Konsep Jaringan

TCP/IP Programming

Oleh Politeknik Elektronika Negeri Surabaya

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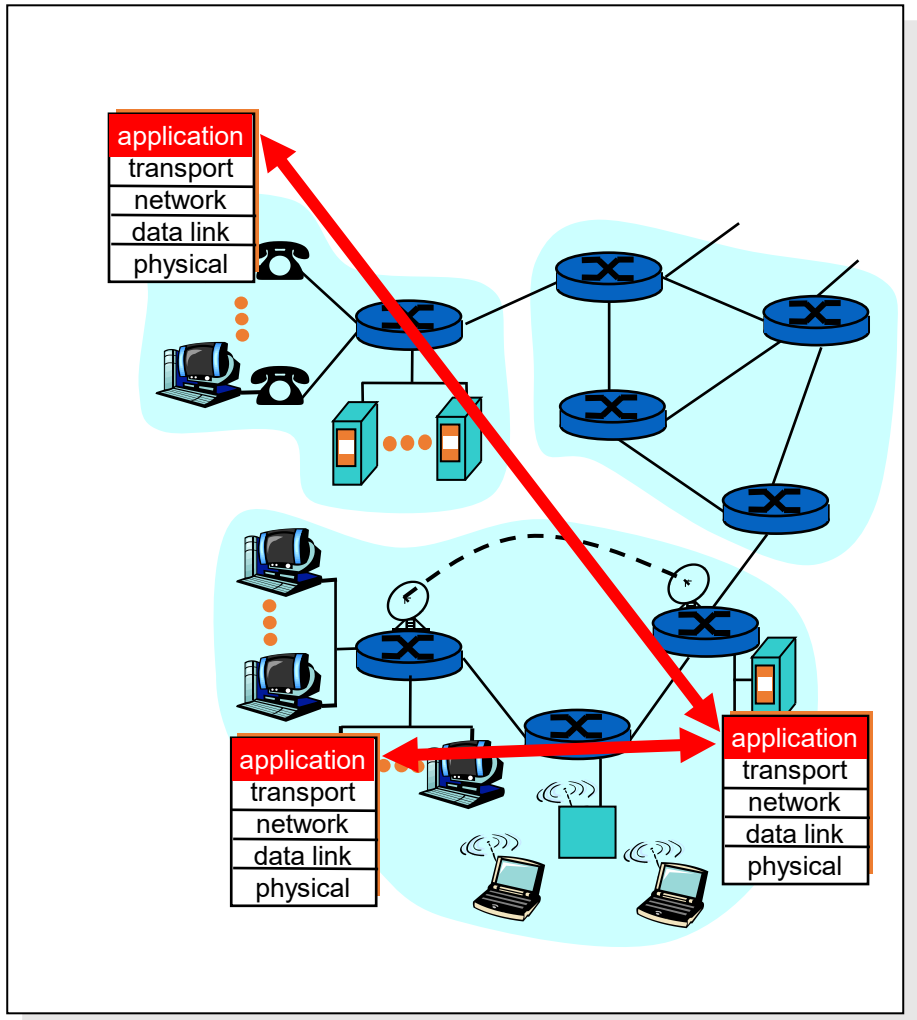
Politeknik Elektronika Negeri Surabaya
Departemen Teknik Informatika dan Komputer

Lecture Overview

- Application layer
  - Client-server
  - Application requirements
- Background
  - TCP vs. UDP
  - Byte ordering
- Socket I/O
  - TCP/UDP server and client
  - I/O multiplexing

Applications and Application-Layer Protocols

- Application: communicating, distributed processes
  - Running in network hosts in “user space”
  - Exchange messages to implement app
  - e.g., email, file transfer, the Web
- Application-layer protocols
  - One “piece” of an app
  - Define messages exchanged by apps and actions taken
  - User services provided by lower layer protocols



Client-Server Paradigm

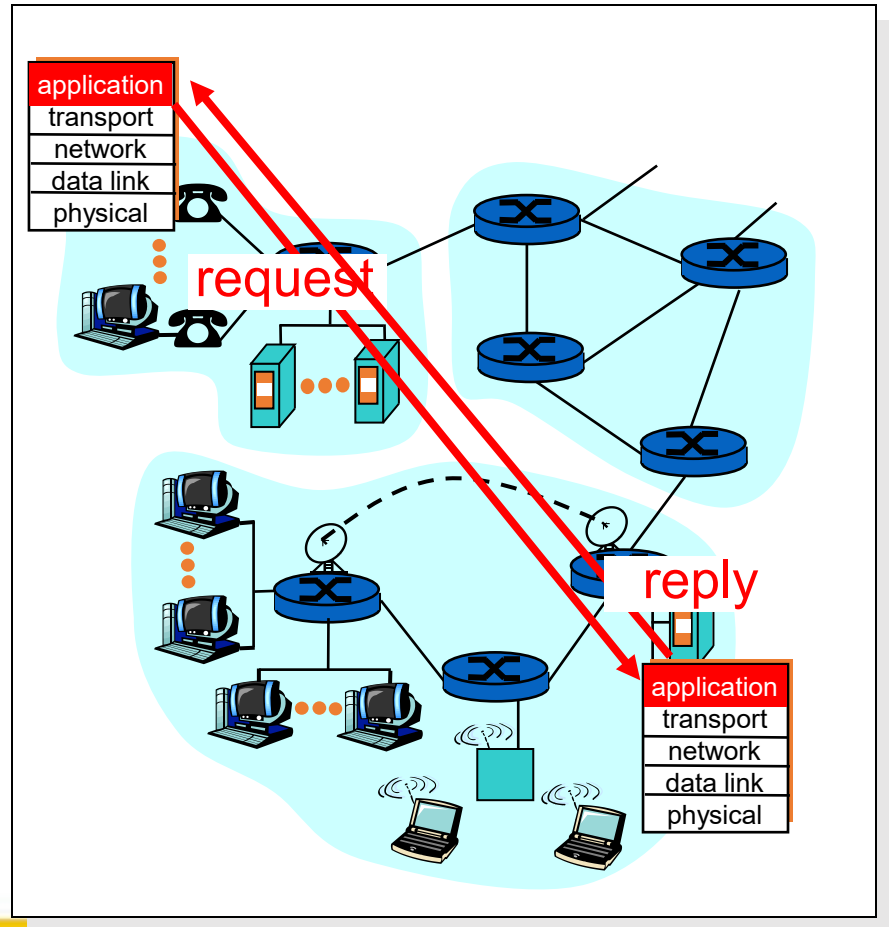
Typical network app has two pieces: *client* and *server*

Client:

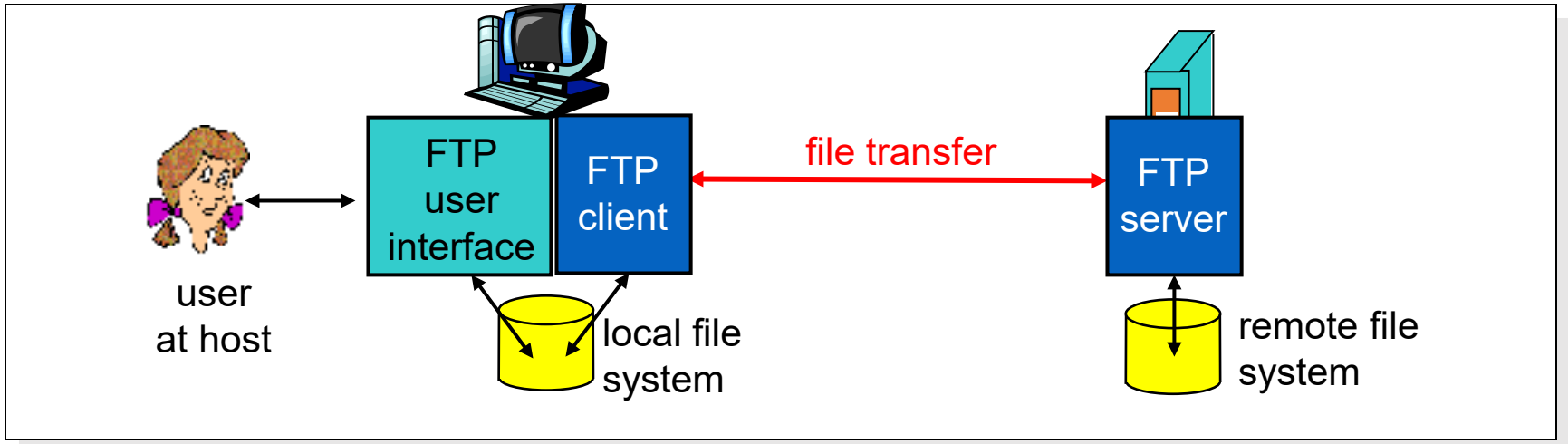
- Initiates contact with server ("speaks first")
- Typically requests service from server,
- For Web, client is implemented in browser; for e-mail, in mail reader

Server:

- Provides requested service to client
- e.g., Web server sends requested Web page, mail server delivers e-mail



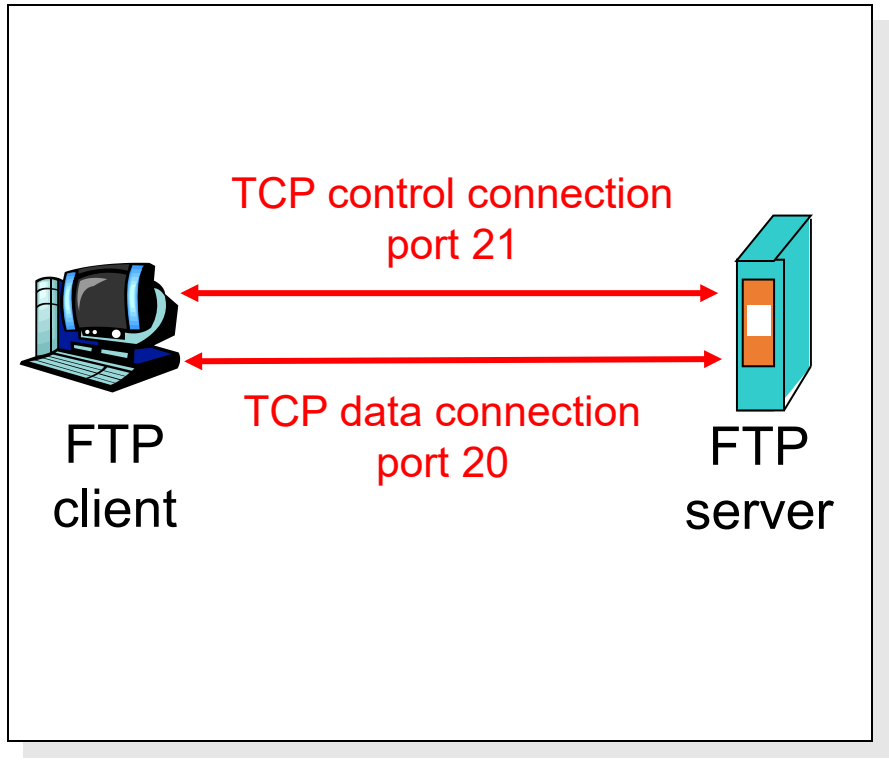
Ftp: The File Transfer Protocol



- Transfer file to/from remote host
- Client/server model
  - *Client:* side that initiates transfer (either to/from remote)
  - *Server:* remote host
- ftp: RFC 959
- ftp server: port 21

Ftp: Separate Control, Data Connections

- Ftp client contacts ftp server at port 21, specifying TCP as transport protocol
- Two parallel TCP connections opened:
  - Control: exchange commands, responses between client, server.
    "out of band control"
  - Data: file data to/from server
- Ftp server maintains "state": current directory, earlier authentication



Ftp Commands, Responses

Sample Commands:

- sent as ASCII text over control channel
- **USER *username***
- **PASS *password***
- **LIST** return list of files in current directory
- **RETR filename** retrieves (gets) file
- **STOR filename** stores (puts) file onto remote host

Sample Return Codes

- status code and phrase
- **331 Username OK, password required**
- **125 data connection already open; transfer starting**
- **425 Can't open data connection**
- **452 Error writing file**

What Transport Service Does an Application Need?

Data loss

- Some apps (e.g., audio) can tolerate some loss
- Other apps (e.g., file transfer, telnet) require 100% reliable data transfer

Timing

- Some apps (e.g., Internet telephony, interactive games) require low delay to be “effective”

Bandwidth

- Some apps (e.g., multimedia) require minimum amount of bandwidth to be “effective”
- Other apps (“elastic apps”) make use of whatever bandwidth they get

Transport Service Requirements of Common Apps

Application	Data loss	Bandwidth	Time Sensitive
file transfer	no loss	elastic	no
e-mail	no loss	elastic	no
web documents	no loss	elastic	no
real-time audio/ video	loss-tolerant	audio: 5Kb-1Mb video:10Kb-5Mb	yes, 100's msec
stored audio/video	loss-tolerant	same as above	yes, few secs
interactive games	loss-tolerant	few Kbps	yes, 100's msec
financial apps	no loss	elastic	yes and no

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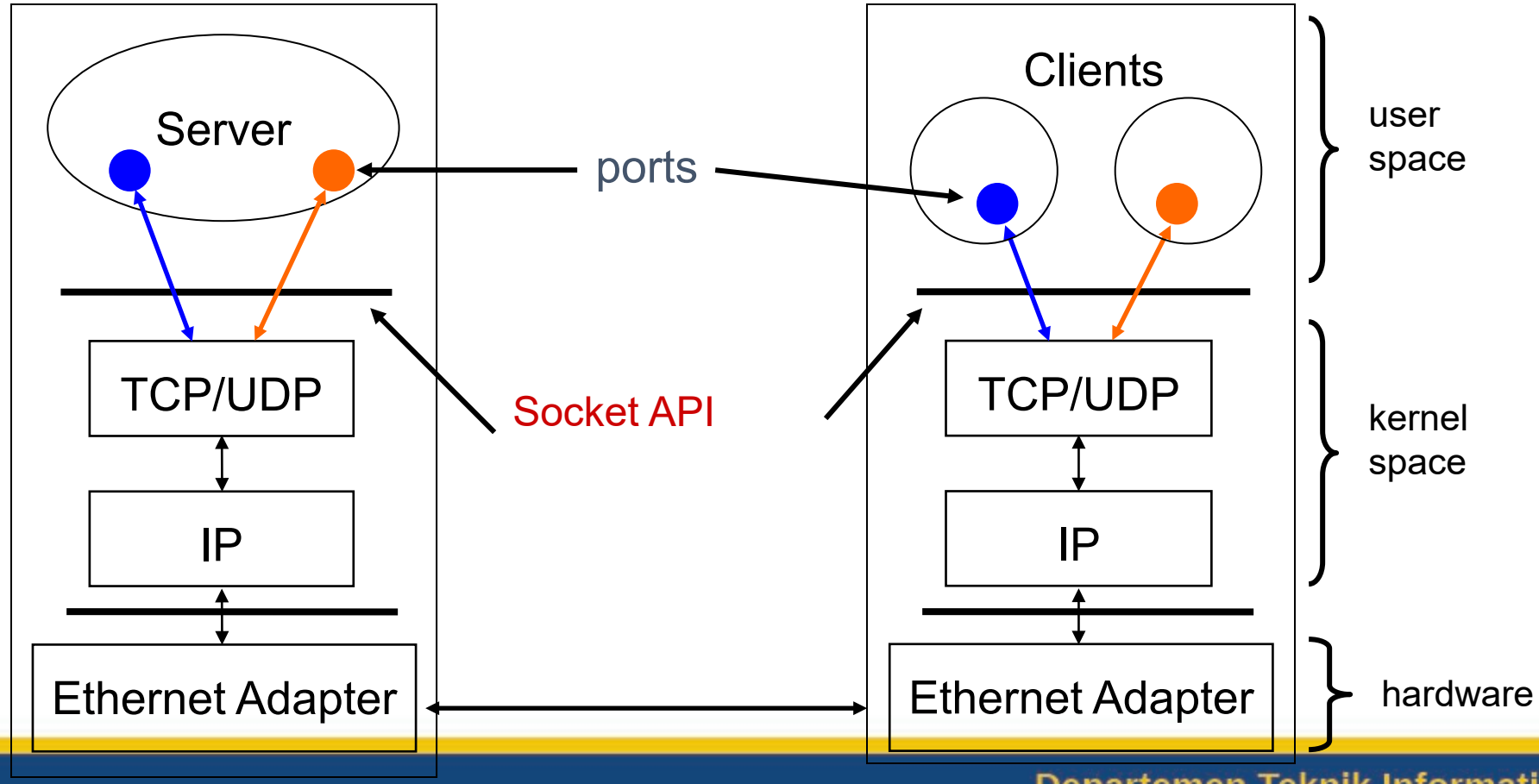
Server and Client

Server and Client exchange messages over the network through a common Socket API



User Datagram Protocol(UDP): An Analogy

UDP	Postal Mail
• Single socket to receive messages • No guarantee of delivery • Not necessarily in-order delivery • Datagram – independent packets • Must address each packet	• Single mailbox to receive letters • Unreliable ☺ • Not necessarily in-order delivery • Letters sent independently • Must address each reply

Example UDP applications

Multimedia, voice over IP

Transmission Control Protocol (TCP): An Analogy

TCP

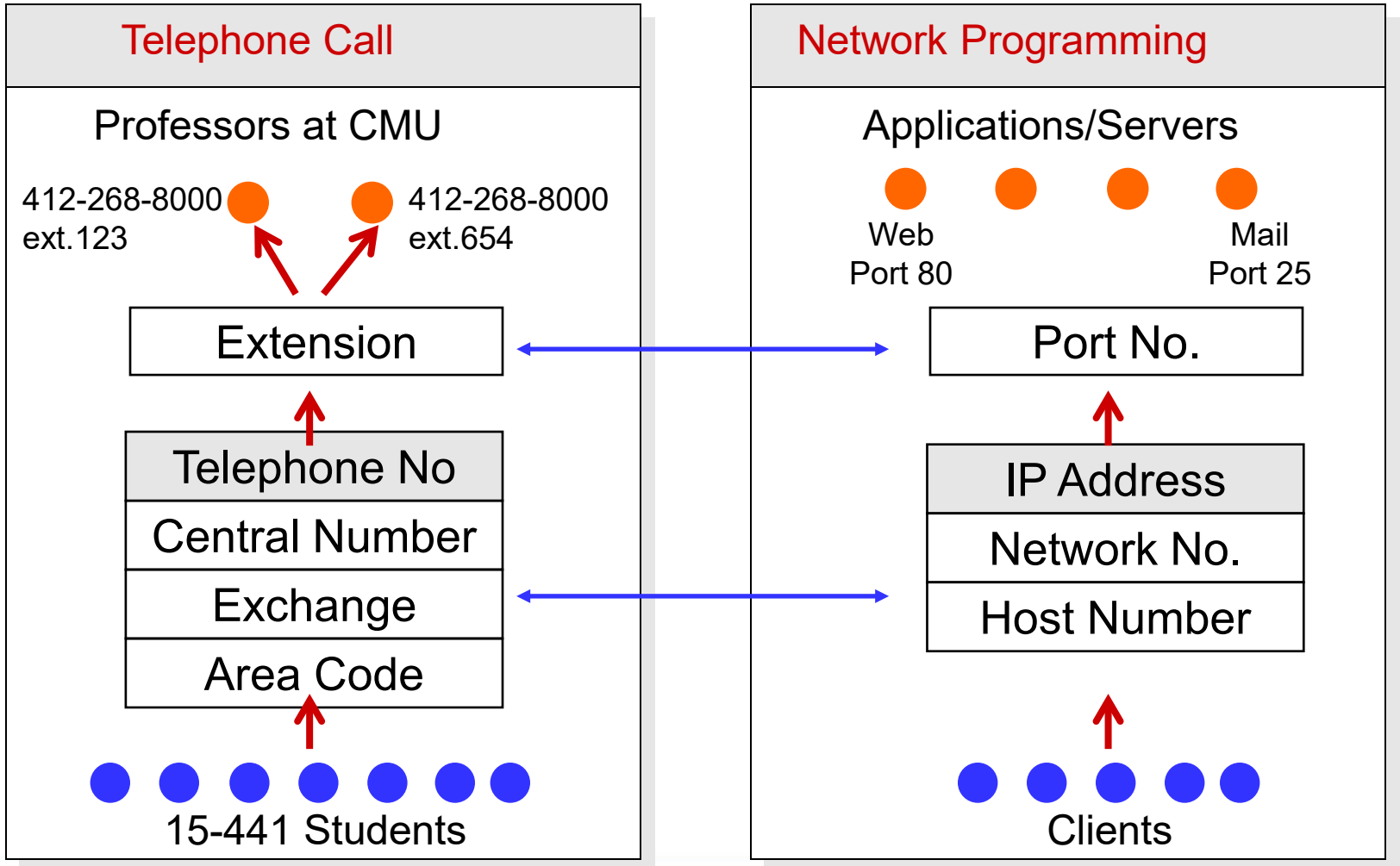
- Reliable – guarantee delivery
- Byte stream – in-order delivery
- Connection-oriented – single socket per connection
- Setup connection followed by data transfer

Telephone Call

- Guaranteed delivery
- In-order delivery
- Connection-oriented
- Setup connection followed by conversation

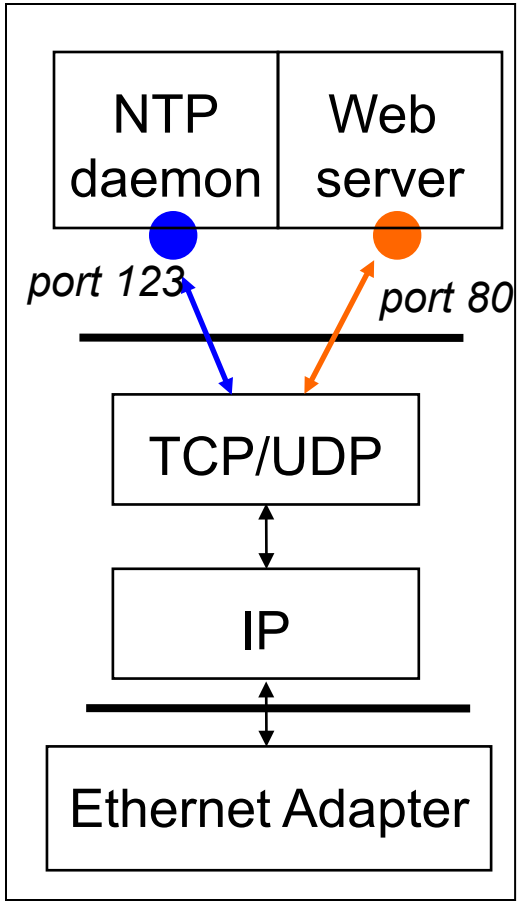
Example TCP applications
Web, Email, Telnet

Network Addressing Analogy



Concept of Port Numbers

- Port numbers are used to identify “entities” on a host
- Port numbers can be
  - Well-known (port 0-1023)
  - Dynamic or private (port 1024-65535)
- Servers/daemons usually use well-known ports
  - Any client can identify the server/service
  - HTTP = 80, FTP = 21, Telnet = 23, ...
  - /etc/service defines well-known ports
- Clients usually use dynamic ports
  - Assigned by the kernel at run time



Names and Addresses

- Each attachment point on Internet is given unique address
  - Based on location within network – like phone numbers
- Humans prefer to deal with names not addresses
  - DNS provides mapping of name to address
  - Name based on administrative ownership of host

Internet Addressing Data Structure

```
#include <netinet/in.h>

/* Internet address structure */
struct in_addr {
        u_long s_addr;          /* 32-bit IPv4 address */
};                              /* network byte ordered */

/* Socket address, Internet style. */
struct sockaddr_in {
      u_char  sin_family;       /* Address Family */
      u_short sin_port;         /* UDP or TCP Port# */
                                /* network byte ordered */
      struct in_addr sin_addr; /* Internet Address */
      char    sin_zero[8];      /* unused */
};
```

- sin_family = AF_INET selects Internet address family

Byte Ordering

```
union {
    u_int32_t addr;  /* 4 bytes address */
    char c[4];
} un;
/* 128.2.194.95 */
un.addr = 0x8002c25f;
/* c[0] = ? */
```

c[0]	c[1]	c[2]	c[3]

- Big Endian → | 128 | 2 | 194 | 95 |
  - Sun Solaris, PowerPC, ...
- Little Endian → | 95 | 194 | 2 | 128 |
  - i386, alpha, ...
- Network byte order = Big Endian

Byte Ordering Functions

- Converts between **host byte order** and **network byte order**
  - 'h' = host byte order
  - 'n' = network byte order
  - 'l' = long (4 bytes), converts IP addresses
  - 's' = short (2 bytes), converts port numbers

```
#include <netinet/in.h>

unsigned long int htonl(unsigned long int hostlong);
unsigned short int htons(unsigned short int
hostshort);
unsigned long int ntohl(unsigned long int netlong);
unsigned short int ntohs(unsigned short int
netshort);
```

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What is a Socket?

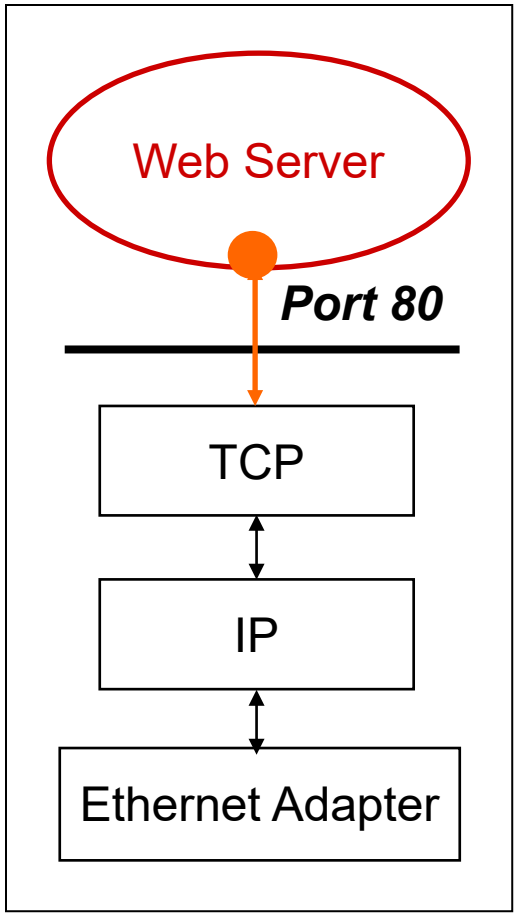
- A socket is a file descriptor that lets an application read/write data from/to the network

```
int fd;          /* socket descriptor */
if ((fd = socket(AF_INET, SOCK_STREAM, 0)) < 0) }
      perror("socket");
      exit(1);
}
```

- ***socket*** returns an integer (socket descriptor)
  - fd < 0 indicates that an error occurred
  - socket descriptors are similar to file descriptors

- AF_INET: associates a socket with the Internet protocol family
- SOCK_STREAM: selects the TCP protocol
- SOCK_DGRAM: selects the UDP protocol

TCP Server



- For example: web server
- **What does a *web server* need to do so that a *web client* can connect to it?**

Socket I/O: socket()

- Since web traffic uses TCP, the web server must create a socket of type SOCK_STREAM

```
int fd;             /* socket descriptor */

if((fd = socket(AF_INET, SOCK_STREAM, 0)) < 0) {
      perror("socket");
      exit(1);
}
```

- ***socket*** returns an integer (**socket descriptor**)
  - ***fd*** < 0 indicates that an error occurred
- **AF_INET** associates a socket with the Internet protocol family
- **SOCK_STREAM selects the TCP protocol**

Socket I/O: bind()

- A ***socket*** can be bound to a ***port***

```
int fd;                                 /* socket descriptor */
struct sockaddr_in srv;     /* used by bind() */

/* create the socket */

srv.sin_family = AF_INET; /* use the Internet addr family */

srv.sin_port = htons(80); /* bind socket 'fd' to port 80*/

/* bind: a client may connect to any of my addresses */
srv.sin_addr.s_addr = htonl(INADDR_ANY);

if(bind(fd, (struct sockaddr*) &srv, sizeof(srv)) < 0) {
        perror("bind"); exit(1);
}
```

- **Still not quite ready to communicate with a client...**

Socket I/O: listen()

- ***listen*** indicates that the server will accept a connection

```
int fd;                          /* socket descriptor */
struct sockaddr_in srv;          /* used by bind() */

/* 1) create the socket */
/* 2) bind the socket to a port */

if(listen(fd, 5) < 0) {
        perror("listen");
        exit(1);
}
```

- **Still not quite ready to communicate with a client...**

Socket I/O: accept()

- ***accept*** blocks waiting for a connection

```
int fd;                                  /* socket descriptor */
struct sockaddr_in srv;                 /* used by bind() */
struct sockaddr_in cli;                 /* used by accept() */
int newfd;                              /* returned by accept() */
int cli_len = sizeof(cli); /* used by accept() */

/* 1) create the socket */
/* 2) bind the socket to a port */
/* 3) listen on the socket */

newfd = accept(fd, (struct sockaddr*) &cli, &cli_len);
if(newfd < 0) {
        perror("accept");    exit(1);
}
```

- ***accept*** returns a new socket (***newfd***) with the same properties as the original socket (***fd***)
  - ***newfd*** < 0 indicates that an error occurred

Socket I/O: accept() continued…

```
struct sockaddr_in cli;          /* used by accept() */
int newfd;                       /* returned by accept() */
int cli_len = sizeof(cli);       /* used by accept() */

newfd = accept(fd, (struct sockaddr*) &cli, &cli_len);
if(newfd < 0) {
      perror("accept");
      exit(1);
}
```

- How does the server know which client it is?
  - **cli.sin_addr.s_addr** contains the client's ***IP address***
  - **cli.sin_port** contains the client's ***port number***
- Now the server can exchange data with the client by using ***read*** and ***write*** on the descriptor ***newfd***.
- Why does ***accept*** need to return a new descriptor?

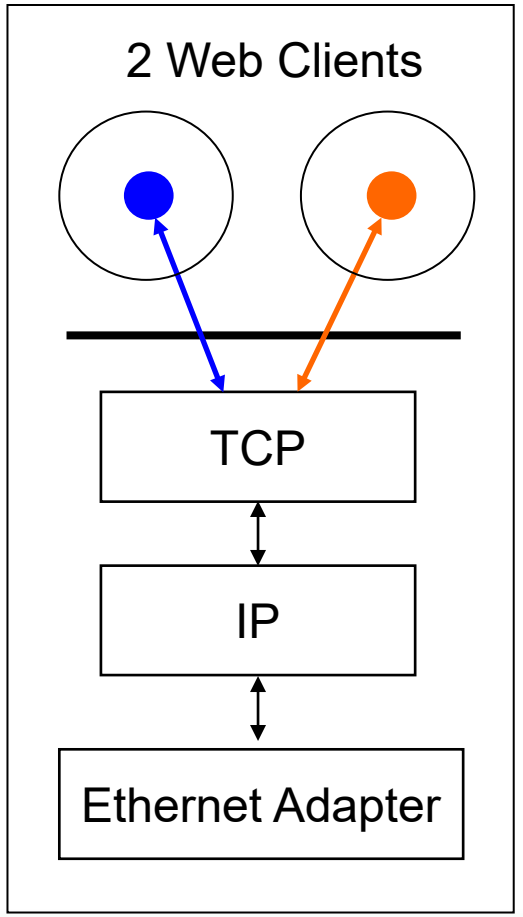
Socket I/O: read()

- ***read*** can be used with a socket
- ***read*** **blocks waiting for data from the client but does not guarantee that sizeof(buf) is read**

```
int fd;                                  /* socket descriptor */
char buf[512];                           /* used by read() */
int nbytes;                             /* used by read() */

/* 1) create the socket */
/* 2) bind the socket to a port */
/* 3) listen on the socket */
/* 4) accept the incoming connection */

if((nbytes = read(newfd, buf, sizeof(buf))) < 0) {
       perror("read"); exit(1);
}
```

TCP Client

- For example: web client
- **How does a *web client* connect to a *web server*?**



Dealing with IP Addresses

- IP Addresses are commonly written as strings (“128.2.35.50”), but programs deal with IP addresses as integers.

Converting strings to numerical address:

```
struct sockaddr_in srv;

srv.sin_addr.s_addr = inet_addr(“128.2.35.50”);
if(srv.sin_addr.s_addr == (in_addr_t) -1) {
      fprintf(stderr, "inet_addr failed!\n"); exit(1);
}
```

Converting a numerical address to a string:

```
struct sockaddr_in srv;
char *t = inet_ntoa(srv.sin_addr);
if(t == 0) {
      fprintf(stderr, “inet_ntoa failed!\n”); exit(1);
}
```

Translating Names to Addresses

- Gethostbyname provides interface to DNS
- Additional useful calls
  - Gethostbyaddr – returns `hostent` given sockaddr_in
  - Getservbyname
    - Used to get service description (typically port number)
    - Returns `servent` based on name

```
#include <netdb.h>

struct hostent *hp; /*ptr to host info for remote*/
struct sockaddr_in peeraddr;
char *name = "www.cs.cmu.edu";

peeraddr.sin_family = AF_INET;
hp = gethostbyname(name)
peeraddr.sin_addr.s_addr = ((struct in_addr*)(hp->h_addr))->s_addr;
```

Socket I/O: connect()

- ***connect*** allows a client to connect to a server...

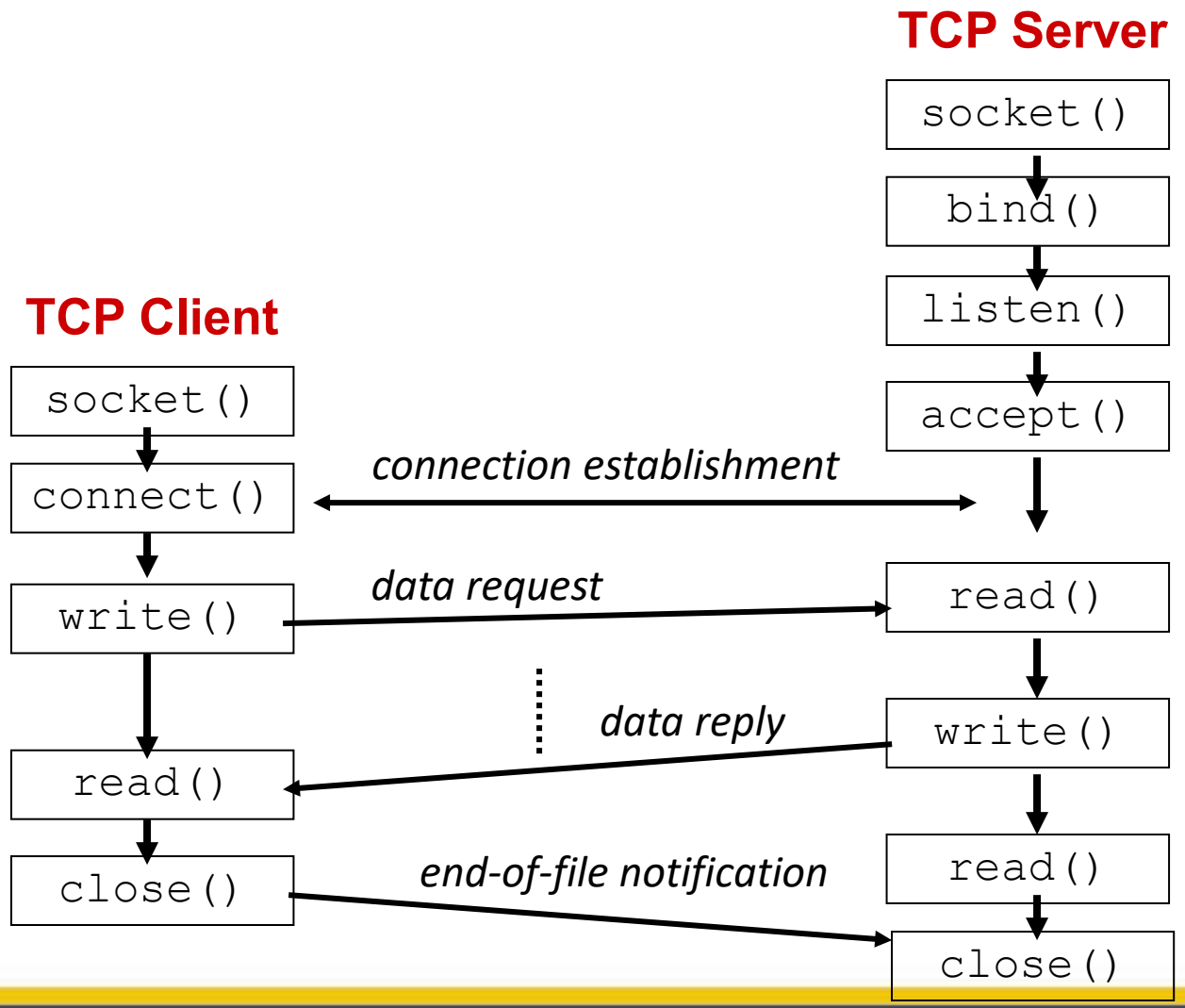
```
int fd;                                 /* socket descriptor */
struct sockaddr_in srv;                 /* used by connect() */

/* create the socket */

/* connect: use the Internet address family */
srv.sin_family = AF_INET;

/* connect: socket 'fd' to port 80 */
srv.sin_port = htons(80);

/* connect: connect to IP Address "128.2.35.50" */
srv.sin_addr.s_addr = inet_addr("128.2.35.50");

if(connect(fd, (struct sockaddr*) &srv, sizeof(srv)) < 0) {
        perror("connect"); exit(1);
}
```

Socket I/O: write()

- ***write*** can be used with a socket

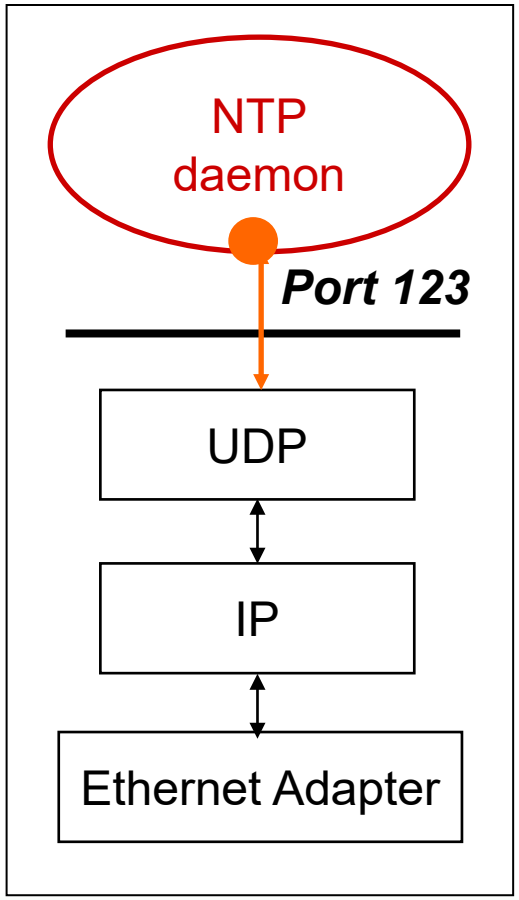
```
int fd;                          /* socket descriptor */
struct sockaddr_in srv;          /* used by connect() */
char buf[512];                   /* used by write() */
int nbytes;                      /* used by write() */

/* 1) create the socket */
/* 2) connect() to the server */

/* Example: A client could "write" a request to a server
*/
if((nbytes = write(fd, buf, sizeof(buf))) < 0) {
      perror("write");
      exit(1);
}
```

Review: TCP Client-Server Interaction



from UNIX Network Programming Volume 1, figure 4.1

UDP Server Example



- For example: NTP daemon
- **What does a *UDP server* need to do so that a *UDP client* can connect to it?**

Socket I/O: socket()

- The UDP server must create a **datagram** socket…

```
int fd;            /* socket descriptor */

if((fd = socket(AF_INET, SOCK_DGRAM, 0)) < 0) {
      perror("socket");
      exit(1);
}
```

- ***socket*** returns an integer (**socket descriptor**)
  - ***fd*** < 0 indicates that an error occurred

- AF_INET: associates a socket with the Internet protocol family
- **SOCK_DGRAM: selects the UDP protocol**

Socket I/O: bind()

- A ***socket*** can be bound to a ***port***

```
int fd;                                /* socket descriptor */
struct sockaddr_in srv;     /* used by bind() */

/* create the socket */

/* bind: use the Internet address family */
srv.sin_family = AF_INET;

/* bind: socket 'fd' to port 80*/
srv.sin_port = htons(80);

/* bind: a client may connect to any of my addresses */
srv.sin_addr.s_addr = htonl(INADDR_ANY);

if(bind(fd, (struct sockaddr*) &srv, sizeof(srv)) < 0) {
        perror("bind"); exit(1);
}
```

- **Now the UDP server is ready to accept packets…**

Socket I/O: recvfrom()

- ***read*** does not provide the client's address to the UDP server

```
int fd;                          /* socket descriptor */
struct sockaddr_in srv;          /* used by bind() */
struct sockaddr_in cli;          /* used by recvfrom() */
char buf[512];                   /* used by recvfrom() */
int cli_len = sizeof(cli);       /* used by recvfrom() */
int nbytes;                      /* used by recvfrom() */

/* 1) create the socket */
/* 2) bind to the socket */

nbytes = recvfrom(fd, buf, sizeof(buf), 0 /* flags */,
                  (struct sockaddr*) &cli, &cli_len);
if(nbytes < 0) {
      perror("recvfrom"); exit(1);
}
```

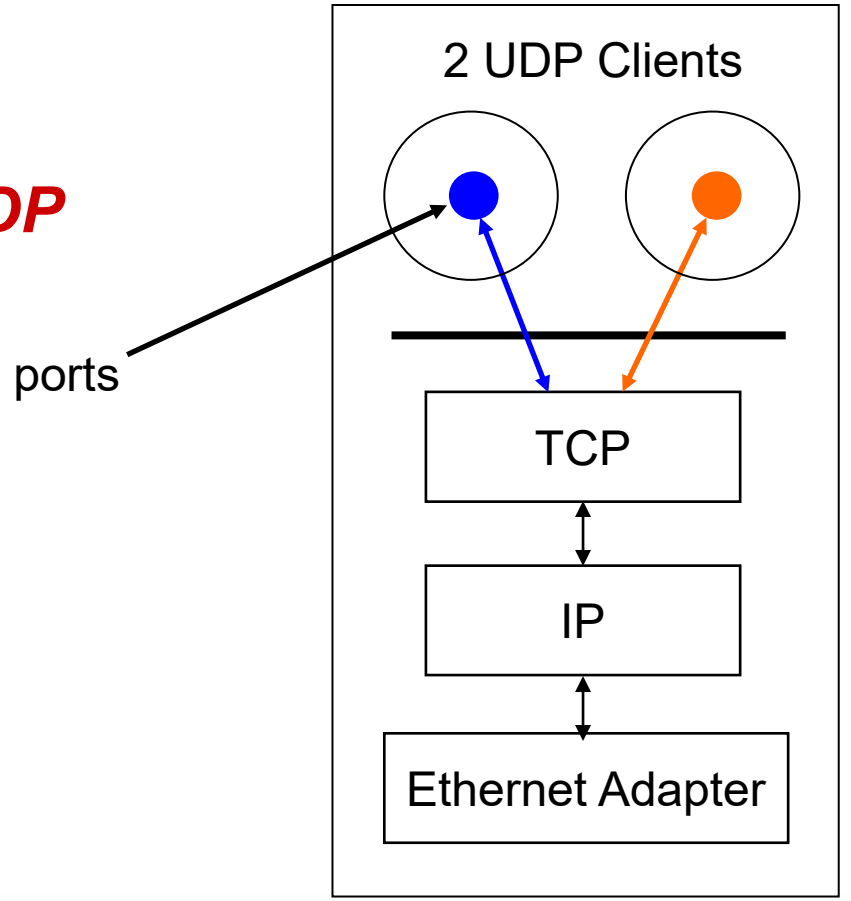
Socket I/O: recvfrom() continued…

```
nbytes = recvfrom(fd, buf, sizeof(buf), 0 /* flags */,
                  (struct sockaddr*) cli, &cli_len);
```

- The actions performed by ***recvfrom***
  - returns the number of bytes read (***nbytes***)
  - copies ***nbytes*** of data into ***buf***
  - returns the address of the client (***cli***)
  - returns the length of ***cli*** (***cli_len***)
  - don't worry about flags

UDP Client Example

- **How does a *UDP client* communicate with a *UDP server*?**

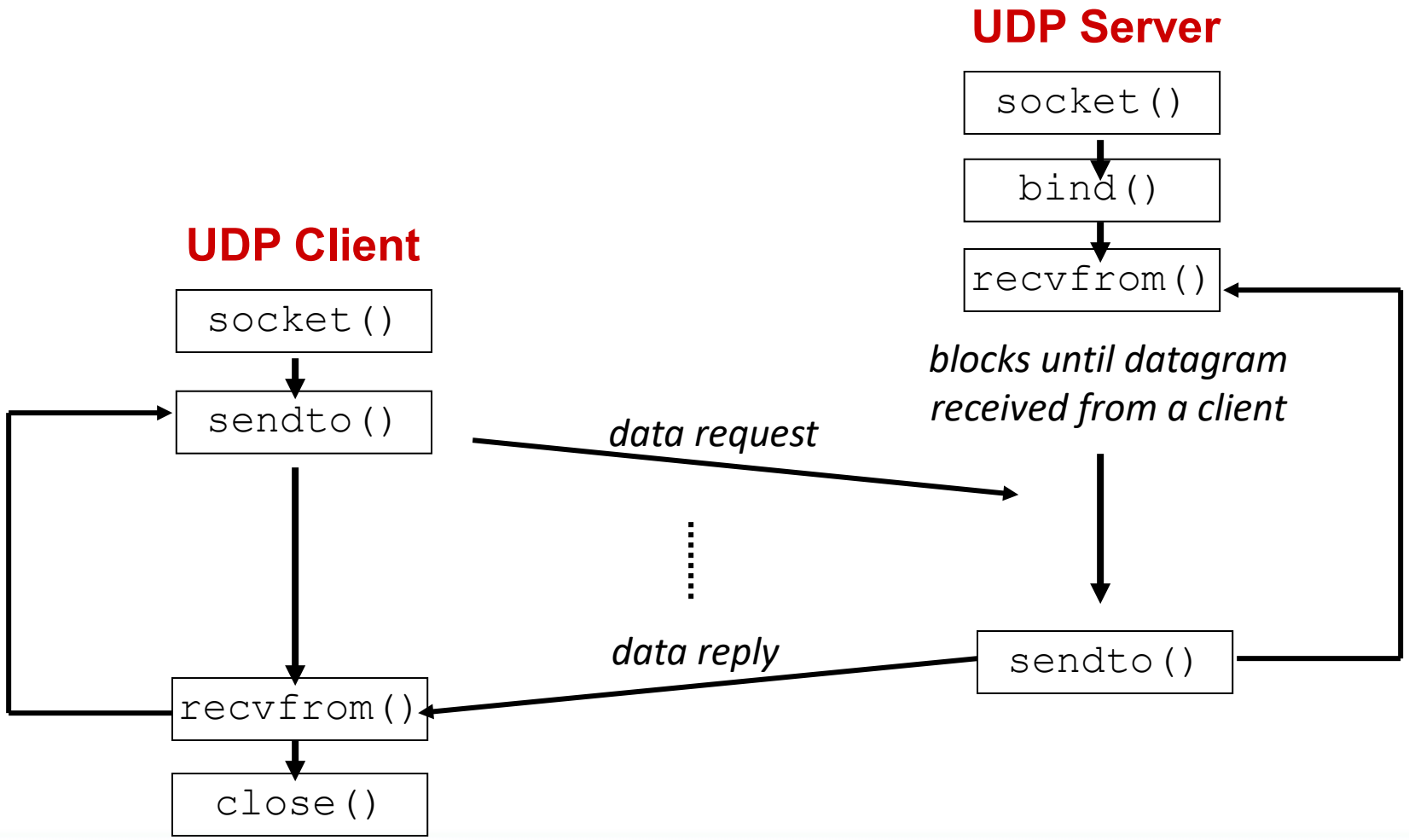


Socket I/O: sendto()

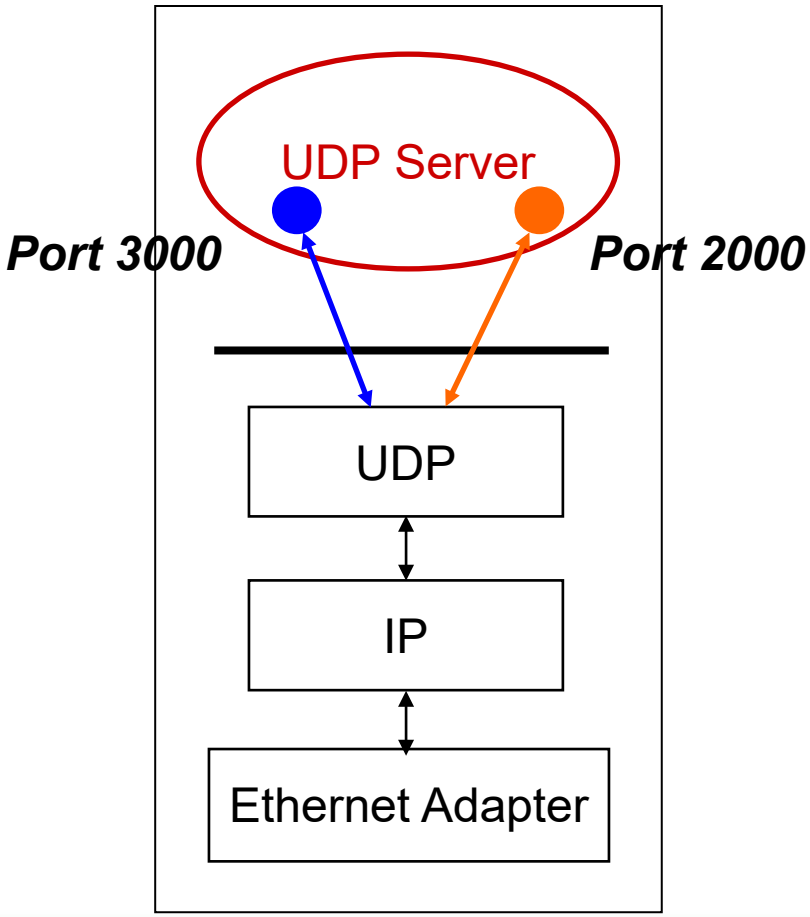
- ***write*** is not allowed
- Notice that the UDP client does not ***bind*** a port number
  - a port number is **dynamically assigned** when the first ***sendto*** is called

```
int fd;                                  /* socket descriptor */
struct sockaddr_in srv;                  /* used by sendto() */

/* 1) create the socket */

/* sendto: send data to IP Address "128.2.35.50" port 80 */
srv.sin_family = AF_INET;
srv.sin_port = htons(80);
srv.sin_addr.s_addr = inet_addr("128.2.35.50");

nbytes = sendto(fd, buf, sizeof(buf), 0 /* flags */,
                  (struct sockaddr*) &srv, sizeof(srv));
if(nbytes < 0) {
       perror("sendto");    exit(1);
}
```

Review: UDP Client-Server Interaction



The UDP Server



- **How can the *UDP server* service multiple ports simultaneously?**

UDP Server: Servicing Two Ports

```
int s1;                              /* socket descriptor 1 */
int s2;                              /* socket descriptor 2 */

/* 1) create socket s1 */
/* 2) create socket s2 */
/* 3) bind s1 to port 2000 */
/* 4) bind s2 to port 3000 */

while(1) {
        recvfrom(s1, buf, sizeof(buf), ...);
        /* process buf */

        recvfrom(s2, buf, sizeof(buf), ...);
        /* process buf */
}
```

- **What problems does this code have?**

Socket I/O: select()

```
int select(int maxfds, fd_set *readfds, fd_set *writefds,
           fd_set *exceptfds, struct timeval *timeout);

FD_CLR(int fd, fd_set *fds);   /* clear the bit for fd in fds */
FD_ISSET(int fd, fd_set *fds); /* is the bit for fd in fds? */
FD_SET(int fd, fd_set *fds);   /* turn on the bit for fd in fds */
FD_ZERO(fd_set *fds);          /* clear all bits in fds */
```

- ***maxfds***: number of descriptors to be tested
  - descriptors (0, 1, ... maxfds-1) will be tested
- ***readfds***: a set of *fds* we want to check if data is available
  - returns a set of *fds* ready to read
  - if input argument is *NULL*, not interested in that condition
- ***writefds***: returns a set of *fds* ready to write
- ***exceptfds***: returns a set of *fds* with exception conditions

Socket I/O: select()

```
int select(int maxfds, fd_set *readfds, fd_set *writefds,
           fd_set *exceptfds, struct timeval *timeout);

struct timeval {
      long tv_sec;       /* seconds /
      long tv_usec;            /* microseconds */
}
```

- ***timeout***
  - if NULL, wait forever and return only when one of the descriptors is ready for I/O
  - otherwise, wait up to a fixed amount of time specified by *timeout*
    - if we don't want to wait at all, create a timeout structure with timer value equal to 0

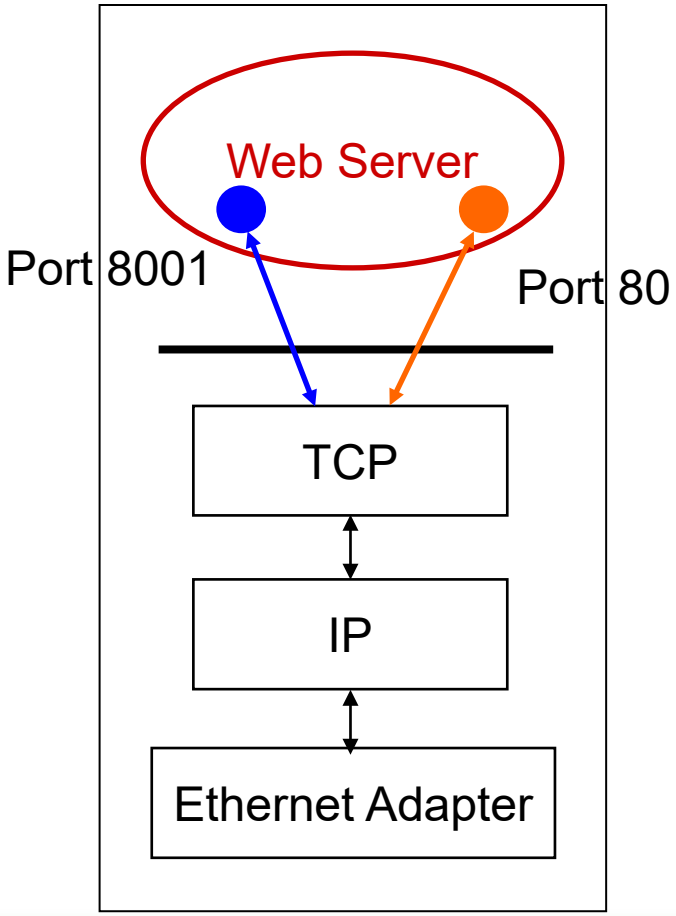
- Refer to the man page for more information

Socket I/O: select()

- ***select*** allows synchronous I/O multiplexing

```
int s1, s2;                     /* socket descriptors */
fd_set readfds;         /* used by select() */

/* create and bind s1 and s2 */
while(1) {
        FD_ZERO(&readfds);              /* initialize the fd set
*/
        FD_SET(s1, &readfds);   /* add s1 to the fd set */
        FD_SET(s2, &readfds);   /* add s2 to the fd set */

        if(select(s2+1, &readfds, 0, 0, 0) < 0) {
                perror("select");
                exit(1);
        }
        if(FD_ISSET(s1, &readfds)) {
                recvfrom(s1, buf, sizeof(buf), ...);
                /* process buf */
        }
        /* do the same for s2 */
}
```

More Details About a Web Server



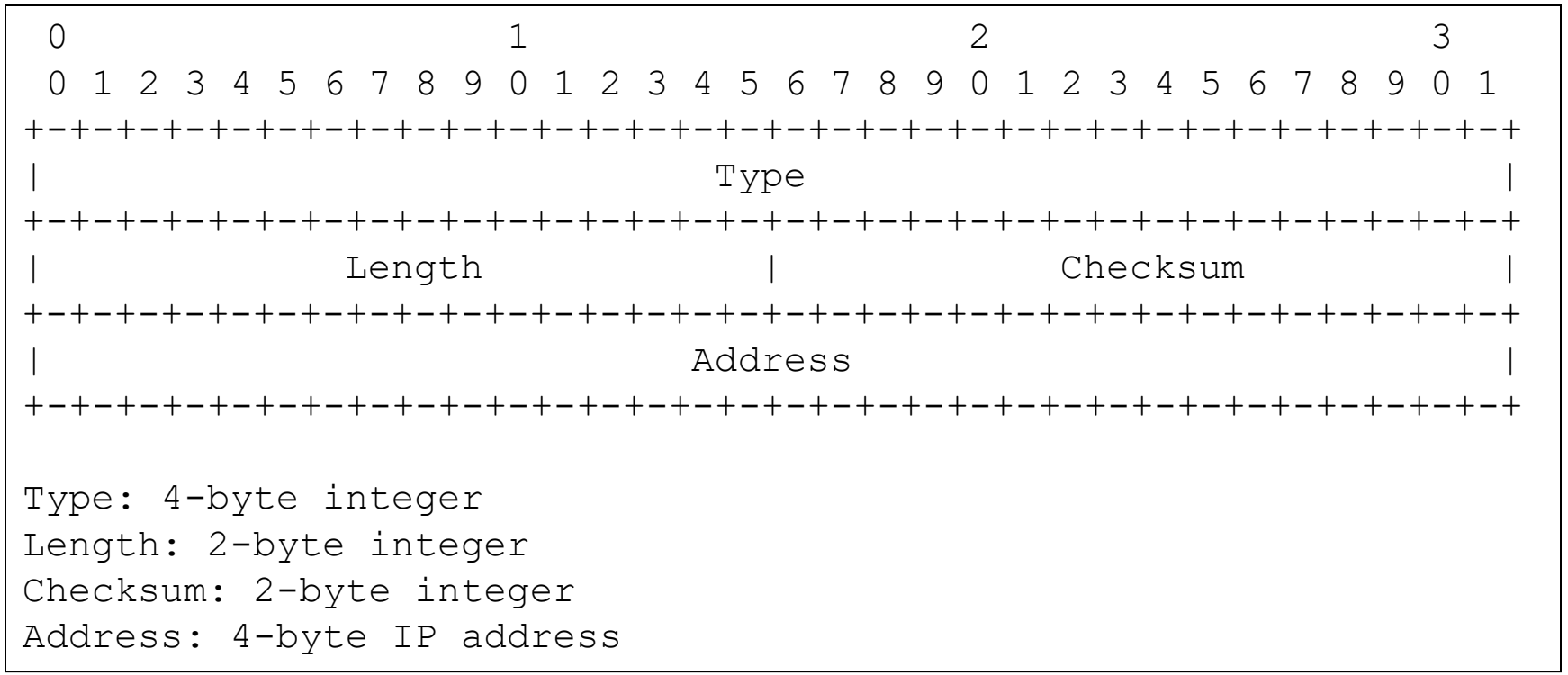
How can a a *web server* manage multiple connections simultaneously?

Socket I/O: select()

```
int fd, next=0;                              /* original socket */
int newfd[10];                          /* new socket descriptors */
while(1) {
        fd_set readfds;
        FD_ZERO(&readfds); FD_SET(fd, &readfds);

        /* Now use FD_SET to initialize other newfd's
           that have already been returned by accept() */

        select(maxfd+1, &readfds, 0, 0, 0);
        if(FD_ISSET(fd, &readfds)) {
                newfd[next++] = accept(fd, ...);
        }
        /* do the following for each descriptor newfd[n] */
        if(FD_ISSET(newfd[n], &readfds)) {
                read(newfd[n], buf, sizeof(buf));
                /* process data */
        }
}
```

- **Now the web server can support multiple connections...**

A Few Programming Notes: Representing Packets



A Few Programming Notes: Building a Packet in a Buffer

```
struct packet {
        u_int32_t type;
        u_int16_t length;
        u_int16_t checksum;
        u_int32_t address;
};

/* ========================================== */
char buf[1024];
struct packet *pkt;

pkt = (struct packet*) buf;
pkt->type = htonl(1);
pkt->length = htons(2);
pkt->checksum = htons(3);
pkt->address = htonl(4);
```

Socket Programming References

- Man page
  - usage: man <function name>
- Textbook
  - Sections 2.6, 2.7
  - demo programs written in Java
- Unix Network Programming : Networking APIs: Sockets and XTI (Volume 1)
  - Section 2, 3, 4, 6, 8
  - ultimate socket programming bible!

Apa itu Wireshark ?

- Network Protocol Analyzer yang paling popular and “de-facto” untuk stadar analisa packets
  - Open-Source (GNU Public License)
  - Multi-platform (Windows, Linux, OS X, Solaris, FreeBSD, NetBSD, and others)
  - Easily extensible
  - Large development group
- Sebelumnya bernama“Ethereal”

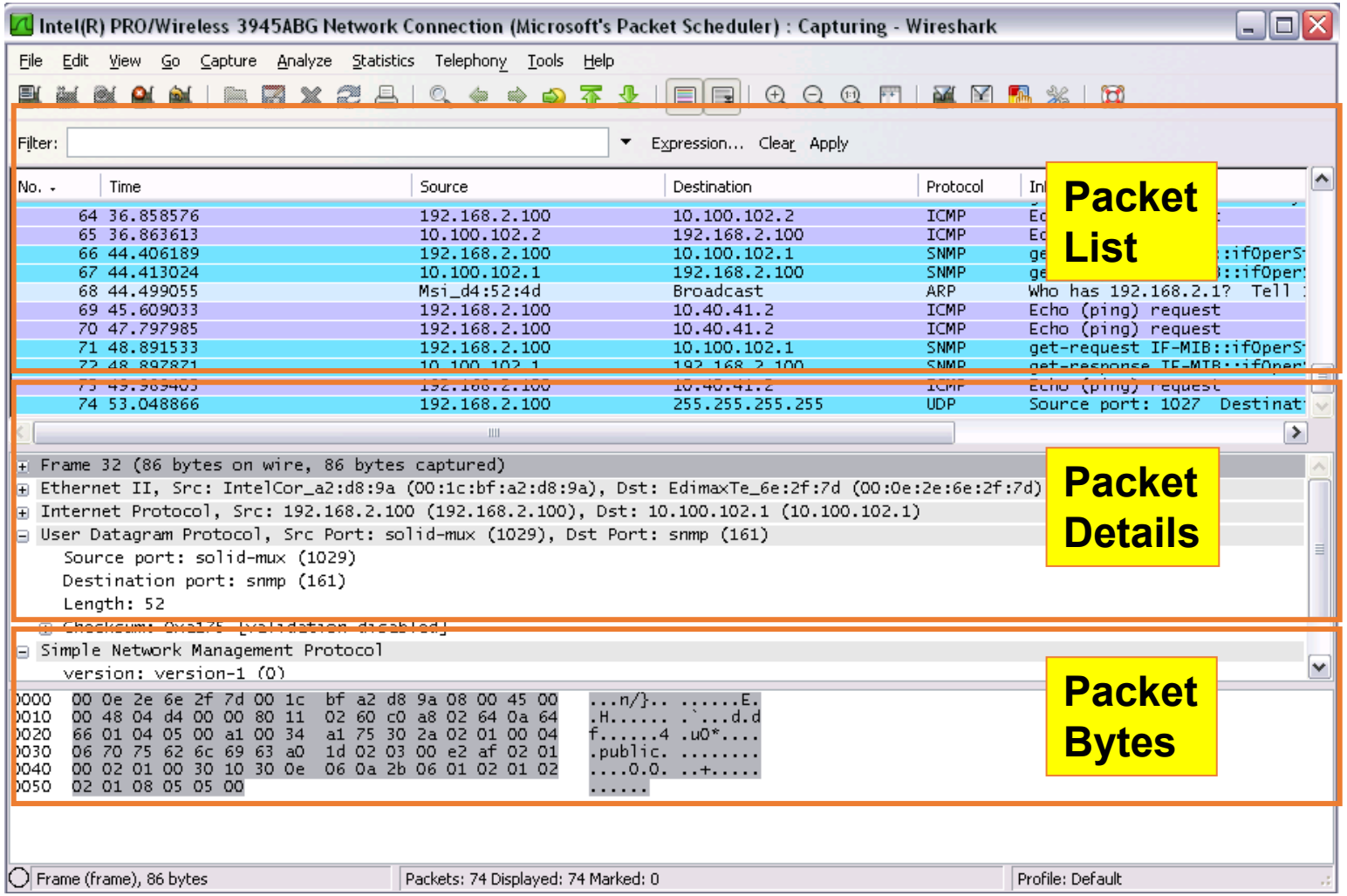
Apa itu Wireshark ?

- Features
  - Deep inspection untuk ribuan jenis protocol
  - Live capture and offline analysis
  - Standard three-pane packet browser
  - Mempunyai tiga jenis user interface: GUI, or via the TTY-mode TShark utility
  - The most powerful display filters in the industry
  - Kaya fitur untuk VoIP analysis
  - Penyadapan Data online dapat menggunakan beberapa interface seperti :Ethernet, IEEE 802.11, PPP/HDLC, ATM, Bluetooth, USB, Token Ring, Frame Relay, FDDI, and others
  - Coloring rules dapat diaplikasi plied to the packet list for quick, intuitive analysis
  - Output fdap to XML, PostScript®, CSV, or plain text

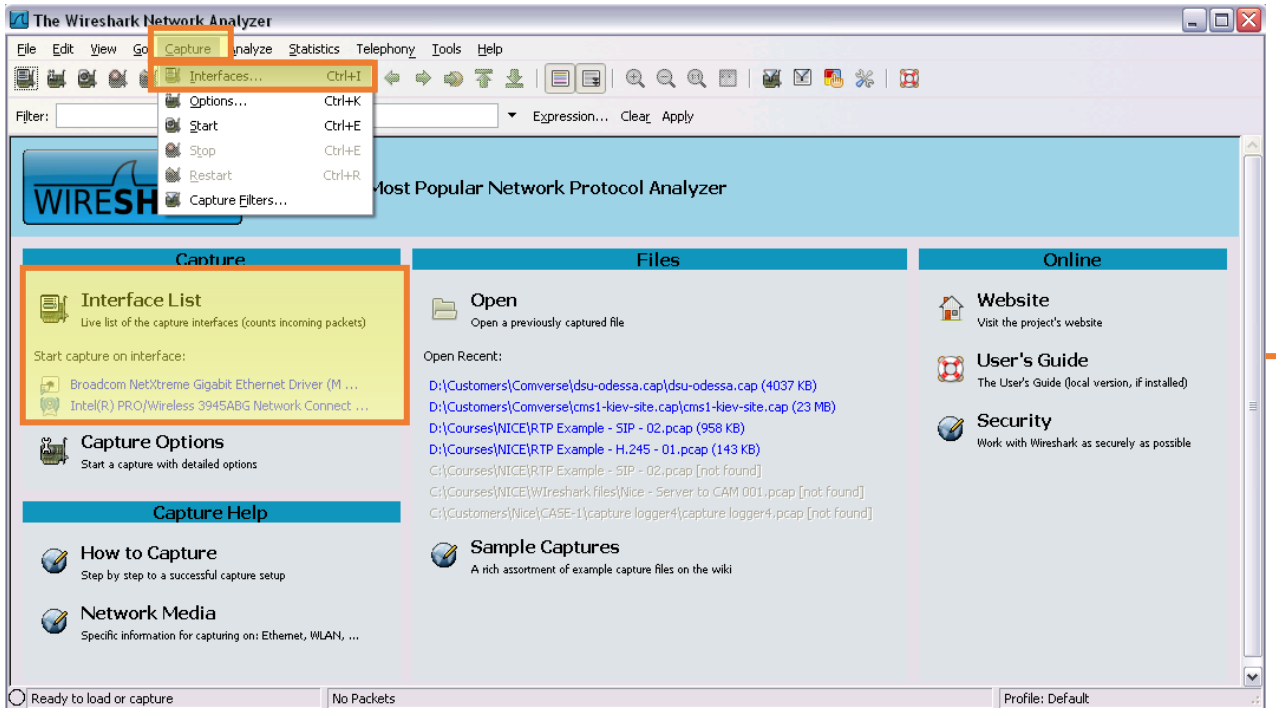
What is Wireshark?

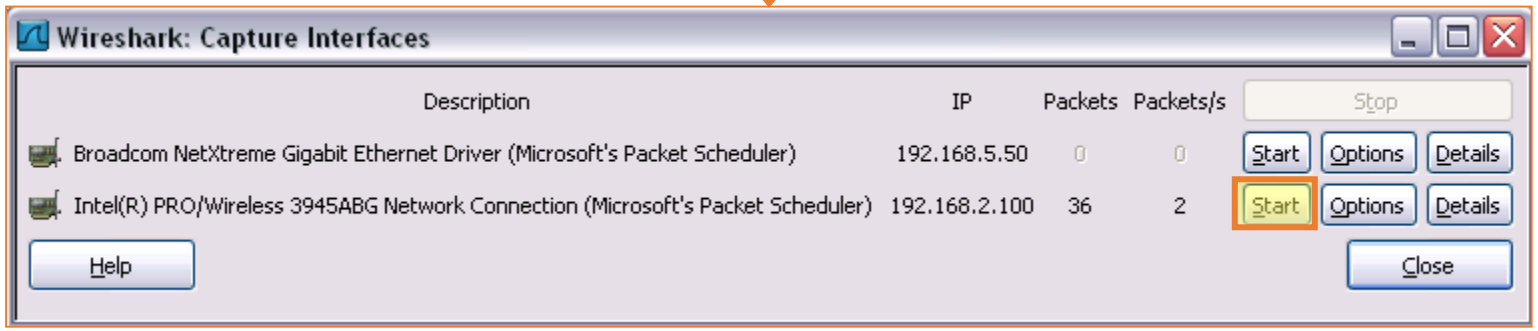
- What we can:
  - Capture network traffic
  - Decode packet protocols using dissectors
  - Define filters – capture and display
  - Watch smart statistics
  - Analyze problems
  - Interactively browse that traffic
- Some examples people use Wireshark for:
  - Network administrators: **troubleshoot network problems**
  - Network security engineers: **examine security problems**
  - Developers: **debug protocol implementations**
  - People: **learn network protocol internals**

Interfaces

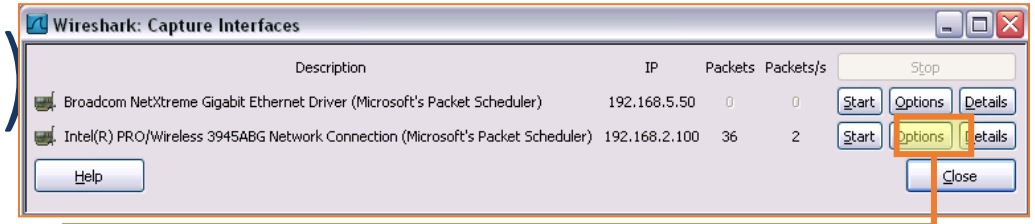

Intel(R) PRO/Wireless 3945ABG Network Connection (Microsoft's Packet Scheduler) : Capturing - Wireshark
File Edit View Go Capture Analyze Statistics Telephony Tools Help
Filter: Expression... Clear Apply
No. Time Source Destination Protocol
64 36.858576 192.168.2.100 10.100.102.2 ICMP
65 36.863613 10.100.102.2 192.168.2.100 ICMP
66 44.406189 192.168.2.100 10.100.102.1 SNMP
67 44.413024 10.100.102.1 192.168.2.100 SNMP
68 44.499055 Msi_d4:52:4d Broadcast ARP Who has 192.168.2.1? Tell
69 45.609033 192.168.2.100 10.40.41.2 ICMP Echo (ping) request
70 47.797985 192.168.2.100 10.40.41.2 ICMP Echo (ping) request
71 48.891533 192.168.2.100 10.100.102.1 SNMP get-request IF-MIB::ifOperS
74 53.048866 192.168.2.100 255.255.255.255 UDP Source port: 1027 Destinat
Packet List
Frame 32 (86 bytes on wire, 86 bytes captured)
Ethernet II, Src: IntelCor_a2:d8:9a (00:1c:bf:a2:d8:9a), Dst: EdimaxTe_6e:2f:7d (00:0e:2e:6e:2f:7d)
Internet Protocol, Src: 192.168.2.100 (192.168.2.100), Dst: 10.100.102.1 (10.100.102.1)
User Datagram Protocol, Src Port: solid-mux (1029), Dst Port: snmp (161)
Source port: solid-mux (1029)
Destination port: snmp (161)
Length: 52
Simple Network Management Protocol
version: version-1 (0)
Packet Details
0000 00 0e 2e 6e 2f 7d 00 1c bf a2 d8 9a 08 00 45 00 ...n/}.. ......E.
0010 00 48 04 d4 00 00 80 11 02 60 c0 a8 02 64 0a 64 .H..... .`...d.d
0020 66 01 04 05 00 a1 00 34 a1 75 30 2a 02 01 00 04 f......4 .u0*....
0030 06 70 75 62 6c 69 63 a0 1d 02 03 00 e2 af 02 01 .public. ....
0040 00 02 01 00 30 10 30 0e 06 0a 2b 06 01 02 01 02 ....0.0. ..+.....
0050 02 01 08 05 05 00 ......
Packet Bytes
Frame (frame), 86 bytes
Packets: 74 Displayed: 74 Marked: 0
Profile: Default

Capturing Packets (1/3)



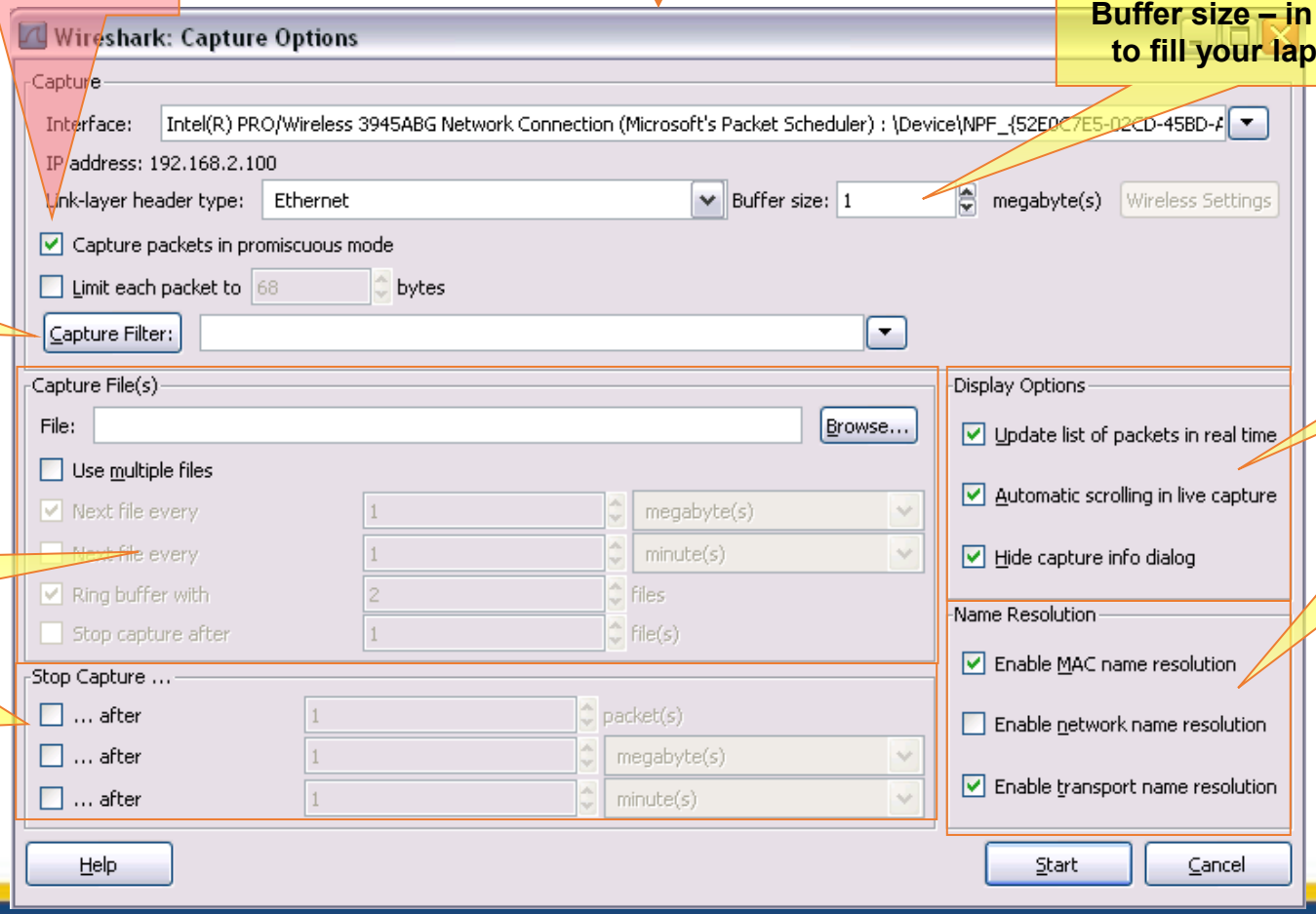


Capturing Packets (2/3)



Capture all packets on the network

Buffer size – in order not to fill your laptop disk



Capture filter

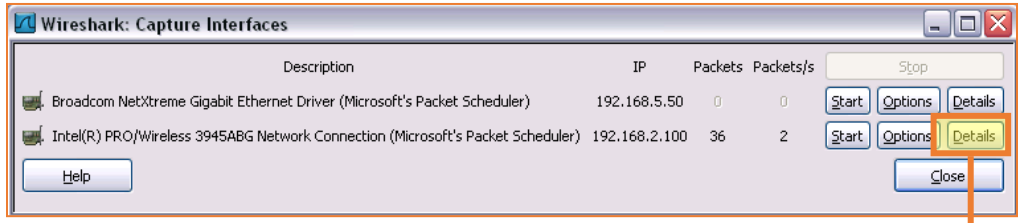
Display options

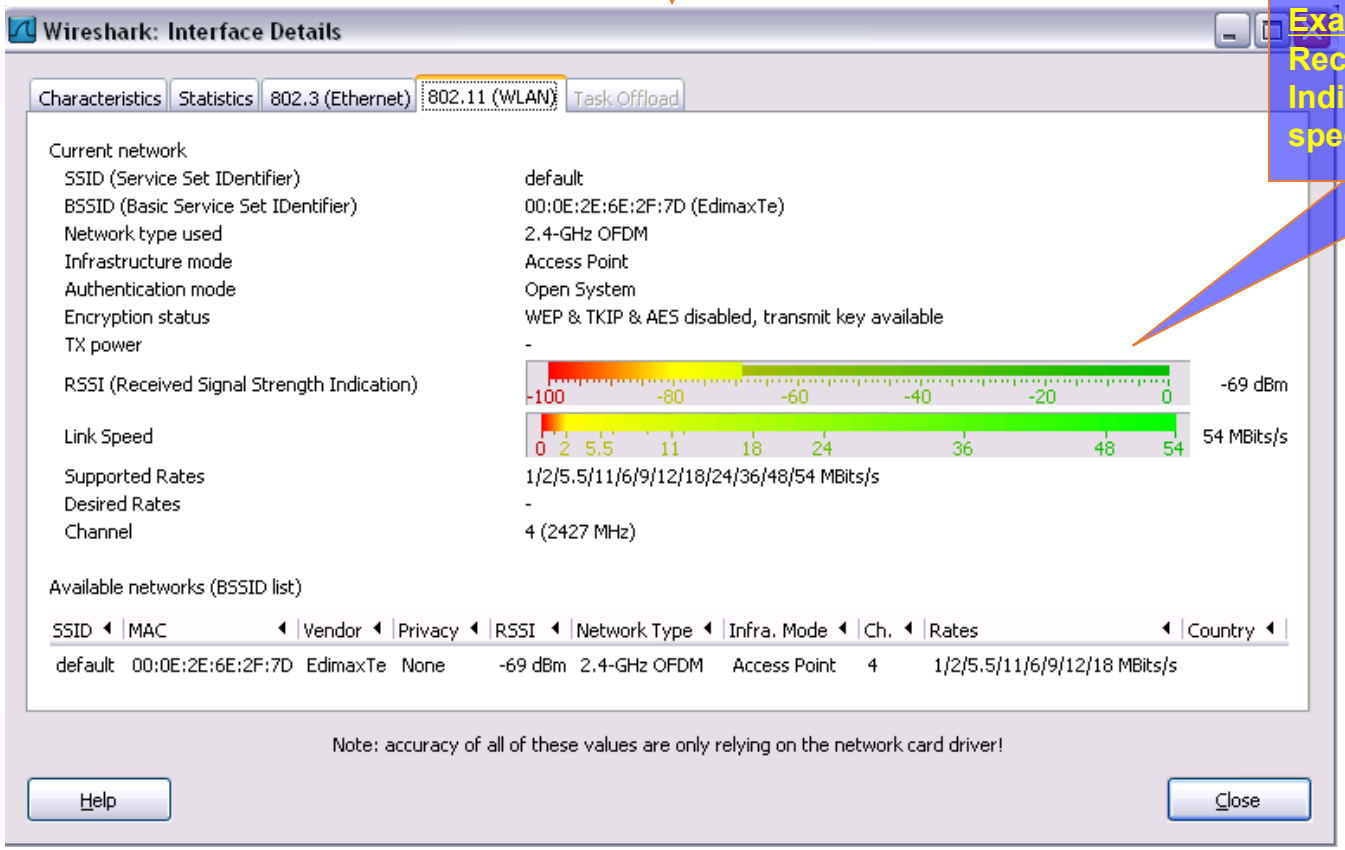
Capture in multiple files

Name resolution options

When to automatically stop the capture

Capturing Packets (3/3)





Example (W-LAN):
Received Signal Strength Indication (RSSI) and Link speed (BW)

Analyzing Packets (1/9)

- Ethernet Frame Example

No.	Time	Source	Destination	Protocol	Info
4	23.227539	1.1.1.1	127.0.0.1	UDP	Source port: 33333 Destinat
5	23.838867	212.179.1.202	10.159.3.103	FTP	Response: 200 Type set to I.
6	23.857421	10.159.3.103	212.179.1.202	FTP	Request: SIZE upload1_1936
7	23.996093	212.179.1.202	10.159.3.103	FTP	Response: 213 11026917
8	24.012695	10.159.3.103	212.179.1.202	FTP	Request: MDTM upload1_1936
9	24.208984	212.179.1.202	10.159.3.103	FTP	Response: 213 20071202174050
10	24.266601	10.159.3.103	212.179.1.202	FTP	Request: PASV
11	24.391601	212.179.1.202	10.159.3.103	FTP	Response: 227 Entering Passi

```
Frame 10 (60 bytes on wire, 60 bytes captured)
    Arrival Time: Jan 13, 2008 11:44:18.844726000
    [Time delta from previous captured frame: 0.057617000 seconds]
    [Time delta from previous displayed frame: 0.057617000 seconds]
    [Time since reference or first frame: 24.266601000 seconds]
    Frame Number: 10
    Frame Length: 60 bytes
    Capture Length: 60 bytes
    [Frame is marked: False]
    [Protocols in frame: eth:ip:tcp:ftp]
    [Coloring Rule Name: TCP]
    [Coloring Rule String: tcp]
Ethernet II, Src: Xerox_00:00:00 (01:00:01:00:00:00), Dst: d4:c8:20:00:01:00 (d4:c8:20:00:01:00)
  Destination: d4:c8:20:00:01:00 (d4:c8:20:00:01:00)
      Address: d4:c8:20:00:01:00 (d4:c8:20:00:01:00)
      .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
      .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
  Source: Xerox_00:00:00 (01:00:01:00:00:00)
      Address: Xerox_00:00:00 (01:00:01:00:00:00)
      .... ...1 .... .... .... .... = IG bit: Group address (multicast/broadcast)
      .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
    Type: IP (0x0800)
Internet Protocol, Src: 10.159.3.103 (10.159.3.103), Dst: 212.179.1.202 (212.179.1.202)
Transmission Control Protocol, Src Port: mps-raft (1700), Dst Port: ftp (21), Seq: 47, Ack: 55, Len: 6
File Transfer Protocol (FTP)
```

Analyzing Packets (2/9)

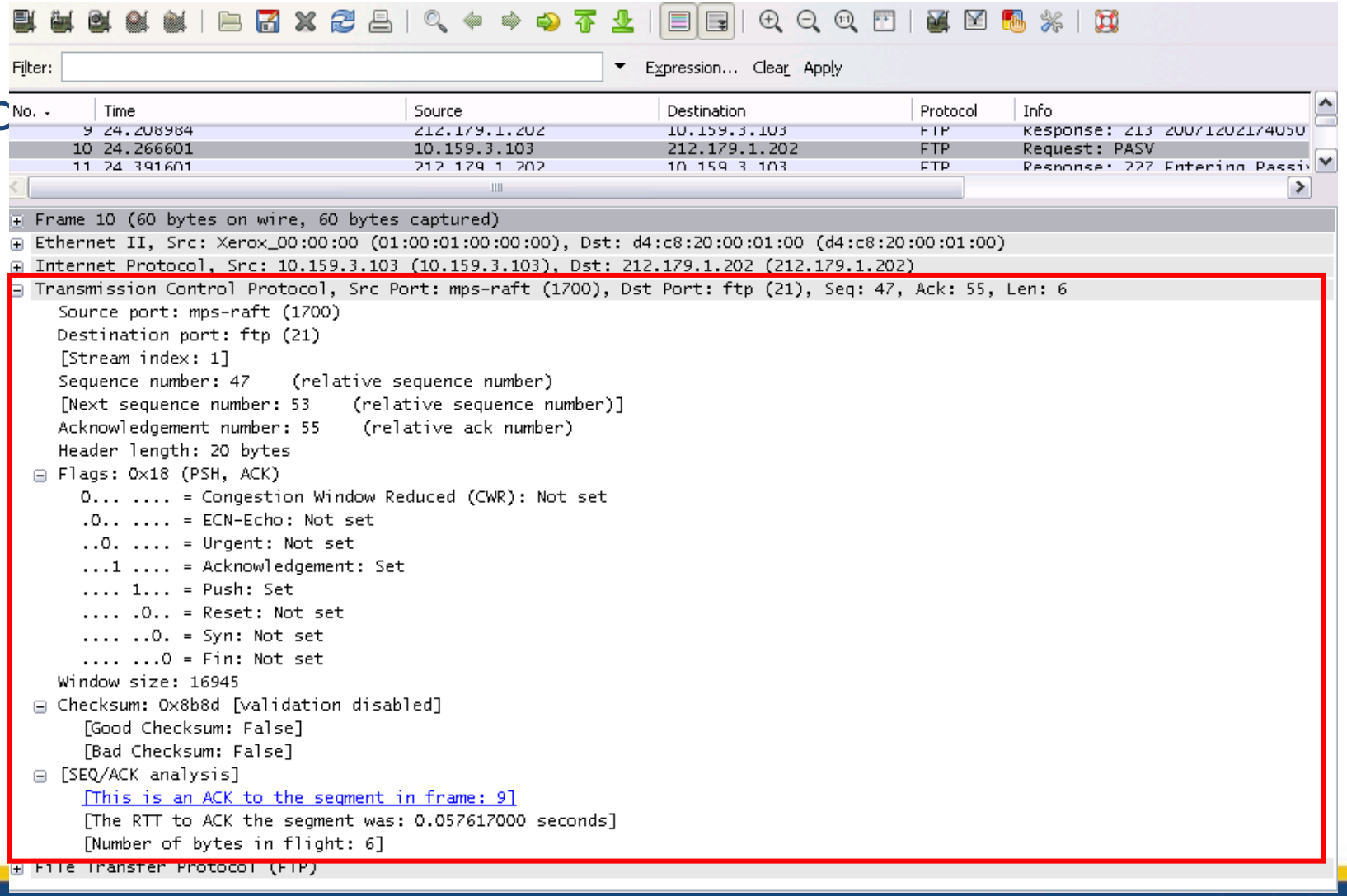
- IP Pac

No.	Time	Source	Destination	Protocol	Info
4	23.227539	1.1.1.1	127.0.0.1	UDP	Source port: 33333 Destinat
5	23.838867	212.179.1.202	10.159.3.103	FTP	Response: 200 Type set to I.
6	23.857421	10.159.3.103	212.179.1.202	FTP	Request: SIZE upload1_1936
7	23.996093	212.179.1.202	10.159.3.103	FTP	Response: 213 11026917
8	24.012695	10.159.3.103	212.179.1.202	FTP	Request: MDTM upload1_1936
9	24.208984	212.179.1.202	10.159.3.103	FTP	Response: 213 20071202174050
10	24.266601	10.159.3.103	212.179.1.202	FTP	Request: PASV

```
⊞ Frame 10 (60 bytes on wire, 60 bytes captured)
⊞ Ethernet II, Src: Xerox_00:00:00 (01:00:01:00:00:00), Dst: d4:c8:20:00:01:00 (d4:c8:20:00:01:00)
⊟ Internet Protocol, Src: 10.159.3.103 (10.159.3.103), Dst: 212.179.1.202 (212.179.1.202)
    Version: 4
    Header length: 20 bytes
  ⊟ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
      0000 00.. = Differentiated Services Codepoint: Default (0x00)
      .... ..0. = ECN-Capable Transport (ECT): 0
      .... ...0 = ECN-CE: 0
    Total Length: 46
    Identification: 0x5f49 (24393)
  ⊟ Flags: 0x04 (Don't Fragment)
      0... = Reserved bit: Not set
      .1.. = Don't fragment: Set
      ..0. = More fragments: Not set
    Fragment offset: 0
    Time to live: 128
    Protocol: TCP (0x06)
  ⊟ Header checksum: 0xb6fd [correct]
      [Good: True]
      [Bad : False]
    Source: 10.159.3.103 (10.159.3.103)
    Destination: 212.179.1.202 (212.179.1.202)
⊞ Transmission Control Protocol, Src Port: mps-raft (1700), Dst Port: ftp (21), Seq: 47, Ack: 55, Len: 6
⊞ File Transfer Protocol (FTP)
```

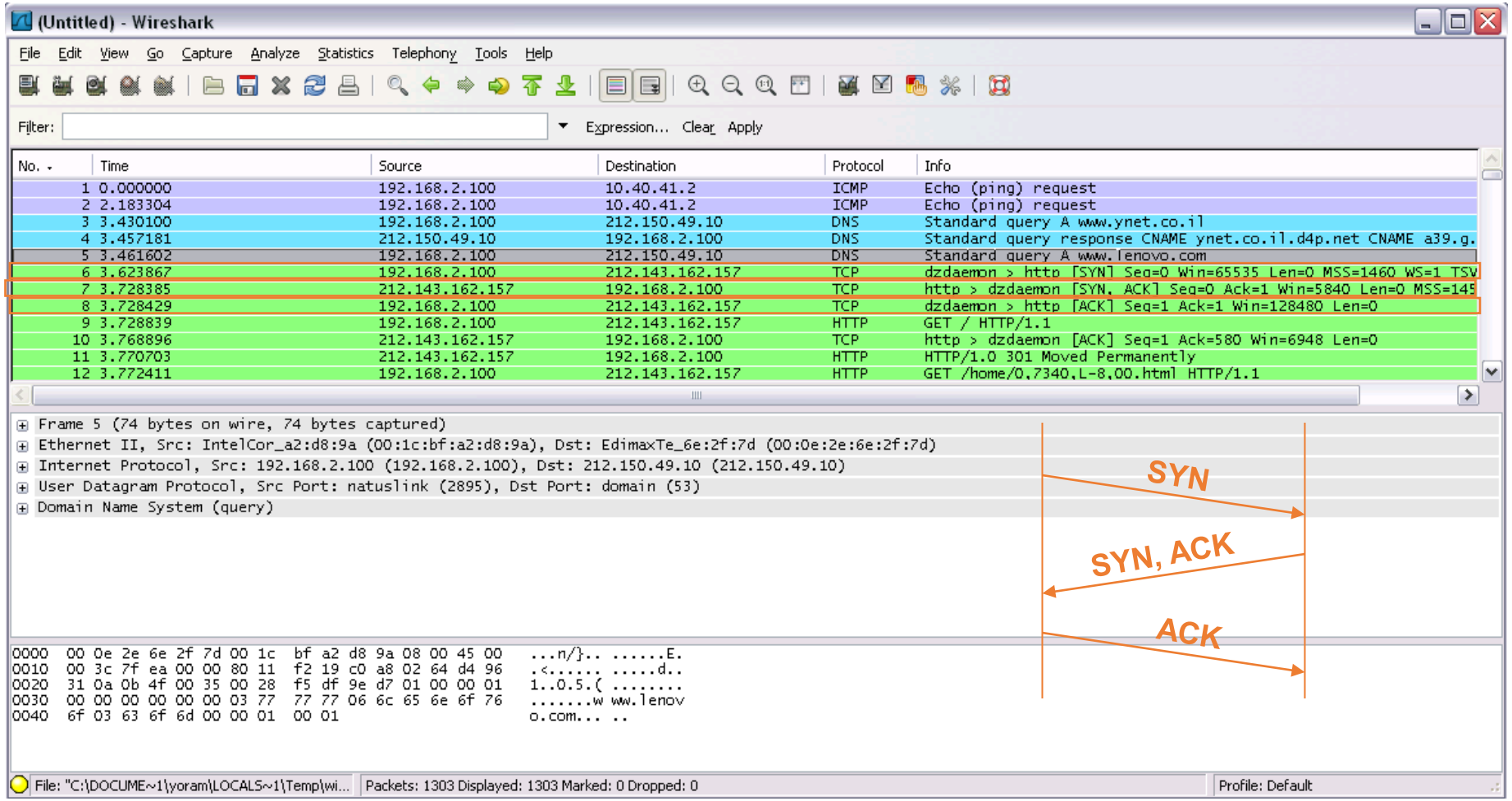
Analyzing Packets (3/9)

- TCP Pac



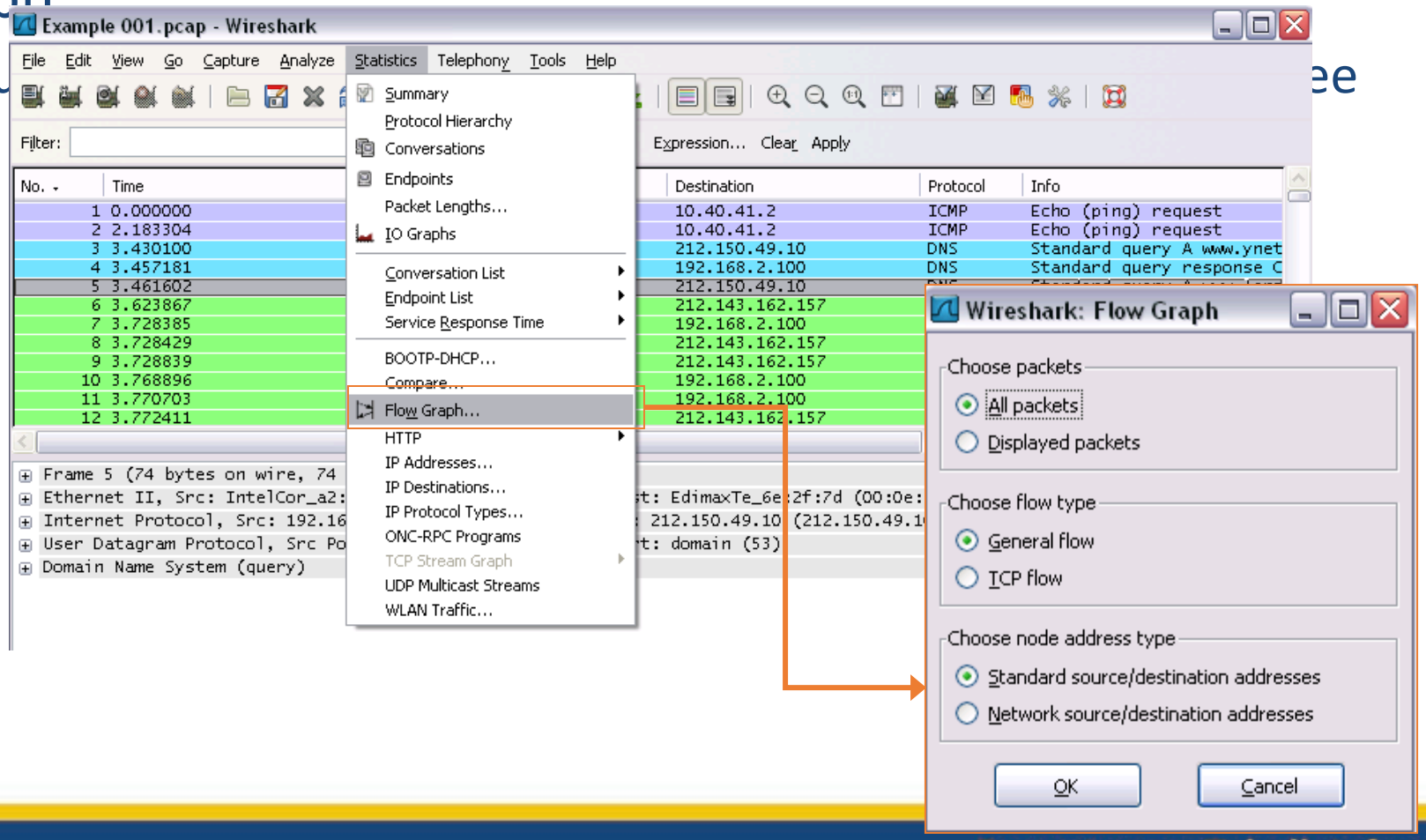
Analyzing Packets (4/9)

- TCP



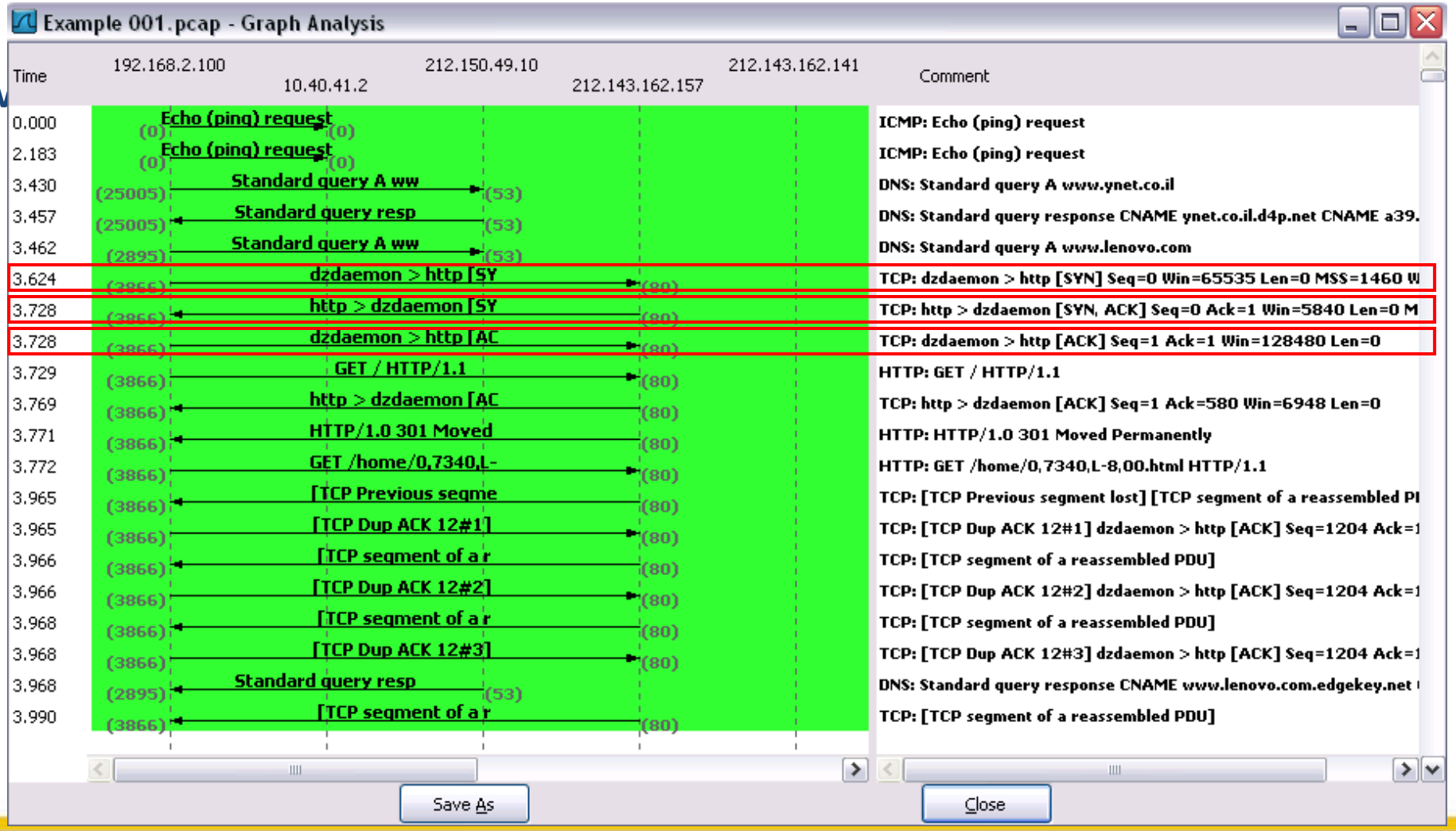
Analyzing Packets (5/9)

- Flow Graph
  - Giving u



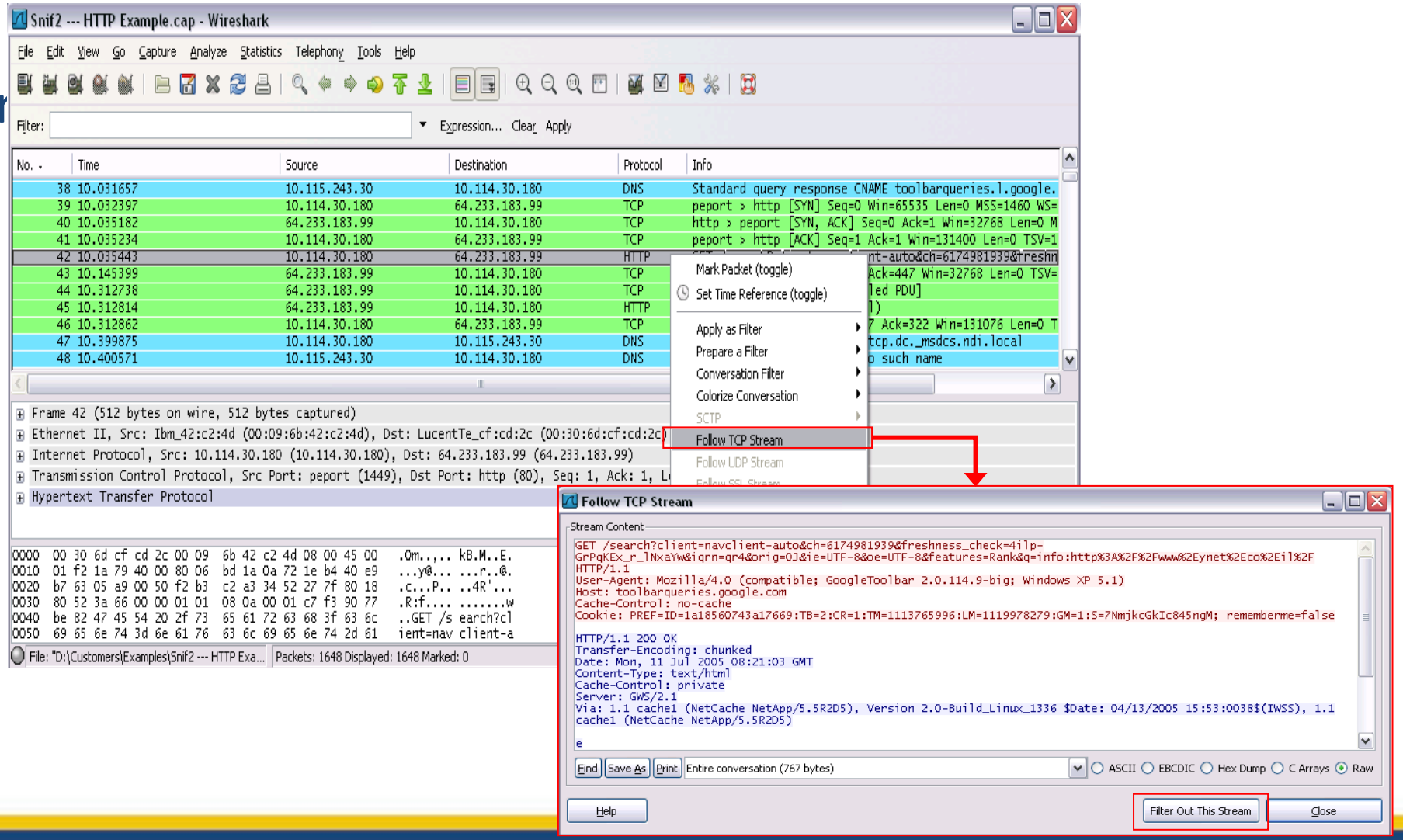
Analyzing Packets (6/9)

- Flow



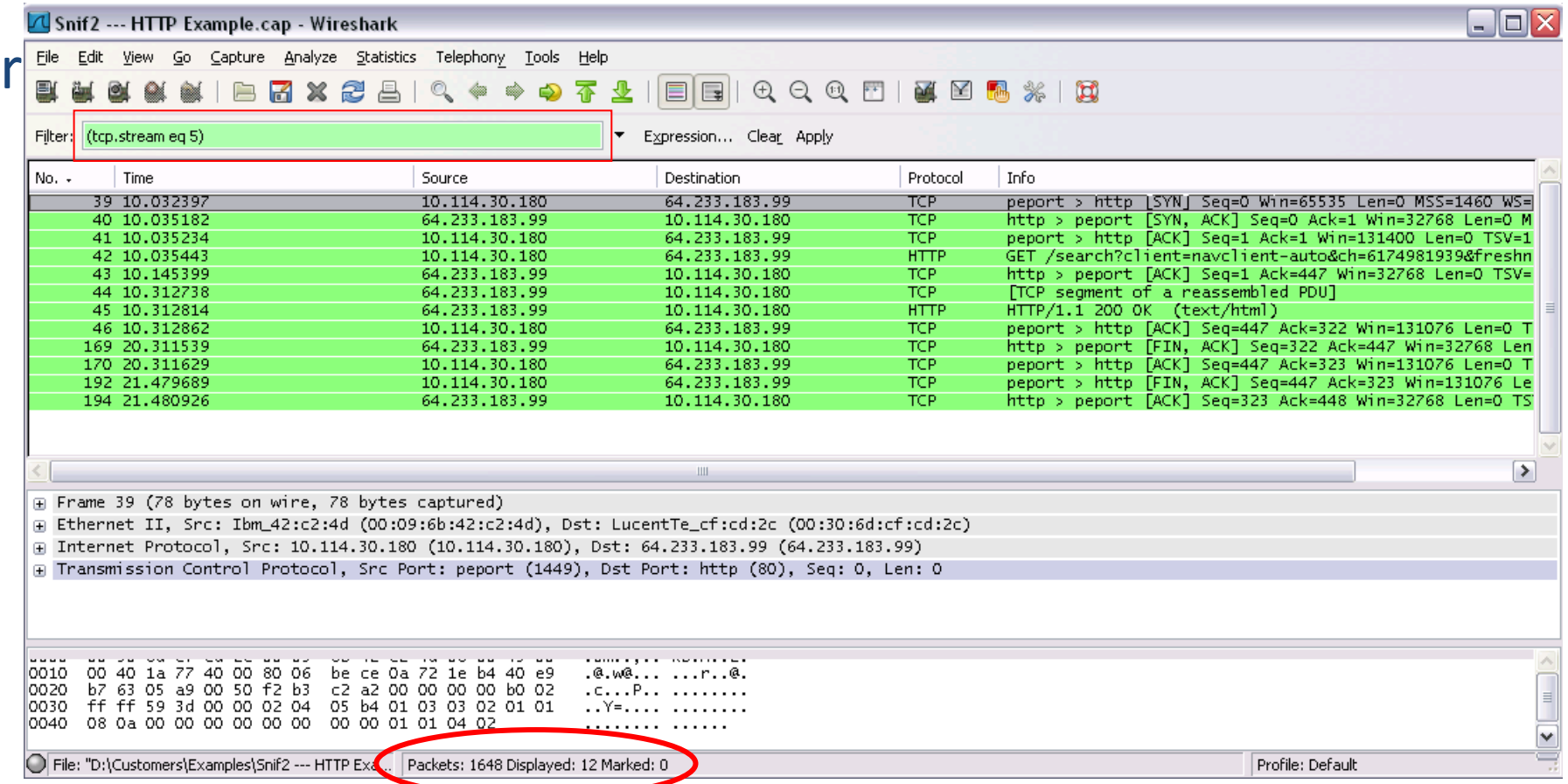
Analyzing Packets (7/9)

- Filter



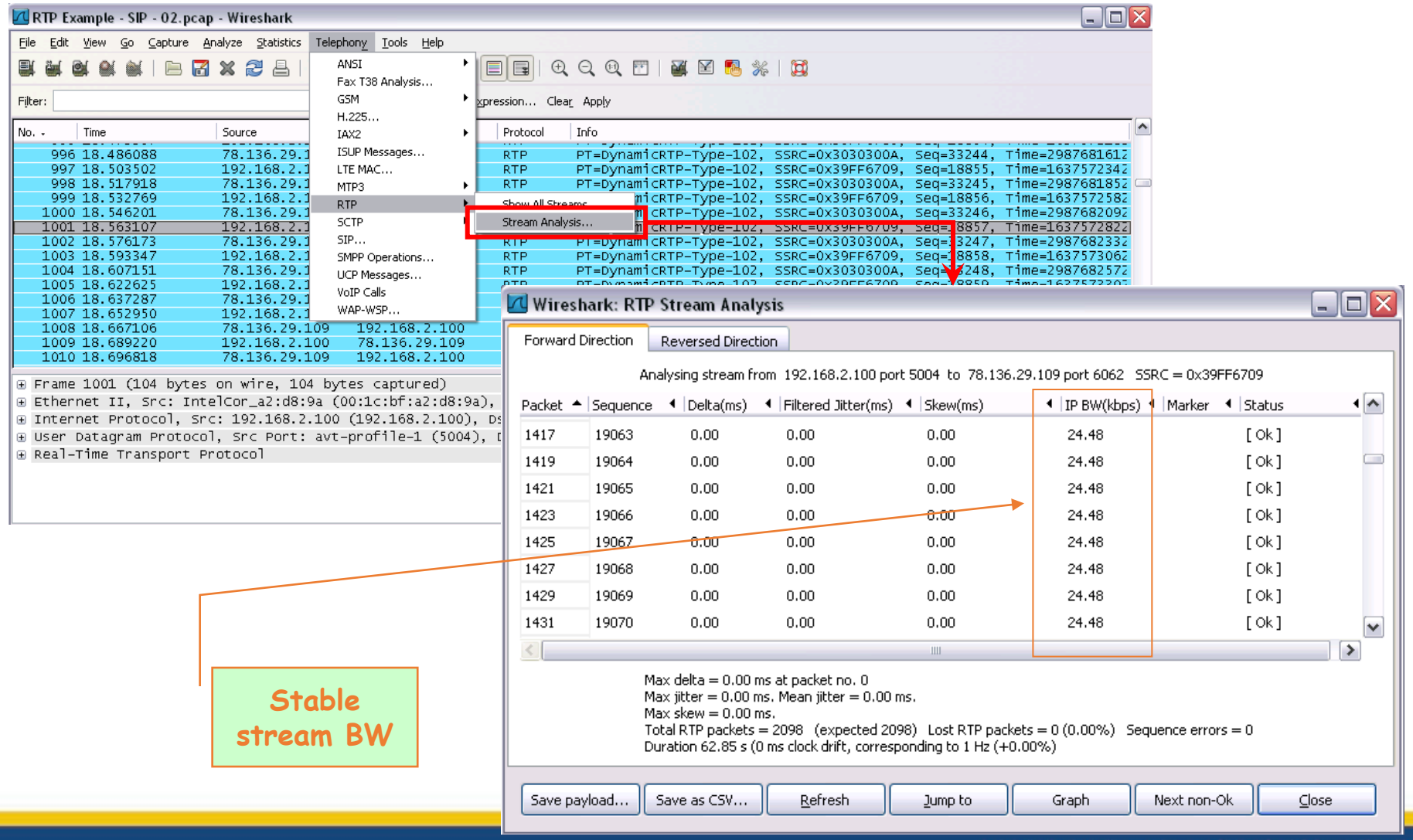
Analyzing Packets (8/9)

- Filter



Analyzing Packets (9/9)

- RTP

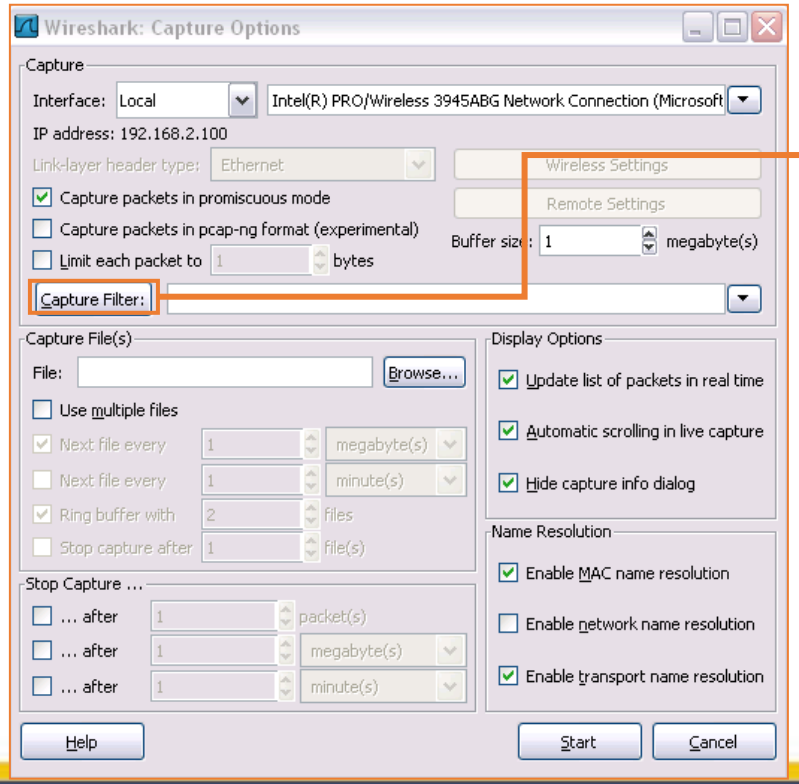


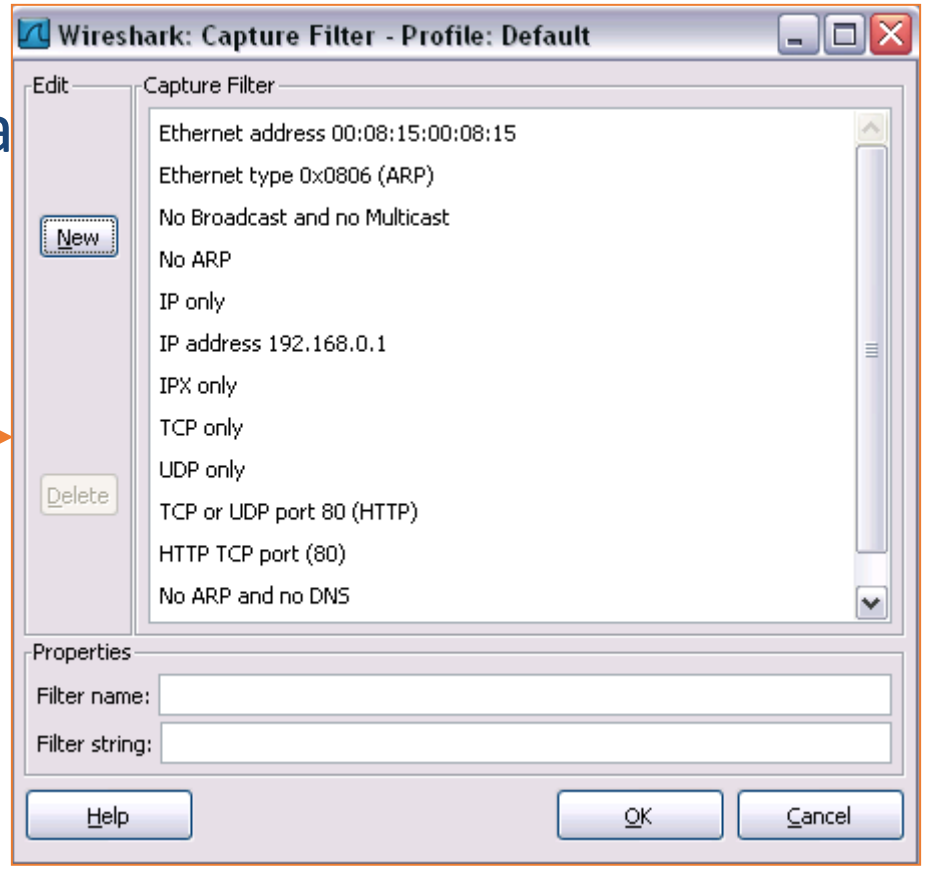
Stable stream BW

Filtering Packets (1/4)

- Applying Filter when Capturing Pa

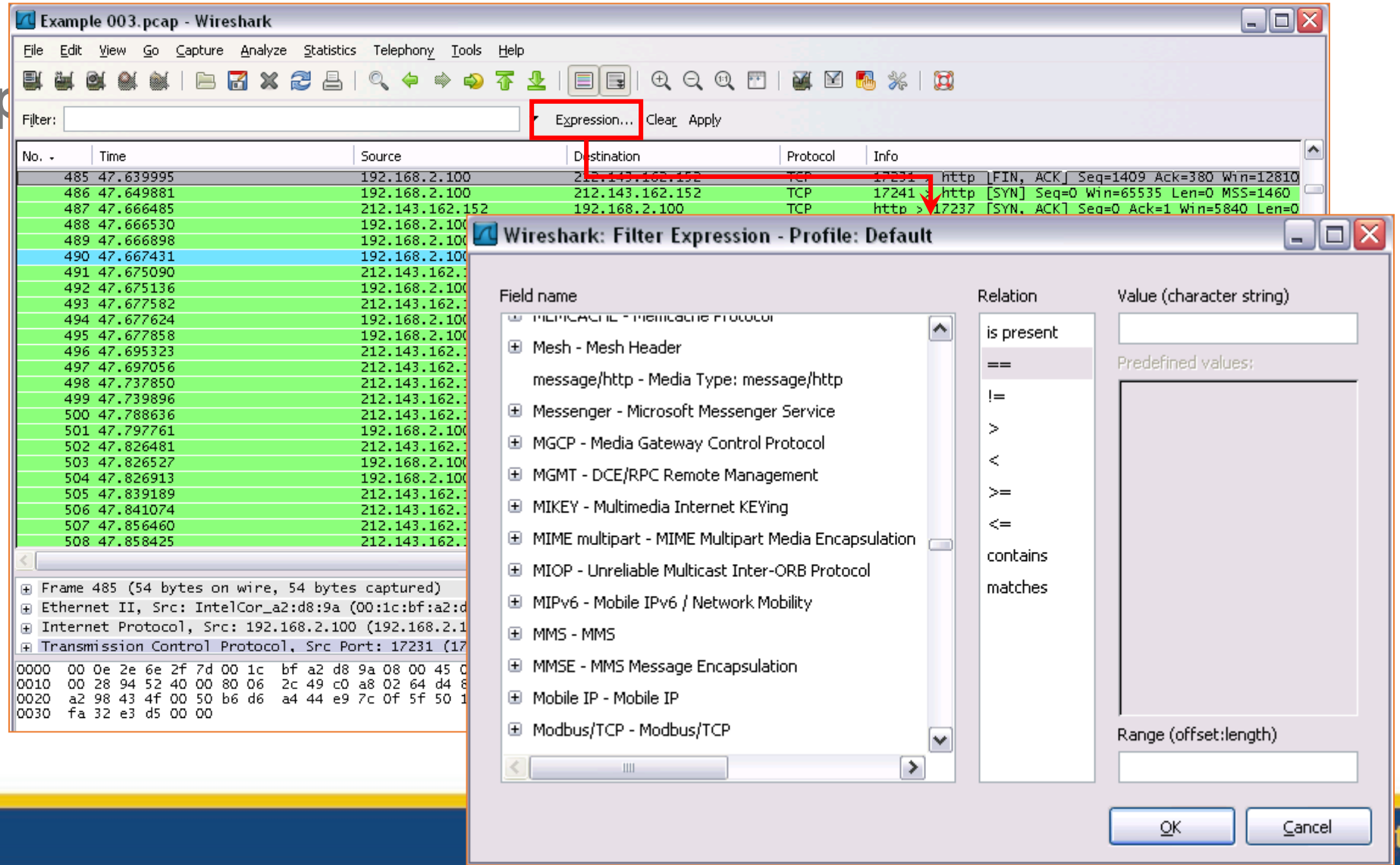
Capture → Interfaces → Options:





Filtering Packets (2/4)

- Ap



Filtering Packets (3/4)

- Examples:
  - Capture only traffic to or from IP address 172.18.5.4
    - **host 172.18.5.4**
  - Capture traffic to or from a range of IP addresses
    - **net 192.168.0.0/24**
    - **net 192.168.0.0 mask 255.255.255.0**
  - Capture traffic from a range of IP addresses
    - **src net 192.168.0.0/24**
    - **src net 192.168.0.0 mask 255.255.255.0**
  - Capture traffic to a range of IP addresses
    - **dst net 192.168.0.0/24**
    - **dst net 192.168.0.0 mask 255.255.255.0**
  - Capture only DNS (port 53) traffic
    - **port 53**
  - Capture non-HTTP and non-SMTP traffic on your server
    - **host www.example.com and not (port 80 or port 25)**
    - **host www.example.com and not port 80 and not port 25**

Filtering Packets (4/4)

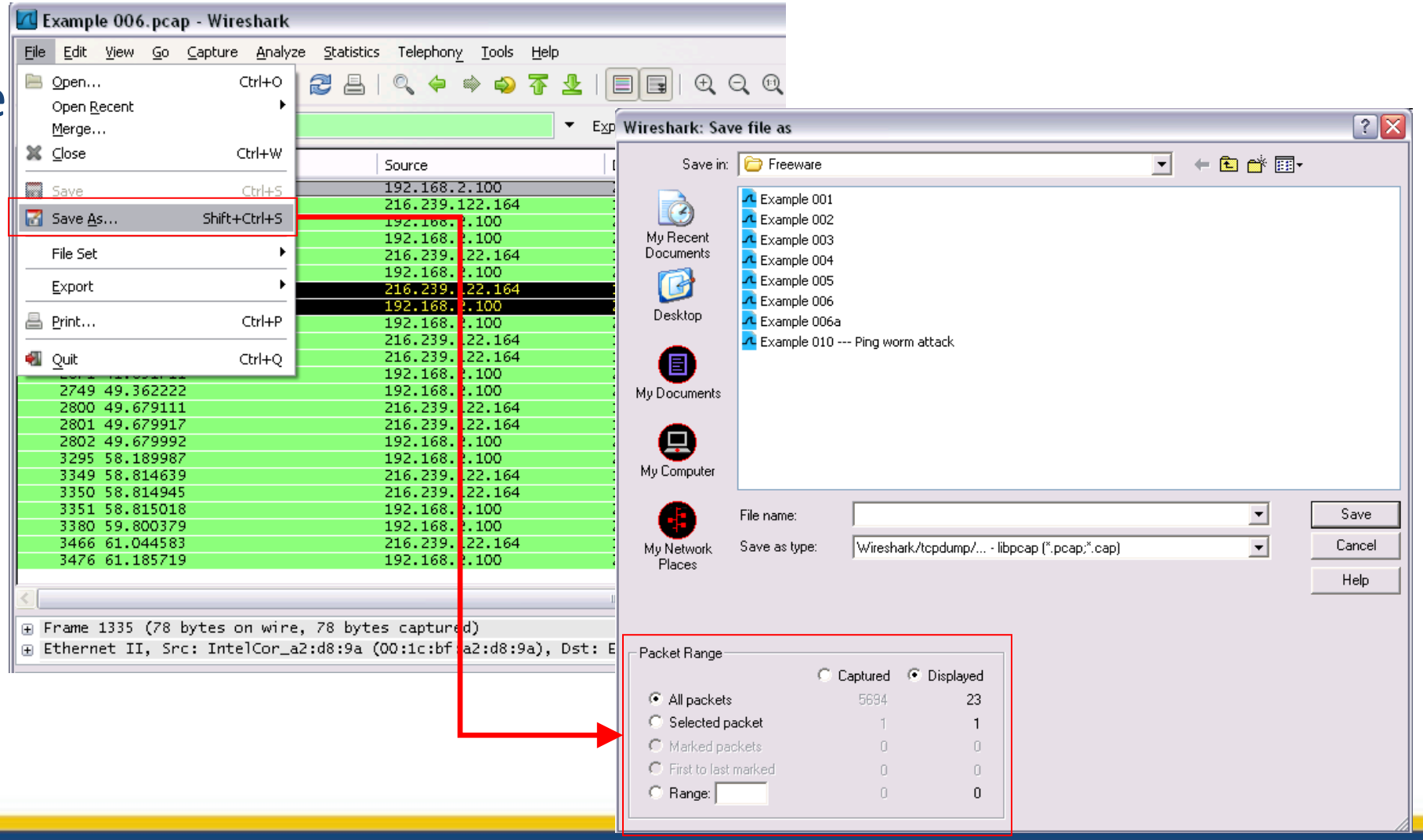
- Examples:
  - Capture except all ARP and DNS traffic
    - **port not 53 and not arp**
  - Capture traffic within a range of ports
    - **(tcp[2:2] > 1500 and tcp[2:2] < 1550) or (tcp[4:2] > 1500 and tcp[4:2] < 1550)**
    - **tcp portrange 1501-1549**
  - Capture only Ethernet type EAPOL
    - **ether proto 0x888e**
  - Capture only IP traffic

    (the shortest filter, but sometimes very useful to get rid of lower layer protocols like ARP and STP)
    - **ip**
  - Capture only unicast traffic

    (useful to get rid of noise on the network if you only want to see traffic to and from your machine, not, for example, broadcast and multicast announcements)
    - **not broadcast and not multicast**

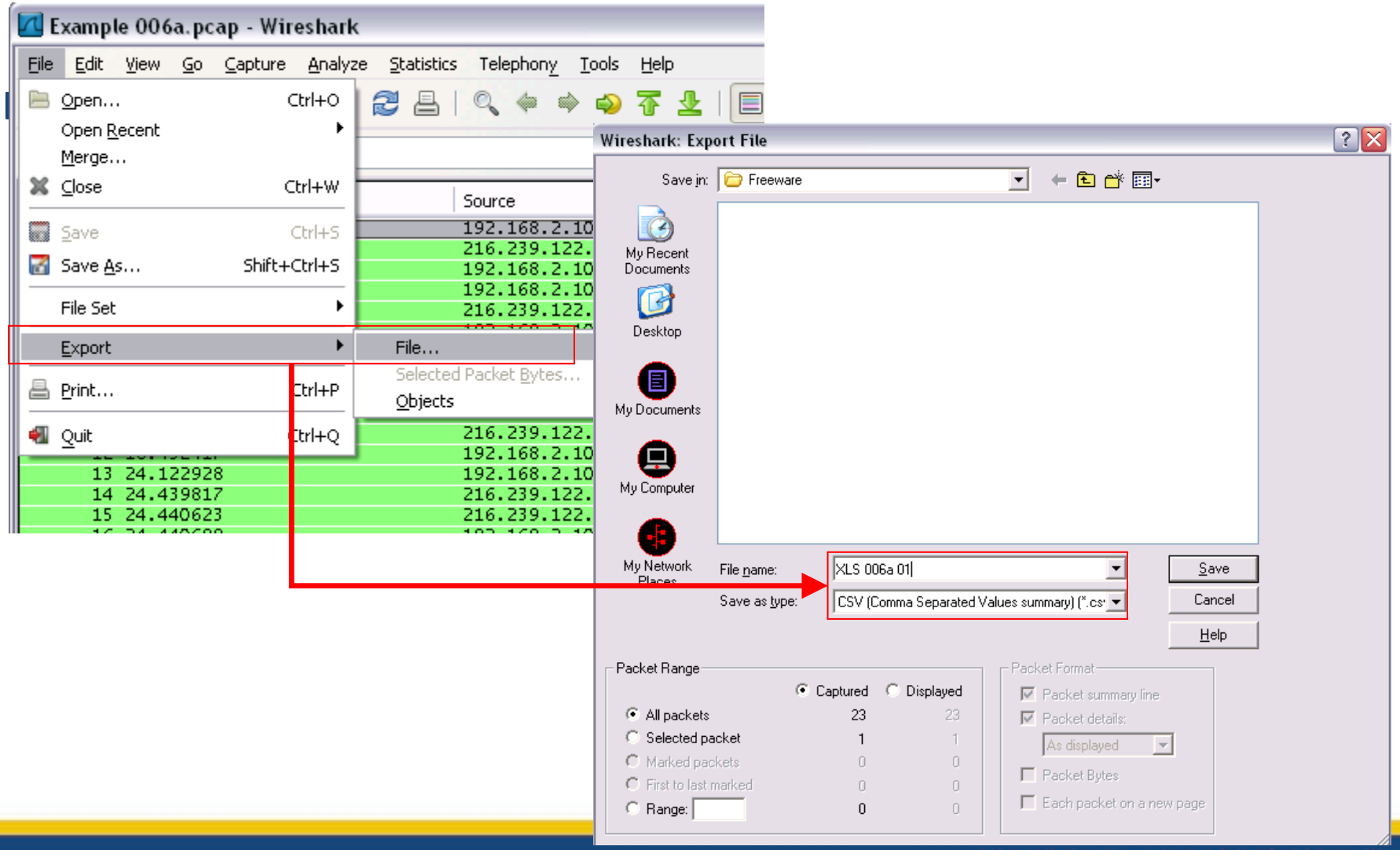
Saving and Manipulating Packets (1/3)

- Save



Saving and Manipulating Packets (2/3)

- Expor



Saving and Manipulating Packets (3/3)

- Expo

No.	Time	Time Variation	Source	Destination	Protocol	Info
1	0	0	192.168.2.100	216.239.122.164	TCP	27837 > http [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=1 TSV=0 TSER=0
2	0.226724	0.226724	216.239.122.164	192.168.2.100	TCP	http > 27837 [SYN, ACK] Seq=0 Ack=1 Win=8190 Len=0 MSS=1380
3	0.226772	4.8E-05	192.168.2.100	216.239.122.164	TCP	27837 > http [ACK] Seq=1 Ack=1 Win=65535 Len=0
4	0.227146	0.227098	192.168.2.100	216.239.122.164	HTTP	GET /i/b.jpg HTTP/1.1
5	0.700674	0.473576	216.239.122.164	192.168.2.100	HTTP	HTTP/1.1 200 OK (JPEG JFIF image)
6	0.883533	0.409957	192.168.2.100	216.239.122.164	TCP	27837 > http [ACK] Seq=649 Ack=767 Win=64769 Len=0
7	1.161312	0.751355	216.239.122.164	192.168.2.100	HTTP	[TCP Retransmission] HTTP/1.1 200 OK (JPEG JFIF image)
8	1.161361	0.410006	192.168.2.100	216.239.122.164	TCP	[TCP Dup ACK 6#1] 27837 > http [ACK] Seq=649 Ack=767 Win=64769 Len=0
9	16.211468	15.801462	192.168.2.100	216.239.122.164	HTTP	GET /i/b.jpg HTTP/1.1
10	16.452024	0.650562	216.239.122.164	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
11	16.452343	15.801781	216.239.122.164	192.168.2.100	HTTP	HTTP/1.1 200 OK (JPEG JFIF image)
12	16.452417	0.650636	192.168.2.100	216.239.122.164	TCP	27837 > http [ACK] Seq=1539 Ack=1533 Win=65535 Len=0
13	24.122928	23.472292	192.168.2.100	216.239.122.164	HTTP	GET /i/b.jpg HTTP/1.1
14	24.439817	0.967525	216.239.122.164	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
15	24.440623	23.473098	216.239.122.164	192.168.2.100	HTTP	HTTP/1.1 200 OK (JPEG JFIF image)
16	24.440698	0.9676	192.168.2.100	216.239.122.164	TCP	27837 > http [ACK] Seq=2384 Ack=2299 Win=64769 Len=0
17	32.950693	31.983093	192.168.2.100	216.239.122.164	HTTP	GET /i/b.jpg HTTP/1.1
18	33.575345	1.592252	216.239.122.164	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
19	33.575651	31.983399	216.239.122.164	192.168.2.100	HTTP	HTTP/1.1 200 OK (JPEG JFIF image)
20	33.575724	1.592325	192.168.2.100	216.239.122.164	TCP	27837 > http [ACK] Seq=3269 Ack=3065 Win=65535 Len=0
21	34.561085	32.96876	192.168.2.100	216.239.122.164	HTTP	GET /b.gif HTTP/1.1
22	35.805289	2.836529	216.239.122.164	192.168.2.100	HTTP	HTTP/1.1 200 OK (GIF89a)
23	35.946425	33.109896	192.168.2.100	216.239.122.164	TCP	27837 > http [ACK] Seq=4080 Ack=3567 Win=65033 Len=0

Packet Statistics (1/8)

- **Protocol**

Wireshark: Protocol Hierarchy Statistics

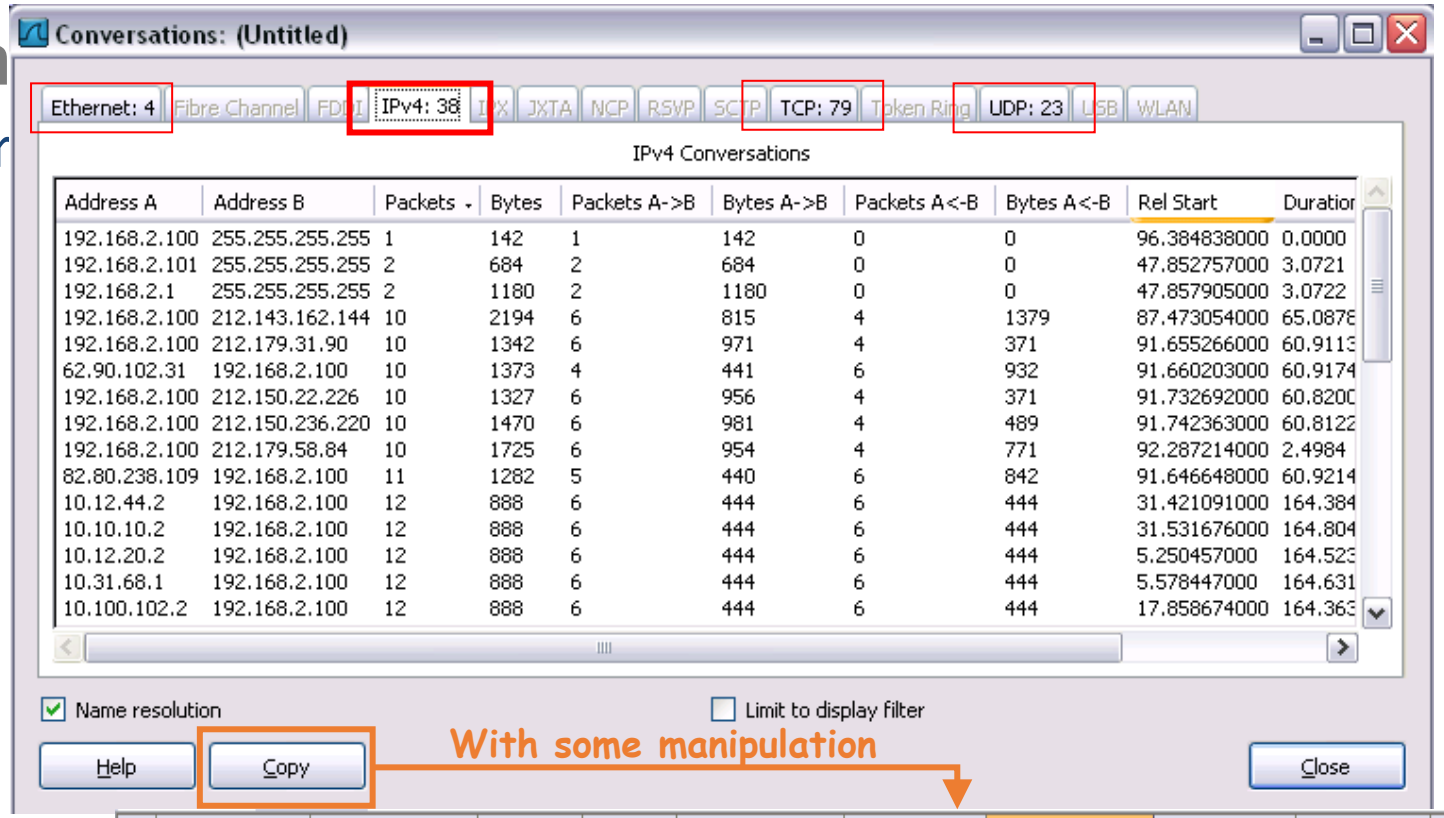
Display filter: none

Protocol	% Packets	Packets	Bytes	Mbit/s	End Packets	End Bytes	End Mbit/s
Frame	100.00 %	1276	385508	0.030	0	0	0.000
Ethernet	100.00 %	1276	385508	0.030	0	0	0.000
Internet Protocol	99.69 %	1272	385340	0.030	0	0	0.000
Internet Control Message Protocol	8.23 %	105	7770	0.001	105	7770	0.001
User Datagram Protocol	4.86 %	62	11029	0.001	0	0	0.000
Simple Network Management Protocol	1.57 %	20	1825	0.000	20	1825	0.000
Bootstrap Protocol	0.31 %	4	1864	0.000	4	1864	0.000
NetBIOS Name Service	0.24 %	3	276	0.000	3	276	0.000
Domain Name Service	2.66 %	34	6922	0.001	34	6922	0.001
Data	0.08 %	1	142	0.000	1	142	0.000
Transmission Control Protocol	86.60 %	1105	366541	0.028	658	149347	0.011
Post Office Protocol	1.41 %	18	1486	0.000	18	1486	0.000
Hypertext Transfer Protocol	33.62 %	429	215708	0.017	388	188597	0.014
Line-based text data	2.27 %	29	21877	0.002	29	21877	0.002
JPEG File Interchange Format	0.08 %	1	59	0.000	1	59	0.000
eXtensible Markup Language	0.39 %	5	2730	0.000	5	2730	0.000
Media Type	0.16 %	2	1160	0.000	2	1160	0.000
Compuserve GIF	0.31 %	4	1285	0.000	4	1285	0.000
Address Resolution Protocol	0.31 %	4	168	0.000	4	168	0.000

Help Close

Packet Statistics (2/8)

- Con
  - Tr

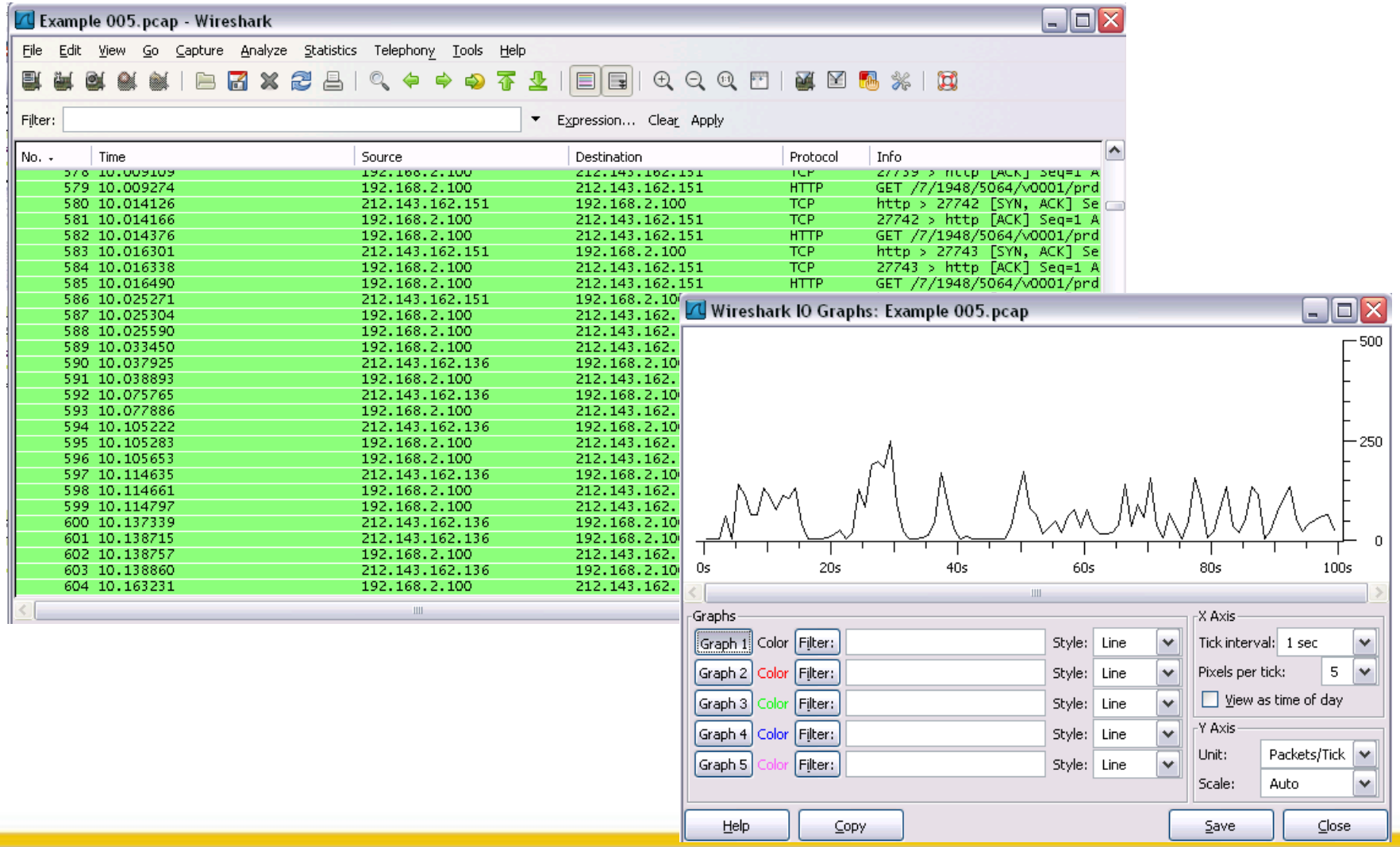


With some manipulation

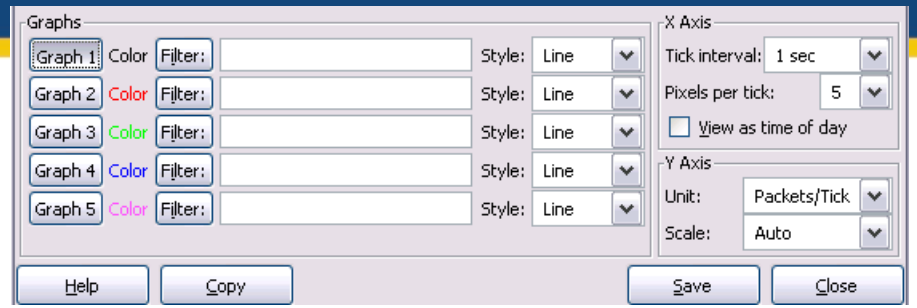
	A	B	C	D	E	F	G	H	I	J	K	L
1	Address A	Address B	Packets	Bytes	Packets A->B	Bytes A->B	Packets A<-B	Bytes A<-B	Rel Start	Duration	bps A->B	bps A<-B
2	10.10.10.1	10.159.3.103	2	124	0	0	2	124	0	42.0039	N/A	23.62
3	1.1.1.1	10.159.3.103	2	120	0	0	2	120	24.49414	1.1885	N/A	807.76
4	1.1.1.1	127.0.0.1	4	248	4	248	0	0	10.713867	14.9814	132.43	N/A
5	10.159.3.103	212.179.1.202	491	458158	185	10643	306	447515	23.216796	15.4082	5525.89	232351.54

Packet Statistics (3/8)

- I/O G



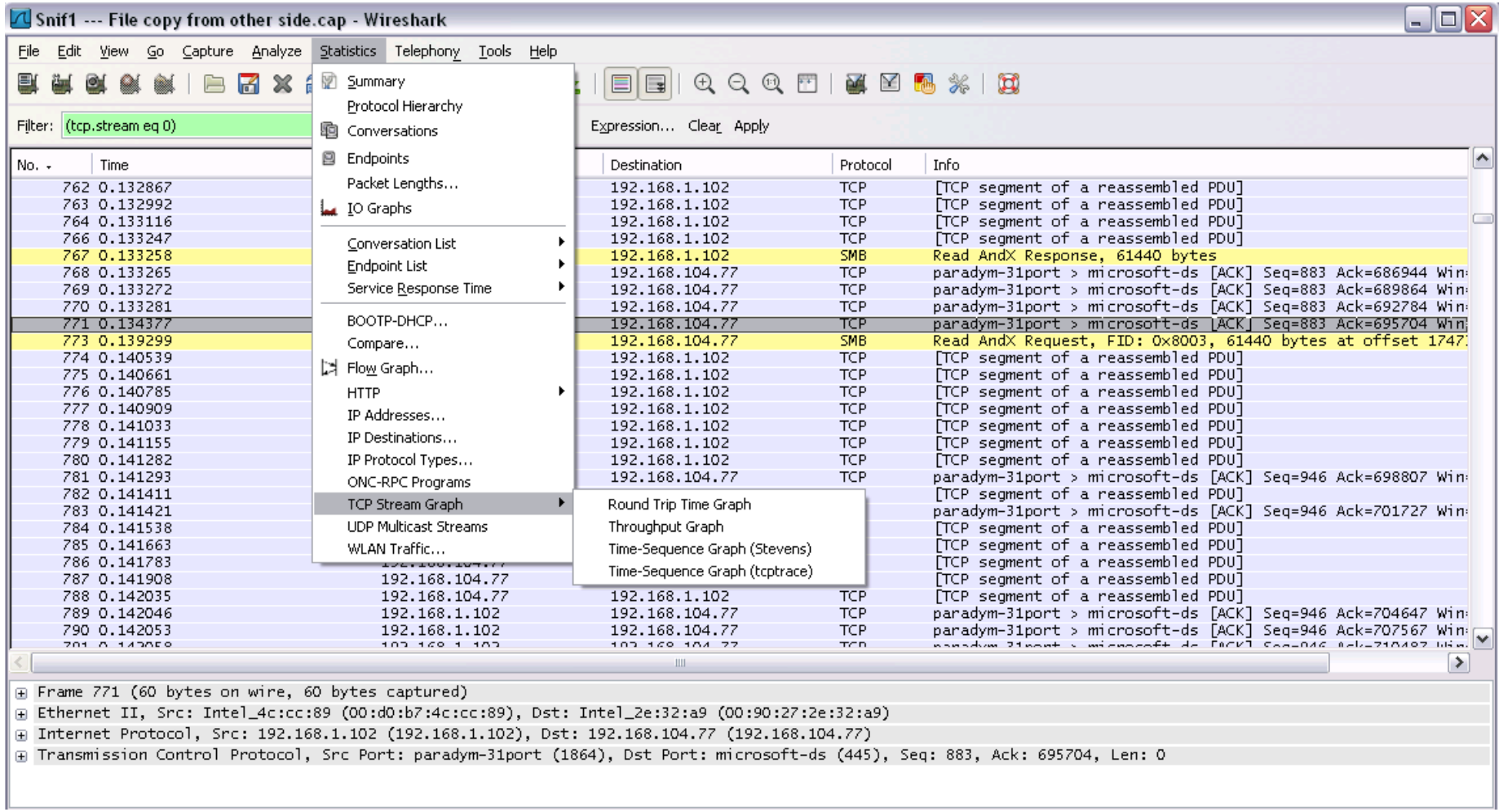
Packet Statistics (4/8)



- Configurable Options
  - I/O Graphs
    - **Graph 1-5**: enable the specific graph 1-5 (graph 1 by default)
    - **Filter**: a display filter for this graph (only the packets that pass this filter will be taken into account for this graph)
    - **Style**: the style of the graph (Line/Impulse/FBar/Dot)
  - X Axis
    - **Tick interval**: an interval in x direction lasts (10/1 minutes or 10/1/0.1/0.01/0.001 seconds)
    - **Pixels per tick**: use 10/5/2/1 pixels per tick interval
    - **View as time of day**: option to view x direction labels as time of day instead of seconds or minutes since beginning of capture
  - Y Axis
    - **Unit**: the unit for the y direction (Packets/Tick, Bytes/Tick, Bits/Tick, Advanced...)
    - **Scale**: the scale for the y unit (Logarithmic,Auto,10,20,50,100,200,...)

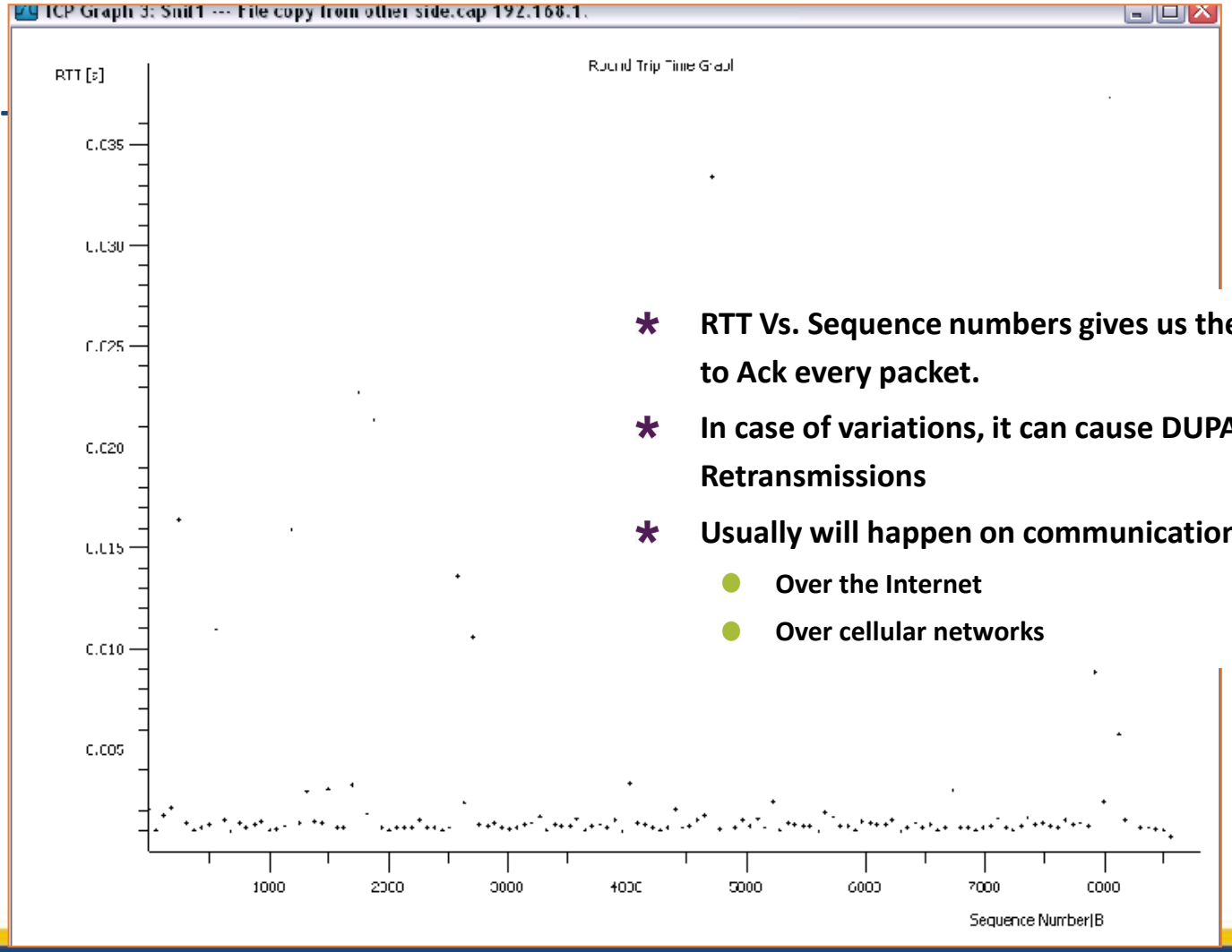
Packet Statistics (5/8)

- TCP



Packet Statistics (6/8)

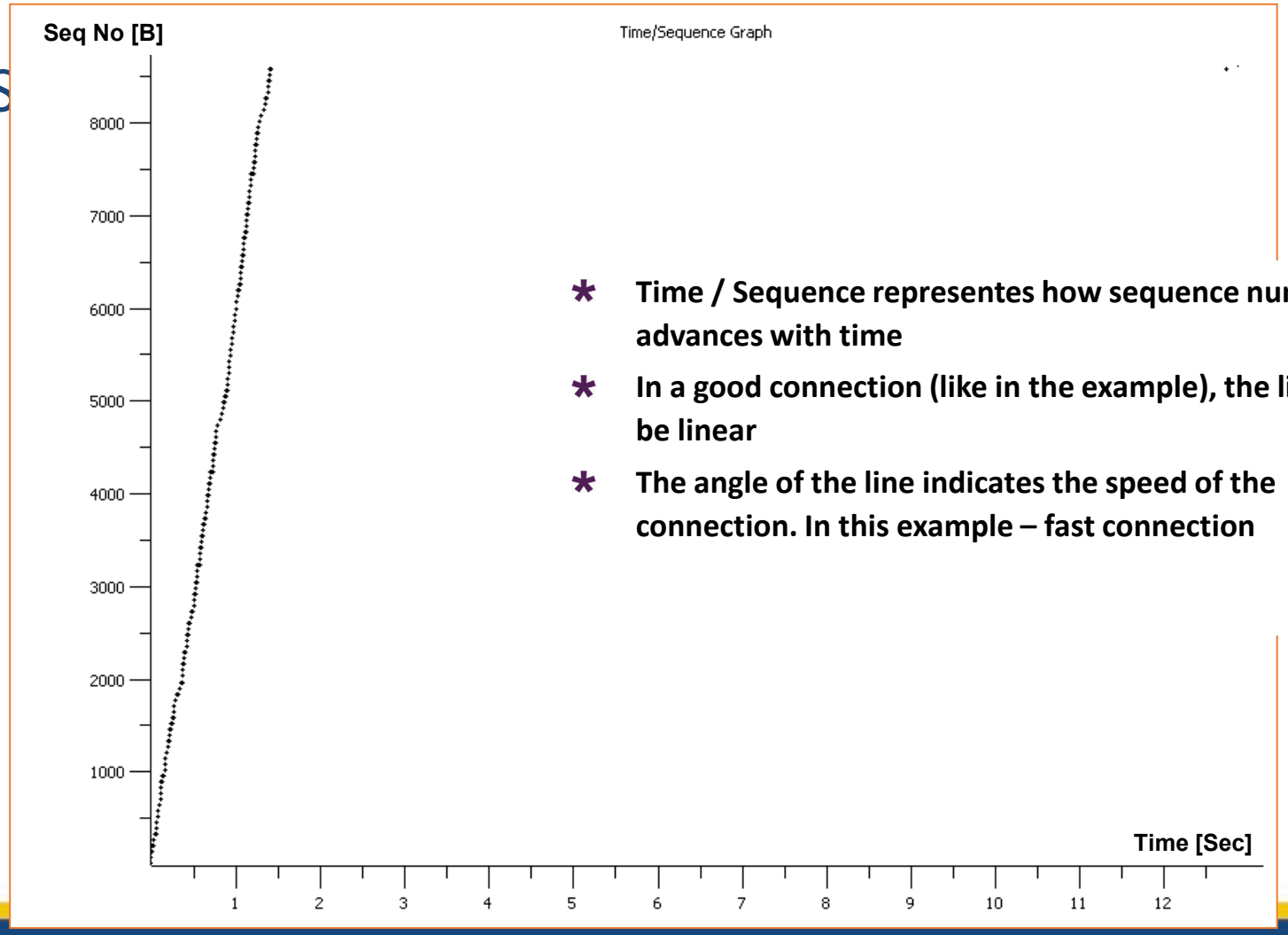
- Round-



- **RTT Vs. Sequence numbers gives us the time that take to Ack every packet.**
- **In case of variations, it can cause DUPACKs and even Retransmissions**
- **Usually will happen on communications lines:**
  - **Over the Internet**
  - **Over cellular networks**

Packet Statistics (7/8)

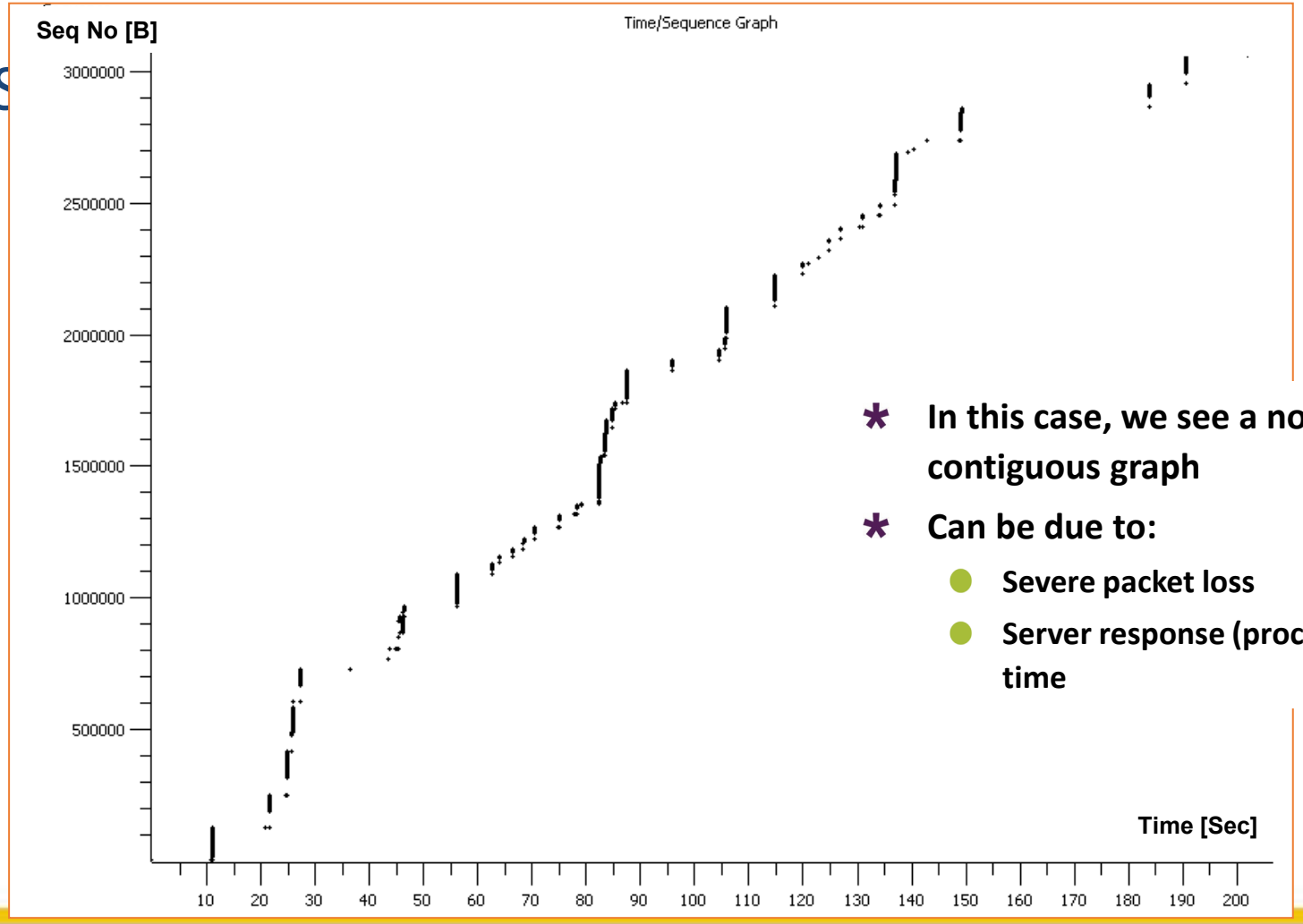
- Time / S



* **Time / Sequence representes how sequence numbers advances with time**
* **In a good connection (like in the example), the line will be linear**
* **The angle of the line indicates the speed of the connection. In this example – fast connection**

Packet Statistics (8/8)

- Time / S



- In this case, we see a non-contiguous graph
- Can be due to:
  - Severe packet loss
  - Server response (processing) time

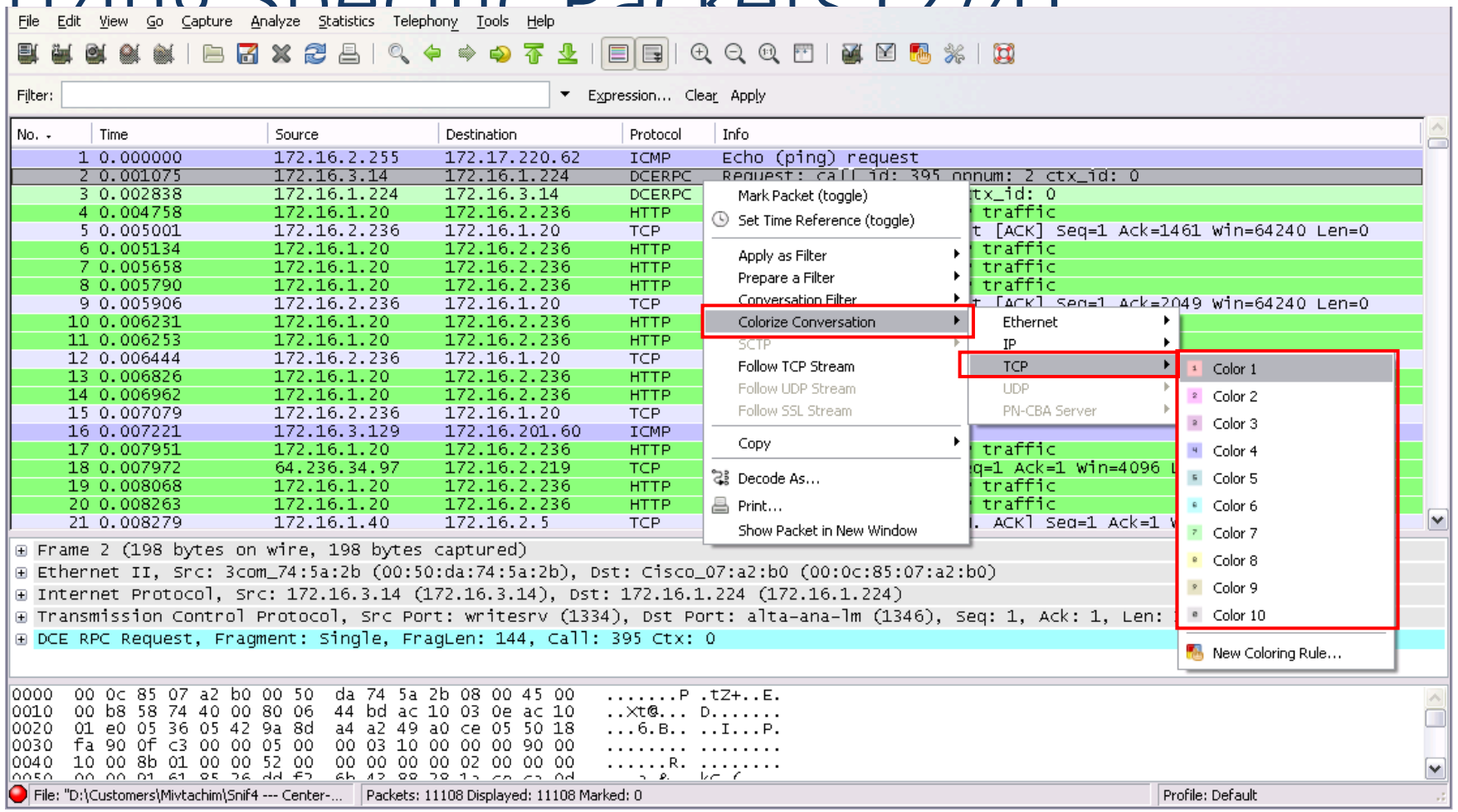
Coloring Specific Packets (1/4)

- Packets colorization
  - Colorize packets according to a filter
  - Allow to emphasize the packets interested in
  - A lot of Coloring Rule examples at the Wireshark Wiki Coloring Rules page at http://wiki.wireshark.org/ColoringRules

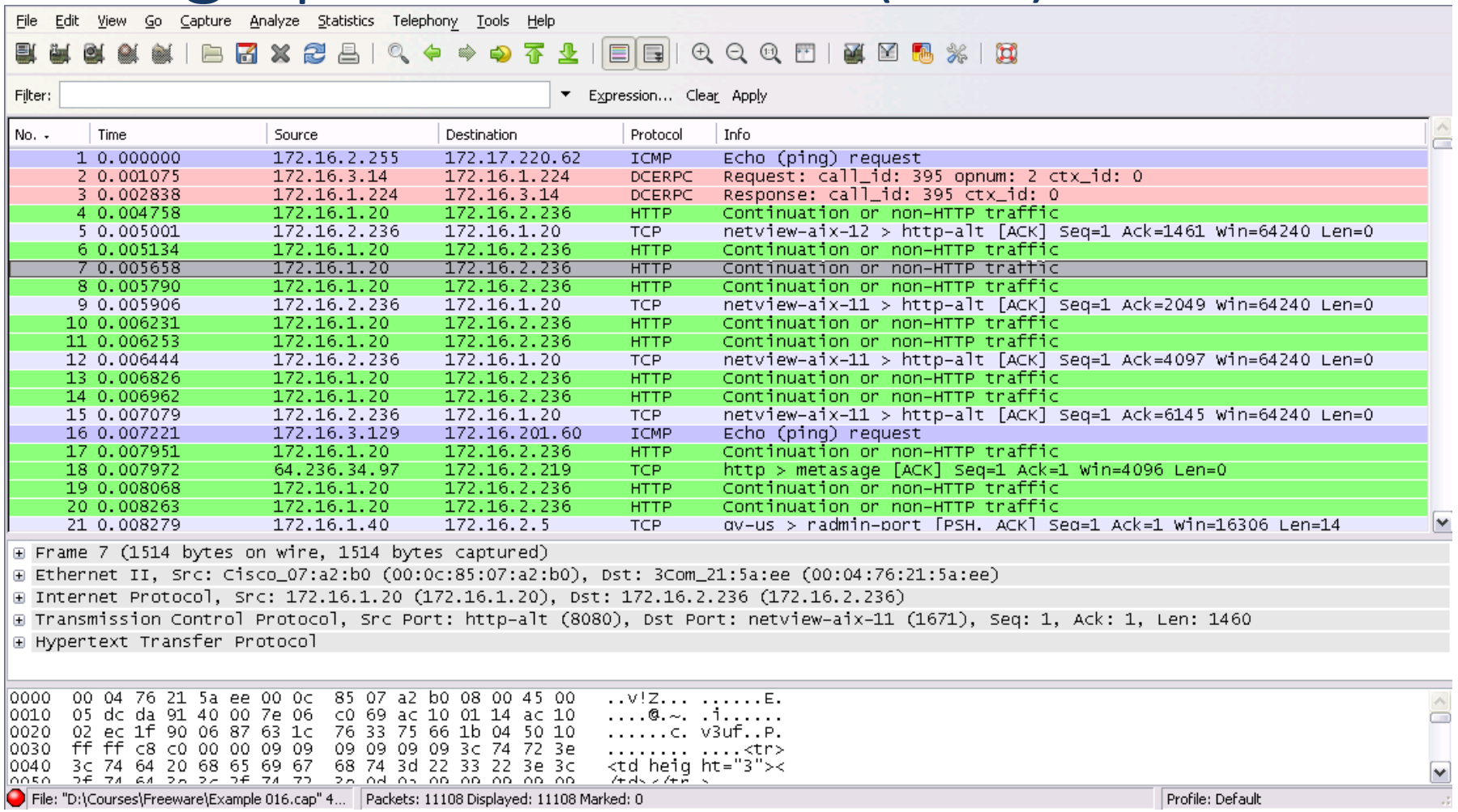
We want to watch a specific protocol through out the capture file

No.	Time	Source	Destination	Protocol	Info
1	0.000000	172.16.2.255	172.17.220.62	ICMP	Echo (ping) request
2	0.001075	172.16.3.14	172.16.1.224	DCERPC	Request: call_id: 395 opnum: 2 ctx_id: 0
3	0.002838	172.16.1.224	172.16.3.14	DCERPC	Response: call_id: 395 ctx_id: 0
4	0.004758	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
5	0.005001	172.16.2.236	172.16.1.20	TCP	netview-aix-12 > http-alt [ACK] Seq=1 Ack=1461 Win=64240 Len=0
6	0.005134	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
7	0.005658	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
8	0.005790	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
9	0.005906	172.16.2.236	172.16.1.20	TCP	netview-aix-11 > http-alt [ACK] Seq=1 Ack=2049 Win=64240 Len=0
10	0.006231	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
11	0.006253	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
12	0.006444	172.16.2.236	172.16.1.20	TCP	netview-aix-11 > http-alt [ACK] Seq=1 Ack=4097 Win=64240 Len=0
13	0.006826	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
14	0.006962	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
15	0.007079	172.16.2.236	172.16.1.20	TCP	netview-aix-11 > http-alt [ACK] Seq=1 Ack=6145 Win=64240 Len=0
16	0.007221	172.16.3.129	172.16.201.60	ICMP	Echo (ping) request
17	0.007951	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
18	0.007972	64.236.34.97	172.16.2.219	TCP	http > metasage [ACK] Seq=1 Ack=1 Win=4096 Len=0
19	0.008068	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
20	0.008263	172.16.1.20	172.16.2.236	HTTP	Continuation or non-HTTP traffic
21	0.008279	172.16.1.40	172.16.2.5	TCP	av-us > radmin-port [PSH, ACK] Seq=1 Ack=1 Win=16306 Len=14

Colorizing Specific Packets (2/4)

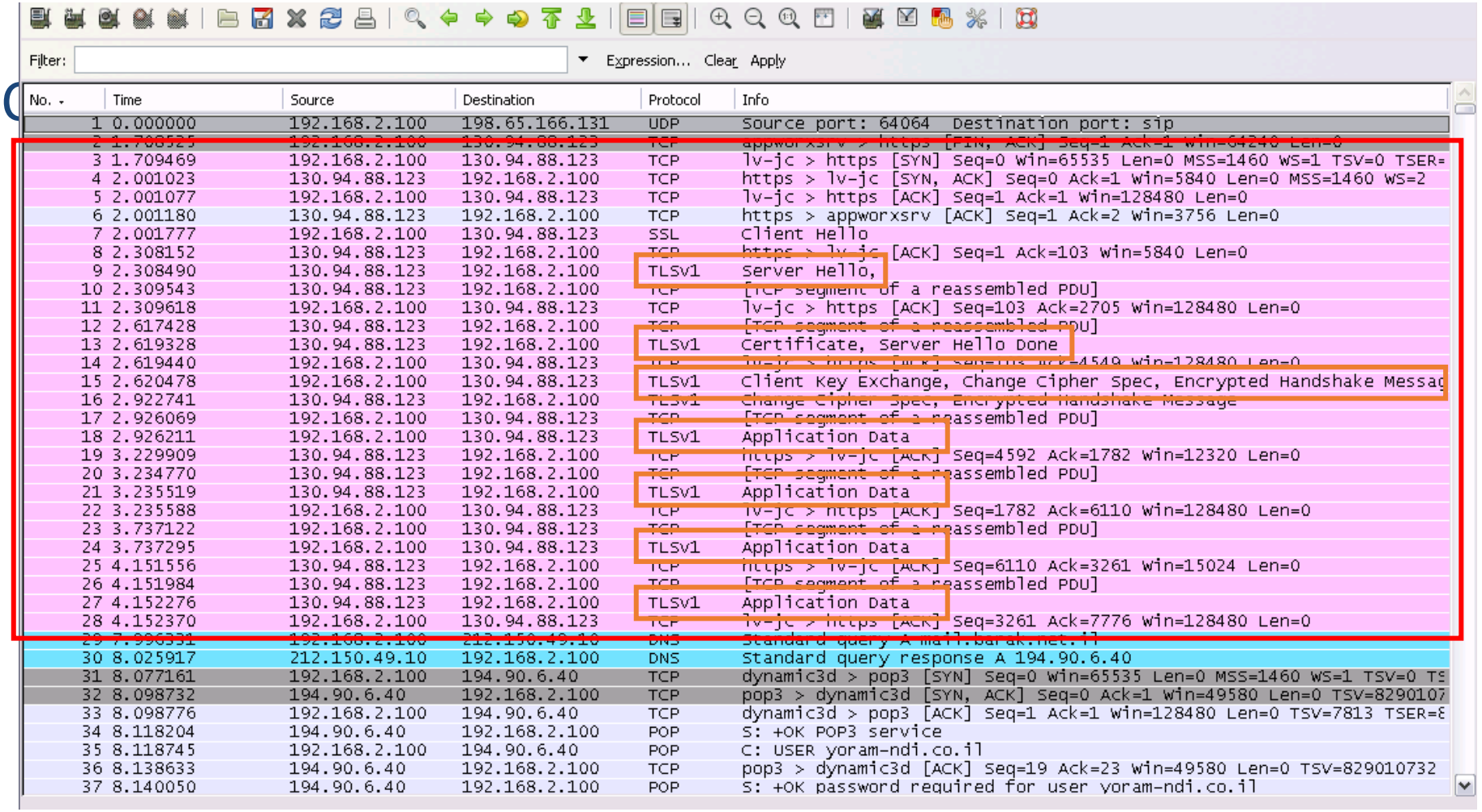


Colorizing Specific Packets (3/4)



Colorizing Specific Packets (4/4)

- TLS C



Filter: Expression... Clear Apply

No.	Time	Source	Destination	Protocol	Info
1	0.000000	192.168.2.100	198.65.166.131	UDP	Source port: 64064 Destination port: sip
3	1.709469	192.168.2.100	130.94.88.123	TCP	lv-jc > https [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=1 TSV=0 TSER=
4	2.001023	130.94.88.123	192.168.2.100	TCP	https > lv-jc [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 WS=2
5	2.001077	192.168.2.100	130.94.88.123	TCP	lv-jc > https [ACK] Seq=1 Ack=1 Win=128480 Len=0
6	2.001180	130.94.88.123	192.168.2.100	TCP	https > appworxsrv [ACK] Seq=1 Ack=2 Win=3756 Len=0
7	2.001777	192.168.2.100	130.94.88.123	SSL	Client Hello
8	2.308152	130.94.88.123	192.168.2.100	TCP	https > lv-jc [ACK] Seq=1 Ack=103 Win=5840 Len=0
9	2.308490	130.94.88.123	192.168.2.100	TLSv1	Server Hello,
10	2.309543	130.94.88.123	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
11	2.309618	192.168.2.100	130.94.88.123	TCP	lv-jc > https [ACK] Seq=103 Ack=2705 Win=128480 Len=0
12	2.617428	130.94.88.123	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
13	2.619328	130.94.88.123	192.168.2.100	TLSv1	Certificate, Server Hello Done
14	2.619440	192.168.2.100	130.94.88.123	TCP	lv-jc > https [ACK] Seq=103 Ack=4549 Win=128480 Len=0
15	2.620478	192.168.2.100	130.94.88.123	TLSv1	Client Key Exchange, Change Cipher Spec, Encrypted Handshake Messag
16	2.922741	130.94.88.123	192.168.2.100	TLSv1	Change Cipher Spec, Encrypted Handshake Message
17	2.926069	192.168.2.100	130.94.88.123	TCP	[TCP segment of a reassembled PDU]
18	2.926211	192.168.2.100	130.94.88.123	TLSv1	Application Data
19	3.229909	130.94.88.123	192.168.2.100	TCP	https > lv-jc [ACK] Seq=4592 Ack=1782 Win=12320 Len=0
20	3.234770	130.94.88.123	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
21	3.235519	130.94.88.123	192.168.2.100	TLSv1	Application Data
22	3.235588	192.168.2.100	130.94.88.123	TCP	lv-jc > https [ACK] Seq=1782 Ack=6110 Win=128480 Len=0
23	3.737122	192.168.2.100	130.94.88.123	TCP	[TCP segment of a reassembled PDU]
24	3.737295	192.168.2.100	130.94.88.123	TLSv1	Application Data
25	4.151556	130.94.88.123	192.168.2.100	TCP	https > lv-jc [ACK] Seq=6110 Ack=3261 Win=15024 Len=0
26	4.151984	130.94.88.123	192.168.2.100	TCP	[TCP segment of a reassembled PDU]
27	4.152276	130.94.88.123	192.168.2.100	TLSv1	Application Data
28	4.152370	192.168.2.100	130.94.88.123	TCP	lv-jc > https [ACK] Seq=3261 Ack=7776 Win=128480 Len=0
29	7.996331	192.168.2.100	212.150.49.10	DNS	Standard query A mail.barak.net.il
30	8.025917	212.150.49.10	192.168.2.100	DNS	Standard query response A 194.90.6.40
31	8.077161	192.168.2.100	194.90.6.40	TCP	dynamic3d > pop3 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=1 TSV=0 TS
32	8.098732	194.90.6.40	192.168.2.100	TCP	pop3 > dynamic3d [SYN, ACK] Seq=0 Ack=1 Win=49580 Len=0 TSV=8290107
33	8.098776	192.168.2.100	194.90.6.40	TCP	dynamic3d > pop3 [ACK] Seq=1 Ack=1 Win=128480 Len=0 TSV=7813 TSER=8
34	8.118204	194.90.6.40	192.168.2.100	POP	S: +OK POP3 service
35	8.118745	192.168.2.100	194.90.6.40	POP	C: USER yoram-ndi.co.il
36	8.138633	194.90.6.40	192.168.2.100	TCP	pop3 > dynamic3d [ACK] Seq=19 Ack=23 Win=49580 Len=0 TSV=829010732
37	8.140050	194.90.6.40	192.168.2.100	POP	S: +OK password required for user yoram-ndi.co.il

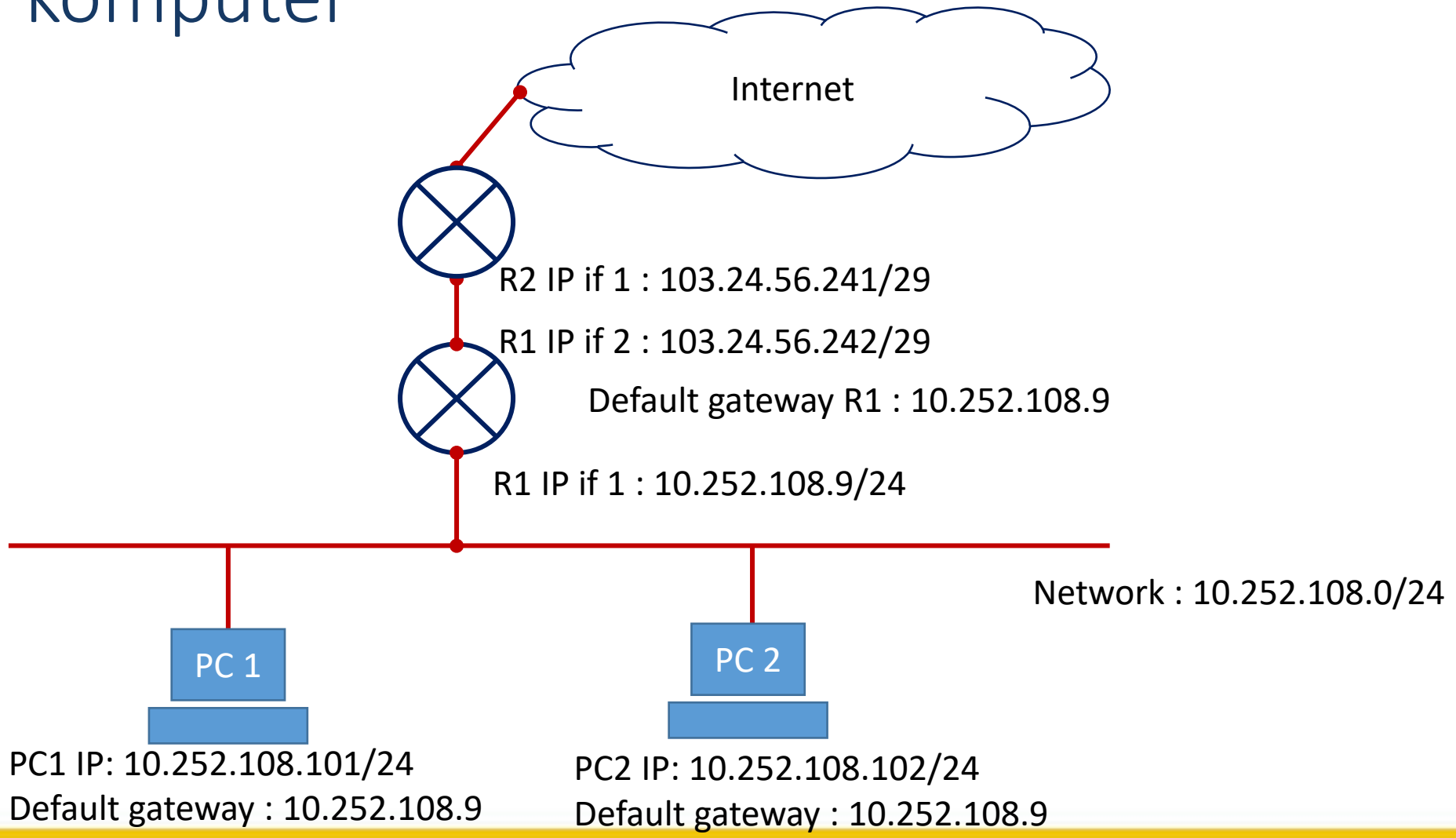
References

- Wireshark Website
  - http://www.wireshark.org
- Wireshark Documentation
  - http://www.wireshark.org/docs/
- Wireshark Wiki
  - http://wiki.wireshark.org
- Network analysis Using Wireshark Cookbook
  - http://www.amazon.com/Network-Analysis-Using-Wireshark-Cookbook/dp/1849517649

Perangkat Router

- Router merupakan peralatan jaringan yang bertugas untuk menghubungkan dua jaringan atau lebih
- Jenis perangkat router dapat berupa
  - komputer yang diaktifkan fungsi *packet forwarding* pada TCP/IP modulnya
  - peralatan khusus yang didesain untuk melakukan fungsi sebagai router
- Router meneruskan paket (packet forwarding) dengan menggunakan protokol routing (*routing protocol*)
- Routing protocol dibedakan menurut algoritma routingnya

Ilustrasi : topologi jaringan di laboratorium jaringan komputer



Referensi

- Aaaaaaaa
- Bbbbbbb
- ccccccc

bridge to the future

http://www.eepis-its.edu