



## 计算机科学与工程系

Department of Computer Science and Engineering

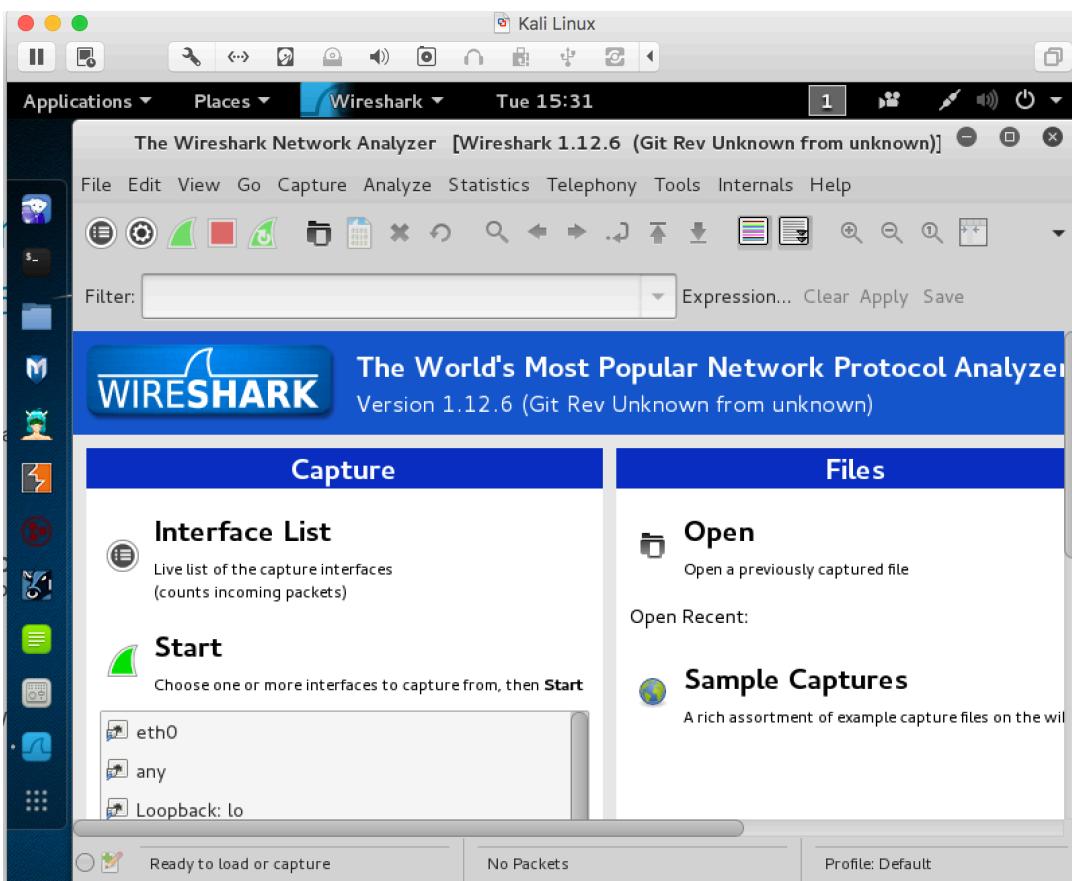
CS 315 Computer Security Course

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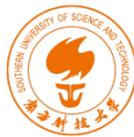
# Lab 1: Packet Sniffing and Wireshark

## ***Introduction***

The first part of the lab introduces packet sniffer, Wireshark. Wireshark is a free open-source network protocol analyzer. It is used for network troubleshooting and communication protocol analysis. Wireshark captures network packets in real time and display them in human-readable format. It provides many advanced features including live capture and offline analysis, three-pane packet browser, coloring rules for analysis. This document uses Wireshark for the experiments, and it covers Wireshark installation, packet capturing, and protocol analysis.

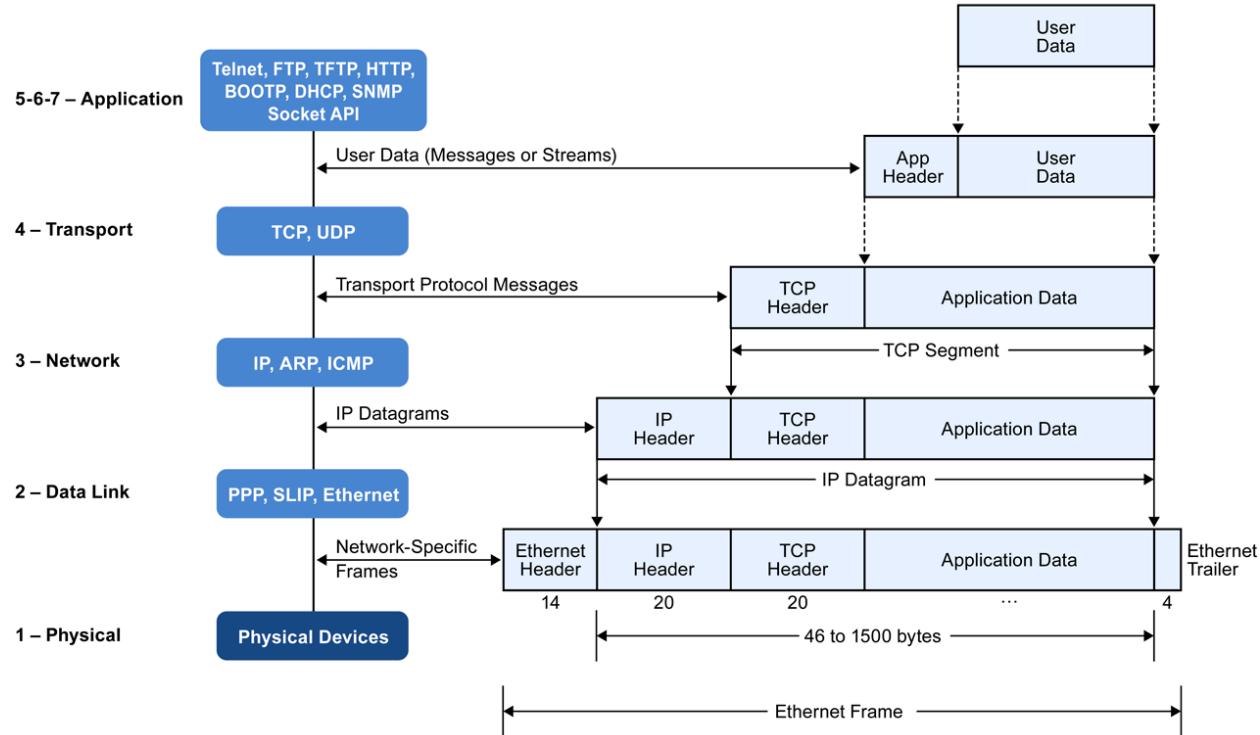


**Figure 1:** Wireshark in Kali Linux



## Background

### TCP/IP Network Stack



**Figure 2:** Encapsulation of Data in the TCP/IP Network Stack

In the Introduction to Computer Networking Course, TCP/IP network stack is introduced and studied. This background section briefly explains the concept of TCP/IP network stack to help you better understand the experiments. TCP/IP is the most commonly used network model for Internet services. Because its most important protocols, the Transmission Control Protocol (TCP) and the Internet Protocol (IP) were the first networking protocols defined in this standard, it is named as TCP/IP. However, it contains multiple layers including application layer, transport layer, network layer, and data link layer.

- **Application Layer:** The application layer includes the protocols used by most applications for providing user services. Examples of application layer protocols are Hypertext Transfer Protocol (HTTP), Secure Shell (SSH), File Transfer Protocol (FTP), and Simple Mail Transfer Protocol (SMTP).

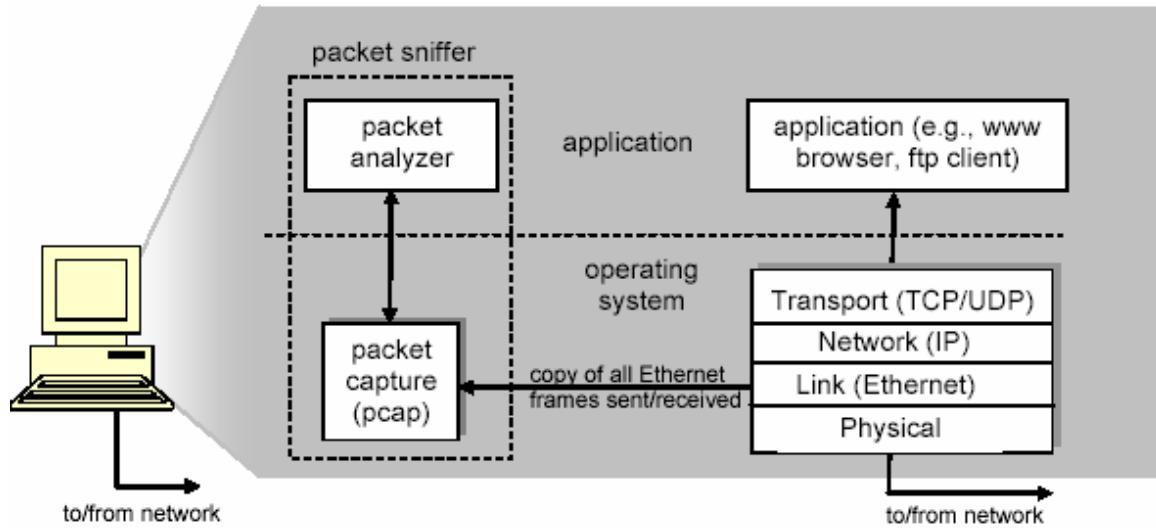
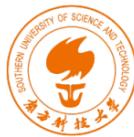
- *Transport Layer*: The transport layer establishes process-to-process connectivity, and it provides end-to-end services that are independent of underlying user data. To implement the process-to-process communication, the protocol introduces a concept of port. The examples of transport layer protocols are Transport Control Protocol (TCP) and User Datagram Protocol (UDP). The TCP provides flow-control, connection establishment, and reliable transmission of data, while the UDP is a connectionless transmission model.
- *Internet Layer*: The Internet layer is responsible for sending packets to across networks. It has two functions: 1) Host identification by using IP addressing system (IPv4 and IPv6); and 2) packets routing from source to destination. The examples of Internet layer protocols are Internet Protocol (IP), Internet Control Message Protocol (ICMP), and Address Resolution Protocol (ARP).
- *Link Layer*: The link layer defines the networking methods within the scope of the local network link. It is used to move the packets between two hosts on the same link. A common example of link layer protocols is Ethernet.

## Packet Sniffer

Packet sniffer is a basic tool for observing network packet exchanges in a computer. As the name suggests, a packet sniffer captures (“sniffs”) packets being sent/received from/by your computer; it will also typically store and/or display the contents of the various protocol fields in these captured packets. A packet sniffer itself is passive. It observes messages being sent and received by applications and protocols running on your computer, but never sends packets itself.

**Figure 3** shows the structure of a packet sniffer. At the right of **Figure 3** are the protocols (in this case, Internet protocols) and applications (such as a web browser or ftp client) that normally run on your computer. The packet sniffer, shown within the dashed rectangle in **Figure 3** is an addition to the usual software in your computer, and consists of two parts. The packet capture library receives a copy of every link-layer frame that is sent from or received by your computer. Messages exchanged by higher layer protocols such as HTTP, FTP, TCP, UDP, DNS, or IP all are eventually encapsulated in link-layer frames that are transmitted over physical media such as an Ethernet cable. In Figure 1, the assumed physical media is an Ethernet, and so all upper-layer protocols are eventually encapsulated within an Ethernet frame. Capturing all link-layer frames thus gives you access to all messages sent/received from/by all protocols and applications executing in your computer.

The second component of a packet sniffer is the packet analyzer, which displays the contents of all fields within a protocol message. In order to do so, the packet analyzer



**Figure 3:** Packet Sniffer Structure

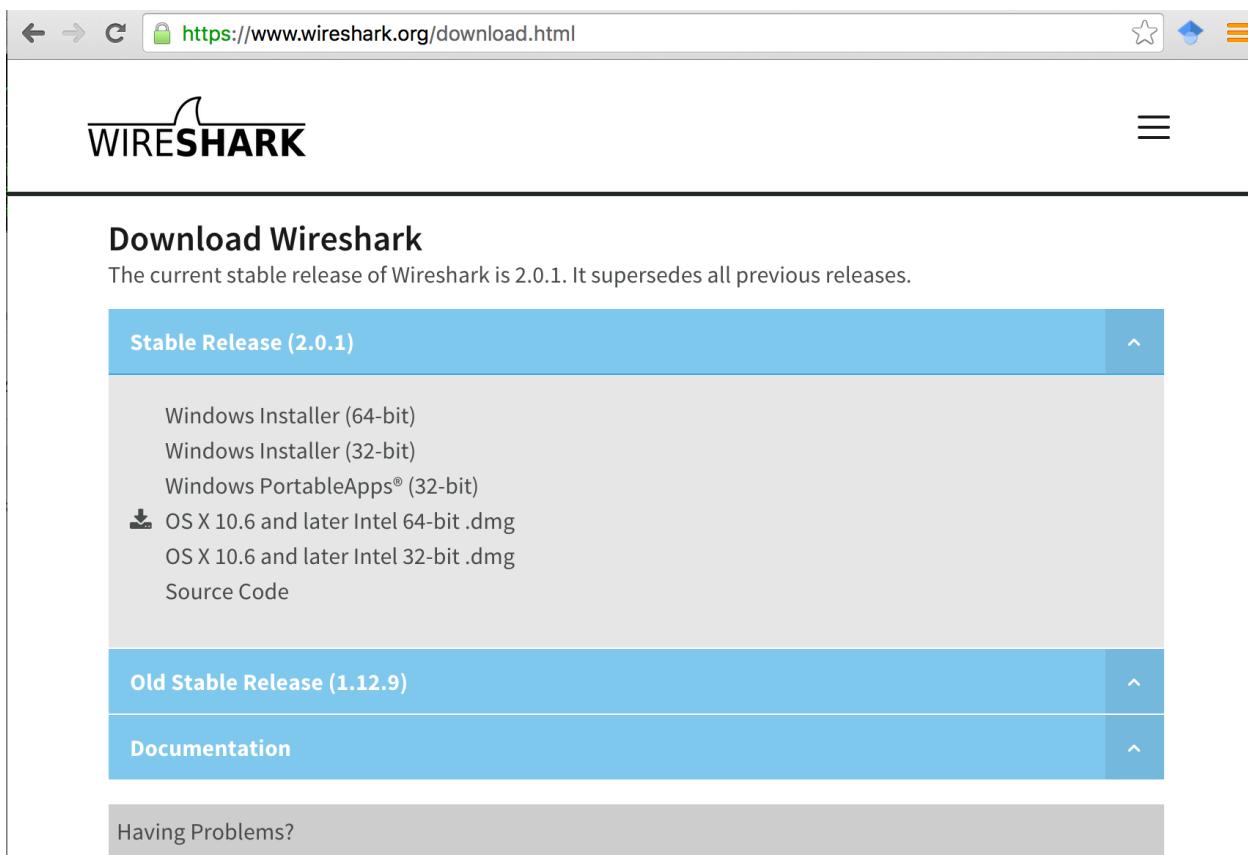
must “understand” the structure of all messages exchanged by protocols. For example, suppose we are interested in displaying the various fields in messages exchanged by the HTTP protocol in **Figure 3**. The packet analyzer understands the format of Ethernet frames, and so can identify the IP datagram within an Ethernet frame. It also understands the IP datagram format, so that it can extract the TCP segment within the IP datagram. Finally, it understands the TCP segment structure, so it can extract the HTTP message contained in the TCP segment. Finally, it understands the HTTP protocol and so, for example, knows that the first bytes of an HTTP message will contain the string “GET,” “POST,” or “HEAD”.

We will be using the Wireshark packet sniffer [<http://www.wireshark.org/>] for these labs, allowing us to display the contents of messages being sent/received from/by protocols at different levels of the protocol stack. (Technically speaking, Wireshark is a packet analyzer that uses a packet capture library in your computer). Wireshark is a free network protocol analyzer that runs on Windows, Linux/Unix, and Mac computers.

## Getting Wireshark

The Kai Linux has Wireshark installed. You can just launch the Kali Linux VM and open Wireshark there. Wireshark can also be downloaded from here:

<https://www.wireshark.org/download.html>

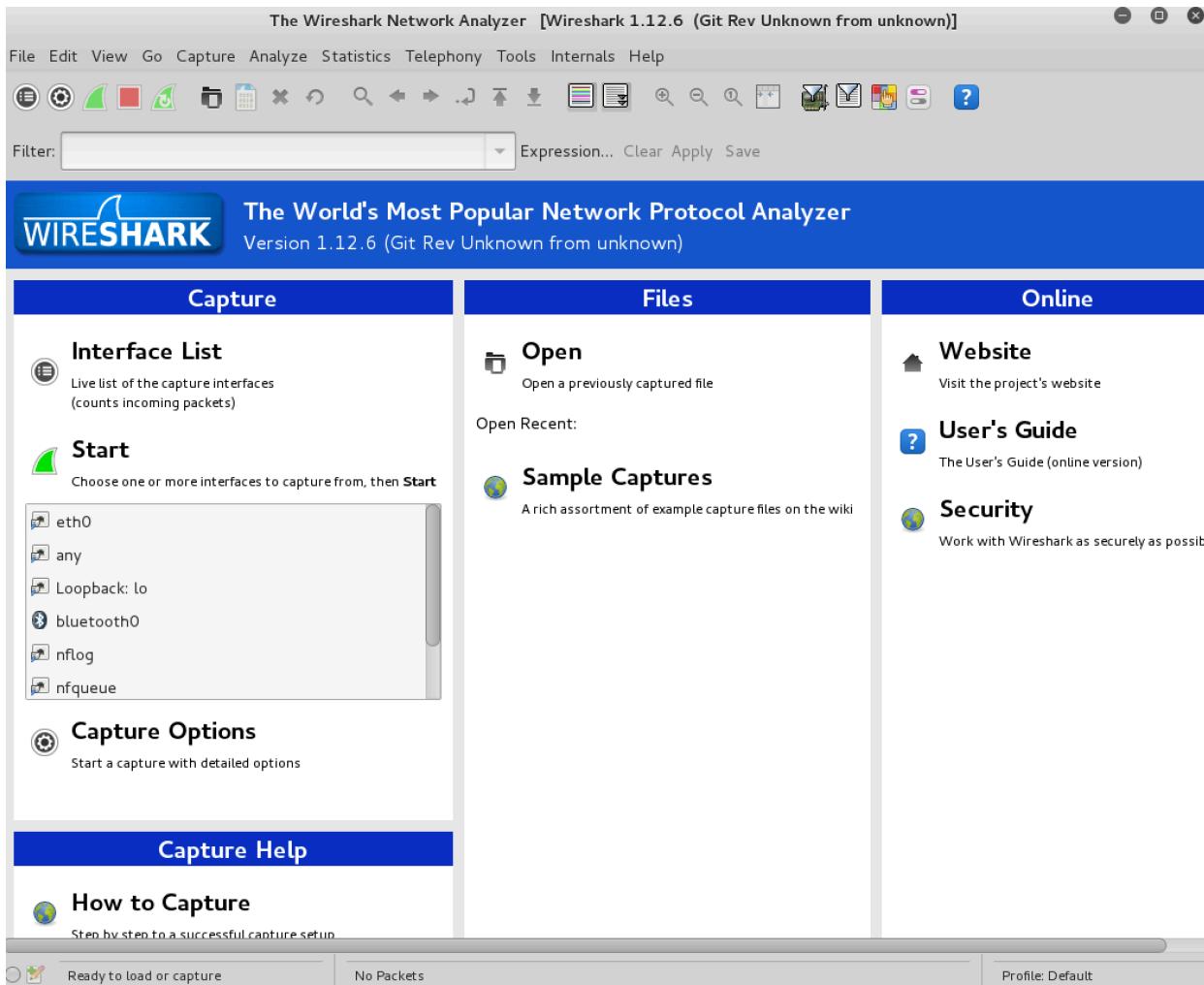


**Figure 4:** Download Page of Wireshark



## Starting Wireshark

When you run the Wireshark program, the Wireshark graphic user interface will be shown as **Figure 5**. Currently, the program is not capturing the packets.



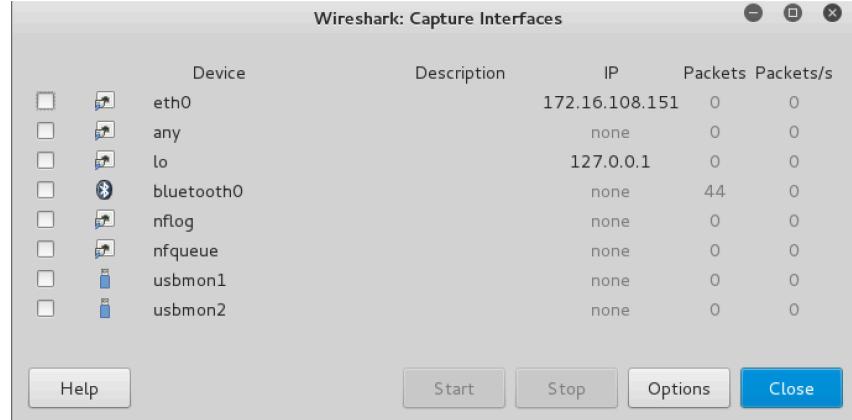
**Figure 5:** Initial Graphic User Interface of Wireshark

Then, you need to choose an interface. If you are running the Wireshark on your laptop, you need to select WiFi interface. If you are at a desktop, you need to select the Ethernet interface being used. Note that there could be multiple interfaces. In general, you can select any interface but that does not mean that traffic will flow through that interface. The

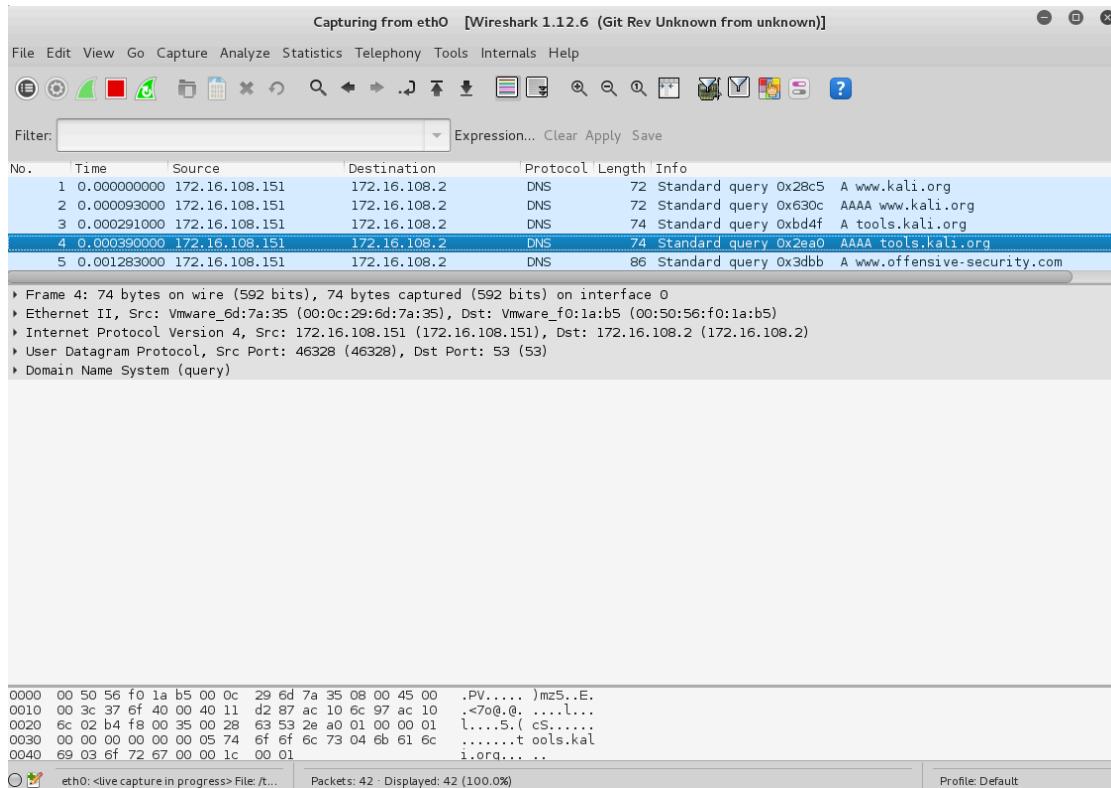


network interfaces (i.e., the physical connections) that your computer has to the network are shown. The attached **Figure 6** was taken from my computer.

After you select the interface, you can click start to capture the packets as shown in **Figure 7**.



**Figure 6:** Capture Interfaces in Wireshark



**Figure 7:** Capturing Packets in Wireshark

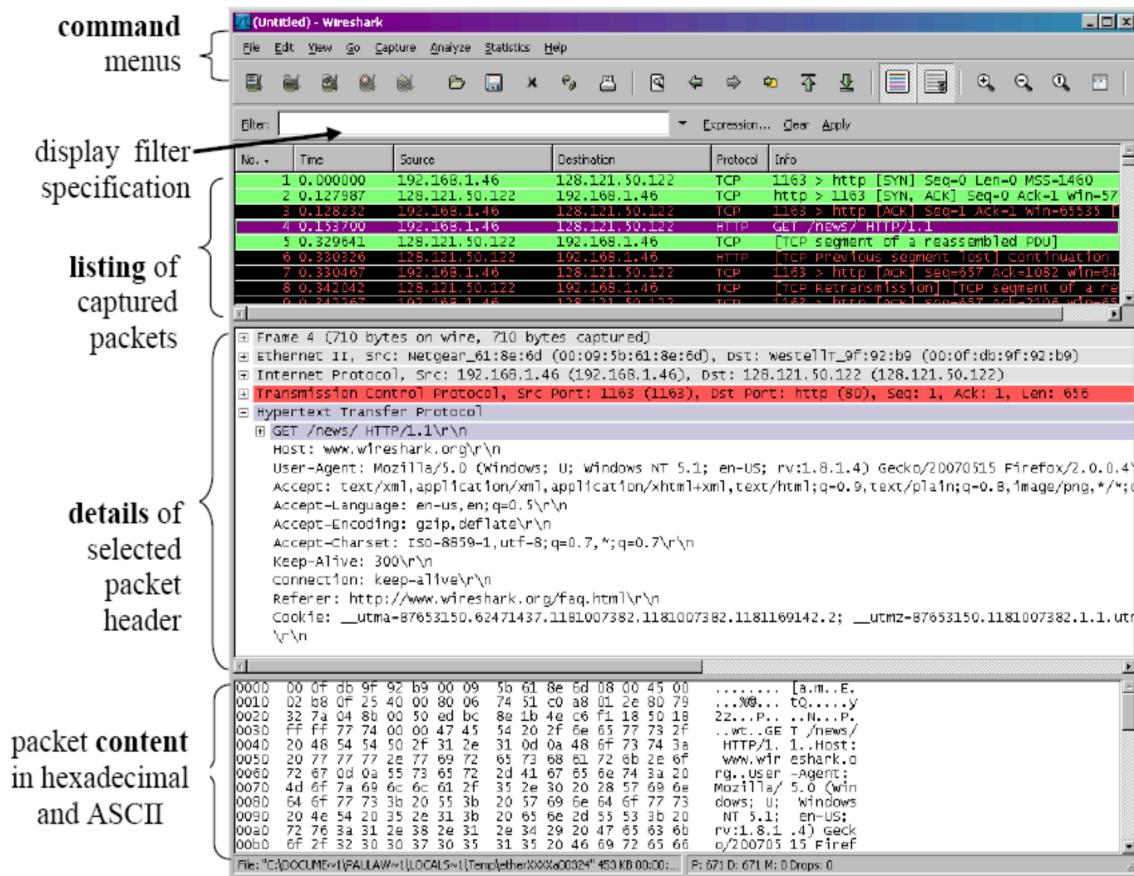
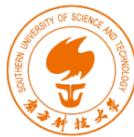


Figure 8: Wireshark Graphical User Interface on Microsoft Windows

The Wireshark interface has five major components:

The **command menus** are standard pulldown menus located at the top of the window. Of interest to us now is the File and Capture menus. The File menu allows you to save captured packet data or open a file containing previously captured packet data, and exit the Wireshark application. The Capture menu allows you to begin packet capture.

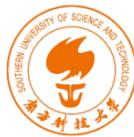
The **packet-listing window** displays a one-line summary for each packet captured, including the packet number (assigned by Wireshark; this is not a packet number contained in any protocol's header), the time at which the packet was captured, the packet's source and destination addresses, the protocol type, and protocol-specific information contained in the packet. The packet listing can be sorted according to any of these categories by clicking on a column name. The protocol type field lists the highest-level protocol that sent or received this packet, i.e., the protocol that is the source or ultimate sink for this packet.



The **packet-header details window** provides details about the packet selected (highlighted) in the packet-listing window. (To select a packet in the packet-listing window, place the cursor over the packet's one-line summary in the packet-listing window and click with the left mouse button.). These details include information about the Ethernet frame and IP datagram that contains this packet. The amount of Ethernet and IP-layer detail displayed can be expanded or minimized by clicking on the right-pointing or down-pointing arrowhead to the left of the Ethernet frame or IP datagram line in the packet details window. If the packet has been carried over TCP or UDP, TCP or UDP details will also be displayed, which can similarly be expanded or minimized. Finally, details about the highest-level protocol that sent or received this packet are also provided.

The **packet-contents window** displays the entire contents of the captured frame, in both ASCII and hexadecimal format.

Towards the top of the Wireshark graphical user interface, is the **packet display filter field**, into which a protocol name or other information can be entered in order to filter the information displayed in the packet-listing window (and hence the packet-header and packet-contents windows). In the example below, we'll use the packet-display filter field to have Wireshark hide (not display) packets except those that correspond to HTTP messages.



## Capturing Packets

After downloading and installing Wireshark, you can launch it and click the name of an interface under Interface List to start capturing packets on that interface. For example, if you want to capture traffic on the wireless network, click your wireless interface.

### Test Run

Do the following steps:

1. Start up the Wireshark program (select an interface and press start to capture packets).
2. Start up your favorite browser (ceweasel in Kali Linux).
3. In your browser, go to Wayne State homepage by typing [www.wayne.edu](http://www.wayne.edu).
4. After your browser has displayed the <http://www.wayne.edu> page, stop Wireshark packet capture by selecting stop in the Wireshark capture window. This will cause the Wireshark capture window to disappear and the main Wireshark window to display all packets captured since you began packet capture see image below:

The screenshot shows the Wireshark interface with the following details:

- File Bar:** File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Tools, Internals, Help.
- Toolbar:** Standard icons for opening files, saving, zooming, and filtering.
- Filter Bar:** A text input field with dropdown options for "Expression...", "Clear", and "Apply".
- Packets List:** A table showing captured packets. The columns are: No., Time, Source, Destination, Protocol, Length, Info. The last few rows are highlighted in red:
  - 7837: 135.2604700, 172.16.108.152, 50.31.164.175, TCP, 54, [TCP Keep-Alive] 33587->443 [ACK], Seq=2186 Ack=3183 Win=42408 Len=0
  - 7838: 135.2606360, 50.31.164.175, 172.16.108.152, TCP, 60, [TCP Keep-Alive ACK] 443->33587 [ACK], Seq=3183 Ack=2187 Win=64240 Len=0
  - 7839: 135.6393630, 172.16.108.1, 172.16.108.255, DB-LSP-D, 223, Dropbox LAN sync Discovery Protocol
  - 7840: 145.2774900, 172.16.108.152, 50.31.164.175, TCP, 54, [TCP Keep-Alive] 33587->443 [ACK], Seq=2186 Ack=3183 Win=42408 Len=0
  - 7841: 145.2776770, 50.31.164.175, 172.16.108.152, TCP, 60, [TCP Keep-Alive ACK] 443->33587 [ACK], Seq=3183 Ack=2187 Win=64240 Len=0
  - 7842: 146.3646130, 50.31.164.175, 172.16.108.152, TCP, 60, 443->33587 [RST, ACK], Seq=3183 Ack=2187 Win=64240 Len=0
- Hex Editor:** Shows the raw hex and ASCII data for the selected packet (packet 7843). The ASCII dump shows: 0000 00 0c 29 6d 7a 35 00 50 56 f0 1a b5 08 00 45 00 .)mz5.P V...E..
- Status Bar:** eth0: <live capture in progress> File: /t... | Packets: 7843 - Displayed: 7843 (100.0%) | Profile: Default



5. Color Coding: You'll probably see packets highlighted in green, blue, and black. Wireshark uses colors to help you identify the types of traffic at a glance. By default, green is TCP traffic, dark blue is DNS traffic, light blue is UDP traffic, and black identifies TCP packets with problems — for example, they could have been delivered out-of-order.
6. You now have live packet data that contains all protocol messages exchanged between your computer and other network entities! However, as you will notice the HTTP messages are not clearly shown because there are many other packets included in the packet capture. Even though the only action you took was to open your browser, there are many other programs in your computer that communicate via the network in the background. To filter the connections to the ones we want to focus on, we have to use the filtering functionality of Wireshark by typing "http" in the filtering field as shown below:

Capturing from eth0 [Wireshark 1.12.6 (Git Rev Unknown from unknown)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: http Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
4124	25.63383500	172.16.108.152	141.217.1.160	HTTP	508	GET /promos/1376/programs-min_1.png HTTP/1.1
4126	25.63398000	172.16.108.152	141.217.1.160	HTTP	513	GET /promos/1376/apply-students-2015.jpg HTTP/1.1
4160	25.66536200	141.217.1.160	172.16.108.152	HTTP	287	HTTP/1.1 200 OK (text/javascript)
4173	25.67091200	172.16.108.152	141.217.1.160	HTTP	528	GET /promos/1376/winter-registration2015-3section_1.jpg HTTP/1.1
4187	25.67288800	141.217.1.160	172.16.108.152	HTTP	1247	HTTP/1.1 200 OK (PNG)
4208	25.67323100	172.16.108.152	141.217.1.160	HTTP	512	GET /promos/1380/flu-shot-wayne-edu.jpg HTTP/1.1
4223	25.68279200	141.217.1.160	172.16.108.152	HTTP	1284	HTTP/1.1 200 OK (GIF89a)
4233	25.68285500	141.217.1.160	172.16.108.152	HTTP	402	HTTP/1.1 200 OK (PNG)
4235	25.68306500	172.16.108.152	141.217.1.160	HTTP	508	GET /images/news/van-jones-news.jpg HTTP/1.1
4236	25.68308400	172.16.108.152	141.217.1.160	HTTP	518	GET /_resources/images/footer/give-to-wsu.gif HTTP/1.1
4250	25.68478900	141.217.1.160	172.16.108.152	HTTP	1402	HTTP/1.1 200 OK (PNG)

▶ Frame 4126: 513 bytes on wire (4104 bits), 513 bytes captured (4104 bits) on interface 0  
▶ Ethernet II, Src: VMware\_6d:7a:35 (00:0c:29:6d:7a:35), Dst: VMware\_f0:1a:b5 (00:50:56:f0:1a:b5)  
▶ Internet Protocol Version 4, Src: 172.16.108.152 (172.16.108.152), Dst: 141.217.1.160 (141.217.1.160)  
▶ Transmission Control Protocol, Src Port: 52099 (52099), Dst Port: 80 (80), Seq: 1, Ack: 1, Len: 459  
▶ Hypertext Transfer Protocol

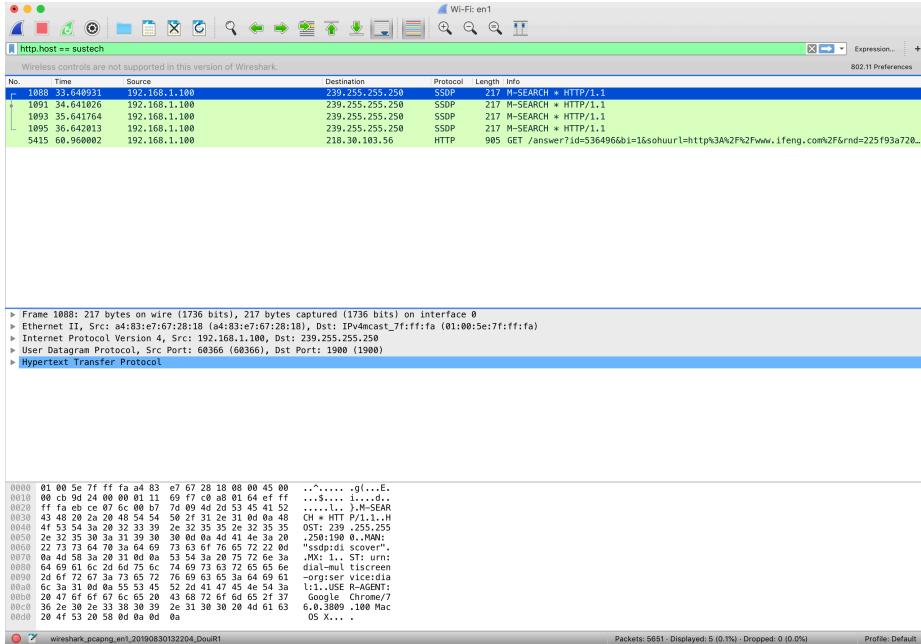
0000 00 50 56 f0 1a b5 00 0c 29 6d 7a 35 08 00 45 00 .PV..... )mz5.,E.  
0010 01 f3 32 ce 40 00 40 06 5e 15 ac 10 6c 98 8d d9 ..2.0.0. ^...,l...  
0020 01 a0 cb 83 00 50 f1 b7 ba 26 14 6a 7a c6 50 18 ...P., &.jz.P.  
0030 72 10 c3 8a 00 00 47 45 54 20 2f 70 72 6f 6d 6f r....GE T /promo  
0040 73 2f 31 33 37 36 2f 61 70 70 6c 79 2d 73 74 75 s/1376/a pply-stu  
0050 64 65 6e 74 73 2d 32 30 31 35 6e 6a 70 67 20 49 dents-20 15.jpg H  
0060 54 54 50 2f 31 2e 31 0d 0a 48 6f 73 74 3a 20 77 TTP/1.1. .Host: w  
0070 01 79 6e 65 2e 65 64 75 0d 0a 55 73 65 72 20 41 ayne.edu .User-A  
0080 67 65 6e 74 3a 20 4d 6f 7a 69 6c 6e 61 2f 35 2e gent: Mo zilla/5.  
0090 30 20 28 58 31 31 3b 20 4c 69 6e 75 78 20 69 36 0 (X11; Linux 16  
00a0 38 36 3b 20 72 76 3a 33 31 29 30 29 47 65 63 86; rv:3 1.0) Gec  
00b0 6b 6f 2f 32 30 31 30 30 31 30 20 46 69 72 65 ko/20100 101 Fire  
00c0 66 6f 78 2f 33 31 2e 30 20 49 63 65 77 65 61 73 fox/31.0 Icweas  
00d0 65 6c 2f 33 31 2e 38 2e 30 0d 0a 41 63 63 65 70 el/31.8. 0.Accep  
00e0 74 3a 20 69 6d 61 67 65 2f 70 6e 67 2c 69 6d 61 t: image /png,ima  
00f0 67 65 2f 2a 3b 71 3d 30 2e 38 2c 2a 2f 2a 3b 71 ge/\*q=0 .8,\*/\*;q  
0100 66 6f 78 2f 33 31 2e 30 20 49 63 65 77 65 61 73

eth0: <live capture in progress> File: /... Packets: 5085 · Displayed: 60 (1.2%) Profile: Default

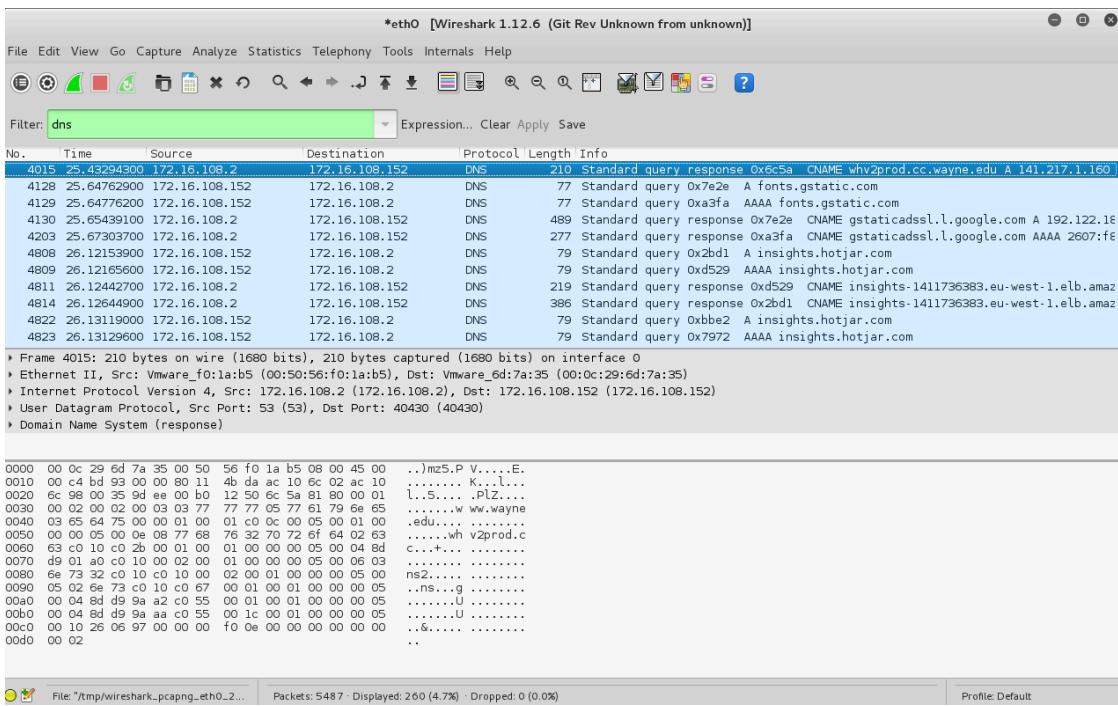
Notice that we now view only the packets that are of protocol HTTP. However, we also still do not have the exact communication we want to focus on because using HTTP as a filter is not descriptive enough to allow us to find our connection to <http://www.wayne.edu>. We need to be more precise if we want to capture the correct set of packets.



7. To further filter packets in Wireshark, we need to use a more precise filter. By setting the http.host==sustech, we are restricting the view to packets that have as an http host the www.wayne.edu website. Notice that we need two equal signs to perform the match “==” not just one. See the screenshot below:

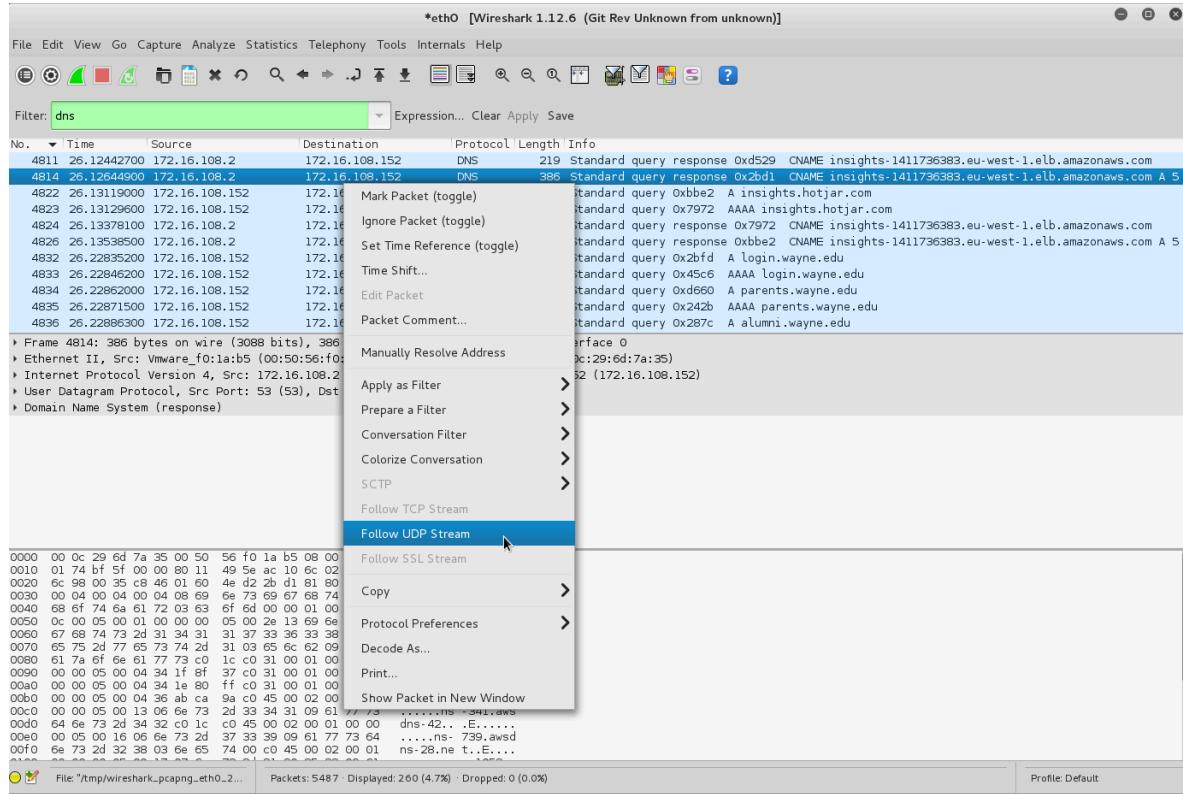


8. Now, we can try another protocol. Let's use Domain Name System (DNS) protocol as an example here.

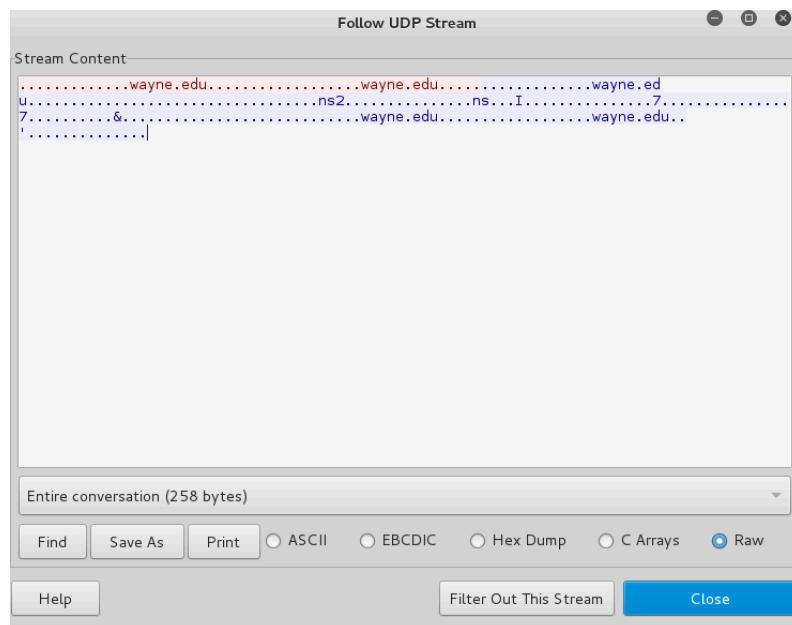




9. Let's try now to find out what are those packets contain by following one of the conversations (also called network flows), select one of the packets and press the right mouse button (if you are on a Mac use the command button and click), you should see something similar to the screen below:

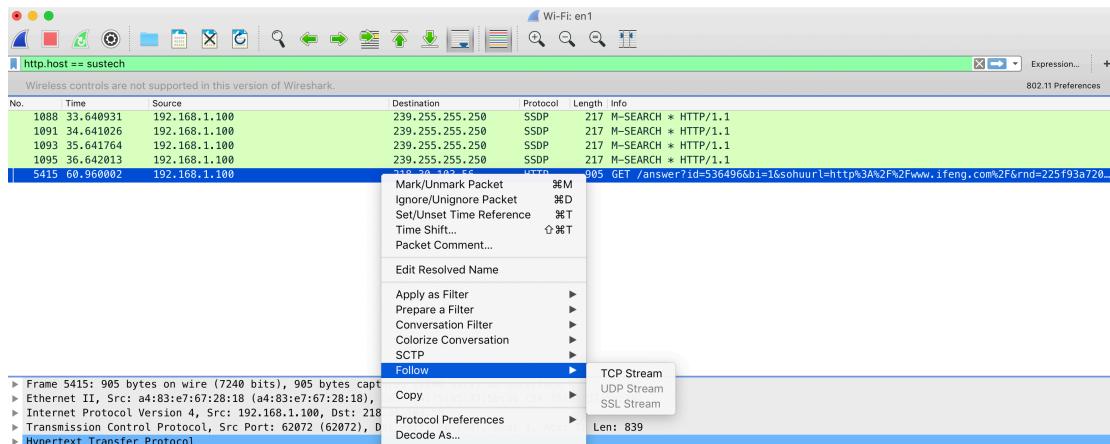


Click on **Follow UDP Stream**, and then you will see following screen.

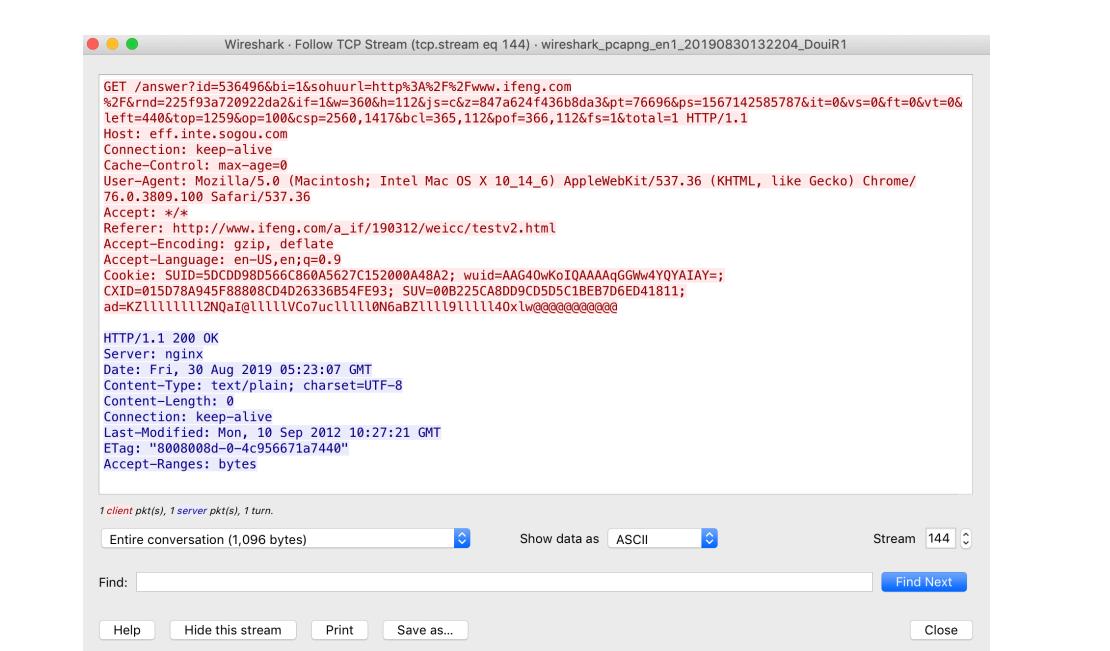




10. If we close this window and change the filter back to “http.host==www.wayne.edu” and then follow a packet from the list of packets that match that filter, we should get the something similar to the following screens. Note that we click on **Follow TCP Stream** this time.



```
0000  54 75 95 37 5b 39 a4 83 e7 67 28 18 08 00 45 00 Tu.7[9.. .g@...E.
0010  03 7b 00 00 40 00 40 06 34 1a c0 a0 01 64 da 1e .(.,@. 4...d..
0020  67 38 f2 78 00 50 c7 dd af dd e7 3a 58 a4 80 18 .g@x.P. .(x@...
0030  03 7b 00 00 40 00 40 06 34 1a c0 a0 01 64 da 1e .(.,@. 4...d..
0040  f4 26 47 45 54 20 61 66 73 77 65 72 3f 60 64 .66ET /a nswer?i=d
0050  3d 35 33 36 34 39 36 26 62 69 31 26 73 67 68 =536496& bi=1&soh
0060  75 75 72 6c 3d 68 74 74 70 25 33 41 25 32 46 25 url=hht pk3A%2F%
0070  32 46 77 77 77 2e 69 66 65 6e 67 2e 63 6f 6d 25 2Fwww.if eng.com%
0080  32 46 26 72 6d 64 3d 32 32 35 66 39 33 61 37 32 2F&rnd=2 25f93a72
0090  30 39 32 32 64 3d 32 2d 69 68 3d 2b 63 6f 33 68 60 2d 61 31 65 6f 6d 33
00a0  38 34 37 61 36 32 34 66 34 33 36 62 38 64 61 33 690122 6j@&6z=
00b0  26 70 74 3d 37 36 36 39 36 26 70 72 73 3d 31 35 36 847a624f 436bb0d3
00c0  37 31 34 32 35 38 35 37 38 37 26 69 74 3d 38 26 6pt=7669 6&ps=156
00d0  71425857 87&it=6&
```



## Questions for the Lab

1. Carefully read the lab instructions and finish all tasks above.
2. If a packet is highlighted by black, what does it mean for the packet?
3. What is the filter command for listing all outgoing http traffic?
4. Why does DNS use Follow UDP Stream while HTTP use Follow TCP Stream?
5. Using Wireshark to capture the FTP password.

There is a FTP server installed on the Kali Linux VM. You need to use a terminal to log into the server and use Wireshark to capture the password. The username for the FTP server is csc5991-student, and the password is [WSU-csc5991.] without the brackets. You will user the username and password to login the FTP server while Wireshark is running. Note that the FTP server is installed on the localhost, make sure you select the right interface for the capturing. You need to explain to me how you find the password and a screenshot of the password packet. Have fun!