SharkFest'17 US

Wireshark & Time
Accurate Handling of Timing When Capturing Frames

Tuesday June 20, 2017
Thursday June 22, 2017

Werner Fischer
Principal Networking Consultant | avodaq AG

About me

- From Germany (sorry again for the accent)
- More than a decade Dual-CCIE (R/S, Security)
- Sniffer Certified Master
- Wireshark Certified Network Analyst
- VMware Certified Professional
- IPv6 Forum Certified Engineer (Gold)
- More than 20 years in the networking area

AGENDA

- Time basic
- Time Protocols
- NTP
- PTP
- Wrap-UP

Capture Files and other useful infos:
http://goo.gl/LGNWo8

Enterprise ToD Landscape

- Accurate/Secure/Reliable ToD for server/routers/applications for improved network operations and business operations
- Frequency and Time Synchronization

A Note on Terminology with Timing

- **Accuracy** – how close a measurement is to a true value
- **Precision** – how close repeated measurements are to each other
- **Frequency** – Reference signal drives circuits to a common standard
    - “10 Mhz is the same everywhere”
- **Phase** – making sure two systems understand when things start and stop- agree on milestones
    - “Everyone clapping together”

Precision Timing is essential

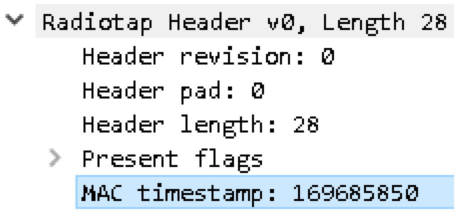
- Clock is the one of the most important component of any modern electrical system
- Network and applications also need accurate timing information to correlate all the events
  - Network Analysis
  - Application transactions
  - Data Forensics
  - Event-log analysis
- Timestamps mainly mandatory for compliance

Timing Challenge for up-to-date Networks

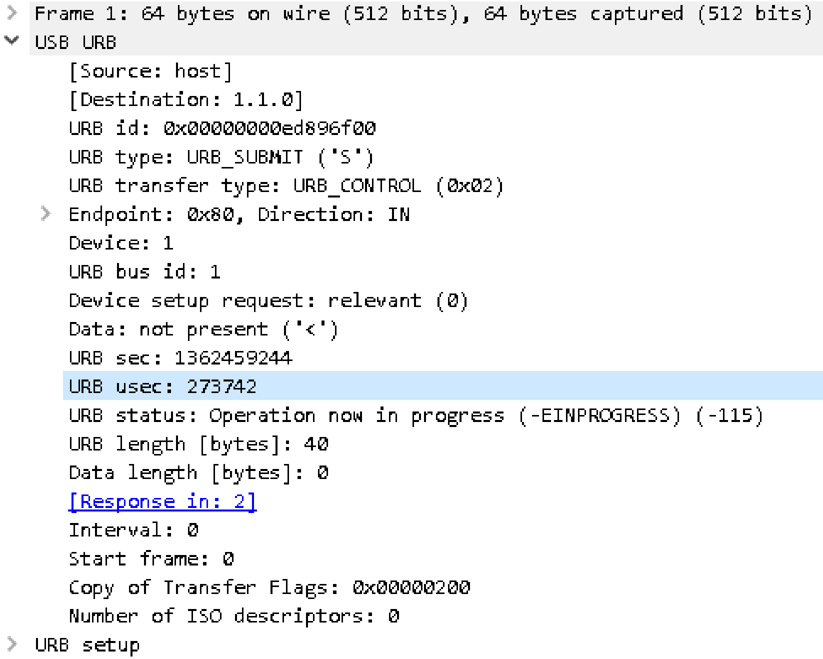
- Switches can forward the Frames in a matter of microseconds
- Ultra low latency switches for high frequency trading
- Some assumptions about the network
  - The transmission delays are almost constant over time (or at least change slowly)
  - The transmission delays are symmetrical between master and slave (i.e. time to travel from master to slave is the same as from slave to master)

Different Timestamps for different encapsulation

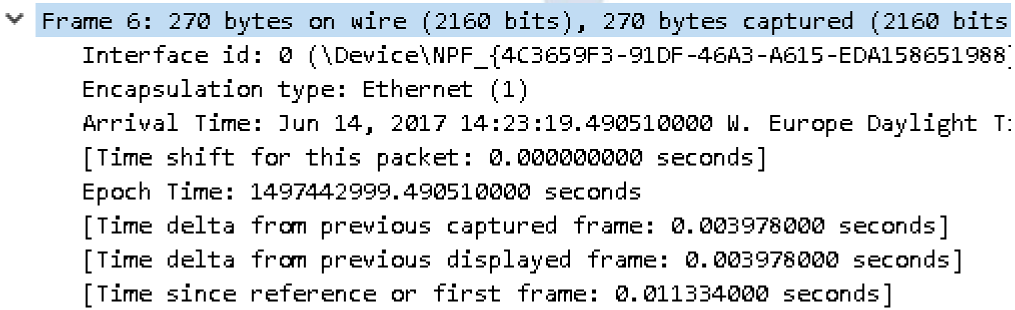
- frame.time
- prism.did.mactime
- radiotap.mactime
- …



```
Radiotap Header v0, Length 28
    Header revision: 0
    Header pad: 0
    Header length: 28
  > Present flags
    MAC timestamp: 169685850
```



```
> Frame 1: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
v USB URB
    [Source: host]
    [Destination: 1.1.0]
    URB id: 0x00000000ed896f00
    URB type: URB_SUBMIT ('S')
    URB transfer type: URB_CONTROL (0x02)
  > Endpoint: 0x80, Direction: IN
    Device: 1
    URB bus id: 1
    Device setup request: relevant (0)
    Data: not present ('<')
    URB sec: 1362459244
    URB usec: 273742
    URB status: Operation now in progress (-EINPROGRESS) (-115)
    URB length [bytes]: 40
    Data length [bytes]: 0
    [Response in: 2]
    Interval: 0
    Start frame: 0
    Copy of Transfer Flags: 0x00000200
    Number of ISO descriptors: 0
> URB setup
```



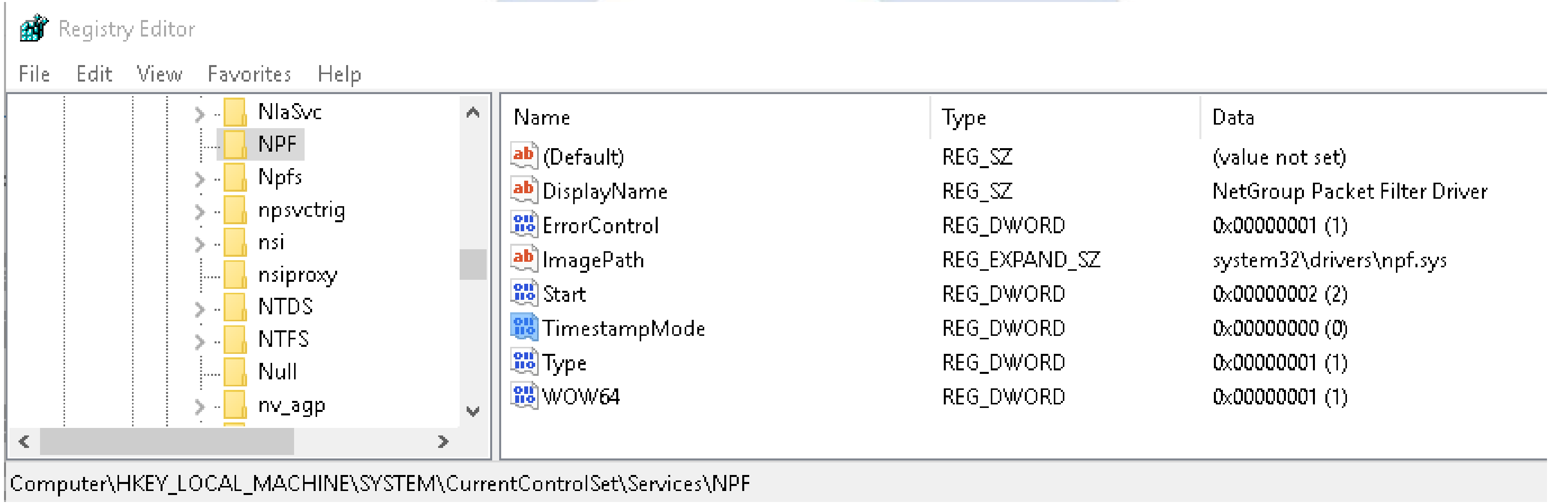
```
v Frame 6: 270 bytes on wire (2160 bits), 270 bytes captured (2160 bits
    Interface id: 0 (\Device\NPF_{4C3659F3-91DF-46A3-A615-EDA158651988}
    Encapsulation type: Ethernet (1)
    Arrival Time: Jun 14, 2017 14:23:19.490510000 W. Europe Daylight T:
    [Time shift for this packet: 0.000000000 seconds]
    Epoch Time: 1497442999.490510000 seconds
    [Time delta from previous captured frame: 0.003978000 seconds]
    [Time delta from previous displayed frame: 0.003978000 seconds]
    [Time since reference or first frame: 0.011334000 seconds]
```

WinPcap and Time

- Timestamp Mode adjusted by registry

http://seclists.org/wireshark/2010/Aug/311

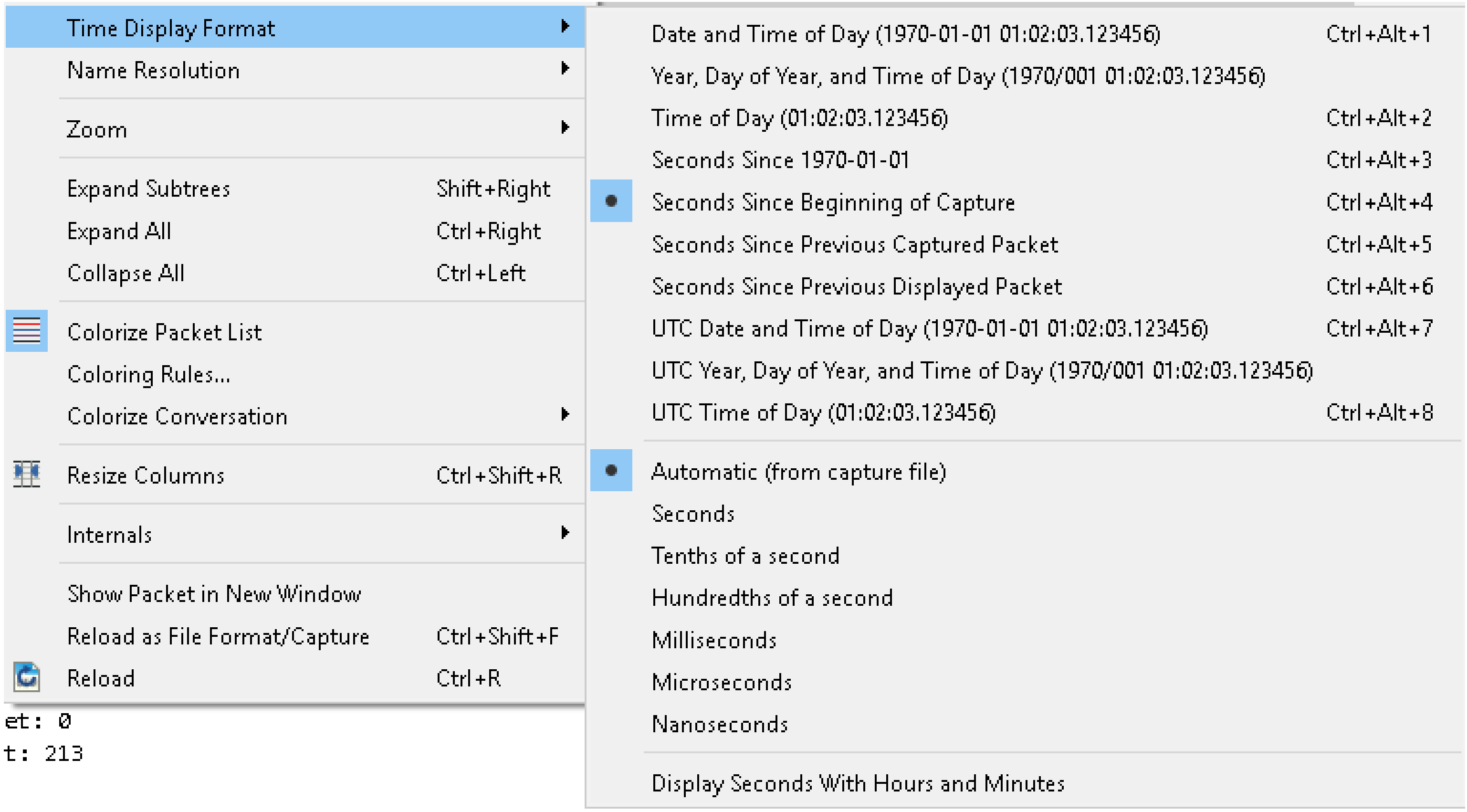
- WinPcap is synchronized with the system clock only once, at the beginning of the capture !



Name	Type	Data
(Default)	REG_SZ	(value not set)
DisplayName	REG_SZ	NetGroup Packet Filter Driver
ErrorControl	REG_DWORD	0x00000001 (1)
ImagePath	REG_EXPAND_SZ	system32\drivers\npf.sys
Start	REG_DWORD	0x00000002 (2)
TimestampMode	REG_DWORD	0x00000000 (0)
Type	REG_DWORD	0x00000001 (1)
WOW64	REG_DWORD	0x00000001 (1)

Computer\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\NPF

Wireshark and Time Display Format


Time Display Format
Name Resolution
Zoom
Expand Subtrees Shift+Right
Expand All Ctrl+Right
Collapse All Ctrl+Left
Colorize Packet List
Coloring Rules...
Colorize Conversation
Resize Columns Ctrl+Shift+R
Internals
Show Packet in New Window
Reload as File Format/Capture Ctrl+Shift+F
Reload Ctrl+R
et: 0
t: 213
Date and Time of Day (1970-01-01 01:02:03.123456) Ctrl+Alt+1
Year, Day of Year, and Time of Day (1970/001 01:02:03.123456)
Time of Day (01:02:03.123456) Ctrl+Alt+2
Seconds Since 1970-01-01 Ctrl+Alt+3
● Seconds Since Beginning of Capture Ctrl+Alt+4
Seconds Since Previous Captured Packet Ctrl+Alt+5
Seconds Since Previous Displayed Packet Ctrl+Alt+6
UTC Date and Time of Day (1970-01-01 01:02:03.123456) Ctrl+Alt+7
UTC Year, Day of Year, and Time of Day (1970/001 01:02:03.123456)
UTC Time of Day (01:02:03.123456) Ctrl+Alt+8
● Automatic (from capture file)
Seconds
Tenths of a second
Hundredths of a second
Milliseconds
Microseconds
Nanoseconds
Display Seconds With Hours and Minutes

AGENDA

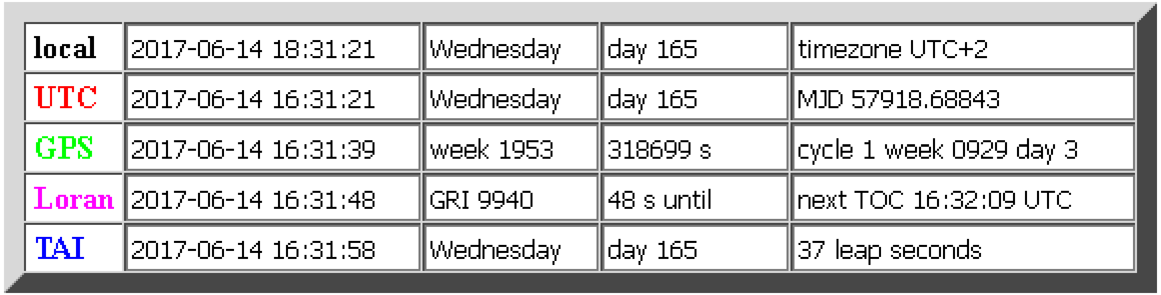
- Time basic
- Time Protocols
- NTP
- PTP
- Wrap-UP

Different Time Sources available

- NTP (Network Time Protocol)
  - Several RFCs
  - time synchronization protocol for packet network
- GPS (Global Position System)
- IRIG (And other serial timing protocols)
- PTP (Precision Timing Protocol)
  - Defined in IEEE1588
  - Another time synchronization protocol for packet network

Different Time Scales

- The relationships in real time

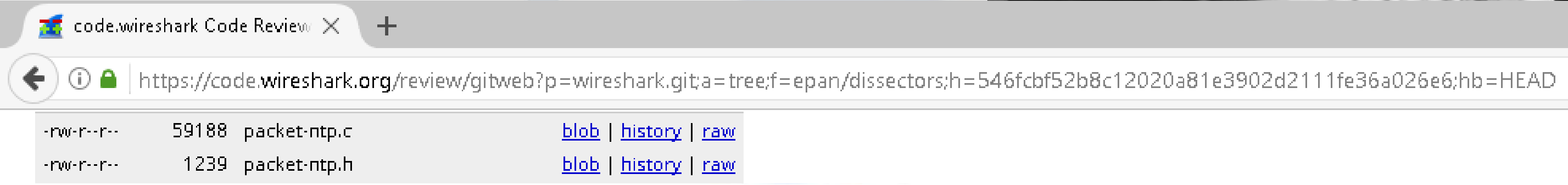


local	2017-06-14 18:31:21	Wednesday	day 165	timezone UTC+2
UTC	2017-06-14 16:31:21	Wednesday	day 165	MJD 57918.68843
GPS	2017-06-14 16:31:39	week 1953	318699 s	cycle 1 week 0929 day 3
Loran	2017-06-14 16:31:48	GRI 9940	48 s until	next TOC 16:32:09 UTC
TAI	2017-06-14 16:31:58	Wednesday	day 165	37 leap seconds

- http://www.leapsecond.com/java/gpsclock.htm

AGENDA

- Time basic
- Time Protocols
- NTP
- PTP
- Wrap-UP

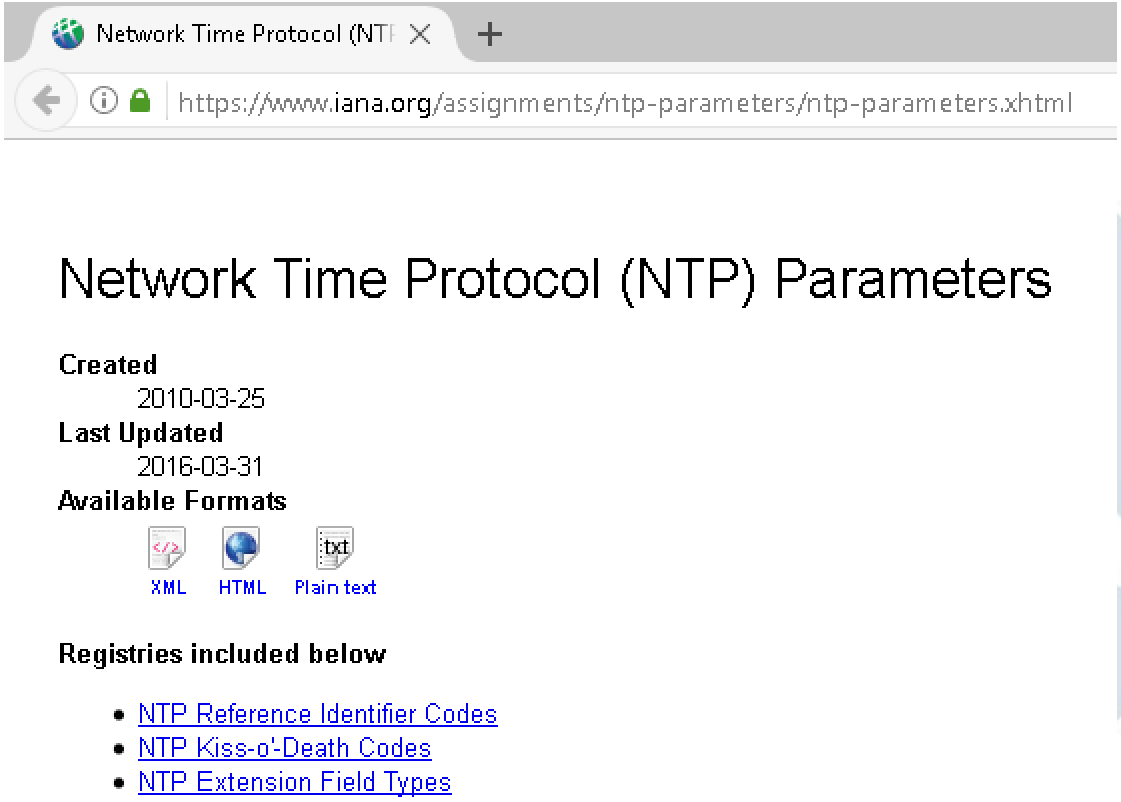


code.wireshark Code Review

https://code.wireshark.org/review/gitweb?p=wireshark.git;a=tree;f=epan/dissectors;h=546fcbf52b8c12020a81e3902d2111fe36a026e6;hb=HEAD

```
-rw-r--r--   59188  packet-ntp.c    blob | history | raw
-rw-r--r--    1239  packet-ntp.h    blob | history | raw
```

IANA and NTP Parameters


Network Time Protocol (NTF
https://www.iana.org/assignments/ntp-parameters/ntp-parameters.xhtml
XML
HTML
Plain text

Network Time Protocol (NTP) Parameters

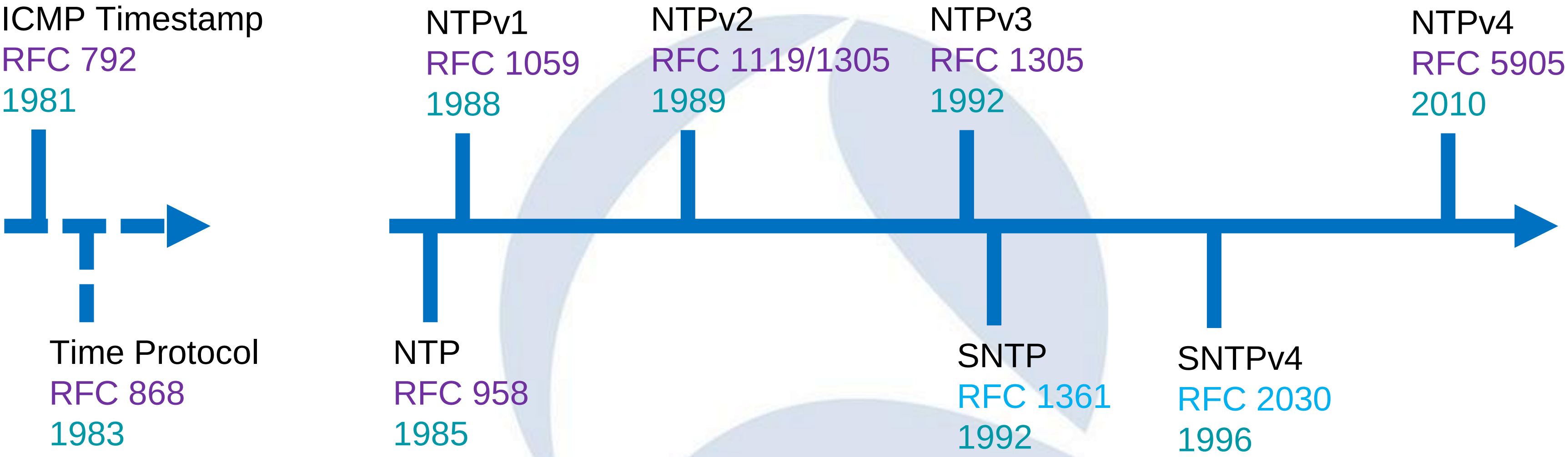
Created
2010-03-25
Last Updated
2016-03-31
Available Formats

Registries included below

- NTP Reference Identifier Codes
- NTP Kiss-o'-Death Codes
- NTP Extension Field Types

- Great resource for reference
- https://www.iana.org/assignments/ntp-parameters/ntp-parameters.xhtml

History of NTP



ICMP Timestamp
RFC 792
1981

Time Protocol
RFC 868
1983

NTP
RFC 958
1985

NTPv1
RFC 1059
1988

NTPv2
RFC 1119/1305
1989

NTPv3
RFC 1305
1992

SNTP
RFC 1361
1992

SNTPv4
RFC 2030
1996

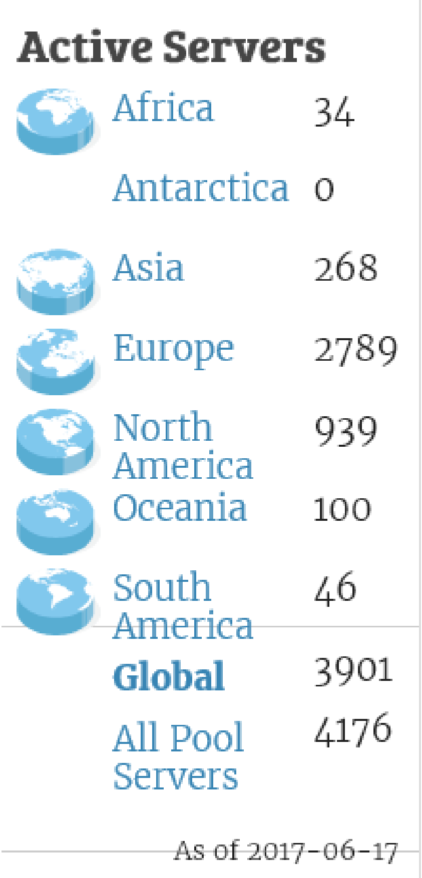
NTPv4
RFC 5905
2010

Useful (S)NTP RFCs – only for your reference

- RFC 1305
  - Network Time Protocol (Version 3) Specification, Implementation and Analysis
- RFC 2030
  - Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI
- RFC 5905
  - Network Time Protocol Version 4: Protocol and Algorithms Specification
- RFC 5906
  - Network Time Protocol Version 4: Autokey Specification
- RFC 5907
  - Definitions of Managed Objects for Network Time Protocol Version 4 (NTPv4)
- RFC 7821
  - UDP Checksum Complement in the Network Time Protocol (NTP)
- RFC 7822
  - Network Time Protocol Version 4 (NTPv4) Extension Fields

NTP Pool Project

- http://www.pool.ntp.org/en/
- “ …big virtual cluster of timeservers providing reliable easy to use NTP service for millions of clients …”



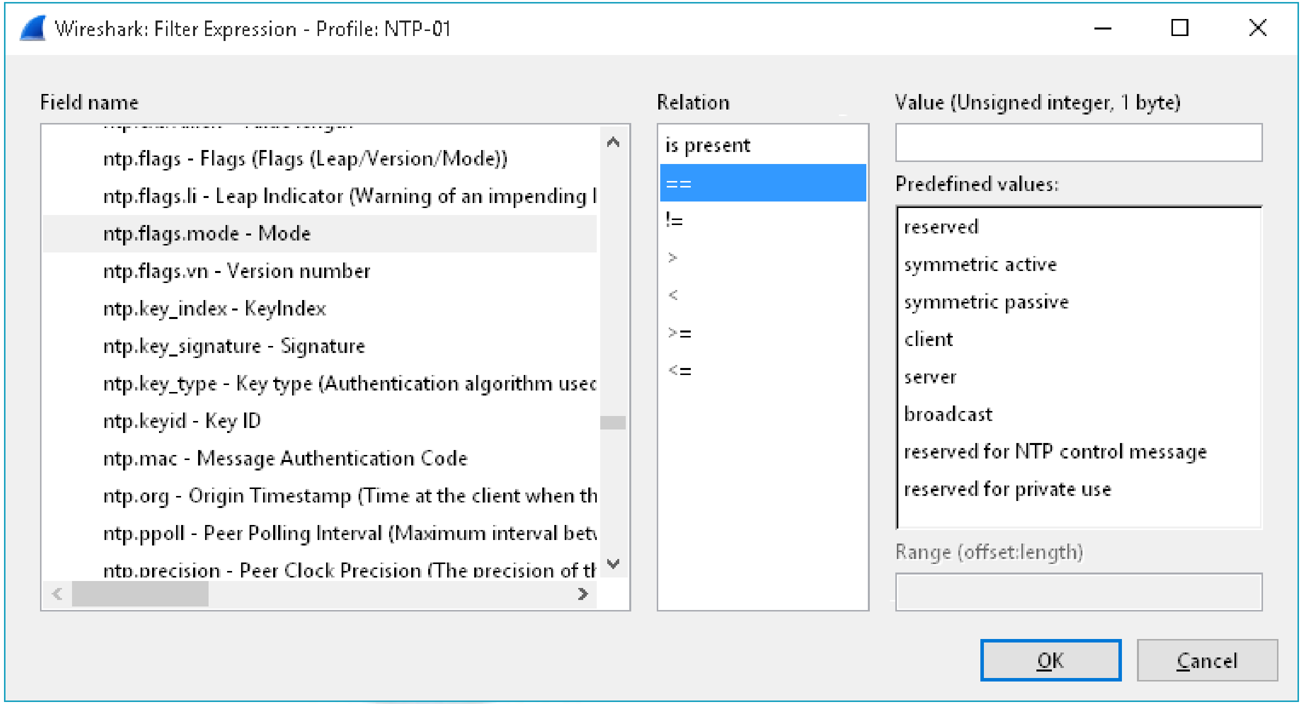
Active Servers

Africa	34
Antarctica	0
Asia	268
Europe	2789
North America	939
Oceania	100
South America	46
Global	3901
All Pool Servers	4176

As of 2017-06-17

NTP Modes

- Peer
- Client
- Server
- Broadcast/ Multicast
- Control
- Private Use



Wireshark: Filter Expression - Profile: NTP-01

Field name

ntp.flags - Flags (Flags (Leap/Version/Mode))
ntp.flags.li - Leap Indicator (Warning of an impending l
ntp.flags.mode - Mode
ntp.flags.vn - Version number
ntp.key_index - KeyIndex
ntp.key_signature - Signature
ntp.key_type - Key type (Authentication algorithm usec
ntp.keyid - Key ID
ntp.mac - Message Authentication Code
ntp.org - Origin Timestamp (Time at the client when th
ntp.ppoll - Peer Polling Interval (Maximum interval betv
ntp.precision - Peer Clock Precision (The precision of th

Relation

is present
==
!=
>
<
>=
<=

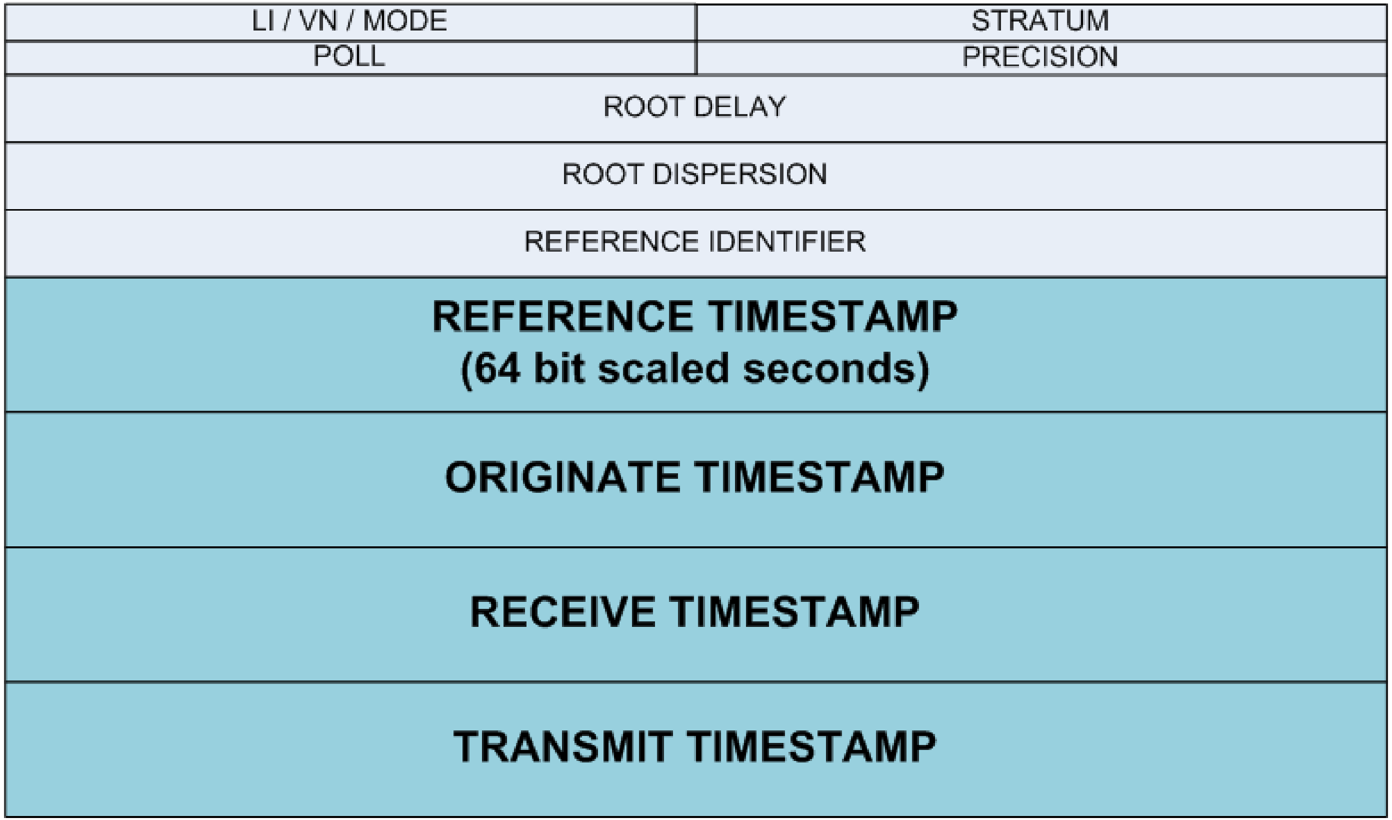
Value (Unsigned integer, 1 byte)

Predefined values:

reserved
symmetric active
symmetric passive
client
server
broadcast
reserved for NTP control message
reserved for private use

Range (offset:length)

NTP Message Format



LI / VN / MODE

STRATUM

POLL

PRECISION

ROOT DELAY

ROOT DISPERSION

REFERENCE IDENTIFIER

REFERENCE TIMESTAMP
(64 bit scaled seconds)

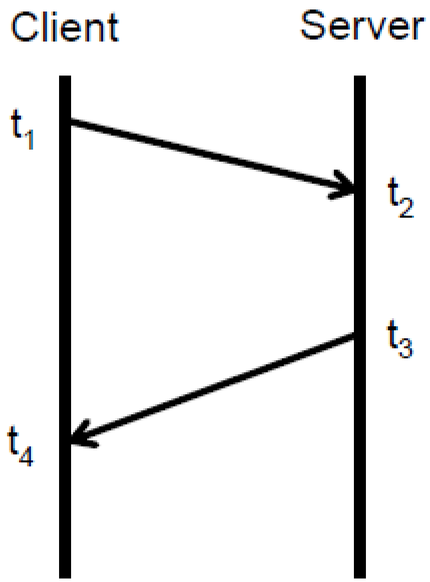
ORIGINATE TIMESTAMP

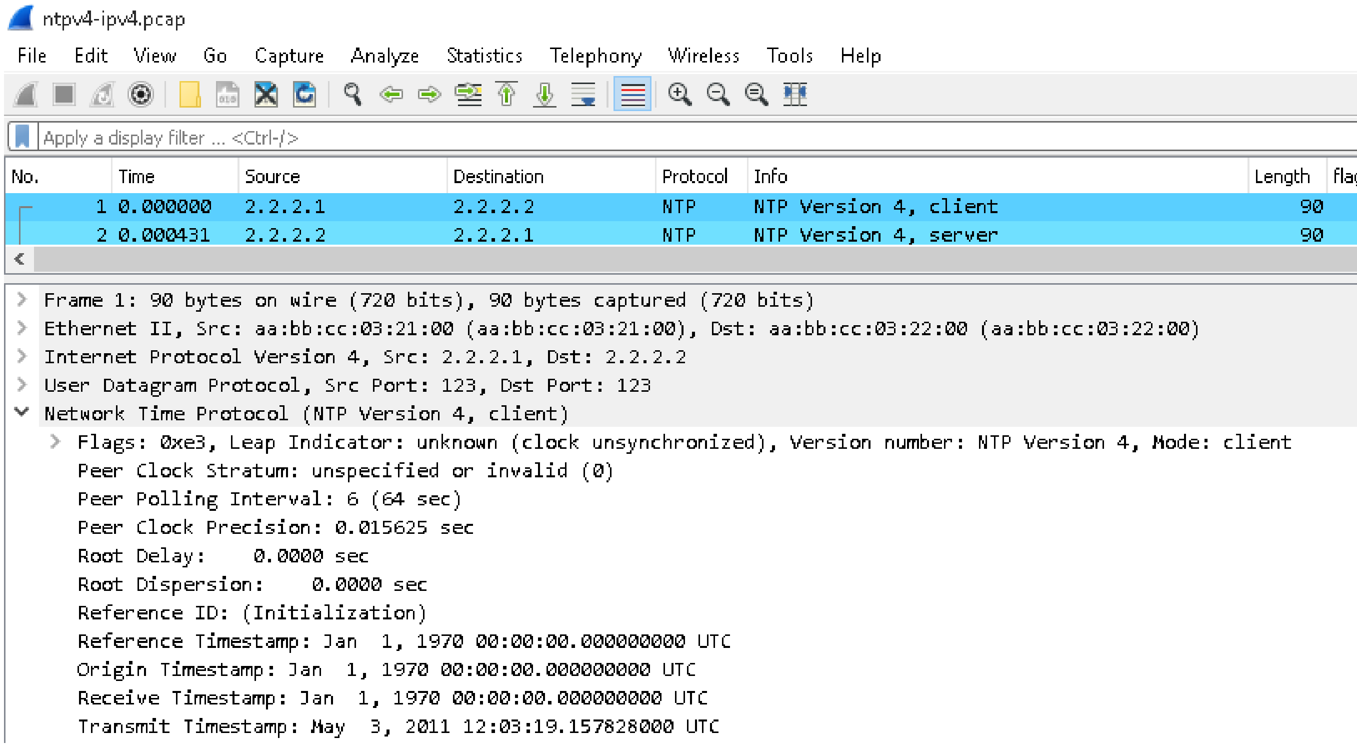
RECEIVE TIMESTAMP

TRANSMIT TIMESTAMP

Basic NTP Time Information Exchange

- Client Request



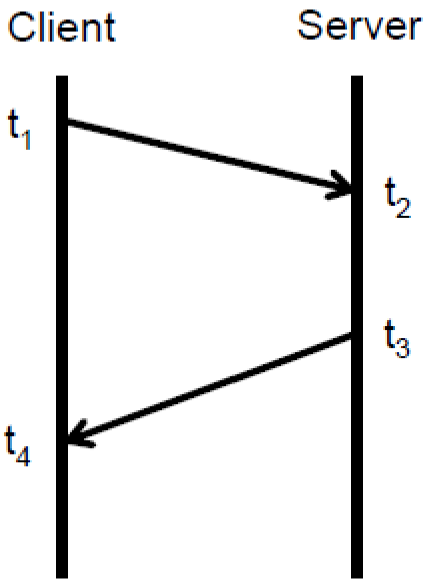

ntpv4-ipv4.pcap
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

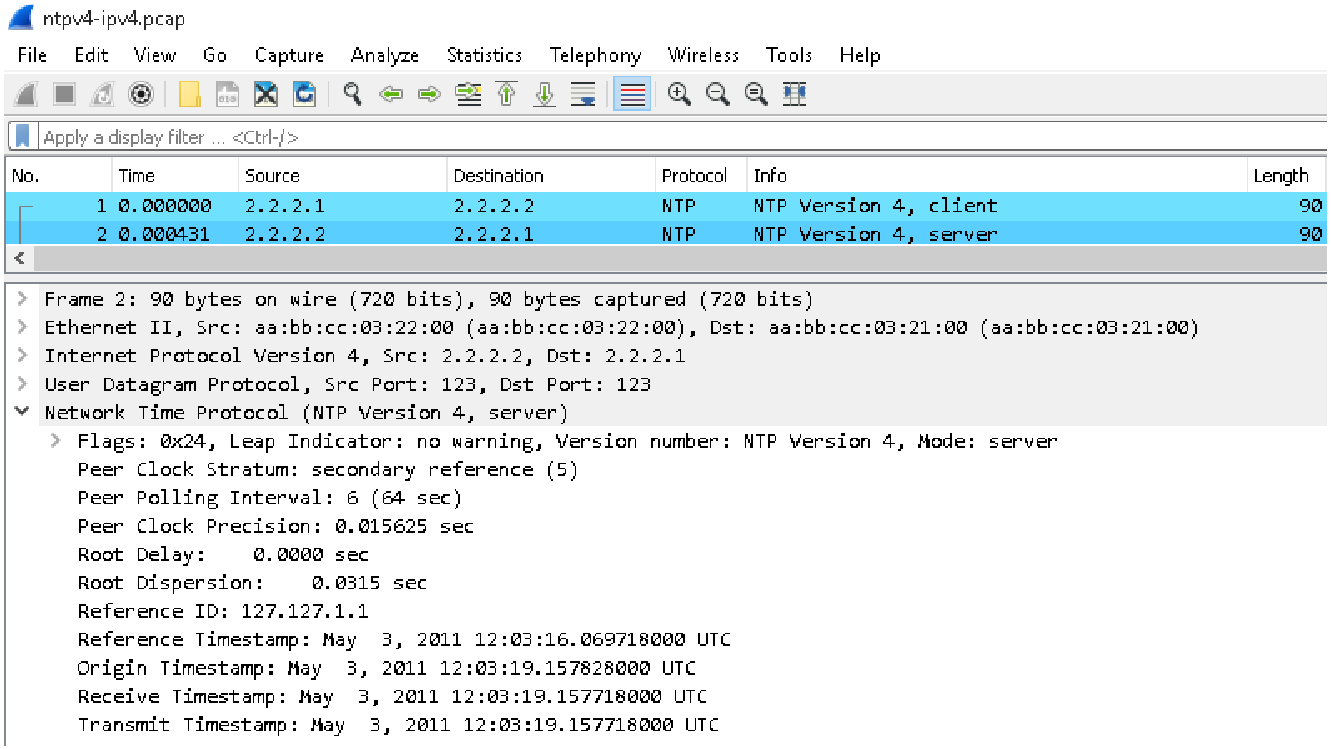
No.	Time	Source	Destination	Protocol	Info	Length	flag
1	0.000000	2.2.2.1	2.2.2.2	NTP	NTP Version 4, client	90	
2	0.000431	2.2.2.2	2.2.2.1	NTP	NTP Version 4, server	90	

```
> Frame 1: 90 bytes on wire (720 bits), 90 bytes captured (720 bits)
> Ethernet II, Src: aa:bb:cc:03:21:00 (aa:bb:cc:03:21:00), Dst: aa:bb:cc:03:22:00 (aa:bb:cc:03:22:00)
> Internet Protocol Version 4, Src: 2.2.2.1, Dst: 2.2.2.2
> User Datagram Protocol, Src Port: 123, Dst Port: 123
v Network Time Protocol (NTP Version 4, client)
  > Flags: 0xe3, Leap Indicator: unknown (clock unsynchronized), Version number: NTP Version 4, Mode: client
    Peer Clock Stratum: unspecified or invalid (0)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0.015625 sec
    Root Delay:    0.0000 sec
    Root Dispersion:    0.0000 sec
    Reference ID: (Initialization)
    Reference Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: May  3, 2011 12:03:19.157828000 UTC
```

Basic NTP Time Information Exchange

- Server Response





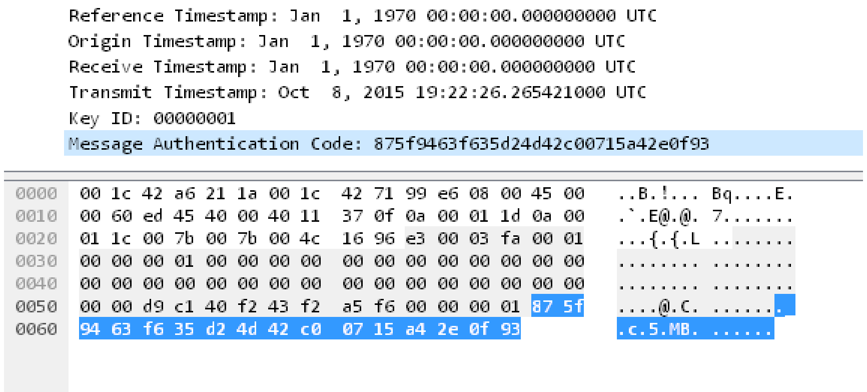
ntpv4-ipv4.pcap
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Info	Length
1	0.000000	2.2.2.1	2.2.2.2	NTP	NTP Version 4, client	90
2	0.000431	2.2.2.2	2.2.2.1	NTP	NTP Version 4, server	90

```
> Frame 2: 90 bytes on wire (720 bits), 90 bytes captured (720 bits)
> Ethernet II, Src: aa:bb:cc:03:22:00 (aa:bb:cc:03:22:00), Dst: aa:bb:cc:03:21:00 (aa:bb:cc:03:21:00)
> Internet Protocol Version 4, Src: 2.2.2.2, Dst: 2.2.2.1
> User Datagram Protocol, Src Port: 123, Dst Port: 123
v Network Time Protocol (NTP Version 4, server)
  > Flags: 0x24, Leap Indicator: no warning, Version number: NTP Version 4, Mode: server
    Peer Clock Stratum: secondary reference (5)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0.015625 sec
    Root Delay:    0.0000 sec
    Root Dispersion:    0.0315 sec
    Reference ID: 127.127.1.1
    Reference Timestamp: May  3, 2011 12:03:16.069718000 UTC
    Origin Timestamp: May  3, 2011 12:03:19.157828000 UTC
    Receive Timestamp: May  3, 2011 12:03:19.157718000 UTC
    Transmit Timestamp: May  3, 2011 12:03:19.157718000 UTC
```

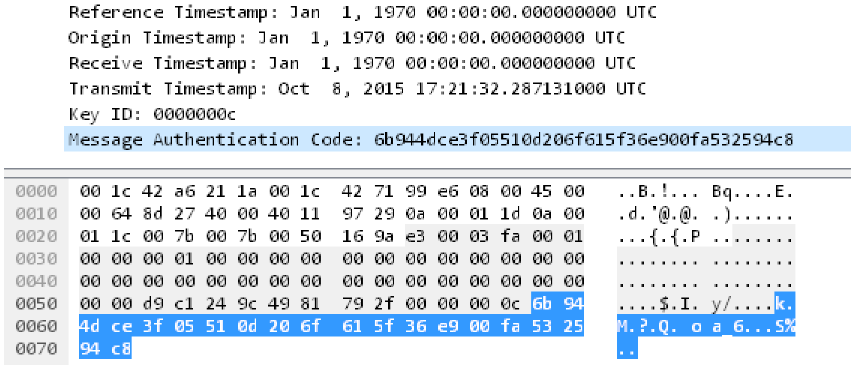
Basic NTP Authentication

- MD5



```
Reference Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
Transmit Timestamp: Oct  8, 2015 19:22:26.265421000 UTC
Key ID: 00000001
Message Authentication Code: 875f9463f635d24d42c00715a42e0f93

0000  00 1c 42 a6 21 1a 00 1c  42 71 99 e6 08 00 45 00   ..B.!... Bq....E.
0010  00 60 ed 45 40 00 40 11  37 0f 0a 00 01 1d 0a 00   .`.E@.@. 7.......
0020  01 1c 00 7b 00 7b 00 4c  16 96 e3 00 03 fa 00 01   ...{.{.L ........
0030  00 00 00 01 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0040  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0050  00 00 d9 c1 40 f2 43 f2  a5 f6 00 00 00 01 87 5f   ....@.C. ........
0060  94 63 f6 35 d2 4d 42 c0  07 15 a4 2e 0f 93         .c.5.MB. ......
```

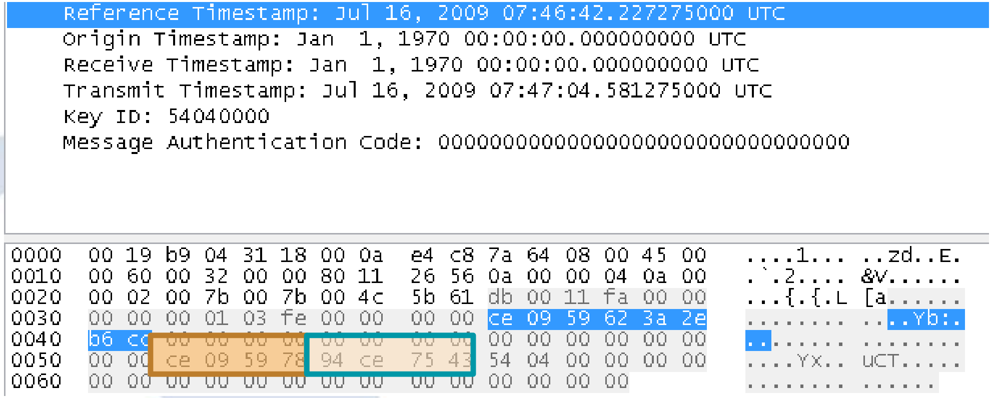
- SHA-1



```
Reference Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
Transmit Timestamp: Oct  8, 2015 17:21:32.287131000 UTC
Key ID: 0000000c
Message Authentication Code: 6b944dce3f05510d206f615f36e900fa532594c8

0000  00 1c 42 a6 21 1a 00 1c  42 71 99 e6 08 00 45 00   ..B.!... Bq....E.
0010  00 64 8d 27 40 00 40 11  97 29 0a 00 01 1d 0a 00   .d.'@.@. .)......
0020  01 1c 00 7b 00 7b 00 50  16 9a e3 00 03 fa 00 01   ...{.{.P ........
0030  00 00 00 01 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0040  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0050  00 00 d9 c1 24 9c 49 81  79 2f 00 00 00 0c 6b 94   ....$.I. y/....k.
0060  4d ce 3f 05 51 0d 20 6f  61 5f 36 e9 00 fa 53 25   M.?.Q. o a_6...S%
0070  94 c8                                              ..
```

NTP Timestamps

- NTP use 64 bit-Timestamps
  - They consist of a 32-bit part for seconds and a 32-bit part for fractional second
  - The time scale rolls over every 2^{32} seconds (136 years)
  - Theoretical resolution of 2^{-32} seconds (233 picoseconds)
  - It uses an epoch of 1 January 1900
  - The first rollover occurs in 2036, prior to the UNIX year 2038 problem



```
    Reference Timestamp: Jul 16, 2009 07:46:42.227275000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: Jul 16, 2009 07:47:04.581275000 UTC
    Key ID: 54040000
    Message Authentication Code: 00000000000000000000000000000000
```

```
0000  00 19 b9 04 31 18 00 0a  e4 c8 7a 64 08 00 45 00   ....1... ..zd..E.
0010  00 60 00 32 00 00 80 11  26 56 0a 00 00 04 0a 00   .`.2.... &V......
0020  00 02 00 7b 00 7b 00 4c  5b 61 db 00 11 fa 00 00   ...{.{.L [a......
0030  00 00 00 01 03 fe 00 00  00 00 ce 09 59 62 3a 2e   ........ ....Yb:.
0040  b6 ce 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0050  00 00 ce 09 59 78 94 ce  75 43 54 04 00 00 00 00   ....Yx.. uCT.....
0060  00 00 00 00 00 00 00 00  00 00 00 00 00 00         ........ ......
```

Time.sec

Seconds

32 bit

Time.Frac

Fraction

32 bit

NTP and DHCP / DHCPv6

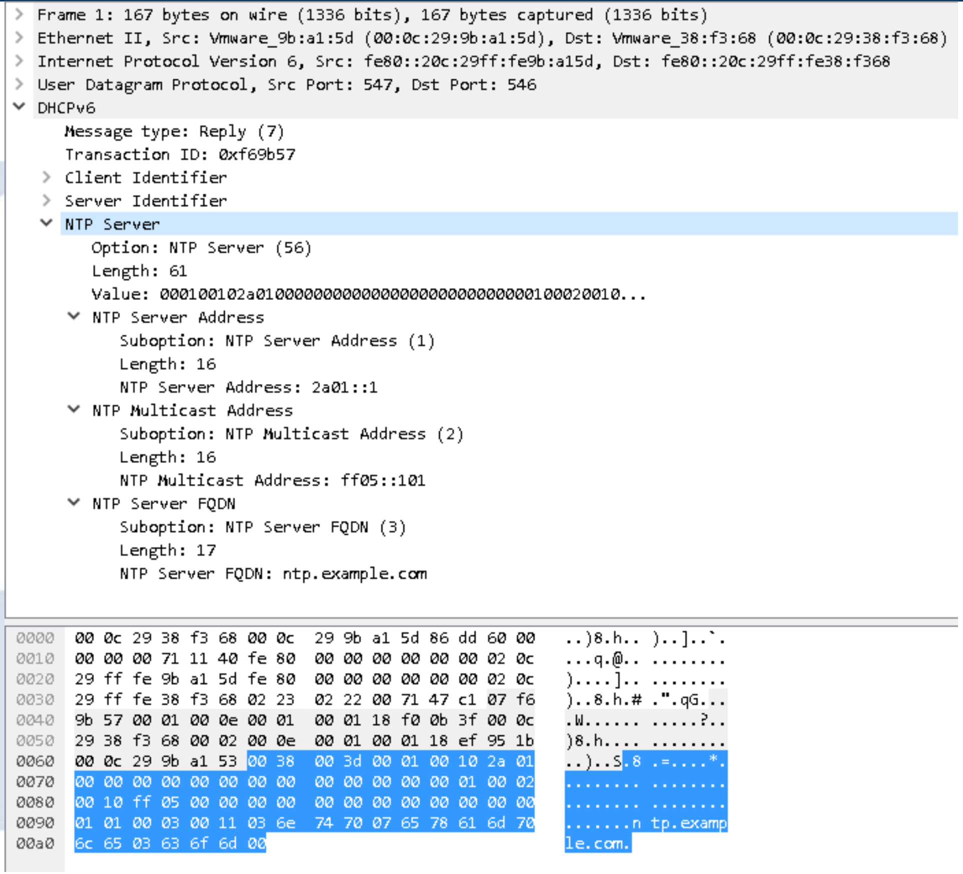
- IPv4 and DHCP

  Option 42

- IPv6 and DHCPv6
  - SNTP

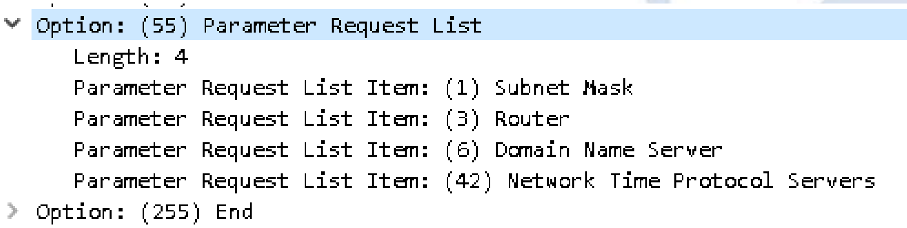
    dhcpv6.requested_option_code == 31
  - NTP

    dhcpv6.requested_option_code == 56



```
> Frame 1: 167 bytes on wire (1336 bits), 167 bytes captured (1336 bits)
> Ethernet II, Src: Vmware_9b:a1:5d (00:0c:29:9b:a1:5d), Dst: Vmware_38:f3:68 (00:0c:29:38:f3:68)
> Internet Protocol Version 6, Src: fe80::20c:29ff:fe9b:a15d, Dst: fe80::20c:29ff:fe38:f368
> User Datagram Protocol, Src Port: 547, Dst Port: 546
v DHCPv6
    Message type: Reply (7)
    Transaction ID: 0xf69b57
  > Client Identifier
  > Server Identifier
  v NTP Server
      Option: NTP Server (56)
      Length: 61
      Value: 000100102a0100000000000000000000000000010002001 0...
    v NTP Server Address
        Suboption: NTP Server Address (1)
        Length: 16
        NTP Server Address: 2a01::1
    v NTP Multicast Address
        Suboption: NTP Multicast Address (2)
        Length: 16
        NTP Multicast Address: ff05::101
    v NTP Server FQDN
        Suboption: NTP Server FQDN (3)
        Length: 17
        NTP Server FQDN: ntp.example.com
```

```
0000  00 0c 29 38 f3 68 00 0c  29 9b a1 5d 86 dd 60 00   ..)8.h.. )..]..`.
0010  00 00 00 71 11 40 fe 80  00 00 00 00 00 00 02 0c   ...q.@.. ........
0020  29 ff fe 9b a1 5d fe 80  00 00 00 00 00 00 02 0c   )....].. ........
0030  29 ff fe 38 f3 68 02 23  02 22 00 71 47 c1 07 f6   )..8.h.# .".qG...
0040  9b 57 00 01 00 0e 00 01  00 01 18 f0 0b 3f 00 0c   .W...... .....?..
0050  29 38 f3 68 00 02 00 0e  00 01 00 01 18 ef 95 1b   )8.h.... ........
0060  00 0c 29 9b a1 53 00 38  00 3d 00 01 00 10 2a 01   ..)..S.8 .=....*.
0070  00 00 00 00 00 00 00 00  00 00 00 00 00 01 00 02   ........ ........
0080  00 10 ff 05 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0090  01 01 00 03 00 11 03 6e  74 70 07 65 78 61 6d 70   .......n tp.examp
00a0  6c 65 03 63 6f 6d 00                              le.com.
```



```
v Option: (55) Parameter Request List
    Length: 4
    Parameter Request List Item: (1) Subnet Mask
    Parameter Request List Item: (3) Router
    Parameter Request List Item: (6) Domain Name Server
    Parameter Request List Item: (42) Network Time Protocol Servers
> Option: (255) End
```

NTP and Multicast

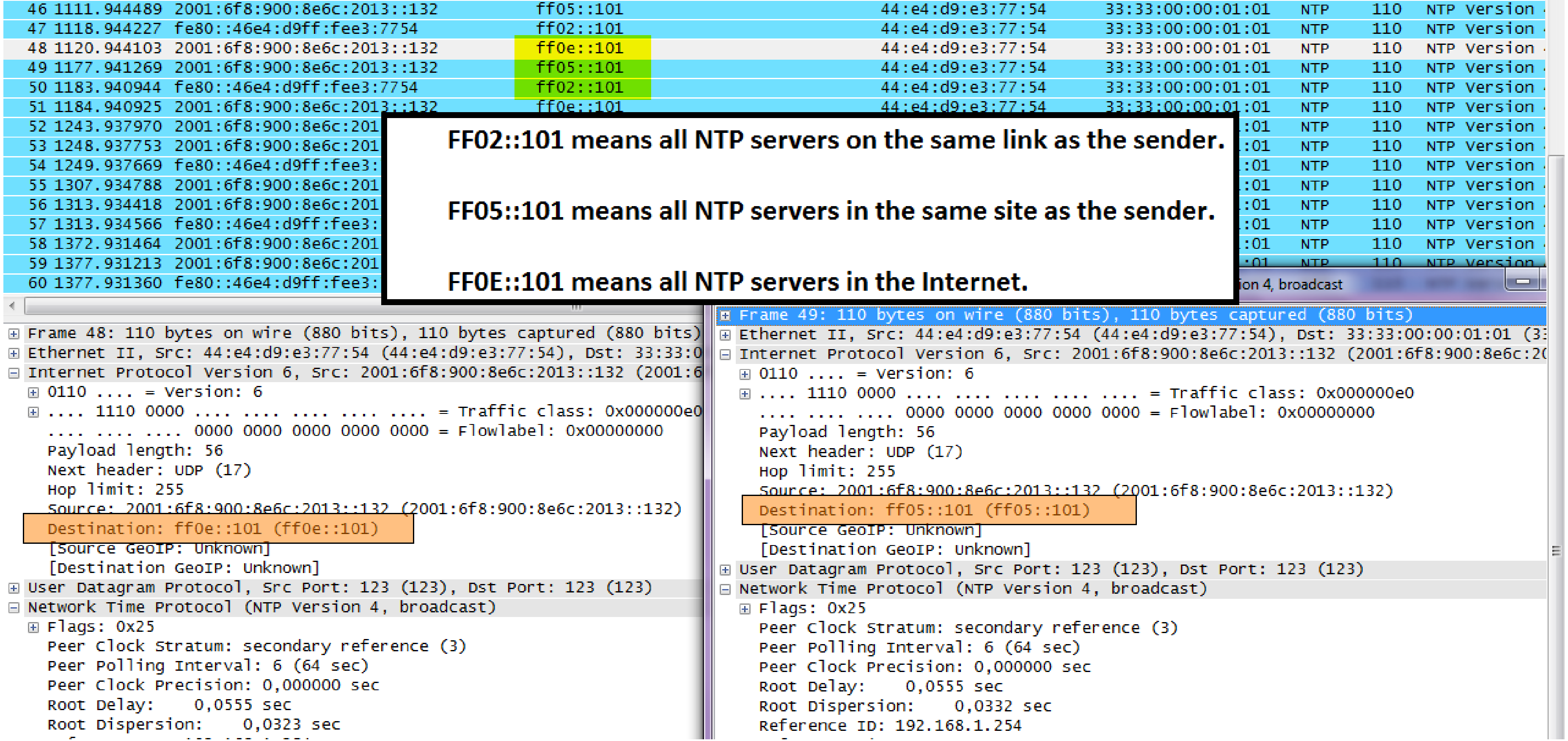
- IPv4 and IGMP

  (Internet Group Management Protocol)

- IPv6 and MLD

  (Multicast Listener Discovery)

NTP and Multicast with IPv6



```
46 1111.944489  2001:6f8:900:8e6c:2013::132   ff05::101    44:e4:d9:e3:77:54   33:33:00:00:01:01   NTP   110   NTP Version
47 1118.944227  fe80::46e4:d9ff:fee3:7754     ff02::101    44:e4:d9:e3:77:54   33:33:00:00:01:01   NTP   110   NTP Version
48 1120.944103  2001:6f8:900:8e6c:2013::132   ff0e::101    44:e4:d9:e3:77:54   33:33:00:00:01:01   NTP   110   NTP Version
49 1177.941269  2001:6f8:900:8e6c:2013::132   ff05::101    44:e4:d9:e3:77:54   33:33:00:00:01:01   NTP   110   NTP Version
50 1183.940944  fe80::46e4:d9ff:fee3:7754     ff02::101    44:e4:d9:e3:77:54   33:33:00:00:01:01   NTP   110   NTP Version
51 1184.940925  2001:6f8:900:8e6c:2013::132   ff0e::101    44:e4:d9:e3:77:54   33:33:00:00:01:01   NTP   110   NTP Version
52 1243.937970  2001:6f8:900:8e6c:201                                                       :01   NTP   110   NTP Version
53 1248.937753  2001:6f8:900:8e6c:201                                                       :01   NTP   110   NTP Version
54 1249.937669  fe80::46e4:d9ff:fee3:                                                       :01   NTP   110   NTP Version
55 1307.934788  2001:6f8:900:8e6c:201                                                       :01   NTP   110   NTP Version
56 1313.934418  2001:6f8:900:8e6c:201                                                       :01   NTP   110   NTP Version
57 1313.934566  fe80::46e4:d9ff:fee3:                                                       :01   NTP   110   NTP Version
58 1372.931464  2001:6f8:900:8e6c:201                                                       :01   NTP   110   NTP Version
59 1377.931213  2001:6f8:900:8e6c:201                                                       :01   NTP   110   NTP Version
60 1377.931360  fe80::46e4:d9ff:fee3:                                                       ion 4, broadcast
```

FF02::101 means all NTP servers on the same link as the sender.

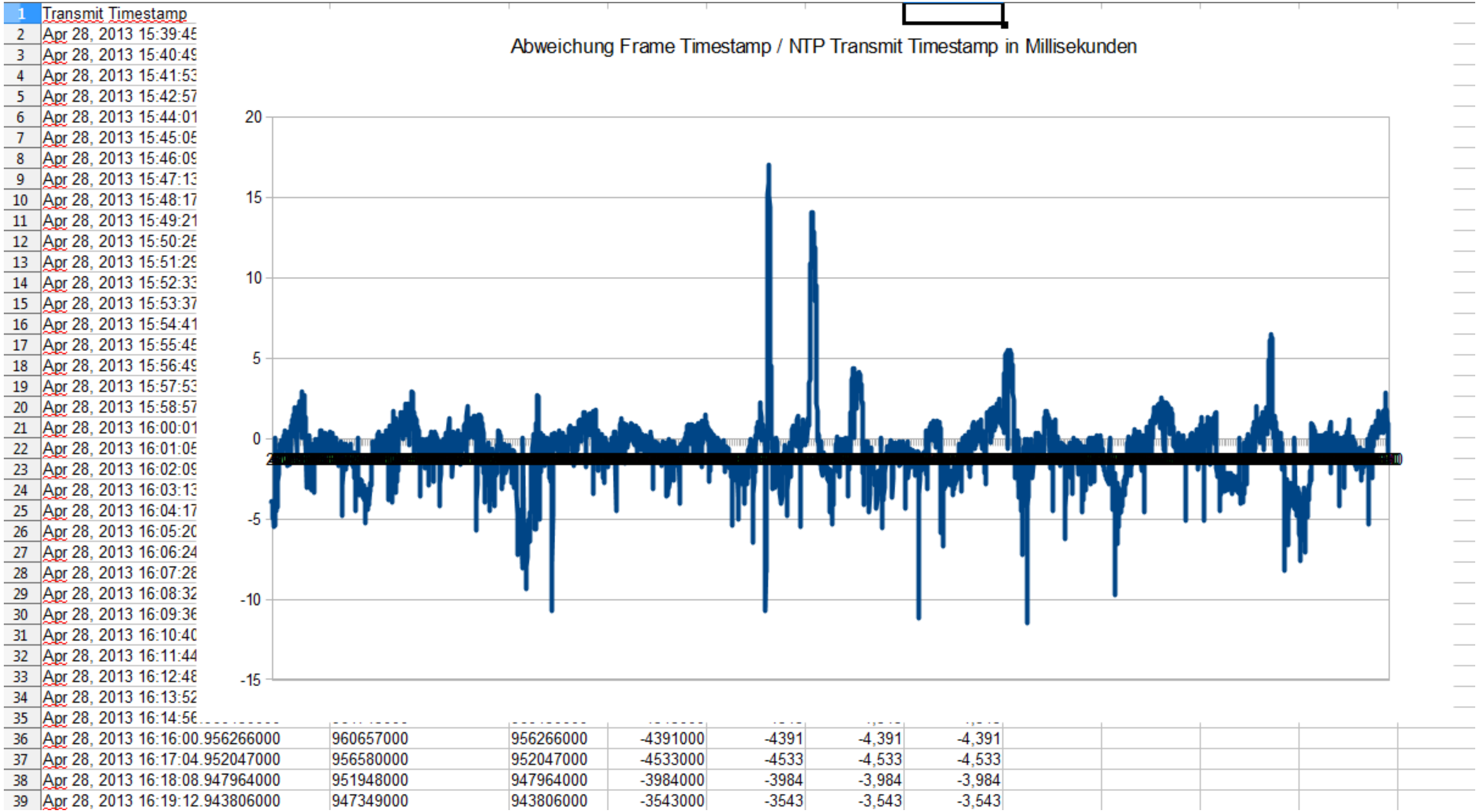
FF05::101 means all NTP servers in the same site as the sender.

FF0E::101 means all NTP servers in the Internet.

```
⊞ Frame 48: 110 bytes on wire (880 bits), 110 bytes captured (880 bits)
⊞ Ethernet II, Src: 44:e4:d9:e3:77:54 (44:e4:d9:e3:77:54), Dst: 33:33:0
⊟ Internet Protocol Version 6, Src: 2001:6f8:900:8e6c:2013::132 (2001:6
  ⊞ 0110 .... = Version: 6
  ⊞ .... 1110 0000 .... .... .... .... .... = Traffic class: 0x000000e0
    .... .... .... 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000
    Payload length: 56
    Next header: UDP (17)
    Hop limit: 255
    Source: 2001:6f8:900:8e6c:2013::132 (2001:6f8:900:8e6c:2013::132)
    Destination: ff0e::101 (ff0e::101)
    [Source GeoIP: Unknown]
    [Destination GeoIP: Unknown]
⊞ User Datagram Protocol, Src Port: 123 (123), Dst Port: 123 (123)
⊟ Network Time Protocol (NTP Version 4, broadcast)
  ⊞ Flags: 0x25
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000000 sec
    Root Delay:     0,0555 sec
    Root Dispersion:     0,0323 sec
```

```
⊞ Frame 49: 110 bytes on wire (880 bits), 110 bytes captured (880 bits)
⊞ Ethernet II, Src: 44:e4:d9:e3:77:54 (44:e4:d9:e3:77:54), Dst: 33:33:00:00:01:01 (3
⊟ Internet Protocol Version 6, Src: 2001:6f8:900:8e6c:2013::132 (2001:6f8:900:8e6c:2
  ⊞ 0110 .... = Version: 6
  ⊞ .... 1110 0000 .... .... .... .... .... = Traffic class: 0x000000e0
    .... .... .... 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000
    Payload length: 56
    Next header: UDP (17)
    Hop limit: 255
    Source: 2001:6f8:900:8e6c:2013::132 (2001:6f8:900:8e6c:2013::132)
    Destination: ff05::101 (ff05::101)
    [Source GeoIP: Unknown]
    [Destination GeoIP: Unknown]
⊞ User Datagram Protocol, Src Port: 123 (123), Dst Port: 123 (123)
⊟ Network Time Protocol (NTP Version 4, broadcast)
  ⊞ Flags: 0x25
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000000 sec
    Root Delay:     0,0555 sec
    Root Dispersion:     0,0332 sec
    Reference ID: 192.168.1.254
```

NTP Multicast versus frame.time

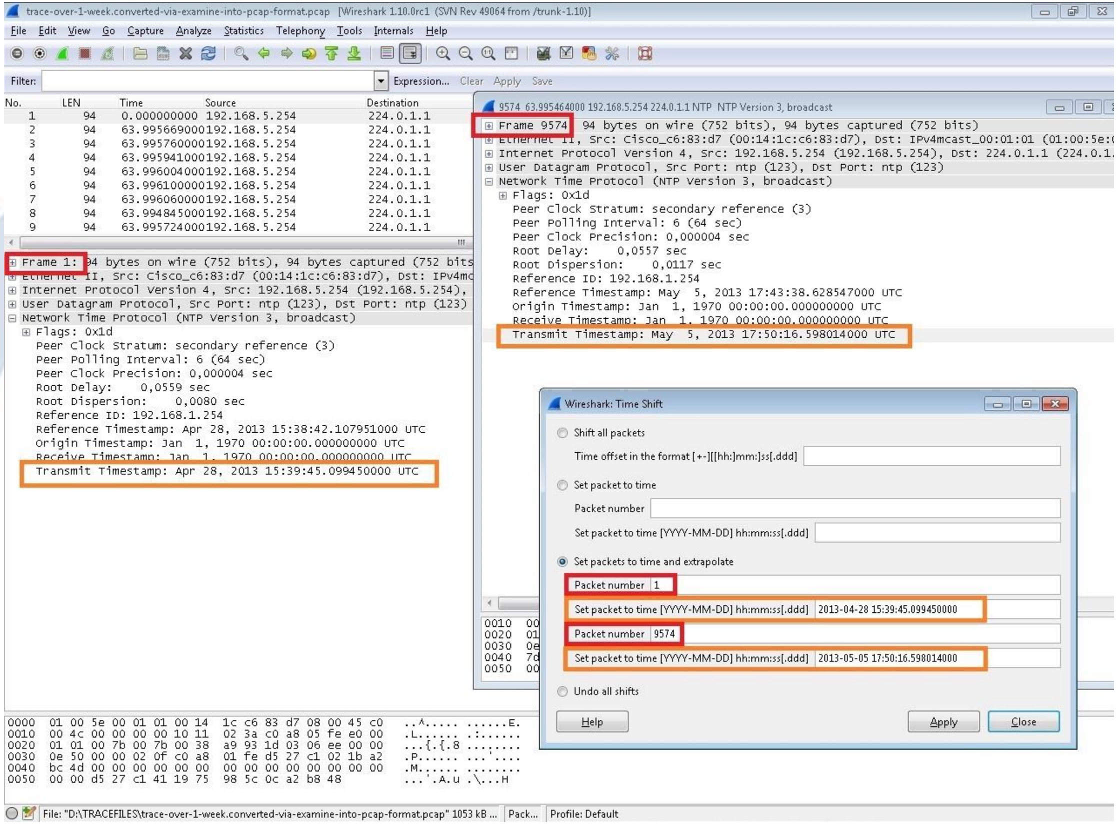


1	Transmit Timestamp						
2	Apr 28, 2013 15:39:45						
3	Apr 28, 2013 15:40:49						
4	Apr 28, 2013 15:41:53						
5	Apr 28, 2013 15:42:57						
6	Apr 28, 2013 15:44:01						
7	Apr 28, 2013 15:45:05						
8	Apr 28, 2013 15:46:09						
9	Apr 28, 2013 15:47:13						
10	Apr 28, 2013 15:48:17						
11	Apr 28, 2013 15:49:21						
12	Apr 28, 2013 15:50:25						
13	Apr 28, 2013 15:51:29						
14	Apr 28, 2013 15:52:33						
15	Apr 28, 2013 15:53:37						
16	Apr 28, 2013 15:54:41						
17	Apr 28, 2013 15:55:45						
18	Apr 28, 2013 15:56:49						
19	Apr 28, 2013 15:57:53						
20	Apr 28, 2013 15:58:57						
21	Apr 28, 2013 16:00:01						
22	Apr 28, 2013 16:01:05						
23	Apr 28, 2013 16:02:09						
24	Apr 28, 2013 16:03:13						
25	Apr 28, 2013 16:04:17						
26	Apr 28, 2013 16:05:20						
27	Apr 28, 2013 16:06:24						
28	Apr 28, 2013 16:07:28						
29	Apr 28, 2013 16:08:32						
30	Apr 28, 2013 16:09:36						
31	Apr 28, 2013 16:10:40						
32	Apr 28, 2013 16:11:44						
33	Apr 28, 2013 16:12:48						
34	Apr 28, 2013 16:13:52						
35	Apr 28, 2013 16:14:56						
36	Apr 28, 2013 16:16:00.956266000	960657000	956266000	-4391000	-4391	-4,391	-4,391
37	Apr 28, 2013 16:17:04.952047000	956580000	952047000	-4533000	-4533	-4,533	-4,533
38	Apr 28, 2013 16:18:08.947964000	951948000	947964000	-3984000	-3984	-3,984	-3,984
39	Apr 28, 2013 16:19:12.943806000	947349000	943806000	-3543000	-3543	-3,543	-3,543

Time adjustment

- Time Shift for different capture file formats – sometimes needed
- File:

“trace-over-1-week.converted-via-examine-into-pcap-format.pcap”



File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression... Clear Apply Save
Help
Apply
Close
Pack...
Profile: Default

trace-over-1-week.converted-via-examine-into-pcap-format.pcap [Wireshark 1.10.0rc1 (SVN Rev 49064 from /trunk-1.10)]

```
No.    LEN   Time        Source          Destination
  1     94   0.000000000 192.168.5.254   224.0.1.1
  2     94   63.995669000192.168.5.254   224.0.1.1
  3     94   63.995760000192.168.5.254   224.0.1.1
  4     94   63.995941000192.168.5.254   224.0.1.1
  5     94   63.996004000192.168.5.254   224.0.1.1
  6     94   63.996100000192.168.5.254   224.0.1.1
  7     94   63.996060000192.168.5.254   224.0.1.1
  8     94   63.994845000192.168.5.254   224.0.1.1
  9     94   63.995724000192.168.5.254   224.0.1.1
```

```
⊞ Frame 1: 94 bytes on wire (752 bits), 94 bytes captured (752 bits
⊞ Ethernet II, Src: Cisco_c6:83:d7 (00:14:1c:c6:83:d7), Dst: IPv4mc
⊞ Internet Protocol Version 4, Src: 192.168.5.254 (192.168.5.254),
⊞ User Datagram Protocol, Src Port: ntp (123), Dst Port: ntp (123)
⊟ Network Time Protocol (NTP Version 3, broadcast)
  ⊞ Flags: 0x1d
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000004 sec
    Root Delay:    0,0559 sec
    Root Dispersion:    0,0080 sec
    Reference ID: 192.168.1.254
    Reference Timestamp: Apr 28, 2013 15:38:42.107951000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: Apr 28, 2013 15:39:45.099450000 UTC
```

9574 63.995464000 192.168.5.254 224.0.1.1 NTP NTP Version 3, broadcast

```
⊞ Frame 9574  94 bytes on wire (752 bits), 94 bytes captured (752 bits)
⊞ Ethernet II, Src: Cisco_c6:83:d7 (00:14:1c:c6:83:d7), Dst: IPv4mcast_00:01:01 (01:00:5e:0
⊞ Internet Protocol Version 4, Src: 192.168.5.254 (192.168.5.254), Dst: 224.0.1.1 (224.0.1.
⊞ User Datagram Protocol, Src Port: ntp (123), Dst Port: ntp (123)
⊟ Network Time Protocol (NTP Version 3, broadcast)
  ⊞ Flags: 0x1d
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000004 sec
    Root Delay:    0,0557 sec
    Root Dispersion:    0,0117 sec
    Reference ID: 192.168.1.254
    Reference Timestamp: May  5, 2013 17:43:38.628547000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: May  5, 2013 17:50:16.598014000 UTC
```

Wireshark: Time Shift

○ Shift all packets

Time offset in the format [+-][[hh:]mm:]ss[.ddd]

○ Set packet to time

Packet number

Set packet to time [YYYY-MM-DD] hh:mm:ss[.ddd]

● Set packets to time and extrapolate

Packet number 1

Set packet to time [YYYY-MM-DD] hh:mm:ss[.ddd] 2013-04-28 15:39:45.099450000

Packet number 9574

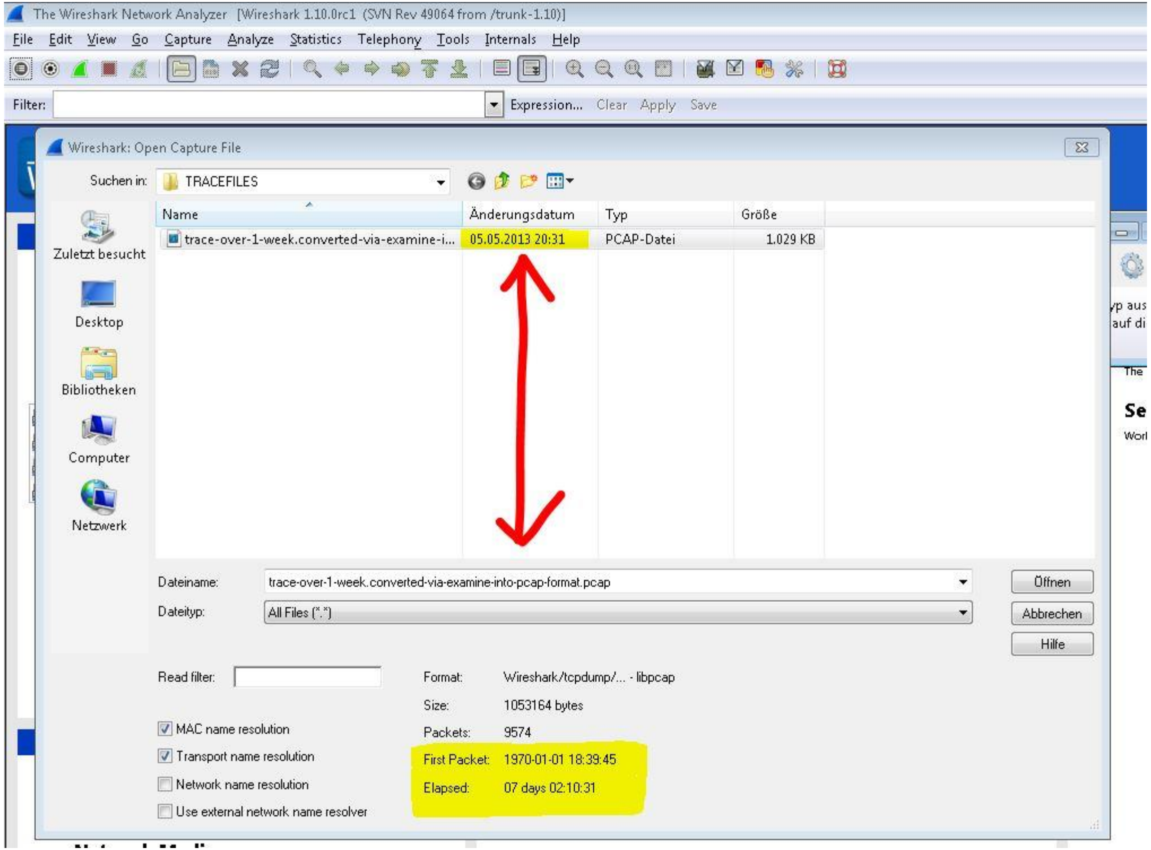
Set packet to time [YYYY-MM-DD] hh:mm:ss[.ddd] 2013-05-05 17:50:16.598014000

○ Undo all shifts

```
0000  01 00 5e 00 01 01 00 14  1c c6 83 d7 08 00 45 c0   ..^..... ......E.
0010  00 4c 00 00 00 00 10 11  02 3a c0 a8 05 fe e0 00   .L...... .:......
0020  01 01 00 7b 00 7b 00 38  a9 93 1d 03 06 ee 00 00   ...{.{.8 ........
0030  0e 50 00 00 02 0f c0 a8  01 fe d5 27 c1 02 1b a2   .P...... ...'....
0040  bc 4d 00 00 00 00 00 00  00 00 00 00 00 00 00 00   .M...... ........
0050  00 00 d5 27 c1 41 19 75  98 5c 0c a2 b8 48         ...'.A.u .\...H
```

File: "D:\TRACEFILES\trace-over-1-week.converted-via-examine-into-pcap-format.pcap" 1053 kB ...

Time adjustment – Step 1


The Wireshark Network Analyzer [Wireshark 1.10.0rc1 (SVN Rev 49064 from /trunk-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression... Clear Apply Save
Wireshark: Open Capture File
Suchen in: TRACEFILES
Zuletzt besucht
Desktop
Bibliotheken
Computer
Netzwerk
Öffnen
Abbrechen
Hilfe

Name	Änderungsdatum	Typ	Größe
trace-over-1-week.converted-via-examine-i...	05.05.2013 20:31	PCAP-Datei	1.029 KB

Dateiname: trace-over-1-week.converted-via-examine-into-pcap-format.pcap

Dateityp: All Files (*.*)

Read filter:

☑ MAC name resolution

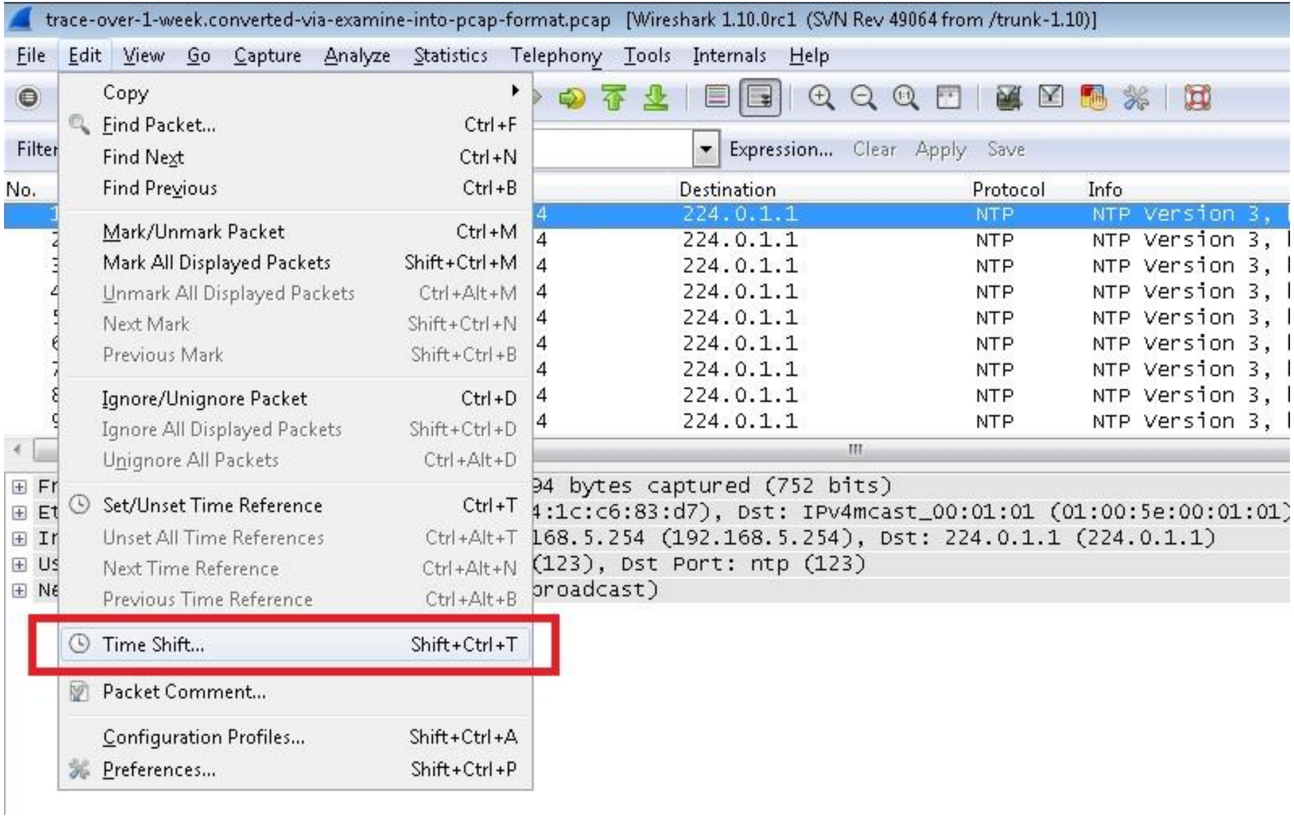
☑ Transport name resolution

☐ Network name resolution

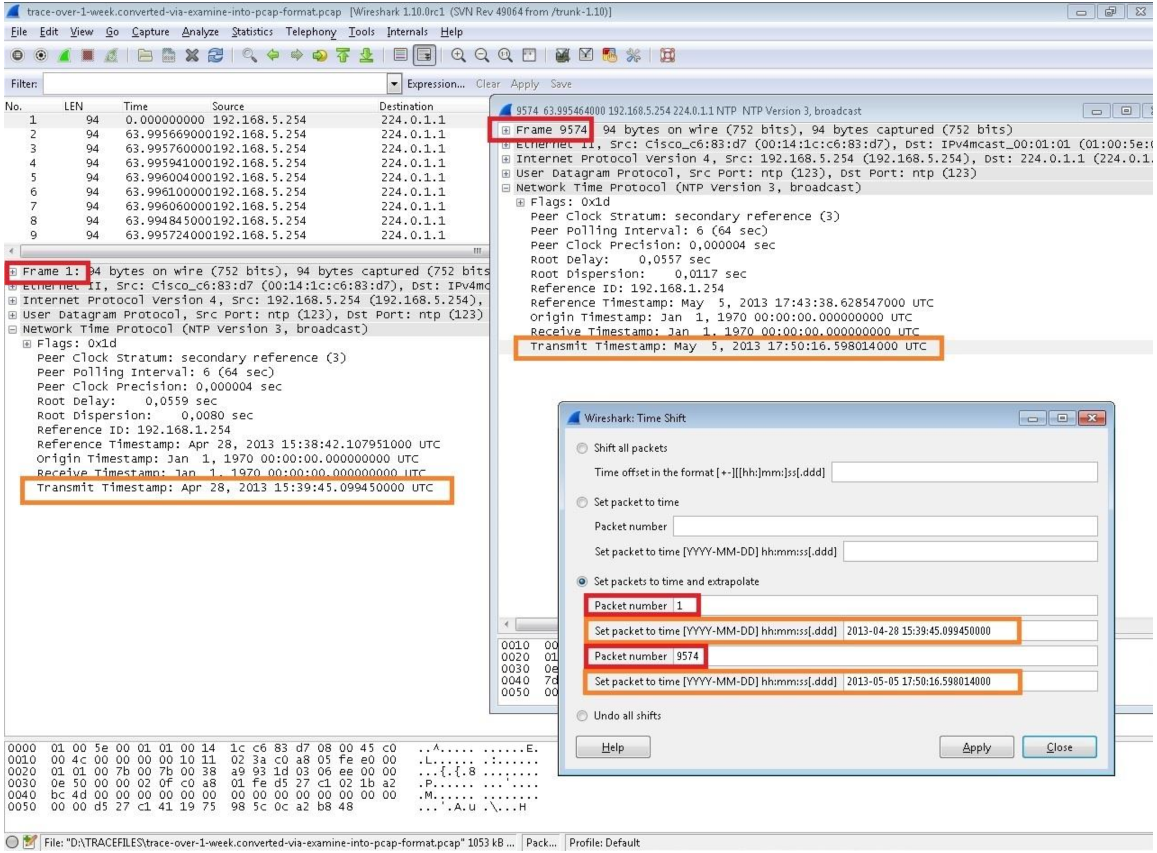
☐ Use external network name resolver

```
Format:       Wireshark/tcpdump/... - libpcap
Size:         1053164 bytes
Packets:      9574
First Packet: 1970-01-01 18:39:45
Elapsed:      07 days 02:10:31
```

Time adjustment – Step 2


trace-over-1-week.converted-via-examine-into-pcap-format.pcap [Wireshark 1.10.0rc1 (SVN Rev 49064 from /trunk-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter
Expression... Clear Apply Save
No.
Destination
Protocol
Info
Copy
Find Packet... Ctrl+F
Find Next Ctrl+N
Find Previous Ctrl+B
Mark/Unmark Packet Ctrl+M
Mark All Displayed Packets Shift+Ctrl+M
Unmark All Displayed Packets Ctrl+Alt+M
Next Mark Shift+Ctrl+N
Previous Mark Shift+Ctrl+B
Ignore/Unignore Packet Ctrl+D
Ignore All Displayed Packets Shift+Ctrl+D
Unignore All Packets Ctrl+Alt+D
Set/Unset Time Reference Ctrl+T
Unset All Time References Ctrl+Alt+T
Next Time Reference Ctrl+Alt+N
Previous Time Reference Ctrl+Alt+B
Time Shift... Shift+Ctrl+T
Packet Comment...
Configuration Profiles... Shift+Ctrl+A
Preferences... Shift+Ctrl+P
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
4 224.0.1.1 NTP NTP Version 3,
Fr 94 bytes captured (752 bits)
Et 4:1c:c6:83:d7), Dst: IPv4mcast_00:01:01 (01:00:5e:00:01:01)
Ir 168.5.254 (192.168.5.254), Dst: 224.0.1.1 (224.0.1.1)
Us (123), Dst Port: ntp (123)
Ne broadcast)

Time adjustment – Step 3


trace-over-1-week.converted-via-examine-into-pcap-format.pcap [Wireshark 1.10.0rc1 (SVN Rev 49064 from /trunk-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression... Clear Apply Save

```
No.     LEN   Time        Source              Destination
  1      94   0.000000000 192.168.5.254       224.0.1.1
  2      94   63.995669000192.168.5.254       224.0.1.1
  3      94   63.995760000192.168.5.254       224.0.1.1
  4      94   63.995941000192.168.5.254       224.0.1.1
  5      94   63.996004000192.168.5.254       224.0.1.1
  6      94   63.996100000192.168.5.254       224.0.1.1
  7      94   63.996060000192.168.5.254       224.0.1.1
  8      94   63.994845000192.168.5.254       224.0.1.1
  9      94   63.995724000192.168.5.254       224.0.1.1
```

```
⊞ Frame 1: 94 bytes on wire (752 bits), 94 bytes captured (752 bits
⊞ Ethernet II, Src: Cisco_c6:83:d7 (00:14:1c:c6:83:d7), Dst: IPv4mc
⊞ Internet Protocol Version 4, Src: 192.168.5.254 (192.168.5.254),
⊞ User Datagram Protocol, Src Port: ntp (123), Dst Port: ntp (123)
⊟ Network Time Protocol (NTP Version 3, broadcast)
  ⊞ Flags: 0x1d
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000004 sec
    Root Delay:    0,0559 sec
    Root Dispersion:    0,0080 sec
    Reference ID: 192.168.1.254
    Reference Timestamp: Apr 28, 2013 15:38:42.107951000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: Apr 28, 2013 15:39:45.099450000 UTC
```

```
0000  01 00 5e 00 01 01 00 14  1c c6 83 d7 08 00 45 c0   ..^..... ......E.
0010  00 4c 00 00 00 00 10 11  02 3a c0 a8 05 fe e0 00   .L...... .:......
0020  01 01 00 7b 00 7b 00 38  a9 93 1d 03 06 ee 00 00   ...{.{.8 ........
0030  0e 50 00 00 02 0f c0 a8  01 fe d5 27 c1 02 1b a2   .P...... ...'....
0040  bc 4d 00 00 00 00 00 00  00 00 00 00 00 00 00 00   .M...... ........
0050  00 00 d5 27 c1 41 19 75  98 5c 0c a2 b8 48         ...'.A.u .\...H
```

File: "D:\TRACEFILES\trace-over-1-week.converted-via-examine-into-pcap-format.pcap" 1053 kB ... | Pack... | Profile: Default

9574 63.995464000 192.168.5.254 224.0.1.1 NTP NTP Version 3, broadcast

```
⊞ Frame 9574  94 bytes on wire (752 bits), 94 bytes captured (752 bits)
⊞ Ethernet II, Src: Cisco_c6:83:d7 (00:14:1c:c6:83:d7), Dst: IPv4mcast_00:01:01 (01:00:5e:
⊞ Internet Protocol Version 4, Src: 192.168.5.254 (192.168.5.254), Dst: 224.0.1.1 (224.0.1.
⊞ User Datagram Protocol, Src Port: ntp (123), Dst Port: ntp (123)
⊟ Network Time Protocol (NTP Version 3, broadcast)
  ⊞ Flags: 0x1d
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000004 sec
    Root Delay:    0,0557 sec
    Root Dispersion:    0,0117 sec
    Reference ID: 192.168.1.254
    Reference Timestamp: May  5, 2013 17:43:38.628547000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: May  5, 2013 17:50:16.598014000 UTC
```

```
0010  00
0020  01
0030  0e
0040  7d
0050  00
```

Wireshark: Time Shift

○ Shift all packets

Time offset in the format [+-][[hh:]mm:]ss[.ddd]

○ Set packet to time

Packet number

Set packet to time [YYYY-MM-DD] hh:mm:ss[.ddd]

● Set packets to time and extrapolate

Packet number: 1

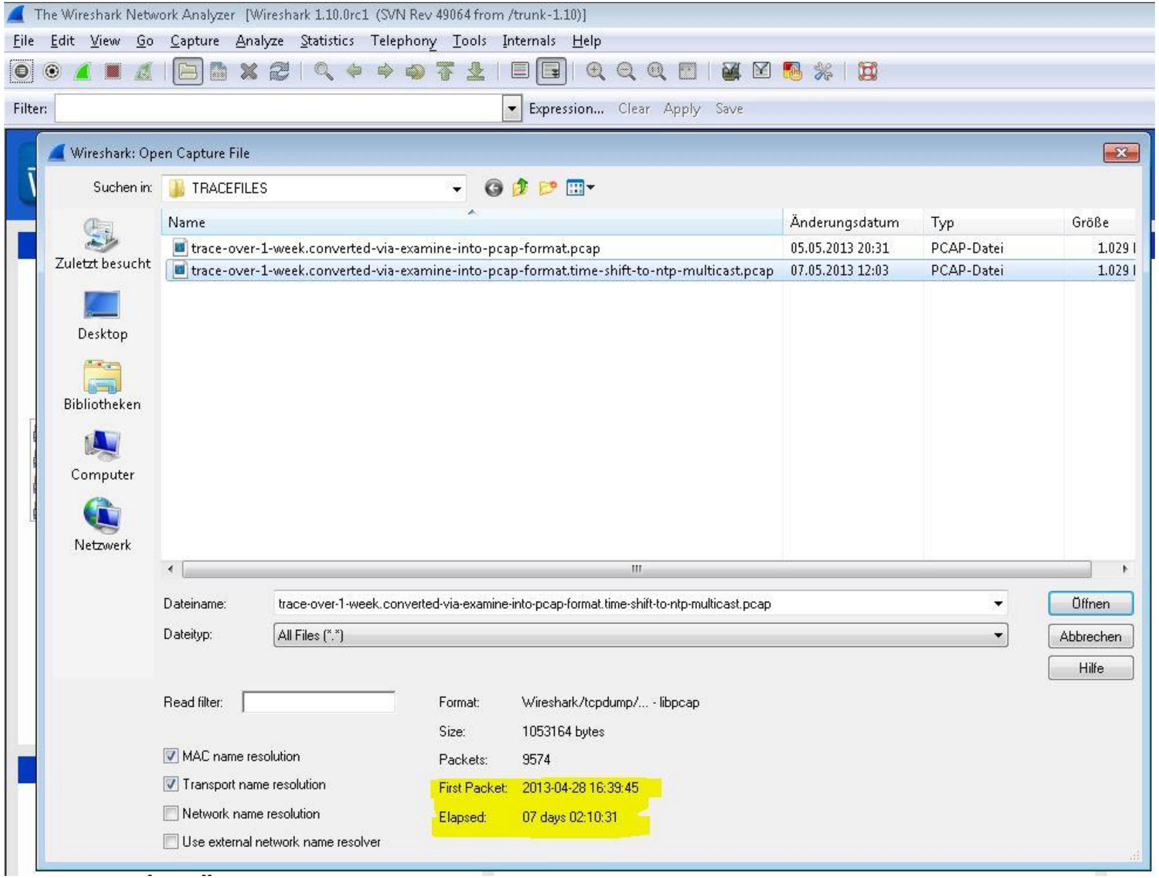
Set packet to time [YYYY-MM-DD] hh:mm:ss[.ddd]: 2013-04-28 15:39:45.099450000

Packet number: 9574

Set packet to time [YYYY-MM-DD] hh:mm:ss[.ddd]: 2013-05-05 17:50:16.598014000

○ Undo all shifts

Time adjustment – Step 4


The Wireshark Network Analyzer [Wireshark 1.10.0rc1 (SVN Rev 49064 from /trunk-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression... Clear Apply Save
Wireshark: Open Capture File
Suchen in: TRACEFILES
Zuletzt besucht
Desktop
Bibliotheken
Computer
Netzwerk
Öffnen
Abbrechen
Hilfe

Name	Änderungsdatum	Typ	Größe
trace-over-1-week.converted-via-examine-into-pcap-format.pcap	05.05.2013 20:31	PCAP-Datei	1.029 I
trace-over-1-week.converted-via-examine-into-pcap-format.time-shift-to-ntp-multicast.pcap	07.05.2013 12:03	PCAP-Datei	1.029 I

Dateiname: trace-over-1-week.converted-via-examine-into-pcap-format.time-shift-to-ntp-multicast.pcap

Dateityp: All Files (*.*)

Read filter:

☑ MAC name resolution

☑ Transport name resolution

☐ Network name resolution

☐ Use external network name resolver

Format: Wireshark/tcpdump/... - libpcap

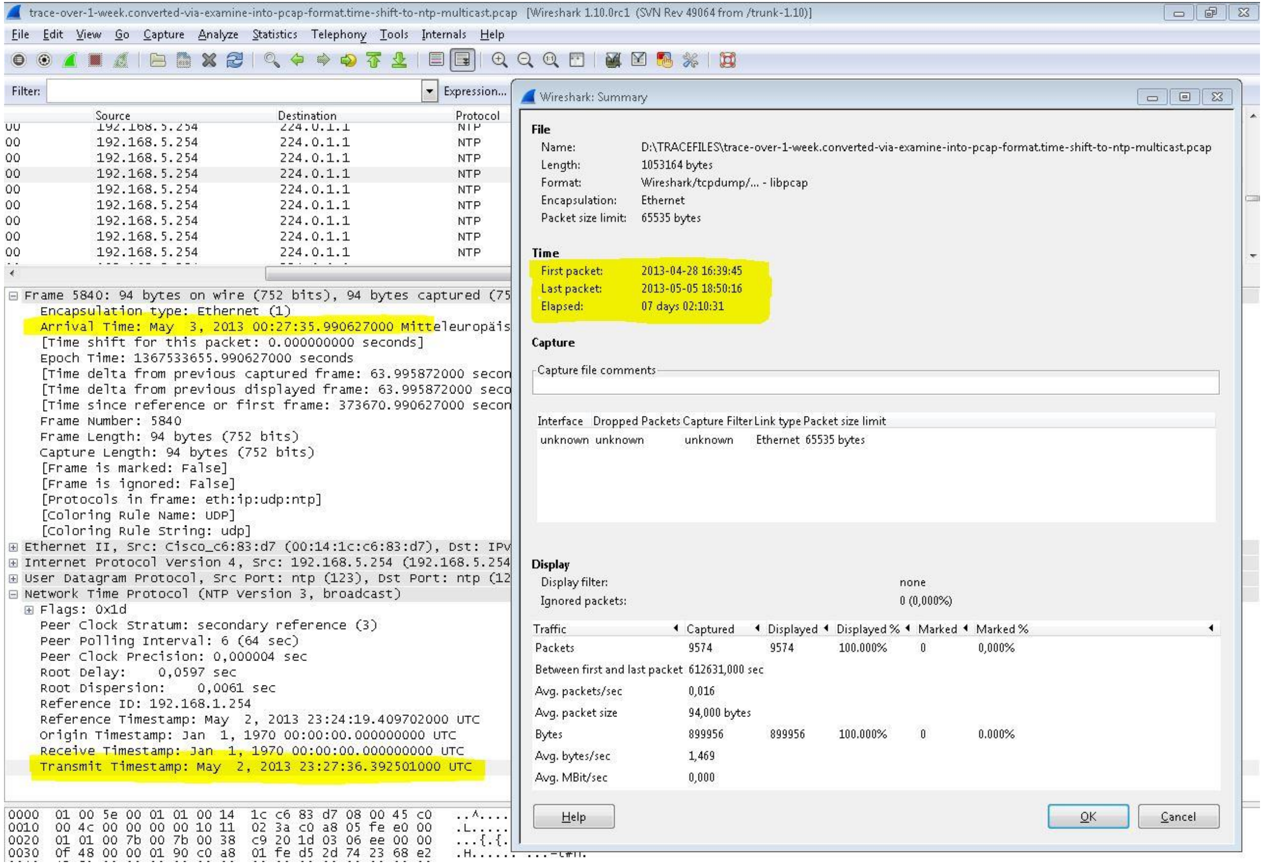
Size: 1053164 bytes

Packets: 9574

First Packet: 2013-04-28 16:39:45

Elapsed: 07 days 02:10:31

Time adjustment – Step 5


trace-over-1-week.converted-via-examine-into-pcap-format.time-shift-to-ntp-multicast.pcap [Wireshark 1.10.0rc1 (SVN Rev 49064 from /trunk-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression...
Wireshark: Summary

```
      Source          Destination     Protocol
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
00    192.168.5.254   224.0.1.1       NTP
```

```
⊟ Frame 5840: 94 bytes on wire (752 bits), 94 bytes captured (75
    Encapsulation type: Ethernet (1)
    Arrival Time: May  3, 2013 00:27:35.990627000 Mitteleuropäis
    [Time shift for this packet: 0.000000000 seconds]
    Epoch Time: 1367533655.990627000 seconds
    [Time delta from previous captured frame: 63.995872000 secon
    [Time delta from previous displayed frame: 63.995872000 seco
    [Time since reference or first frame: 373670.990627000 secon
    Frame Number: 5840
    Frame Length: 94 bytes (752 bits)
    Capture Length: 94 bytes (752 bits)
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: eth:ip:udp:ntp]
    [Coloring Rule Name: UDP]
    [Coloring Rule String: udp]
⊞ Ethernet II, Src: Cisco_c6:83:d7 (00:14:1c:c6:83:d7), Dst: IPv
⊞ Internet Protocol Version 4, Src: 192.168.5.254 (192.168.5.254
⊞ User Datagram Protocol, Src Port: ntp (123), Dst Port: ntp (12
⊟ Network Time Protocol (NTP Version 3, broadcast)
  ⊞ Flags: 0x1d
    Peer Clock Stratum: secondary reference (3)
    Peer Polling Interval: 6 (64 sec)
    Peer Clock Precision: 0,000004 sec
    Root Delay:     0,0597 sec
    Root Dispersion:     0,0061 sec
    Reference ID: 192.168.1.254
    Reference Timestamp: May  2, 2013 23:24:19.409702000 UTC
    Origin Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Receive Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Transmit Timestamp: May  2, 2013 23:27:36.392501000 UTC
```

```
0000  01 00 5e 00 01 01 00 14  1c c6 83 d7 08 00 45 c0   ..^.....
0010  00 4c 00 00 00 00 10 11  02 3a c0 a8 05 fe e0 00   .L......
0020  01 01 00 7b 00 7b 00 38  c9 20 1d 03 06 ee 00 00   ...{.{.
0030  0f 48 00 00 01 90 c0 a8  01 fe d5 2d 74 23 68 e2   .H...... ...-t#h.
```

File

Name:	D:\TRACEFILES\trace-over-1-week.converted-via-examine-into-pcap-format.time-shift-to-ntp-multicast.pcap
Length:	1053164 bytes
Format:	Wireshark/tcpdump/... - libpcap
Encapsulation:	Ethernet
Packet size limit:	65535 bytes

Time

First packet:	2013-04-28 16:39:45
Last packet:	2013-05-05 18:50:16
Elapsed:	07 days 02:10:31

Capture

Capture file comments

Interface	Dropped Packets	Capture Filter	Link type	Packet size limit
unknown	unknown	unknown	Ethernet	65535 bytes

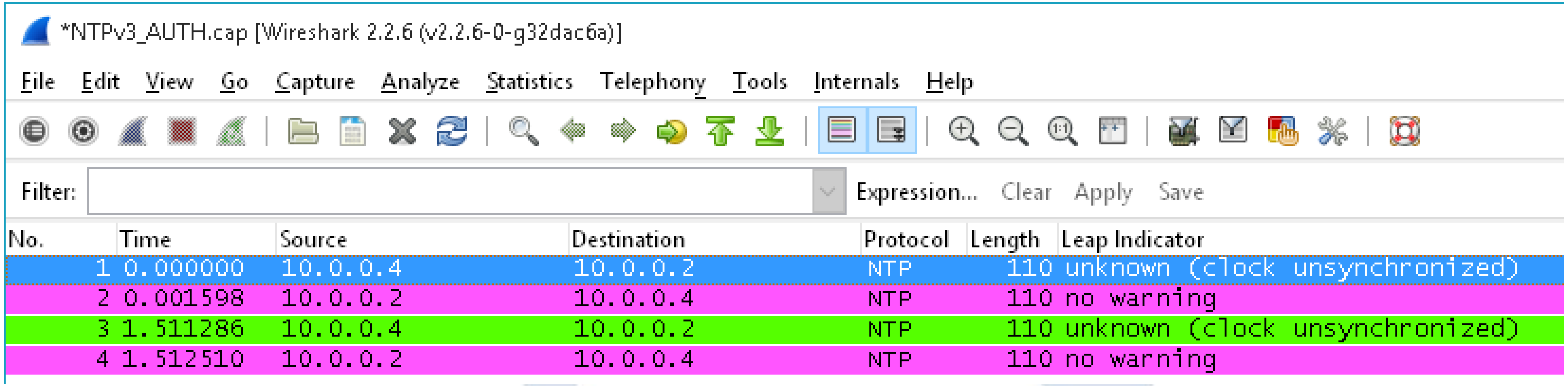
Display

Display filter:	none
Ignored packets:	0 (0,000%)

Traffic	Captured	Displayed	Displayed %	Marked	Marked %
Packets	9574	9574	100.000%	0	0,000%
Between first and last packet	612631,000 sec				
Avg. packets/sec	0,016				
Avg. packet size	94,000 bytes				
Bytes	899956	899956	100.000%	0	0.000%
Avg. bytes/sec	1,469				
Avg. MBit/sec	0,000				

NTP Coloring Rule

- Colors for various NTP message types

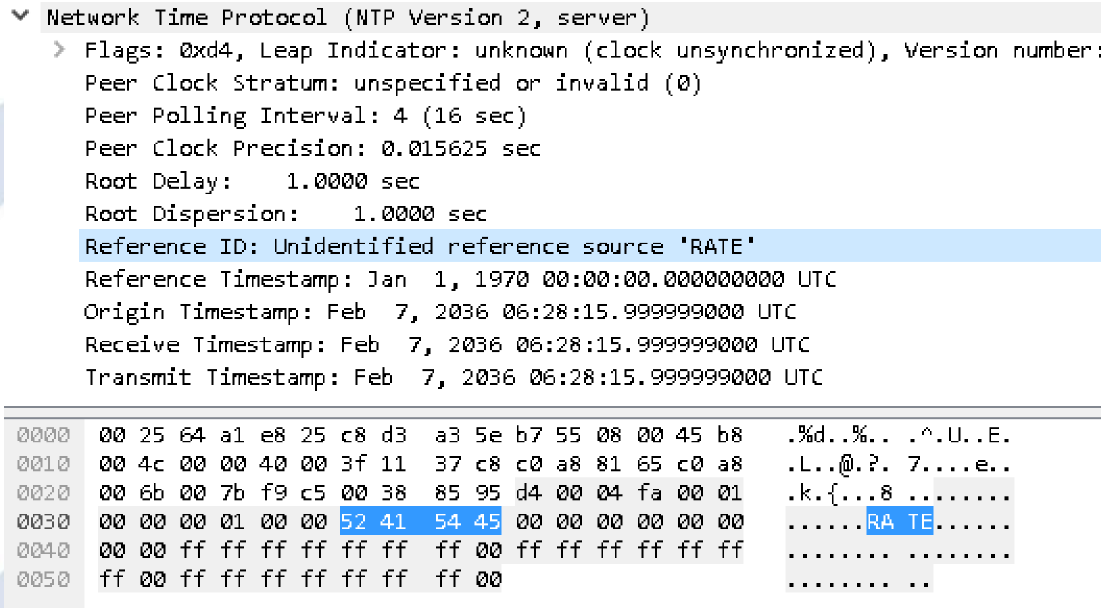

*NTPv3_AUTH.cap [Wireshark 2.2.6 (v2.2.6-0-g32dac6a)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter:
Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Leap Indicator
1	0.000000	10.0.0.4	10.0.0.2	NTP	110	unknown (clock unsynchronized)
2	0.001598	10.0.0.2	10.0.0.4	NTP	110	no warning
3	1.511286	10.0.0.4	10.0.0.2	NTP	110	unknown (clock unsynchronized)
4	1.512510	10.0.0.2	10.0.0.4	NTP	110	no warning

- Wireshark Color Filters for NTP – useful!

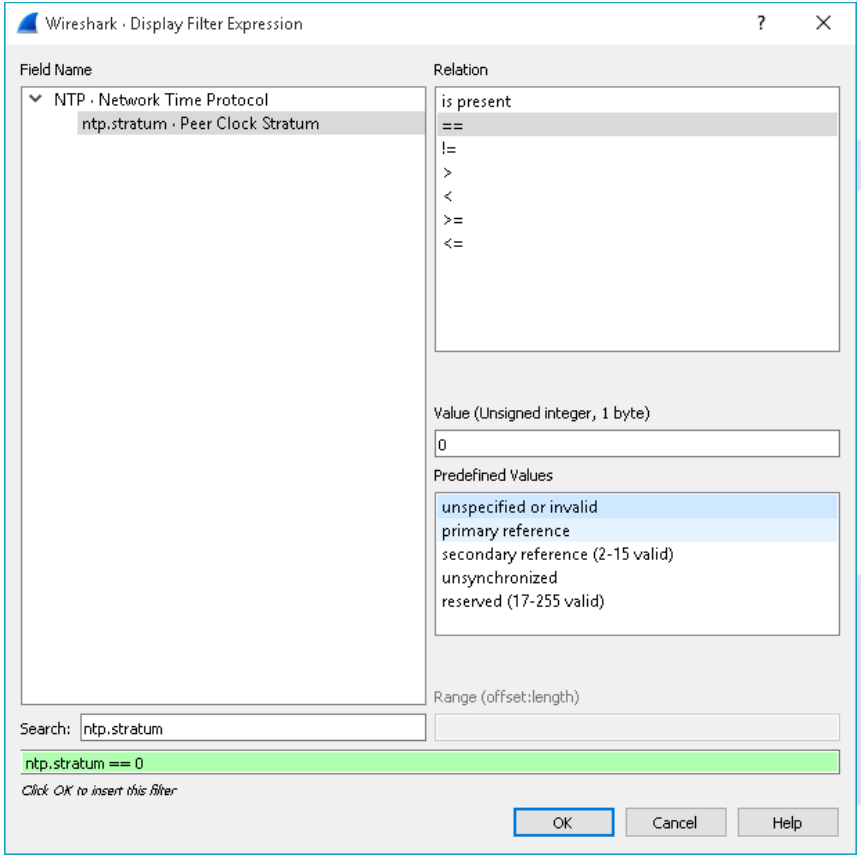
NTP Kiss-of-Death

- Kiss-of-Death packets are used by NTP servers to rate-limit NTP client requests that query too frequently
- Kiss of Death is a **<u>not</u>** a NTP protection protocol



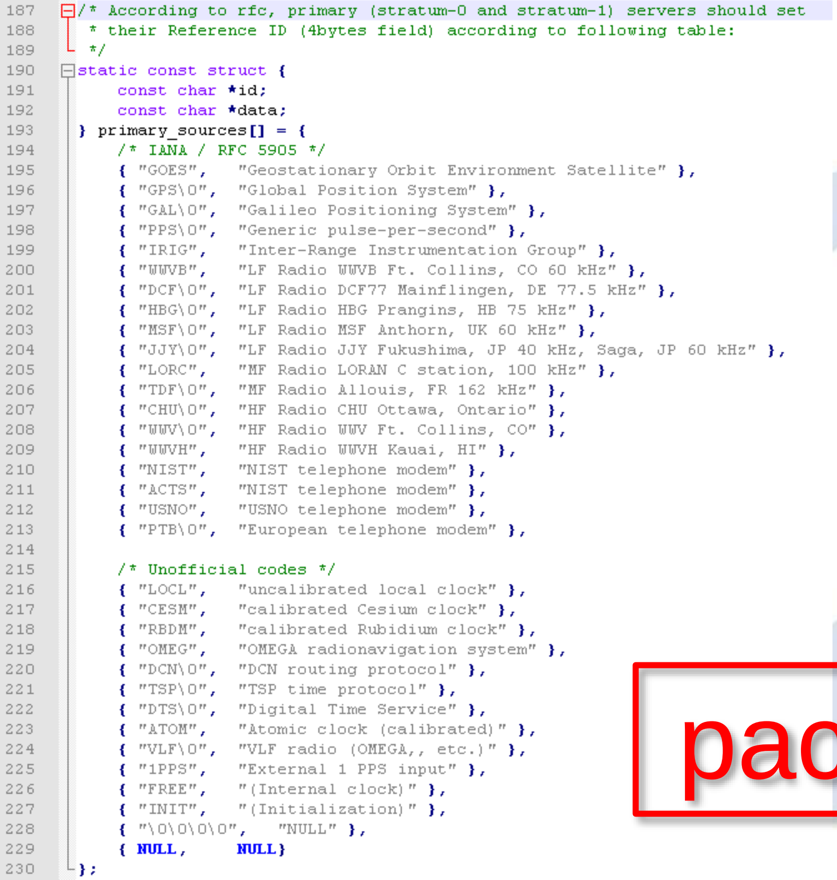
```
v Network Time Protocol (NTP Version 2, server)
  > Flags: 0xd4, Leap Indicator: unknown (clock unsynchronized), Version number
    Peer Clock Stratum: unspecified or invalid (0)
    Peer Polling Interval: 4 (16 sec)
    Peer Clock Precision: 0.015625 sec
    Root Delay:    1.0000 sec
    Root Dispersion:    1.0000 sec
    Reference ID: Unidentified reference source 'RATE'
    Reference Timestamp: Jan  1, 1970 00:00:00.000000000 UTC
    Origin Timestamp: Feb  7, 2036 06:28:15.999999000 UTC
    Receive Timestamp: Feb  7, 2036 06:28:15.999999000 UTC
    Transmit Timestamp: Feb  7, 2036 06:28:15.999999000 UTC

0000  00 25 64 a1 e8 25 c8 d3  a3 5e b7 55 08 00 45 b8   .%d..%.. .^.U..E.
0010  00 4c 00 00 40 00 3f 11  37 c8 c0 a8 81 65 c0 a8   .L..@.?. 7....e..
0020  00 6b 00 7b f9 c5 00 38  85 95 d4 00 04 fa 00 01   .k.{...8 ........
0030  00 00 00 01 00 00 52 41  54 45 00 00 00 00 00 00   ......RA TE......
0040  00 00 ff ff ff ff ff ff  ff 00 ff ff ff ff ff ff   ........ ........
0050  ff 00 ff ff ff ff ff ff  ff 00                     ........ ..
```

ntp.stratum · Peer Clock Stratum



- Stratum is a concept used in NTP and its value indicates the clocks location in the hierarchy
- While a lower stratum often indicates a more accurate clock
- BTW: 2^{256} seconds ?

ntp.refid · Reference ID



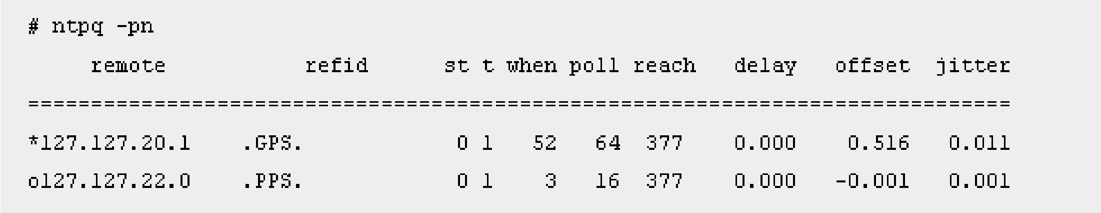
```
/* According to rfc, primary (stratum-0 and stratum-1) servers should set
 * their Reference ID (4bytes field) according to following table:
 */
static const struct {
    const char *id;
    const char *data;
} primary_sources[] = {
    /* IANA / RFC 5905 */
    { "GOES",   "Geostationary Orbit Environment Satellite" },
    { "GPS\0",  "Global Position System" },
    { "GAL\0",  "Galileo Positioning System" },
    { "PPS\0",  "Generic pulse-per-second" },
    { "IRIG",   "Inter-Range Instrumentation Group" },
    { "WWVB",   "LF Radio WWVB Ft. Collins, CO 60 kHz" },
    { "DCF\0",  "LF Radio DCF77 Mainflingen, DE 77.5 kHz" },
    { "HBG\0",  "LF Radio HBG Prangins, HB 75 kHz" },
    { "MSF\0",  "LF Radio MSF Anthorn, UK 60 kHz" },
    { "JJY\0",  "LF Radio JJY Fukushima, JP 40 kHz, Saga, JP 60 kHz" },
    { "LORC",   "MF Radio LORAN C station, 100 kHz" },
    { "TDF\0",  "MF Radio Allouis, FR 162 kHz" },
    { "CHU\0",  "HF Radio CHU Ottawa, Ontario" },
    { "WWV\0",  "HF Radio WWV Ft. Collins, CO" },
    { "WWVH",   "HF Radio WWVH Kauai, HI" },
    { "NIST",   "NIST telephone modem" },
    { "ACTS",   "NIST telephone modem" },
    { "USNO",   "USNO telephone modem" },
    { "PTB\0",  "European telephone modem" },

    /* Unofficial codes */
    { "LOCL",   "uncalibrated local clock" },
    { "CESM",   "calibrated Cesium clock" },
    { "RBDM",   "calibrated Rubidium clock" },
    { "OMEG",   "OMEGA radionavigation system" },
    { "DCN\0",  "DCN routing protocol" },
    { "TSP\0",  "TSP time protocol" },
    { "DTS\0",  "Digital Time Service" },
    { "ATOM",   "Atomic clock (calibrated)" },
    { "VLF\0",  "VLF radio (OMEGA,, etc.)" },
    { "1PPS",   "External 1 PPS input" },
    { "FREE",   "(Internal clock)" },
    { "INIT",   "(Initialization)" },
    { "\0\0\0\0",   "NULL" },
    { NULL,     NULL}
};
```

- Research in the source code – some interesting info
- Use a ASCII2HEX converter for your display filter ☺

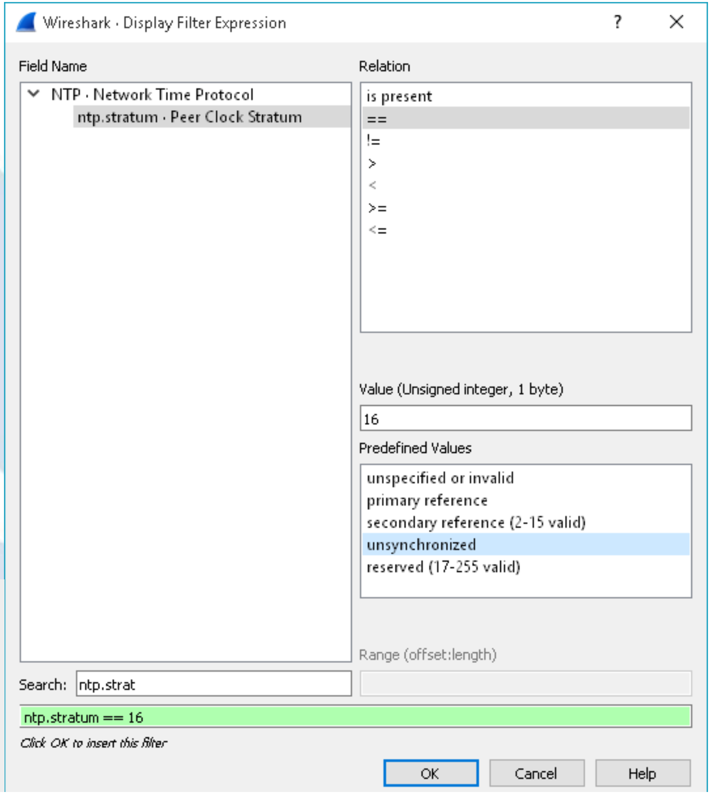
packet-ntp.c

NTP Stratum

- Stratum levels define the distance from the reference clock
- A NTP server that is directly connected to a stratum-0 device is called a stratum-1 server
- NTP clients need some way of judging which time sources are likely to be the most accurate and preventing timing loops
- An NTP client synchronized from a Stratum 4 source would be a Stratum 5 device



```
# ntpq -pn
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
*127.127.20.1    .GPS.            0 l   52   64  377    0.000    0.516   0.011
o127.127.22.0    .PPS.            0 l    3   16  377    0.000   -0.001   0.001
```



Wireshark · Display Filter Expression

Field Name

NTP · Network Time Protocol

ntp.stratum · Peer Clock Stratum

Relation

is present
==
!=
>
<
>=
<=

Value (Unsigned integer, 1 byte)

16

Predefined Values

unspecified or invalid
primary reference
secondary reference (2-15 valid)
unsynchronized
reserved (17-255 valid)

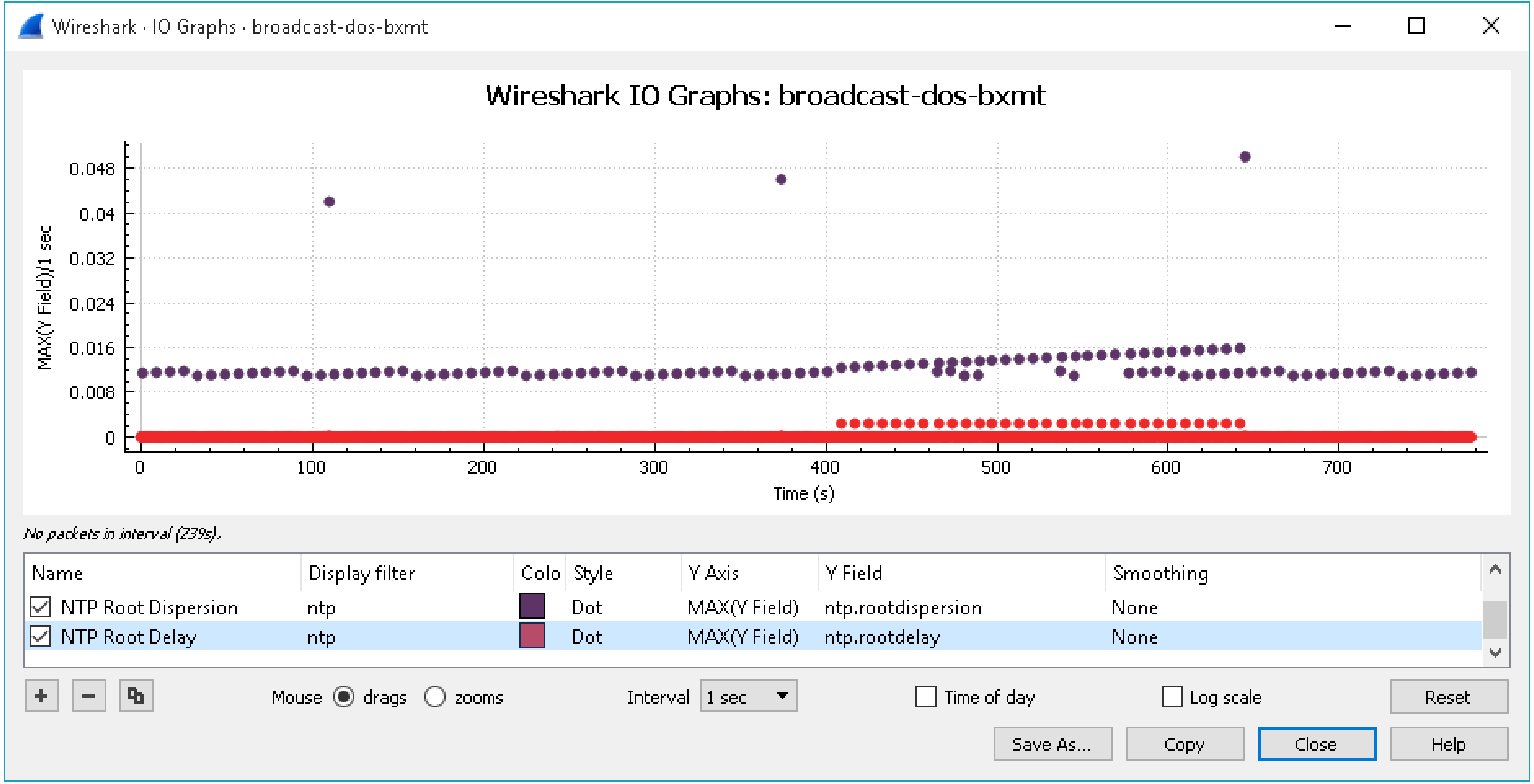
Range (offset:length)

Search: ntp.strat

ntp.stratum == 16

Click OK to insert this filter

NTP Root Delay / Dispersion Monitoring / IO-Graph


Wireshark · IO Graphs · broadcast-dos-bxmt
Wireshark IO Graphs: broadcast-dos-bxmt
MAX(Y Field)/1 sec
0.048
0.04
0.032
0.024
0.016
0.008
0
0
100
200
300
400
500
600
700
Time (s)

No packets in interval (239s).

	Name	Display filter	Colo	Style	Y Axis	Y Field	Smoothing
☑	NTP Root Dispersion	ntp	🟪	Dot	MAX(Y Field)	ntp.rootdispersion	None
☑	NTP Root Delay	ntp	🟥	Dot	MAX(Y Field)	ntp.rootdelay	None

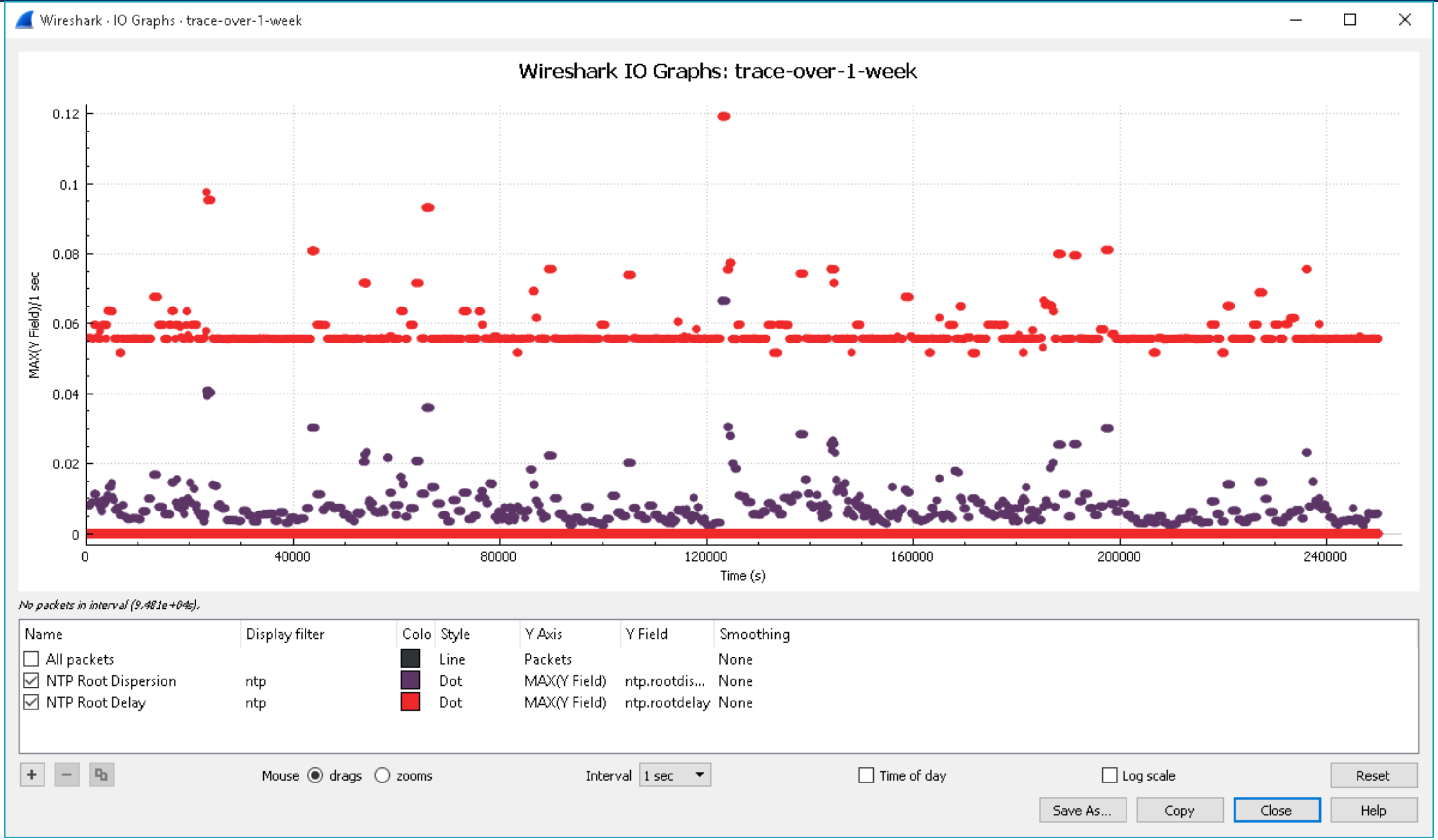
Mouse ● drags ○ zooms

Interval 1 sec

□ Time of day

□ Log scale

NTP Root Delay / Dispersion Monitoring / IO-Graph



No packets in interval (9.481e+04s).

Name	Display filter	Colo	Style	Y Axis	Y Field	Smoothing
☐ All packets		⬛	Line	Packets		None
☑ NTP Root Dispersion	ntp	🟪	Dot	MAX(Y Field)	ntp.rootdis...	None
☑ NTP Root Delay	ntp	🟥	Dot	MAX(Y Field)	ntp.rootdelay	None

Mouse ● drags ○ zooms

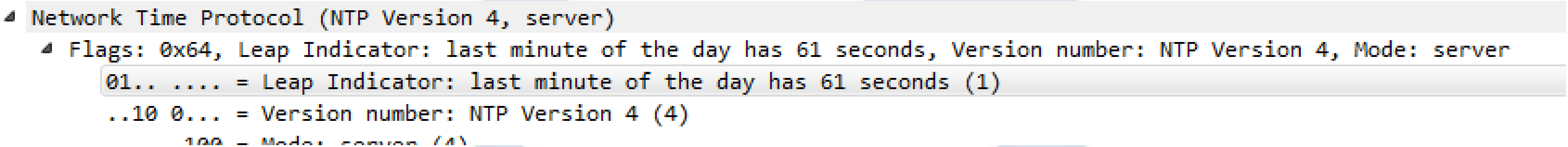
Interval 1 sec

☐ Time of day

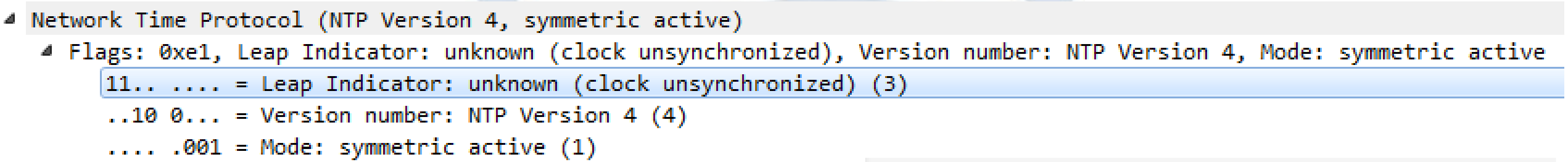
☐ Log scale

NTP Leap Seconds

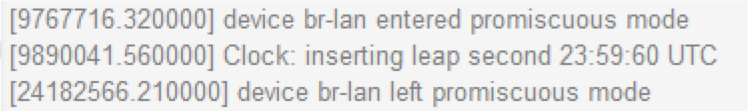
- Leap seconds are scheduled to be inserted into or deleted from the UTC time scale in irregular intervals to keep the UTC time scale synchronized with the Earth rotation



```
◢ Network Time Protocol (NTP Version 4, server)
  ◢ Flags: 0x64, Leap Indicator: last minute of the day has 61 seconds, Version number: NTP Version 4, Mode: server
      01.. .... = Leap Indicator: last minute of the day has 61 seconds (1)
      ..10 0... = Version number: NTP Version 4 (4)
      .... .100 = Mode: server (4)
```



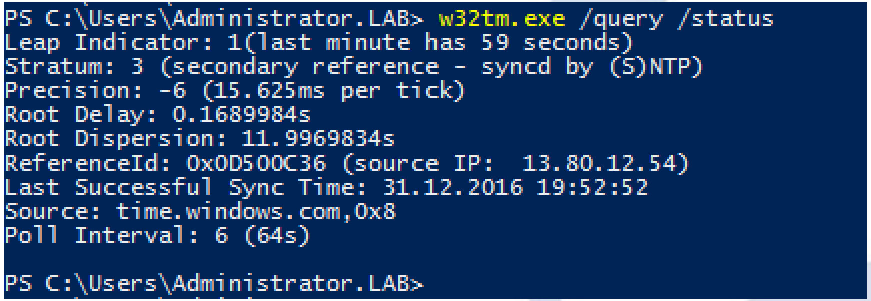
```
◢ Network Time Protocol (NTP Version 4, symmetric active)
  ◢ Flags: 0xe1, Leap Indicator: unknown (clock unsynchronized), Version number: NTP Version 4, Mode: symmetric active
      11.. .... = Leap Indicator: unknown (clock unsynchronized) (3)
      ..10 0... = Version number: NTP Version 4 (4)
      .... .001 = Mode: symmetric active (1)
    Peer Clock Stratum: unspecified or invalid (0)
```



```
[9767716.320000] device br-lan entered promiscuous mode
[9890041.560000] Clock: inserting leap second 23:59:60 UTC
[24182566.210000] device br-lan left promiscuous mode
```

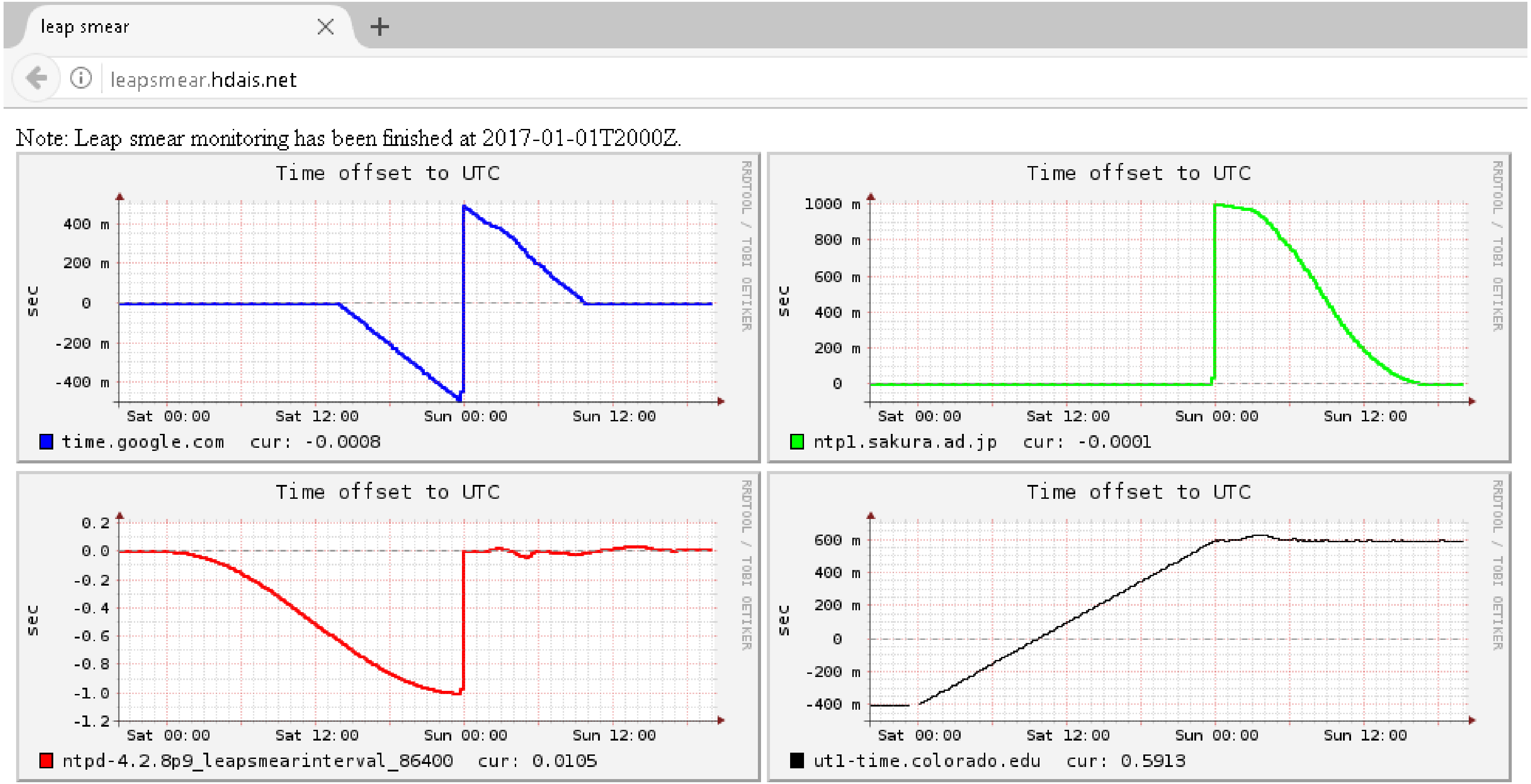
NTP Leap Seconds Smearing

- Workaround for systems get confused if the time is stepped back
- Duplicate timestamps can occur



```
PS C:\Users\Administrator.LAB> w32tm.exe /query /status
Leap Indicator: 1(last minute has 59 seconds)
Stratum: 3 (secondary reference - syncd by (S)NTP)
Precision: -6 (15.625ms per tick)
Root Delay: 0.1689984s
Root Dispersion: 11.9969834s
ReferenceId: 0x0D500C36 (source IP:  13.80.12.54)
Last Successful Sync Time: 31.12.2016 19:52:52
Source: time.windows.com,0x8
Poll Interval: 6 (64s)

PS C:\Users\Administrator.LAB>
```

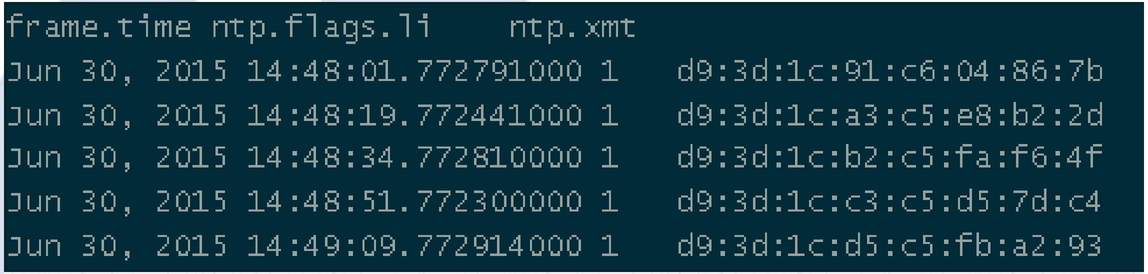
NTP Leap Smearing Monitoring



Note: Leap smear monitoring has been finished at 2017-01-01T2000Z.

Watching NTP leap second with tshark

-
  ```
  tshark -ni eth0 port 123 -R ntp.flags.mode==4 -Eheader=y -Tfields \
  -e frame.time \
  -e ntp.flags.li \
  -e ntp.xmt
  ```



```
frame.time ntp.flags.li    ntp.xmt
Jun 30, 2015 14:48:01.772791000 1   d9:3d:1c:91:c6:04:86:7b
Jun 30, 2015 14:48:19.772441000 1   d9:3d:1c:a3:c5:e8:b2:2d
Jun 30, 2015 14:48:34.772810000 1   d9:3d:1c:b2:c5:fa:f6:4f
Jun 30, 2015 14:48:51.772300000 1   d9:3d:1c:c3:c5:d5:7d:c4
Jun 30, 2015 14:49:09.772914000 1   d9:3d:1c:d5:c5:fb:a2:93
```

Reference:

http://www.theptpguy.net/posts/2015/06/30/watching-the-leap-second-with-tshark

NTP to calibrate your capture file

- Tipp: Use Multicast NTP when possible
- Compare frame.time versus transmit timestamp

  https://isc.sans.edu/forums/diary/What+Time+Is+It+Using+NTP+Traffic+to+Calibrate+PCAP+Timestamps/21135/

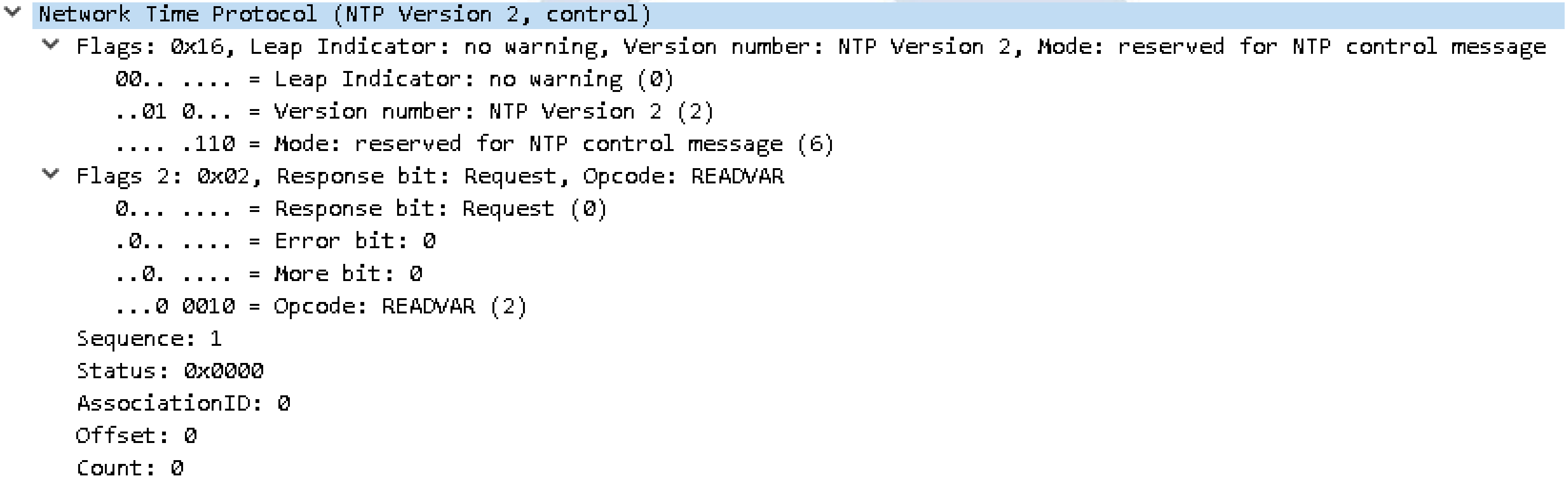
Public NTP Scanning Websites

- Open NTP Monitor (Mode 7) Scanning Project
  - https://ntpmonitorscan.shadowserver.org/
- OpenNTPProject.org - NTP Scanning Project
  - http://www.openntpproject.org/

NTP Mode 6

- Using Nmap – the easiest way ☺

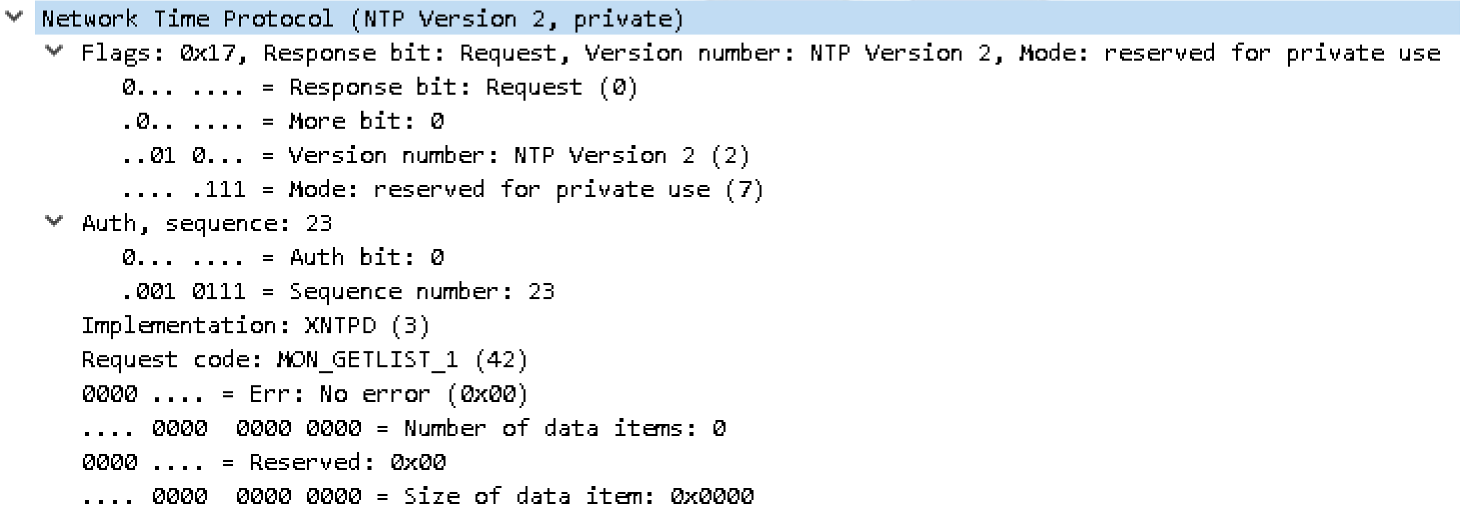
- Mode 6
  - nmap -sU -pU:123 -Pn -n --script=ntp-info <IP>



```
Network Time Protocol (NTP Version 2, control)
  Flags: 0x16, Leap Indicator: no warning, Version number: NTP Version 2, Mode: reserved for NTP control message
     00.. .... = Leap Indicator: no warning (0)
     ..01 0... = Version number: NTP Version 2 (2)
     .... .110 = Mode: reserved for NTP control message (6)
  Flags 2: 0x02, Response bit: Request, Opcode: READVAR
     0... .... = Response bit: Request (0)
     .0.. .... = Error bit: 0
     ..0. .... = More bit: 0
     ...0 0010 = Opcode: READVAR (2)
  Sequence: 1
  Status: 0x0000
  AssociationID: 0
  Offset: 0
  Count: 0
```

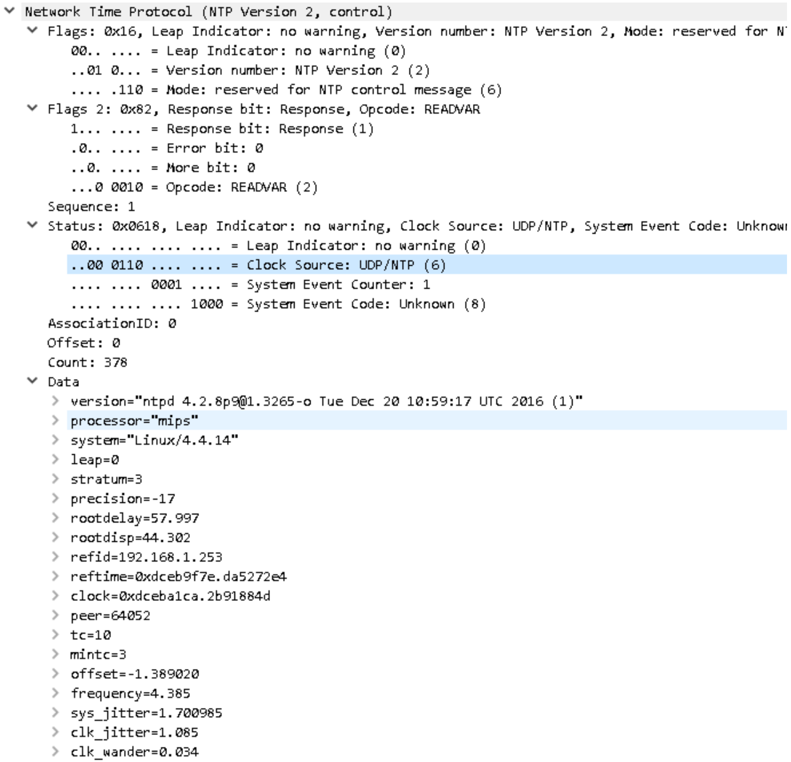
NTP Mode 7

- Mode 7 with Nmap
  - nmap -sU -pU:123 -Pn -n --script=ntp-monlist <IP>

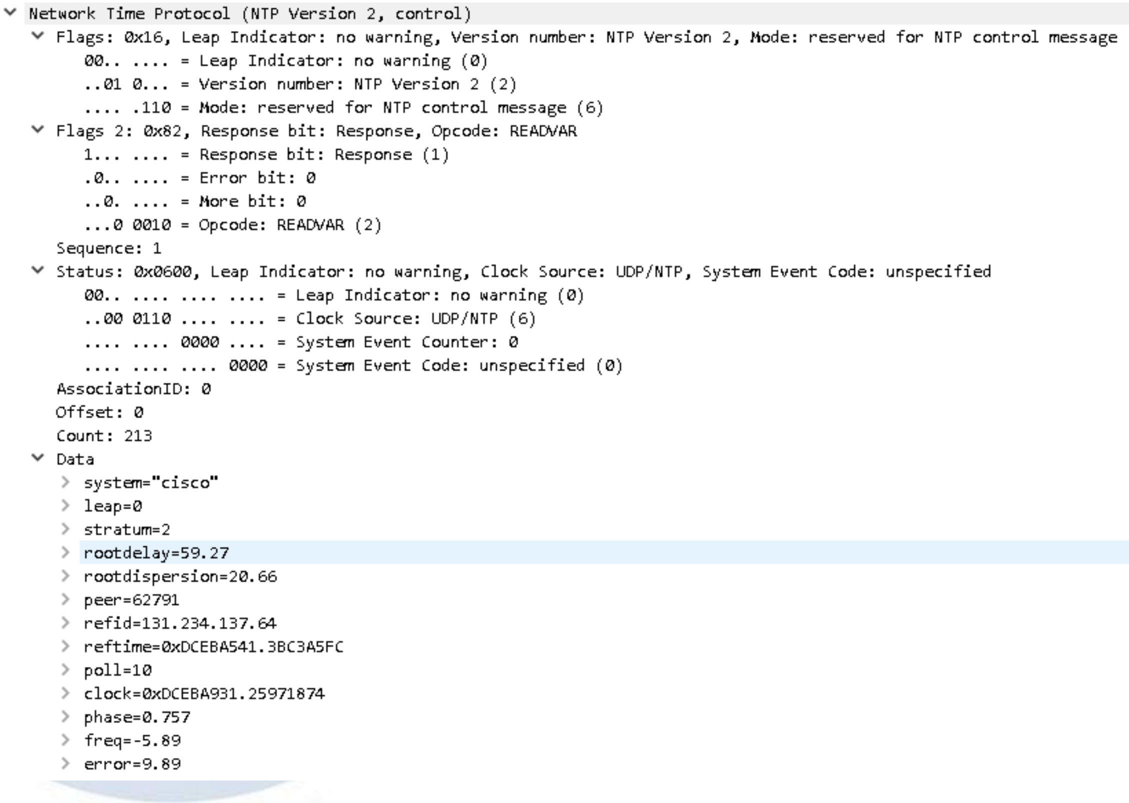


```
Network Time Protocol (NTP Version 2, private)
  Flags: 0x17, Response bit: Request, Version number: NTP Version 2, Mode: reserved for private use
    0... .... = Response bit: Request (0)
    .0.. .... = More bit: 0
    ..01 0... = Version number: NTP Version 2 (2)
    .... .111 = Mode: reserved for private use (7)
  Auth, sequence: 23
    0... .... = Auth bit: 0
    .001 0111 = Sequence number: 23
  Implementation: XNTPD (3)
  Request code: MON_GETLIST_1 (42)
  0000 .... = Err: No error (0x00)
  .... 0000  0000 0000 = Number of data items: 0
  0000 .... = Reserved: 0x00
  .... 0000  0000 0000 = Size of data item: 0x0000
```

NTP Mode 7 - Replies



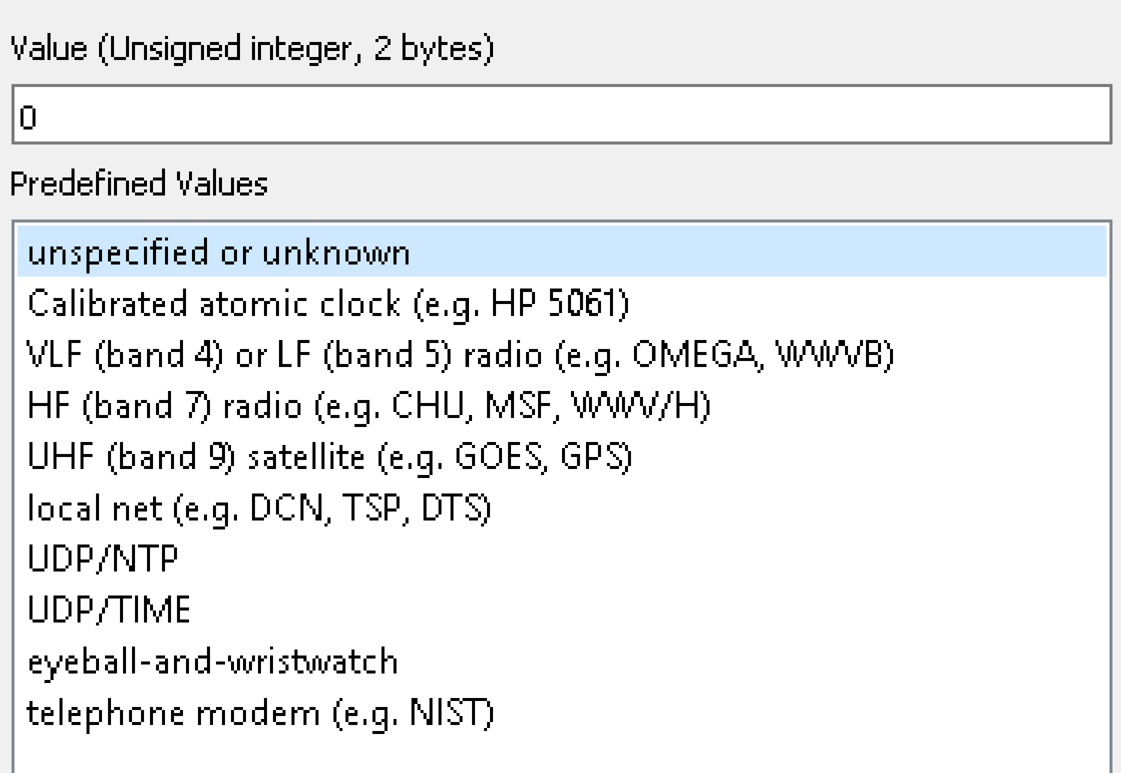
```
Network Time Protocol (NTP Version 2, control)
  Flags: 0x16, Leap Indicator: no warning, Version number: NTP Version 2, Mode: reserved for N
     00.. .... = Leap Indicator: no warning (0)
     ..01 0... = Version number: NTP Version 2 (2)
     .... .110 = Mode: reserved for NTP control message (6)
  Flags 2: 0x82, Response bit: Response, Opcode: READVAR
     1... .... = Response bit: Response (1)
     .0.. .... = Error bit: 0
     ..0. .... = More bit: 0
     ...0 0010 = Opcode: READVAR (2)
  Sequence: 1
  Status: 0x0618, Leap Indicator: no warning, Clock Source: UDP/NTP, System Event Code: Unknow
     00.. .... .... .... = Leap Indicator: no warning (0)
     ..00 0110 .... .... = Clock Source: UDP/NTP (6)
     .... .... 0001 .... = System Event Counter: 1
     .... .... .... 1000 = System Event Code: Unknown (8)
  AssociationID: 0
  Offset: 0
  Count: 378
  Data
     version="ntpd 4.2.8p9@1.3265-o Tue Dec 20 10:59:17 UTC 2016 (1)"
     processor="mips"
     system="Linux/4.4.14"
     leap=0
     stratum=3
     precision=-17
     rootdelay=57.997
     rootdisp=44.302
     refid=192.168.1.253
     reftime=0xdceb9f7e.da5272e4
     clock=0xdceba1ca.2b91884d
     peer=64052
     tc=10
     mintc=3
     offset=-1.389020
     frequency=4.385
     sys_jitter=1.700985
     clk_jitter=1.085
     clk_wander=0.034
```



```
Network Time Protocol (NTP Version 2, control)
  Flags: 0x16, Leap Indicator: no warning, Version number: NTP Version 2, Mode: reserved for NTP control message
     00.. .... = Leap Indicator: no warning (0)
     ..01 0... = Version number: NTP Version 2 (2)
     .... .110 = Mode: reserved for NTP control message (6)
  Flags 2: 0x82, Response bit: Response, Opcode: READVAR
     1... .... = Response bit: Response (1)
     .0.. .... = Error bit: 0
     ..0. .... = More bit: 0
     ...0 0010 = Opcode: READVAR (2)
  Sequence: 1
  Status: 0x0600, Leap Indicator: no warning, Clock Source: UDP/NTP, System Event Code: unspecified
     00.. .... .... .... = Leap Indicator: no warning (0)
     ..00 0110 .... .... = Clock Source: UDP/NTP (6)
     .... .... 0000 .... = System Event Counter: 0
     .... .... .... 0000 = System Event Code: unspecified (0)
  AssociationID: 0
  Offset: 0
  Count: 213
  Data
     system="cisco"
     leap=0
     stratum=2
     rootdelay=59.27
     rootdispersion=20.66
     peer=62791
     refid=131.234.137.64
     reftime=0xDCEBA541.3BC3A5FC
     poll=10
     clock=0xDCEBA931.25971874
     phase=0.757
     freq=-5.89
     error=9.89
```

NTP Control Clock Source / ntp.ctrl.sys_status.clksrc

- Different Kind of sources for NTP available



Value (Unsigned integer, 2 bytes)

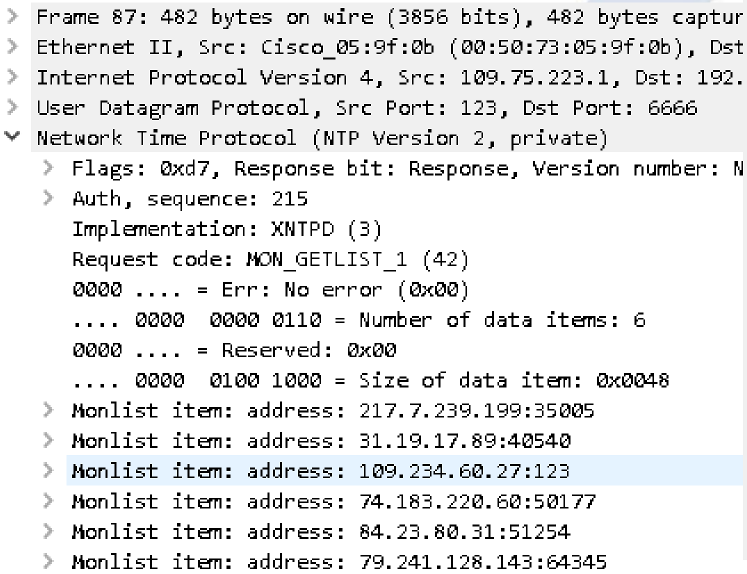
0

Predefined Values

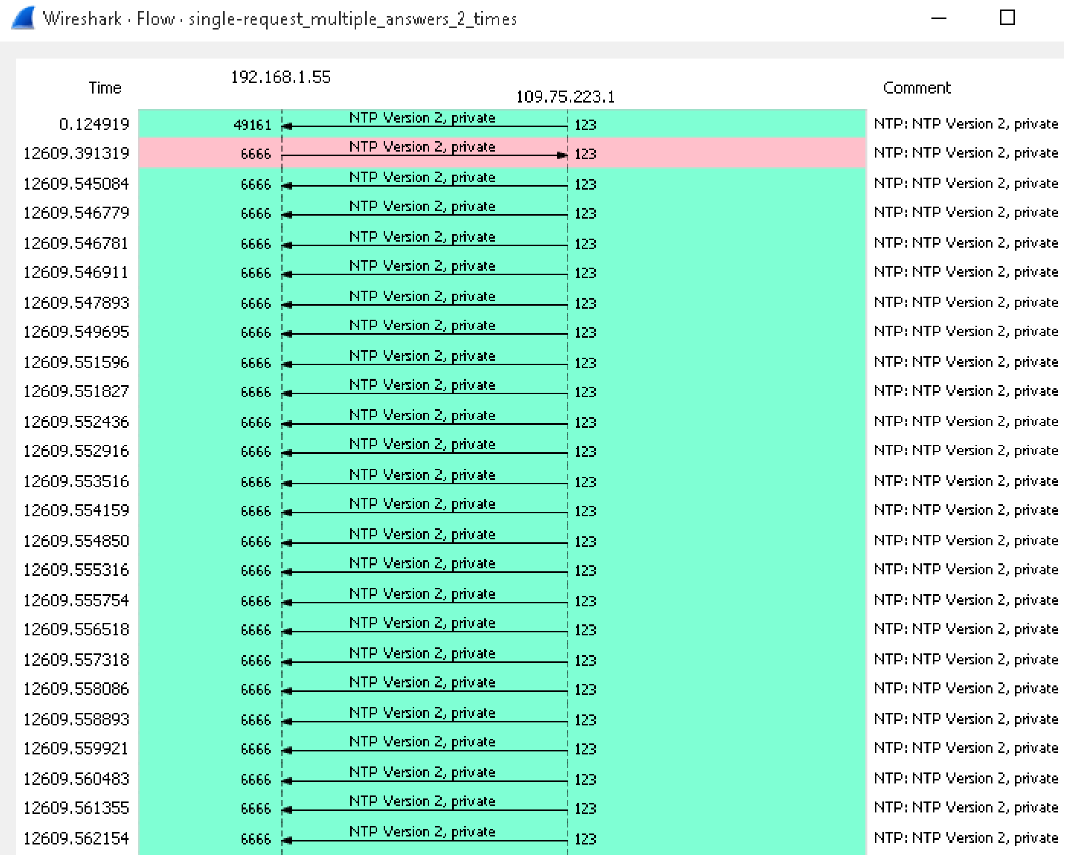
unspecified or unknown
Calibrated atomic clock (e.g. HP 5061)
VLF (band 4) or LF (band 5) radio (e.g. OMEGA, WWVB)
HF (band 7) radio (e.g. CHU, MSF, WWV/H)
UHF (band 9) satellite (e.g. GOES, GPS)
local net (e.g. DCN, TSP, DTS)
UDP/NTP
UDP/TIME
eyeball-and-wristwatch
telephone modem (e.g. NIST)

NTP Amplification Attack / Reflection DDoS attacks

- One single request
- Flooding different Monlist items



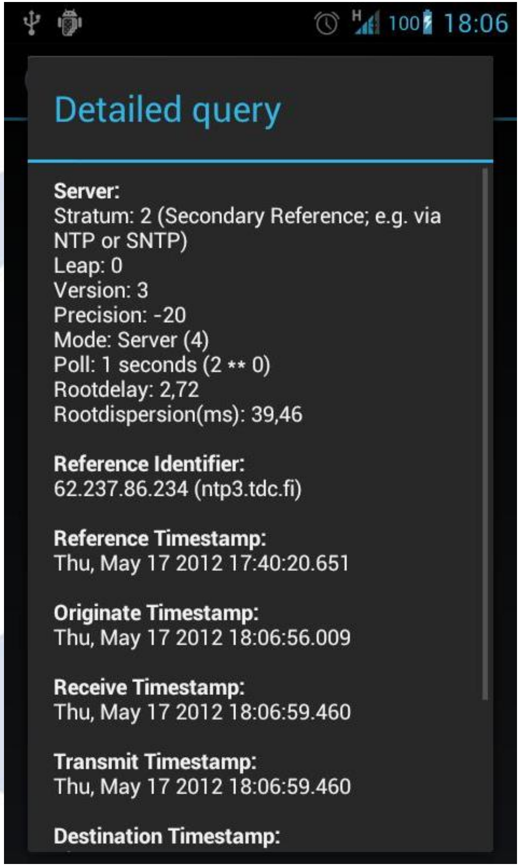
```
> Frame 87: 482 bytes on wire (3856 bits), 482 bytes captur
> Ethernet II, Src: Cisco_05:9f:0b (00:50:73:05:9f:0b), Dst
> Internet Protocol Version 4, Src: 109.75.223.1, Dst: 192.
> User Datagram Protocol, Src Port: 123, Dst Port: 6666
v Network Time Protocol (NTP Version 2, private)
    > Flags: 0xd7, Response bit: Response, Version number: N
    > Auth, sequence: 215
      Implementation: XNTPD (3)
      Request code: MON_GETLIST_1 (42)
      0000 .... = Err: No error (0x00)
      .... 0000  0000 0110 = Number of data items: 6
      0000 .... = Reserved: 0x00
      .... 0000  0100 1000 = Size of data item: 0x0048
    > Monlist item: address: 217.7.239.199:35005
    > Monlist item: address: 31.19.17.89:40540
    > Monlist item: address: 109.234.60.27:123
    > Monlist item: address: 74.183.220.60:50177
    > Monlist item: address: 84.23.80.31:51254
    > Monlist item: address: 79.241.128.143:64345
```



Time	192.168.1.55		109.75.223.1	Comment
0.124919	49161	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.391319	6666	NTP Version 2, private →	123	NTP: NTP Version 2, private
12609.545084	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.546779	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.546781	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.546911	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.547893	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.549695	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.551596	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.551827	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.552436	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.552916	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.553516	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.554159	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.554850	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.555316	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.555754	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.556518	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.557318	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.558086	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.558893	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.559921	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.560483	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.561355	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private
12609.562154	6666	← NTP Version 2, private	123	NTP: NTP Version 2, private

NTP APPs for your Smartphone

- Different kinds of APPs are available for different platforms
- Useful for checking your capture setup and results too ☺



Detailed query

Server:
Stratum: 2 (Secondary Reference; e.g. via NTP or SNTP)
Leap: 0
Version: 3
Precision: -20
Mode: Server (4)
Poll: 1 seconds (2 ** 0)
Rootdelay: 2,72
Rootdispersion(ms): 39,46

Reference Identifier:
62.237.86.234 (ntp3.tdc.fi)

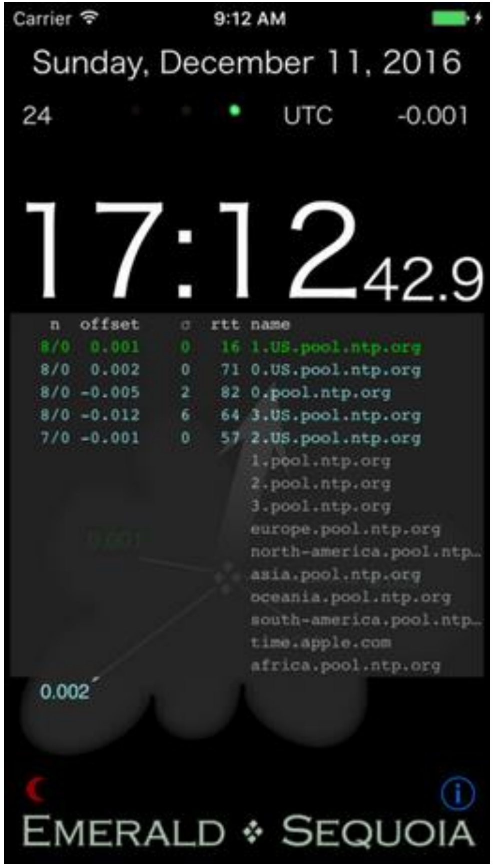
Reference Timestamp:
Thu, May 17 2012 17:40:20.651

Originate Timestamp:
Thu, May 17 2012 18:06:56.009

Receive Timestamp:
Thu, May 17 2012 18:06:59.460

Transmit Timestamp:
Thu, May 17 2012 18:06:59.460

Destination Timestamp:



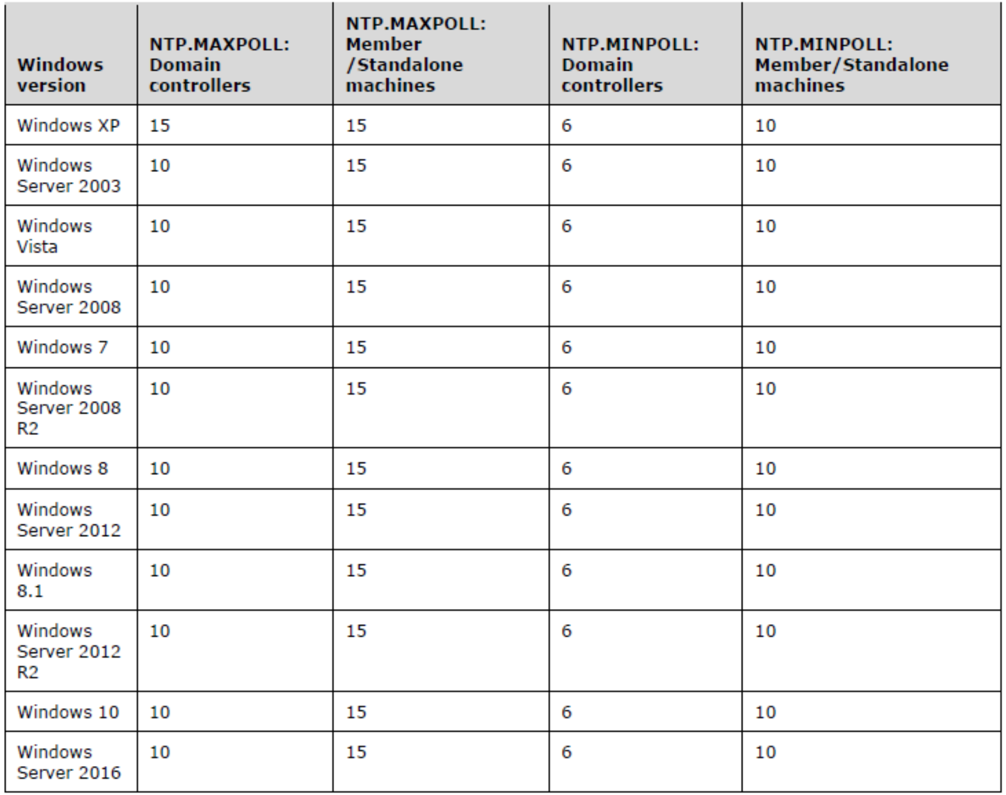
Sunday, December 11, 2016

24 UTC -0.001

17:12 42.9

```
  n  offset     c  rtt name
8/0  0.001      0   16 1.US.pool.ntp.org
8/0  0.002      0   71 0.US.pool.ntp.org
8/0 -0.005      2   82 0.pool.ntp.org
8/0 -0.012      6   64 3.US.pool.ntp.org
7/0 -0.001      0   57 2.US.pool.ntp.org
                       1.pool.ntp.org
                       2.pool.ntp.org
                       3.pool.ntp.org
                       europe.pool.ntp.org
                       north-america.pool.ntp…
                       asia.pool.ntp.org
                       oceania.pool.ntp.org
                       south-america.pool.ntp…
                       time.apple.com
                       africa.pool.ntp.org
```

NTP Polling Intervals - RFCs and the Windows Way

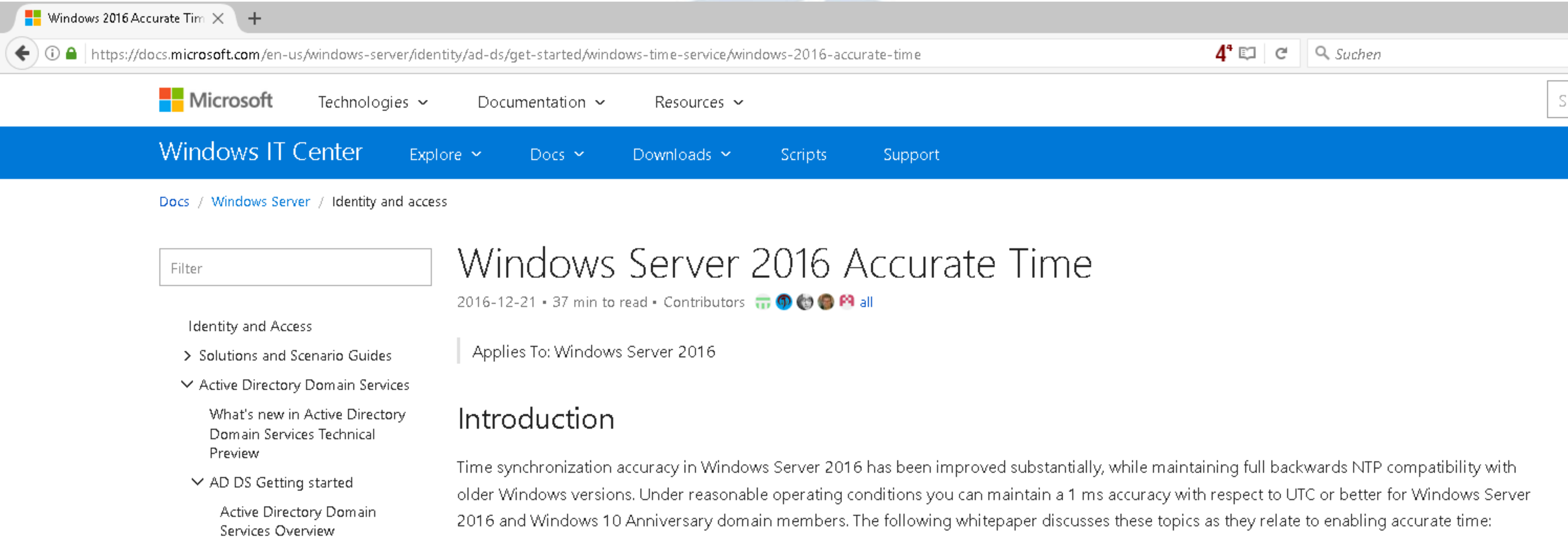


Windows version	NTP.MAXPOLL: Domain controllers	NTP.MAXPOLL: Member /Standalone machines	NTP.MINPOLL: Domain controllers	NTP.MINPOLL: Member/Standalone machines
Windows XP	15	15	6	10
Windows Server 2003	10	15	6	10
Windows Vista	10	15	6	10
Windows Server 2008	10	15	6	10
Windows 7	10	15	6	10
Windows Server 2008 R2	10	15	6	10
Windows 8	10	15	6	10
Windows Server 2012	10	15	6	10
Windows 8.1	10	15	6	10
Windows Server 2012 R2	10	15	6	10
Windows 10	10	15	6	10
Windows Server 2016	10	15	6	10

- RFC 1305
  - NTP.MAXPOLL 1024 seconds, which was the maximum with NTPv3
- RFC 5905
  - poll intervals up to 36 hours

Windows Accurate Time

- Is your Windows Capture Engine part of a domain?



Windows 2016 Accurate Tim
https://docs.microsoft.com/en-us/windows-server/identity/ad-ds/get-started/windows-time-service/windows-2016-accurate-time
Suchen
Microsoft
Technologies
Documentation
Resources
Windows IT Center
Explore
Docs
Downloads
Scripts
Support
Filter

Docs / Windows Server / Identity and access

Identity and Access

- Solutions and Scenario Guides
- Active Directory Domain Services
  - What's new in Active Directory Domain Services Technical Preview
  - AD DS Getting started
    - Active Directory Domain Services Overview

Windows Server 2016 Accurate Time

2016-12-21 • 37 min to read • Contributors all

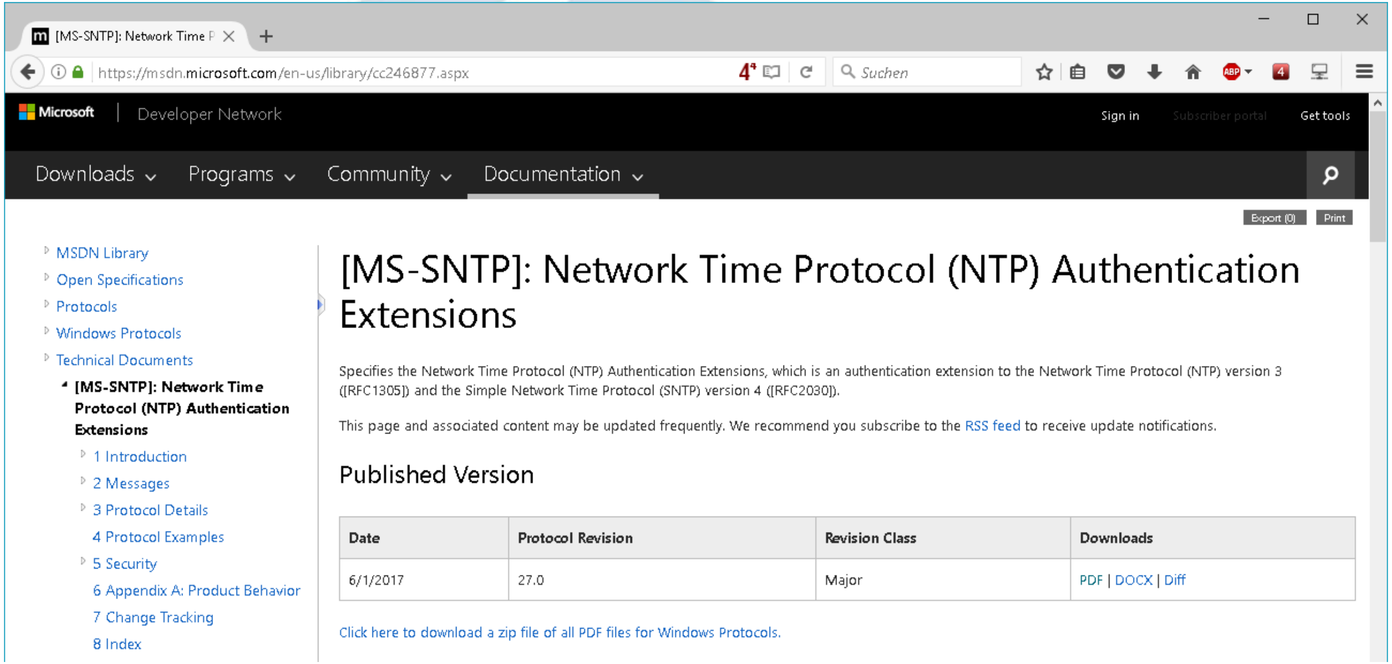
Applies To: Windows Server 2016

Introduction

Time synchronization accuracy in Windows Server 2016 has been improved substantially, while maintaining full backwards NTP compatibility with older Windows versions. Under reasonable operating conditions you can maintain a 1 ms accuracy with respect to UTC or better for Windows Server 2016 and Windows 10 Anniversary domain members. The following whitepaper discusses these topics as they relate to enabling accurate time:

MS-SNTP Extensions

- Microsoft has a custom authentication mechanism in their NTP implementation of the Windows Time Service



- MSDN Library
- Open Specifications
- Protocols
- Windows Protocols
- Technical Documents
  - **[MS-SNTP]: Network Time Protocol (NTP) Authentication Extensions**
    - 1 Introduction
    - 2 Messages
    - 3 Protocol Details
    - 4 Protocol Examples
    - 5 Security
    - 6 Appendix A: Product Behavior
    - 7 Change Tracking
    - 8 Index

[MS-SNTP]: Network Time Protocol (NTP) Authentication Extensions

Specifies the Network Time Protocol (NTP) Authentication Extensions, which is an authentication extension to the Network Time Protocol (NTP) version 3 ([RFC1305]) and the Simple Network Time Protocol (SNTP) version 4 ([RFC2030]).

This page and associated content may be updated frequently. We recommend you subscribe to the RSS feed to receive update notifications.

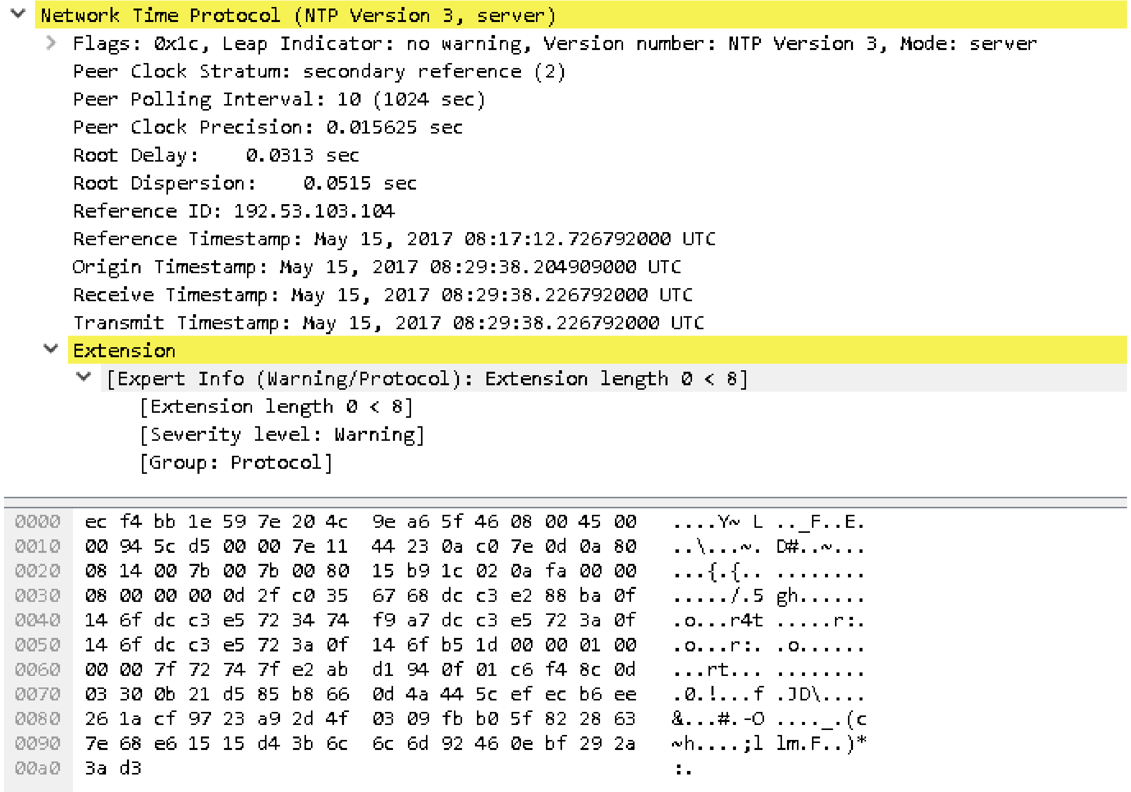
Published Version

Date	Protocol Revision	Revision Class	Downloads
6/1/2017	27.0	Major	PDF | DOCX | Diff

Click here to download a zip file of all PDF files for Windows Protocols.

MS-SNTP Extensions - Wireshark

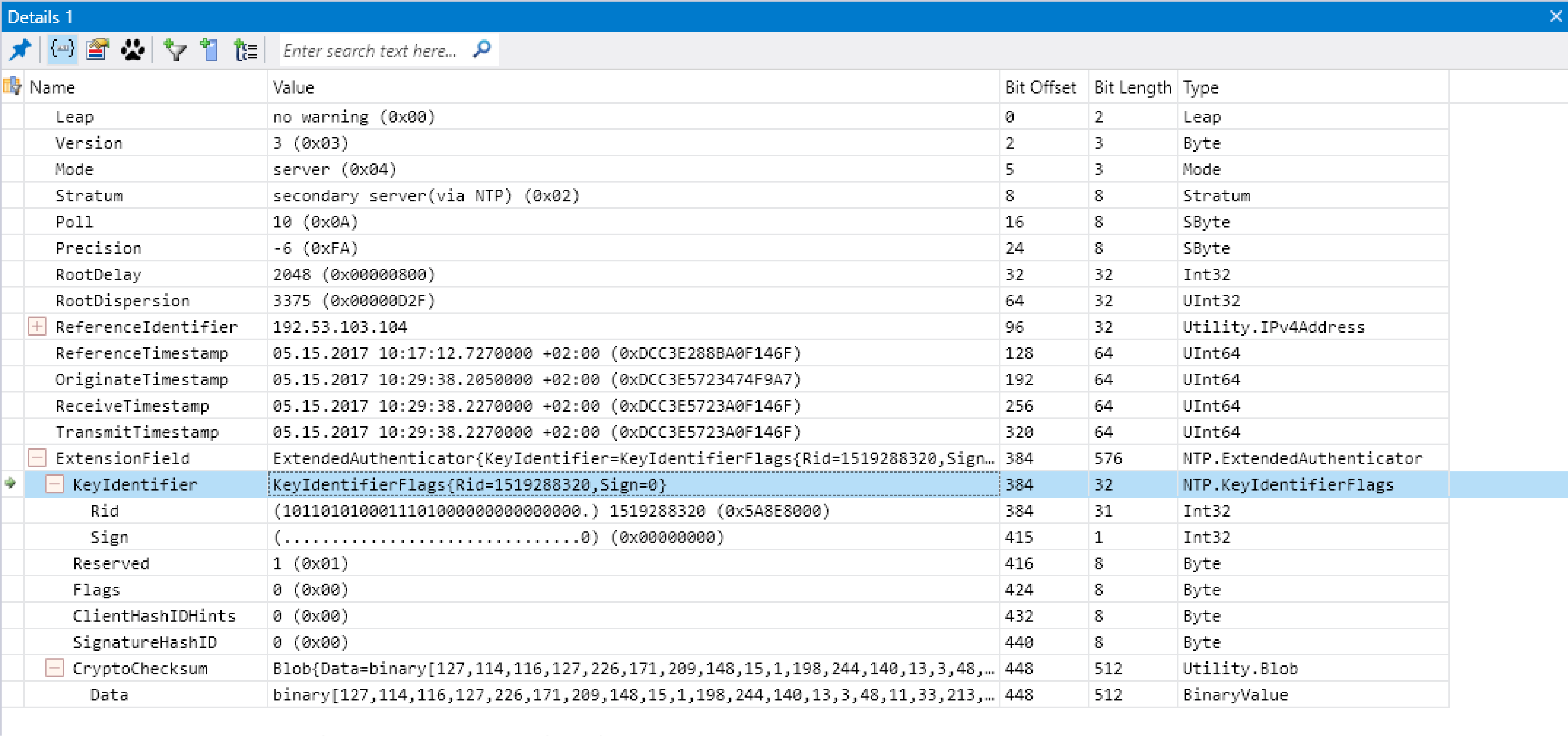
- Decoding with Wireshark not implemented yet ;-)



```
Network Time Protocol (NTP Version 3, server)
  Flags: 0x1c, Leap Indicator: no warning, Version number: NTP Version 3, Mode: server
  Peer Clock Stratum: secondary reference (2)
  Peer Polling Interval: 10 (1024 sec)
  Peer Clock Precision: 0.015625 sec
  Root Delay:    0.0313 sec
  Root Dispersion:    0.0515 sec
  Reference ID: 192.53.103.104
  Reference Timestamp: May 15, 2017 08:17:12.726792000 UTC
  Origin Timestamp: May 15, 2017 08:29:38.204909000 UTC
  Receive Timestamp: May 15, 2017 08:29:38.226792000 UTC
  Transmit Timestamp: May 15, 2017 08:29:38.226792000 UTC
  Extension
    [Expert Info (Warning/Protocol): Extension length 0 < 8]
      [Extension length 0 < 8]
      [Severity level: Warning]
      [Group: Protocol]
```

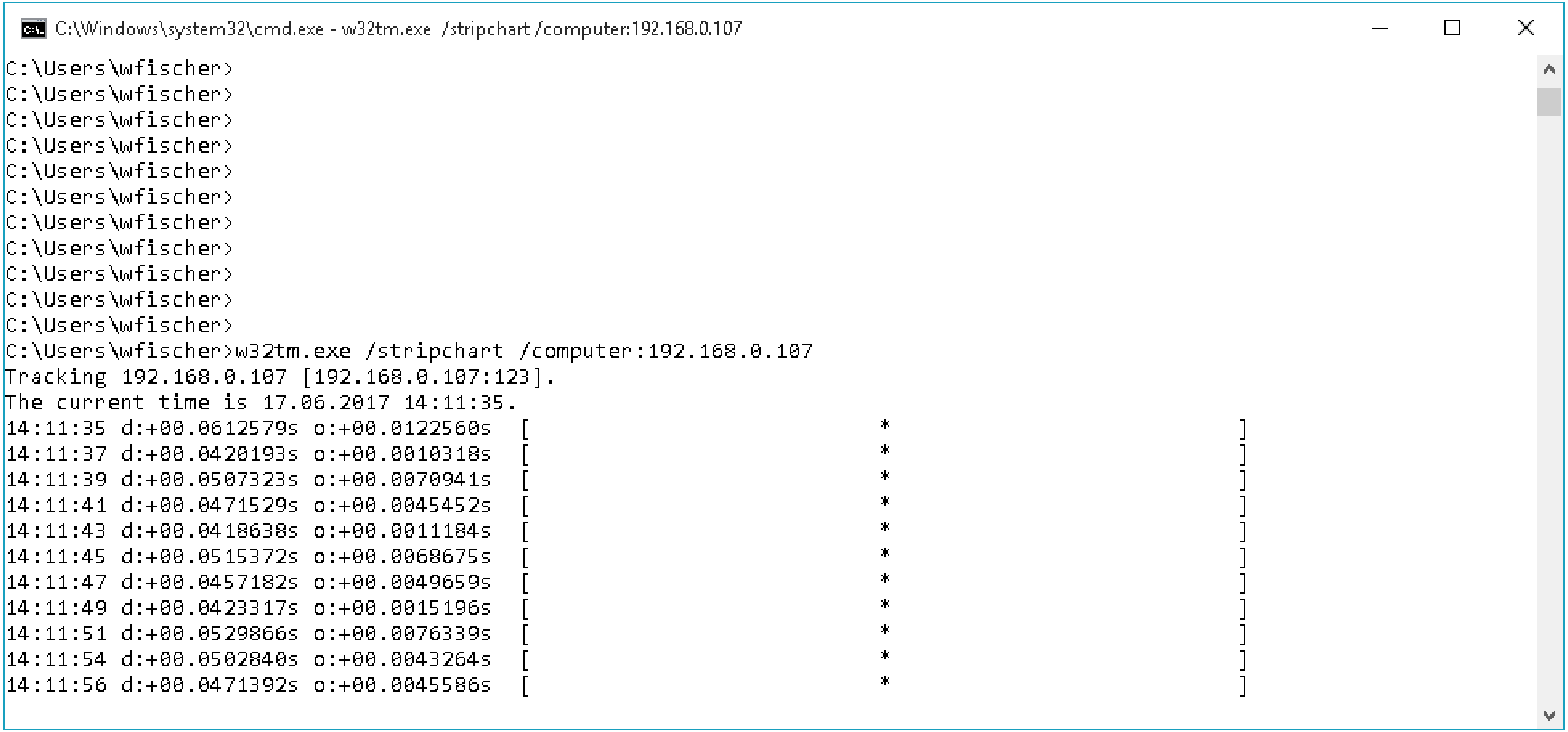
```
0000  ec f4 bb 1e 59 7e 20 4c  9e a6 5f 46 08 00 45 00   ....Y~ L .._F..E.
0010  00 94 5c d5 00 00 7e 11  44 23 0a c0 7e 0d 0a 80   ..\...~. D#..~...
0020  08 14 00 7b 00 7b 00 80  15 b9 1c 02 0a fa 00 00   ...{.{.. ........
0030  08 00 00 00 0d 2f c0 35  67 68 dc c3 e2 88 ba 0f   ...../.5 gh......
0040  14 6f dc c3 e5 72 34 74  f9 a7 dc c3 e5 72 3a 0f   .o...r4t .....r:.
0050  14 6f dc c3 e5 72 3a 0f  14 6f b5 1d 00 00 01 00   .o...r:. .o......
0060  00 00 7f 72 74 7f e2 ab  d1 94 0f 01 c6 f4 8c 0d   ...rt... ........
0070  03 30 0b 21 d5 85 b8 66  0d 4a 44 5c ef ec b6 ee   .0.!...f .JD\....
0080  26 1a cf 97 23 a9 2d 4f  03 09 fb b0 5f 82 28 63   &...#.-O ...._.(c
0090  7e 68 e6 15 15 d4 3b 6c  6c 6d 92 46 0e bf 29 2a   ~h....;l lm.F..)*
00a0  3a d3                                               :.
```

MS-SNTP Extensions – MS Message Analyzer



Name	Value	Bit Offset	Bit Length	Type
Leap	no warning (0x00)	0	2	Leap
Version	3 (0x03)	2	3	Byte
Mode	server (0x04)	5	3	Mode
Stratum	secondary server(via NTP) (0x02)	8	8	Stratum
Poll	10 (0x0A)	16	8	SByte
Precision	-6 (0xFA)	24	8	SByte
RootDelay	2048 (0x00000800)	32	32	Int32
RootDispersion	3375 (0x00000D2F)	64	32	UInt32
⊞ ReferenceIdentifier	192.53.103.104	96	32	Utility.IPv4Address
ReferenceTimestamp	05.15.2017 10:17:12.7270000 +02:00 (0xDCC3E288BA0F146F)	128	64	UInt64
OriginateTimestamp	05.15.2017 10:29:38.2050000 +02:00 (0xDCC3E5723474F9A7)	192	64	UInt64
ReceiveTimestamp	05.15.2017 10:29:38.2270000 +02:00 (0xDCC3E5723A0F146F)	256	64	UInt64
TransmitTimestamp	05.15.2017 10:29:38.2270000 +02:00 (0xDCC3E5723A0F146F)	320	64	UInt64
⊟ ExtensionField	ExtendedAuthenticator{KeyIdentifier=KeyIdentifierFlags{Rid=1519288320,Sign…	384	576	NTP.ExtendedAuthenticator
⊟ KeyIdentifier	KeyIdentifierFlags{Rid=1519288320,Sign=0}	384	32	NTP.KeyIdentifierFlags
Rid	(1011010100011101000000000000000.) 1519288320 (0x5A8E8000)	384	31	Int32
Sign	(...............................0) (0x00000000)	415	1	Int32
Reserved	1 (0x01)	416	8	Byte
Flags	0 (0x00)	424	8	Byte
ClientHashIDHints	0 (0x00)	432	8	Byte
SignatureHashID	0 (0x00)	440	8	Byte
⊟ CryptoChecksum	Blob{Data=binary[127,114,116,127,226,171,209,148,15,1,198,244,140,13,3,48,…	448	512	Utility.Blob
Data	binary[127,114,116,127,226,171,209,148,15,1,198,244,140,13,3,48,11,33,213,…	448	512	BinaryValue

Windows w32tm as a NTP client for testing

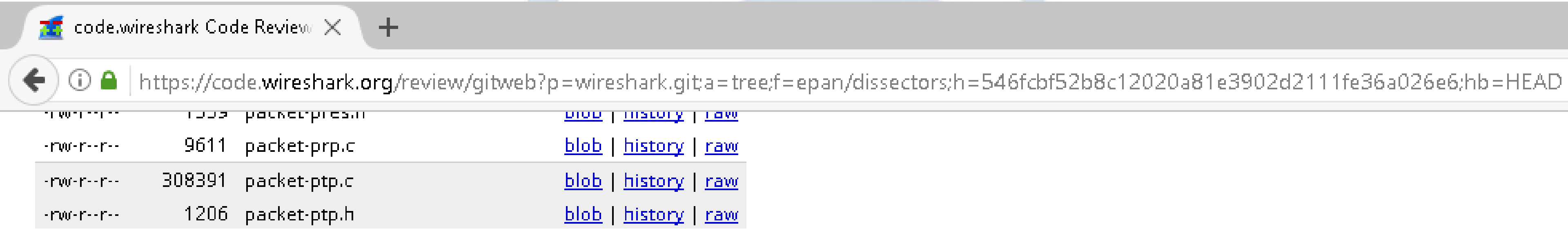


C:\Windows\system32\cmd.exe - w32tm.exe /stripchart /computer:192.168.0.107

```
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>
C:\Users\wfischer>w32tm.exe /stripchart /computer:192.168.0.107
Tracking 192.168.0.107 [192.168.0.107:123].
The current time is 17.06.2017 14:11:35.
14:11:35 d:+00.0612579s o:+00.0122560s  [                           *                           ]
14:11:37 d:+00.0420193s o:+00.0010318s  [                           *                           ]
14:11:39 d:+00.0507323s o:+00.0070941s  [                           *                           ]
14:11:41 d:+00.0471529s o:+00.0045452s  [                           *                           ]
14:11:43 d:+00.0418638s o:+00.0011184s  [                           *                           ]
14:11:45 d:+00.0515372s o:+00.0068675s  [                           *                           ]
14:11:47 d:+00.0457182s o:+00.0049659s  [                           *                           ]
14:11:49 d:+00.0423317s o:+00.0015196s  [                           *                           ]
14:11:51 d:+00.0529866s o:+00.0076339s  [                           *                           ]
14:11:54 d:+00.0502840s o:+00.0043264s  [                           *                           ]
14:11:56 d:+00.0471392s o:+00.0045586s  [                           *                           ]
```

AGENDA

- Time basic
- Time Protocols
- NTP
- PTP
- Wrap-UP



https://code.wireshark.org/review/gitweb?p=wireshark.git;a=tree;f=epan/dissectors;h=546fcbf52b8c12020a81e3902d2111fe36a026e6;hb=HEAD

```
-rw-r--r--     1559  packet-pres.h                blob | history | raw
-rw-r--r--     9611  packet-prp.c                 blob | history | raw
-rw-r--r--   308391  packet-ptp.c                 blob | history | raw
-rw-r--r--     1206  packet-ptp.h                 blob | history | raw
```

IEEE 1588 Precision Time Protocol (PTP)

- IEEE 1588 Precision Time Protocol (PTP) is a highly accurate distributed time synchronization protocol for packet network
- IEEE 1588-2008, as known as IEEE 1588v2 or PTPv2 is the latest IEEE 1588 standard
  - Can direct map to Ethernet, or UDP IPv4.
  - Packet based timing distribution and synchronization.
  - Nanosecond to sub-microsecond accuracy
  - Low administrative effort, easy to manage and maintain
  - Low cost and low resource use, works on high-end or low-end device
  - Support redundant and fault-tolerant
  - No need to implement costly GPS or other dedicated timing network

PTP Overview

- Peer-to-peer transparent clocks
- Time format
- Architectural choices
- Best master selection
- PTP profiles and conformance
- General optional features
- State configuration options
- Compatibility requirements
- Transport specific field
- Security
- Transport of cumulative frequency offset information

Frequency and time Synchronization and Strategies

- Hierarchical architecture for clock and time distribution
- Accuracy better than NTP (from milliseconds to nanoseconds)
- Distribute Time to places where GPS would be impractical (e.g. DC)
- BMC (Best Master Clock) algorithm defines the "Grand Master" used to synchronize a clock domain

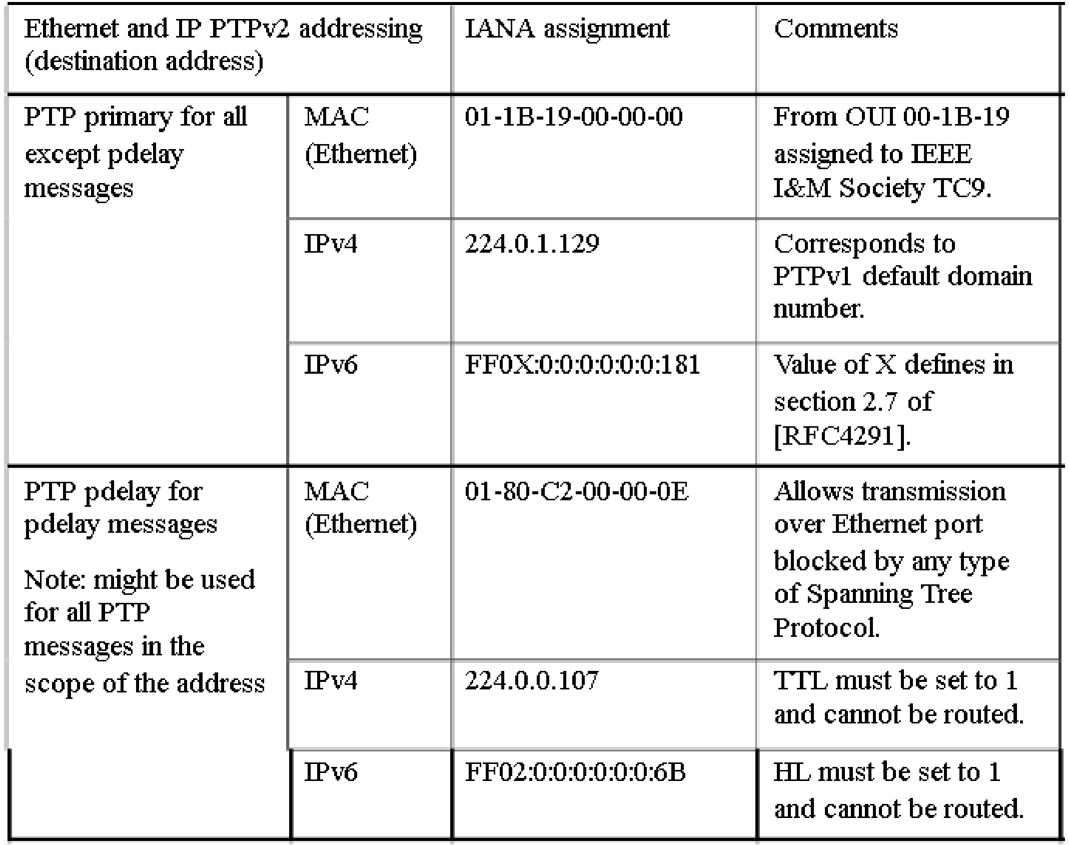
PTPv2 Transport

- PTP over IPv4
- PTP over IPv6
- PTP over Ethernet
  - Note: 802.1AS over Ethernet (802.3) qualifies as a Profile of IEEE 1588-2008
- PTP over DeviceNET
- PTP over ControlNET
- PTP over IEC 61158 Type 10 (Fieldbus)

PTP Packet/Frame Details

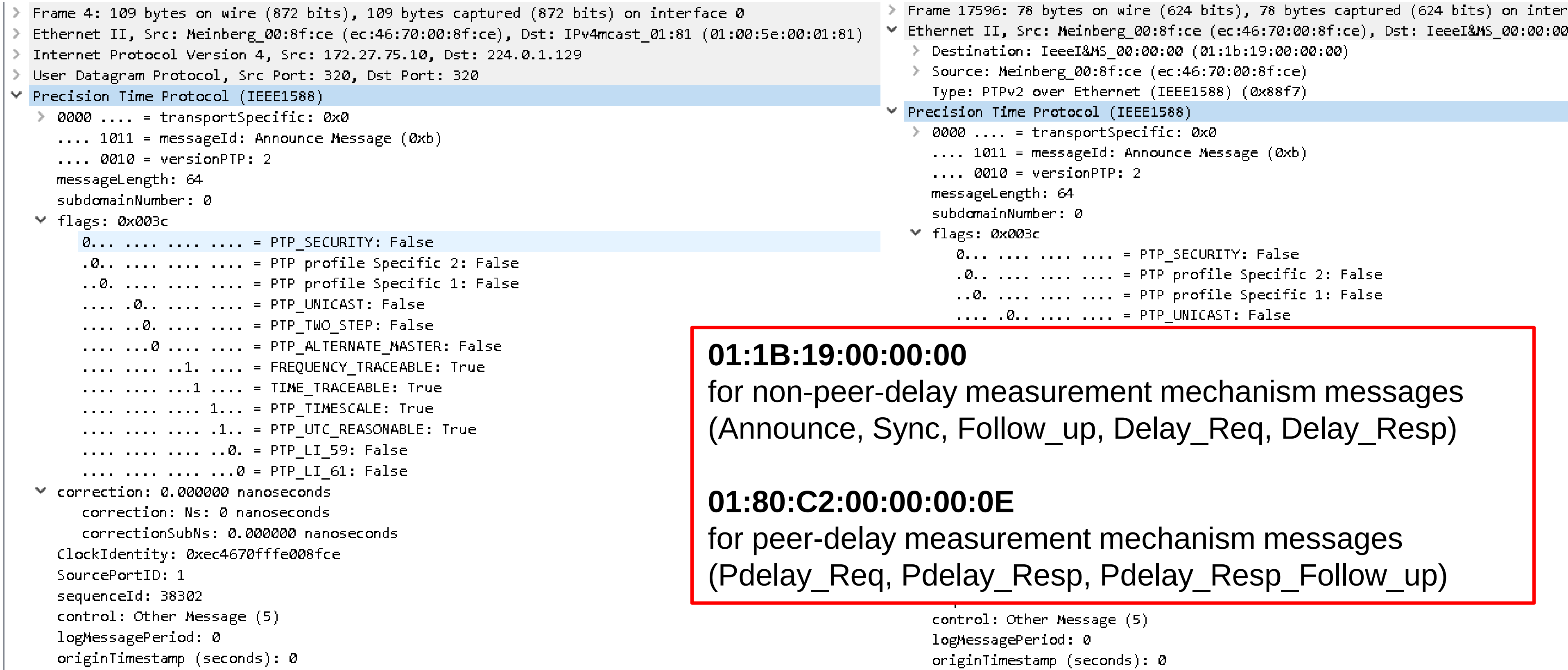
- Communication between master and slave use multicast group address
- Event messages use UDP Port 319
- General message use UDP port 320
- Above applies to both unicast and multicast
- IANA also reserved additional multicast address for PTP, currently it’s not used
  - 224.0.1.130
  - 224.0.1.131
  - 224.0.1.132

PTP addresses



Ethernet and IP PTPv2 addressing (destination address)		IANA assignment	Comments
PTP primary for all except pdelay messages	MAC (Ethernet)	01-1B-19-00-00-00	From OUI 00-1B-19 assigned to IEEE I&M Society TC9.
	IPv4	224.0.1.129	Corresponds to PTPv1 default domain number.
	IPv6	FF0X:0:0:0:0:0:181	Value of X defines in section 2.7 of [RFC4291].
PTP pdelay for pdelay messages Note: might be used for all PTP messages in the scope of the address	MAC (Ethernet)	01-80-C2-00-00-0E	Allows transmission over Ethernet port blocked by any type of Spanning Tree Protocol.
	IPv4	224.0.0.107	TTL must be set to 1 and cannot be routed.
	IPv6	FF02:0:0:0:0:0:0:6B	HL must be set to 1 and cannot be routed.

PTPv2 / General messages / Announce



```
> Frame 4: 109 bytes on wire (872 bits), 109 bytes captured (872 bits) on interface 0
> Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IPv4mcast_01:81 (01:00:5e:00:01:81)
> Internet Protocol Version 4, Src: 172.27.75.10, Dst: 224.0.1.129
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
  > 0000 .... = transportSpecific: 0x0
    .... 1011 = messageId: Announce Message (0xb)
    .... 0010 = versionPTP: 2
    messageLength: 64
    subdomainNumber: 0
  v flags: 0x003c
      0... .... .... .... = PTP_SECURITY: False
      .0.. .... .... .... = PTP profile Specific 2: False
      ..0. .... .... .... = PTP profile Specific 1: False
      .... .0.. .... .... = PTP_UNICAST: False
      .... ..0. .... .... = PTP_TWO_STEP: False
      .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
      .... .... ..1. .... = FREQUENCY_TRACEABLE: True
      .... .... ...1 .... = TIME_TRACEABLE: True
      .... .... .... 1... = PTP_TIMESCALE: True
      .... .... .... .1.. = PTP_UTC_REASONABLE: True
      .... .... .... ..0. = PTP_LI_59: False
      .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
      correction: Ns: 0 nanoseconds
      correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0xec4670fffe008fce
    SourcePortID: 1
    sequenceId: 38302
    control: Other Message (5)
    logMessagePeriod: 0
    originTimestamp (seconds): 0
```

```
> Frame 17596: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on inter
v Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IeeeI&MS_00:00:00
  > Destination: IeeeI&MS_00:00:00 (01:1b:19:00:00:00)
  > Source: Meinberg_00:8f:ce (ec:46:70:00:8f:ce)
    Type: PTPv2 over Ethernet (IEEE1588) (0x88f7)
v Precision Time Protocol (IEEE1588)
  > 0000 .... = transportSpecific: 0x0
    .... 1011 = messageId: Announce Message (0xb)
    .... 0010 = versionPTP: 2
    messageLength: 64
    subdomainNumber: 0
  v flags: 0x003c
      0... .... .... .... = PTP_SECURITY: False
      .0.. .... .... .... = PTP profile Specific 2: False
      ..0. .... .... .... = PTP profile Specific 1: False
      .... .0.. .... .... = PTP_UNICAST: False
    control: Other Message (5)
    logMessagePeriod: 0
    originTimestamp (seconds): 0
```

01:1B:19:00:00:00
for non-peer-delay measurement mechanism messages (Announce, Sync, Follow_up, Delay_Req, Delay_Resp)

01:80:C2:00:00:00:0E
for peer-delay measurement mechanism messages (Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_up)

PTP ToD

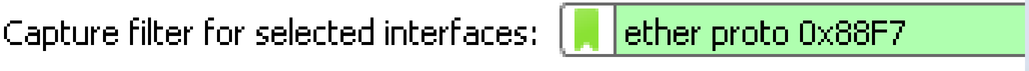
- IEEE 1588v2 PTP is capable of frequency, phase and time-of-day synchronization
- Telecommunication industry requires the synchronization of frequency, phase and time-of-day
- Most of the applications in financial institute and data center networks are interested in Time-of-Day synchronization

PTP – Wireshark Capture and Display Filter

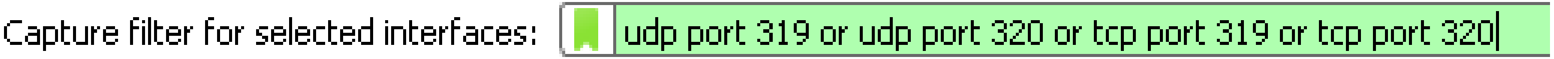
- udp port 319 or udp port 320 or tcp port 319 or tcp port 320

- for PTP over Ethernet packets, specify:

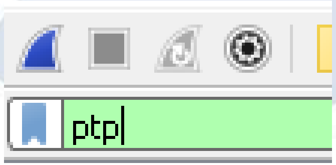
"ether proto 0x88F7”



Capture filter for selected interfaces: ether proto 0x88F7



Capture filter for selected interfaces: udp port 319 or udp port 320 or tcp port 319 or tcp port 320



ptp

PTP Clock Types

- Ordinary Clock (OC)
  - Has a single PTP port in a domain and maintains the timescale of the domain
- Boundary Clock (BC)
  - Has multiple PTP ports in a domain and maintains the timescale of the domain
- Transparent Clock
  - Measures the time taken for a PTP event message to transit the device
    - Peer-to-peer transparent clocks (P2P TC) provide corrections for the propagation delay of the link in addition to the transit time
    - End-to-end transparent clock (E2E TC)

PTP Clock Types

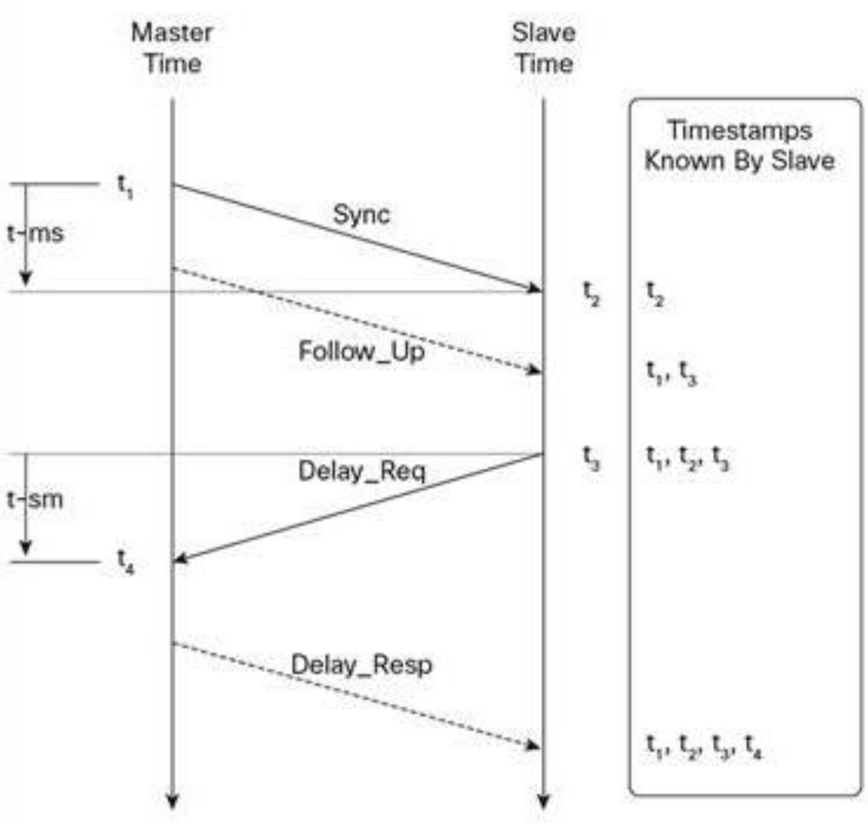
- Slave clock
  - A slave clock receives the time information from a master clock by synchronizing itself with the master clock. It does not redistribute the time to another clock
- Grandmaster clock (GM)
  - A grandmaster clock is the highest-ranking clock within its PTP domain and is the primary reference source for all other PTP elements.

PTP 1-step and 2-step clocks

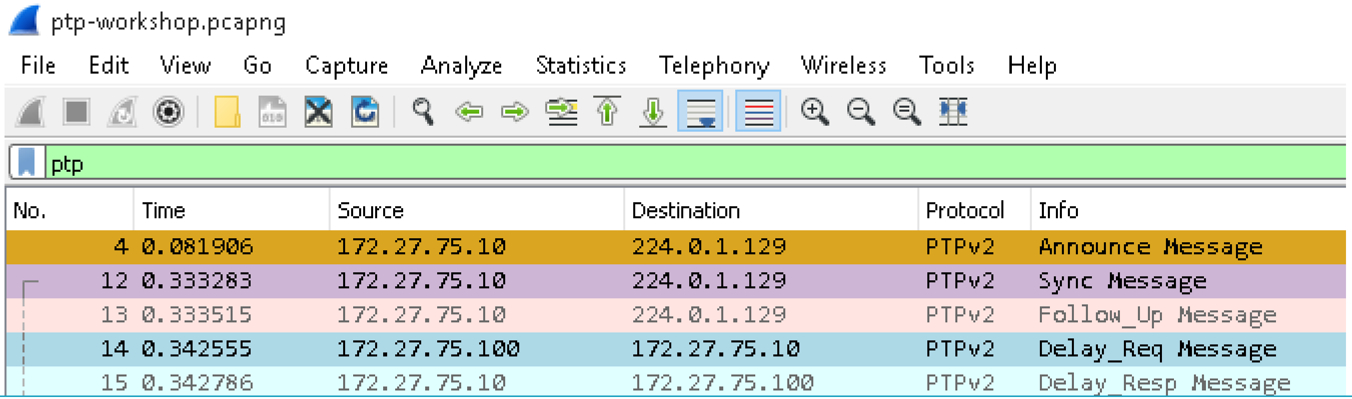
- 1-step clock updates accurate timestamp (t1) in Sync message
- 2-step clock sends accurate timestamp (t1) in a Follow_Up message
  - Simplify design while avoiding queuing noise
  - Ease integration of security extensions

PTP Clock Synchronization Process

- Sync
- Follow Up
- Delay Request
- Delay Response

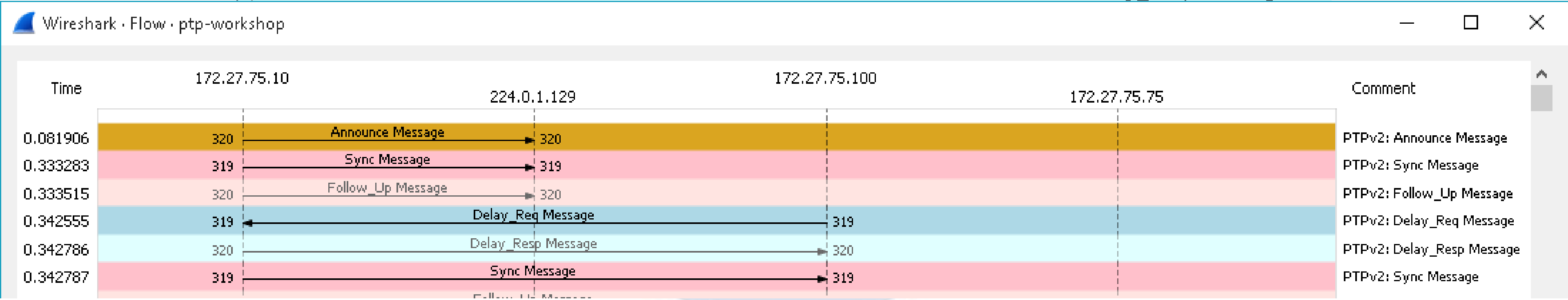


PTP Clock Synchronization Process in Wireshark



ptp

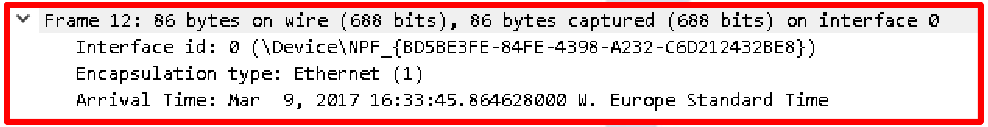
No.	Time	Source	Destination	Protocol	Info
4	0.081906	172.27.75.10	224.0.1.129	PTPv2	Announce Message
12	0.333283	172.27.75.10	224.0.1.129	PTPv2	Sync Message
13	0.333515	172.27.75.10	224.0.1.129	PTPv2	Follow_Up Message
14	0.342555	172.27.75.100	172.27.75.10	PTPv2	Delay_Req Message
15	0.342786	172.27.75.10	172.27.75.100	PTPv2	Delay_Resp Message



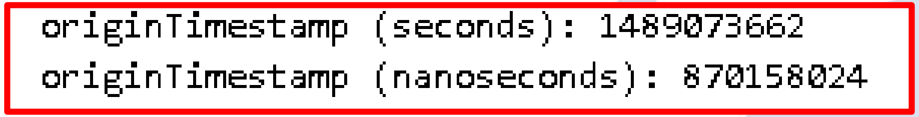
Time		Comment
0.081906	320 Announce Message → 320	PTPv2: Announce Message
0.333283	319 Sync Message → 319	PTPv2: Sync Message
0.333515	320 Follow_Up Message → 320	PTPv2: Follow_Up Message
0.342555	319 ← Delay_Req Message 319	PTPv2: Delay_Req Message
0.342786	320 Delay_Resp Message → 320	PTPv2: Delay_Resp Message
0.342787	319 Sync Message → 319	PTPv2: Sync Message

PTPv2 Sync Message – verify by your own

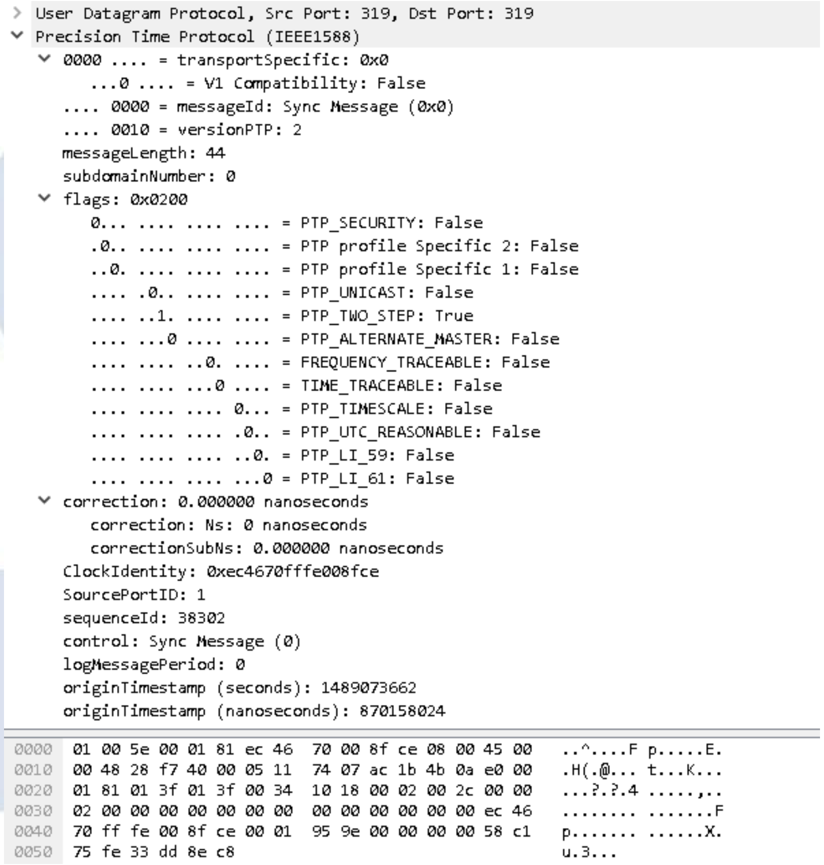
- When was this?
- Was the capture engine in time sync?
  - Hint: Have a look at the originTimestamp and convert it



```
Frame 12: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
    Interface id: 0 (\Device\NPF_{BD5BE3FE-84FE-4398-A232-C6D212432BE8})
    Encapsulation type: Ethernet (1)
    Arrival Time: Mar  9, 2017 16:33:45.864628000 W. Europe Standard Time
```



```
originTimestamp (seconds): 1489073662
originTimestamp (nanoseconds): 870158024
```



```
> User Datagram Protocol, Src Port: 319, Dst Port: 319
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
       ...0 .... = V1 Compatibility: False
    .... 0000 = messageId: Sync Message (0x0)
    .... 0010 = versionPTP: 2
    messageLength: 44
    subdomainNumber: 0
  v flags: 0x0200
       0... .... .... .... = PTP_SECURITY: False
       .0.. .... .... .... = PTP profile Specific 2: False
       ..0. .... .... .... = PTP profile Specific 1: False
       .... .0.. .... .... = PTP_UNICAST: False
       .... ..1. .... .... = PTP_TWO_STEP: True
       .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
       .... .... ..0. .... = FREQUENCY_TRACEABLE: False
       .... .... ...0 .... = TIME_TRACEABLE: False
       .... .... .... 0... = PTP_TIMESCALE: False
       .... .... .... .0.. = PTP_UTC_REASONABLE: False
       .... .... .... ..0. = PTP_LI_59: False
       .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
       correction: Ns: 0 nanoseconds
       correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0xec4670fffe008fce
    SourcePortID: 1
    sequenceId: 38302
    control: Sync Message (0)
    logMessagePeriod: 0
    originTimestamp (seconds): 1489073662
    originTimestamp (nanoseconds): 870158024

0000  01 00 5e 00 01 81 ec 46  70 00 8f ce 08 00 45 00   ..^....F p.....E.
0010  00 48 28 f7 40 00 05 11  74 07 ac 1b 4b 0a e0 00   .H(.@... t...K...
0020  01 81 01 3f 01 3f 00 34  10 18 00 02 00 2c 00 00   ...?.?.4 .....,..
0030  02 00 00 00 00 00 00 00  00 00 00 00 00 00 ec 46   ........ .......F
0040  70 ff fe 00 8f ce 00 01  95 9e 00 00 00 00 58 c1   p....... ......X.
0050  75 fe 33 dd 8e c8                                  u.3...
```

PTPv2 Transmission

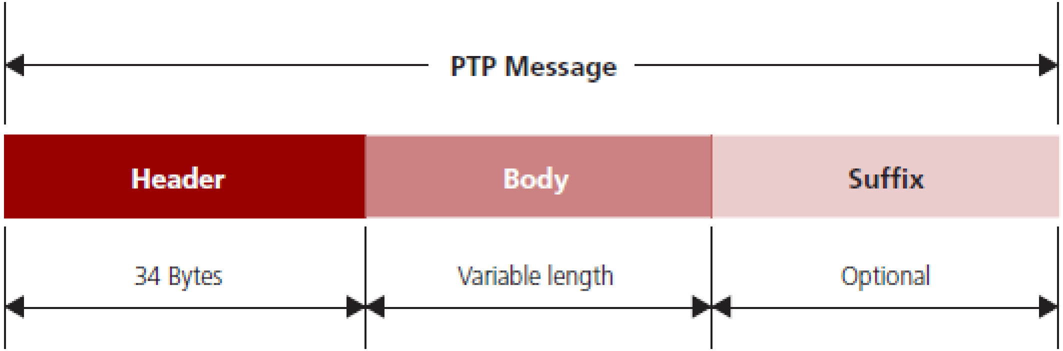
- Mode:
  - Unicast
  - Multicast
- Rates:
  - variable
- Timeouts
  - variable
- TLV and Extensions

PTP Grand Master (GM) selection

- GM-capable stations advertise that fact via ANNOUNCE messages
  - If station hears from station with “better” clock, does not send ANNOUNCE
- Settable “Priority” field can override clock quality
- MAC address is tie breaker
  - Bridges drop all inferior ANNOUNCE messages
- Forward only the best
  - Last one standing is Grand Master for the LAN
- GM is the root of the timing tree
- GM periodically sends the current time

PTP Message Formats

- All PTP Messages consist of a header, body and optional suffix



PTP Message

Header

Body

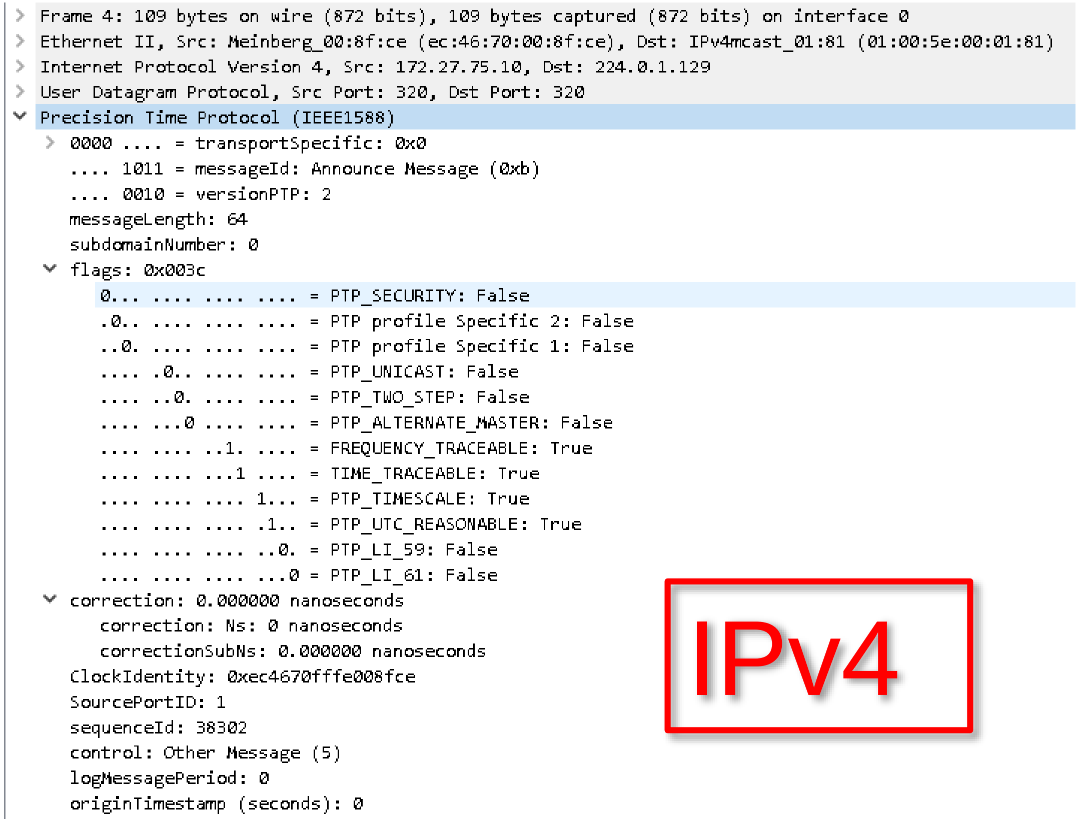
Suffix

34 Bytes

Variable length

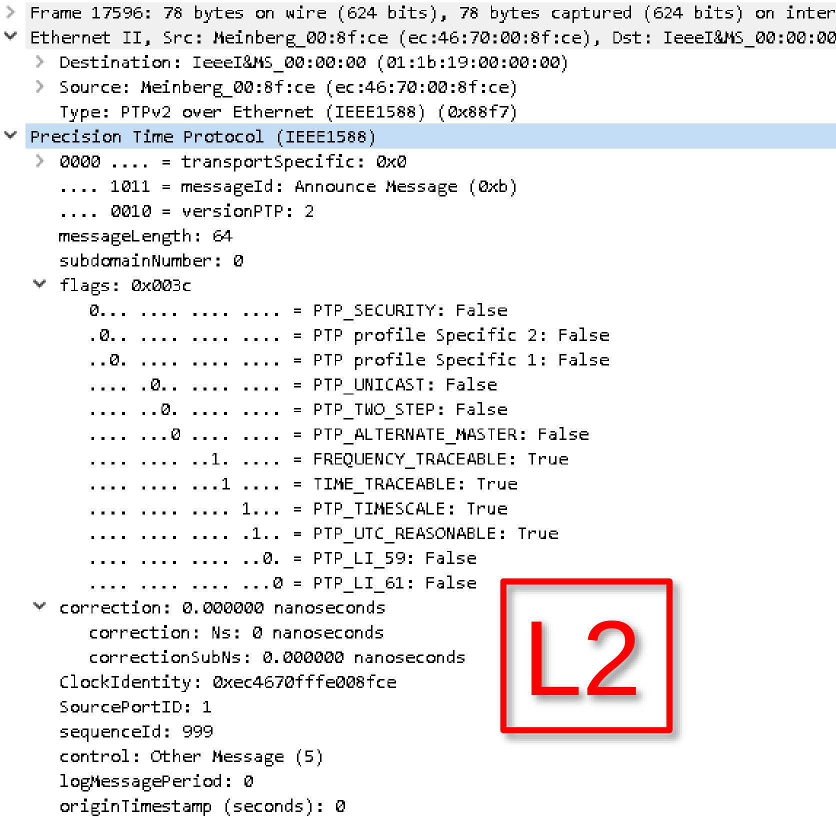
Optional

PTPv2 / General messages / Announce



```
Frame 4: 109 bytes on wire (872 bits), 109 bytes captured (872 bits) on interface 0
Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IPv4mcast_01:81 (01:00:5e:00:01:81)
Internet Protocol Version 4, Src: 172.27.75.10, Dst: 224.0.1.129
User Datagram Protocol, Src Port: 320, Dst Port: 320
Precision Time Protocol (IEEE1588)
  0000 .... = transportSpecific: 0x0
  .... 1011 = messageId: Announce Message (0xb)
  .... 0010 = versionPTP: 2
  messageLength: 64
  subdomainNumber: 0
  flags: 0x003c
    0... .... .... .... = PTP_SECURITY: False
    .0.. .... .... .... = PTP profile Specific 2: False
    ..0. .... .... .... = PTP profile Specific 1: False
    .... .0.. .... .... = PTP_UNICAST: False
    .... ..0. .... .... = PTP_TWO_STEP: False
    .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
    .... .... ..1. .... = FREQUENCY_TRACEABLE: True
    .... .... ...1 .... = TIME_TRACEABLE: True
    .... .... .... 1... = PTP_TIMESCALE: True
    .... .... .... .1.. = PTP_UTC_REASONABLE: True
    .... .... .... ..0. = PTP_LI_59: False
    .... .... .... ...0 = PTP_LI_61: False
  correction: 0.000000 nanoseconds
    correction: Ns: 0 nanoseconds
    correctionSubNs: 0.000000 nanoseconds
  ClockIdentity: 0xec4670fffe008fce
  SourcePortID: 1
  sequenceId: 38302
  control: Other Message (5)
  logMessagePeriod: 0
  originTimestamp (seconds): 0
```

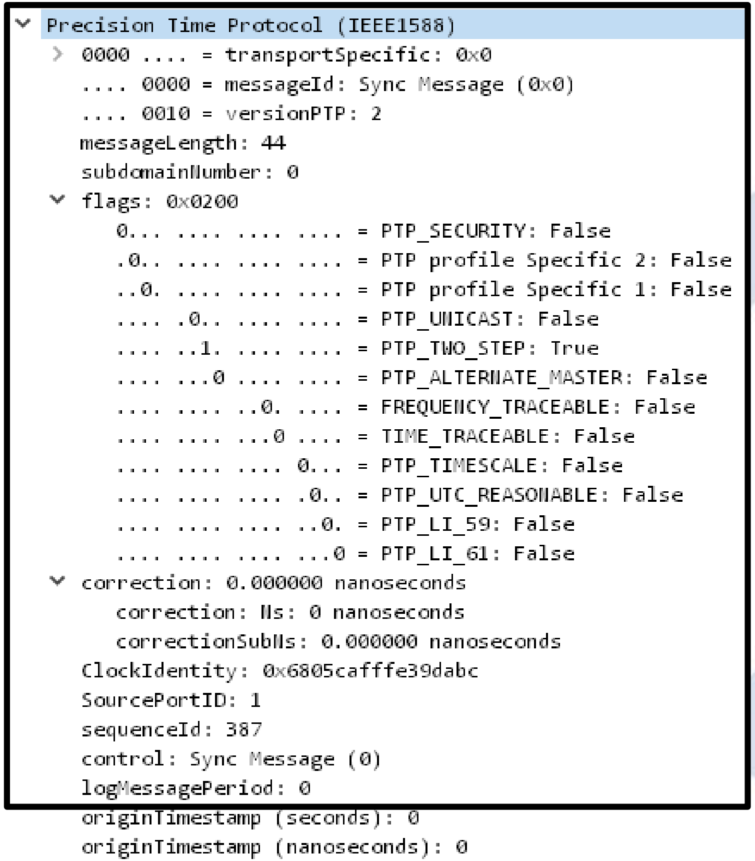
IPv4



```
Frame 17596: 78 bytes on wire (624 bits), 78 bytes captured (624 bits) on inter
Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IeeeI&MS_00:00:00
  Destination: IeeeI&MS_00:00:00 (01:1b:19:00:00:00)
  Source: Meinberg_00:8f:ce (ec:46:70:00:8f:ce)
  Type: PTPv2 over Ethernet (IEEE1588) (0x88f7)
Precision Time Protocol (IEEE1588)
  0000 .... = transportSpecific: 0x0
  .... 1011 = messageId: Announce Message (0xb)
  .... 0010 = versionPTP: 2
  messageLength: 64
  subdomainNumber: 0
  flags: 0x003c
    0... .... .... .... = PTP_SECURITY: False
    .0.. .... .... .... = PTP profile Specific 2: False
    ..0. .... .... .... = PTP profile Specific 1: False
    .... .0.. .... .... = PTP_UNICAST: False
    .... ..0. .... .... = PTP_TWO_STEP: False
    .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
    .... .... ..1. .... = FREQUENCY_TRACEABLE: True
    .... .... ...1 .... = TIME_TRACEABLE: True
    .... .... .... 1... = PTP_TIMESCALE: True
    .... .... .... .1.. = PTP_UTC_REASONABLE: True
    .... .... .... ..0. = PTP_LI_59: False
    .... .... .... ...0 = PTP_LI_61: False
  correction: 0.000000 nanoseconds
    correction: Ns: 0 nanoseconds
    correctionSubNs: 0.000000 nanoseconds
  ClockIdentity: 0xec4670fffe008fce
  SourcePortID: 1
  sequenceId: 999
  control: Other Message (5)
  logMessagePeriod: 0
  originTimestamp (seconds): 0
```

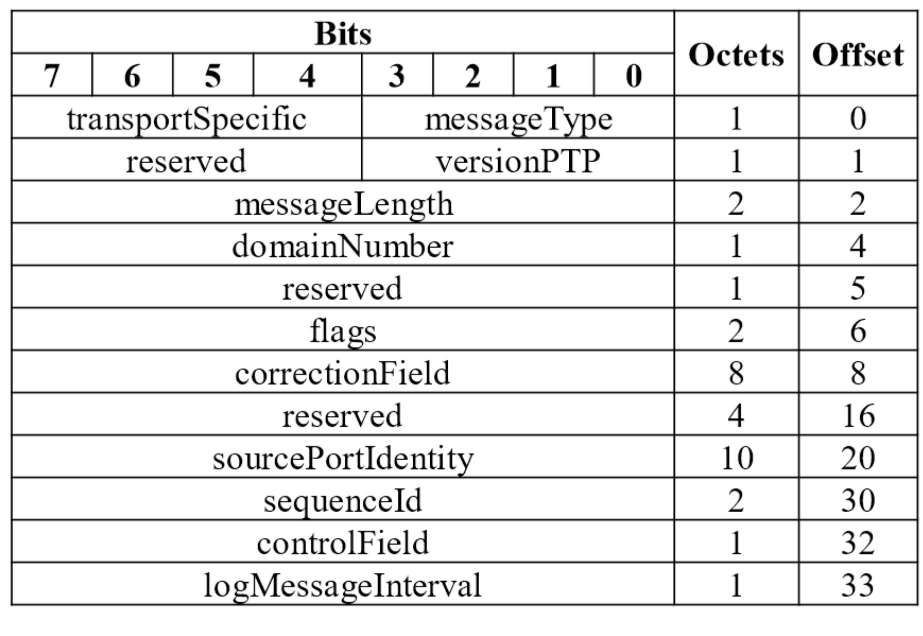
L2

PTP Message Header



```
Precision Time Protocol (IEEE1588)
  0000 .... = transportSpecific: 0x0
  .... 0000 = messageId: Sync Message (0x0)
  .... 0010 = versionPTP: 2
  messageLength: 44
  subdomainNumber: 0
  flags: 0x0200
    0... .... .... .... = PTP_SECURITY: False
    .0.. .... .... .... = PTP profile Specific 2: False
    ..0. .... .... .... = PTP profile Specific 1: False
    .... .0.. .... .... = PTP_UNICAST: False
    .... ..1. .... .... = PTP_TWO_STEP: True
    .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
    .... .... ..0. .... = FREQUENCY_TRACEABLE: False
    .... .... ...0 .... = TIME_TRACEABLE: False
    .... .... .... 0... = PTP_TIMESCALE: False
    .... .... .... .0.. = PTP_UTC_REASONABLE: False
    .... .... .... ..0. = PTP_LI_59: False
    .... .... .... ...0 = PTP_LI_61: False
  correction: 0.000000 nanoseconds
    correction: Ns: 0 nanoseconds
    correctionSubNs: 0.000000 nanoseconds
  ClockIdentity: 0x6805cafffe39dabc
  SourcePortID: 1
  sequenceId: 387
  control: Sync Message (0)
  logMessagePeriod: 0
  originTimestamp (seconds): 0
  originTimestamp (nanoseconds): 0
```

- Common part of PTP Message Header

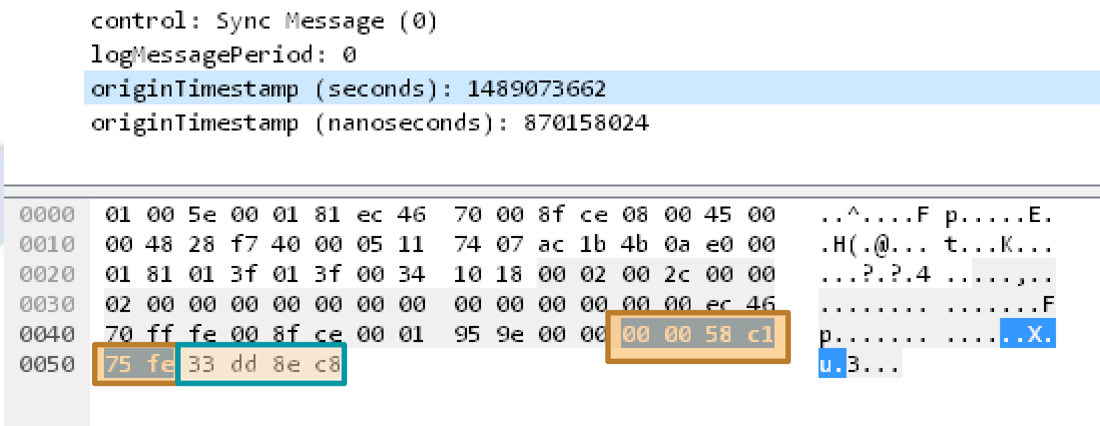


Bits								Octets	Offset
7	6	5	4	3	2	1	0		
transportSpecific				messageType				1	0
reserved				versionPTP				1	1
messageLength								2	2
domainNumber								1	4
reserved								1	5
flags								2	6
correctionField								8	8
reserved								4	16
sourcePortIdentity								10	20
sequenceId								2	30
controlField								1	32
logMessageInterval								1	33

Source: IEEE 1588-2008, Table 18

PTP Timestamps

- PTP use 80 bit-Timestamps
  - They consist of a 48-bit part for seconds and a 32-bit part for nanosecond
  - The time scale rolls over every 2^{48} seconds (8.925.512 years)
  - Theoretical resolution of 2^{32} nanoseconds
  - Timescale from TAI
    - also alternative timescale possible



```
control: Sync Message (0)
logMessagePeriod: 0
originTimestamp (seconds): 1489073662
originTimestamp (nanoseconds): 870158024
```

```
0000  01 00 5e 00 01 81 ec 46  70 00 8f ce 08 00 45 00   ..^....F p.....E.
0010  00 48 28 f7 40 00 05 11  74 07 ac 1b 4b 0a e0 00   .H(.@... t...K...
0020  01 81 01 3f 01 3f 00 34  10 18 00 02 00 2c 00 00   ...?.?.4 .....,..
0030  02 00 00 00 00 00 00 00  00 00 00 00 00 00 ec 46   ........ .......F
0040  70 ff fe 00 8f ce 00 01  95 9e 00 00 00 00 58 c1   p....... ......X.
0050  75 fe 33 dd 8e c8                                  u.3...
```

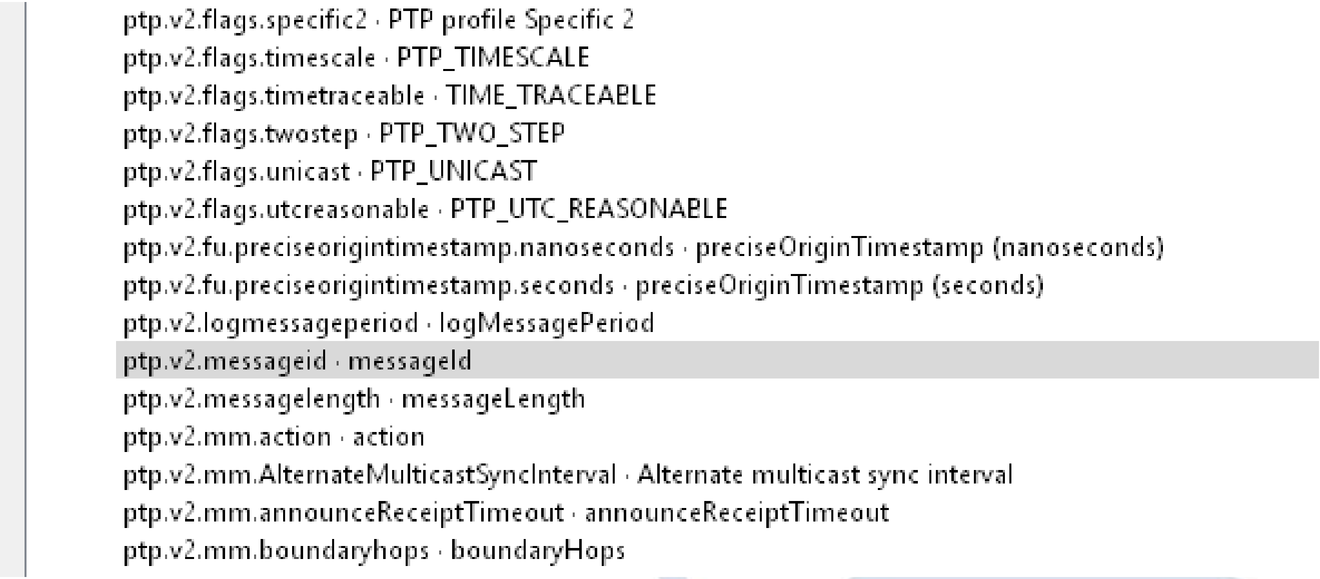
Time.sec
Seconds
48 bit

Time.Frac
Nanoseconds
32 bit

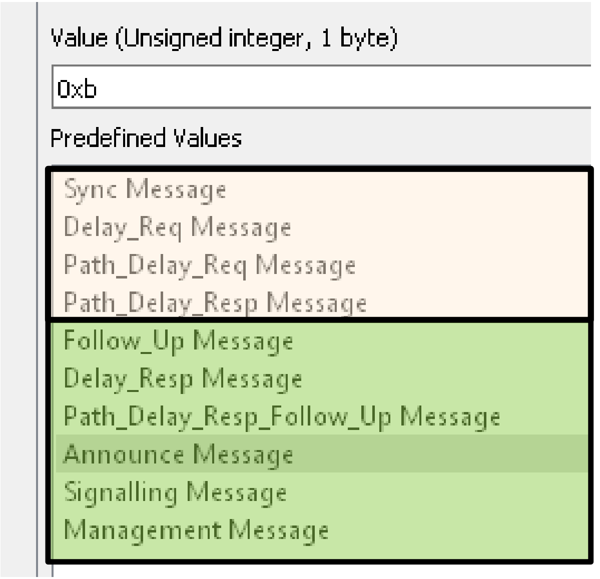
PTPv2 Message Types

- Event messages (need to be accurately time stamped)
  - Sync
  - Delay_Req
  - Pdelay_Req
  - Pdelay_Resp
- General messages (not time stamped)
  - Follow_Up
  - Delay_Resp
  - Pdelay_Resp_Follow_Up
  - Announce
  - Signaling and Management

PTPv2 Message Types



ptp.v2.flags.specific2 · PTP profile Specific 2
ptp.v2.flags.timescale · PTP_TIMESCALE
ptp.v2.flags.timetraceable · TIME_TRACEABLE
ptp.v2.flags.twostep · PTP_TWO_STEP
ptp.v2.flags.unicast · PTP_UNICAST
ptp.v2.flags.utcreasonable · PTP_UTC_REASONABLE
ptp.v2.fu.preciseorigintimestamp.nanoseconds · preciseOriginTimestamp (nanoseconds)
ptp.v2.fu.preciseorigintimestamp.seconds · preciseOriginTimestamp (seconds)
ptp.v2.logmessageperiod · logMessagePeriod
ptp.v2.messageid · messageId
ptp.v2.messagelength · messageLength
ptp.v2.mm.action · action
ptp.v2.mm.AlternateMulticastSyncInterval · Alternate multicast sync interval
ptp.v2.mm.announceReceiptTimeout · announceReceiptTimeout
ptp.v2.mm.boundaryhops · boundaryHops



Value (Unsigned integer, 1 byte)

0xb

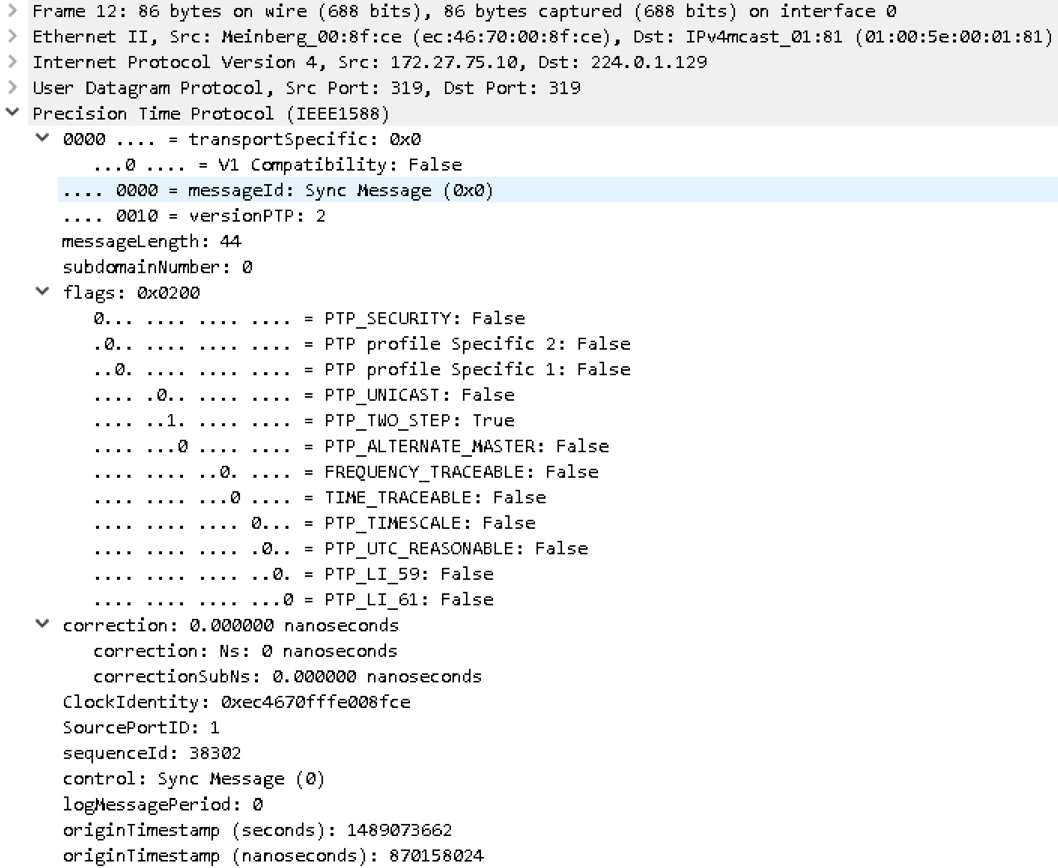
Predefined Values

Sync Message
Delay_Req Message
Path_Delay_Req Message
Path_Delay_Resp Message
Follow_Up Message
Delay_Resp Message
Path_Delay_Resp_Follow_Up Message
Announce Message
Signalling Message
Management Message

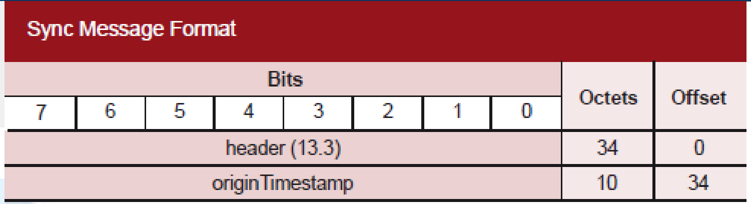
Event messages

General messages

PTP – Sync Message (0x0)



```
> Frame 12: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IPv4mcast_01:81 (01:00:5e:00:01:81)
> Internet Protocol Version 4, Src: 172.27.75.10, Dst: 224.0.1.129
> User Datagram Protocol, Src Port: 319, Dst Port: 319
v Precision Time Protocol (IEEE1588)
   v 0000 .... = transportSpecific: 0x0
        ...0 .... = V1 Compatibility: False
     .... 0000 = messageId: Sync Message (0x0)
     .... 0010 = versionPTP: 2
     messageLength: 44
     subdomainNumber: 0
   v flags: 0x0200
        0... .... .... .... = PTP_SECURITY: False
        .0.. .... .... .... = PTP profile Specific 2: False
        ..0. .... .... .... = PTP profile Specific 1: False
        .... .0.. .... .... = PTP_UNICAST: False
        .... ..1. .... .... = PTP_TWO_STEP: True
        .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
        .... .... ..0. .... = FREQUENCY_TRACEABLE: False
        .... .... ...0 .... = TIME_TRACEABLE: False
        .... .... .... 0... = PTP_TIMESCALE: False
        .... .... .... .0.. = PTP_UTC_REASONABLE: False
        .... .... .... ..0. = PTP_LI_59: False
        .... .... .... ...0 = PTP_LI_61: False
   v correction: 0.000000 nanoseconds
        correction: Ns: 0 nanoseconds
        correctionSubNs: 0.000000 nanoseconds
     ClockIdentity: 0xec4670fffe008fce
     SourcePortID: 1
     sequenceId: 38302
     control: Sync Message (0)
     logMessagePeriod: 0
     originTimestamp (seconds): 1489073662
     originTimestamp (nanoseconds): 870158024
```



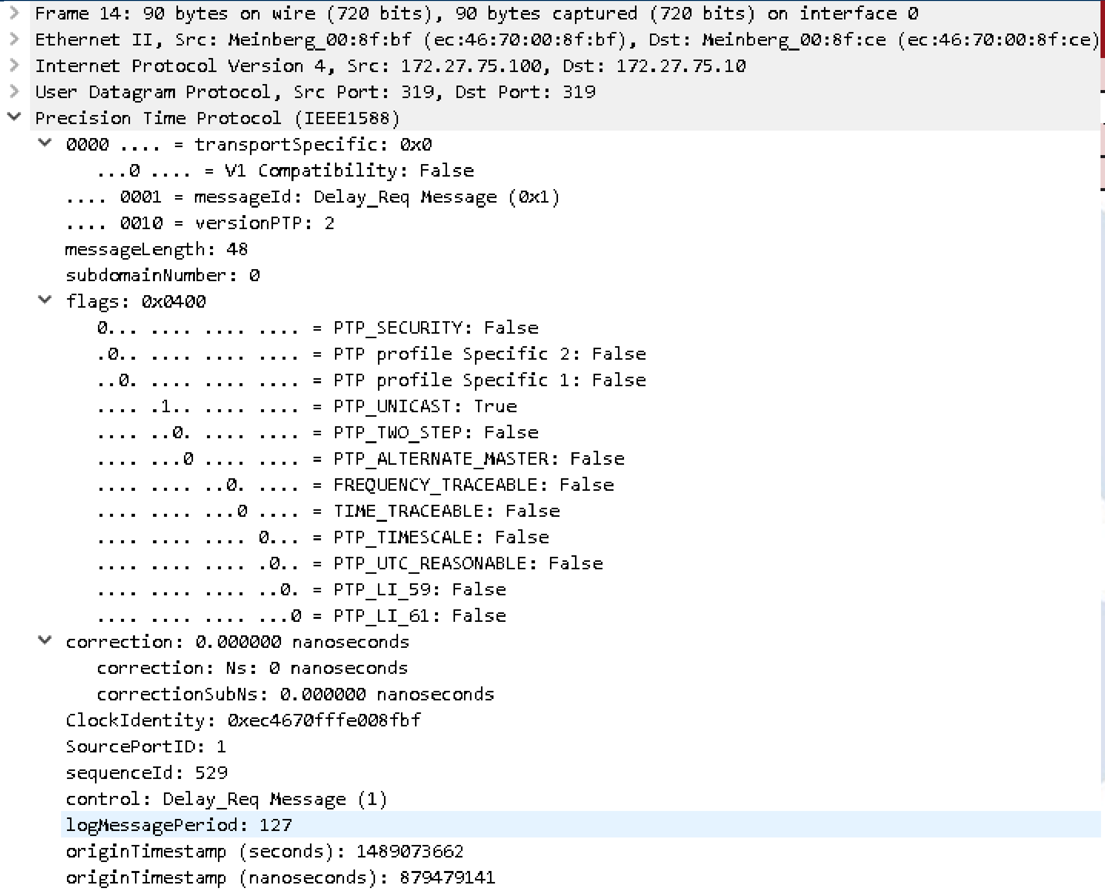
Sync Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
originTimestamp								10	34

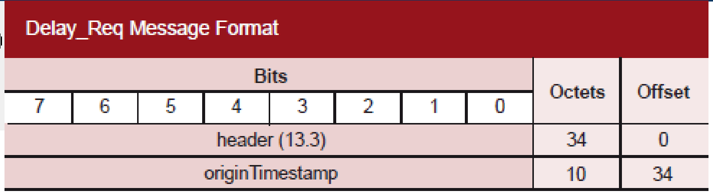
IPv4

Event messages

PTP - Delay_Req Message (0x1)



```
> Frame 14: 90 bytes on wire (720 bits), 90 bytes captured (720 bits) on interface 0
> Ethernet II, Src: Meinberg_00:8f:bf (ec:46:70:00:8f:bf), Dst: Meinberg_00:8f:ce (ec:46:70:00:8f:ce)
> Internet Protocol Version 4, Src: 172.27.75.100, Dst: 172.27.75.10
> User Datagram Protocol, Src Port: 319, Dst Port: 319
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
       ...0 .... = V1 Compatibility: False
    .... 0001 = messageId: Delay_Req Message (0x1)
    .... 0010 = versionPTP: 2
    messageLength: 48
    subdomainNumber: 0
  v flags: 0x0400
       0... .... .... .... = PTP_SECURITY: False
       .0.. .... .... .... = PTP profile Specific 2: False
       ..0. .... .... .... = PTP profile Specific 1: False
       .... .1.. .... .... = PTP_UNICAST: True
       .... ..0. .... .... = PTP_TWO_STEP: False
       .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
       .... .... ..0. .... = FREQUENCY_TRACEABLE: False
       .... .... ...0 .... = TIME_TRACEABLE: False
       .... .... .... 0... = PTP_TIMESCALE: False
       .... .... .... .0.. = PTP_UTC_REASONABLE: False
       .... .... .... ..0. = PTP_LI_59: False
       .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
       correction: Ns: 0 nanoseconds
       correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0xec4670fffe008fbf
    SourcePortID: 1
    sequenceId: 529
    control: Delay_Req Message (1)
    logMessagePeriod: 127
    originTimestamp (seconds): 1489073662
    originTimestamp (nanoseconds): 879479141
```



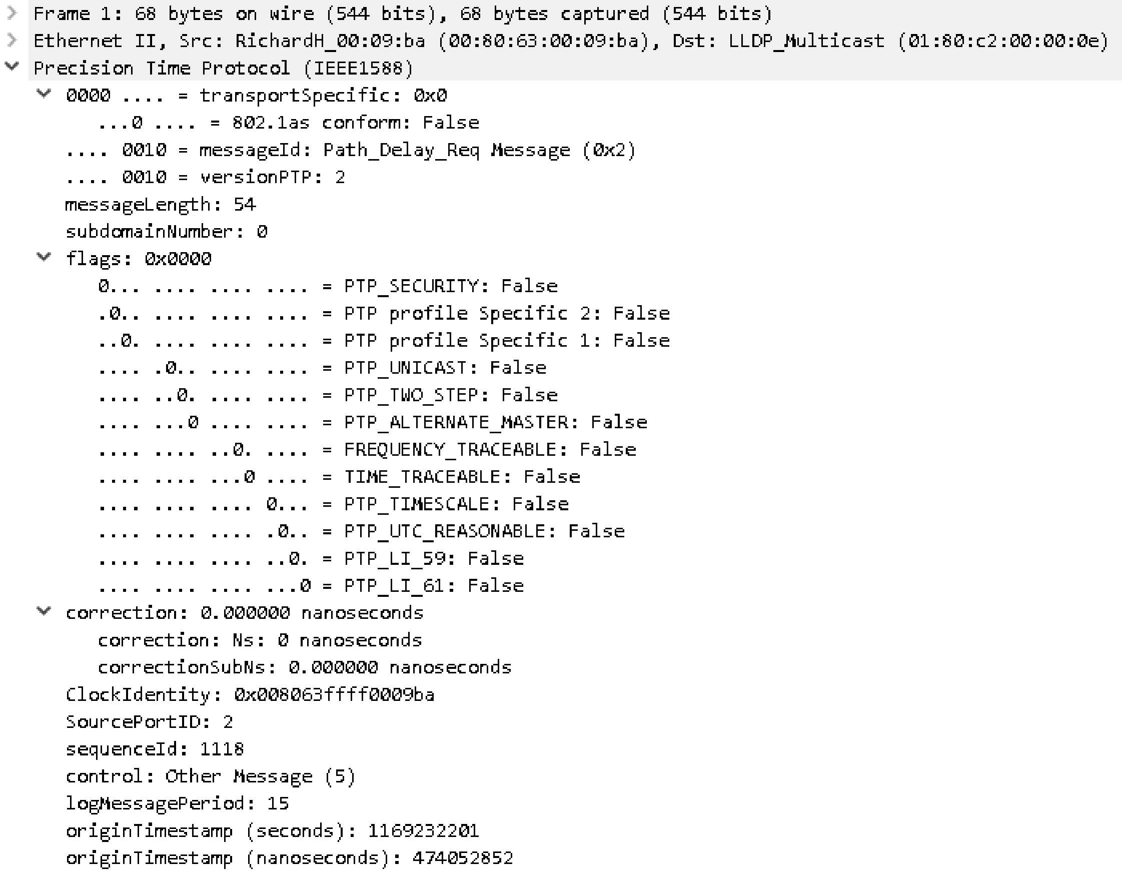
Delay_Req Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
originTimestamp								10	34

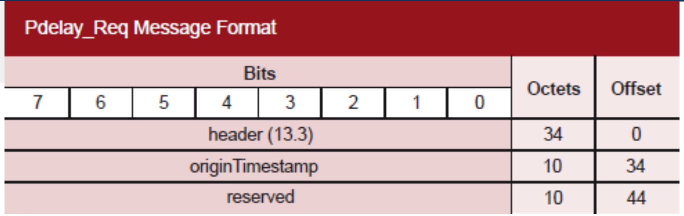
IPv4

Event messages

PTP - Path_Delay_Req Message (0x2)



```
> Frame 1: 68 bytes on wire (544 bits), 68 bytes captured (544 bits)
> Ethernet II, Src: RichardH_00:09:ba (00:80:63:00:09:ba), Dst: LLDP_Multicast (01:80:c2:00:00:0e)
v Precision Time Protocol (IEEE1588)
   v 0000 .... = transportSpecific: 0x0
        ...0 .... = 802.1as conform: False
     .... 0010 = messageId: Path_Delay_Req Message (0x2)
     .... 0010 = versionPTP: 2
     messageLength: 54
     subdomainNumber: 0
   v flags: 0x0000
        0... .... .... .... = PTP_SECURITY: False
        .0.. .... .... .... = PTP profile Specific 2: False
        ..0. .... .... .... = PTP profile Specific 1: False
        .... .0.. .... .... = PTP_UNICAST: False
        .... ..0. .... .... = PTP_TWO_STEP: False
        .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
        .... .... ..0. .... = FREQUENCY_TRACEABLE: False
        .... .... ...0 .... = TIME_TRACEABLE: False
        .... .... .... 0... = PTP_TIMESCALE: False
        .... .... .... .0.. = PTP_UTC_REASONABLE: False
        .... .... .... ..0. = PTP_LI_59: False
        .... .... .... ...0 = PTP_LI_61: False
   v correction: 0.000000 nanoseconds
        correction: Ns: 0 nanoseconds
        correctionSubNs: 0.000000 nanoseconds
     ClockIdentity: 0x008063ffff0009ba
     SourcePortID: 2
     sequenceId: 1118
     control: Other Message (5)
     logMessagePeriod: 15
     originTimestamp (seconds): 1169232201
     originTimestamp (nanoseconds): 474052852
```



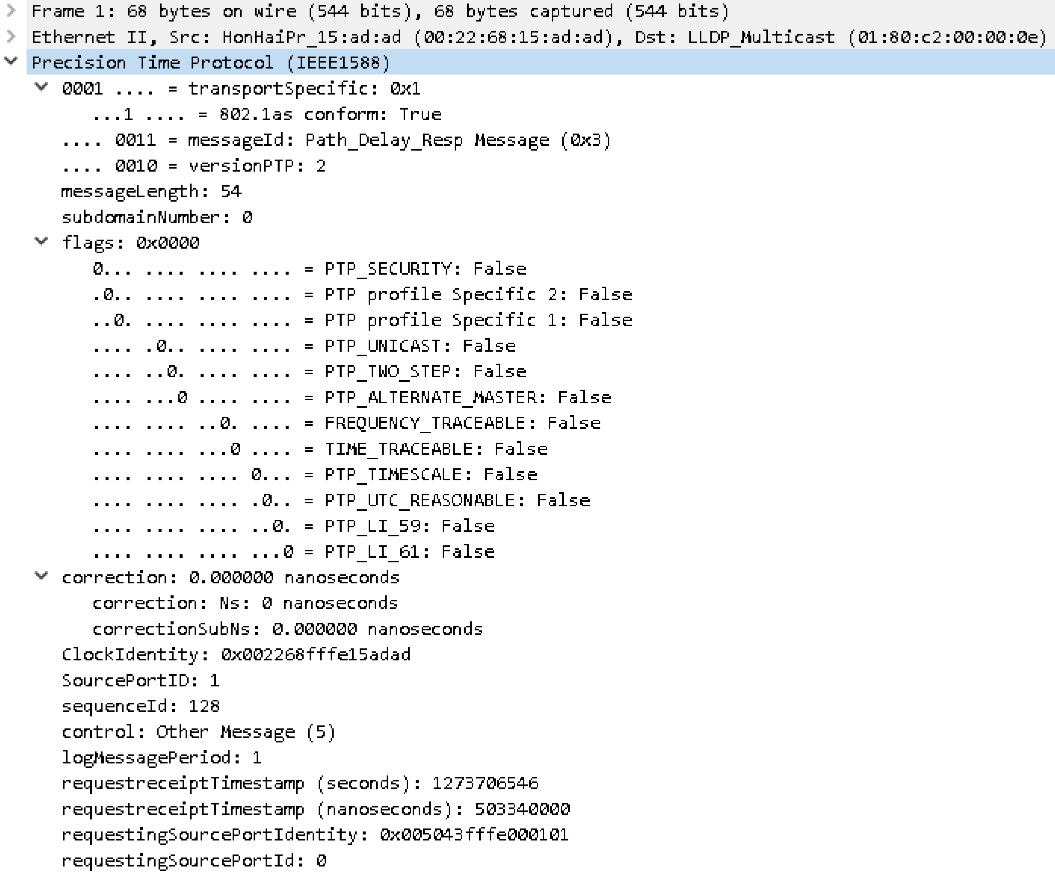
Pdelay_Req Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
originTimestamp								10	34
reserved								10	44

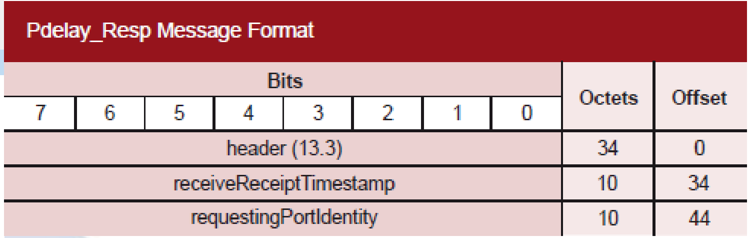
L2

Event messages

PTP - Path_Delay_Resp Message (0x3)



```
> Frame 1: 68 bytes on wire (544 bits), 68 bytes captured (544 bits)
> Ethernet II, Src: HonHaiPr_15:ad:ad (00:22:68:15:ad:ad), Dst: LLDP_Multicast (01:80:c2:00:00:0e)
v Precision Time Protocol (IEEE1588)
    v 0001 .... = transportSpecific: 0x1
          ...1 .... = 802.1as conform: True
      .... 0011 = messageId: Path_Delay_Resp Message (0x3)
      .... 0010 = versionPTP: 2
      messageLength: 54
      subdomainNumber: 0
    v flags: 0x0000
          0... .... .... .... = PTP_SECURITY: False
          .0.. .... .... .... = PTP profile Specific 2: False
          ..0. .... .... .... = PTP profile Specific 1: False
          .... .0.. .... .... = PTP_UNICAST: False
          .... ..0. .... .... = PTP_TWO_STEP: False
          .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
          .... .... ..0. .... = FREQUENCY_TRACEABLE: False
          .... .... ...0 .... = TIME_TRACEABLE: False
          .... .... .... 0... = PTP_TIMESCALE: False
          .... .... .... .0.. = PTP_UTC_REASONABLE: False
          .... .... .... ..0. = PTP_LI_59: False
          .... .... .... ...0 = PTP_LI_61: False
    v correction: 0.000000 nanoseconds
          correction: Ns: 0 nanoseconds
          correctionSubNs: 0.000000 nanoseconds
      ClockIdentity: 0x002268fffe15adad
      SourcePortID: 1
      sequenceId: 128
      control: Other Message (5)
      logMessagePeriod: 1
      requestreceiptTimestamp (seconds): 1273706546
      requestreceiptTimestamp (nanoseconds): 503340000
      requestingSourcePortIdentity: 0x005043fffe000101
      requestingSourcePortId: 0
```



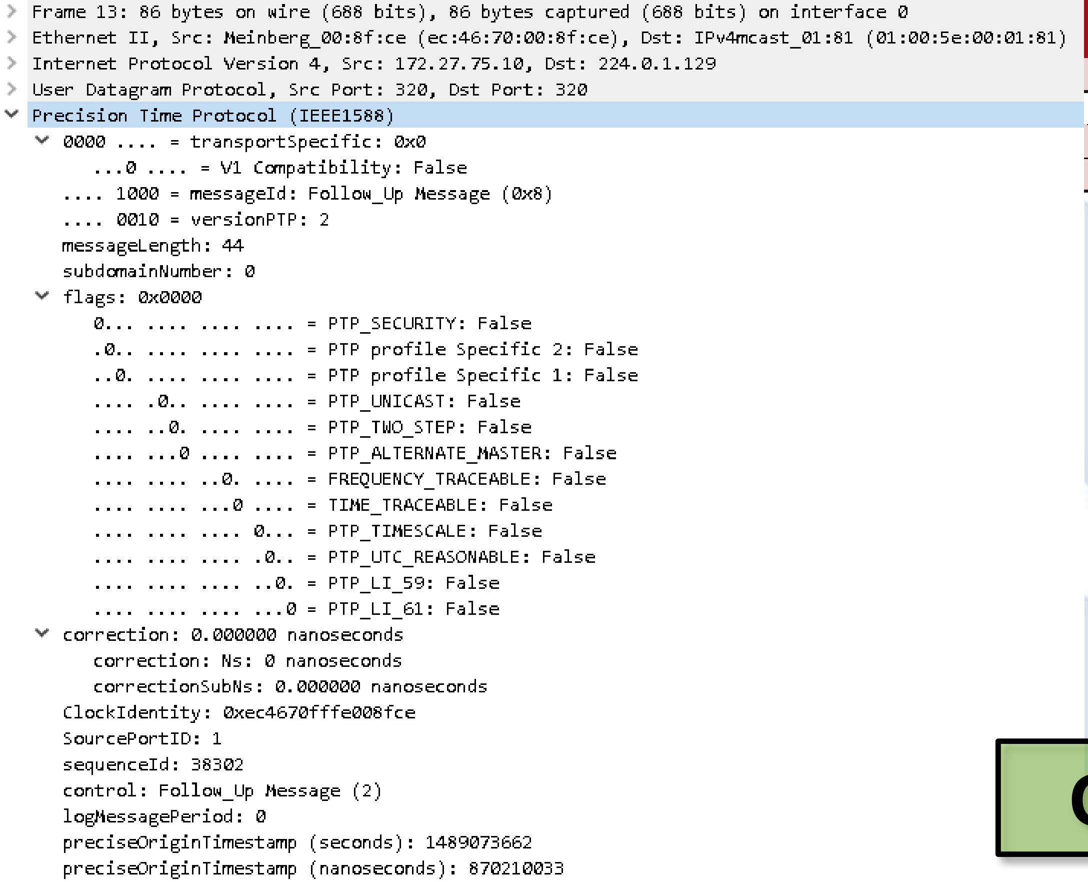
Pdelay_Resp Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
receiveReceiptTimestamp								10	34
requestingPortIdentity								10	44

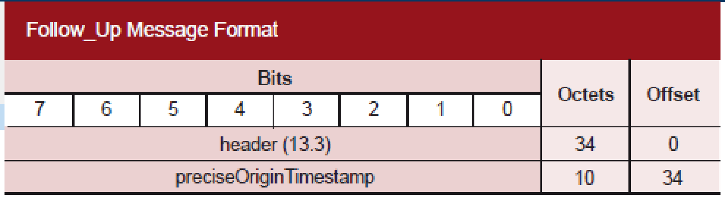
L2

Event messages

PTP - Follow_Up Message (0x8)



```
> Frame 13: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on interface 0
> Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IPv4mcast_01:81 (01:00:5e:00:01:81)
> Internet Protocol Version 4, Src: 172.27.75.10, Dst: 224.0.1.129
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
       ...0 .... = V1 Compatibility: False
    .... 1000 = messageId: Follow_Up Message (0x8)
    .... 0010 = versionPTP: 2
    messageLength: 44
    subdomainNumber: 0
  v flags: 0x0000
       0... .... .... .... = PTP_SECURITY: False
       .0.. .... .... .... = PTP profile Specific 2: False
       ..0. .... .... .... = PTP profile Specific 1: False
       .... .0.. .... .... = PTP_UNICAST: False
       .... ..0. .... .... = PTP_TWO_STEP: False
       .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
       .... .... ..0. .... = FREQUENCY_TRACEABLE: False
       .... .... ...0 .... = TIME_TRACEABLE: False
       .... .... .... 0... = PTP_TIMESCALE: False
       .... .... .... .0.. = PTP_UTC_REASONABLE: False
       .... .... .... ..0. = PTP_LI_59: False
       .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
       correction: Ns: 0 nanoseconds
       correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0xec4670fffe008fce
    SourcePortID: 1
    sequenceId: 38302
    control: Follow_Up Message (2)
    logMessagePeriod: 0
    preciseOriginTimestamp (seconds): 1489073662
    preciseOriginTimestamp (nanoseconds): 870210033
```



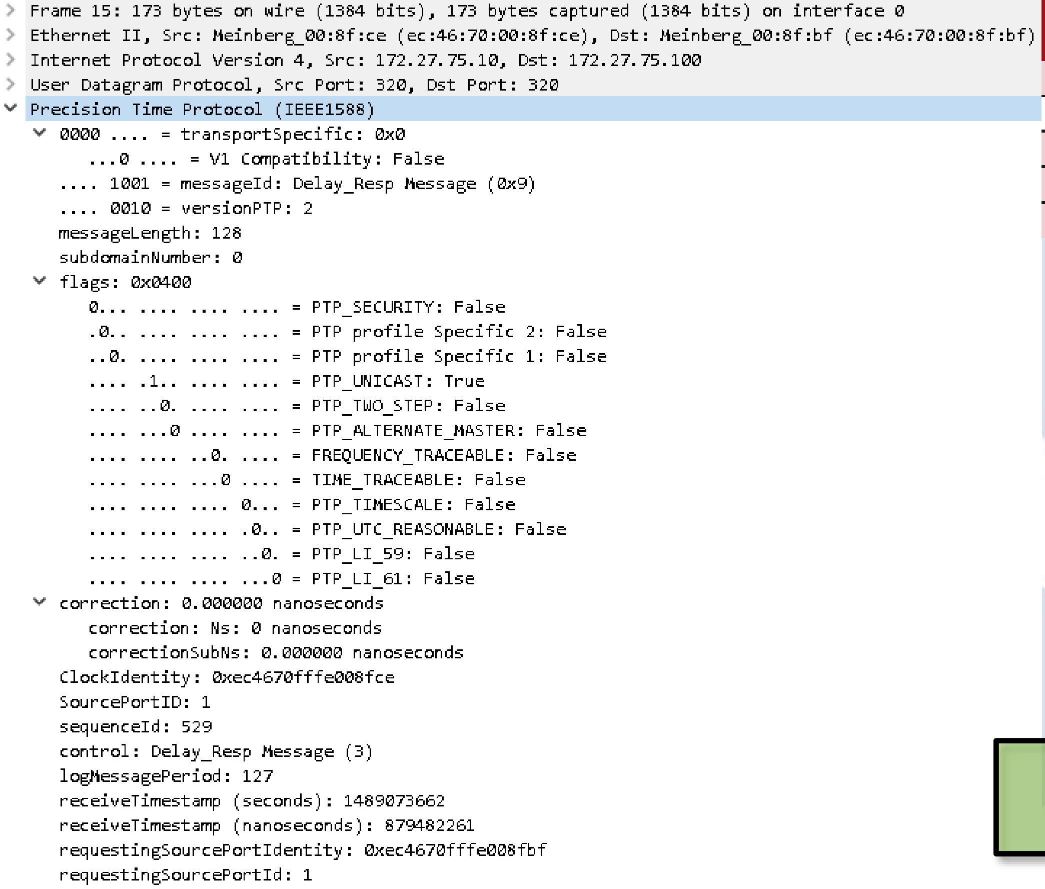
Follow_Up Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
preciseOriginTimestamp								10	34

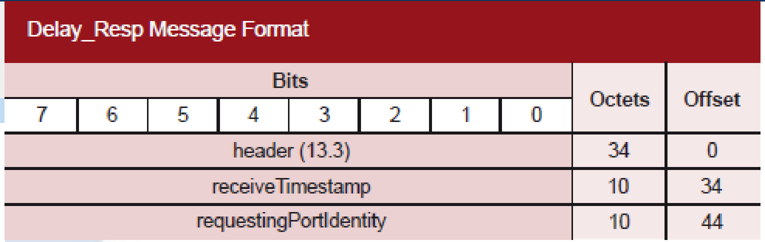
IPv4

General messages

PTP - Delay_Resp Message (0x9)



```
> Frame 15: 173 bytes on wire (1384 bits), 173 bytes captured (1384 bits) on interface 0
> Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: Meinberg_00:8f:bf (ec:46:70:00:8f:bf)
> Internet Protocol Version 4, Src: 172.27.75.10, Dst: 172.27.75.100
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
   v 0000 .... = transportSpecific: 0x0
        ...0 .... = V1 Compatibility: False
     .... 1001 = messageId: Delay_Resp Message (0x9)
     .... 0010 = versionPTP: 2
     messageLength: 128
     subdomainNumber: 0
   v flags: 0x0400
        0... .... .... .... = PTP_SECURITY: False
        .0.. .... .... .... = PTP profile Specific 2: False
        ..0. .... .... .... = PTP profile Specific 1: False
        .... .1.. .... .... = PTP_UNICAST: True
        .... ..0. .... .... = PTP_TWO_STEP: False
        .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
        .... .... ..0. .... = FREQUENCY_TRACEABLE: False
        .... .... ...0 .... = TIME_TRACEABLE: False
        .... .... .... 0... = PTP_TIMESCALE: False
        .... .... .... .0.. = PTP_UTC_REASONABLE: False
        .... .... .... ..0. = PTP_LI_59: False
        .... .... .... ...0 = PTP_LI_61: False
   v correction: 0.000000 nanoseconds
        correction: Ns: 0 nanoseconds
        correctionSubNs: 0.000000 nanoseconds
     ClockIdentity: 0xec4670fffe008fce
     SourcePortID: 1
     sequenceId: 529
     control: Delay_Resp Message (3)
     logMessagePeriod: 127
     receiveTimestamp (seconds): 1489073662
     receiveTimestamp (nanoseconds): 879482261
     requestingSourcePortIdentity: 0xec4670fffe008fbf
     requestingSourcePortId: 1
```



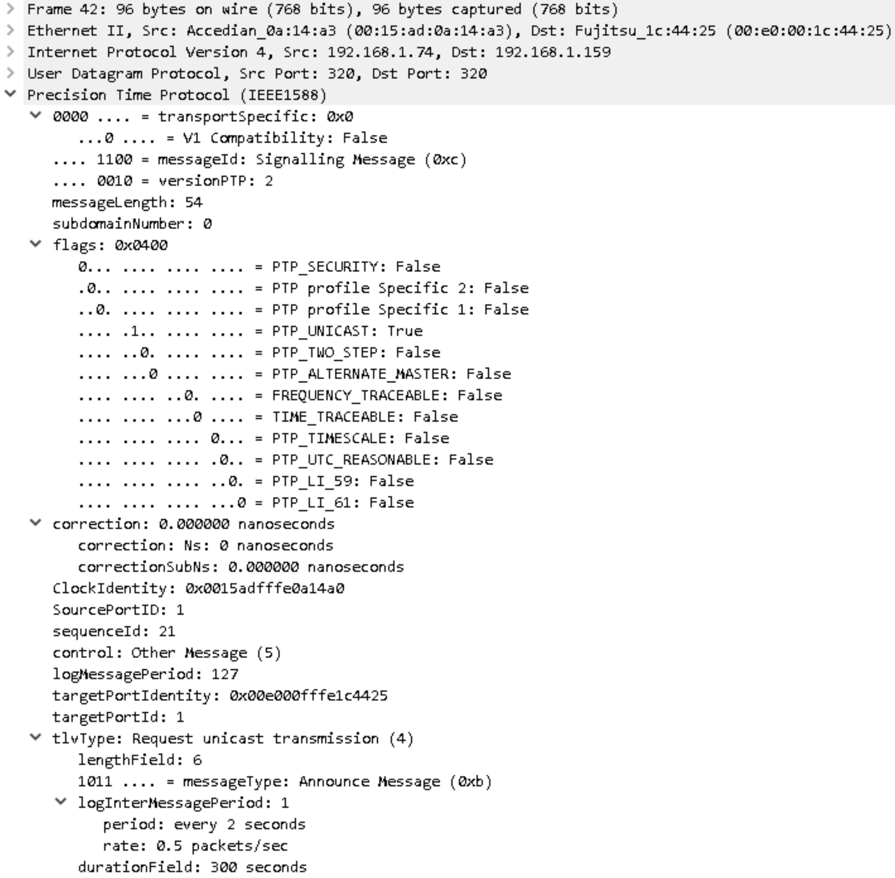
Delay_Resp Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
receiveTimestamp								10	34
requestingPortIdentity								10	44

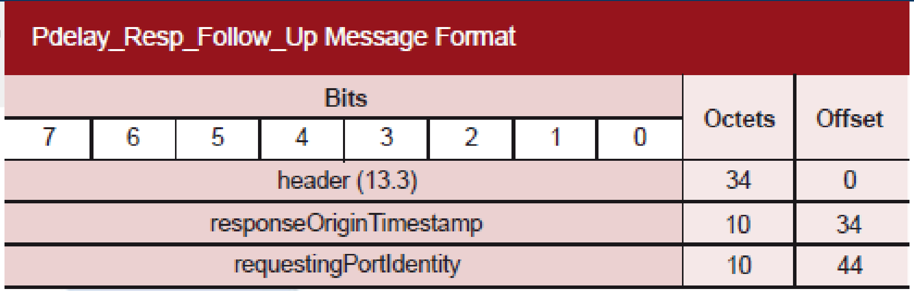
IPv4

General messages

PTP - Path_Delay_Resp_Follow_Up Message (0xa)



```
> Frame 42: 96 bytes on wire (768 bits), 96 bytes captured (768 bits)
> Ethernet II, Src: Accedian_0a:14:a3 (00:15:ad:0a:14:a3), Dst: Fujitsu_1c:44:25 (00:e0:00:1c:44:25)
> Internet Protocol Version 4, Src: 192.168.1.74, Dst: 192.168.1.159
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
        ...0 .... = V1 Compatibility: False
    .... 1100 = messageId: Signalling Message (0xc)
    .... 0010 = versionPTP: 2
    messageLength: 54
    subdomainNumber: 0
  v flags: 0x0400
        0... .... .... .... = PTP_SECURITY: False
        .0.. .... .... .... = PTP profile Specific 2: False
        ..0. .... .... .... = PTP profile Specific 1: False
        .... .1.. .... .... = PTP_UNICAST: True
        .... ..0. .... .... = PTP_TWO_STEP: False
        .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
        .... .... ..0. .... = FREQUENCY_TRACEABLE: False
        .... .... ...0 .... = TIME_TRACEABLE: False
        .... .... .... 0... = PTP_TIMESCALE: False
        .... .... .... .0.. = PTP_UTC_REASONABLE: False
        .... .... .... ..0. = PTP_LI_59: False
        .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
        correction: Ns: 0 nanoseconds
        correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0x0015adfffe0a14a0
    SourcePortID: 1
    sequenceId: 21
    control: Other Message (5)
    logMessagePeriod: 127
    targetPortIdentity: 0x00e000fffe1c4425
    targetPortId: 1
  v tlvType: Request unicast transmission (4)
        lengthField: 6
        1011 .... = messageType: Announce Message (0xb)
      v logInterMessagePeriod: 1
            period: every 2 seconds
            rate: 0.5 packets/sec
        durationField: 300 seconds
```



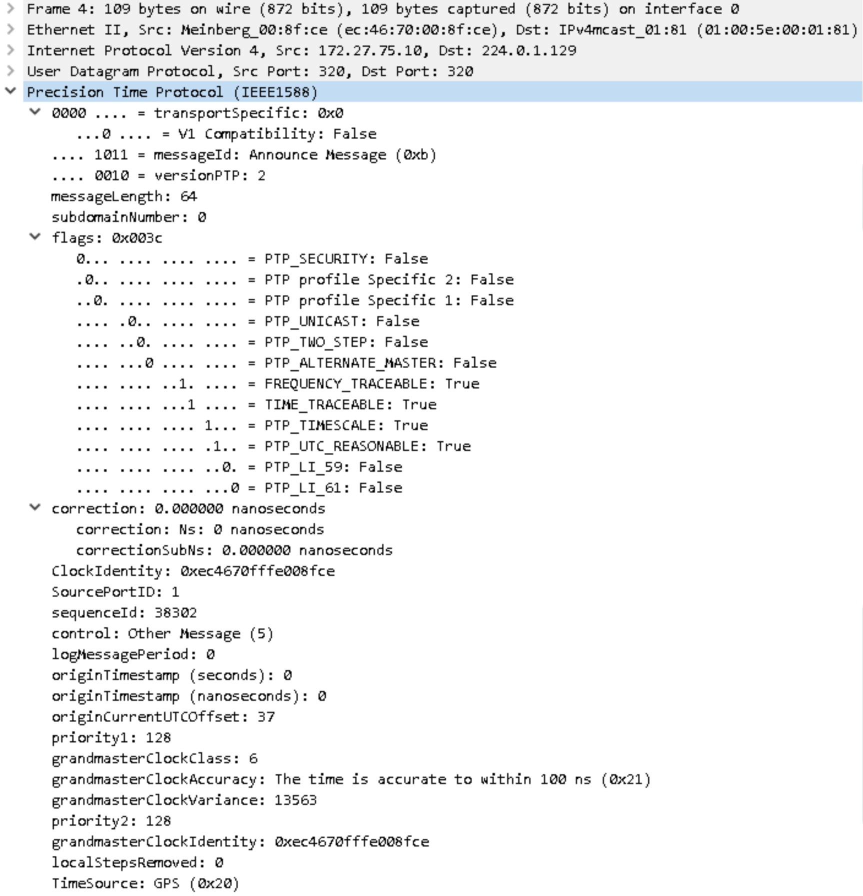
Pdelay_Resp_Follow_Up Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
responseOriginTimestamp								10	34
requestingPortIdentity								10	44

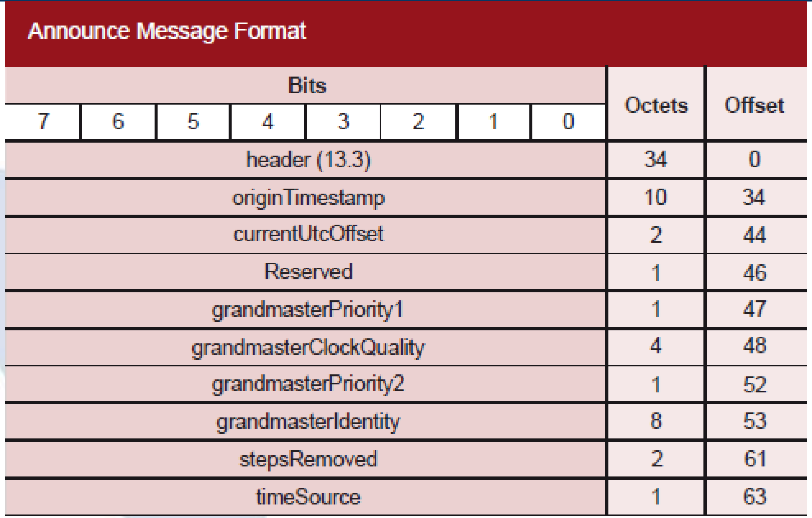
IPv4

General messages

PTP - Announce Message (0xb)



```
> Frame 4: 109 bytes on wire (872 bits), 109 bytes captured (872 bits) on interface 0
> Ethernet II, Src: Meinberg_00:8f:ce (ec:46:70:00:8f:ce), Dst: IPv4mcast_01:81 (01:00:5e:00:01:81)
> Internet Protocol Version 4, Src: 172.27.75.10, Dst: 224.0.1.129
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
       ...0 .... = V1 Compatibility: False
    .... 1011 = messageId: Announce Message (0xb)
    .... 0010 = versionPTP: 2
    messageLength: 64
    subdomainNumber: 0
  v flags: 0x003c
       0... .... .... .... = PTP_SECURITY: False
       .0.. .... .... .... = PTP profile Specific 2: False
       ..0. .... .... .... = PTP profile Specific 1: False
       .... .0.. .... .... = PTP_UNICAST: False
       .... ..0. .... .... = PTP_TWO_STEP: False
       .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
       .... .... ..1. .... = FREQUENCY_TRACEABLE: True
       .... .... ...1 .... = TIME_TRACEABLE: True
       .... .... .... 1... = PTP_TIMESCALE: True
       .... .... .... .1.. = PTP_UTC_REASONABLE: True
       .... .... .... ..0. = PTP_LI_59: False
       .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
       correction: Ns: 0 nanoseconds
       correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0xec4670fffe008fce
    SourcePortID: 1
    sequenceId: 38302
    control: Other Message (5)
    logMessagePeriod: 0
    originTimestamp (seconds): 0
    originTimestamp (nanoseconds): 0
    originCurrentUTCOffset: 37
    priority1: 128
    grandmasterClockClass: 6
    grandmasterClockAccuracy: The time is accurate to within 100 ns (0x21)
    grandmasterClockVariance: 13563
    priority2: 128
    grandmasterClockIdentity: 0xec4670fffe008fce
    localStepsRemoved: 0
    TimeSource: GPS (0x20)
```



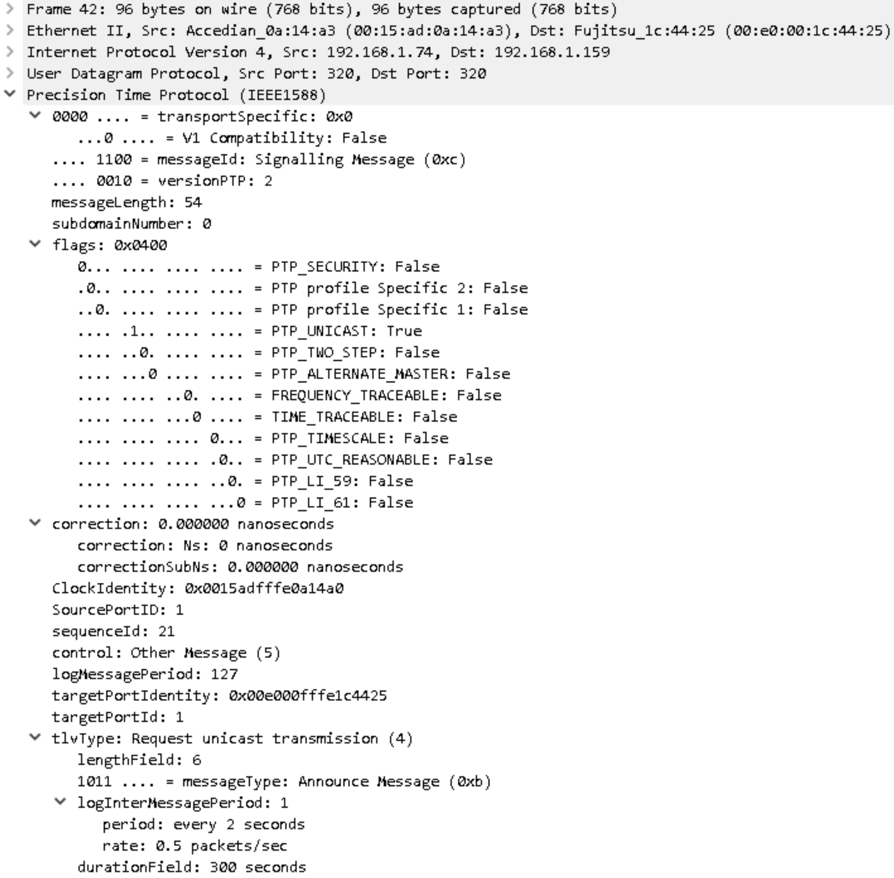
Announce Message Format

Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
originTimestamp								10	34
currentUtcOffset								2	44
Reserved								1	46
grandmasterPriority1								1	47
grandmasterClockQuality								4	48
grandmasterPriority2								1	52
grandmasterIdentity								8	53
stepsRemoved								2	61
timeSource								1	63

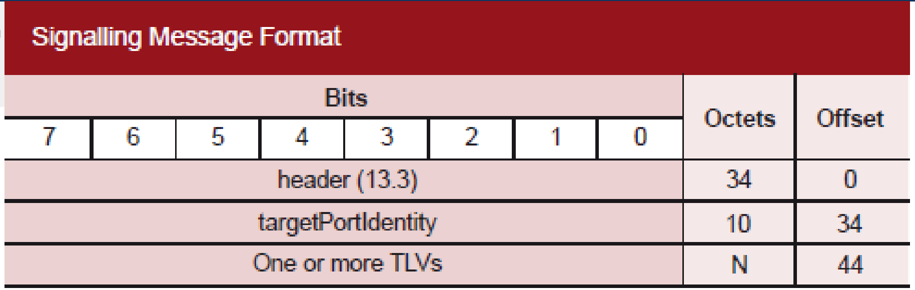
IPv4

General messages

PTP - Signalling Message (0xc)



```
> Frame 42: 96 bytes on wire (768 bits), 96 bytes captured (768 bits)
> Ethernet II, Src: Accedian_0a:14:a3 (00:15:ad:0a:14:a3), Dst: Fujitsu_1c:44:25 (00:e0:00:1c:44:25)
> Internet Protocol Version 4, Src: 192.168.1.74, Dst: 192.168.1.159
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
       ...0 .... = V1 Compatibility: False
    .... 1100 = messageId: Signalling Message (0xc)
    .... 0010 = versionPTP: 2
    messageLength: 54
    subdomainNumber: 0
  v flags: 0x0400
       0... .... .... .... = PTP_SECURITY: False
       .0.. .... .... .... = PTP profile Specific 2: False
       ..0. .... .... .... = PTP profile Specific 1: False
       .... .1.. .... .... = PTP_UNICAST: True
       .... ..0. .... .... = PTP_TWO_STEP: False
       .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
       .... .... ..0. .... = FREQUENCY_TRACEABLE: False
       .... .... ...0 .... = TIME_TRACEABLE: False
       .... .... .... 0... = PTP_TIMESCALE: False
       .... .... .... .0.. = PTP_UTC_REASONABLE: False
       .... .... .... ..0. = PTP_LI_59: False
       .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
       correction: Ns: 0 nanoseconds
       correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0x0015adfffe0a14a0
    SourcePortID: 1
    sequenceId: 21
    control: Other Message (5)
    logMessagePeriod: 127
    targetPortIdentity: 0x00e000fffe1c4425
    targetPortId: 1
  v tlvType: Request unicast transmission (4)
       lengthField: 6
       1011 .... = messageType: Announce Message (0xb)
     v logInterMessagePeriod: 1
          period: every 2 seconds
          rate: 0.5 packets/sec
       durationField: 300 seconds
```



Signalling Message Format

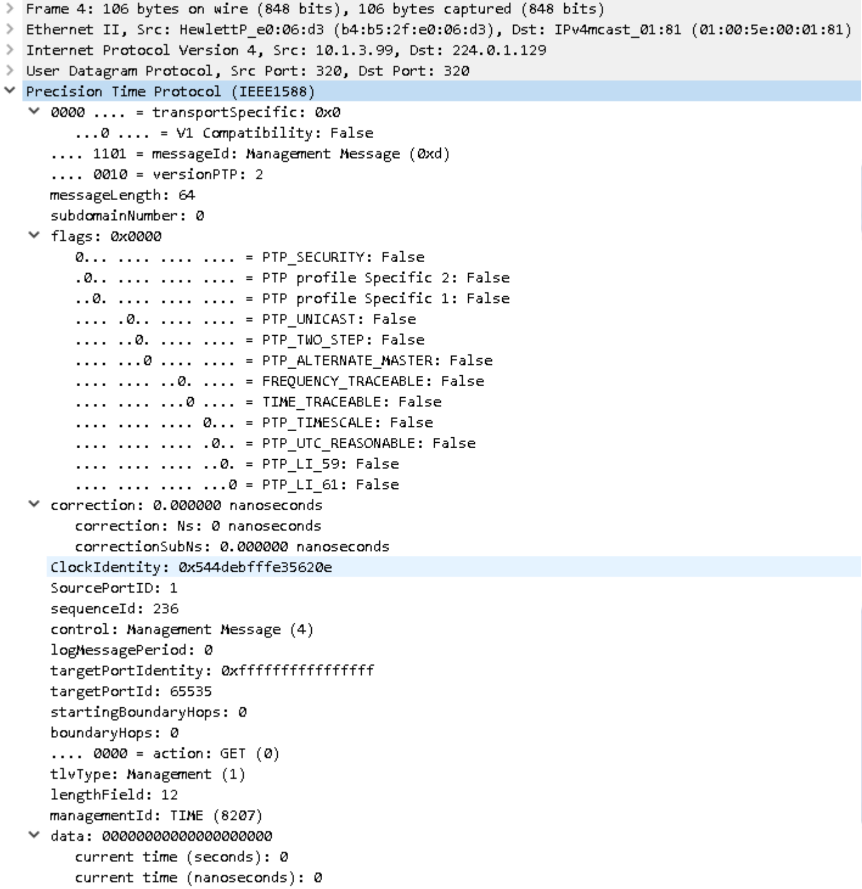
Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
targetPortIdentity								10	34
One or more TLVs								N	44

A Signaling message is used to transport a sequence of one or more TLV entities.

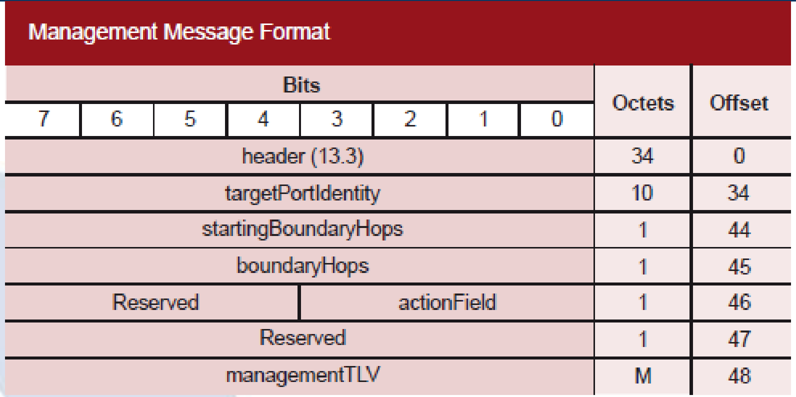
IPv4

General messages

PTP - Management Message (0xd)



```
> Frame 4: 106 bytes on wire (848 bits), 106 bytes captured (848 bits)
> Ethernet II, Src: HewlettP_e0:06:d3 (b4:b5:2f:e0:06:d3), Dst: IPv4mcast_01:81 (01:00:5e:00:01:81)
> Internet Protocol Version 4, Src: 10.1.3.99, Dst: 224.0.1.129
> User Datagram Protocol, Src Port: 320, Dst Port: 320
v Precision Time Protocol (IEEE1588)
  v 0000 .... = transportSpecific: 0x0
       ...0 .... = V1 Compatibility: False
    .... 1101 = messageId: Management Message (0xd)
    .... 0010 = versionPTP: 2
    messageLength: 64
    subdomainNumber: 0
  v flags: 0x0000
       0... .... .... .... = PTP_SECURITY: False
       .0.. .... .... .... = PTP profile Specific 2: False
       ..0. .... .... .... = PTP profile Specific 1: False
       .... .0.. .... .... = PTP_UNICAST: False
       .... ..0. .... .... = PTP_TWO_STEP: False
       .... ...0 .... .... = PTP_ALTERNATE_MASTER: False
       .... .... ..0. .... = FREQUENCY_TRACEABLE: False
       .... .... ...0 .... = TIME_TRACEABLE: False
       .... .... .... 0... = PTP_TIMESCALE: False
       .... .... .... .0.. = PTP_UTC_REASONABLE: False
       .... .... .... ..0. = PTP_LI_59: False
       .... .... .... ...0 = PTP_LI_61: False
  v correction: 0.000000 nanoseconds
       correction: Ns: 0 nanoseconds
       correctionSubNs: 0.000000 nanoseconds
    ClockIdentity: 0x544debfffe35620e
    SourcePortID: 1
    sequenceId: 236
    control: Management Message (4)
    logMessagePeriod: 0
    targetPortIdentity: 0xffffffffffffffff
    targetPortId: 65535
    startingBoundaryHops: 0
    boundaryHops: 0
    .... 0000 = action: GET (0)
    tlvType: Management (1)
    lengthField: 12
    managementId: TIME (8207)
  v data: 00000000000000000000
       current time (seconds): 0
       current time (nanoseconds): 0
```



Management Message Format

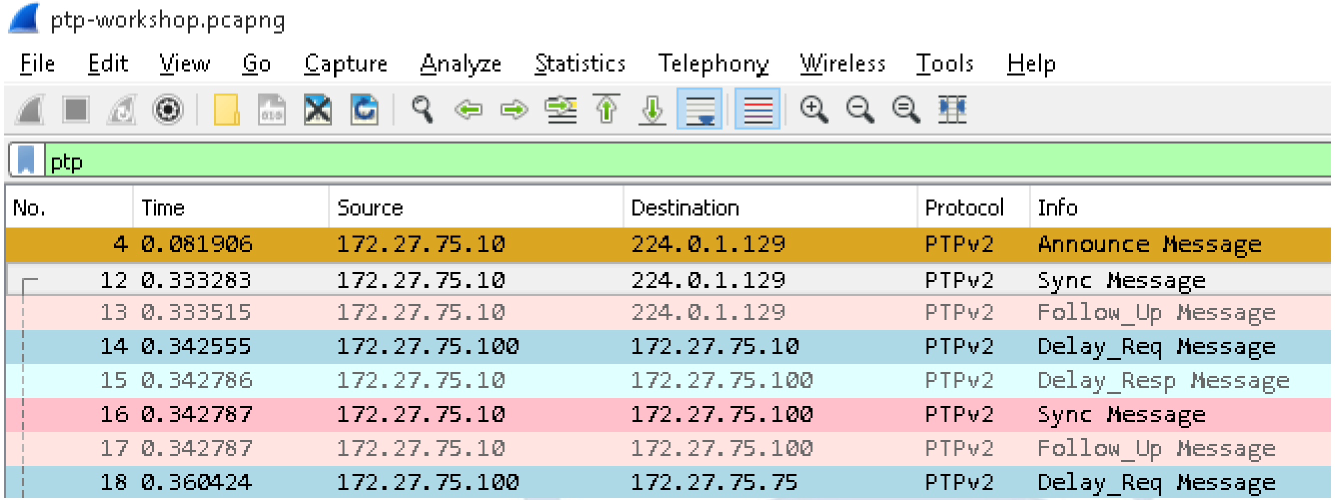
Bits								Octets	Offset
7	6	5	4	3	2	1	0		
header (13.3)								34	0
targetPortIdentity								10	34
startingBoundaryHops								1	44
boundaryHops								1	45
Reserved				actionField				1	46
Reserved								1	47
managementTLV								M	48

IPv4

General messages

PTPv2 Coloring Rule

- Colors for various PTP message types



ptp-workshop.pcapng

ptp

No.	Time	Source	Destination	Protocol	Info
4	0.081906	172.27.75.10	224.0.1.129	PTPv2	Announce Message
12	0.333283	172.27.75.10	224.0.1.129	PTPv2	Sync Message
13	0.333515	172.27.75.10	224.0.1.129	PTPv2	Follow_Up Message
14	0.342555	172.27.75.100	172.27.75.10	PTPv2	Delay_Req Message
15	0.342786	172.27.75.10	172.27.75.100	PTPv2	Delay_Resp Message
16	0.342787	172.27.75.10	172.27.75.100	PTPv2	Sync Message
17	0.342787	172.27.75.10	172.27.75.100	PTPv2	Follow_Up Message
18	0.360424	172.27.75.100	172.27.75.75	PTPv2	Delay_Req Message

- Wireshark Color Filters for PTP (Tutorial)
  - https://www.iol.unh.edu/sites/default/files/knowledgebase/1588/Wireshark_color_filters_tutorial.pdf

PTP Delay measurement

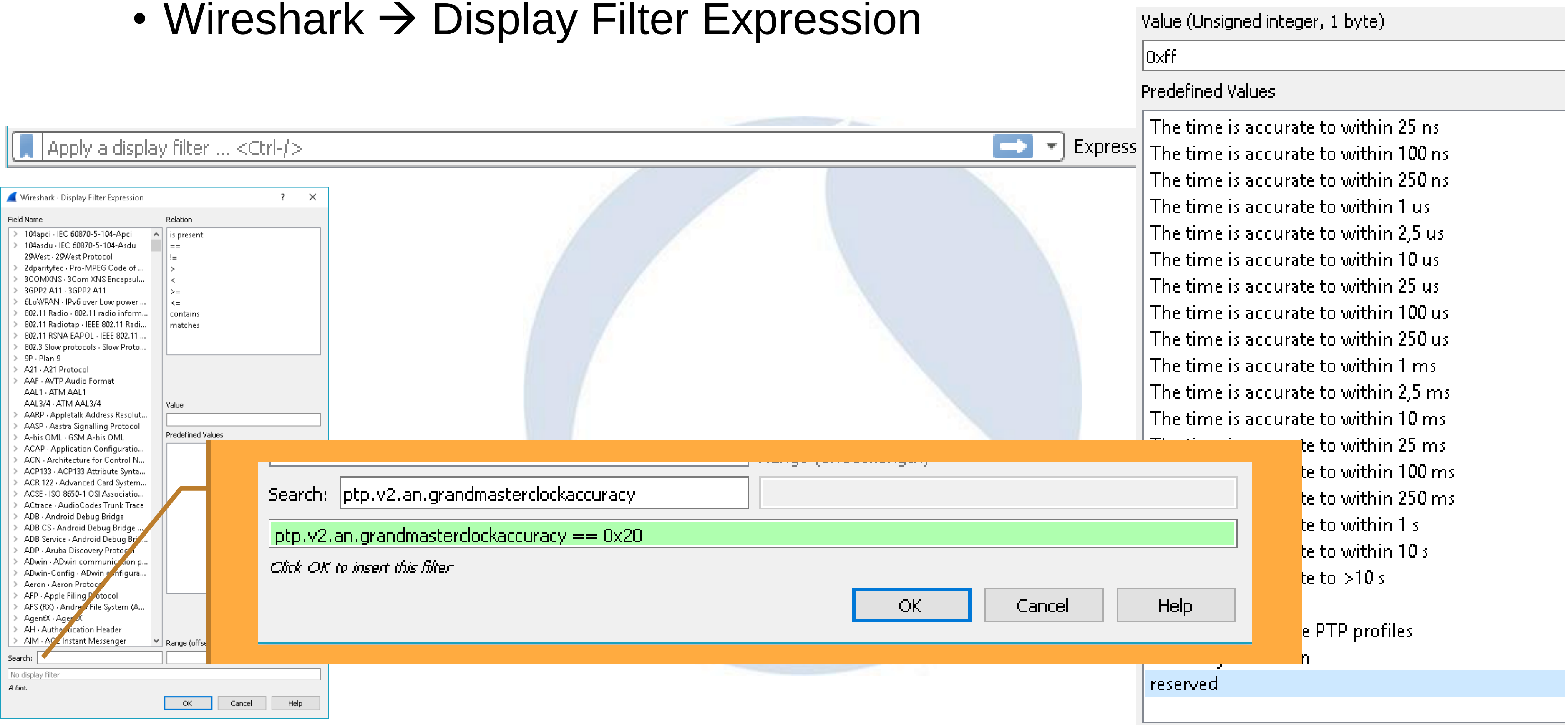
- Path delay mechanisms
  - peer delay
  - delay request response

PTP and QoS

- For Carrier Ethernet Network (CEN), 1588v2 requires a dedicated CoS or even a dedicated EVC – with stringent requirements on Frame Loss Ratio, Frame Delay and Inter-frame Delay Variation
- For L3 - IPv4/v6 - the Traffic Classifier (DSCP) can be used for marking → Test with heavy Load also ☺

PTPv2 / ptp.v2.an.grandmasterclockaccuracy

- Wireshark → Display Filter Expression



Apply a display filter … <Ctrl-/>

Wireshark · Display Filter Expression

Field Name

104apci · IEC 60870-5-104-Apci
104asdu · IEC 60870-5-104-Asdu
29West · 29West Protocol
2dparityfec · Pro-MPEG Code of ...
3COMXNS · 3Com XNS Encapsul...
3GPP2 A11 · 3GPP2 A11
6LoWPAN · IPv6 over Low power ...
802.11 Radio · 802.11 radio inform...
802.11 Radiotap · IEEE 802.11 Radi...
802.11 RSNA EAPOL · IEEE 802.11 ...
802.3 Slow protocols · Slow Proto...
9P · Plan 9
A21 · A21 Protocol
AAF · AVTP Audio Format
AAL1 · ATM AAL1
AAL3/4 · ATM AAL3/4
AARP · Appletalk Address Resolut...
AASP · Aastra Signalling Protocol
A-bis OML · GSM A-bis OML
ACAP · Application Configuratio...
ACN · Architecture for Control N...
ACP133 · ACP133 Attribute Synta...
ACR 122 · Advanced Card System...
ACSE · ISO 8650-1 OSI Associatio...
ACtrace · AudioCodes Trunk Trace
ADB · Android Debug Bridge
ADB CS · Android Debug Bridge ...
ADB Service · Android Debug Bri...
ADP · Aruba Discovery Protoc...
ADwin · ADwin communication p...
ADwin-Config · ADwin configura...
Aeron · Aeron Protocol
AFP · Apple Filing Protocol
AFS (RX) · Andrew File System (A...
AgentX · AgentX
AH · Authentication Header
AIM · AOL Instant Messenger

Relation

is present
==
!=
>
<
>=
<=
contains
matches

Value

Predefined Values

Range (offset:length)

Search:

No display filter

A hint.

Search: ptp.v2.an.grandmasterclockaccuracy

ptp.v2.an.grandmasterclockaccuracy == 0x20

Click OK to insert this filter

Value (Unsigned integer, 1 byte)

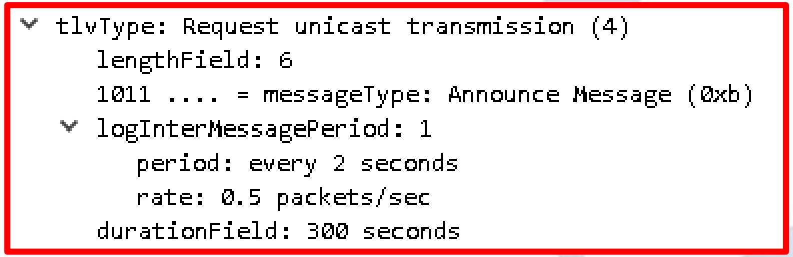
0xff

Predefined Values

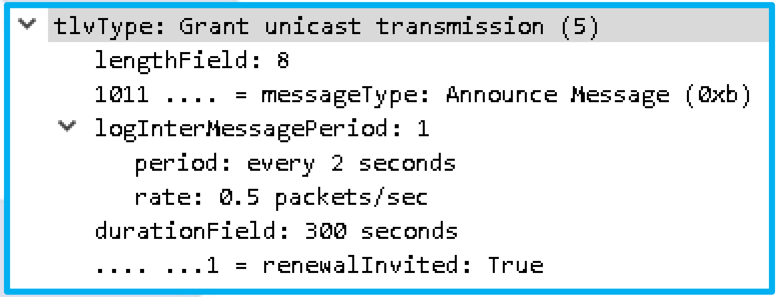
The time is accurate to within 25 ns
The time is accurate to within 100 ns
The time is accurate to within 250 ns
The time is accurate to within 1 us
The time is accurate to within 2,5 us
The time is accurate to within 10 us
The time is accurate to within 25 us
The time is accurate to within 100 us
The time is accurate to within 250 us
The time is accurate to within 1 ms
The time is accurate to within 2,5 ms
The time is accurate to within 10 ms
The time is accurate to within 25 ms
te to within 100 ms
te to within 250 ms
te to within 1 s
te to within 10 s
te to >10 s
e PTP profiles
n
reserved

PTPv2 / ptp.v2.sig.tlv.tlv Type

- Request unicast transmission
  - Switch from Multicast to Unicast
  - Advantage from PTPv2 (PTPv1 only Multicast)



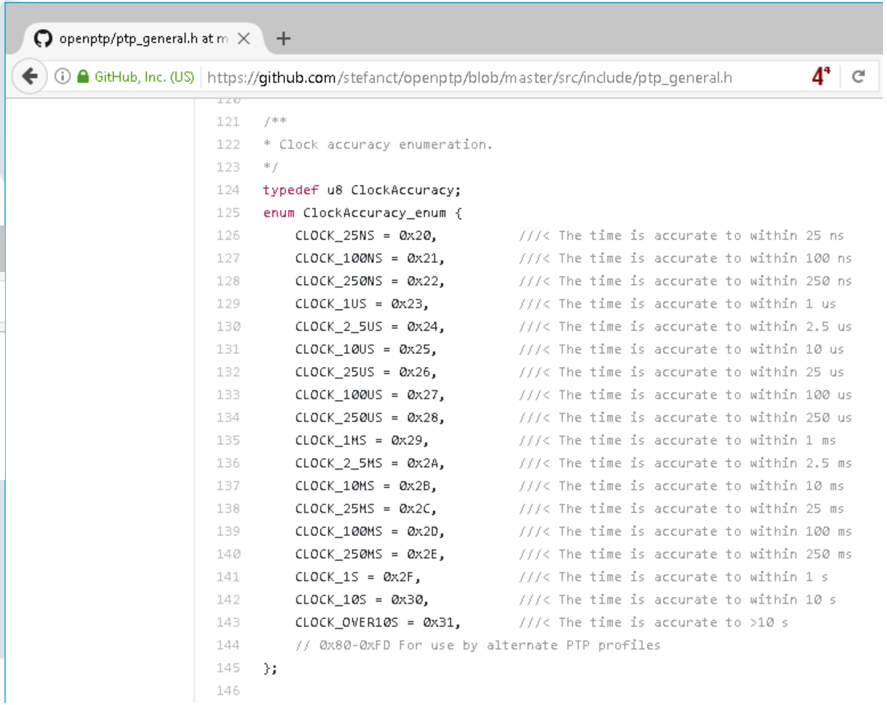
```
˅ tlvType: Request unicast transmission (4)
    lengthField: 6
    1011 .... = messageType: Announce Message (0xb)
  ˅ logInterMessagePeriod: 1
      period: every 2 seconds
      rate: 0.5 packets/sec
    durationField: 300 seconds
```



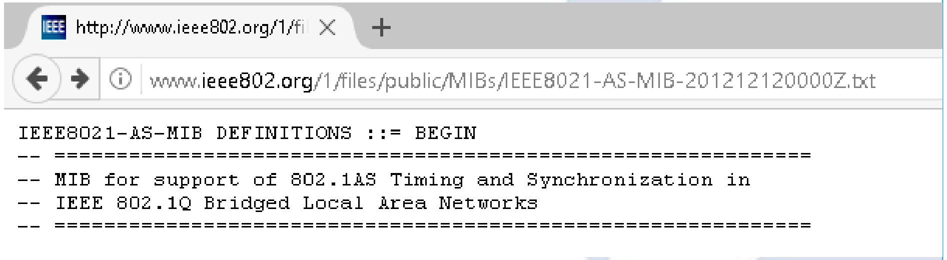
```
˅ tlvType: Grant unicast transmission (5)
    lengthField: 8
    1011 .... = messageType: Announce Message (0xb)
  ˅ logInterMessagePeriod: 1
      period: every 2 seconds
      rate: 0.5 packets/sec
    durationField: 300 seconds
    .... ...1 = renewalInvited: True
```

PTPv2 / ptp.v2.an.tlvType

- Demos:
  - Wireshark → Display Filter Expression
  - Source on github for openptp
  - IEEE MIB 802.1AS


openptp/ptp_general.h at m
GitHub, Inc. (US)
https://github.com/stefanct/openptp/blob/master/src/include/ptp_general.h

```
/**
* Clock accuracy enumeration.
*/
typedef u8 ClockAccuracy;
enum ClockAccuracy_enum {
    CLOCK_25NS = 0x20,          ///< The time is accurate to within 25 ns
    CLOCK_100NS = 0x21,         ///< The time is accurate to within 100 ns
    CLOCK_250NS = 0x22,         ///< The time is accurate to within 250 ns
    CLOCK_1US = 0x23,           ///< The time is accurate to within 1 us
    CLOCK_2_5US = 0x24,         ///< The time is accurate to within 2.5 us
    CLOCK_10US = 0x25,          ///< The time is accurate to within 10 us
    CLOCK_25US = 0x26,          ///< The time is accurate to within 25 us
    CLOCK_100US = 0x27,         ///< The time is accurate to within 100 us
    CLOCK_250US = 0x28,         ///< The time is accurate to within 250 us
    CLOCK_1MS = 0x29,           ///< The time is accurate to within 1 ms
    CLOCK_2_5MS = 0x2A,         ///< The time is accurate to within 2.5 ms
    CLOCK_10MS = 0x2B,          ///< The time is accurate to within 10 ms
    CLOCK_25MS = 0x2C,          ///< The time is accurate to within 25 ms
    CLOCK_100MS = 0x2D,         ///< The time is accurate to within 100 ms
    CLOCK_250MS = 0x2E,         ///< The time is accurate to within 250 ms
    CLOCK_1S = 0x2F,            ///< The time is accurate to within 1 s
    CLOCK_10S = 0x30,           ///< The time is accurate to within 10 s
    CLOCK_OVER10S = 0x31,       ///< The time is accurate to >10 s
    // 0x80-0xFD For use by alternate PTP profiles
};
```


http://www.ieee802.org/1/fi
www.ieee802.org/1/files/public/MIBs/IEEE8021-AS-MIB-201212120000Z.txt

```
IEEE8021-AS-MIB DEFINITIONS ::= BEGIN
-- ===================================================================
-- MIB for support of 802.1AS Timing and Synchronization in
-- IEEE 802.1Q Bridged Local Area Networks
-- ===================================================================
```

PTP Profiles

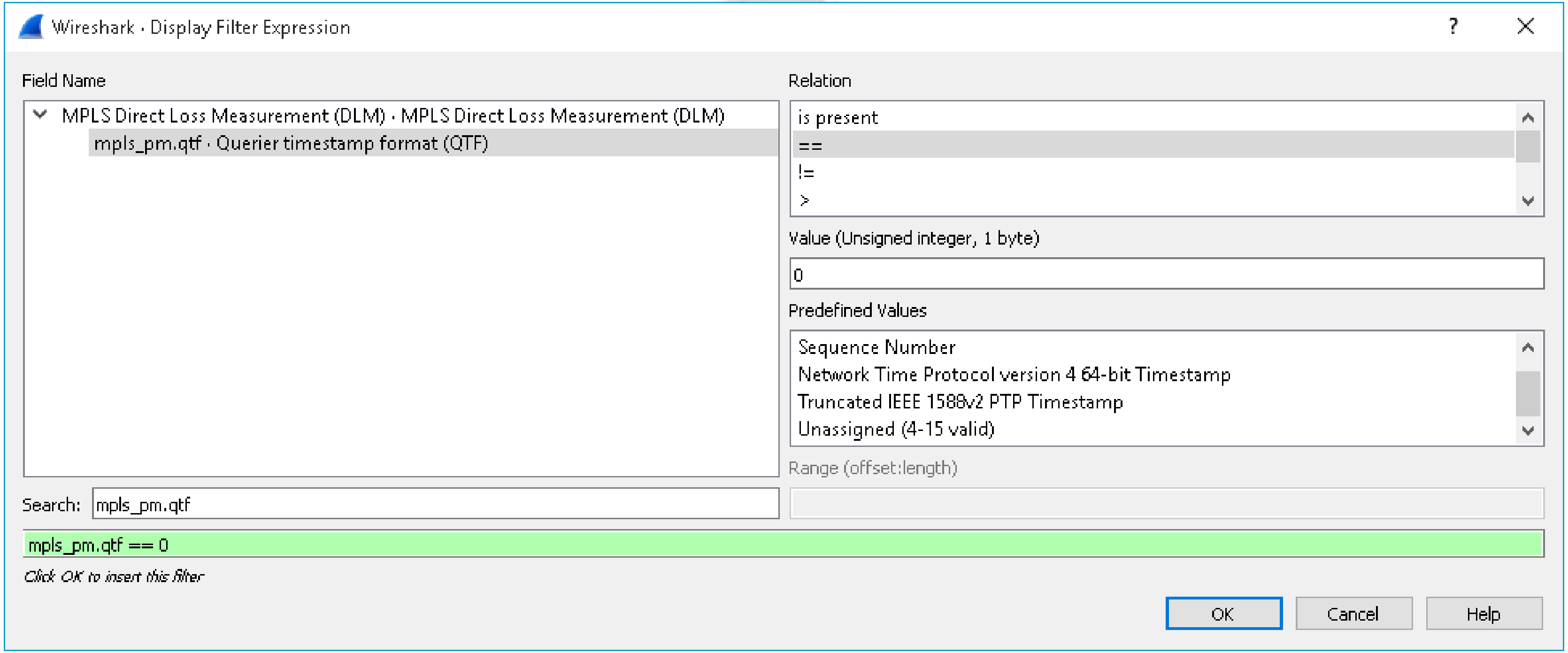
- IEEE-C37.238 Power Profile
  - for power system applications
- IEEE 802.1AS-2011
  - for audio and video applications
- ITU-1 G.8265.1 Frequency Profile
  - for frequency synchronization
- ITU-T G.8275.1 Time and Phase Profile with full timing support (on new network)
- ITU-T G.8275.2 Time and Phase Profile with partial timing support (on existing network)

PTP Message Rates

- Different profiles have different message rates
  - G.8265.1
    - Announce message rate
      - Minimum rate: one packet every 16 seconds, Maximum rate: 8 packets per second, Default rate: one packet every 2 seconds
    - Sync message rate
      - Minimum rate: one packet every 16 seconds, Maximum rate: 128 packets per second
    - Delay_Req/Delay_Resp message rate
      - Minimum rate: one packet every 16 seconds, Maximum rate: 128 packets per second
  - G.8275.1
    - Announce message rate
      - 8 packets per seconds
    - Sync message rate
      - 16 packets per seconds
    - Delay_Req/Delay_Resp message rate
      - 16 packets per seconds

MPLS Loss and Delay Measurement – RFC 6374

- Time, Time, Time … also in the MPLS World



Field Name

MPLS Direct Loss Measurement (DLM) · MPLS Direct Loss Measurement (DLM)

mpls_pm.qtf · Querier timestamp format (QTF)

Relation

is present
==
!=
>

Value (Unsigned integer, 1 byte)

0

Predefined Values

Sequence Number
Network Time Protocol version 4 64-bit Timestamp
Truncated IEEE 1588v2 PTP Timestamp
Unassigned (4-15 valid)

Range (offset:length)

Search: mpls_pm.qtf

mpls_pm.qtf == 0

Click OK to insert this filter

NTP & PTP Comparison

Criteria	NTP	PTP
Peak time transfer error	> 1ms	> 100 ns
Primary error source	Router	Router, Switches, Network Stack, Port contention
Implementation	Hard- or Software Server/Clients	Hardware (mainly Master) Software (Clients, Slaves)
Mode of operation	Clients pull time from server	Master push time to slave
On path support	Non existent and not possible	Not required,but possible through transparent clock (enhances performance)
Epoch	0:00:00 1 January 1900	0:00:00 1 January 1970
Monitoring and Management	Exists (SNMP MIBs), Test Clients	Extensive inband metrics for monitoring and management

Session Summary

- Highly accurate timing synchronization solution in sub-microsecond level can be done by IEEE 1588 PTP
- IEEE 1588 PTPv2 and NTP are widely used timing synchronization protocols in the packet networks
- Data center switches support PTP in hardware today
- Delivery accurate timing information to client under heavy network load must be tested
- PTPv2 solutions need to be carefully designed and reviewed before enabled in production network

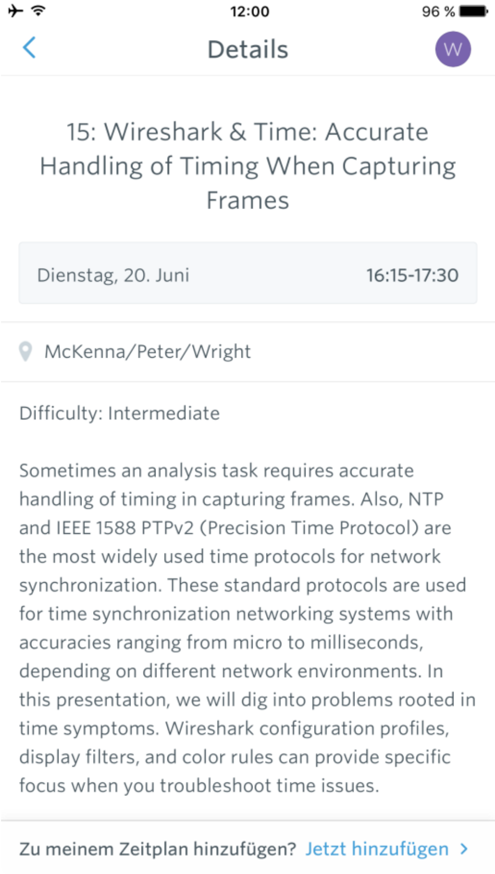
→ WIRESHARK is the tool for displaying the different time information, but remember the capture engine ☺

Future View

- Network Time Protocol Version 4 (NTPv4) Extension Fields
- Multipath PTP/NTP (RFC 8039)
- Authentication with PTPv2

Please provide Session Feedback

- Use the guidebook app on your smartphone
- Fill out the required fields



12:00 96 %

Details

15: Wireshark & Time: Accurate Handling of Timing When Capturing Frames

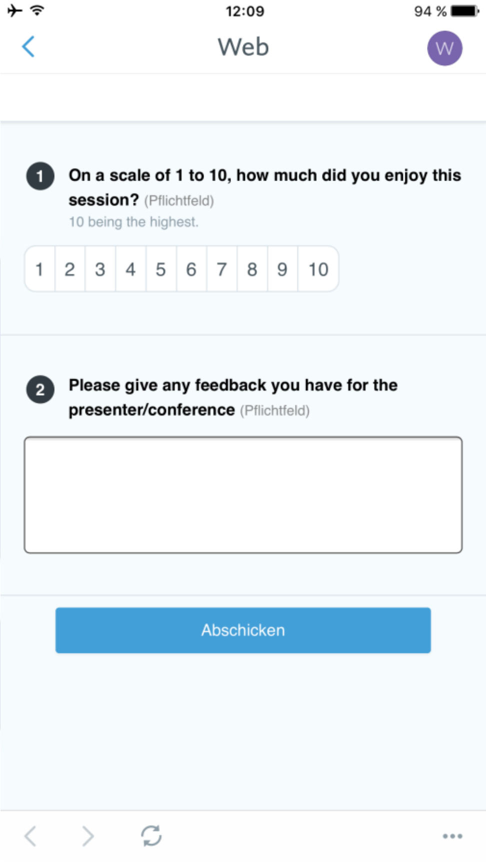
Dienstag, 20. Juni 16:15-17:30

McKenna/Peter/Wright

Difficulty: Intermediate

Sometimes an analysis task requires accurate handling of timing in capturing frames. Also, NTP and IEEE 1588 PTPv2 (Precision Time Protocol) are the most widely used time protocols for network synchronization. These standard protocols are used for time synchronization networking systems with accuracies ranging from micro to milliseconds, depending on different network environments. In this presentation, we will dig into problems rooted in time symptoms. Wireshark configuration profiles, display filters, and color rules can provide specific focus when you troubleshoot time issues.

Zu meinem Zeitplan hinzufügen? Jetzt hinzufügen ›



12:09 94 %

Web

1 On a scale of 1 to 10, how much did you enjoy this session? (Pflichtfeld)
10 being the highest.

1 2 3 4 5 6 7 8 9 10

2 Please give any feedback you have for the presenter/conference (Pflichtfeld)

Abschicken

Slogan SharkFest 2017 from my party

Spanning Tree of Network Analyst

1. Listen
2. Learn
3. Practice

Thank you for your attention !