Processing Ethernet Flight Test Data with Open Source Tools

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Legacy Aircraft Flight Test – Avionics upgrade

- New data system utilizing IRIG 106 Chapter 10 recorder
- On-board real time display using IADS connecting to recorder over Ethernet
- ARINC-429, Ethernet, MIL-STD 1553, Video
- Documentation of all systems (LRUs) not initially provided

Data Interpretation

- Interface Control Document for data description
- Example: Encapsulated ARINC-429 data
- Data Format in Ethernet packet
  - 8 bytes consisting of 32-bit Data ID and 32-bit ARINC-429 data

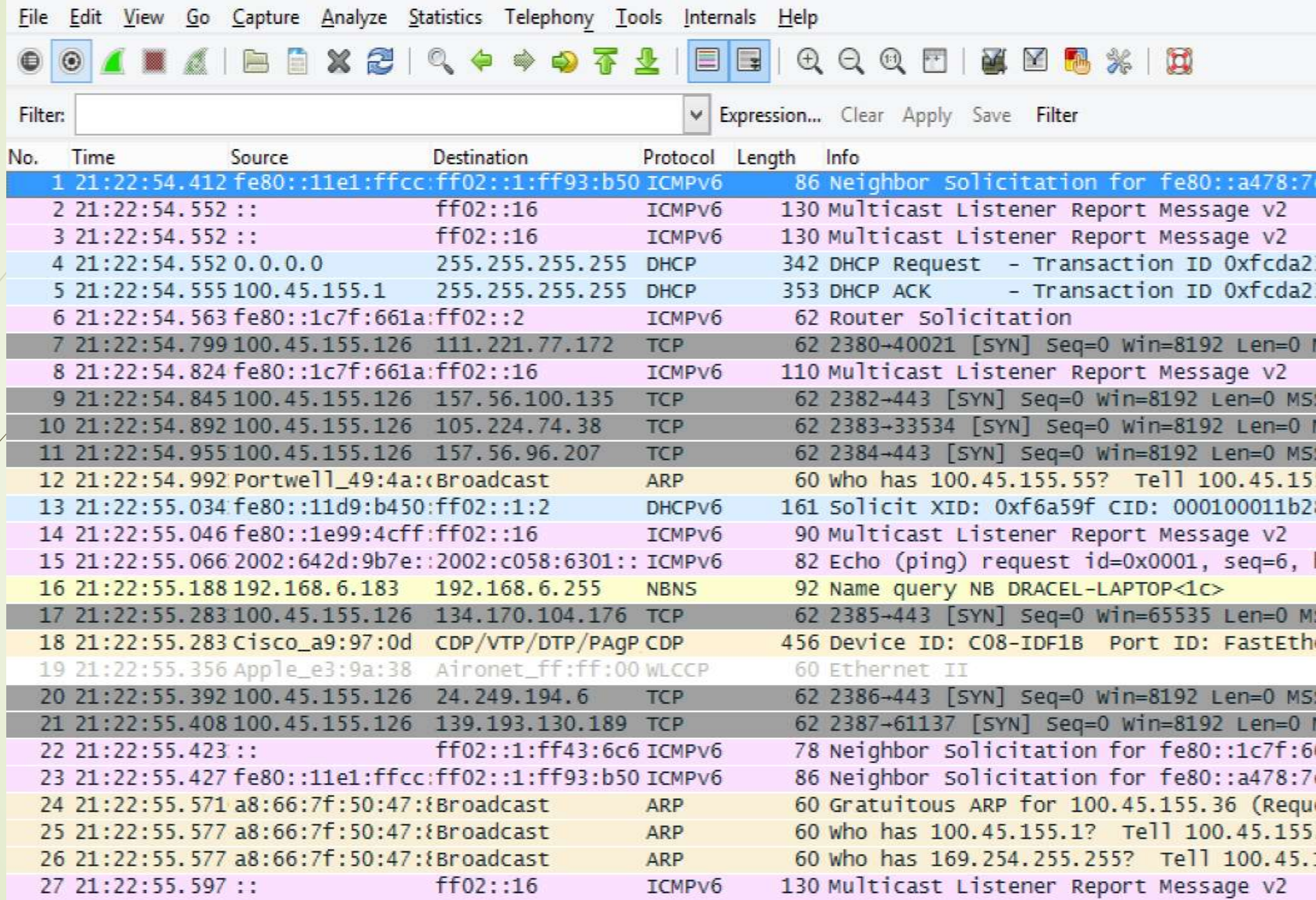
Mode	Label	DataID	Description
ALT	102	268d10	Altitude Reference
IAS	103	268d18	Indicated Airspeed Reference
VS	104	268d20	Vertical Speed Reference
MACH	106	268d30	Mach Reference

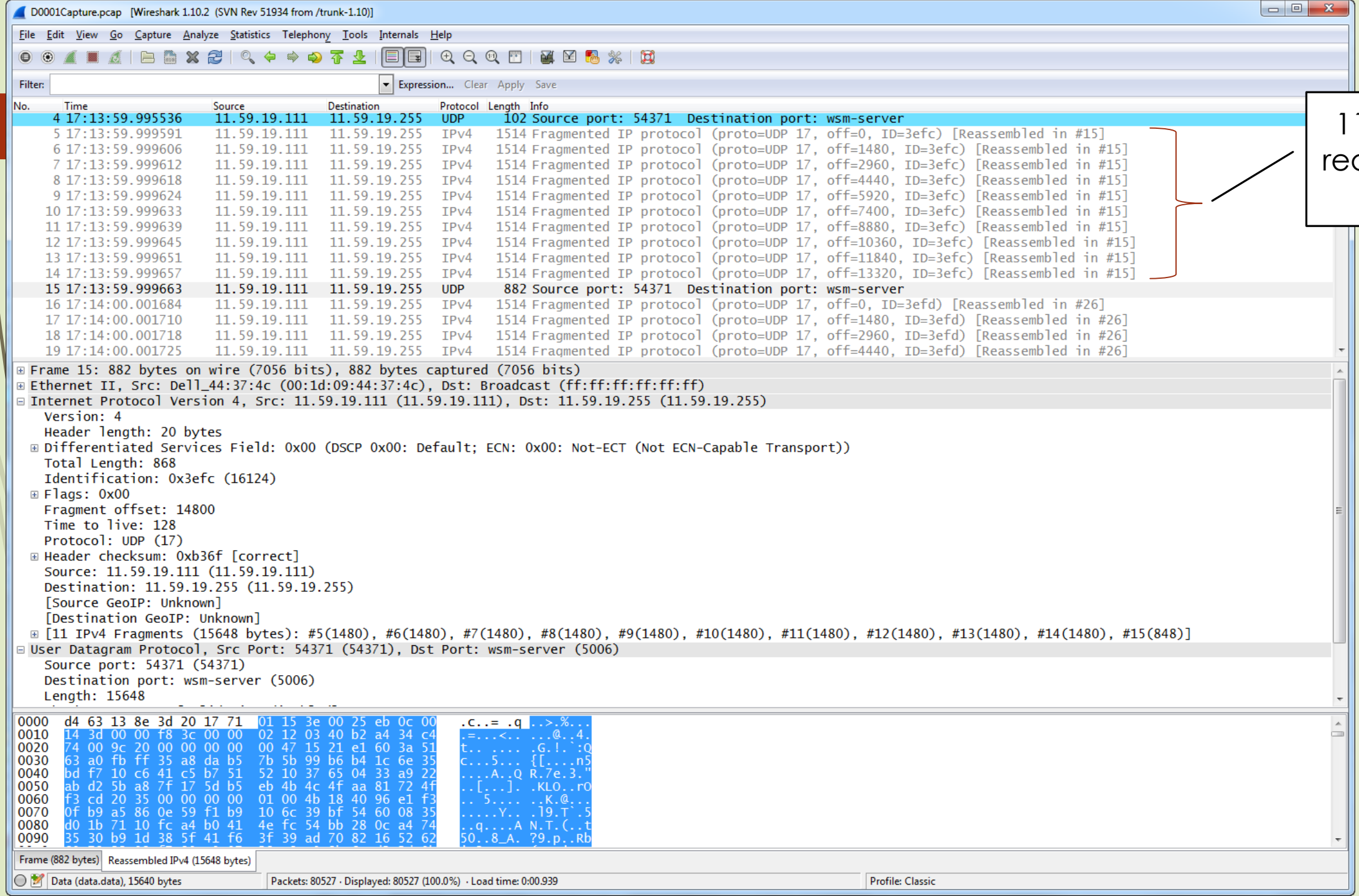
Label 103: FMS IAS Reference

Bit	Description
1-8	Octal Label=103
9-10	00 = All Call; 10 = Left Unit; 01 = Right Unit; 11 = Center Unit
11	Note [5]
12	Speed Reference Condition: 1=Manual Mode 0=Performance Mode
13	Caution Flag: 0=false 1=true (flag set)
14	0.062500 \
15	0.125 \
16	0.25 > Knots
17	0.5 /
18	1.0 /
28	1024.0 /
29	0 = Positive, 1 = Negative
30	0 Failure Warning 1 No Comp Data 0 Functional Test 1 Normal Op
31	0 0 1 1
32	Parity (Odd)

Wireshark for Ethernet Analysis

- Huge following with lots of tutorials
- Customizable and programmable (lua)
- Works in real-time monitor mode or offline processing of PCAP files
- Cross platform (Windows, Mac, Linux)
- Data filtering and export

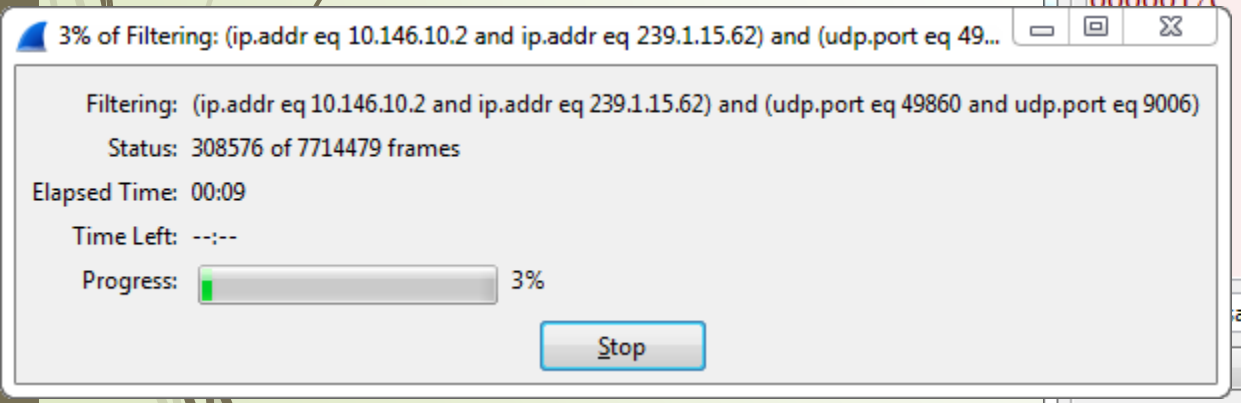

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Filter: Expression... Clear Apply Save Filter
No. Time Source Destination Protocol Length Info
1 21:22:54.412 fe80::11e1:ffcc: ff02::1:ff93:b50 ICMPv6 86 Neighbor Solicitation for fe80::a478:7
2 21:22:54.552 :: ff02::16 ICMPv6 130 Multicast Listener Report Message v2
3 21:22:54.552 :: ff02::16 ICMPv6 130 Multicast Listener Report Message v2
4 21:22:54.552 0.0.0.0 255.255.255.255 DHCP 342 DHCP Request - Transaction ID 0xfcda2
5 21:22:54.555 100.45.155.1 255.255.255.255 DHCP 353 DHCP ACK - Transaction ID 0xfcda2
6 21:22:54.563 fe80::1c7f:661a: ff02::2 ICMPv6 62 Router Solicitation
7 21:22:54.799 100.45.155.126 111.221.77.172 TCP 62 2380→40021 [SYN] Seq=0 Win=8192 Len=0
8 21:22:54.824 fe80::1c7f:661a: ff02::16 ICMPv6 110 Multicast Listener Report Message v2
9 21:22:54.845 100.45.155.126 157.56.100.135 TCP 62 2382→443 [SYN] Seq=0 Win=8192 Len=0 MS
10 21:22:54.892 100.45.155.126 105.224.74.38 TCP 62 2383→33534 [SYN] Seq=0 Win=8192 Len=0
11 21:22:54.955 100.45.155.126 157.56.96.207 TCP 62 2384→443 [SYN] Seq=0 Win=8192 Len=0 MS
12 21:22:54.992 Portwell_49:4a:(Broadcast ARP 60 Who has 100.45.155.55? Tell 100.45.15
13 21:22:55.034 fe80::11d9:b450: ff02::1:2 DHCPv6 161 Solicit XID: 0xf6a59f CID: 000100011b2
14 21:22:55.046 fe80::1e99:4cff: ff02::16 ICMPv6 90 Multicast Listener Report Message v2
15 21:22:55.066 2002:642d:9b7e:: 2002:c058:6301:: ICMPv6 82 Echo (ping) request id=0x0001, seq=6,
16 21:22:55.188 192.168.6.183 192.168.6.255 NBNS 92 Name query NB DRACEL-LAPTOP<1c>
17 21:22:55.283 100.45.155.126 134.170.104.176 TCP 62 2385→443 [SYN] Seq=0 Win=65535 Len=0 M
18 21:22:55.283 Cisco_a9:97:0d CDP/VTP/DTP/PAgP CDP 456 Device ID: C08-IDF1B Port ID: FastEth
19 21:22:55.356 Apple_e3:9a:38 Aironet_ff:ff:00 WLCCP 60 Ethernet II
20 21:22:55.392 100.45.155.126 24.249.194.6 TCP 62 2386→443 [SYN] Seq=0 Win=8192 Len=0 MS
21 21:22:55.408 100.45.155.126 139.193.130.189 TCP 62 2387→61137 [SYN] Seq=0 Win=8192 Len=0
22 21:22:55.423 :: ff02::1:ff43:6c6 ICMPv6 78 Neighbor Solicitation for fe80::1c7f:6
23 21:22:55.427 fe80::11e1:ffcc: ff02::1:ff93:b50 ICMPv6 86 Neighbor Solicitation for fe80::a478:7
24 21:22:55.571 a8:66:7f:50:47:(Broadcast ARP 60 Gratuitous ARP for 100.45.155.36 (Requ
25 21:22:55.577 a8:66:7f:50:47:(Broadcast ARP 60 Who has 100.45.155.1? Tell 100.45.155
26 21:22:55.577 a8:66:7f:50:47:(Broadcast ARP 60 Who has 169.254.255.255? Tell 100.45.1
27 21:22:55.597 :: ff02::16 ICMPv6 130 Multicast Listener Report Message v2

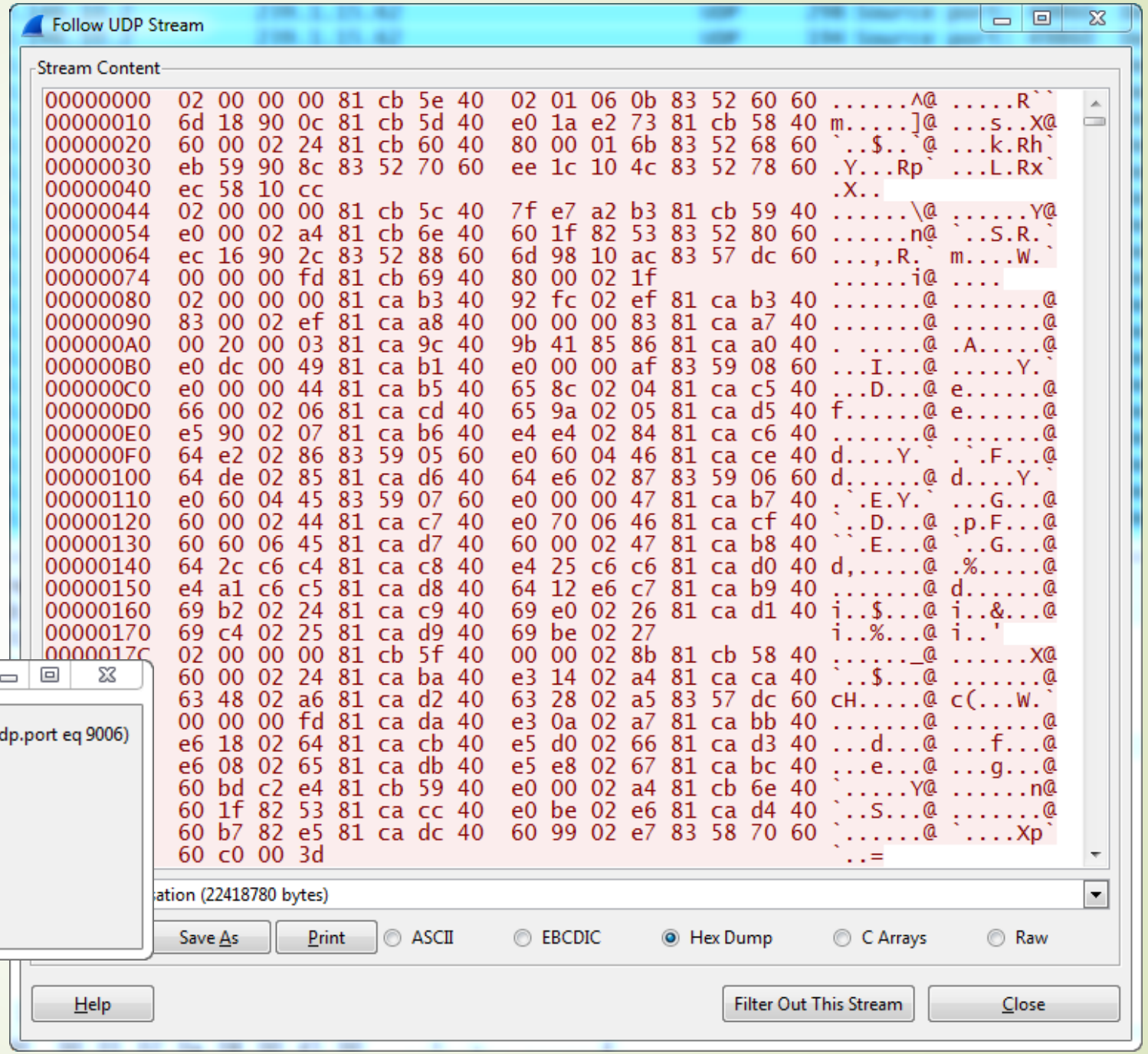


11 Fragments reassembled in Pkt #15

Follow UDP Stream

- Choose a packet first
- Launch from Analyze
- Default display Raw
- Save





Save file output

```
00000000  02 00 00 00 81 cb 5e 40  02 01 06 0b 83 52 60 60 ......^@ .....R``
00000010  6d 18 90 0c 81 cb 5d 40  e0 1a e2 73 81 cb 58 40 m.....]@ ...s..X@
00000020  60 00 02 24 81 cb 60 40  80 00 01 6b 83 52 68 60 `..$..`@ ...k.Rh`
00000030  eb 59 90 8c 83 52 70 60  ee 1c 10 4c 83 52 78 60 .Y...Rp` ...L.Rx`
00000040  ec 58 10 cc                                     .X..
00000044  02 00 00 00 81 cb 5c 40  7f e7 a2 b3 81 cb 59 40 ......\@ ......Y@
00000054  e0 00 02 a4 81 cb 6e 40  60 1f 82 53 83 52 80 60 ......n@ `..S.R.`
00000064  ec 16 90 2c 83 52 88 60  6d 98 10 ac 83 57 dc 60 ...,.R.` m....W.`
00000074  00 00 00 fd 81 cb 69 40  80 00 02 1f           ......i@ ....
00000080  02 00 00 00 81 ca b3 40  92 fc 02 ef 81 ca b3 40 .......@ .......@
00000090  83 00 02 ef 81 ca a8 40  00 00 00 83 81 ca a7 40 .......@ .......@
000000A0  00 20 00 03 81 ca 9c 40  9b 41 85 86 81 ca a0 40 . .....@ .A.....@
000000B0  e0 dc 00 49 81 ca b1 40  e0 00 00 af 83 59 08 60 ...I...@ .....Y.`
000000C0  e0 00 00 44 81 ca b5 40  65 8c 02 04 81 ca c5 40 ...D...@ e......@
000000D0  66 00 02 06 81 ca cd 40  65 9a 02 05 81 ca d5 40 f......@ e......@
000000E0  e5 90 02 07 81 ca b6 40  e4 e4 02 84 81 ca c6 40 .......@ .......@
000000F0  64 e2 02 86 83 59 05 60  e0 60 04 46 81 ca ce 40 d....Y.` .`.F...@
00000100  64 de 02 85 81 ca d6 40  64 e6 02 87 83 59 06 60 d......@ d....Y.`
```

Why Python

- Open source
- Cross platform
- Lots of tutorials – backed by Google
- Huge number of libraries
- Interpreted environment
- Great first language
- Object based

Libraries

- dpkt
  - Google Code: https://code.google.com/p/dpkt/
- socket
- binascii
- struct
- datetime

Data Manipulation

- Pandas
  - http://pandas.pydata.org/
- Matplotlib
  - http://matplotlib.org/
- Numpy
  - http://www.numpy.org/
- Scientific Python
  - http://scipy.org/

Examine Raw Packet Data

```
Example Data
0000   01 00 5e 01 0a 5b 02 00 00 01 02 08 08 00 45 00
0010   00 a0 bd 3f 00 00 40 11 b1 1c 0a 92 08 03 ef 01 – 10.145.8.3
0020   0a 5b 5d 8a 24 1e 00 8c 00 00 02 00 00 00 26 8f – 02 = data marker
0030   c0 40 00 00 00 19 26 8f 00 40 82 00 44 01 26 8f
0040   40 40 00 40 44 11 26 8f 80 40 92 0a 28 09 26 8f
0050   c8 40 80 00 00 99 26 8f 18 40 00 00 00 c1 26 91
0060   40 40 7f fb a0 13 26 91 48 40 7f fa fc 93 26 91
0070   00 40 7f f0 a0 03 26 91 08 40 ff f0 a0 83 26 91
0080   b8 40 e0 00 00 eb 26 8d 20 40 60 00 04 22 26 8d
0090   18 40 00 00 00 c2 26 8d 30 40 60 b4 00 62 26 8d – 268d10 NDO
00a0   10 40 6e a6 00 42 26 8d 07 40 7f f0 a0 26 78 d8 – 32 bits of data
00b0   1d e6
```

Walk thru Packets

```
pcapReader = dpkt.pcap.Reader(file(filename,'rb'))
for ts, data in pcapReader:
    ether = dpkt.ethernet.Ethernet(data)
    if ether.type == dpkt.ethernet.ETH_TYPE_IP:
        ip  = ether.data
        tcp = ip.data
        src = socket.inet_ntoa(ip.src)
```

Process Packets

```
if src == addr:
    a = binascii.hexlify(str(tcp.data))
    if a[0:2] == '02':
        d10 = a.find('268d10')
        d10val = int(a[d10+9:d10+13],16)
        if d10val != lastd10:
            print "%s %s d10 = %s" % (secstostring(ts), src, d10val)
            lastd10 = d10val
        d18 = a.find('268d18')
        d18val = int(a[d18+9:d18+13],16) * 0.0625
```

Packet Utilities

- PCAP Replay
  - PlayCap
    - http://www.signal11.us/oss/playcap/
  - TCP Replay
    - http://tcpreplay.synfin.net/
- Scapy
  - http://www.secdev.org/projects/scapy/
- Ngrep
  - http://ngrep.sourceforge.net/

Colasoft

- Offer a number of free tools
  - http://www.colasoft.com/products/freeware.php
- Colasoft Packet Player
  - http://www.colasoft.com/packet_player/
- Capsa Free
- Colasoft MAC Scanner
- Colasoft Ping Tool
- Colasoft Packet Builder

SolarWinds

- Lots of free and trial tools:
  - http://www.solarwinds.com/downloads/
- IP Address Manager
  - Free and trial version
- Subnet Calculator

Chapter 10 Tools

- IRIG106.org tools
- EMC Packet Viewer, Chapter 10 Validator
- Common Mission Debrief Program (CMDP)

Questions?