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Technology · Connections · Results

Diagnosing Network Problems with Packet Trace

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SHARE in Boston

A Few Things To Consider

- Know your network
  - What does a performing network look like? Establish a baseline.
  - Do you have a good benchmark trace?
  - Network map?
  - Is it documented?
  - Is there a Change Log?
- Know the protocols
  - What protocols are involved?
    - TCP/IP?
    - UDP?
    - ICMP?
- What's the problem?
  - During development, debugging may be needed
  - Did it even hit z/OS, z/VM or zLinux TCP/IP?
  - Why is the SYN failing?
  - Is the response time reasonable?
  - TCP retransmission packets
  - Dropped TCP packets

How to Take a Packet Trace?

- z/OS CTRACE
  - SYSTCPDA – packet trace
  - SYSTCPOT – OSAENTA trace

  - Set up an External Writer Proc

```
E.g., SYS1.PROCLIB(AESWRT):

//IEFPROC EXEC PGM=ITTTRCWR,REGION=0K,TIME=1440,DPRTY=15
//TRCOUT01 DD DISP=SHR,DSN=trace.dataset
```

  - Set up tracing parameters

```
E.g., SYS1.PARMLIB(CTAESPRM):
TRACEOPTS ON WTR(AESWRT)
```

z/OS CTRACE: SYSTCPDA

- To Start Tracing:

```
TRACE CT,WTRSTART=AESWRT
V TCPIP,,PKT,CLEAR
V TCPIP,,PKT,LINKN=<link>,ON,FULL,PROT=TCP,IP=<ip addr>
TRACE CT,ON,COMP=SYSTCPDA,SUB=(TCPIP),PARM=CTAESPRM
```

- To Stop Tracing:

```
V TCPIP,,PKT,OFF
TRACE CT,OFF,COMP=SYSTCPDA,SUB=(TCPIP)
TRACE CT,WTRSTOP=AESWRT,FLUSH
```

- To View Tracing Status:

```
D TRACE,WTR=AESWRT
```

Verify that the external writer is active

```
D TCPIP,,NETSTAT,DE
```

Verify that **TrRecCnt** is non-zero and incrementing

z/OS CTRACE: SYSTCPOT

OSA-Express Network Traffic Analyzer (OSAENTA)

- Tracing from the perspective of the OSA.
- The trace function is controlled by z/OS Communication Server, while the data is collected in the OSA at the network port.
- The host can be an LPAR with **z/OS, z/VM** or **Linux**.
- Layer 2 data: MAC headers, VLAN tags, ARP packets
- Data not available in a Sniffer: packets to/from other stacks sharing the OSA, or packets discarded by the OSA

z/OS CTRACE: SYSTCPOT

Pre-Reqs:

- Install the microcode for the OSA (2094DEVICE PSP and the 2096DEVICE PSP).
- Update the OSA using the Hardware Management Console (HMC) to:
  - Define more data devices to systems that will use the trace function.
  - Set the security for the OSA:

    LOGICAL PARTITION - Only packets from the LPAR

    CHPID - All packets using this CHPID
- Verify the TRLE definitions for the OSA that it has one DATAPATH address available for tracing. Note that **two** DATAPATH addresses are required – one for data transfers and the other for trace data.

z/OS CTRACE: SYSTCPOT

- To Start Tracing:

```
TRACE CT,WTRSTART=AESWRT
V TCPIP,,OSAENTA,PORTNAME=<port>,CLEAR
V TCPIP,,OSAENTA,PORTNAME=<port>,ON,NOFILTER=ALL
TRACE CT,ON,COMP=SYSTCPOT,SUB=(TCPIP),PARM=CTAESPRM
```

To Stop Tracing:

```
V TCPIP,,OSAENTA,PORTNAME=<port>,OFF
TRACE CT,OFF,COMP=SYSTCPOT,SUB=(TCPIP)
TRACE CT,WTRSTOP=AESWRT,FLUSH
```

- To View Tracing Status:

```
D TRACE,WTR=AESWRT
```

Verify that the external writer is active

z/OS CTRACE: SYSTCPOT

- To View Tracing Status (continued):

```
D TCPIP,,NETSTAT,DE
 OSA-EXPRESS NETWORK TRAFFIC ANALYZER INFORMATION:
  OSA PORTNAME: DR281920          OSA DEVSTATUS:     READY
    OSA INTFNAME: EZANTADR281920  OSA INTFSTATUS:    READY
    OSA SPEED:    1000            OSA AUTHORIZATION: LOGICAL PARTITION
    OSAENTA CUMULATIVE TRACE STATISTICS:
      DATAMEGS:    1                     FRAMES:          3625
      DATABYTES:   1641283               FRAMESDISCARDED: 0
      FRAMESLOST: 0
    OSAENTA ACTIVE TRACE STATISTICS:
      DATAMEGS:    0                     FRAMES:          23
      DATABYTES:   6148                  FRAMESDISCARDED: 0
      FRAMESLOST: 0                      TIMEACTIVE:      2
    OSAENTA TRACE SETTINGS:           STATUS: ON
      DATAMEGSLIMIT: 2147483647          FRAMESLIMIT:     2147483647
      ABBREV:        480                 TIMELIMIT:       10080
      DISCARD:       NONE
    OSAENTA TRACE FILTERS:            NOFILTER: ALL
      DEVICEID: *
      MAC:      *
      VLANID:   *
      ETHTYPE:  *
      IPADDR:   *
      PROTOCOL: *
      PORTNUM:  *
```

Using IPCS to Decode CTRACE

```
//TSO    EXEC PGM=IKJEFT01,DYNAMNBR=60,
// PARM='%BLSCDDIR DSNAME(&SYSUID..BATCH.DDIR) VOLUME(AES003)'
//SYSPROC  DD DISP=SHR,DSN=SYS1.SBLSCLI0
//TRACE    DD DISP=SHR,DSN=trace.dataset    <=== INPUT
//IPCSPRNT DD SYSOUT=*
//SYSTSPRT DD SYSOUT=*
//SYSTSIN  DD *
  IPCS NOPARM
    DROPD FILE(TRACE)
    SETDEF NOCONFIRM PRINT NOTERM
    CTRACE DDNAME(TRACE) COMP(SYSTCPDA) +
        SUB((TCPIP)) OPTIONS(( FTP(20,21) )) FULL GMT
  END /* IPCS */
//
```

Specify COMP(SYSTCPOT) for OSAENTA trace

Sample IPCS Output

```
IPCS PRINT LOG FOR USER AESDJC1                                                        05:15:13 02/24/08
_________________________________________________________________________________________________________
 COMPONENT TRACE FULL FORMAT
 SYSNAME(ADCD)
 COMP(SYSTCPDA)SUBNAME((TCPIP))
 OPTIONS((FTP(20,21)))
 z/OS TCP/IP Packet Trace Formatter, (C) IBM 2000-2005, 2005.047
 FILE(TRACE)
**** 2008/02/22
RcdNr Sysname  Mnemonic Entry Id   Time Stamp      Description
----- -------- -------- -------- --------------- --------------------------------
---------------------------------------------------------------------------------
804059 ADCD     PACKET   00000004 20:48:42.883175 Packet Trace
 From Interface     : ETH1             Device: LCS Ethernet     Full=52
  Tod Clock         : 2008/02/22 20:48:42.883162                Intfx: 4
  Sequence #        : 0                Flags: Pkt
 IpHeader: Version  : 4                Header Length: 20
  Tos               : 00               QOS: Routine Normal Service
  Packet Length     : 52               ID Number: AD04
  Fragment          : DontFragment     Offset: 0
  TTL               : 64               Protocol: TCP            CheckSum: 23F2 FFFF
  Source            : 137.72.43.110
  Destination       : 137.72.43.207
 TCP
  Source Port       : 28265 ()         Destination Port: 21    (ftp)
  Sequence Number   : 1439084340       Ack Number: 0
  Header Length     : 32               Flags: Syn
  Window Size       : 65534            CheckSum: 91D2 FFFF Urgent Data Pointer: 0000
   Option           : Max Seg Size Len: 4 MSS: 1460
   Option           : NOP
   Option           : Window Scale OPT Len: 3 Shift: 0
   Option           : NOP
   Option           : NOP
   Option           : SACK Permitted
IP Header           : 20
000000 45000034 AD044000 400623F2 89482B6E  89482BCF
```

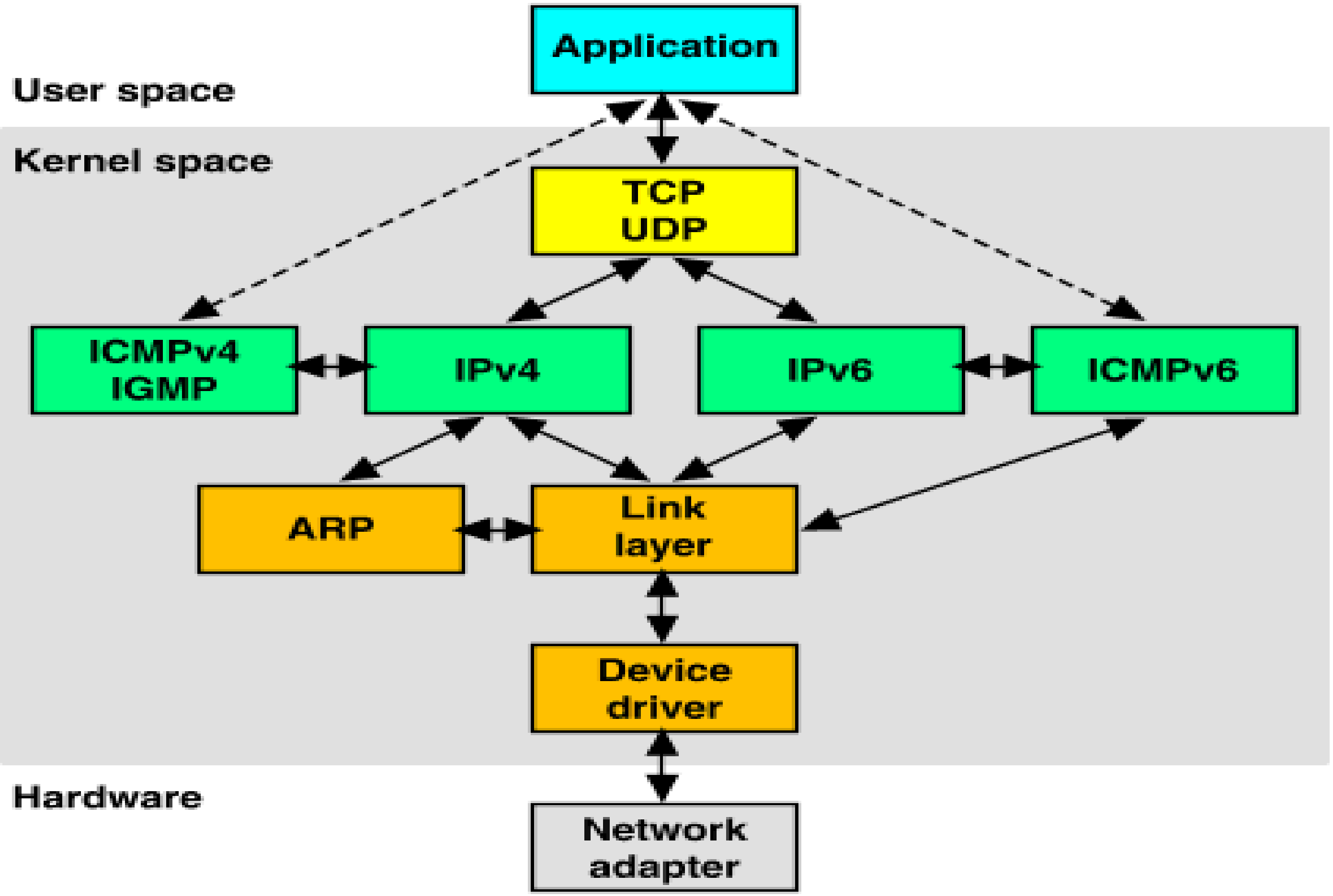
z/VM:

- To enable the trace:
  - NETSTAT OBEY PACKETTRACESIZE 256
  - NETSTAT OBEY TRACEONLY ETH0 ENDTRACEONLY
- To start data collection:
  - TRSOURCE ID TCP TYPE GT BLOCK FOR USER tcpip_userid
  - TRSOURCE ENABLE ID TCP
- To stop data collection:
  - NETSTAT OBEY PACKETTRACESIZE 0
  - NETSTAT OBEY TRACEONLY ENDTRACEONLY
  - TRSOURCE DISABLE ID TCP
- To analyze a TRF trace file:
  - IPFORMAT command
  - Use the TRF2TCPD utility to convert the TRF file to pcap (tcpdump) format

Know Your Protocols and Applications - TCP

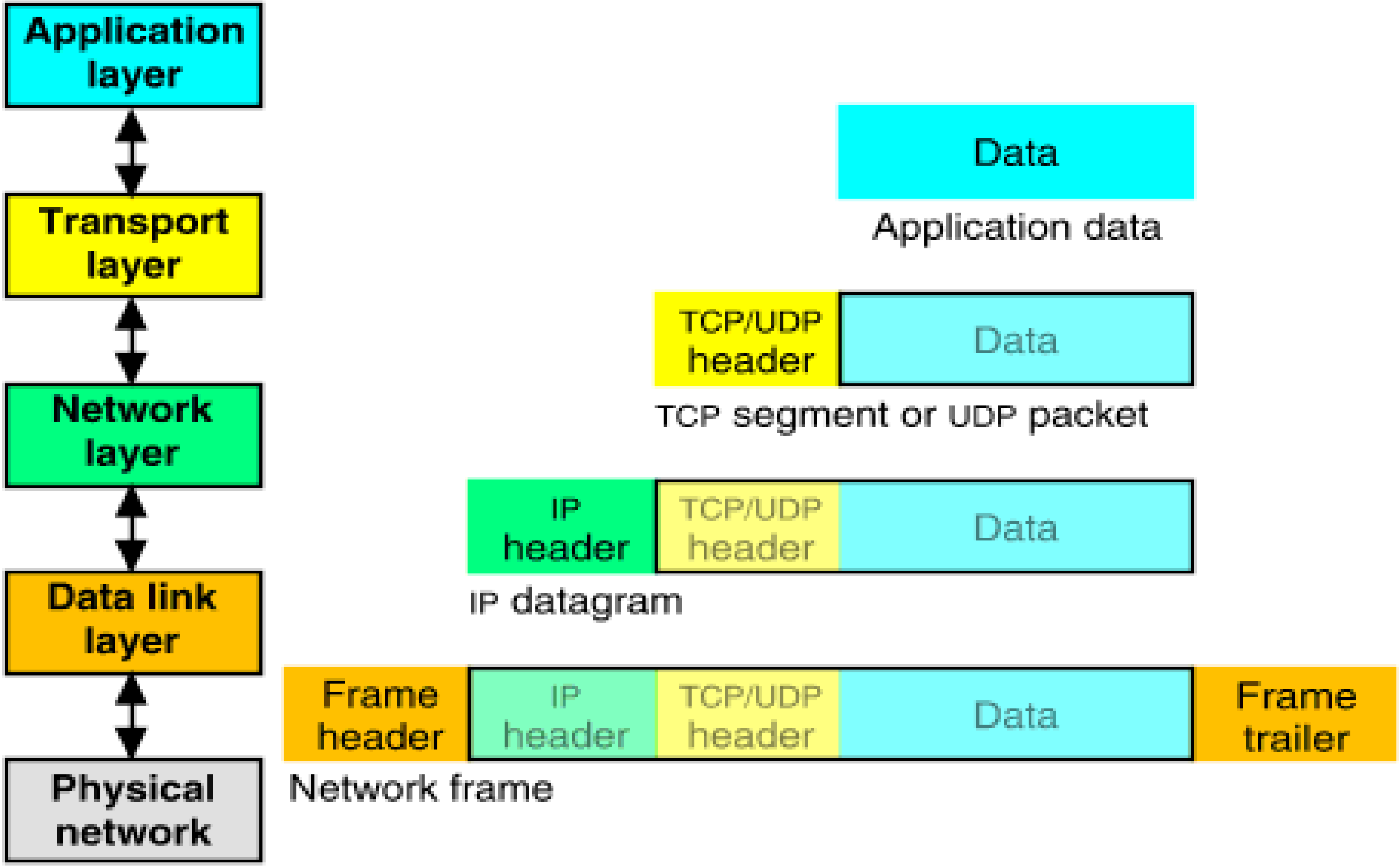
- TCP Functions
  - Establish Connections
  - Manage Connections
  - Terminate Connections
  - Handling and Packaging Data
  - Transferring Data
  - Providing Reliability
  - Flow Control and Congestion Avoidance

Networking Stack Support for TCP/IP



Source: http://uw713doc.sco.com/en/NET_tcpip/tcpN.tcpip_stack.html

Encapsulation of Application Data within a Network Stack



Source: http://uw713doc.sco.com/en/NET_tcpip/tcpN.tcpip_stack.html

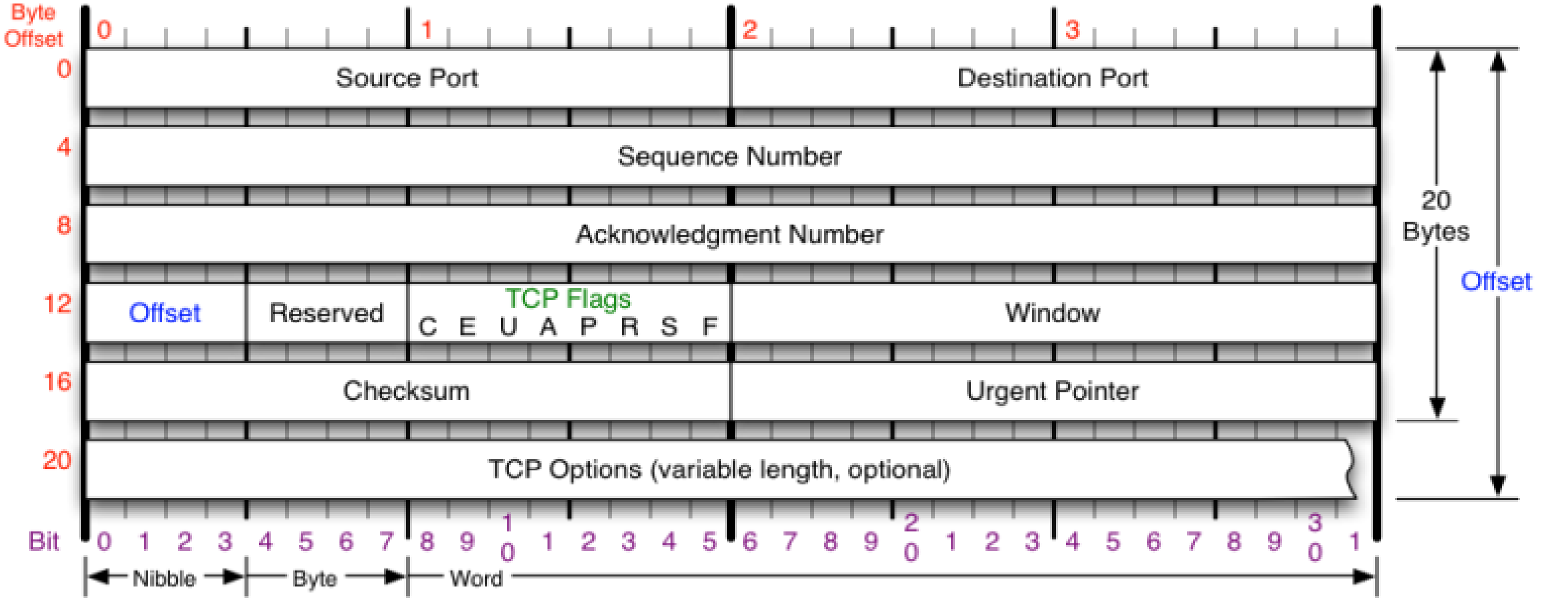
TCP Algorithms

- Nagle Algorithm
  - Prevent tiny-gram congestion
  - Small segments cannot be transmitted until the outstanding data is acknowledged
- Sliding Window
  - Avoid overflowing the buffer
  - *Receiver* sends the ACK w/advertised window size
- Slow Start
  - Avoid network congestion
  - *Sender* adjusts transmission rate based on the rate at which ACKs are received – congestion window (cwnd)

TCP Algorithms

- Congestion Avoidance
  - Avoid packet loss (timeout or duplicate ACKs)
  - Slow down the transmission rate when congestion occurs
- Fast Retransmit
  - Retransmit the missing segment without timeout
  - If 3 or more duplicate ACKs in a row => strong indication that the segment has been lost
  - 1 or 2 duplicate ACKs in a row => segments are reordered
- Fast Recovery
  - Don’t reduce the flow abruptly after Fast Retransmit (because data still is flowing between 2 ends; the duplicate ACK can only be sent after another segment is received)
  - After Fast Retransmit, start Congestion Avoidance, but not Slow Start

TCP Header Format



TCP Flags

C E U A P R S F

Congestion Window
C 0x80 Reduced (CWR)
E 0x40 ECN Echo (ECE)
U 0x20 Urgent
A 0x10 Ack
P 0x08 Push
R 0x04 Reset
S 0x02 Syn
F 0x01 Fin

Congestion Notification

ECN (Explicit Congestion Notification). See RFC 3168 for full details, valid states below.

Packet State	DSB	ECN bits
Syn	0 0	1 1
Syn-Ack	0 0	0 1
Ack	0 1	0 0
No Congestion	0 1	0 0
No Congestion	1 0	0 0
Congestion	1 1	0 0
Receiver Response	1 1	0 1
Sender Response	1 1	1 1

TCP Options

0 End of Options List
1 No Operation (NOP, Pad)
2 Maximum segment size
3 Window Scale
4 Selective ACK ok
8 Timestamp

Checksum

Checksum of entire TCP segment and pseudo header (parts of IP header)

Offset

Number of 32-bit words in TCP header, minimum value of 5. Multiply by 4 to get byte count.

RFC 793

Please refer to RFC 793 for the complete Transmission Control Protocol (TCP) Specification.

Source http://nmap.org/book/images/hdr/MJB-TCP-Header-800x564.png

TCP Flags Explained

- ACK – Acknowledge receipt of the packet
- PSH – Push – Send the data (flush TCP buffer) immediately
- SYN – Synchronize Sequence Number – Establish a connection
- FIN – Finish – Terminate the connection
- RST – Reset – Abnormal Session Disconnection
- URG – Urgent – Tell Receiver to process immediately

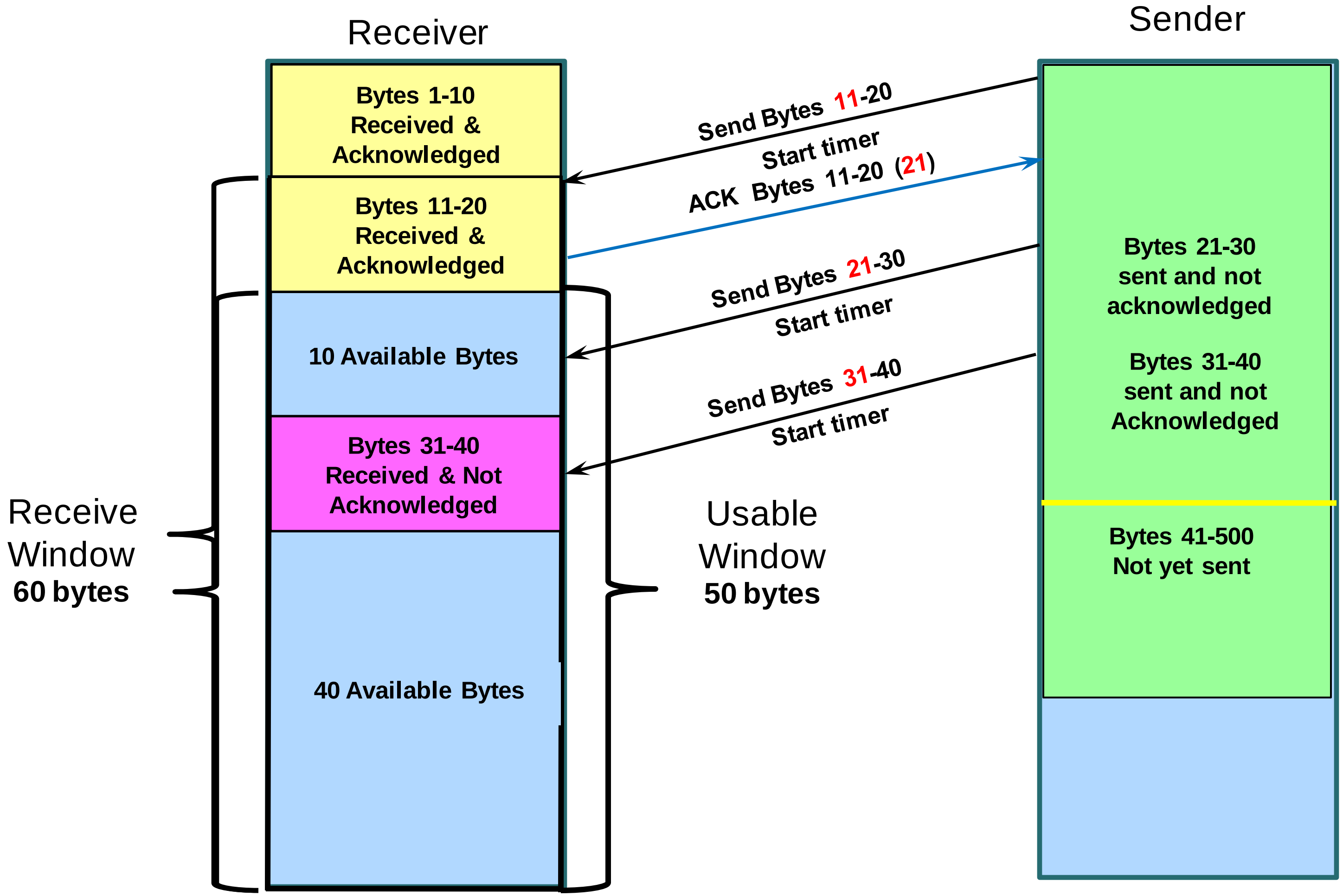
Sliding Window Acknowledgement

- **Advertised window size -** This field contains the amount of data that may be transmitted into the buffer.
- **Sequence number** – Identifies the first byte of data in this segment.
- **Acknowledgment number** – Identifies the next byte of data that a recipient is expecting to receive.
- With this information, a sliding-window protocol is implemented.

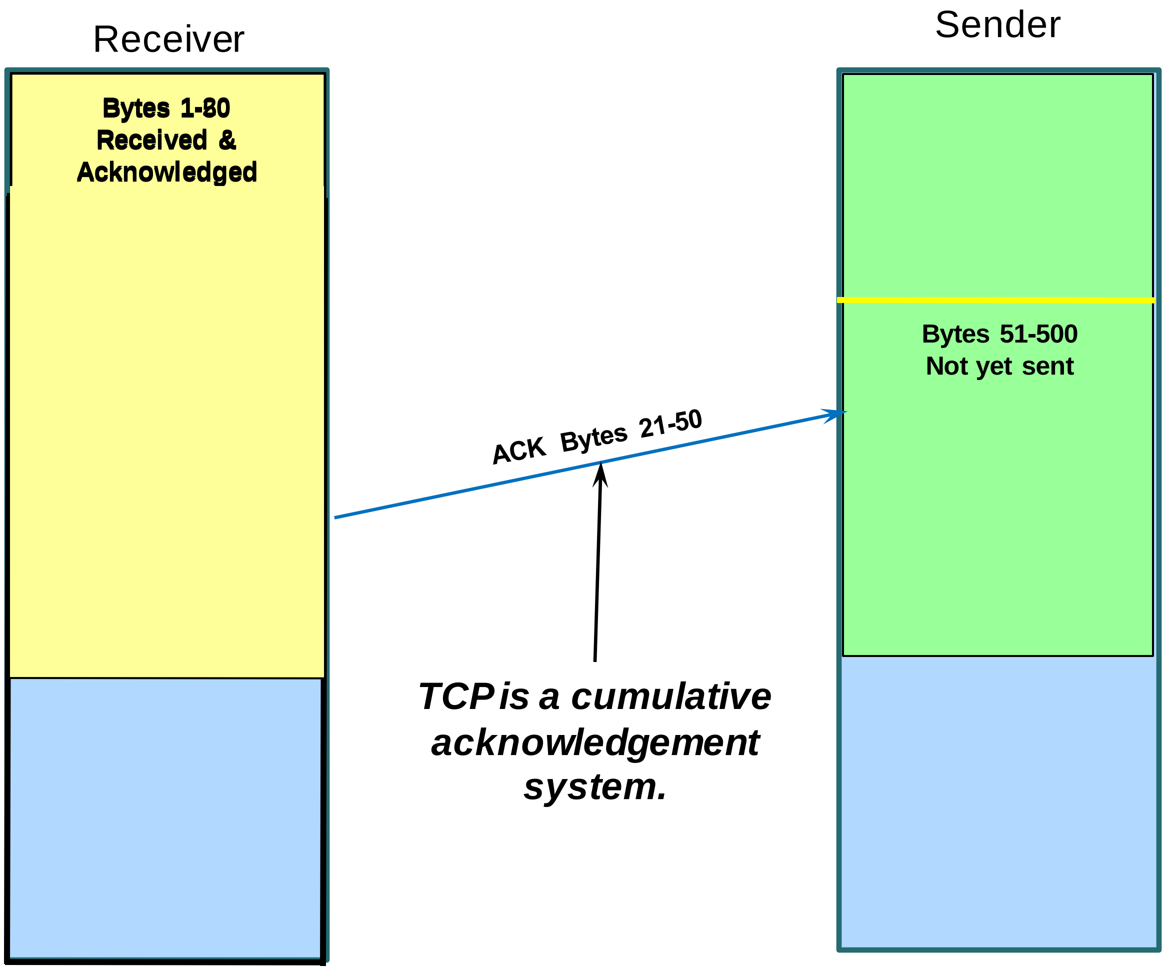
Sliding Window Acknowledgement

- Transmit categories
  1. Bytes Sent And Acknowledged
  2. Bytes Sent But Not Yet Acknowledged
  3. Bytes Not Yet Sent For Which Recipient Is Ready
  4. Bytes Not Yet Sent For Which Recipient Is Not Ready
- Receive categories
  1. Bytes Received And Acknowledged. This is the receiver’s complement to Transmit Categories #1 and #2.
  2. Bytes Not Yet Received For Which Recipient Is Ready. This is the receiver’s complement to Transmit Category #3.
  3. Bytes Not Yet Received For Which Recipient Is Not Ready. This is the receiver’s complement to Transmit Category #4.

Sliding Window Acknowledgement


Receiver
Sender
Bytes 1-10 Received & Acknowledged
Bytes 11-20 Received & Acknowledged
10 Available Bytes
Bytes 31-40 Received & Not Acknowledged
40 Available Bytes
Send Bytes 11-20
Start timer
ACK Bytes 11-20 (21)
Send Bytes 21-30
Start timer
Send Bytes 31-40
Start timer
Bytes 21-30 sent and not acknowledged
Bytes 31-40 sent and not Acknowledged
Bytes 41-500 Not yet sent
Receive Window 60 bytes
Usable Window 50 bytes

Sliding Window Acknowledgement



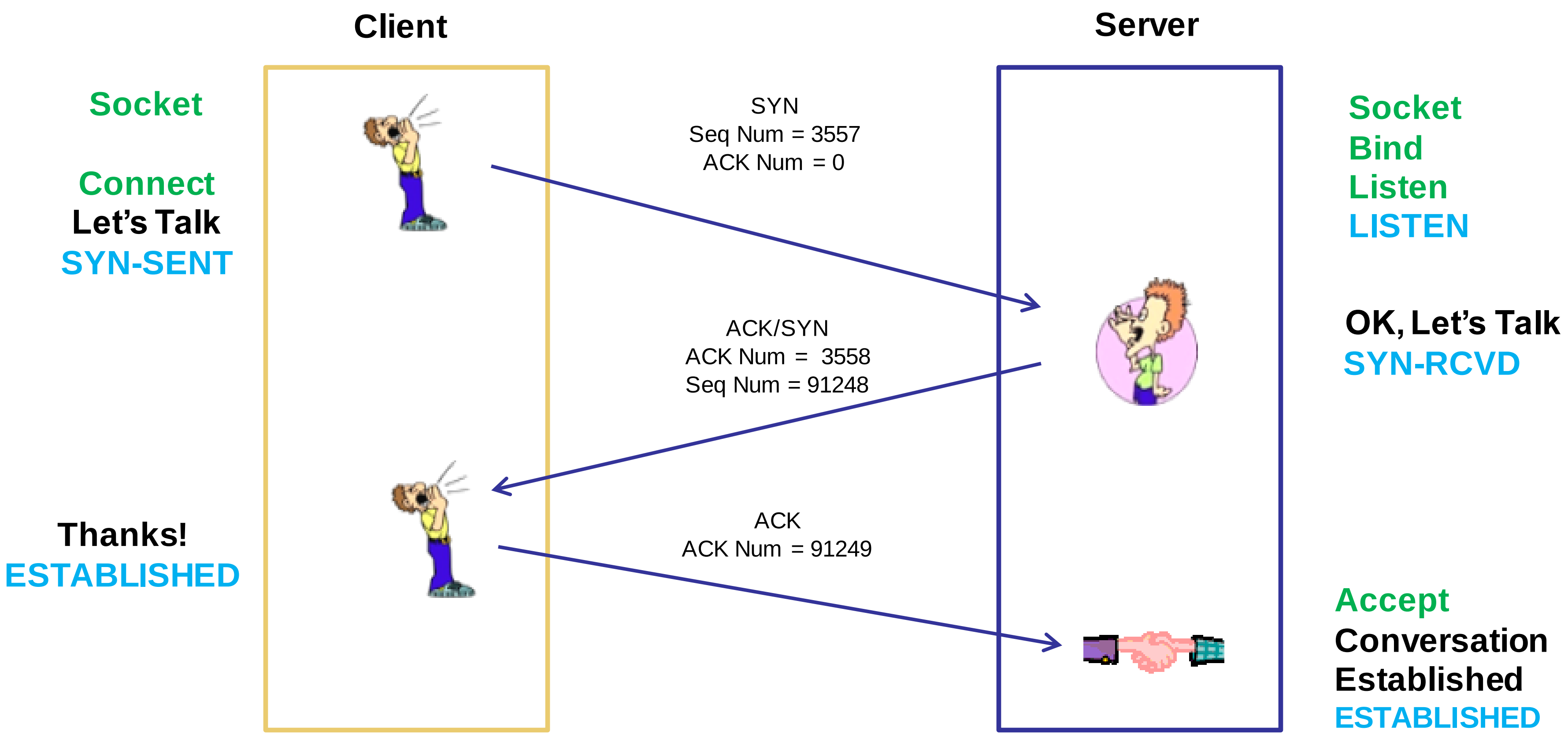
TCP is a cumulative acknowledgement system.

TCP Sequence of Events

- Establishing a connection
- Data transfer
- Termination

Establishing a Connection

The 3 Way Handshake



Client

Server

Socket

Connect

Let's Talk

SYN-SENT

SYN
Seq Num = 3557
ACK Num = 0

Socket
Bind
Listen
LISTEN

OK, Let's Talk

SYN-RCVD

ACK/SYN
ACK Num = 3558
Seq Num = 91248

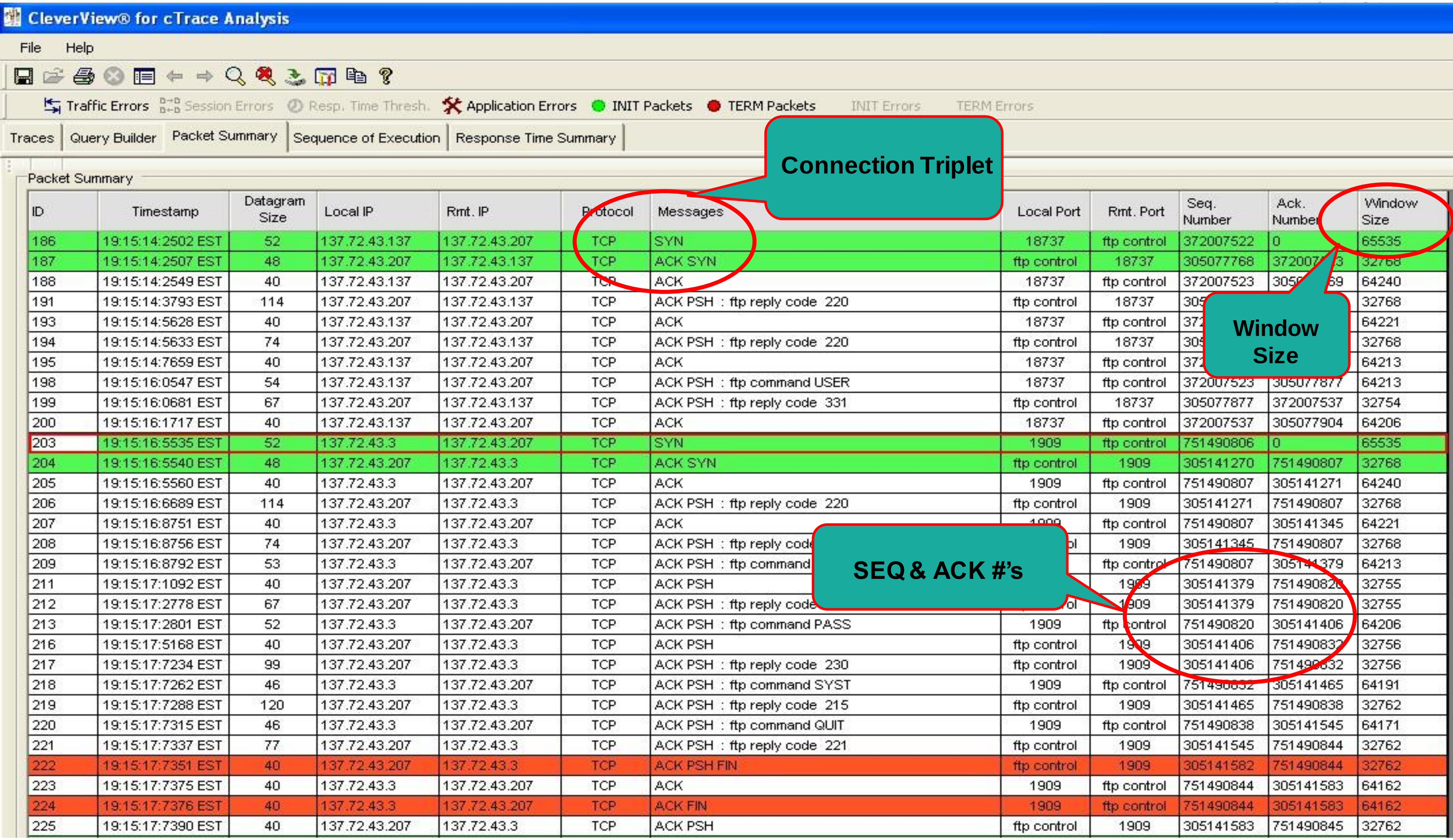
Thanks!

ESTABLISHED

ACK
ACK Num = 91249

Accept
Conversation
Established
ESTABLISHED

Establishing a Connection
The 3 Way Handshake



Connection Triplet

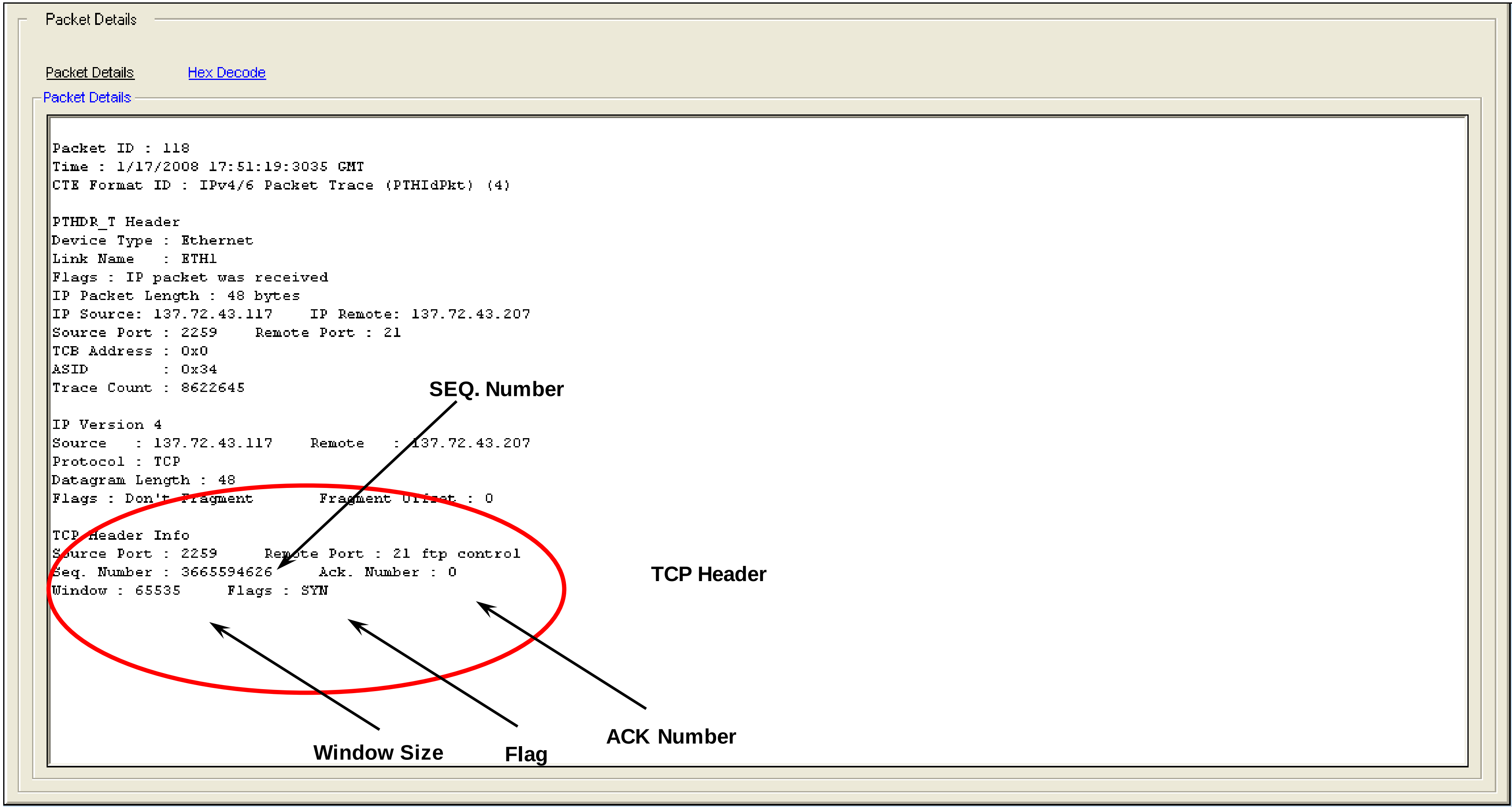
Window Size

SEQ & ACK #'s

Packet Summary

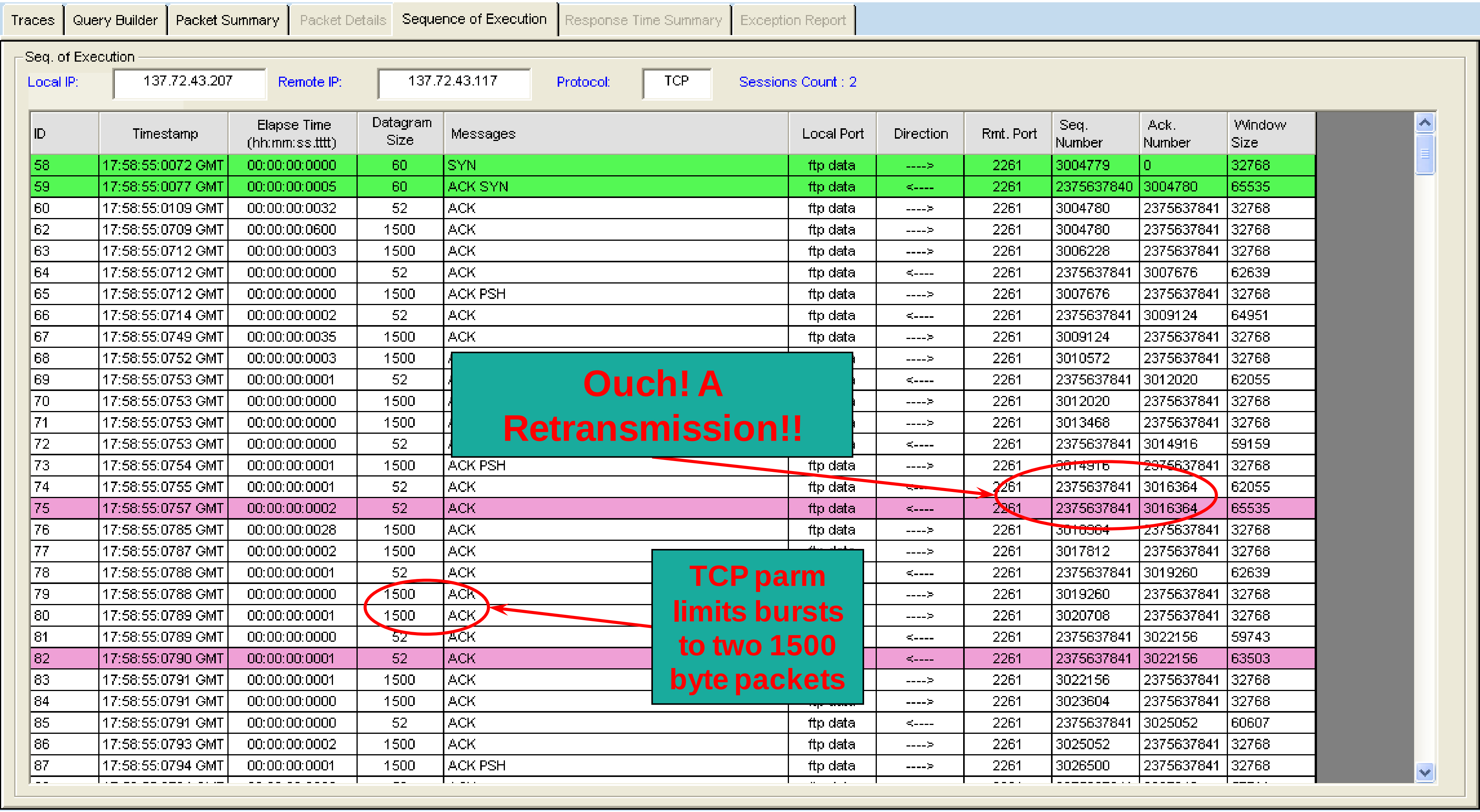
ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
186	19:15:14:2502 EST	52	137.72.43.137	137.72.43.207	TCP	SYN	18737	ftp control	372007522	0	65535
187	19:15:14:2507 EST	48	137.72.43.207	137.72.43.137	TCP	ACK SYN	ftp control	18737	305077768	[illegible]	32768
188	19:15:14:2549 EST	40	137.72.43.137	137.72.43.207	TCP	ACK	18737	ftp control	372007523	[illegible]	64240
191	19:15:14:3793 EST	114	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	18737	[illegible]	[illegible]	32768
193	19:15:14:5628 EST	40	137.72.43.137	137.72.43.207	TCP	ACK	18737	ftp control	[illegible]	[illegible]	64221
194	19:15:14:5633 EST	74	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	18737	[illegible]	[illegible]	32768
195	19:15:14:7659 EST	40	137.72.43.137	137.72.43.207	TCP	ACK	18737	ftp control	[illegible]	[illegible]	64213
198	19:15:16:0547 EST	54	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command USER	18737	ftp control	372007523	305077877	64213
199	19:15:16:0681 EST	67	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 331	ftp control	18737	305077877	372007537	32754
200	19:15:16:1717 EST	40	137.72.43.137	137.72.43.207	TCP	ACK	18737	ftp control	372007537	305077904	64206
203	19:15:16:5535 EST	52	137.72.43.3	137.72.43.207	TCP	SYN	1909	ftp control	751490806	0	65535
204	19:15:16:5540 EST	48	137.72.43.207	137.72.43.3	TCP	ACK SYN	ftp control	1909	305141270	751490807	32768
205	19:15:16:5560 EST	40	137.72.43.3	137.72.43.207	TCP	ACK	1909	ftp control	751490807	305141271	64240
206	19:15:16:6689 EST	114	137.72.43.207	137.72.43.3	TCP	ACK PSH : ftp reply code 220	ftp control	1909	305141271	751490807	32768
207	19:15:16:8751 EST	40	137.72.43.3	137.72.43.207	TCP	ACK	1909	ftp control	751490807	305141345	64221
208	19:15:16:8756 EST	74	137.72.43.207	137.72.43.3	TCP	ACK PSH : ftp reply code [illegible]	[illegible]	1909	305141345	751490807	32768
209	19:15:16:8792 EST	53	137.72.43.3	137.72.43.207	TCP	ACK PSH : ftp command [illegible]	[illegible]	ftp control	751490807	305141379	64213
211	19:15:17:1092 EST	40	137.72.43.207	137.72.43.3	TCP	ACK PSH	[illegible]	1909	305141379	751490820	32755
212	19:15:17:2778 EST	67	137.72.43.207	137.72.43.3	TCP	ACK PSH : ftp reply code [illegible]	[illegible]	1909	305141379	751490820	32755
213	19:15:17:2801 EST	52	137.72.43.3	137.72.43.207	TCP	ACK PSH : ftp command PASS	1909	ftp control	751490820	305141406	64206
216	19:15:17:5168 EST	40	137.72.43.207	137.72.43.3	TCP	ACK PSH	ftp control	1909	305141406	751490832	32756
217	19:15:17:7234 EST	99	137.72.43.207	137.72.43.3	TCP	ACK PSH : ftp reply code 230	ftp control	1909	305141406	751490832	32756
218	19:15:17:7262 EST	46	137.72.43.3	137.72.43.207	TCP	ACK PSH : ftp command SYST	1909	ftp control	751490832	305141465	64191
219	19:15:17:7288 EST	120	137.72.43.207	137.72.43.3	TCP	ACK PSH : ftp reply code 215	ftp control	1909	305141465	751490838	32762
220	19:15:17:7315 EST	46	137.72.43.3	137.72.43.207	TCP	ACK PSH : ftp command QUIT	1909	ftp control	751490838	305141545	64171
221	19:15:17:7337 EST	77	137.72.43.207	137.72.43.3	TCP	ACK PSH : ftp reply code 221	ftp control	1909	305141545	751490844	32762
222	19:15:17:7351 EST	40	137.72.43.207	137.72.43.3	TCP	ACK PSH FIN	ftp control	1909	305141582	751490844	32762
223	19:15:17:7375 EST	40	137.72.43.3	137.72.43.207	TCP	ACK	1909	ftp control	751490844	305141583	64162
224	19:15:17:7376 EST	40	137.72.43.3	137.72.43.207	TCP	ACK FIN	1909	ftp control	751490844	305141583	64162
225	19:15:17:7390 EST	40	137.72.43.207	137.72.43.3	TCP	ACK PSH	ftp control	1909	305141583	751490845	32762

Establishing a Connection
Packet Details



```
Packet ID : 118
Time : 1/17/2008 17:51:19:3035 GMT
CTE Format ID : IPv4/6 Packet Trace (PTHIdPkt) (4)

PTHDR_T Header
Device Type : Ethernet
Link Name   : ETH1
Flags : IP packet was received
IP Packet Length : 48 bytes
IP Source: 137.72.43.117    IP Remote: 137.72.43.207
Source Port : 2259    Remote Port : 21
TCB Address : 0x0
ASID        : 0x34
Trace Count : 8622645

IP Version 4
Source   : 137.72.43.117    Remote   : 137.72.43.207
Protocol : TCP
Datagram Length : 48
Flags : Don't Fragment       Fragment Offset : 0

TCP Header Info
Source Port : 2259     Remote Port : 21 ftp control
Seq. Number : 3665594626     Ack. Number : 0
Window : 65535     Flags : SYN
```

Data Transfer



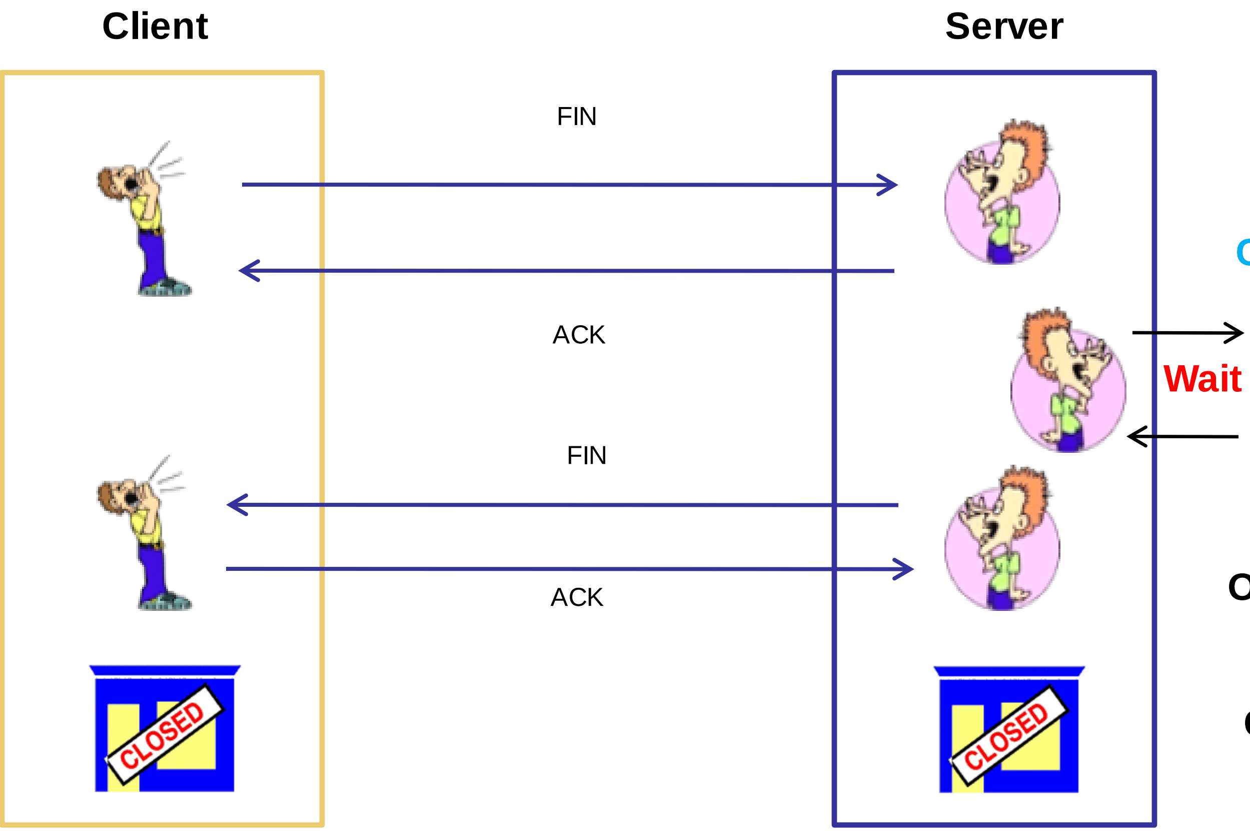
Local IP: 137.72.43.207 Remote IP: 137.72.43.117 Protocol: TCP Sessions Count : 2

ID	Timestamp	Elapse Time (hh:mm:ss.tttt)	Datagram Size	Messages	Local Port	Direction	Rmt. Port	Seq. Number	Ack. Number	Window Size
58	17:58:55:0072 GMT	00:00:00:0000	60	SYN	ftp data	---->	2261	3004779	0	32768
59	17:58:55:0077 GMT	00:00:00:0005	60	ACK SYN	ftp data	<----	2261	2375637840	3004780	65535
60	17:58:55:0109 GMT	00:00:00:0032	52	ACK	ftp data	---->	2261	3004780	2375637841	32768
62	17:58:55:0709 GMT	00:00:00:0600	1500	ACK	ftp data	---->	2261	3004780	2375637841	32768
63	17:58:55:0712 GMT	00:00:00:0003	1500	ACK	ftp data	---->	2261	3006228	2375637841	32768
64	17:58:55:0712 GMT	00:00:00:0000	52	ACK	ftp data	<----	2261	2375637841	3007676	62639
65	17:58:55:0712 GMT	00:00:00:0000	1500	ACK PSH	ftp data	---->	2261	3007676	2375637841	32768
66	17:58:55:0714 GMT	00:00:00:0002	52	ACK	ftp data	<----	2261	2375637841	3009124	64951
67	17:58:55:0749 GMT	00:00:00:0035	1500	ACK	ftp data	---->	2261	3009124	2375637841	32768
68	17:58:55:0752 GMT	00:00:00:0003	1500	[illegible]	[illegible]	---->	2261	3010572	2375637841	32768
69	17:58:55:0753 GMT	00:00:00:0001	52	[illegible]	[illegible]	<----	2261	2375637841	3012020	62055
70	17:58:55:0753 GMT	00:00:00:0000	1500	[illegible]	[illegible]	---->	2261	3012020	2375637841	32768
71	17:58:55:0753 GMT	00:00:00:0000	1500	[illegible]	[illegible]	---->	2261	3013468	2375637841	32768
72	17:58:55:0753 GMT	00:00:00:0000	52	[illegible]	[illegible]	<----	2261	2375637841	3014916	59159
73	17:58:55:0754 GMT	00:00:00:0001	1500	ACK PSH	ftp data	---->	2261	3014916	2375637841	32768
74	17:58:55:0755 GMT	00:00:00:0001	52	ACK	ftp data	<----	2261	2375637841	3016364	62055
75	17:58:55:0757 GMT	00:00:00:0002	52	ACK	ftp data	<----	2261	2375637841	3016364	65535
76	17:58:55:0785 GMT	00:00:00:0028	1500	ACK	ftp data	---->	2261	3016364	2375637841	32768
77	17:58:55:0787 GMT	00:00:00:0002	1500	ACK	ftp data	---->	2261	3017812	2375637841	32768
78	17:58:55:0788 GMT	00:00:00:0001	52	ACK	[illegible]	<----	2261	2375637841	3019260	62639
79	17:58:55:0788 GMT	00:00:00:0000	1500	ACK	[illegible]	---->	2261	3019260	2375637841	32768
80	17:58:55:0789 GMT	00:00:00:0001	1500	ACK	[illegible]	---->	2261	3020708	2375637841	32768
81	17:58:55:0789 GMT	00:00:00:0000	52	ACK	[illegible]	<----	2261	2375637841	3022156	59743
82	17:58:55:0790 GMT	00:00:00:0001	52	ACK	[illegible]	<----	2261	2375637841	3022156	63503
83	17:58:55:0791 GMT	00:00:00:0001	1500	ACK	[illegible]	---->	2261	3022156	2375637841	32768
84	17:58:55:0791 GMT	00:00:00:0000	1500	ACK	ftp data	---->	2261	3023604	2375637841	32768
85	17:58:55:0791 GMT	00:00:00:0000	52	ACK	ftp data	<----	2261	2375637841	3025052	60607
86	17:58:55:0793 GMT	00:00:00:0002	1500	ACK	ftp data	---->	2261	3025052	2375637841	32768
87	17:58:55:0794 GMT	00:00:00:0001	1500	ACK PSH	ftp data	---->	2261	3026500	2375637841	32768

Ouch! A Retransmission!!

TCP parm limits bursts to two 1500 byte packets

Connection Termination



I'm done!
FIN-WAIT1

Ok!
FIN-WAIT2

You're done!

OK!
TIME-WAIT

Connection
Closed

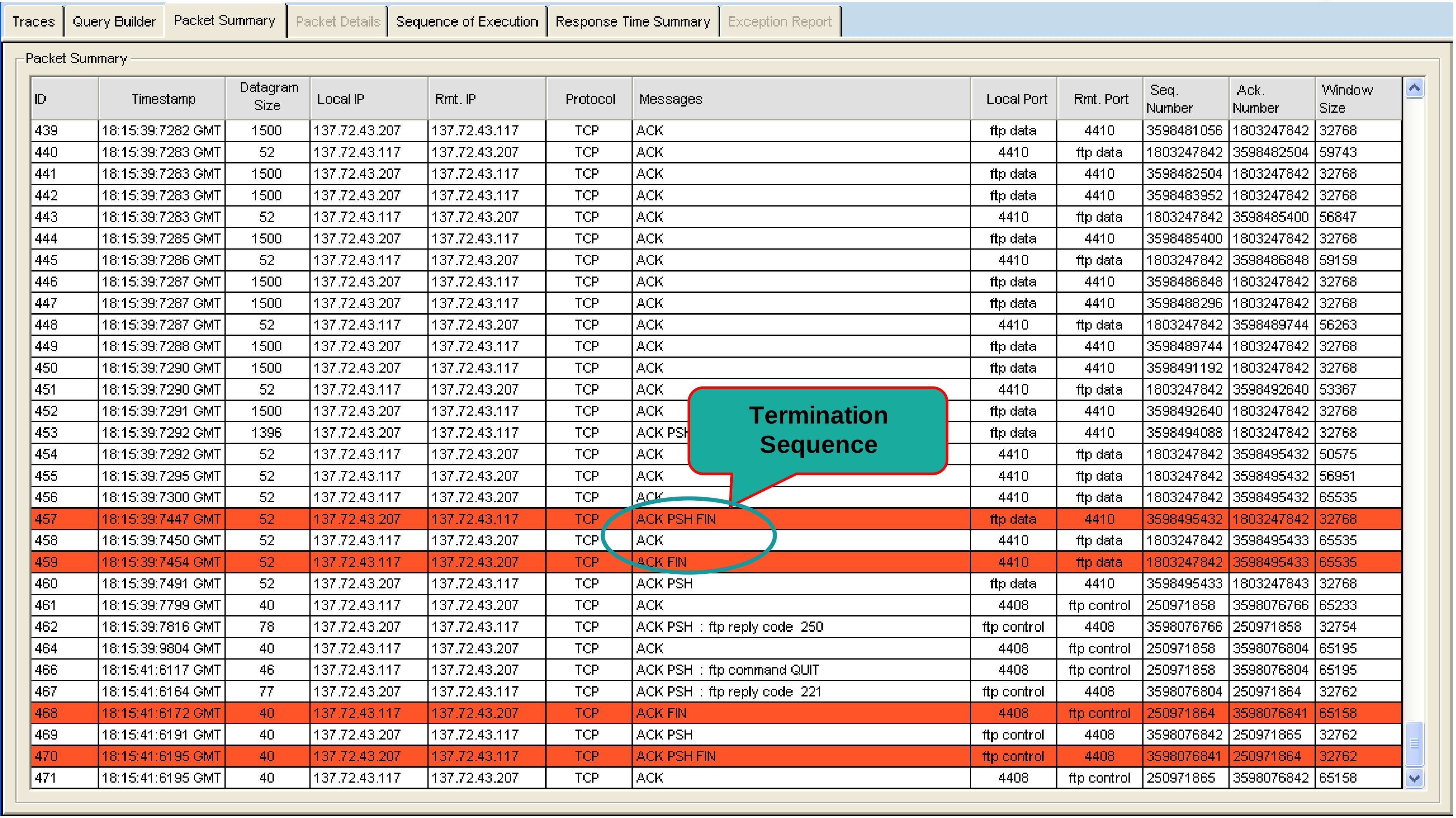
OK!
CLOSE-WAIT

Hey,
Application,
We're Shutting
down!
LAST-ACK

OK, Goodbye
CLOSED

Connection
Closed

Connection Termination

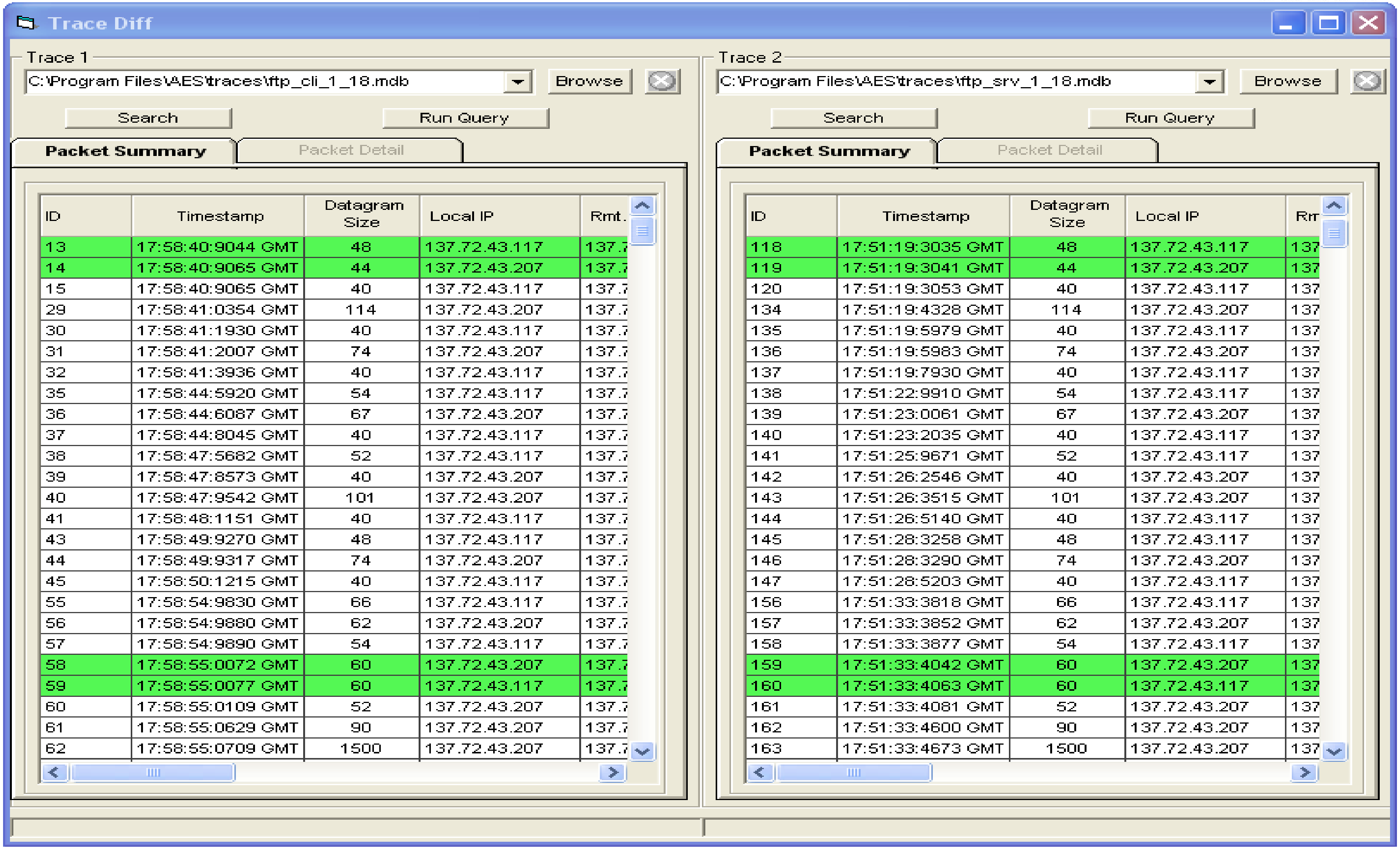


Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
439	18:15:39:7282 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598481056	1803247842	32768
440	18:15:39:7283 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598482504	59743
441	18:15:39:7283 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598482504	1803247842	32768
442	18:15:39:7283 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598483952	1803247842	32768
443	18:15:39:7283 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598485400	56847
444	18:15:39:7285 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598485400	1803247842	32768
445	18:15:39:7286 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598486848	59159
446	18:15:39:7287 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598486848	1803247842	32768
447	18:15:39:7287 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598488296	1803247842	32768
448	18:15:39:7287 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598489744	56263
449	18:15:39:7288 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598489744	1803247842	32768
450	18:15:39:7290 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598491192	1803247842	32768
451	18:15:39:7290 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598492640	53367
452	18:15:39:7291 GMT	1500	137.72.43.207	137.72.43.117	TCP	ACK	ftp data	4410	3598492640	1803247842	32768
453	18:15:39:7292 GMT	1396	137.72.43.207	137.72.43.117	TCP	ACK PSH	ftp data	4410	3598494088	1803247842	32768
454	18:15:39:7292 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598495432	50575
455	18:15:39:7295 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598495432	56951
456	18:15:39:7300 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598495432	65535
457	18:15:39:7447 GMT	52	137.72.43.207	137.72.43.117	TCP	ACK PSH FIN	ftp data	4410	3598495432	1803247842	32768
458	18:15:39:7450 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK	4410	ftp data	1803247842	3598495433	65535
459	18:15:39:7454 GMT	52	137.72.43.117	137.72.43.207	TCP	ACK FIN	4410	ftp data	1803247842	3598495433	65535
460	18:15:39:7491 GMT	52	137.72.43.207	137.72.43.117	TCP	ACK PSH	ftp data	4410	3598495433	1803247843	32768
461	18:15:39:7799 GMT	40	137.72.43.117	137.72.43.207	TCP	ACK	4408	ftp control	250971858	3598076766	65233
462	18:15:39:7816 GMT	78	137.72.43.207	137.72.43.117	TCP	ACK PSH : ftp reply code 250	ftp control	4408	3598076766	250971858	32754
464	18:15:39:9804 GMT	40	137.72.43.117	137.72.43.207	TCP	ACK	4408	ftp control	250971858	3598076804	65195
466	18:15:41:6117 GMT	46	137.72.43.117	137.72.43.207	TCP	ACK PSH : ftp command QUIT	4408	ftp control	250971858	3598076804	65195
467	18:15:41:6164 GMT	77	137.72.43.207	137.72.43.117	TCP	ACK PSH : ftp reply code 221	ftp control	4408	3598076804	250971864	32762
468	18:15:41:6172 GMT	40	137.72.43.117	137.72.43.207	TCP	ACK FIN	4408	ftp control	250971864	3598076841	65158
469	18:15:41:6191 GMT	40	137.72.43.207	137.72.43.117	TCP	ACK PSH	ftp control	4408	3598076842	250971865	32762
470	18:15:41:6195 GMT	40	137.72.43.207	137.72.43.117	TCP	ACK PSH FIN	ftp control	4408	3598076841	250971864	32762
471	18:15:41:6195 GMT	40	137.72.43.117	137.72.43.207	TCP	ACK	4408	ftp control	250971865	3598076842	65158

Termination Sequence

Comparing Traces



Trace 1

C:\Program Files\AES\traces\ftp_cli_1_18.mdb

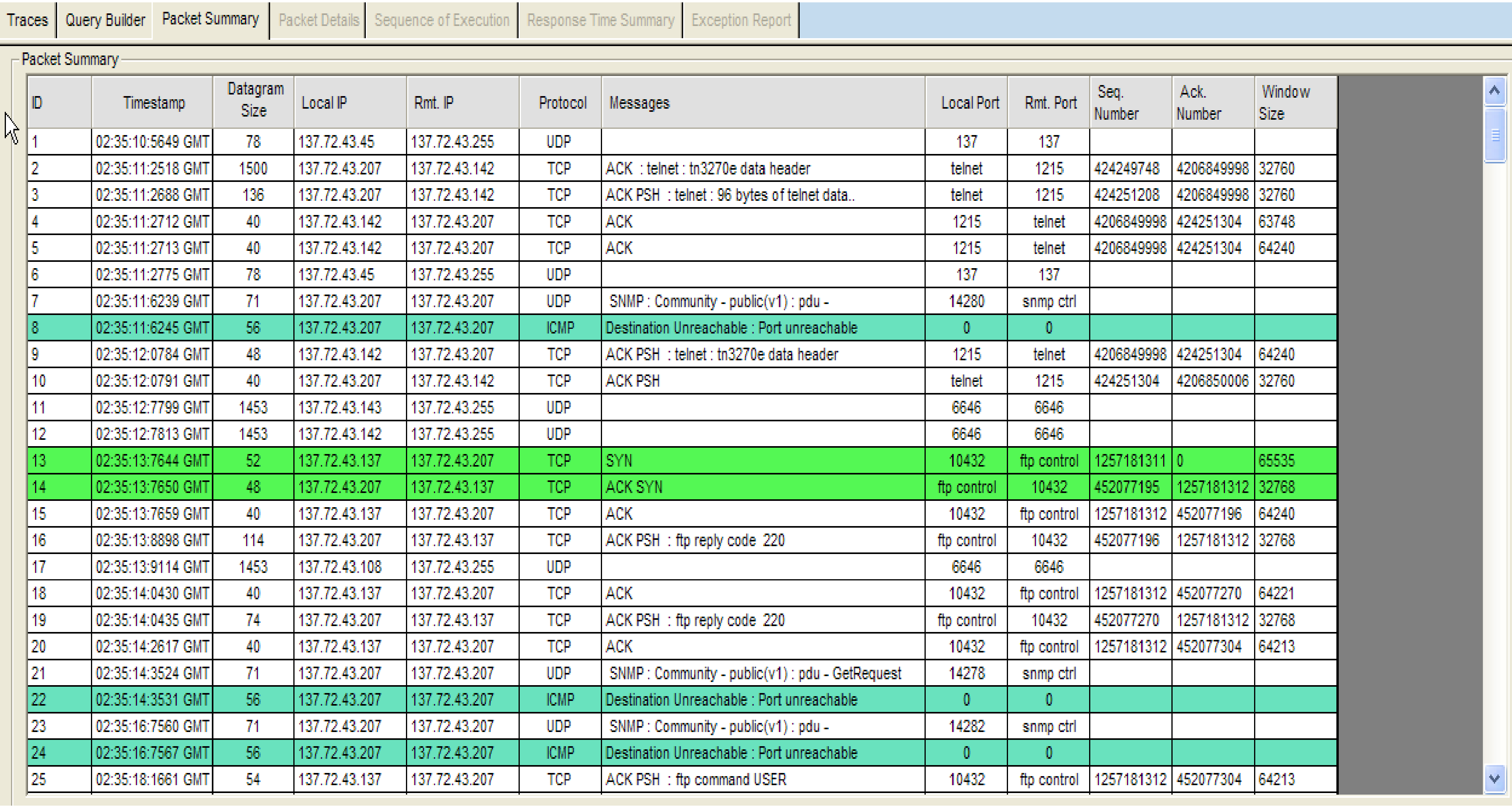
ID	Timestamp	Datagram Size	Local IP	Rmt.
13	17:58:40:9044 GMT	48	137.72.43.117	137.7
14	17:58:40:9065 GMT	44	137.72.43.207	137.7
15	17:58:40:9065 GMT	40	137.72.43.117	137.7
29	17:58:41:0354 GMT	114	137.72.43.207	137.7
30	17:58:41:1930 GMT	40	137.72.43.117	137.7
31	17:58:41:2007 GMT	74	137.72.43.207	137.7
32	17:58:41:3936 GMT	40	137.72.43.117	137.7
35	17:58:44:5920 GMT	54	137.72.43.117	137.7
36	17:58:44:6087 GMT	67	137.72.43.207	137.7
37	17:58:44:8045 GMT	40	137.72.43.117	137.7
38	17:58:47:5682 GMT	52	137.72.43.117	137.7
39	17:58:47:8573 GMT	40	137.72.43.207	137.7
40	17:58:47:9542 GMT	101	137.72.43.207	137.7
41	17:58:48:1151 GMT	40	137.72.43.117	137.7
43	17:58:49:9270 GMT	48	137.72.43.117	137.7
44	17:58:49:9317 GMT	74	137.72.43.207	137.7
45	17:58:50:1215 GMT	40	137.72.43.117	137.7
55	17:58:54:9830 GMT	66	137.72.43.117	137.7
56	17:58:54:9880 GMT	62	137.72.43.207	137.7
57	17:58:54:9890 GMT	54	137.72.43.117	137.7
58	17:58:55:0072 GMT	60	137.72.43.207	137.7
59	17:58:55:0077 GMT	60	137.72.43.117	137.7
60	17:58:55:0109 GMT	52	137.72.43.207	137.7
61	17:58:55:0629 GMT	90	137.72.43.207	137.7
62	17:58:55:0709 GMT	1500	137.72.43.207	137.7

Trace 2

C:\Program Files\AES\traces\ftp_srv_1_18.mdb

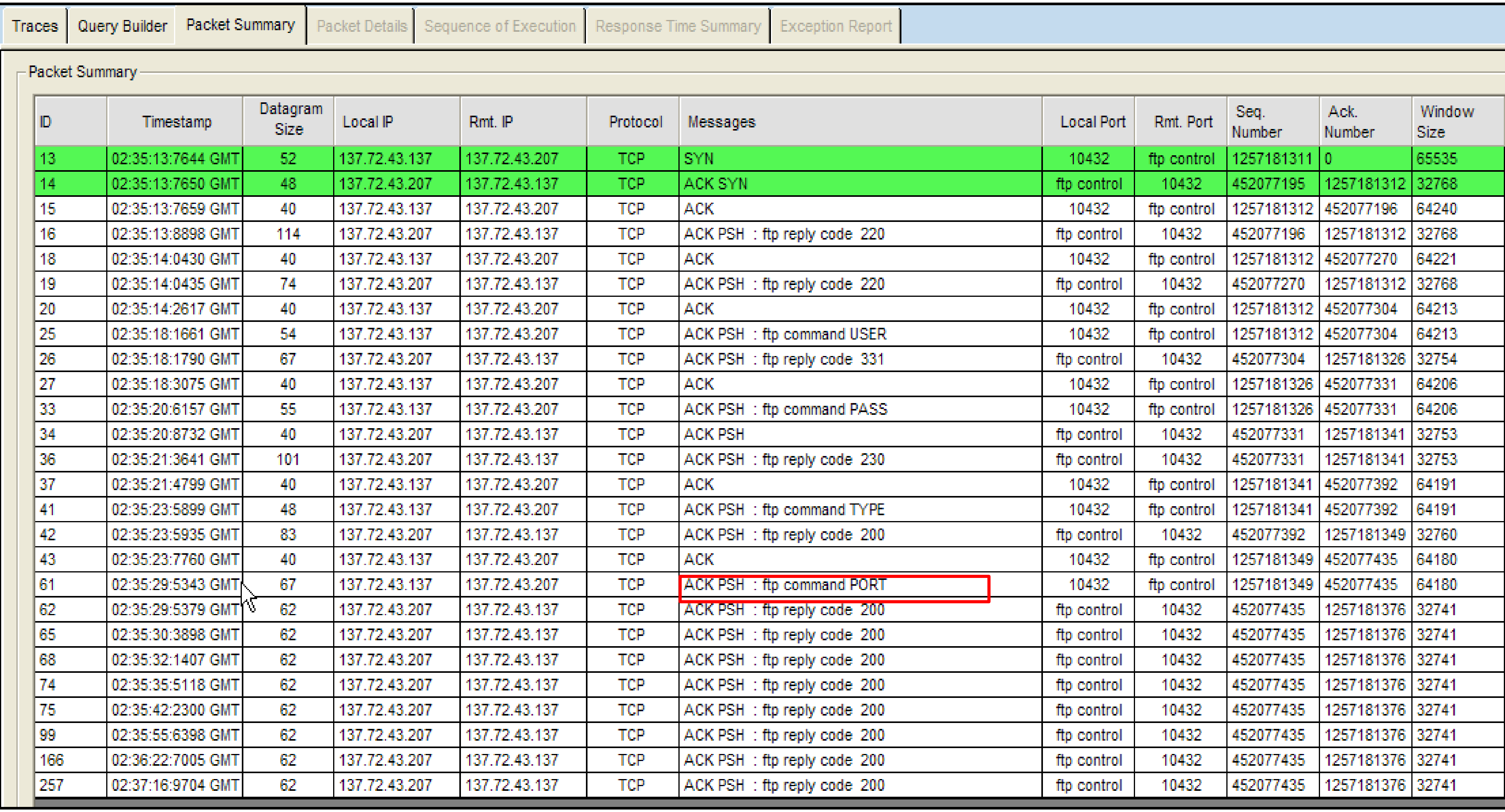
ID	Timestamp	Datagram Size	Local IP	Rr
118	17:51:19:3035 GMT	48	137.72.43.117	137
119	17:51:19:3041 GMT	44	137.72.43.207	137
120	17:51:19:3053 GMT	40	137.72.43.117	137
134	17:51:19:4328 GMT	114	137.72.43.207	137
135	17:51:19:5979 GMT	40	137.72.43.117	137
136	17:51:19:5983 GMT	74	137.72.43.207	137
137	17:51:19:7930 GMT	40	137.72.43.117	137
138	17:51:22:9910 GMT	54	137.72.43.117	137
139	17:51:23:0061 GMT	67	137.72.43.207	137
140	17:51:23:2035 GMT	40	137.72.43.117	137
141	17:51:25:9671 GMT	52	137.72.43.117	137
142	17:51:26:2546 GMT	40	137.72.43.207	137
143	17:51:26:3515 GMT	101	137.72.43.207	137
144	17:51:26:5140 GMT	40	137.72.43.117	137
145	17:51:28:3258 GMT	48	137.72.43.117	137
146	17:51:28:3290 GMT	74	137.72.43.207	137
147	17:51:28:5203 GMT	40	137.72.43.117	137
156	17:51:33:3818 GMT	66	137.72.43.117	137
157	17:51:33:3852 GMT	62	137.72.43.207	137
158	17:51:33:3877 GMT	54	137.72.43.117	137
159	17:51:33:4042 GMT	60	137.72.43.207	137
160	17:51:33:4063 GMT	60	137.72.43.117	137
161	17:51:33:4081 GMT	52	137.72.43.207	137
162	17:51:33:4600 GMT	90	137.72.43.207	137
163	17:51:33:4673 GMT	1500	137.72.43.207	137

FTP Diagnosis



ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
1	02:35:10:5649 GMT	78	137.72.43.45	137.72.43.255	UDP		137	137			
2	02:35:11:2518 GMT	1500	137.72.43.207	137.72.43.142	TCP	ACK : telnet : tn3270e data header	telnet	1215	424249748	4206849998	32760
3	02:35:11:2688 GMT	136	137.72.43.207	137.72.43.142	TCP	ACK PSH : telnet : 96 bytes of telnet data..	telnet	1215	424251208	4206849998	32760
4	02:35:11:2712 GMT	40	137.72.43.142	137.72.43.207	TCP	ACK	1215	telnet	4206849998	424251304	63748
5	02:35:11:2713 GMT	40	137.72.43.142	137.72.43.207	TCP	ACK	1215	telnet	4206849998	424251304	64240
6	02:35:11:2775 GMT	78	137.72.43.45	137.72.43.255	UDP		137	137			
7	02:35:11:6239 GMT	71	137.72.43.207	137.72.43.207	UDP	SNMP : Community - public(v1) : pdu -	14280	snmp ctrl			
8	02:35:11:6245 GMT	56	137.72.43.207	137.72.43.207	ICMP	Destination Unreachable : Port unreachable	0	0			
9	02:35:12:0784 GMT	48	137.72.43.142	137.72.43.207	TCP	ACK PSH : telnet : tn3270e data header	1215	telnet	4206849998	424251304	64240
10	02:35:12:0791 GMT	40	137.72.43.207	137.72.43.142	TCP	ACK PSH	telnet	1215	424251304	4206850006	32760
11	02:35:12:7799 GMT	1453	137.72.43.143	137.72.43.255	UDP		6646	6646			
12	02:35:12:7813 GMT	1453	137.72.43.142	137.72.43.255	UDP		6646	6646			
13	02:35:13:7644 GMT	52	137.72.43.137	137.72.43.207	TCP	SYN	10432	ftp control	1257181311	0	65535
14	02:35:13:7650 GMT	48	137.72.43.207	137.72.43.137	TCP	ACK SYN	ftp control	10432	452077195	1257181312	32768
15	02:35:13:7659 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077196	64240
16	02:35:13:8898 GMT	114	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	10432	452077196	1257181312	32768
17	02:35:13:9114 GMT	1453	137.72.43.108	137.72.43.255	UDP		6646	6646			
18	02:35:14:0430 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077270	64221
19	02:35:14:0435 GMT	74	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	10432	452077270	1257181312	32768
20	02:35:14:2617 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077304	64213
21	02:35:14:3524 GMT	71	137.72.43.207	137.72.43.207	UDP	SNMP : Community - public(v1) : pdu - GetRequest	14278	snmp ctrl			
22	02:35:14:3531 GMT	56	137.72.43.207	137.72.43.207	ICMP	Destination Unreachable : Port unreachable	0	0			
23	02:35:16:7560 GMT	71	137.72.43.207	137.72.43.207	UDP	SNMP : Community - public(v1) : pdu -	14282	snmp ctrl			
24	02:35:16:7567 GMT	56	137.72.43.207	137.72.43.207	ICMP	Destination Unreachable : Port unreachable	0	0			
25	02:35:18:1661 GMT	54	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command USER	10432	ftp control	1257181312	452077304	64213

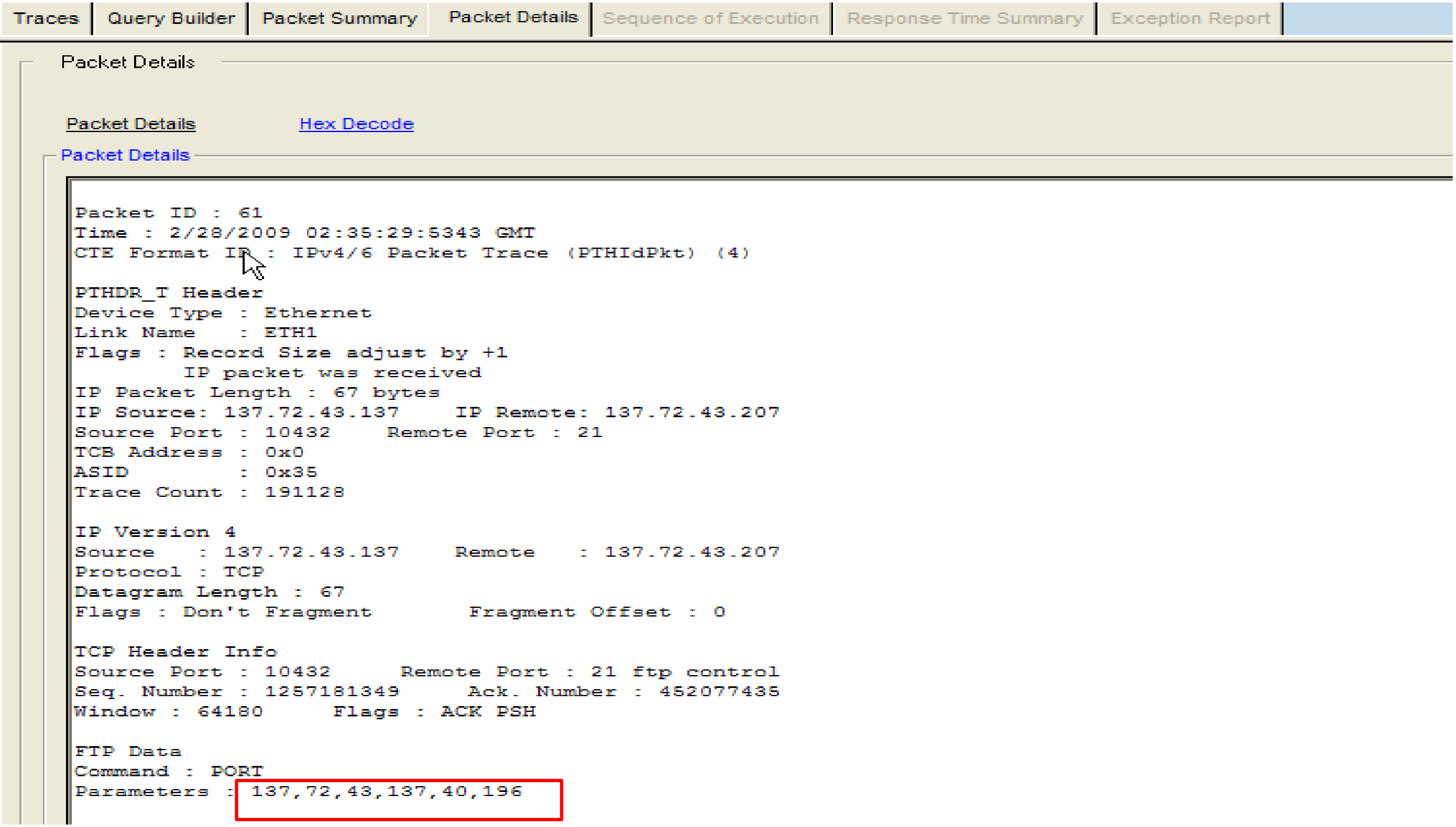
FTP Diagnosis – zoom in on FTP ports: Control connection vs. Data connection



Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
13	02:35:13:7644 GMT	52	137.72.43.137	137.72.43.207	TCP	SYN	10432	ftp control	1257181311	0	65535
14	02:35:13:7650 GMT	48	137.72.43.207	137.72.43.137	TCP	ACK SYN	ftp control	10432	452077195	1257181312	32768
15	02:35:13:7659 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077196	64240
16	02:35:13:8898 GMT	114	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	10432	452077196	1257181312	32768
18	02:35:14:0430 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077270	64221
19	02:35:14:0435 GMT	74	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	10432	452077270	1257181312	32768
20	02:35:14:2617 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077304	64213
25	02:35:18:1661 GMT	54	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command USER	10432	ftp control	1257181312	452077304	64213
26	02:35:18:1790 GMT	67	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 331	ftp control	10432	452077304	1257181326	32754
27	02:35:18:3075 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181326	452077331	64206
33	02:35:20:6157 GMT	55	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command PASS	10432	ftp control	1257181326	452077331	64206
34	02:35:20:8732 GMT	40	137.72.43.207	137.72.43.137	TCP	ACK PSH	ftp control	10432	452077331	1257181341	32753
36	02:35:21:3641 GMT	101	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 230	ftp control	10432	452077331	1257181341	32753
37	02:35:21:4799 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181341	452077392	64191
41	02:35:23:5899 GMT	48	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command TYPE	10432	ftp control	1257181341	452077392	64191
42	02:35:23:5935 GMT	83	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077392	1257181349	32760
43	02:35:23:7760 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181349	452077435	64180
61	02:35:29:5343 GMT	67	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command PORT	10432	ftp control	1257181349	452077435	64180
62	02:35:29:5379 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
65	02:35:30:3898 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
68	02:35:32:1407 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
74	02:35:35:5118 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
75	02:35:42:2300 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
99	02:35:55:6398 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
166	02:36:22:7005 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741
257	02:37:16:9704 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741

FTP Diagnosis – Analyze the PORT command



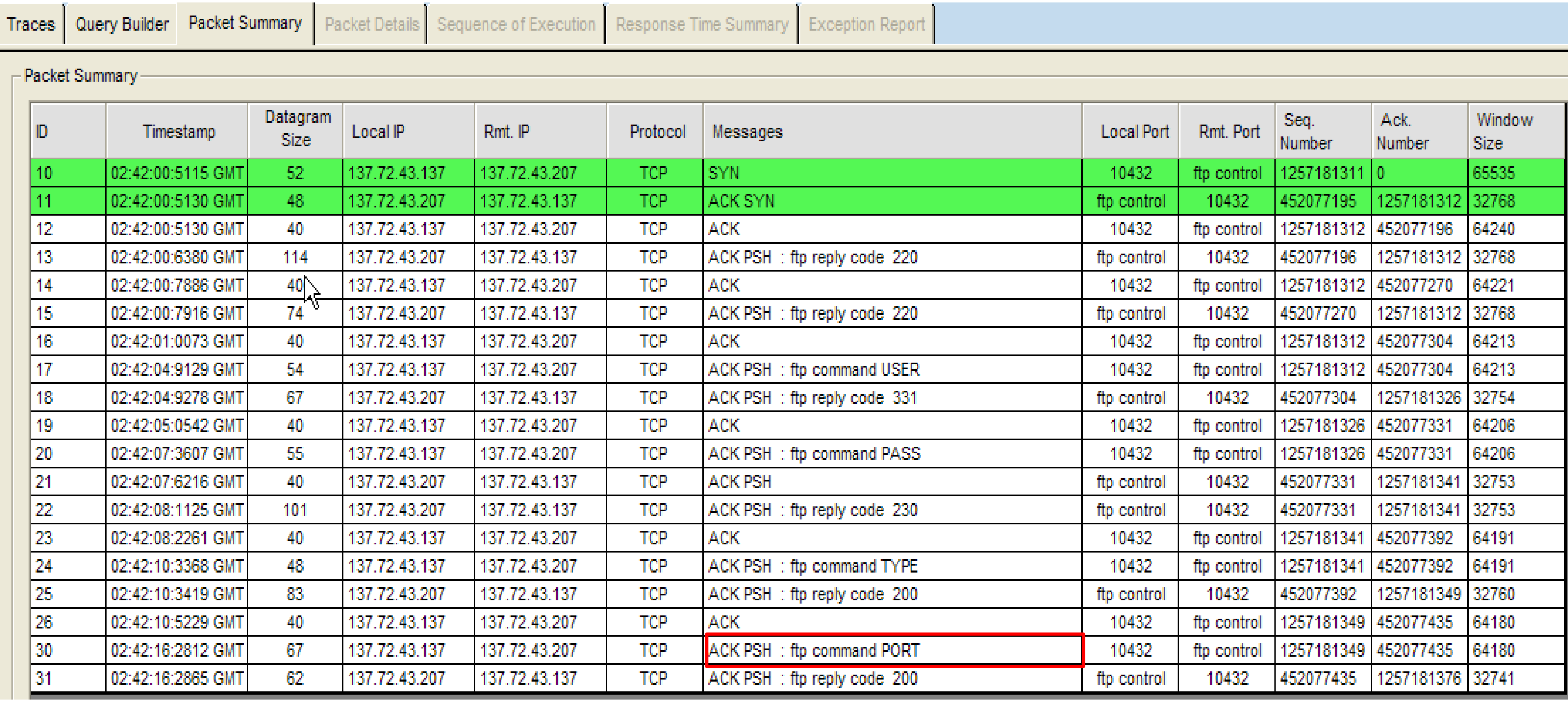
```
Packet ID : 61
Time : 2/28/2009 02:35:29:5343 GMT
CTE Format ID : IPv4/6 Packet Trace (PTHIdPkt) (4)

PTHDR_T Header
Device Type : Ethernet
Link Name   : ETH1
Flags : Record Size adjust by +1
        IP packet was received
IP Packet Length : 67 bytes
IP Source: 137.72.43.137    IP Remote: 137.72.43.207
Source Port : 10432    Remote Port : 21
TCB Address : 0x0
ASID        : 0x35
Trace Count : 191128

IP Version 4
Source    : 137.72.43.137    Remote    : 137.72.43.207
Protocol : TCP
Datagram Length : 67
Flags : Don't Fragment       Fragment Offset : 0

TCP Header Info
Source Port : 10432     Remote Port : 21 ftp control
Seq. Number : 1257181349     Ack. Number : 452077435
Window : 64180     Flags : ACK PSH

FTP Data
Command : PORT
Parameters : 137,72,43,137,40,196
```

FTP Diagnosis – Analyze the PORT command continued

PORT 137,72,43,137,40,196

- Specifies that the FTP Server will initiate the data connection
- Client’s IP Address: 137.72.43.137
- Client’s Port: 40 * 256 + 196 = 10436
- Expect to see a SYN packet:
  - from server (137.72.43.207)
  - to client (137.72.43.137)

FTP Diagnosis – check the equivalent Sniffer trace



Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
10	02:42:00:5115 GMT	52	137.72.43.137	137.72.43.207	TCP	SYN	10432	ftp control	1257181311	0	65535
11	02:42:00:5130 GMT	48	137.72.43.207	137.72.43.137	TCP	ACK SYN	ftp control	10432	452077195	1257181312	32768
12	02:42:00:5130 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077196	64240
13	02:42:00:6380 GMT	114	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	10432	452077196	1257181312	32768
14	02:42:00:7886 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077270	64221
15	02:42:00:7916 GMT	74	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 220	ftp control	10432	452077270	1257181312	32768
16	02:42:01:0073 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181312	452077304	64213
17	02:42:04:9129 GMT	54	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command USER	10432	ftp control	1257181312	452077304	64213
18	02:42:04:9278 GMT	67	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 331	ftp control	10432	452077304	1257181326	32754
19	02:42:05:0542 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181326	452077331	64206
20	02:42:07:3607 GMT	55	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command PASS	10432	ftp control	1257181326	452077331	64206
21	02:42:07:6216 GMT	40	137.72.43.207	137.72.43.137	TCP	ACK PSH	ftp control	10432	452077331	1257181341	32753
22	02:42:08:1125 GMT	101	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 230	ftp control	10432	452077331	1257181341	32753
23	02:42:08:2261 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181341	452077392	64191
24	02:42:10:3368 GMT	48	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command TYPE	10432	ftp control	1257181341	452077392	64191
25	02:42:10:3419 GMT	83	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077392	1257181349	32760
26	02:42:10:5229 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	10432	ftp control	1257181349	452077435	64180
30	02:42:16:2812 GMT	67	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command PORT	10432	ftp control	1257181349	452077435	64180
31	02:42:16:2865 GMT	62	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	10432	452077435	1257181376	32741

FTP Diagnosis

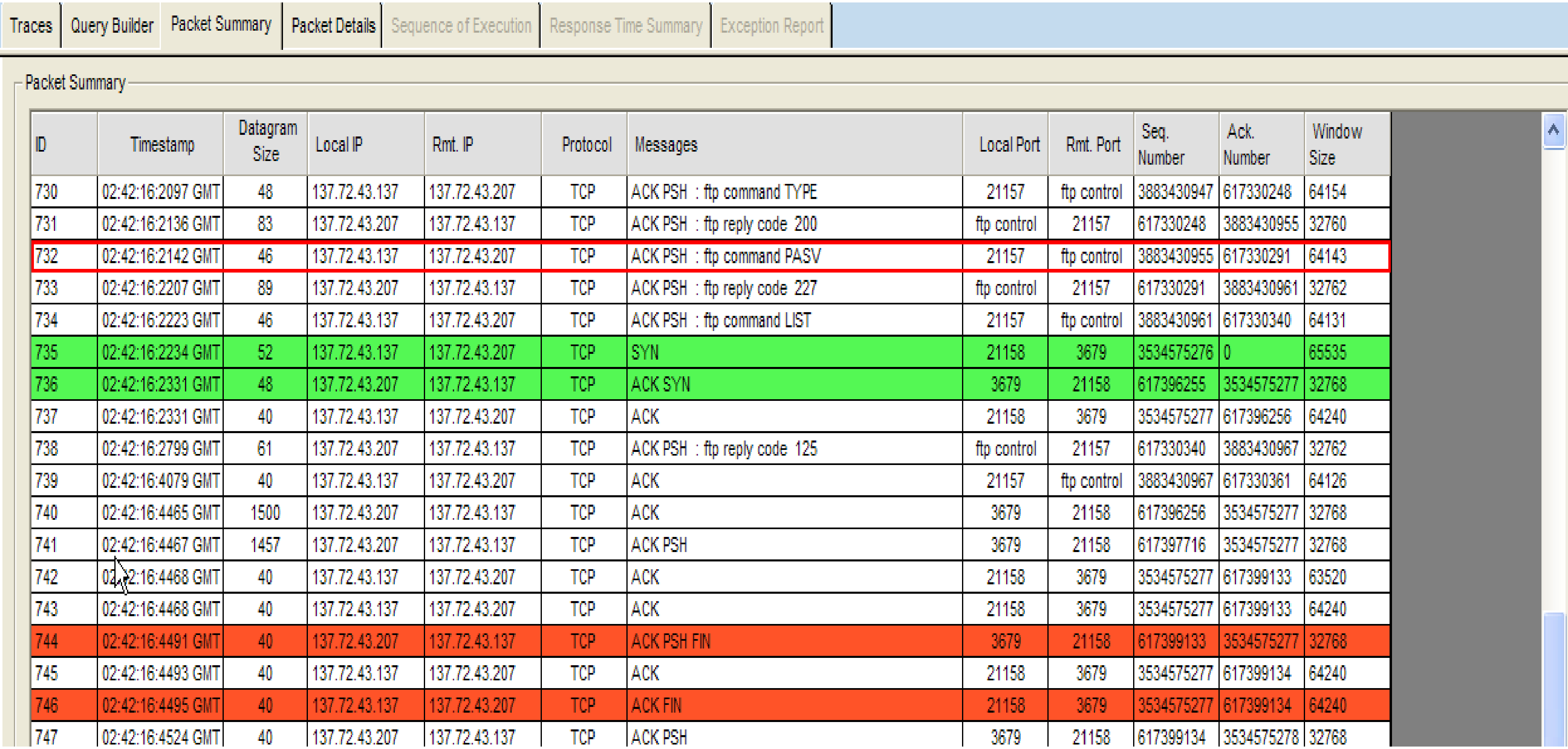
Sniffer trace shows the PORT command was sent to the server but there was no SYN packet coming in – SYN packet was “lost”

Might be related to firewall issues - check firewall setting, FTP.DATA and TCP PROFILE settings.

Passive FTP:

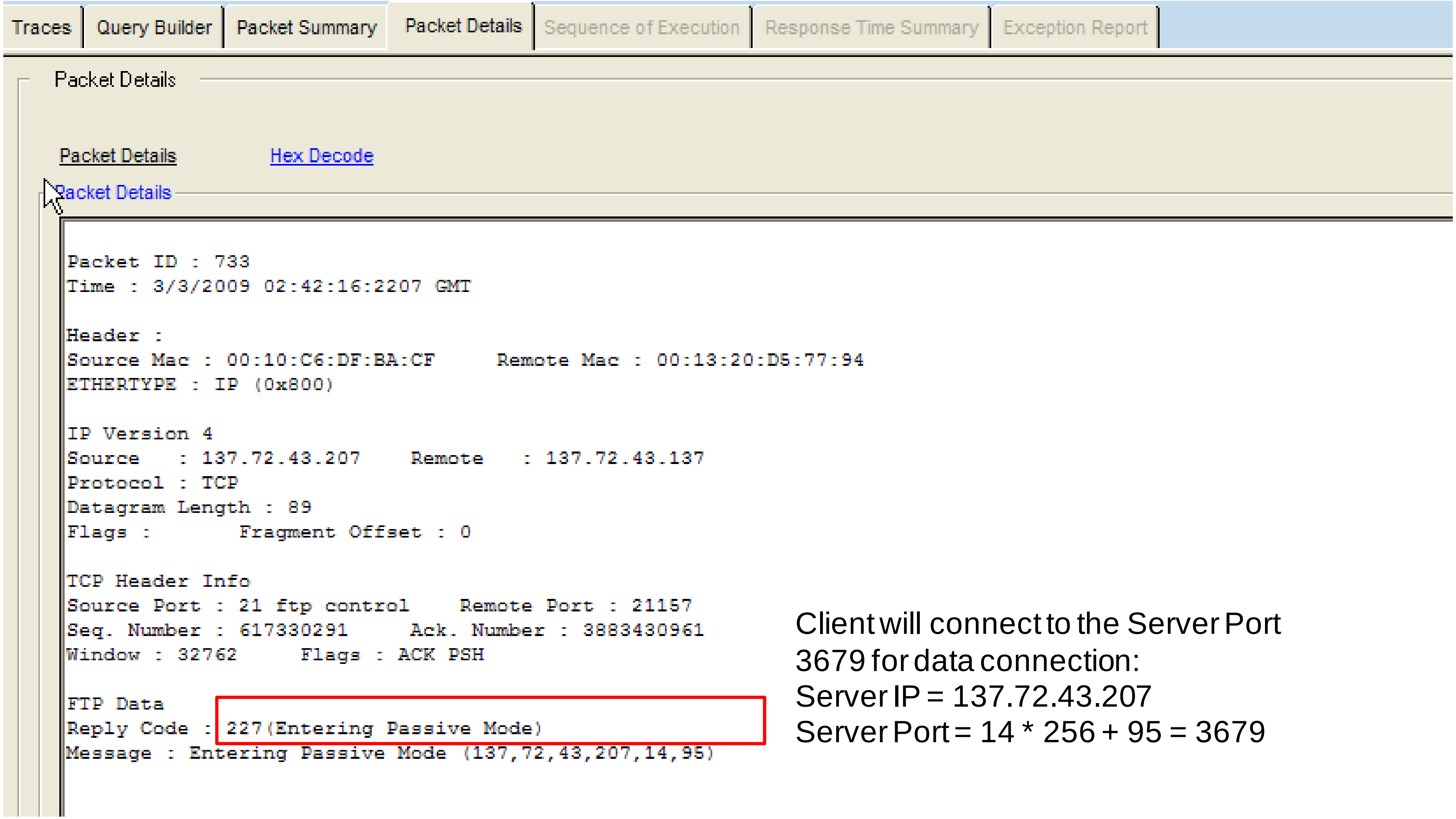
- Client initiates the data connection.
- Check to reply to the PASV command to determine the IP address and Port number of the server for the data connection.

FTP Diagnosis – Passive FTP



ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
730	02:42:16:2097 GMT	48	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command TYPE	21157	ftp control	3883430947	617330248	64154
731	02:42:16:2136 GMT	83	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 200	ftp control	21157	617330248	3883430955	32760
732	02:42:16:2142 GMT	46	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command PASV	21157	ftp control	3883430955	617330291	64143
733	02:42:16:2207 GMT	89	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 227	ftp control	21157	617330291	3883430961	32762
734	02:42:16:2223 GMT	46	137.72.43.137	137.72.43.207	TCP	ACK PSH : ftp command LIST	21157	ftp control	3883430961	617330340	64131
735	02:42:16:2234 GMT	52	137.72.43.137	137.72.43.207	TCP	SYN	21158	3679	3534575276	0	65535
736	02:42:16:2331 GMT	48	137.72.43.207	137.72.43.137	TCP	ACK SYN	3679	21158	617396255	3534575277	32768
737	02:42:16:2331 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	21158	3679	3534575277	617396256	64240
738	02:42:16:2799 GMT	61	137.72.43.207	137.72.43.137	TCP	ACK PSH : ftp reply code 125	ftp control	21157	617330340	3883430967	32762
739	02:42:16:4079 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	21157	ftp control	3883430967	617330361	64126
740	02:42:16:4465 GMT	1500	137.72.43.207	137.72.43.137	TCP	ACK	3679	21158	617396256	3534575277	32768
741	02:42:16:4467 GMT	1457	137.72.43.207	137.72.43.137	TCP	ACK PSH	3679	21158	617397716	3534575277	32768
742	02:42:16:4468 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	21158	3679	3534575277	617399133	63520
743	02:42:16:4468 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	21158	3679	3534575277	617399133	64240
744	02:42:16:4491 GMT	40	137.72.43.207	137.72.43.137	TCP	ACK PSH FIN	3679	21158	617399133	3534575277	32768
745	02:42:16:4493 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK	21158	3679	3534575277	617399134	64240
746	02:42:16:4495 GMT	40	137.72.43.137	137.72.43.207	TCP	ACK FIN	21158	3679	3534575277	617399134	64240
747	02:42:16:4524 GMT	40	137.72.43.207	137.72.43.137	TCP	ACK PSH	3679	21158	617399134	3534575278	32768

FTP Diagnosis – Analyze the PASV Reply



```
Packet ID : 733
Time : 3/3/2009 02:42:16:2207 GMT

Header :
Source Mac : 00:10:C6:DF:BA:CF     Remote Mac : 00:13:20:D5:77:94
ETHERTYPE : IP (0x800)

IP Version 4
Source    : 137.72.43.207    Remote    : 137.72.43.137
Protocol : TCP
Datagram Length : 89
Flags :        Fragment Offset : 0

TCP Header Info
Source Port : 21 ftp control    Remote Port : 21157
Seq. Number : 617330291     Ack. Number : 3883430961
Window : 32762     Flags : ACK PSH

FTP Data
Reply Code : 227(Entering Passive Mode)
Message : Entering Passive Mode (137,72,43,207,14,95)
```

Client will connect to the Server Port 3679 for data connection:
Server IP = 137.72.43.207
Server Port = 14 * 256 + 95 = 3679

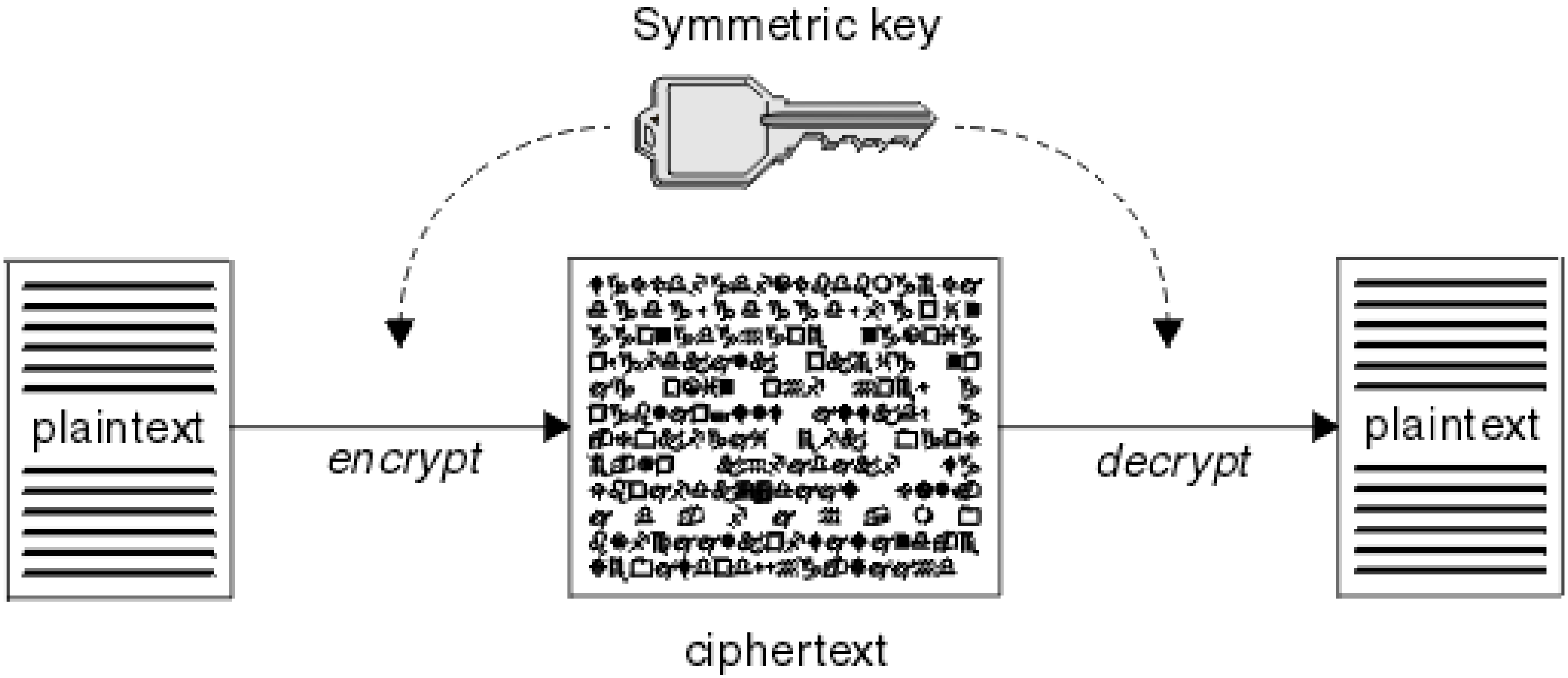
TLS/SSL
https (Port 443), AT-TLS (appl. port)

- Transport Layer Security provides security for communications over networks by encrypting the segments at the transport layer end to end.

- TLS V1.0 (RFC 2246) is based on SSL V3.0.

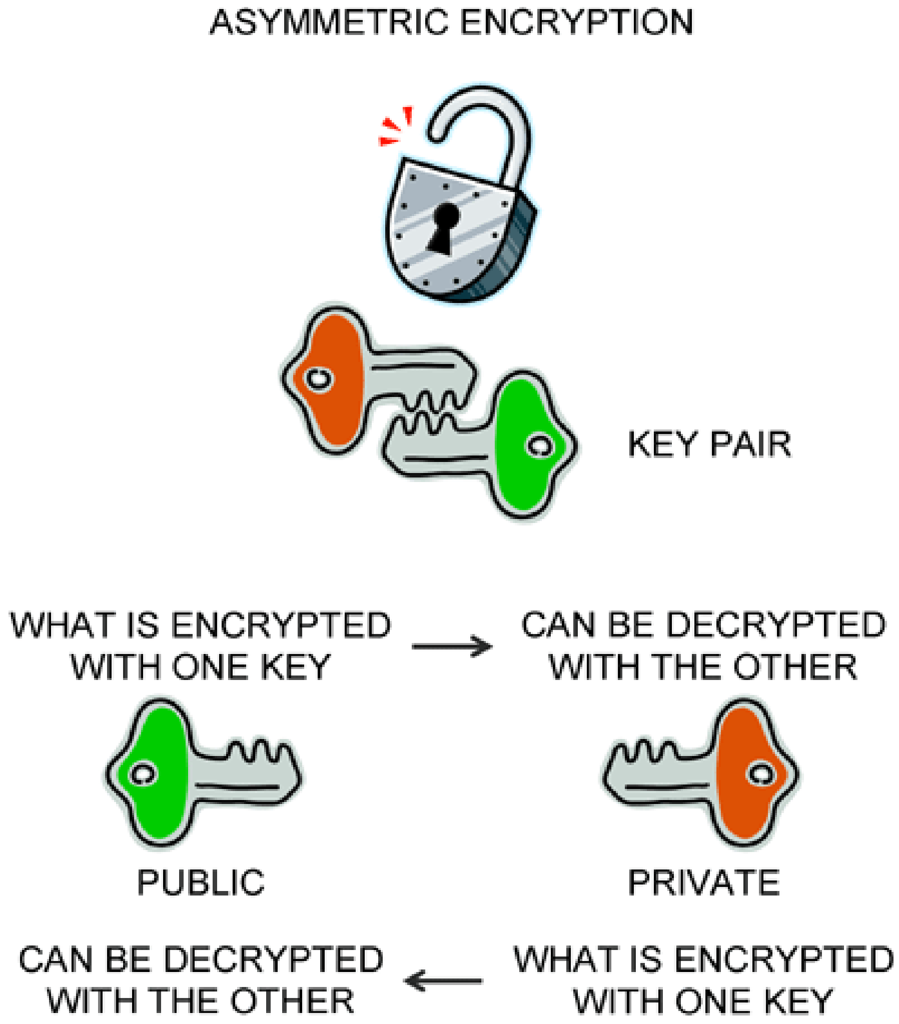
- It does not require the client and the server to arrange for a secret key to be exchanged *before* the transaction.
  - Asymmetric keys (public/private) for handshaking and secret key exchange.
  - Secret key (symmetric) mechanism for subsequent communication.

TLS/SSL, AT-TLS – Secret Key (Symmetric)



Source: http://http://middleware.its.state.nc.us/middleware/Documentation/en_US/htm/csqzas00/csq01skc.gif

TLS/SSL, AT-TLS – Public/Private Keys



WHAT IS ENCRYPTED WITH ONE KEY → CAN BE DECRYPTED WITH THE OTHER

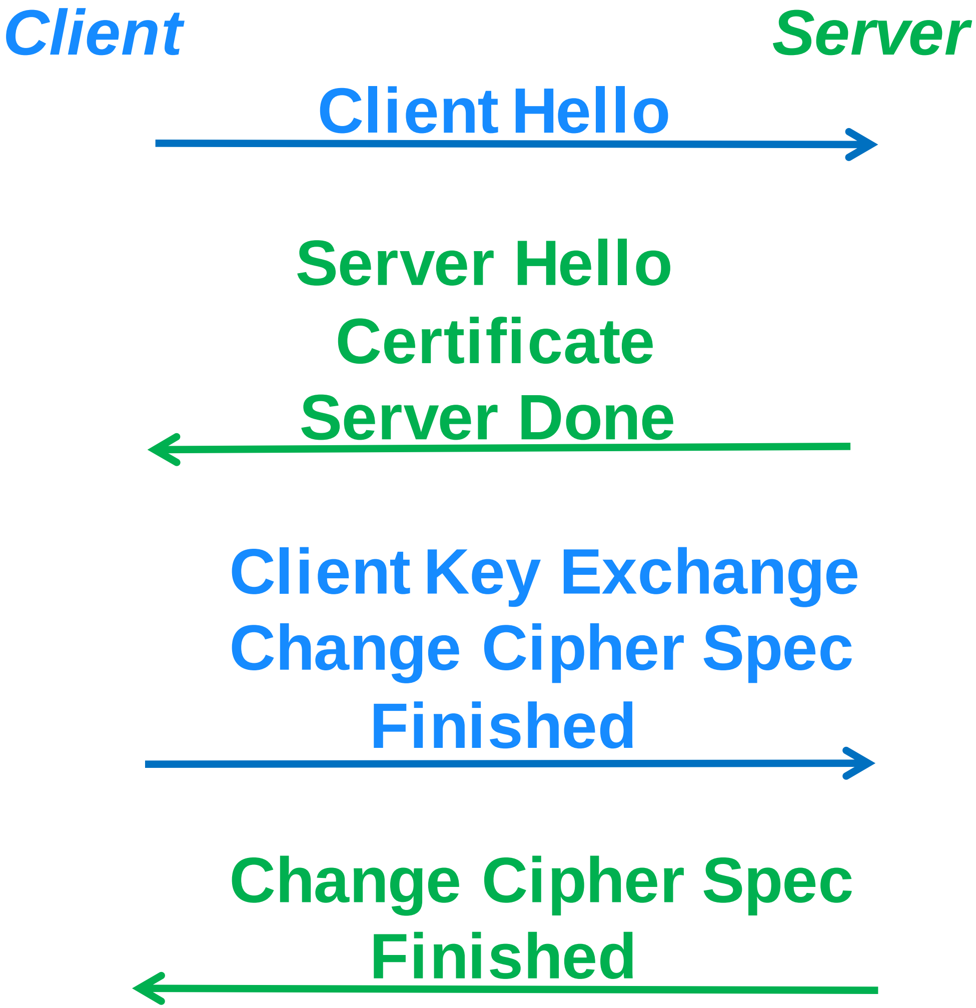
CAN BE DECRYPTED WITH THE OTHER ← WHAT IS ENCRYPTED WITH ONE KEY

Source: http://www.teracomtraining.com/tutorials/teracom-tutorial-asymmetric-encryption.gif

TLS/SSL Basic Flow

- Negotiate cipher suites and compression algorithms.
- Authenticate the server (and optionally the client) through certificates and public/private keys.
- Exchange random numbers and a pre-master secret, which is used with other data to create a shared secret key – the **Master Secret** is used to encrypt/decrypt the data.

TLS/SSL Handshake – Server Authentication



Client

Server

Client Hello

Server Hello
Certificate
Server Done

Client Key Exchange
Change Cipher Spec
Finished

Change Cipher Spec
Finished

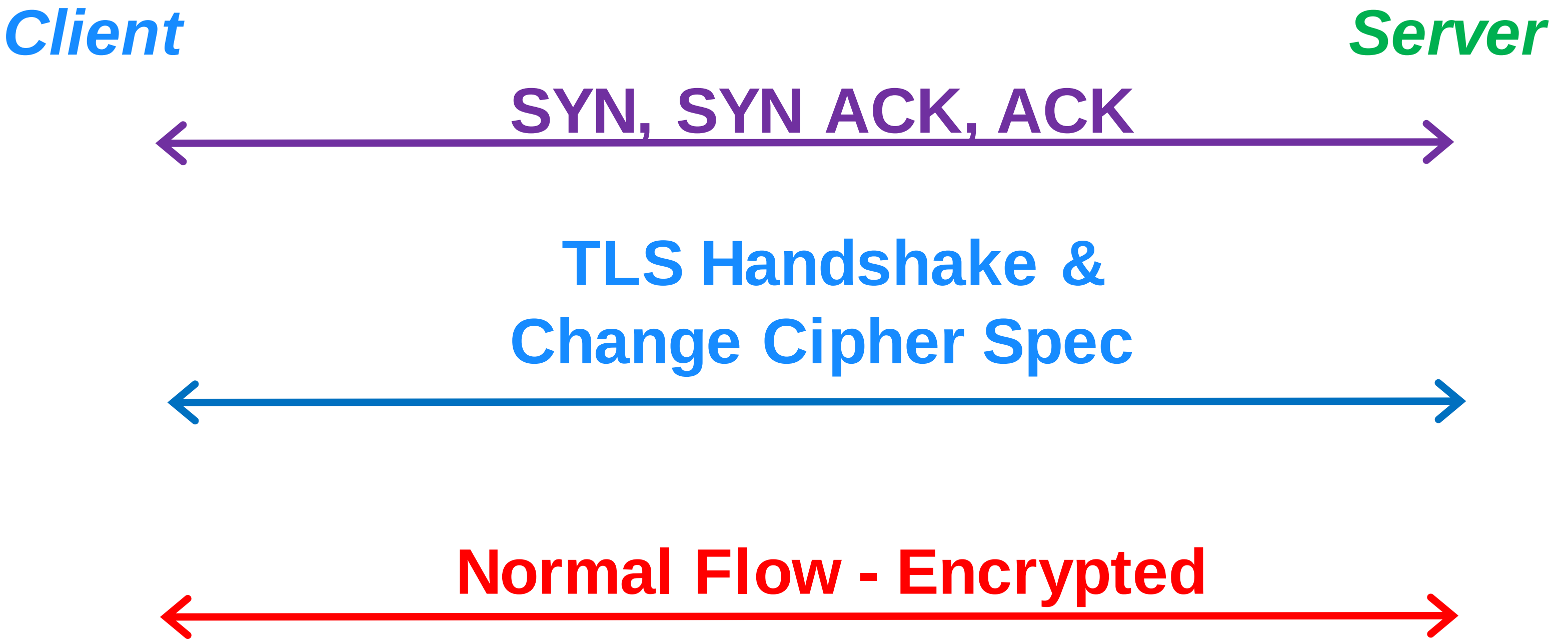
Hello
Highest SSL/TLS version supported
Ciphers and Compression Method
Session ID
Random data for key generation

Certificate:
Server Certificate – contains server's public key.

Client Key Exchange
Premaster secret encrypted by server's public key. Both the client and the server generate the Master Secret key (symmetric) on their own using the pre-master secret and the random data that is generated from the SERVER_HELLO and CLIENT_HELLO commands.

Change Cipher Spec
Indicates that all subsequent data will be encrypted.

AT-TLS Flow



Client

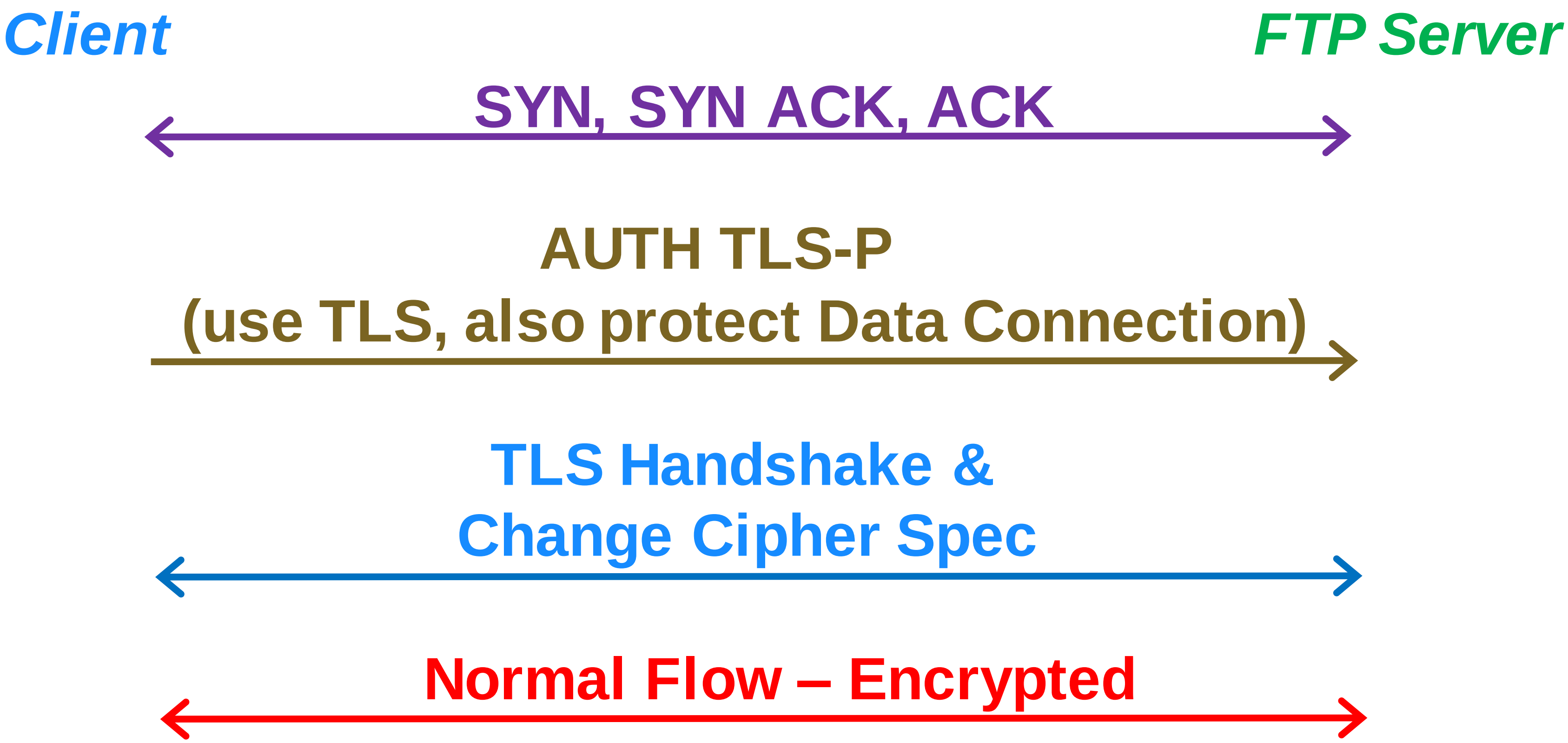
Server

SYN, SYN ACK, ACK

TLS Handshake &
Change Cipher Spec

Normal Flow - Encrypted

FTPS – FTP w/SSL Control Connection



Client

FTP Server

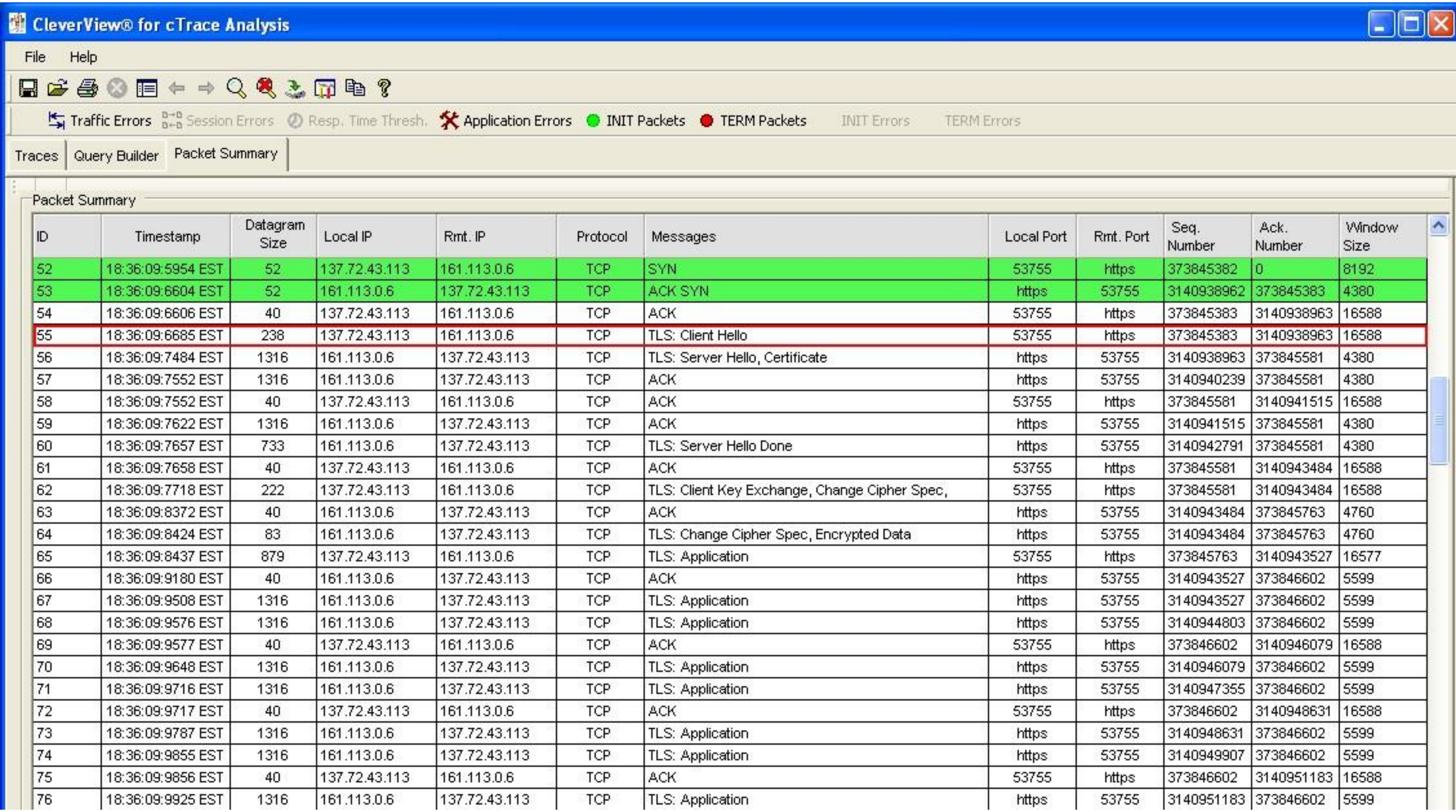
SYN, SYN ACK, ACK

AUTH TLS-P
(use TLS, also protect Data Connection)

TLS Handshake &
Change Cipher Spec

Normal Flow – Encrypted

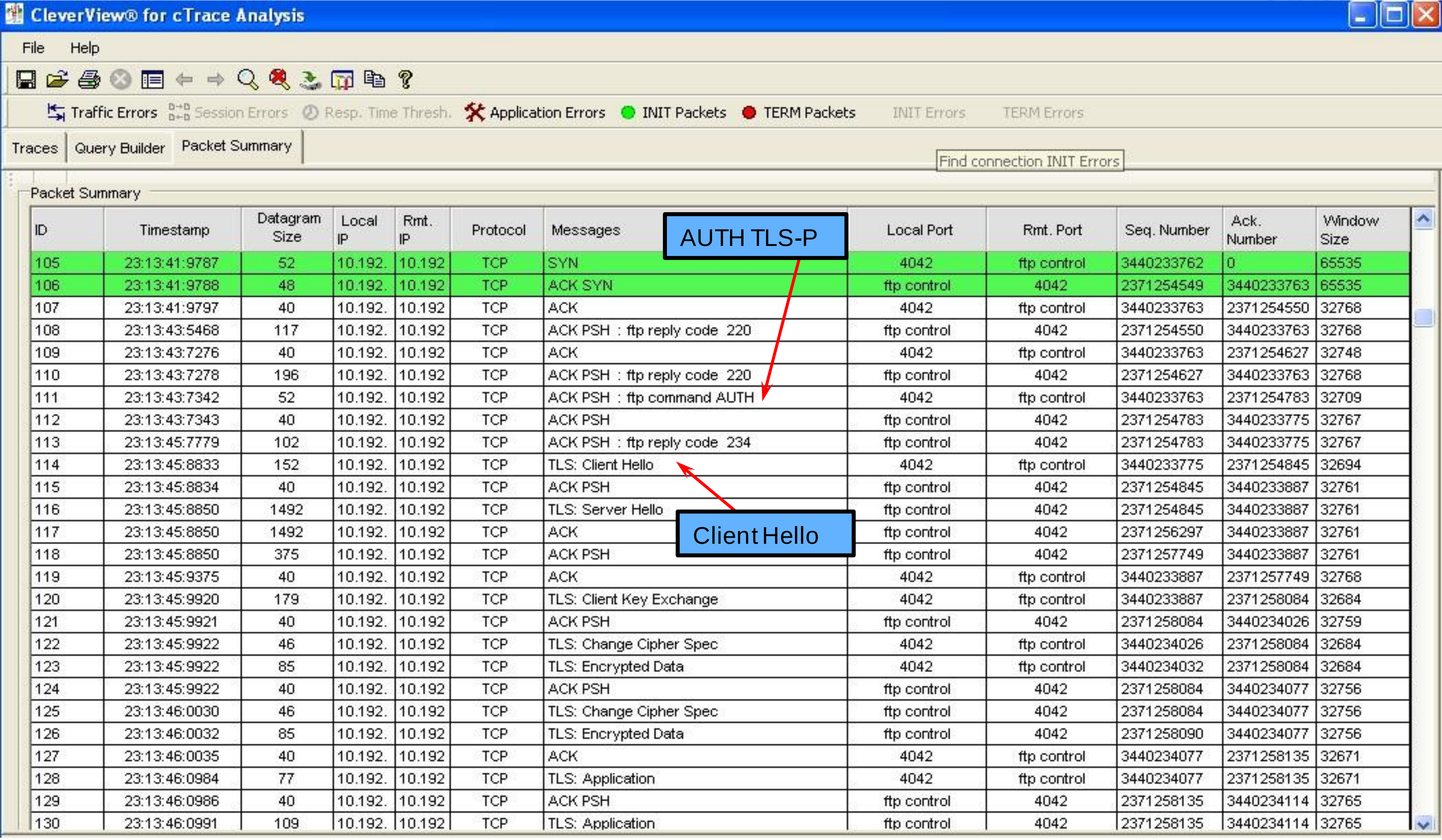
HTTPS (Port 443)



Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
52	18:36:09:5954 EST	52	137.72.43.113	161.113.0.6	TCP	SYN	53755	https	373845382	0	8192
53	18:36:09:6604 EST	52	161.113.0.6	137.72.43.113	TCP	ACK SYN	https	53755	3140938962	373845383	4380
54	18:36:09:6606 EST	40	137.72.43.113	161.113.0.6	TCP	ACK	53755	https	373845383	3140938963	16588
55	18:36:09:6685 EST	238	137.72.43.113	161.113.0.6	TCP	TLS: Client Hello	53755	https	373845383	3140938963	16588
56	18:36:09:7484 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Server Hello, Certificate	https	53755	3140938963	373845581	4380
57	18:36:09:7552 EST	1316	161.113.0.6	137.72.43.113	TCP	ACK	https	53755	3140940239	373845581	4380
58	18:36:09:7552 EST	40	137.72.43.113	161.113.0.6	TCP	ACK	53755	https	373845581	3140941515	16588
59	18:36:09:7622 EST	1316	161.113.0.6	137.72.43.113	TCP	ACK	https	53755	3140941515	373845581	4380
60	18:36:09:7657 EST	733	161.113.0.6	137.72.43.113	TCP	TLS: Server Hello Done	https	53755	3140942791	373845581	4380
61	18:36:09:7658 EST	40	137.72.43.113	161.113.0.6	TCP	ACK	53755	https	373845581	3140943484	16588
62	18:36:09:7718 EST	222	137.72.43.113	161.113.0.6	TCP	TLS: Client Key Exchange, Change Cipher Spec,	53755	https	373845581	3140943484	16588
63	18:36:09:8372 EST	40	161.113.0.6	137.72.43.113	TCP	ACK	https	53755	3140943484	373845763	4760
64	18:36:09:8424 EST	83	161.113.0.6	137.72.43.113	TCP	TLS: Change Cipher Spec, Encrypted Data	https	53755	3140943484	373845763	4760
65	18:36:09:8437 EST	879	137.72.43.113	161.113.0.6	TCP	TLS: Application	53755	https	373845763	3140943527	16577
66	18:36:09:9180 EST	40	161.113.0.6	137.72.43.113	TCP	ACK	https	53755	3140943527	373846602	5599
67	18:36:09:9508 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140943527	373846602	5599
68	18:36:09:9576 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140944803	373846602	5599
69	18:36:09:9577 EST	40	137.72.43.113	161.113.0.6	TCP	ACK	53755	https	373846602	3140946079	16588
70	18:36:09:9648 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140946079	373846602	5599
71	18:36:09:9716 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140947355	373846602	5599
72	18:36:09:9717 EST	40	137.72.43.113	161.113.0.6	TCP	ACK	53755	https	373846602	3140948631	16588
73	18:36:09:9787 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140948631	373846602	5599
74	18:36:09:9855 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140949907	373846602	5599
75	18:36:09:9856 EST	40	137.72.43.113	161.113.0.6	TCP	ACK	53755	https	373846602	3140951183	16588
76	18:36:09:9925 EST	1316	161.113.0.6	137.72.43.113	TCP	TLS: Application	https	53755	3140951183	373846602	5599

AT-TLS - FTP w/SSL



Packet Summary

ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Local Port	Rmt. Port	Seq. Number	Ack. Number	Window Size
105	23:13:41:9787	52	10.192.	10.192	TCP	SYN	4042	ftp control	3440233762	0	65535
106	23:13:41:9788	48	10.192.	10.192	TCP	ACK SYN	ftp control	4042	2371254549	3440233763	65535
107	23:13:41:9797	40	10.192.	10.192	TCP	ACK	4042	ftp control	3440233763	2371254550	32768
108	23:13:43:5468	117	10.192.	10.192	TCP	ACK PSH : ftp reply code 220	ftp control	4042	2371254550	3440233763	32768
109	23:13:43:7276	40	10.192.	10.192	TCP	ACK	4042	ftp control	3440233763	2371254627	32748
110	23:13:43:7278	196	10.192.	10.192	TCP	ACK PSH : ftp reply code 220	ftp control	4042	2371254627	3440233763	32768
111	23:13:43:7342	52	10.192.	10.192	TCP	ACK PSH : ftp command AUTH	4042	ftp control	3440233763	2371254783	32709
112	23:13:43:7343	40	10.192.	10.192	TCP	ACK PSH	ftp control	4042	2371254783	3440233775	32767
113	23:13:45:7779	102	10.192.	10.192	TCP	ACK PSH : ftp reply code 234	ftp control	4042	2371254783	3440233775	32767
114	23:13:45:8833	152	10.192.	10.192	TCP	TLS: Client Hello	4042	ftp control	3440233775	2371254845	32694
115	23:13:45:8834	40	10.192.	10.192	TCP	ACK PSH	ftp control	4042	2371254845	3440233887	32761
116	23:13:45:8850	1492	10.192.	10.192	TCP	TLS: Server Hello	ftp control	4042	2371254845	3440233887	32761
117	23:13:45:8850	1492	10.192.	10.192	TCP	ACK	ftp control	4042	2371256297	3440233887	32761
118	23:13:45:8850	375	10.192.	10.192	TCP	ACK PSH	ftp control	4042	2371257749	3440233887	32761
119	23:13:45:9375	40	10.192.	10.192	TCP	ACK	4042	ftp control	3440233887	2371257749	32768
120	23:13:45:9920	179	10.192.	10.192	TCP	TLS: Client Key Exchange	4042	ftp control	3440233887	2371258084	32684
121	23:13:45:9921	40	10.192.	10.192	TCP	ACK PSH	ftp control	4042	2371258084	3440234026	32759
122	23:13:45:9922	46	10.192.	10.192	TCP	TLS: Change Cipher Spec	4042	ftp control	3440234026	2371258084	32684
123	23:13:45:9922	85	10.192.	10.192	TCP	TLS: Encrypted Data	4042	ftp control	3440234032	2371258084	32684
124	23:13:45:9922	40	10.192.	10.192	TCP	ACK PSH	ftp control	4042	2371258084	3440234077	32756
125	23:13:46:0030	46	10.192.	10.192	TCP	TLS: Change Cipher Spec	ftp control	4042	2371258084	3440234077	32756
126	23:13:46:0032	85	10.192.	10.192	TCP	TLS: Encrypted Data	ftp control	4042	2371258090	3440234077	32756
127	23:13:46:0035	40	10.192.	10.192	TCP	ACK	4042	ftp control	3440234077	2371258135	32671
128	23:13:46:0984	77	10.192.	10.192	TCP	TLS: Application	4042	ftp control	3440234077	2371258135	32671
129	23:13:46:0986	40	10.192.	10.192	TCP	ACK PSH	ftp control	4042	2371258135	3440234114	32765
130	23:13:46:0991	109	10.192.	10.192	TCP	TLS: Application	ftp control	4042	2371258135	3440234114	32765

AUTH TLS-P

Client Hello

TLS Header

Offset	Length	Description	Decimal Value	Meaning
0	1	Content Type	20 (0x14)	Change Cipher Spec
			21 (0x15)	Alert
			22 (0x16)	Handshake
			23 (0x17)	Application
1	2	Version		
1	1	Major Version	3	
2	1	Minor Version	0	SSLv3
			1	TLS 1.0
			2	TLS 1.1
			3	TLS 1.2
3	2	Length	N	The length of the Protocol Message
5	N	Protocol Message		

Sample TLS/SSL Decoding

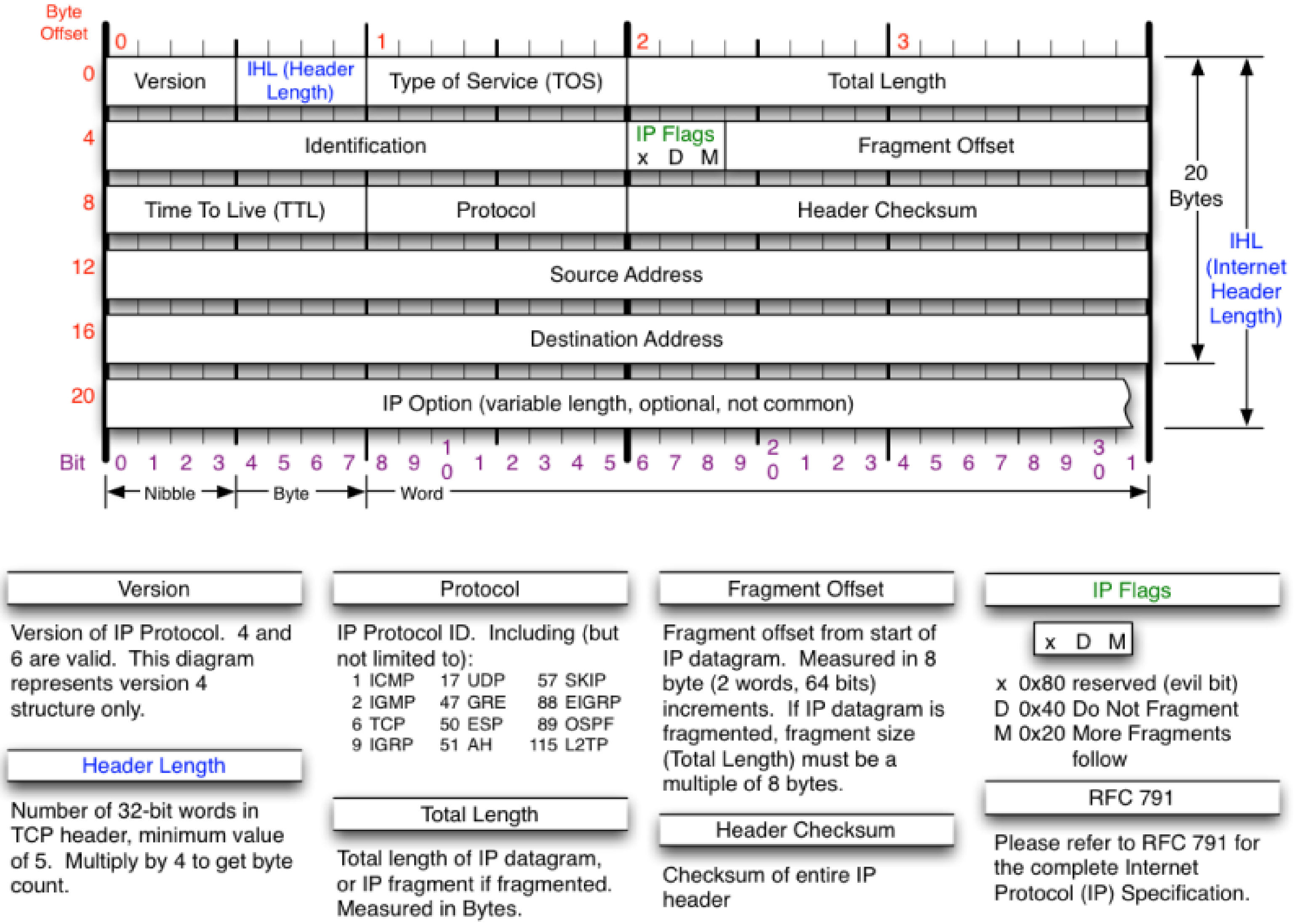
Hex Data:

```
16 03 01 00 C1 01 00 00 BD 03 01 4B 71 F1 69 DA 10 ….

Secure Socket Layer
   TLSv1 Record Layer: Handshake Protocol: Client Hello
      Content Type: Handshake (22)
      Version: TLS 1.0 (0x0301)
      Length: 193
      Handshake Protocol: Client Hello
         Handshake Type: Client Hello (1)
         Length: 189
         Version: TLS 1.0 (0x0301)
         Random
            GMT Unix Time: Feb 9, 2010 15:36:09.0000000000
            Random Bytes: DA10 ….
         Session ID Length: 32
         Session ID: 2D585DAEF198D9BB951DD9F58D7766465B88A493B98ACC3C...
         Cipher Suites Length: 70
         Cipher Suites (35 suites)
             Cipher Suite: TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA
             Cipher Suite: TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA
             Cipher Suite: …….
```

28 Random Bytes - to be used with the premaster secret to generate the symmetric key.

Ciphers are listed in order of preference – from the strongest to the weakest

IP Header Format



Byte Offset	0		1	2		3
0	Version	IHL (Header Length)	Type of Service (TOS)	Total Length		
4	Identification			IP Flags x D M	Fragment Offset	
8	Time To Live (TTL)		Protocol	Header Checksum		
12	Source Address					
16	Destination Address					
20	IP Option (variable length, optional, not common)					

Bit 0 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8 9 20 1 2 3 4 5 6 7 8 9 30 1
Nibble
Byte
Word
20 Bytes
IHL (Internet Header Length)

Version

Version of IP Protocol. 4 and 6 are valid. This diagram represents version 4 structure only.

Header Length

Number of 32-bit words in TCP header, minimum value of 5. Multiply by 4 to get byte count.

Protocol

IP Protocol ID. Including (but not limited to):

1 ICMP	17 UDP	57 SKIP
2 IGMP	47 GRE	88 EIGRP
6 TCP	50 ESP	89 OSPF
9 IGRP	51 AH	115 L2TP

Total Length

Total length of IP datagram, or IP fragment if fragmented. Measured in Bytes.

Fragment Offset

Fragment offset from start of IP datagram. Measured in 8 byte (2 words, 64 bits) increments. If IP datagram is fragmented, fragment size (Total Length) must be a multiple of 8 bytes.

Header Checksum

Checksum of entire IP header

IP Flags

x D M

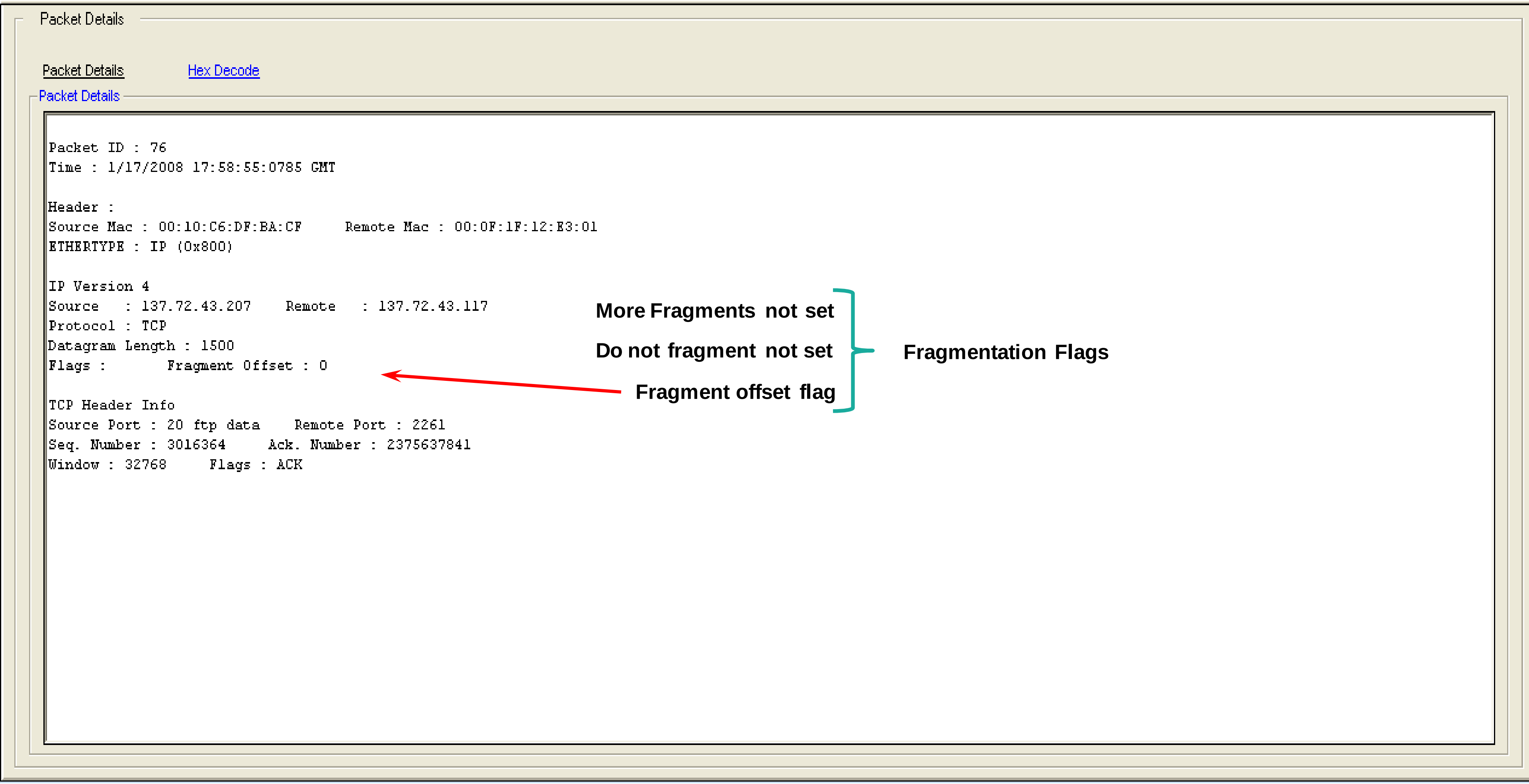
x 0x80 reserved (evil bit)
D 0x40 Do Not Fragment
M 0x20 More Fragments follow

RFC 791

Please refer to RFC 791 for the complete Internet Protocol (IP) Specification.

Source: http://nmap.org/book/images/hdr/MJB-IP-Header-800x576.png

Sample IP Header Decoding



```
Packet ID : 76
Time : 1/17/2008 17:58:55:0785 GMT

Header :
Source Mac : 00:10:C6:DF:BA:CF     Remote Mac : 00:0F:1F:12:E3:01
ETHERTYPE : IP (0x800)

IP Version 4
Source   : 137.72.43.207    Remote   : 137.72.43.117
Protocol : TCP
Datagram Length : 1500
Flags :       Fragment Offset : 0

TCP Header Info
Source Port : 20 ftp data    Remote Port : 2261
Seq. Number : 3016364     Ack. Number : 2375637841
Window : 32768     Flags : ACK
```

More Fragments not set

Do not fragment not set

Fragment offset flag

Fragmentation Flags

A Malformed IP Header

Hex Data:

45 00 00 88 3A 99 40 00 80 06 00 00 0A 00 00 0D C0 56 21 29

45	Version:4 , Length: 5x4 = 20 bytes
00	TOS
0088	Total length: 0x88 = 136
3A99	IP ID (unique for each packet until it wraps)
4000	Flags: Don’t fragment, Fragment Offset: 0
80	Time to live: 128
06	Protocol: TCP
0000	Checksum: 0
0A00000D	Source IP: 10.0.0.13
C0562129	Destination IP: 192.86.33.41

Header Checksum

Right out of RFC's 791 (IP) and 793 (TCP):

"The checksum field is the 16 bit one's complement of the one's complement sum of all 16 bit words in the header. For purposes of computing the checksum, the value of the checksum field is zero.“

What the ???

Header Checksum

Hex Data:

45 00 00 88 3A 99 40 00 80 06 00 00 0A 00 00 0D C0 56 21 29

0x4500 + 0x0088 = 0x4588

0x4588 + 0x3A99 = 0x8021

0x8021 + 0x4000 = 0xC021

0xC021 + 0x8006 = 0x14027

* Add the carry bit to the result and keep it 16-bit * -> 0x4028

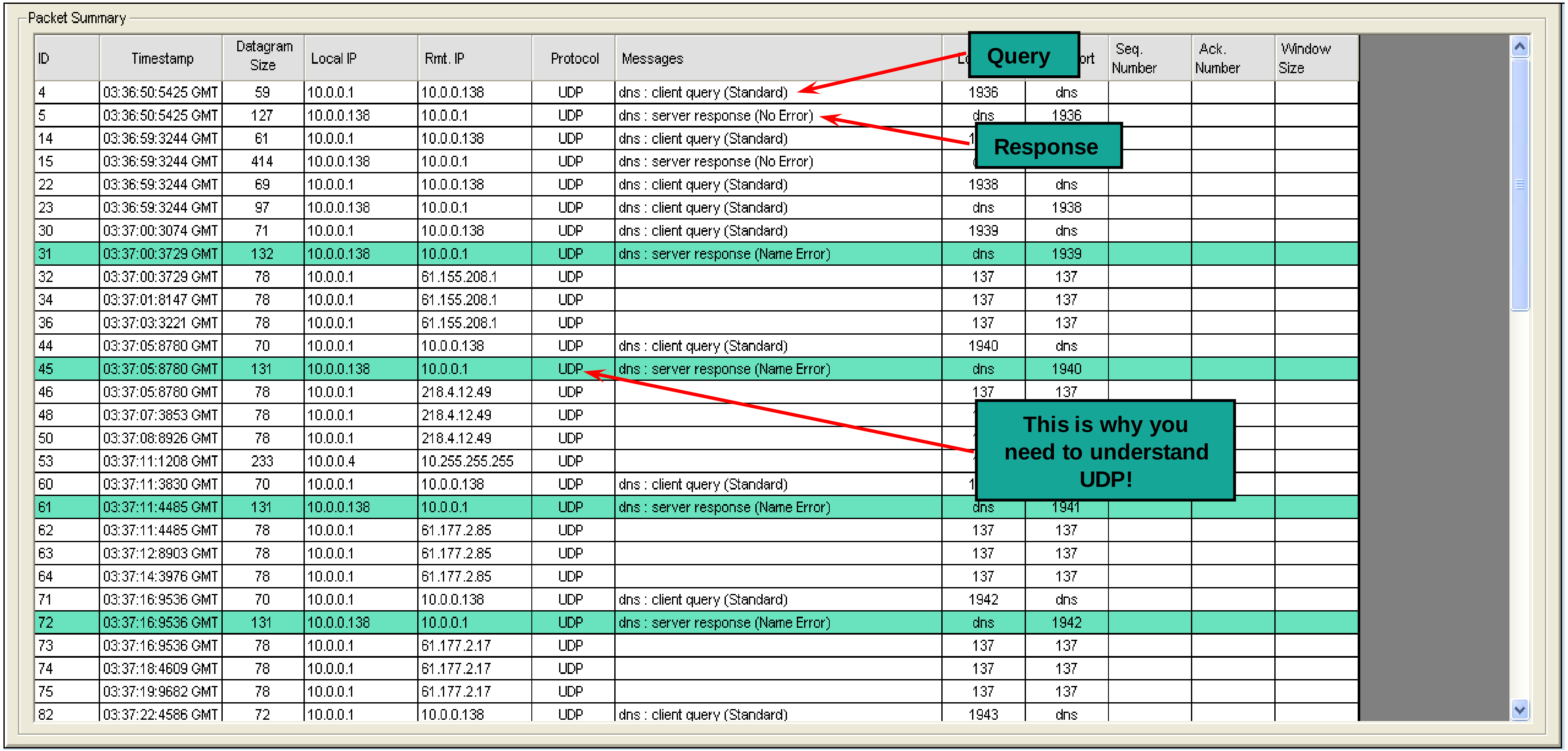
….

0x2BB5 -> taking one’s complement -> **0xD44A**

Working Our Way Through a DNS Trace

- Case #1 – A successful DNS query
  - Submit a name for an IP Address Request
- Case #2 – A failed DNS query
  - Name does not exist

DNS Query Packets



Packet Summary

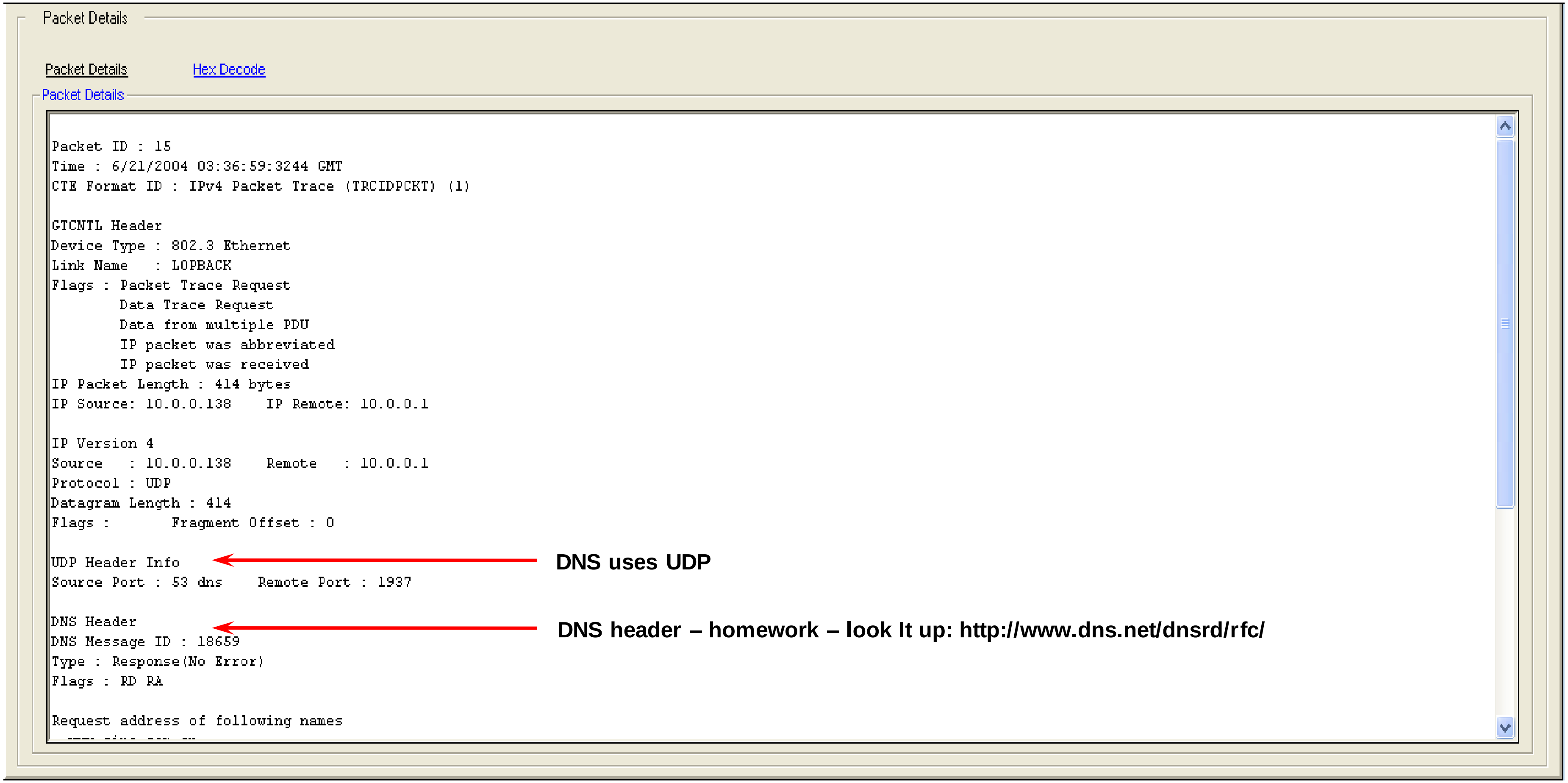
ID	Timestamp	Datagram Size	Local IP	Rmt. IP	Protocol	Messages	Lo[illegible]	[illegible]ort	Seq. Number	Ack. Number	Window Size
4	03:36:50:5425 GMT	59	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	1936	dns			
5	03:36:50:5425 GMT	127	10.0.0.138	10.0.0.1	UDP	dns : server response (No Error)	dns	1936			
14	03:36:59:3244 GMT	61	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	[illegible]	[illegible]			
15	03:36:59:3244 GMT	414	10.0.0.138	10.0.0.1	UDP	dns : server response (No Error)	[illegible]	[illegible]			
22	03:36:59:3244 GMT	69	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	1938	dns			
23	03:36:59:3244 GMT	97	10.0.0.138	10.0.0.1	UDP	dns : client query (Standard)	dns	1938			
30	03:37:00:3074 GMT	71	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	1939	dns			
31	03:37:00:3729 GMT	132	10.0.0.138	10.0.0.1	UDP	dns : server response (Name Error)	dns	1939			
32	03:37:00:3729 GMT	78	10.0.0.1	61.155.208.1	UDP		137	137			
34	03:37:01:8147 GMT	78	10.0.0.1	61.155.208.1	UDP		137	137			
36	03:37:03:3221 GMT	78	10.0.0.1	61.155.208.1	UDP		137	137			
44	03:37:05:8780 GMT	70	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	1940	dns			
45	03:37:05:8780 GMT	131	10.0.0.138	10.0.0.1	UDP	dns : server response (Name Error)	dns	1940			
46	03:37:05:8780 GMT	78	10.0.0.1	218.4.12.49	UDP		137	137			
48	03:37:07:3853 GMT	78	10.0.0.1	218.4.12.49	UDP		[illegible]	[illegible]			
50	03:37:08:8926 GMT	78	10.0.0.1	218.4.12.49	UDP		[illegible]	[illegible]			
53	03:37:11:1208 GMT	233	10.0.0.4	10.255.255.255	UDP		[illegible]	[illegible]			
60	03:37:11:3830 GMT	70	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	[illegible]	[illegible]			
61	03:37:11:4485 GMT	131	10.0.0.138	10.0.0.1	UDP	dns : server response (Name Error)	dns	1941			
62	03:37:11:4485 GMT	78	10.0.0.1	61.177.2.85	UDP		137	137			
63	03:37:12:8903 GMT	78	10.0.0.1	61.177.2.85	UDP		137	137			
64	03:37:14:3976 GMT	78	10.0.0.1	61.177.2.85	UDP		137	137			
71	03:37:16:9536 GMT	70	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	1942	dns			
72	03:37:16:9536 GMT	131	10.0.0.138	10.0.0.1	UDP	dns : server response (Name Error)	dns	1942			
73	03:37:16:9536 GMT	78	10.0.0.1	61.177.2.17	UDP		137	137			
74	03:37:18:4609 GMT	78	10.0.0.1	61.177.2.17	UDP		137	137			
75	03:37:19:9682 GMT	78	10.0.0.1	61.177.2.17	UDP		137	137			
82	03:37:22:4586 GMT	72	10.0.0.1	10.0.0.138	UDP	dns : client query (Standard)	1943	dns			

Query

Response

This is why you need to understand UDP!

A Successful DNS query

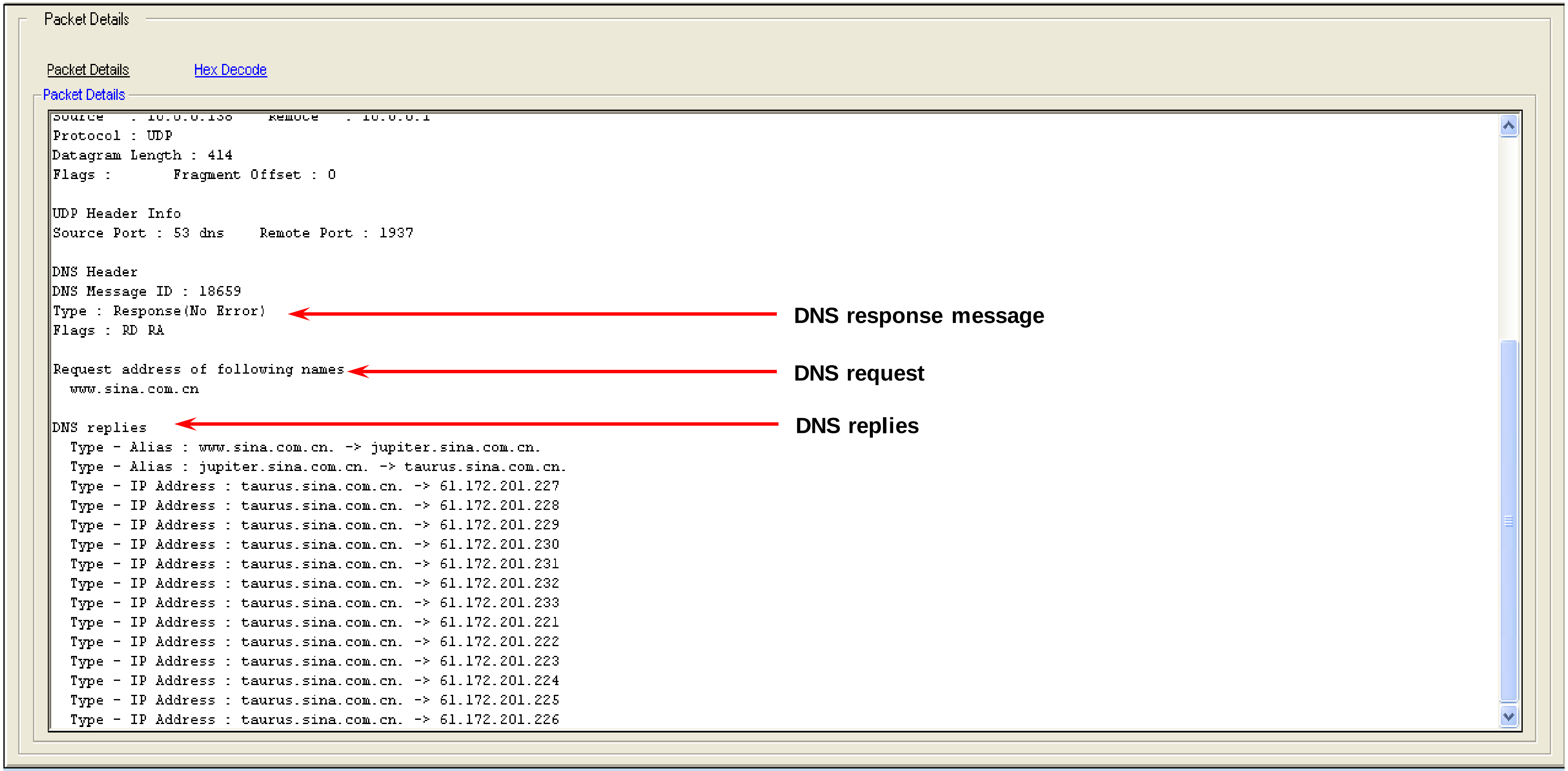


```
Packet ID : 15
Time : 6/21/2004 03:36:59:3244 GMT
CTE Format ID : IPv4 Packet Trace (TRCIDPCKT) (1)

GTCNTL Header
Device Type : 802.3 Ethernet
Link Name   : LOPBACK
Flags : Packet Trace Request
        Data Trace Request
        Data from multiple PDU
        IP packet was abbreviated
        IP packet was received
IP Packet Length : 414 bytes
IP Source: 10.0.0.138    IP Remote: 10.0.0.1

IP Version 4
Source   : 10.0.0.138    Remote   : 10.0.0.1
Protocol : UDP
Datagram Length : 414
Flags :       Fragment Offset : 0

UDP Header Info
Source Port : 53 dns    Remote Port : 1937

DNS Header
DNS Message ID : 18659
Type : Response(No Error)
Flags : RD RA

Request address of following names
```

DNS uses UDP

DNS header – homework – look It up: http://www.dns.net/dnsrd/rfc/

A Successful DNS Query



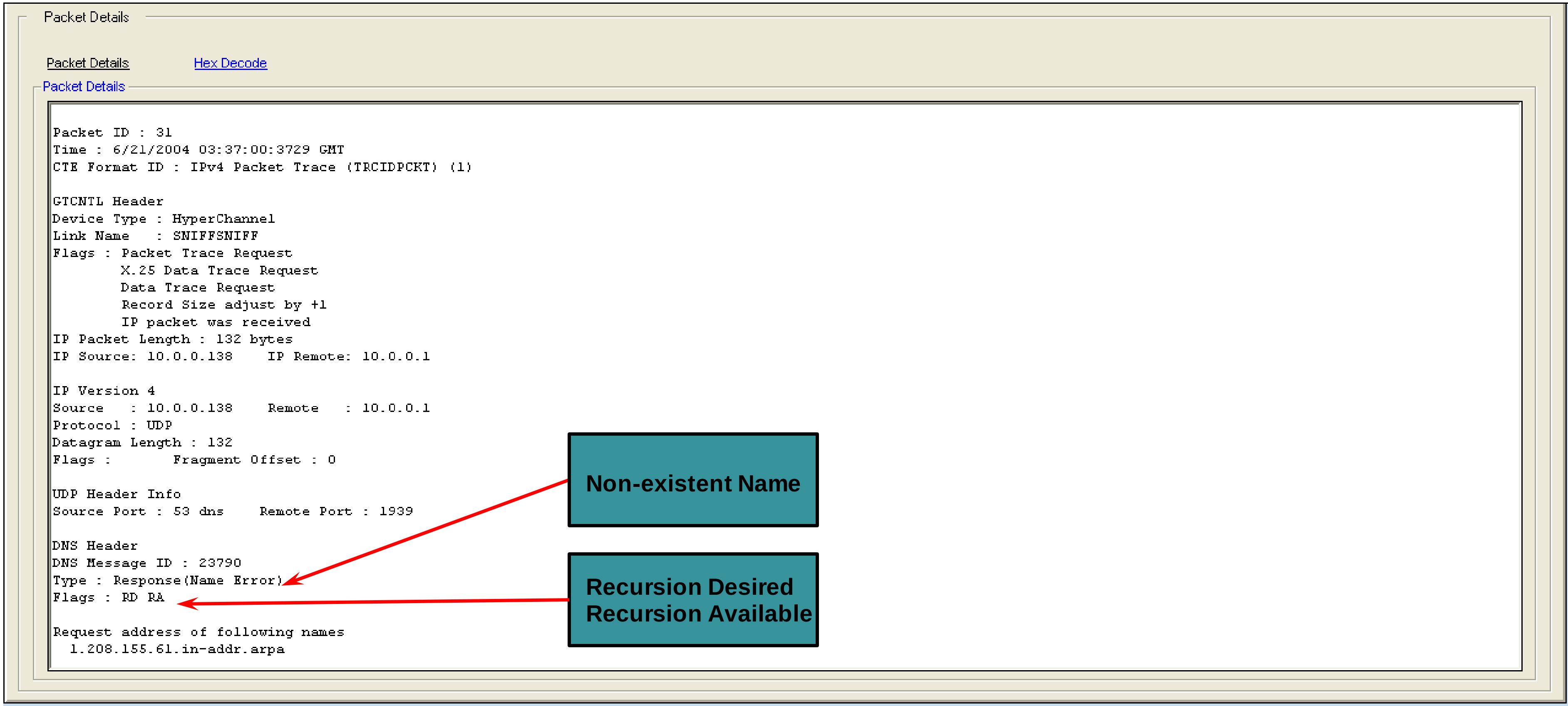
```
Source   : 10.0.0.138    Remote   : 10.0.0.1
Protocol : UDP
Datagram Length : 414
Flags :       Fragment Offset : 0

UDP Header Info
Source Port : 53 dns    Remote Port : 1937

DNS Header
DNS Message ID : 18659
Type : Response(No Error)
Flags : RD RA

Request address of following names
  www.sina.com.cn

DNS replies
  Type - Alias : www.sina.com.cn. -> jupiter.sina.com.cn.
  Type - Alias : jupiter.sina.com.cn. -> taurus.sina.com.cn.
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.227
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.228
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.229
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.230
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.231
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.232
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.233
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.221
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.222
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.223
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.224
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.225
  Type - IP Address : taurus.sina.com.cn. -> 61.172.201.226
```

DNS response message

DNS request

DNS replies

A Failed DNS Query



```
Packet ID : 31
Time : 6/21/2004 03:37:00:3729 GMT
CTE Format ID : IPv4 Packet Trace (TRCIDPCKT) (1)

GTCNTL Header
Device Type : HyperChannel
Link Name    : SNIFFSNIFF
Flags : Packet Trace Request
        X.25 Data Trace Request
        Data Trace Request
        Record Size adjust by +1
        IP packet was received
IP Packet Length : 132 bytes
IP Source: 10.0.0.138    IP Remote: 10.0.0.1

IP Version 4
Source   : 10.0.0.138    Remote   : 10.0.0.1
Protocol : UDP
Datagram Length : 132
Flags :       Fragment Offset : 0

UDP Header Info
Source Port : 53 dns    Remote Port : 1939

DNS Header
DNS Message ID : 23790
Type : Response(Name Error)
Flags : RD RA

Request address of following names
  1.208.155.61.in-addr.arpa
```

Enterprise Extender

- SNA Transport over UDP ‘Pipelines’ through IP cloud
- No changes to SNA applications, just Comm. Server
- Requires correlated VTAM – TCP/IP definitions and priorities

  - VTAM XCA Node & Switched Node - COS match w/ Remote CP
  - IP Link = IUTSAMEH, UDP Ports based on TOS priorities
  - 12000 (C0 = net/control TOS) up to 12004 (20 = low TOS)

Enterprise Extender

- SNA “handshaking” still happens at “lowest level”
  (Preserves SNA error checking/handling)

- With 3 packet header additions for routing flow control…

  1) Rapid Transport Protocol (RTP)

     “Hybrid” routing layer between IP/UDP packets & SNA

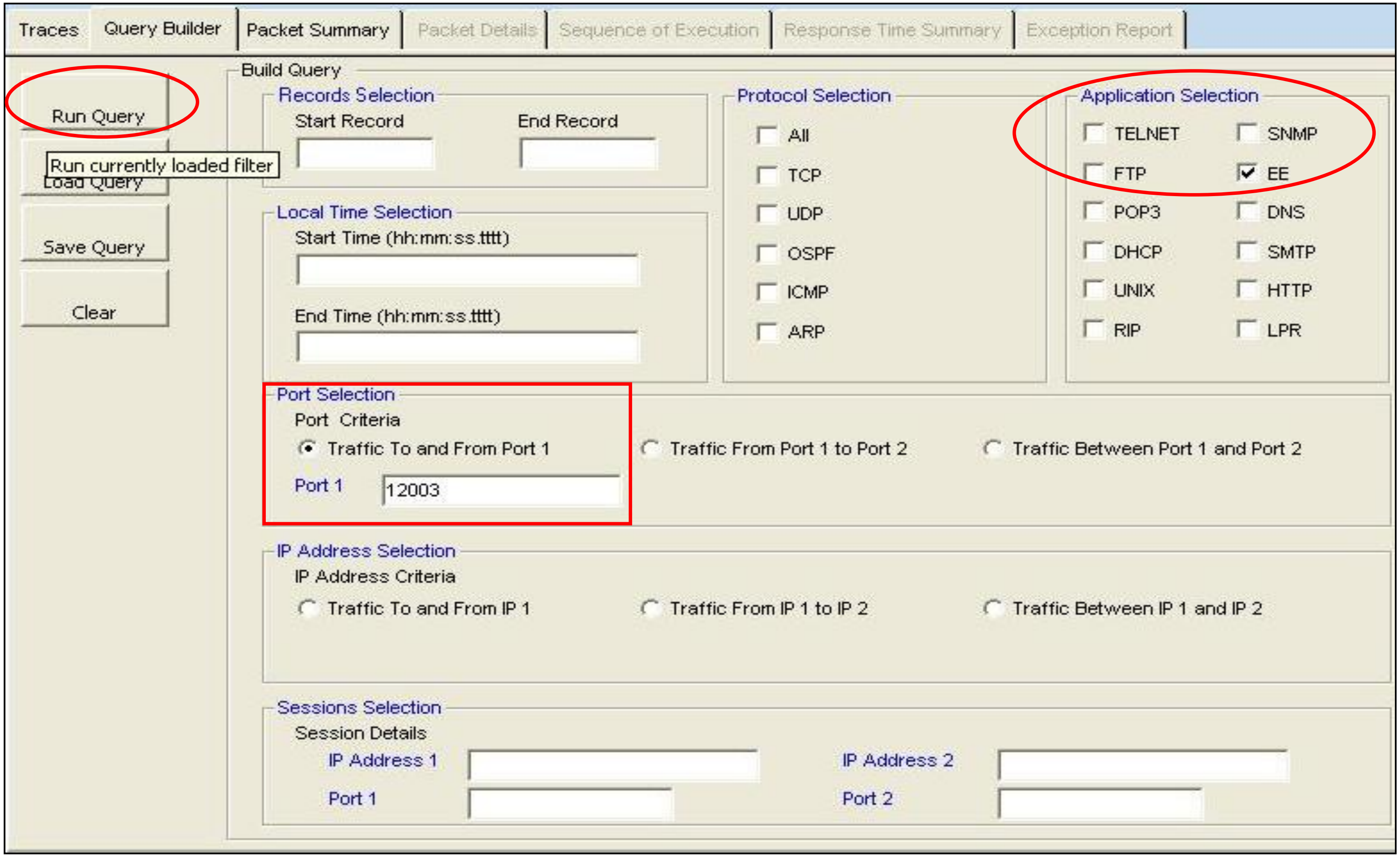
  2) Automatic Network Routing (ANR)

     Correlation between IP-style priorities (TOS) and…
     SNA-style session and path priorities (COS and TG’s)

  3) First, Adaptive Rate-Based Flow (ARB), now ARB2

     Provides algorithm to better handle performance
     Avoids potential “lost data” issues since connectionless

Enterprise Extender Packet Filtering



Build Query

Records Selection
Start Record
End Record

Local Time Selection
Start Time (hh:mm:ss.tttt)
End Time (hh:mm:ss.tttt)

Protocol Selection
□ All
□ TCP
□ UDP
□ OSPF
□ ICMP
□ ARP

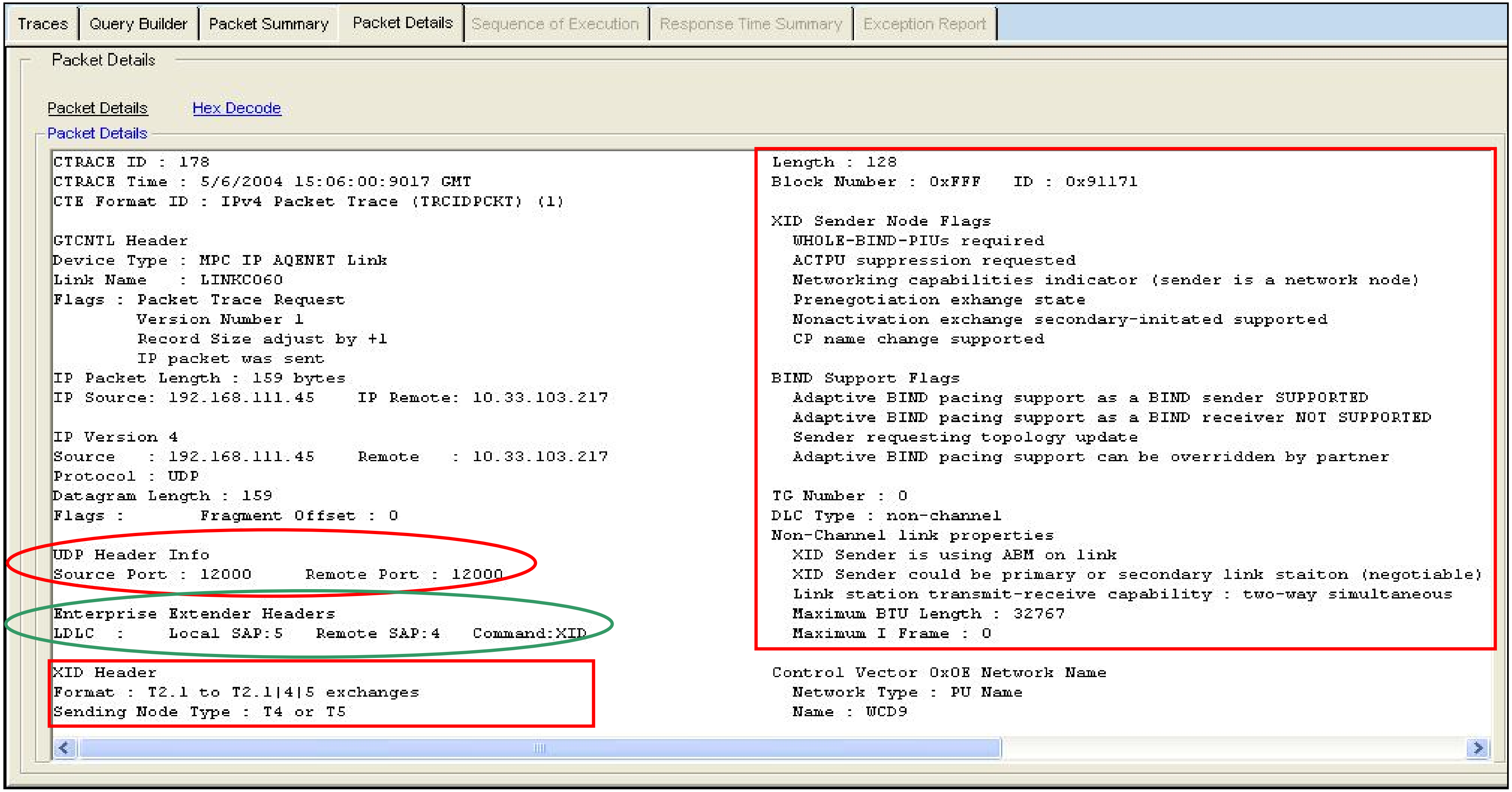
Application Selection
□ TELNET
□ SNMP
□ FTP
☑ EE
□ POP3
□ DNS
□ DHCP
□ SMTP
□ UNIX
□ HTTP
□ RIP
□ LPR

Port Selection
Port Criteria
● Traffic To and From Port 1
○ Traffic From Port 1 to Port 2
○ Traffic Between Port 1 and Port 2
Port 1: 12003

IP Address Selection
IP Address Criteria
○ Traffic To and From IP 1
○ Traffic From IP 1 to IP 2
○ Traffic Between IP 1 and IP 2

Sessions Selection
Session Details
IP Address 1
IP Address 2
Port 1
Port 2

EE XID Init Packet: ‘Packet Details’ (Part 1)

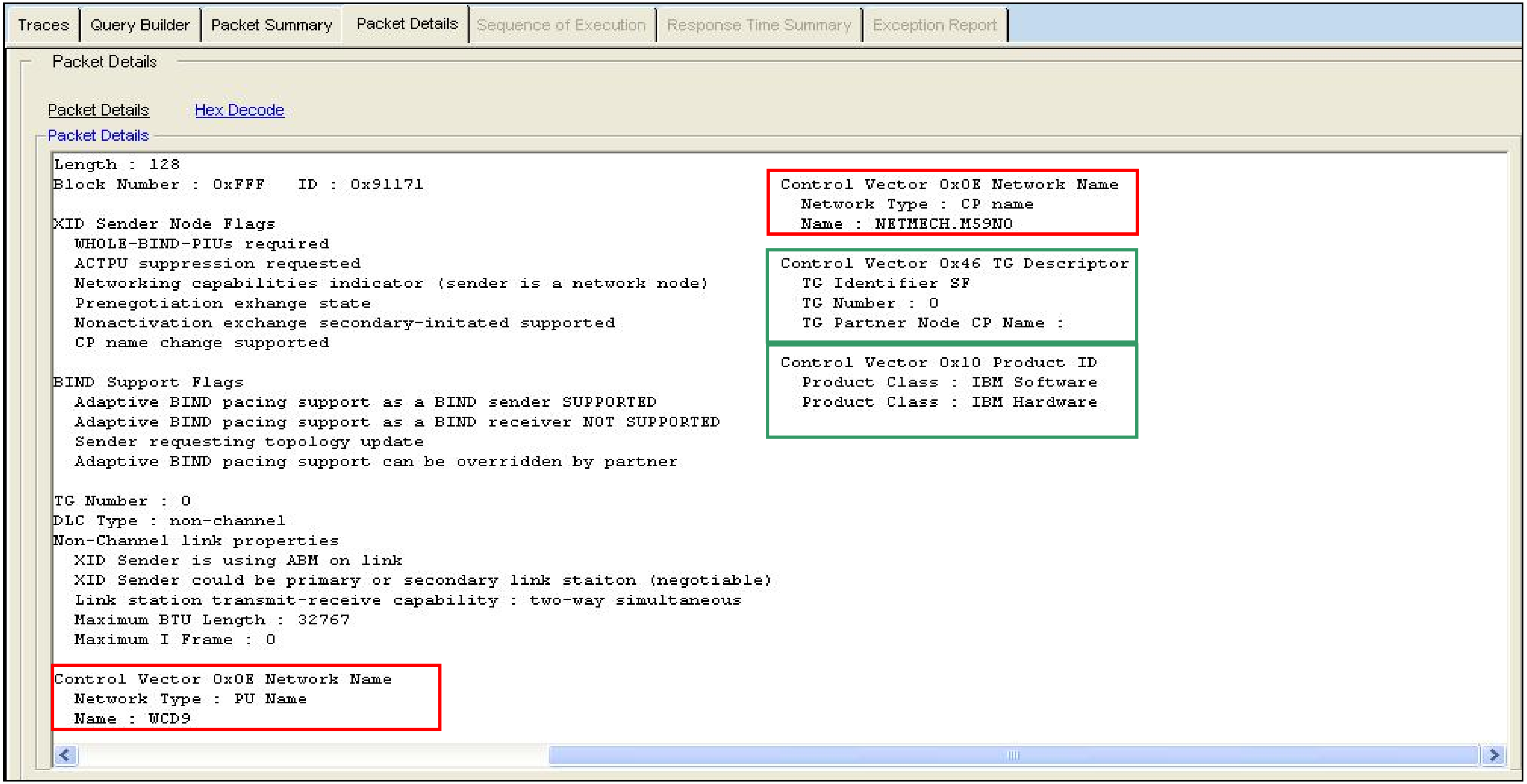


```
CTRACE ID : 178
CTRACE Time : 5/6/2004 15:06:00:9017 GMT
CTE Format ID : IPv4 Packet Trace (TRCIDPCKT) (1)

GTCNTL Header
Device Type : MPC IP AQENET Link
Link Name    : LINKC060
Flags : Packet Trace Request
        Version Number 1
        Record Size adjust by +1
        IP packet was sent
IP Packet Length : 159 bytes
IP Source: 192.168.111.45    IP Remote: 10.33.103.217

IP Version 4
Source    : 192.168.111.45    Remote    : 10.33.103.217
Protocol : UDP
Datagram Length : 159
Flags :        Fragment Offset : 0

UDP Header Info
Source Port : 12000     Remote Port : 12000

Enterprise Extender Headers
LDLC  :    Local SAP:5    Remote SAP:4    Command:XID

XID Header
Format : T2.1 to T2.1|4|5 exchanges
Sending Node Type : T4 or T5
```

```
Length : 128
Block Number : 0xFFF    ID : 0x91171

XID Sender Node Flags
  WHOLE-BIND-PIUs required
  ACTPU suppression requested
  Networking capabilities indicator (sender is a network node)
  Prenegotiation exhange state
  Nonactivation exchange secondary-initated supported
  CP name change supported

BIND Support Flags
  Adaptive BIND pacing support as a BIND sender SUPPORTED
  Adaptive BIND pacing support as a BIND receiver NOT SUPPORTED
  Sender requesting topology update
  Adaptive BIND pacing support can be overridden by partner

TG Number : 0
DLC Type : non-channel
Non-Channel link properties
  XID Sender is using ABM on link
  XID Sender could be primary or secondary link staiton (negotiable)
  Link station transmit-receive capability : two-way simultaneous
  Maximum BTU Length : 32767
  Maximum I Frame : 0

Control Vector 0x0E Network Name
  Network Type : PU Name
  Name : UCD9
```

SHARE in Boston

EE XID Init Packet: ‘Packet Details’ (Part 2)



```
Length : 128
Block Number : 0xFFF   ID : 0x91171

XID Sender Node Flags
  WHOLE-BIND-PIUs required
  ACTPU suppression requested
  Networking capabilities indicator (sender is a network node)
  Prenegotiation exhange state
  Nonactivation exchange secondary-initated supported
  CP name change supported

BIND Support Flags
  Adaptive BIND pacing support as a BIND sender SUPPORTED
  Adaptive BIND pacing support as a BIND receiver NOT SUPPORTED
  Sender requesting topology update
  Adaptive BIND pacing support can be overridden by partner

TG Number : 0
DLC Type : non-channel
Non-Channel link properties
  XID Sender is using ABM on link
  XID Sender could be primary or secondary link staiton (negotiable)
  Link station transmit-receive capability : two-way simultaneous
  Maximum BTU Length : 32767
  Maximum I Frame : 0

Control Vector 0x0E Network Name
  Network Type : PU Name
  Name : WCD9
```

```
Control Vector 0x0E Network Name
  Network Type : CP name
  Name : NETMECH.M59N0

Control Vector 0x46 TG Descriptor
  TG Identifier SF
  TG Number : 0
  TG Partner Node CP Name :

Control Vector 0x10 Product ID
  Product Class : IBM Software
  Product Class : IBM Hardware
```