate budgets of latency and jitter
- Build and measure longest path
- Deploy with confidence

Strategies

Building POCs

Understand the technology

Test on real world networks

Scale can be hard to test

Practice Troubleshooting

Where it all goes wrong

Where it all goes wrong

Where it all goes wrong

Bad Clock Setup

Where it all goes wrong

Bad Clock Setup

Where it all goes wrong

Gear incompatibility

Troubleshooting

Troubleshooting

Don’t forget the BASICS!

Troubleshooting

Ability to bypass the network

Get some real test gear (Xena, Netprobe etc)

Practice scientific method

Pause

Seems like a lot to deal with

But we've already come a long way already

In Practice

Tale of two unis

- Uni A
  - No IT engagement
  - No POC
  - Integrators onsite, can't see devices… no network guys to help
  - May as well go home
- Uni B
  - Complete IT engagement. They WANT to help!
  - POC
  - Documented latency
  - Seamless whole building implementation

AV/IT convergence presents a range of challenges and opportunities, but with the right approach, can be implemented with a great deal of success

Thankyou

Q & A