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Section 1: Obtaining the Evidence

This section focuses on the basics of network forensics while covering essential concepts, tools, and techniques involved in executing a network forensic investigation.

The following chapters will be covered in this section:

- `Chapter 1`, *Introducing Network Forensics*
- `Chapter 2`, *Technical Concepts and Acquiring Evidence*

1
Introduction to Network Forensics

Network forensics is one of the sub-branches of digital forensics where the data being analyzed is the network traffic going to and from the system under observation. The purposes of this type of observation are collecting information, obtaining legal evidence, establishing a root-cause analysis of an event, analyzing malware behavior, and so on. Professionals familiar with **digital forensics and incident response** (**DFIR**) know that even the most careful suspects leave traces and artifacts behind. But forensics generally also includes imaging the systems for memory and hard drives, which can be analyzed later. So, how do network forensics come into the picture? Why do we need to perform network forensics at all? Well, the answer to this question is relatively simple.

Let's consider a scenario where you are hunting for some unknown attackers in a massive corporate infrastructure containing thousands of systems. In such a case, it would be practically impossible to image and analyze every system. The following two scenarios would also be problematic:

- Instances where the disk drives may not be available
- Cases where the attack is in progress, and you may not want to tip off the attackers

Whenever an intrusion or a digital crime happens over the wire, whether it was successful or not, the artifacts left behind can help us understand and recreate not only the intent of the attack, but also the actions performed by the attackers.

If the attack was successful, what activities were conducted by the attackers on the system? What happened next? Generally, most severe attacks, such as **Advanced Package Tool** (**APT**), **ransomware**, **espionage**, and others, start from a single instance of an unauthorized entry into a network and then evolve into a long-term project for the attackers until the day their goals are met; however, throughout this period the information flowing in and out of the network goes through many different devices, such as routers, firewalls, hubs, switches, web proxies, and others. Our goal is to identify and analyze all these different artifacts. Throughout this chapter, we will discuss the following:

- Network forensics methodology
- Sources of evidence
- A few necessary case studies demonstrating hands-on network forensics

Technical requirements

To perform the exercises covered in this chapter, you will require the following:

- A laptop/desktop computer with an i5/i7 processor or any other equivalent AMD processor with at least 8 GB RAM and around 100 GB of free space.
- VMware Player/VirtualBox installation with Kali OS installed. You can download it from `https://www.offensive-security.com/kali-linux-vm-vmware-virtualbox-image-download/`.
- Installing Wireshark on Windows: `https://www.wireshark.org/docs/wsug_html_chunked/ChBuildInstallWinInstall.html`.
- Netcat From Kali Linux (already installed).
- Download NetworkMiner from `https://www.netresec.com/?page=Networkminer`.

Every investigation requires a precise methodology. We will discuss the popular network forensics methodology used widely across the industry in the next section.

To install Wireshark on Windows, go to `https://www.wireshark.org/docs/wsug_html_chunked/ChBuildInstallWinInstall.html`.

Network forensics investigation methodology

To assure accurate and meaningful results at the end of a network forensic exercise, you, as a forensic investigator, must follow a rigid path through a methodological framework. This path is shown in the following diagram:

Obtain, **Strategize**, **Collect**, **Analyze**, and **Report** (**OSCAR**) is one such framework that ensures appropriate and constant results. Let's look at each phase from a network forensics point of view:

- **Obtain information**: Obtaining information about the incident and the environment is one of the first things to do in a network forensics exercise. The goal of this phase is to familiarize a forensic investigator with the type of incident. The timestamps and timeline of the event, the people, systems, and endpoints involved in the incident—all of these facts are crucial in building up a detailed picture of the event.
- **Strategize**: Planning the investigation is one of the critical phases in a network forensics scenario, since logs from various devices can differ in their nature; for example, the volatility of log entries from a firewall compared with that of details such as the ARP of a system would be very different. A good strategy would impact the overall outcome of the investigation. Therefore, you should keep the following points in mind while strategizing the entire forensics investigation process:
    - Define clear goals and timelines
    - Find the sources of evidence
    - Analyze the cost and value of the sources
    - Prioritize acquisition
    - Plan timely updates for the client

- **Collect**: In the previous phase, we saw how we need to strategize and plan the acquisition of evidence. In the collect phase, we will go ahead and acquire the evidence as per the plan; however, collecting the evidence itself requires you to document all the systems that are accessed and used, capturing and saving the data streams to the hard drive and collecting logs from servers and firewalls. Best practices for evidence collection include the following:
    - Make copies of the evidence and generate cryptographic hashes for verifiability
    - Never work on the original evidence; use copies of the data instead
    - Use industry-standard tools
    - Document all your actions
- **Analyze**: The analysis phase is the core phase where you start working on the data and try your hands at the riddle. In this phase, you will make use of multiple automated and manual techniques using a variety of tools to correlate data from various sources, establishing a timeline of events, eliminating false positives, and creating working theories to support evidence. We will spend most of the time in this book discussing the analysis of data.
- **Report**: The report that you produce must be in layman's terms—that is, it should be understood by non-techie people, such as legal teams, lawyers, juries, insurance teams, and so on. The report should contain executive summaries backed by the technical evidence. This phase is considered one of the essential stages, since the last four steps need to be explained in this one.

For more on OSCAR methodology, you can visit `https://www.researchgate.net/figure/OSCAR-methodology_fig2_325465892`.

Source of network evidence

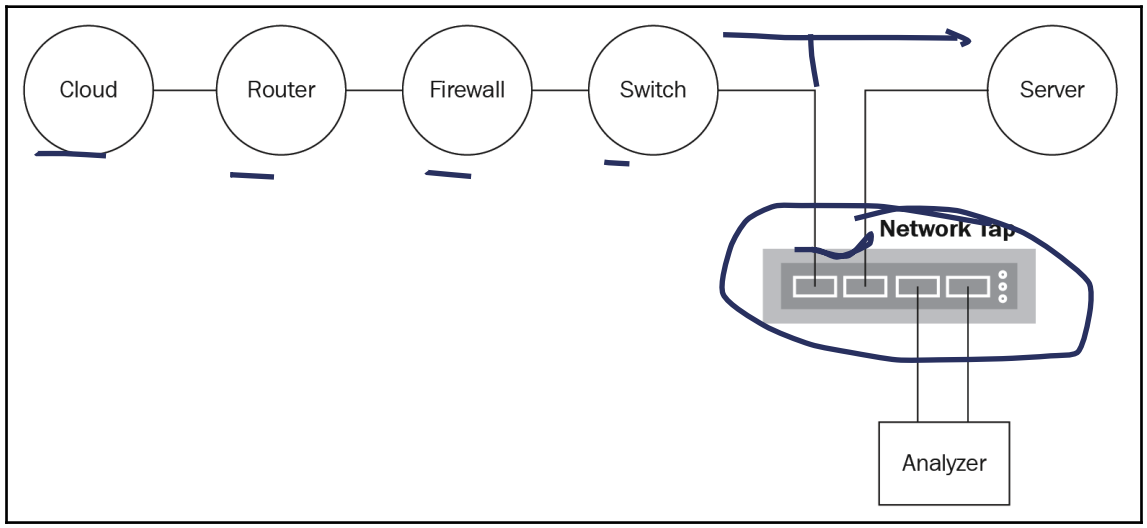
Network evidence can be collected from a variety of sources and we will discuss these sources in the next section. The sources that we will be discussing are:

- Tapping the wire and the air
- CAM table on a network switch
- Routing tables on routers
- Dynamic Host Configuration Protocol logs
- DNS server logs
- Domain controller/ authentication servers/ system logs
- IDS/IPS logs
- Firewall logs
- Proxy Server logs

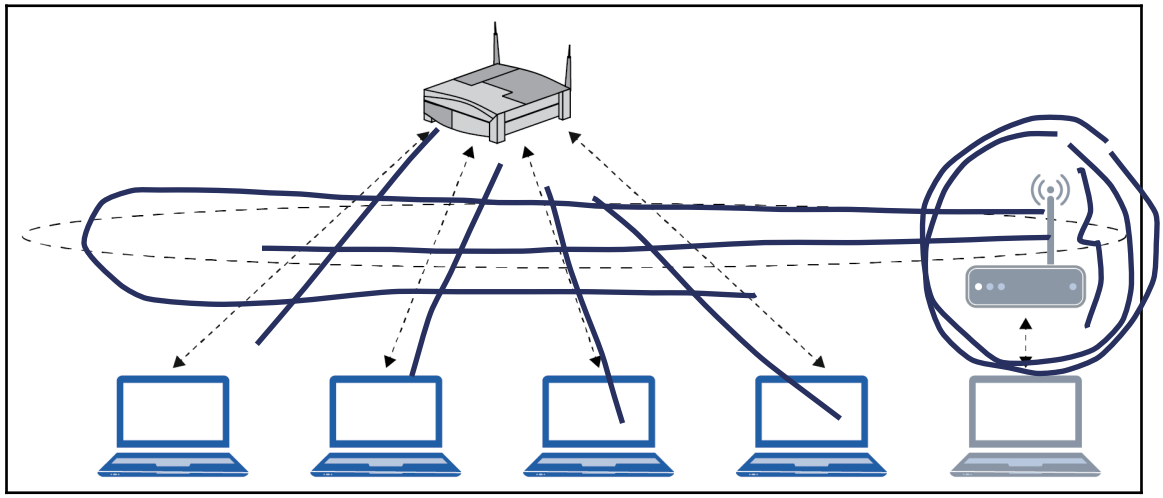
Tapping the wire and the air

One of the purest and most raw forms of information capture is to put taps on network and optical fiber cables to snoop on traffic.

Many commercial vendors provide network taps and SPAN ports on their devices for snooping where they will forward all traffic seen on the particular port to the analyzer system. The technique is shown in the following diagram:



In the case of WLAN or Wi-Fi, the captures can be performed by putting an external wireless receptor into promiscuous mode and recording all the traffic for a particular wireless access point on a particular channel. This technique is shown in the following diagram:



CAM table on a network switch

Network switches contain content-addressable memory tables that store the mapping between a system's MAC address and the physical ports. In a large setup, this table becomes extremely handy, as it can pinpoint a MAC address on the network to a wall-jacked system, since mappings are available to the physical ports. Switches also provide network-mirroring capabilities, which will allow the investigators to see all the data from other VLANs and systems.

Routing tables on routers

Routing tables in a router maps ports on the router to the networks that they connect. The following table is a routing table. These tables allow us to investigate the path that the network traffic takes while traveling through various devices:

Routing Table

Destination	Gateway	Genmask	Metric	Interface	Type
122.176.127.70	0.0.0.0	255.255.255.255	0	Internet WAN	Dynamic
192.168.1.0	0.0.0.0	255.255.255.0	0	LAN	Dynamic
0.0.0.0	122.176.127.70	0.0.0.0	0	Internet WAN	Dynamic

Refresh

Most of the routers have inbuilt packet filters and firewall capabilities as well. This means that they can be configured to log denied or certain types of traffic traveling to and from the network.

Dynamic Host Configuration Protocol logs

Dynamic Host Configuration Protocol (**DHCP**) servers generally log entries when a specific IP address is assigned to a particular MAC address, when a lease was renewed on the network, the timestamp it renewed, and so on, thus having significant value in network forensics. The following screenshot of the router's DHCP table presents a list of dynamically allocated hosts:

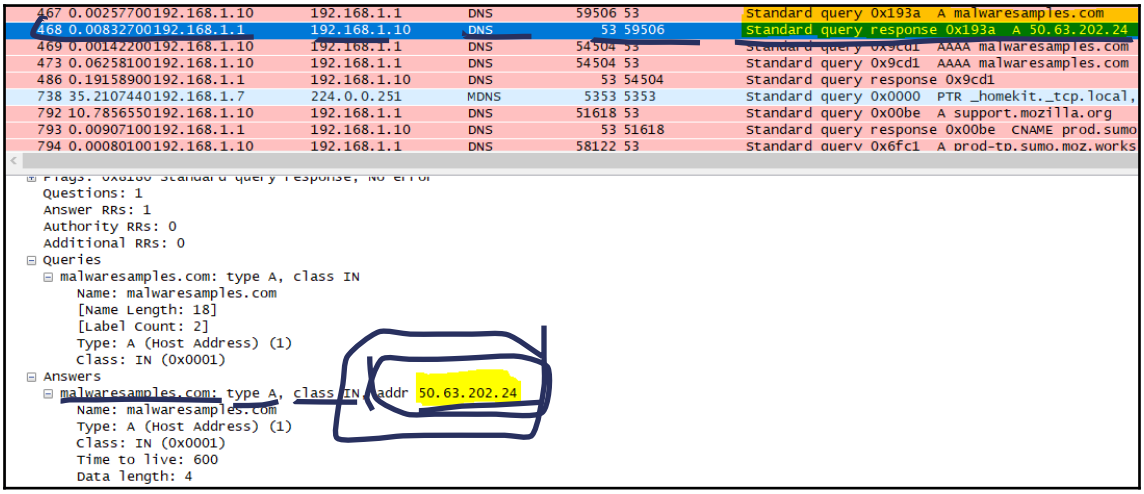
DHCP Clients Table

Host Name	IP Address	MAC Address	Remaining Lease Time (in seconds)
android-73355629bd9b62e5	[illegible]	[illegible]	26518
iPad	192.168.1.3	54:99:63:82:64:f5	24818
iPhone	192.168.1.4	70:f0:87:bf:17:ab	22451
XboxOne	192.168.1.6	30:59:b7:e5:f9:89	27815
Apex	192.168.1.7	2c:33:61:77:23:ef	26599
Lucideuss-MBP	192.168.1.8	8c:85:90:74:fe:ee	25825
Chromecast	192.168.1.9	54:60:09:84:3f:24	19346
DESKTOP-PESQ21S	192.168.1.10	b0:10:41:c8:46:df	25062

Refresh Close

DNS servers logs

Name server query logs can help understand IP-to-hostname resolution at specific times. Consider a scenario where, as soon as a system got infected with malware on the network, it tried to connect back to a certain domain for command and control. Let's see an example as follows:



We can see in the preceding screenshot that a DNS request was resolved for `malwaresamples.com` website and the resolved IP address was returned.

Having access to the DNS query packets can reveal **Indicators of Compromise** for a particular malware on the network while quickly revealing the IP address of the system making the query, and can be dealt with ease.

Domain controller/authentication servers/ system logs

Authentication servers can allow an investigator to view login attempts, the time of the login, and various other login-related activities throughout the network. Consider a scenario where a group of attackers tries to use a compromised host to log into the database server by using the compromised machine as a launchpad (pivoting). In such cases, authentication logs will quickly reveal not only the infected system, but also the number of failed/passed attempts from the system to the database server.

IDS/IPS logs

From a forensic standpoint, intrusion detection/prevention system logs are the most helpful. IDS/IDPS logs provide not only the IP address, but also the matched signatures, on-going attacks, malware presence, command-and-control servers, the IP and port for the source and destination systems, a timeline, and much more. We will cover IDS/IPS scenarios in the latter half of this book.

Firewall logs

Firewall logs provide a detailed view of activities on the network. Not only do firewall solutions protect a server or a network from unwanted connections, they also help to identify the type of traffic, provide a trust score to the outbound endpoint, block unwanted ports and connection attempts, and much more. We will look at firewalls in more detail in the upcoming chapters.

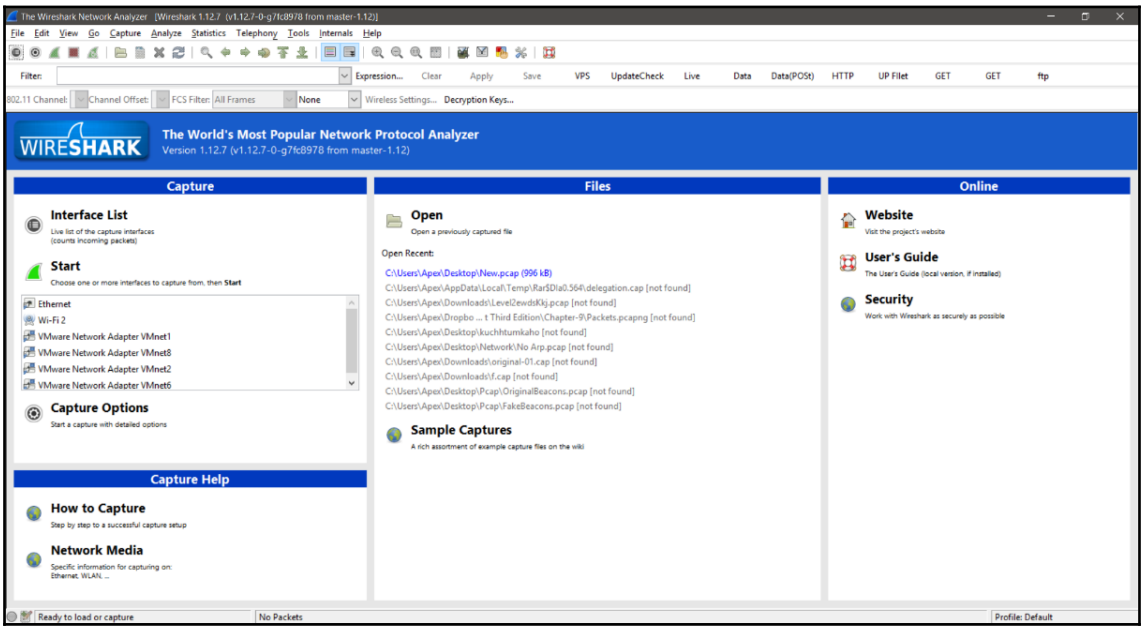
Proxy server logs

Web proxies are also one of the most useful features for a forensic investigator. Web proxy logs help uncover internal threats while providing explicit detail on events such as surfing habits, the source of web-based malware, the user's behavior on the network, and so on.

Since we now have an idea about the various types of logs we can consider for analysis, let us quickly familiarize ourselves on the basics of Wireshark.

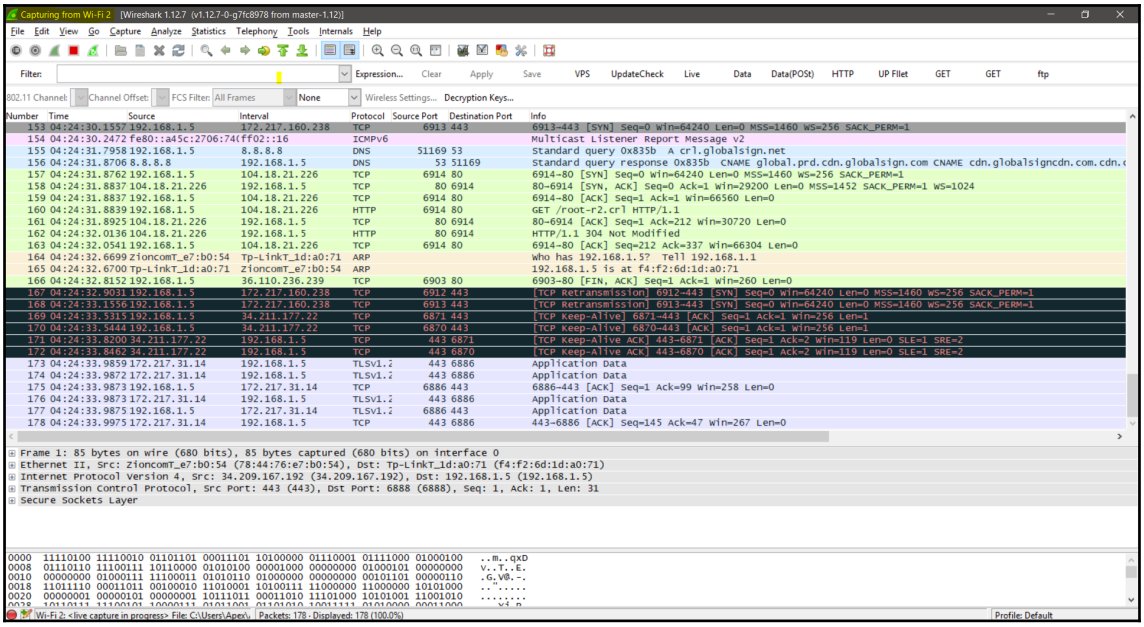
Wireshark essentials

Readers who are familiar with the basics of Wireshark can skip this section and proceed with the case studies; however, readers who are unfamiliar with the basics or who need to brush up on Wireshark essentials, can feel free to continue through this section. Let's look at some of the most basic features of Wireshark. Look at the following screenshot:



Wireshark

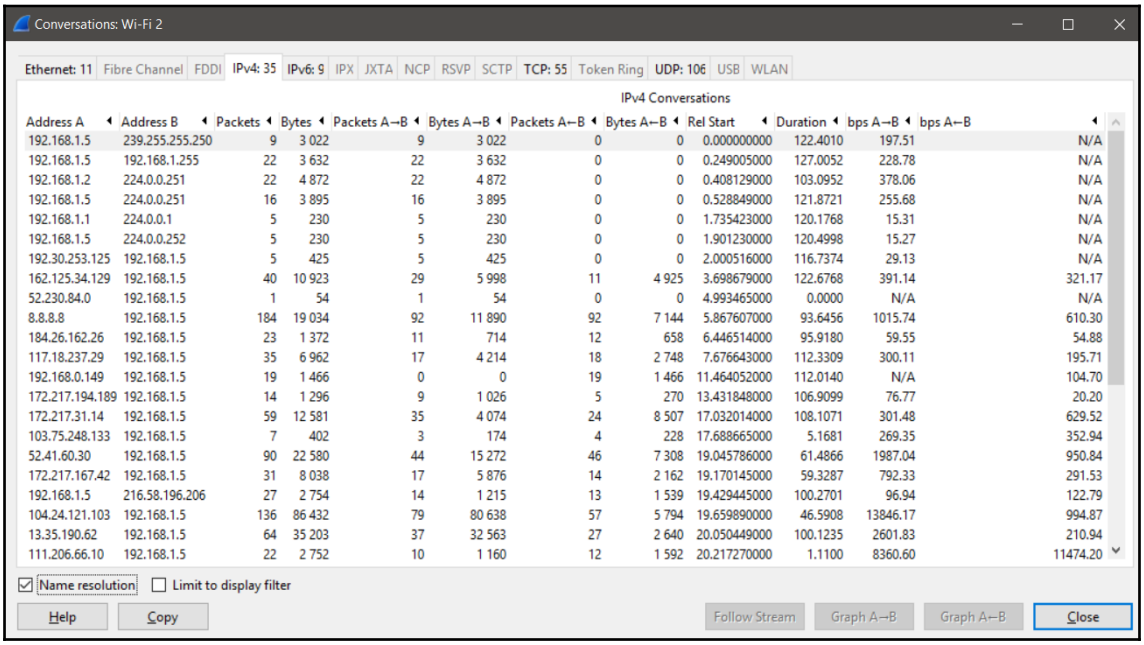
Once we execute Wireshark, we are presented with a screen similar to the preceding picture. On the left-hand side, we have a list of the available interfaces to capture packets from. In the middle, we have recent packet capture files and on the right- hand side, we have online help and user guides. To start a new packet-capture, you can select an interface, such as Ethernet, if you are connected over the wire, or Wi-Fi, if you are connected on a wireless network. Similarly, if you need to open a packet-capture file, you can press the **Open** button, browse to the capture file, and load it in the Wireshark tool. Let's capture packets from the wireless interface by selecting **Wi-Fi** and pressing the **Start** button, as shown in the following screenshot:



We can see from the preceding screenshot that we have various types of packets flowing on the network. Let's understand TCP conversations, endpoints, and basic Wireshark filters in the upcoming sections.

Identifying conversations and endpoints

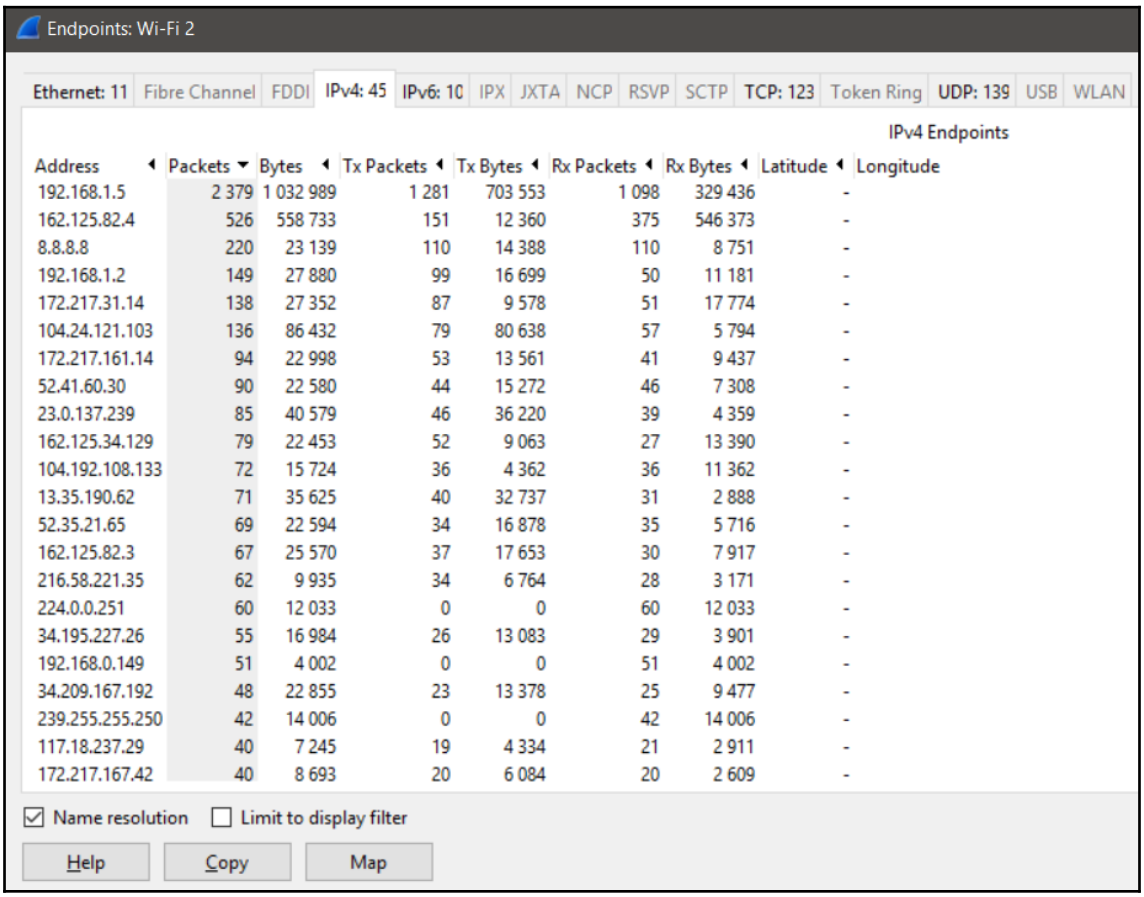
You may want to view the list of IP endpoints that your system is communicating with. To achieve this, you can navigate to the **Statistics** tab and select **Conversations**, as shown in the following screenshot:



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
192.168.1.5	239.255.255.250	9	3 022	9	3 022	0	0	0.000000000	122.4010	197.51	N/A
192.168.1.5	192.168.1.255	22	3 632	22	3 632	0	0	0.249005000	127.0052	228.78	N/A
192.168.1.2	224.0.0.251	22	4 872	22	4 872	0	0	0.408129000	103.0952	378.06	N/A
192.168.1.5	224.0.0.251	16	3 895	16	3 895	0	0	0.528849000	121.8721	255.68	N/A
192.168.1.1	224.0.0.1	5	230	5	230	0	0	1.735423000	120.1768	15.31	N/A
192.168.1.5	224.0.0.252	5	230	5	230	0	0	1.901230000	120.4998	15.27	N/A
192.30.253.125	192.168.1.5	5	425	5	425	0	0	2.000516000	116.7374	29.13	N/A
162.125.34.129	192.168.1.5	40	10 923	29	5 998	11	4 925	3.698679000	122.6768	391.14	321.17
52.230.84.0	192.168.1.5	1	54	1	54	0	0	4.993465000	0.0000	N/A	N/A
8.8.8.8	192.168.1.5	184	19 034	92	11 890	92	7 144	5.867607000	93.6456	1015.74	610.30
184.26.162.26	192.168.1.5	23	1 372	11	714	12	658	6.446514000	95.9180	59.55	54.88
117.18.237.29	192.168.1.5	35	6 962	17	4 214	18	2 748	7.676643000	112.3309	300.11	195.71
192.168.0.149	192.168.1.5	19	1 466	0	0	19	1 466	11.464052000	112.0140	N/A	104.70
172.217.194.189	192.168.1.5	14	1 296	9	1 026	5	270	13.431848000	106.9099	76.77	20.20
172.217.31.14	192.168.1.5	59	12 581	35	4 074	24	8 507	17.032014000	108.1071	301.48	629.52
103.75.248.133	192.168.1.5	7	402	3	174	4	228	17.688665000	5.1681	269.35	352.94
52.41.60.30	192.168.1.5	90	22 580	44	15 272	46	7 308	19.045786000	61.4866	1987.04	950.84
172.217.167.42	192.168.1.5	31	8 038	17	5 876	14	2 162	19.170145000	59.3287	792.33	291.53
192.168.1.5	216.58.196.206	27	2 754	14	1 215	13	1 539	19.429445000	100.2701	96.94	122.79
104.24.121.103	192.168.1.5	136	86 432	79	80 638	57	5 794	19.659890000	46.5908	13846.17	994.87
13.35.190.62	192.168.1.5	64	35 203	37	32 563	27	2 640	20.050449000	100.1235	2601.83	210.94
111.206.66.10	192.168.1.5	22	2 752	10	1 160	12	1 592	20.217270000	1.1100	8360.60	11474.20

We can see that we have a variety of endpoints that are having conversations, the number of bytes transferred between the endpoints, and the duration of their data exchange. These options become extremely handy when you want to investigate malicious traffic and identify the key endpoints that are being contracted. Additionally, we can see that most of the conversations in the preceding screenshot involves `192.168.1.15` but we may not recognize the IP addresses its talking to.

We can also make use of the **Endpoints** option from the **Statistics** tab, as shown in the following screenshot:

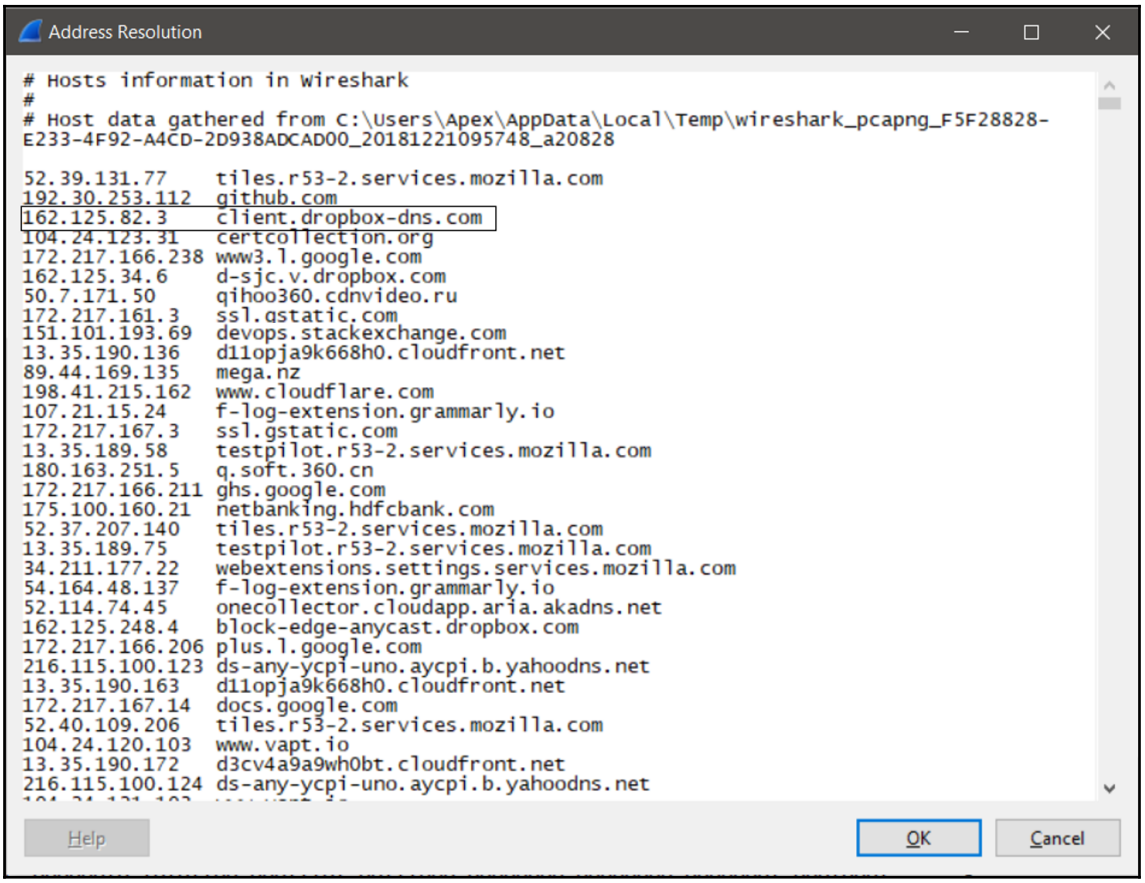


Address	Packets	Bytes	Tx Packets	Tx Bytes	Rx Packets	Rx Bytes	Latitude	Longitude
192.168.1.5	2 379	1 032 989	1 281	703 553	1 098	329 436	-	
162.125.82.4	526	558 733	151	12 360	375	546 373	-	
8.8.8.8	220	23 139	110	14 388	110	8 751	-	
192.168.1.2	149	27 880	99	16 699	50	11 181	-	
172.217.31.14	138	27 352	87	9 578	51	17 774	-	
104.24.121.103	136	86 432	79	80 638	57	5 794	-	
172.217.161.14	94	22 998	53	13 561	41	9 437	-	
52.41.60.30	90	22 580	44	15 272	46	7 308	-	
23.0.137.239	85	40 579	46	36 220	39	4 359	-	
162.125.34.129	79	22 453	52	9 063	27	13 390	-	
104.192.108.133	72	15 724	36	4 362	36	11 362	-	
13.35.190.62	71	35 625	40	32 737	31	2 888	-	
52.35.21.65	69	22 594	34	16 878	35	5 716	-	
162.125.82.3	67	25 570	37	17 653	30	7 917	-	
216.58.221.35	62	9 935	34	6 764	28	3 171	-	
224.0.0.251	60	12 033	0	0	60	12 033	-	
34.195.227.26	55	16 984	26	13 083	29	3 901	-	
192.168.0.149	51	4 002	0	0	51	4 002	-	
34.209.167.192	48	22 855	23	13 378	25	9 477	-	
239.255.255.250	42	14 006	0	0	42	14 006	-	
117.18.237.29	40	7 245	19	4 334	21	2 911	-	
172.217.167.42	40	8 693	20	6 084	20	2 609	-	

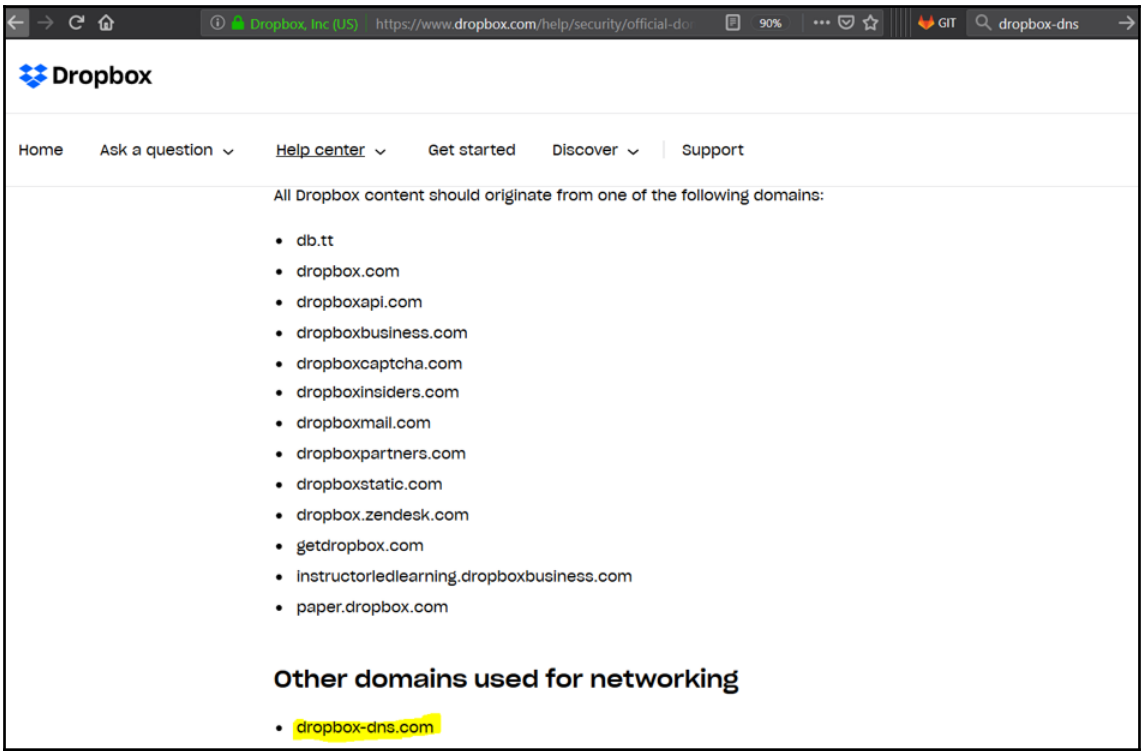
From the preceding screenshot, we can see all the endpoints, and sorting them using the number of packets will give us a clear understanding of the endpoints that are transmitting the highest number of packets, which is again quite handy when it comes to analyzing anomalous network behavior.

Identifying the IP endpoints

Domain names were invented to make it more easy to remember sites with common phrases. Having a list of IP addresses in the previous section would make no sense to us, but having a list that shows the resolution of the IPs into domain names can help us a lot. On clicking the **Show address resolution** / **Resolved Addresses** option, we will be presented with the following:



Well, this now makes proper sense, as we have a list of IP addresses with their domain resolutions that can help us eliminate the false positives. We saw in the previous endpoint section that the second-highest number of packets in the endpoints originated from `162.125.34.6`. Since we don't have an idea of what IP address this could be, we can easily refer to the address resolutions and figure out that this is `dropbox-dns.com`, which looks suspicious. Let's search for it on Google using the string `client.dropbox-dns.com`, and browsing the first result from the search, we have the following result:



We can see from the preceding search result (the official Dropbox website, `https://www.dropbox.com/`) that the domain is a legitimate Dropbox domain and the traffic originating to and from it is safe (assuming that Dropbox is permitted on the network or if allowed for a select group of users that the traffic is associated with those users only). This resolution not only helps us identify domains, but also speaks a lot about the software running on the target as well. We already identified Dropbox as running on the system. We also identified the following domains from the **Resolved Addresses** pane in Wireshark:

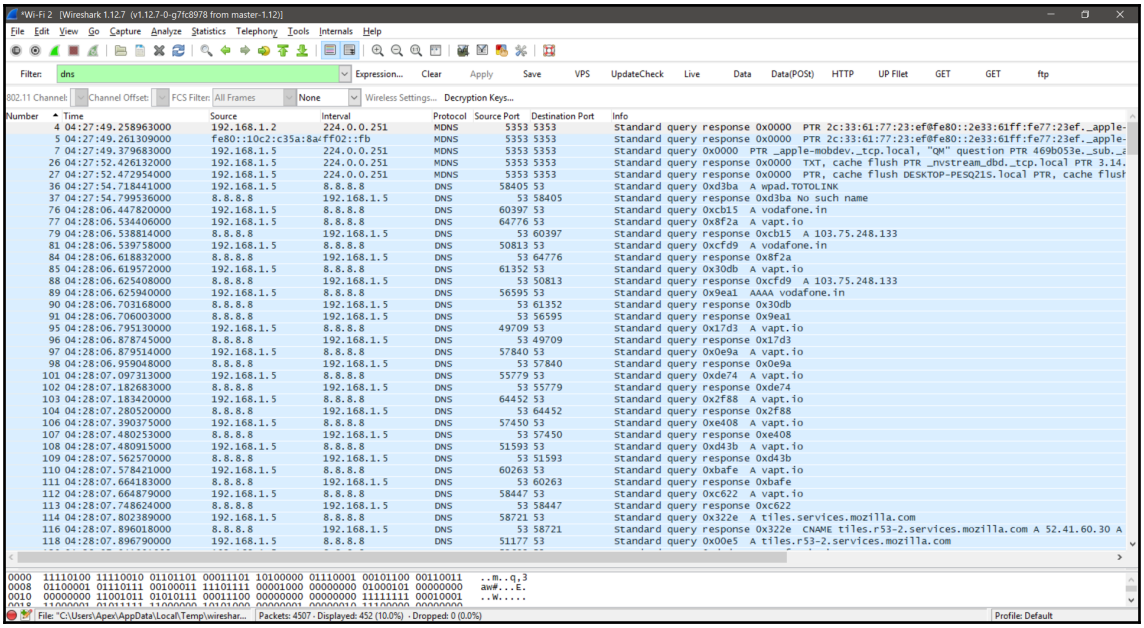
- A Gmail account being accessed
- A Qihoo 360 antivirus

- An HDFC bank account
- The Grammarly plugin
- The Firefox browser

Basic filters

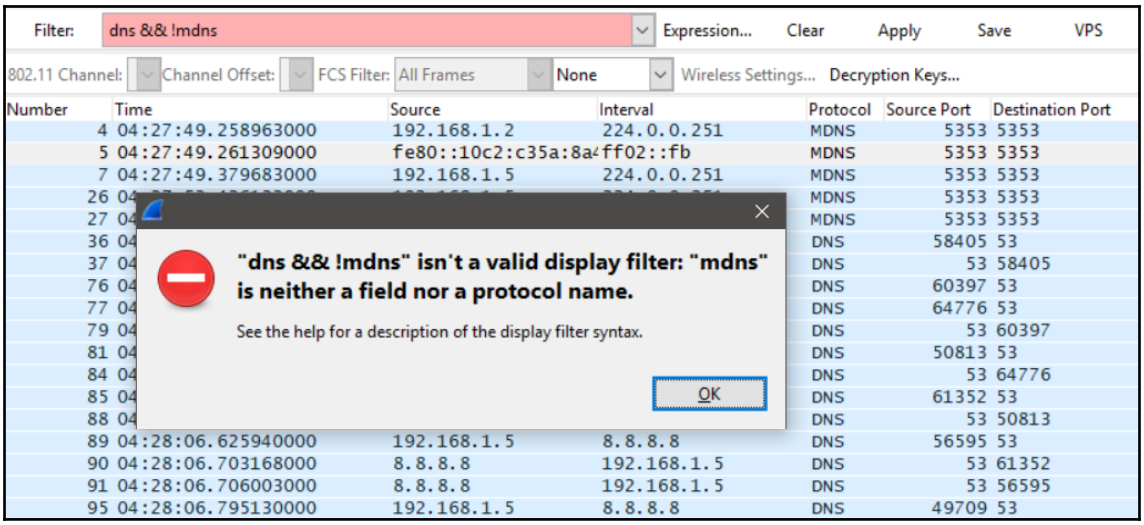
Network forensics requires you to pinpoint a variety of packets to establish a clear vision for the investigation. Let's explore how we can do this by going through the following steps:

Set up some basic display filters in Wireshark to only view packets of interest, as shown in the following screenshot:



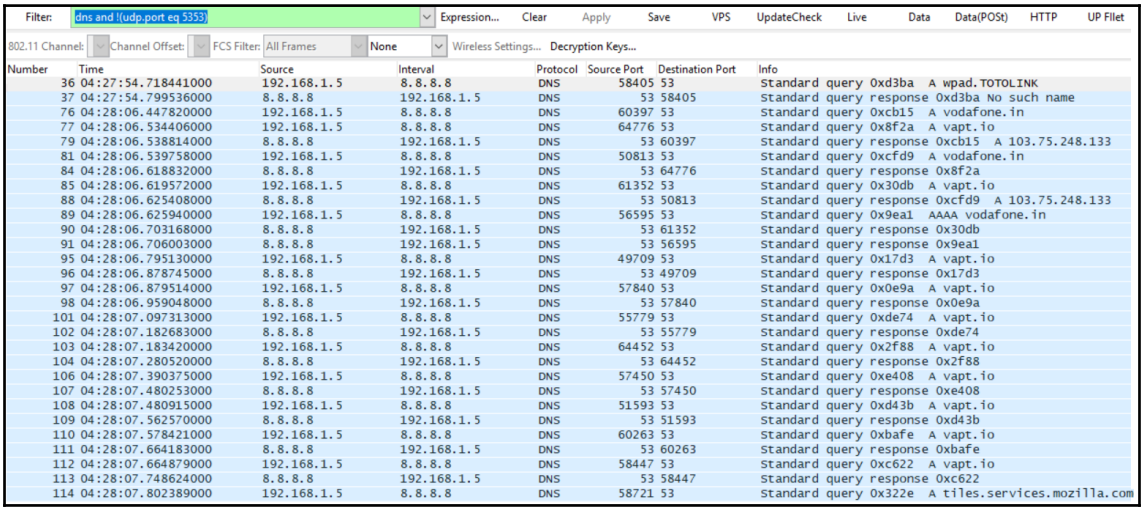
We can see that simply typing in `dns` as the filter will display DNS packets only; however, we can see that MDNS protocol packets are also displayed.

Considering that we only require DNS packets and not MDNS protocol packets, we can set the filter as `dns && !mdns`, where `!` denotes a NOT operation, as shown in the following screenshot:



Number	Time	Source	Interval	Protocol	Source Port	Destination Port
4	04:27:49.258963000	192.168.1.2	224.0.0.251	MDNS	5353	5353
5	04:27:49.261309000	fe80::10c2:c35a:8a4	ff02::fb	MDNS	5353	5353
7	04:27:49.379683000	192.168.1.5	224.0.0.251	MDNS	5353	5353
26	04			MDNS	5353	5353
27	04			MDNS	5353	5353
36	04			DNS	58405	53
37	04			DNS	53	58405
76	04			DNS	60397	53
77	04			DNS	64776	53
79	04			DNS	53	60397
81	04			DNS	50813	53
84	04			DNS	53	64776
85	04			DNS	61352	53
88	04			DNS	53	50813
89	04:28:06.625940000	192.168.1.5	8.8.8.8	DNS	56595	53
90	04:28:06.703168000	8.8.8.8	192.168.1.5	DNS	53	61352
91	04:28:06.706003000	8.8.8.8	192.168.1.5	DNS	53	56595
95	04:28:06.795130000	192.168.1.5	8.8.8.8	DNS	49709	53

We can see from this that we don't have an exact filter for MDNS. So, how do we filter the MDNS packets out? We can see that the MDNS protocol communicates over port `5353`. Let's filter that out instead of using an `!mdns` filter, as shown in the following screenshot:

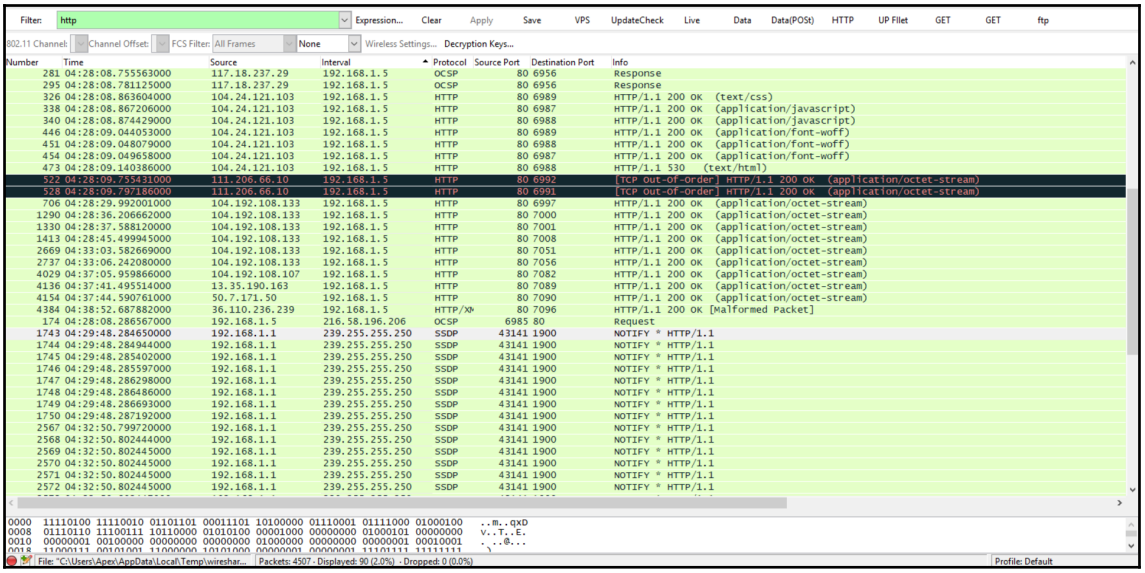


Number	Time	Source	Interval	Protocol	Source Port	Destination Port	Info
36	04:27:54.718441000	192.168.1.5	8.8.8.8	DNS	58405	53	Standard query 0xd3ba A wpad.TOTOLINK
37	04:27:54.799536000	8.8.8.8	192.168.1.5	DNS	53	58405	Standard query response 0xd3ba No such name
76	04:28:06.447820000	192.168.1.5	8.8.8.8	DNS	60397	53	Standard query 0xcb15 A vodafone.in
77	04:28:06.534406000	192.168.1.5	8.8.8.8	DNS	64776	53	Standard query 0x8f2a A vapt.io
79	04:28:06.538814000	8.8.8.8	192.168.1.5	DNS	53	60397	Standard query response 0xcb15 A 103.75.248.133
81	04:28:06.539758000	192.168.1.5	8.8.8.8	DNS	50813	53	Standard query 0xcfd9 A vodafone.in
84	04:28:06.618832000	8.8.8.8	192.168.1.5	DNS	53	64776	Standard query response 0x8f2a
85	04:28:06.619572000	192.168.1.5	8.8.8.8	DNS	61352	53	Standard query 0x30db A vapt.io
88	04:28:06.625408000	8.8.8.8	192.168.1.5	DNS	53	50813	Standard query response 0xcfd9 A 103.75.248.133
89	04:28:06.625940000	192.168.1.5	8.8.8.8	DNS	56595	53	Standard query 0x9ea1 AAAA vodafone.in
90	04:28:06.703168000	8.8.8.8	192.168.1.5	DNS	53	61352	Standard query response 0x30db
91	04:28:06.706003000	8.8.8.8	192.168.1.5	DNS	53	56595	Standard query response 0x9ea1
95	04:28:06.795130000	192.168.1.5	8.8.8.8	DNS	49709	53	Standard query 0x17d3 A vapt.io
96	04:28:06.878745000	8.8.8.8	192.168.1.5	DNS	53	49709	Standard query response 0x17d3
97	04:28:06.879514000	192.168.1.5	8.8.8.8	DNS	57840	53	Standard query 0x0e9a A vapt.io
98	04:28:06.959048000	8.8.8.8	192.168.1.5	DNS	53	57840	Standard query response 0x0e9a
101	04:28:07.097313000	192.168.1.5	8.8.8.8	DNS	55779	53	Standard query 0xde74 A vapt.io
102	04:28:07.182683000	8.8.8.8	192.168.1.5	DNS	53	55779	Standard query response 0xde74
103	04:28:07.183420000	192.168.1.5	8.8.8.8	DNS	64452	53	Standard query 0x2f88 A vapt.io
104	04:28:07.280520000	8.8.8.8	192.168.1.5	DNS	53	64452	Standard query response 0x2f88
106	04:28:07.390375000	192.168.1.5	8.8.8.8	DNS	57450	53	Standard query 0xe408 A vapt.io
107	04:28:07.480253000	8.8.8.8	192.168.1.5	DNS	53	57450	Standard query response 0xe408
108	04:28:07.480915000	192.168.1.5	8.8.8.8	DNS	51593	53	Standard query 0xd43b A vapt.io
109	04:28:07.562570000	8.8.8.8	192.168.1.5	DNS	53	51593	Standard query response 0xd43b
110	04:28:07.578421000	192.168.1.5	8.8.8.8	DNS	60263	53	Standard query 0xbafe A vapt.io
111	04:28:07.664183000	8.8.8.8	192.168.1.5	DNS	53	60263	Standard query response 0xbafe
112	04:28:07.664879000	192.168.1.5	8.8.8.8	DNS	58447	53	Standard query 0xc622 A vapt.io
113	04:28:07.748624000	8.8.8.8	192.168.1.5	DNS	53	58447	Standard query response 0xc622
114	04:28:07.802389000	192.168.1.5	8.8.8.8	DNS	58721	53	Standard query 0x322e A tiles.services.mozilla.com

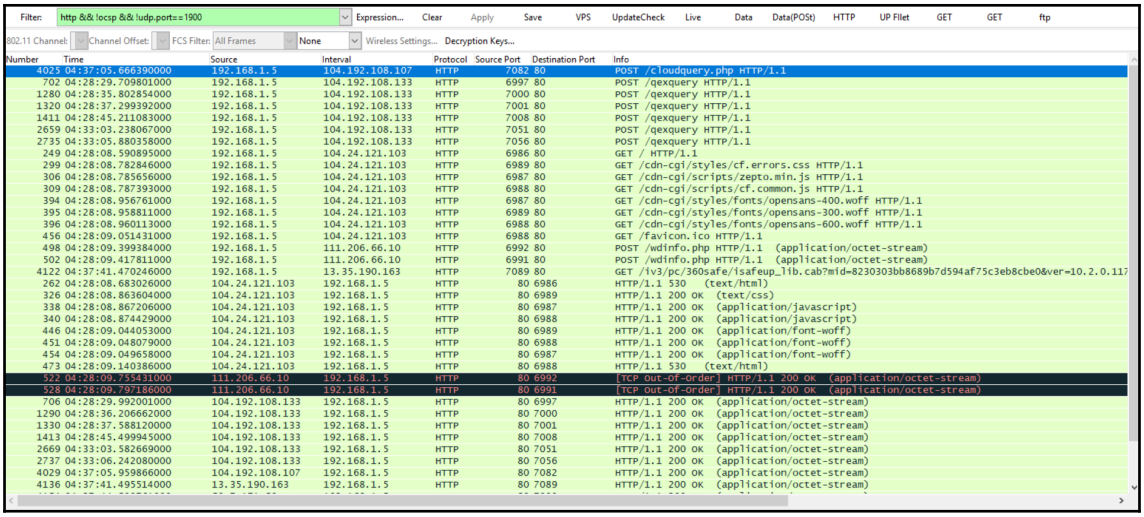
We can see that providing the filter `dns and !(udp.port eq 5353)` presents us with only the DNS packets. Here, `eq` means equal, the `!` means NOT, and `udp.port` means the UDP port. This means that, in layman's terms, we are asking Wireshark to filter DNS packets while removing all the packets that communicate over UDP port `5353`.

In the latest version of Wireshark `mdns` is a valid protocol and display filter such as `dns && !mdns` works fine.

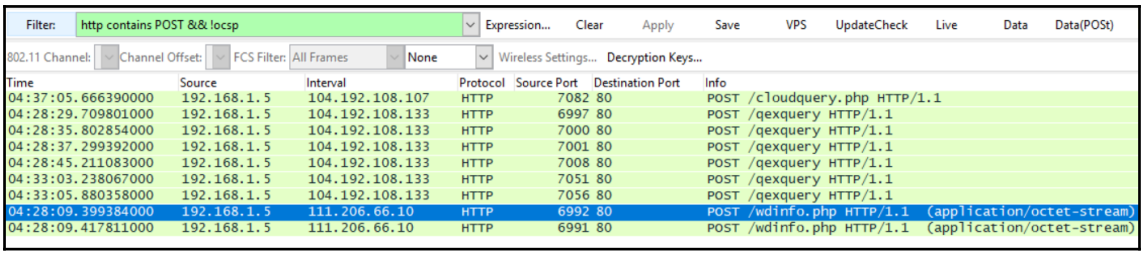
Similarly, for HTTP, we can type in `http` as the filter, as shown in the following screenshot:



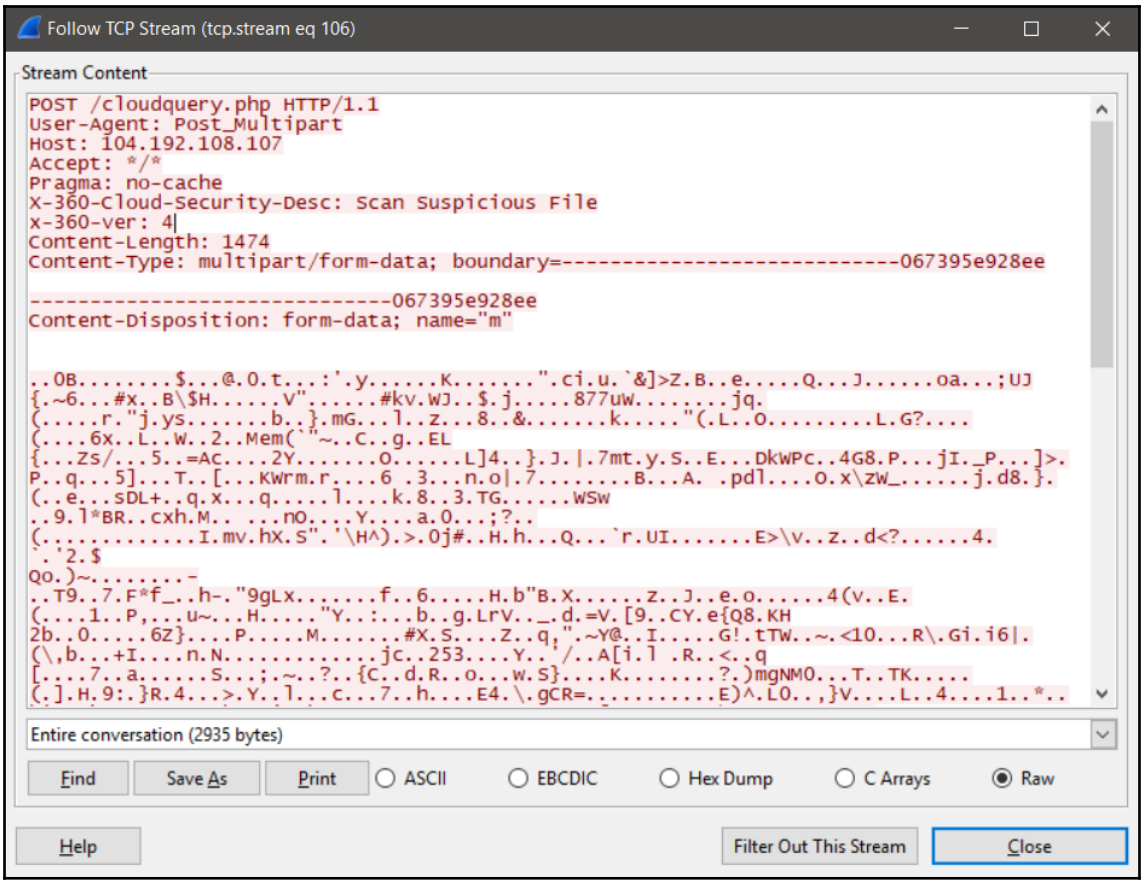
However, we also have OCSP and **Simple Service Discovery Protocol** (**SSDP**) protocol data alongside the data that is filtered from the stream. To filter out the OCSP and SSDP protocol data, we can type in `http && !ocsp`, and since SSDP poses a similar problem to MDNS, we can type `!udp.port==1900`. This means that the entire filter becomes `http && !ocsp && !udp.port==1900`, as shown in the following screenshot:



We can see from this that we have successfully filtered HTTP packets. But can we search through them and filter only HTTP POST packets? Yes, we can, using the expression `http contains POST && !ocsp` as shown in the following screenshot.



We can see that providing the `HTTP contains POST` filter filters out all the non-HTTP POST requests. Let's analyze the request by right-clicking and selecting the option to follow the HTTP stream, as shown in the following screenshot:

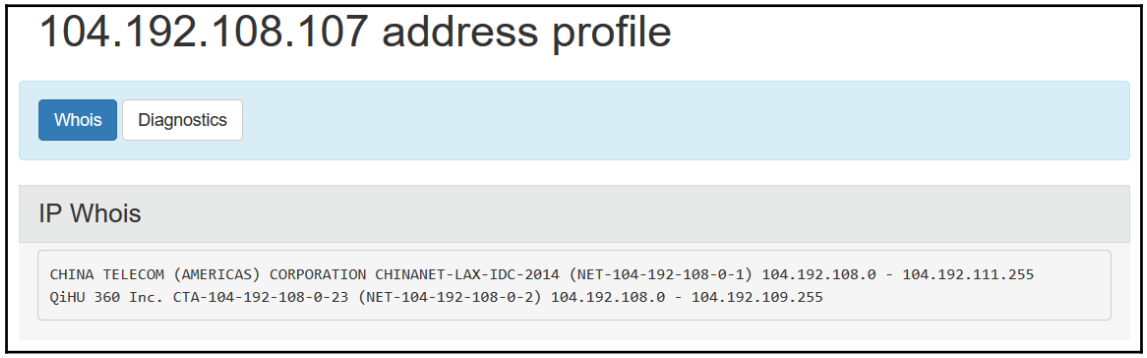


We can see that this looks like a file that has been sent out somewhere, but since it has headers such as `x-360-cloud-security-desc`, it looks as though it's the cloud antivirus that is scanning a suspicious file found on the network.

Let's take note of the IP address and match it with the address resolutions, as shown in the following screenshot:

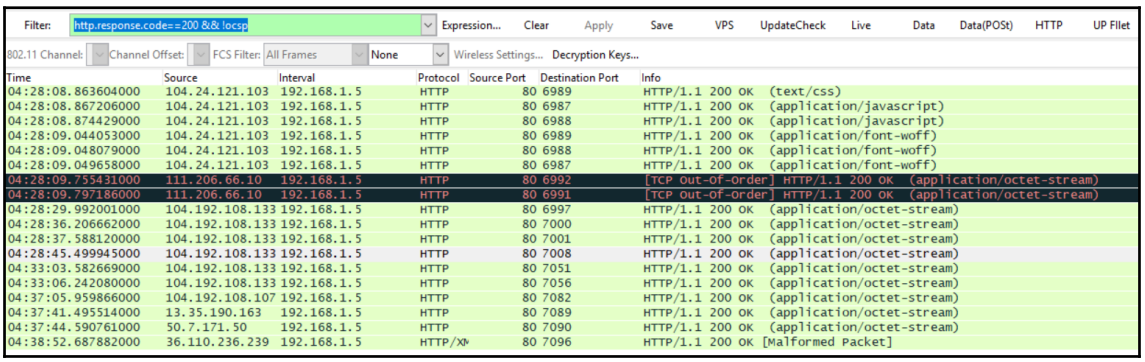
```
# Address resolution IPv4 Hash table
#
# With 120 entries
#
Key:0x4d832734 IP: 52.39.131.77, Name: tiles.r53-2.services.mozilla.com
Key:0x70fd1ec0 IP: 192.30.253.112, Name: github.com
Key:0x3527da2 IP: 162.125.82.3, Name: client.dropbox-dns.com
Key:0x1f7b1868 IP: 104.24.123.31, Name: certcollection.org
Key:0x3a1d9ac IP: 172.217.161.3, Name: ssl.gstatic.com
Key:0x32ab0732 IP: 50.7.171.50, Name: qihoo360.cdnvideo.ru
Key:0xcea6d9ac IP: 172.217.166.206, Name: plus.l.google.com
Key:0x6b6cc068 IP: 104.192.108.107, Name: 104.192.108.107
Key:0x16b1d322 IP: 34.211.177.22, Name: webextensions.settings.services.mozilla.com
```

Well, the address resolutions have failed us this time. Let's search the IP on `https://who.is/`, as shown in the following screenshot:



Yes, it belongs to the QiHU 360 antivirus.

We can also select HTTP packets based on the response codes, as shown in the following screenshot:



We can see that we have filtered the packets using `http.response.code==200`, where `200` denotes a status OK response. This is handy when investigating packet captures from compromised servers, as it gives us a clear picture of the files that have been accessed and shows us how the server responded to particular requests.

It also allows us to figure out whether the implemented protections are working well, because upon receiving a malicious request, in most cases, the protection firewall issues a **404 (NOT FOUND)** or a **403 (Forbidden)** response code instead of 200 (OK).

Let's now jump into some case studies and make use of the basics that we just learned.

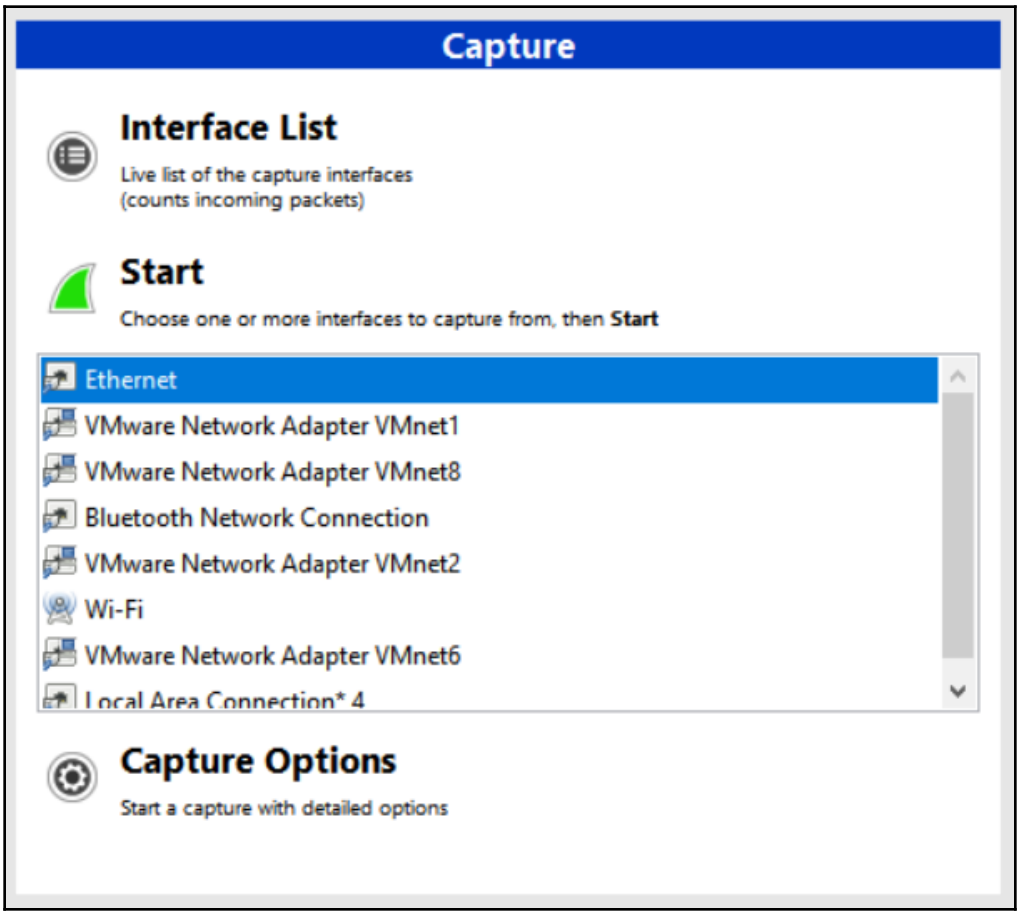
Exercise 1 – a noob's keylogger

Consider a scenario where an attacker has planted a keylogger on one of the systems in the network. Your job as an investigator is to find the following pieces of information:

- Find the infected system
- Trace the data to the server
- Find the frequency of the data that is being sent
- Find what other information is carried besides the keystrokes
- Try to uncover the attacker
- Extract and reconstruct the files that have been sent to the attacker

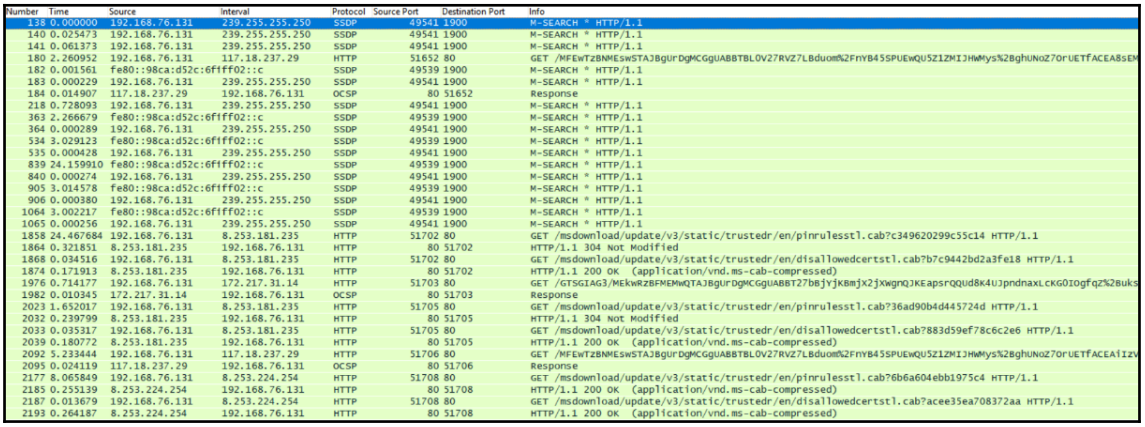
Additionally, in this exercise, you need to assume that the **packet capture** (**PCAP**) file is not available and that you have to do the sniffing-out part as well. Let's say that you are connected to a mirror port on the network where you can see all the data traveling to and from the network.

We can begin our process as follows. We already know that we are connected via a mirror port. Let's sniff around on the interface of choice. If connected to the mirror port, choose the default interface and proceed with collecting packets, as shown in the following screenshot:



Most keyloggers work on the web (HTTP), FTP, and email for delivering the keystrokes back to the attacker. We will try all of these to check whether there's anything unusual with packets from these protocols.

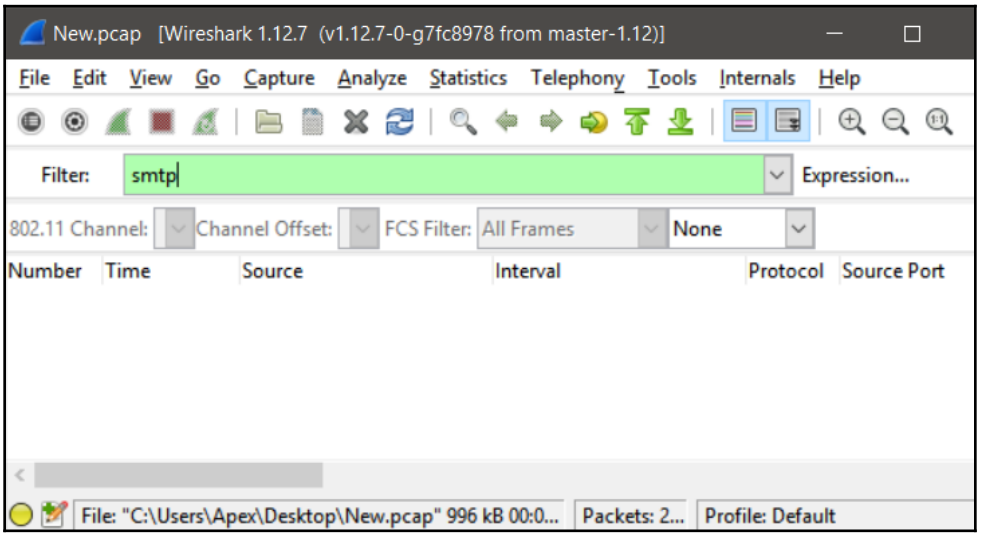
Let's try HTTP first by setting the `http` filter, as shown in the following screenshot:



Number	Time	Source	Interval	Protocol	Source Port	Destination Port	Info
138	0.000000	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
140	0.025473	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
141	0.061373	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
180	2.260952	192.168.76.131	117.18.237.29	HTTP	51652	80	GET /MFEwTzBNMEswSTAJBgUrDgMCGgUABBTBL0V27RVZ7LBduom%2FnYB45SPUEwQU5Z1ZMIJHWMys%2BghUNoZ7OrUETfACEA8sEM
182	0.001561	fe80::98ca:d52c:6fff:f02::c		SSDP	49539	1900	M-SEARCH * HTTP/1.1
183	0.000229	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
184	0.014907	117.18.237.29	192.168.76.131	OCSP		80 51652	Response
218	0.728093	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
363	2.266679	fe80::98ca:d52c:6fff:f02::c		SSDP	49539	1900	M-SEARCH * HTTP/1.1
364	0.000289	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
534	3.029123	fe80::98ca:d52c:6fff:f02::c		SSDP	49539	1900	M-SEARCH * HTTP/1.1
535	0.000428	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
839	24.159910	fe80::98ca:d52c:6fff:f02::c		SSDP	49539	1900	M-SEARCH * HTTP/1.1
840	0.000274	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
905	3.014578	fe80::98ca:d52c:6fff:f02::c		SSDP	49539	1900	M-SEARCH * HTTP/1.1
906	0.000380	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
1064	3.002217	fe80::98ca:d52c:6fff:f02::c		SSDP	49539	1900	M-SEARCH * HTTP/1.1
1065	0.000256	192.168.76.131	239.255.255.250	SSDP	49541	1900	M-SEARCH * HTTP/1.1
1858	24.467684	192.168.76.131	8.253.181.235	HTTP	51702	80	GET /msdownload/update/v3/static/trustedr/en/pinrulesstl.cab?c349620299c55c14 HTTP/1.1
1864	0.321851	8.253.181.235	192.168.76.131	HTTP		80 51702	HTTP/1.1 304 Not Modified
1868	0.034516	192.168.76.131	8.253.181.235	HTTP	51702	80	GET /msdownload/update/v3/static/trustedr/en/disallowedcertstl.cab?b7c9442bd2a3fe18 HTTP/1.1
1874	0.171913	8.253.181.235	192.168.76.131	HTTP		80 51702	HTTP/1.1 200 OK (application/vnd.ms-cab-compressed)
1976	0.714177	192.168.76.131	172.217.31.14	HTTP	51703	80	GET /GTSGIAG3/MEkwRzBFMEMwQTAJBgUrDgMCGgUABBT27bBjYjK8mjX2jXwgnQJKEapsrQQUd8K4UJpndnaxLCkGOIOgfqZ%2Buks
1982	0.010345	172.217.31.14	192.168.76.131	OCSP		80 51703	Response
2023	1.652017	192.168.76.131	8.253.181.235	HTTP	51705	80	GET /msdownload/update/v3/static/trustedr/en/pinrulesstl.cab?36ad90b4d445724d HTTP/1.1
2032	0.239799	8.253.181.235	192.168.76.131	HTTP		80 51705	HTTP/1.1 304 Not Modified
2033	0.035317	192.168.76.131	8.253.181.235	HTTP	51705	80	GET /msdownload/update/v3/static/trustedr/en/disallowedcertstl.cab?883d59ef78c6c2e6 HTTP/1.1
2039	0.180772	8.253.181.235	192.168.76.131	HTTP		80 51705	HTTP/1.1 200 OK (application/vnd.ms-cab-compressed)
2092	5.233444	192.168.76.131	117.18.237.29	HTTP	51706	80	GET /MFEwTzBNMEswSTAJBgUrDgMCGgUABBTBL0V27RVZ7LBduom%2FnYB45SPUEwQU5Z1ZMIJHWMys%2BghUNoZ7OrUETfACEAIIzv
2095	0.024119	117.18.237.29	192.168.76.131	OCSP		80 51706	Response
2177	8.065849	192.168.76.131	8.253.224.254	HTTP	51708	80	GET /msdownload/update/v3/static/trustedr/en/pinrulesstl.cab?6b6a604ebb1975c4 HTTP/1.1
2185	0.255139	8.253.224.254	192.168.76.131	HTTP		80 51708	HTTP/1.1 200 OK (application/vnd.ms-cab-compressed)
2187	0.013679	192.168.76.131	8.253.224.254	HTTP	51708	80	GET /msdownload/update/v3/static/trustedr/en/disallowedcertstl.cab?acee35ea708372aa HTTP/1.1
2193	0.264187	8.253.224.254	192.168.76.131	HTTP		80 51708	HTTP/1.1 200 OK (application/vnd.ms-cab-compressed)

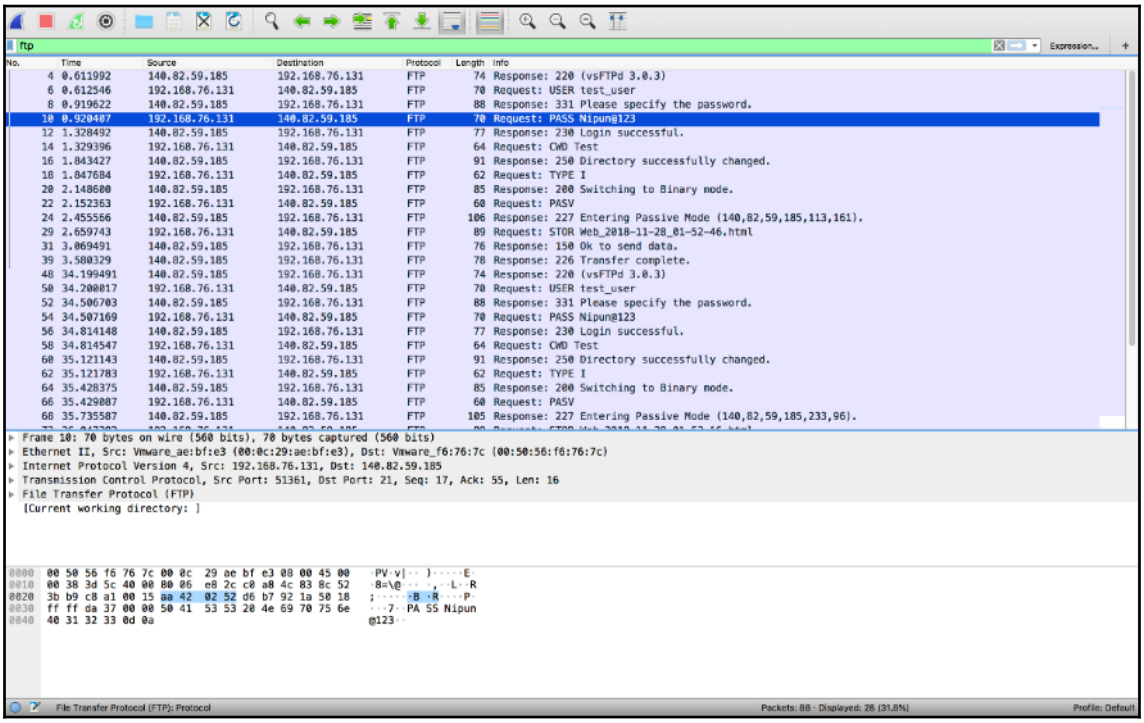
There is HTTP data, but everything seems fine.

Let's try a couple of protocols, SMTP and POP, to check for anything unusual with the email protocol, as shown in the following screenshot:



Everything seems fine here as well.

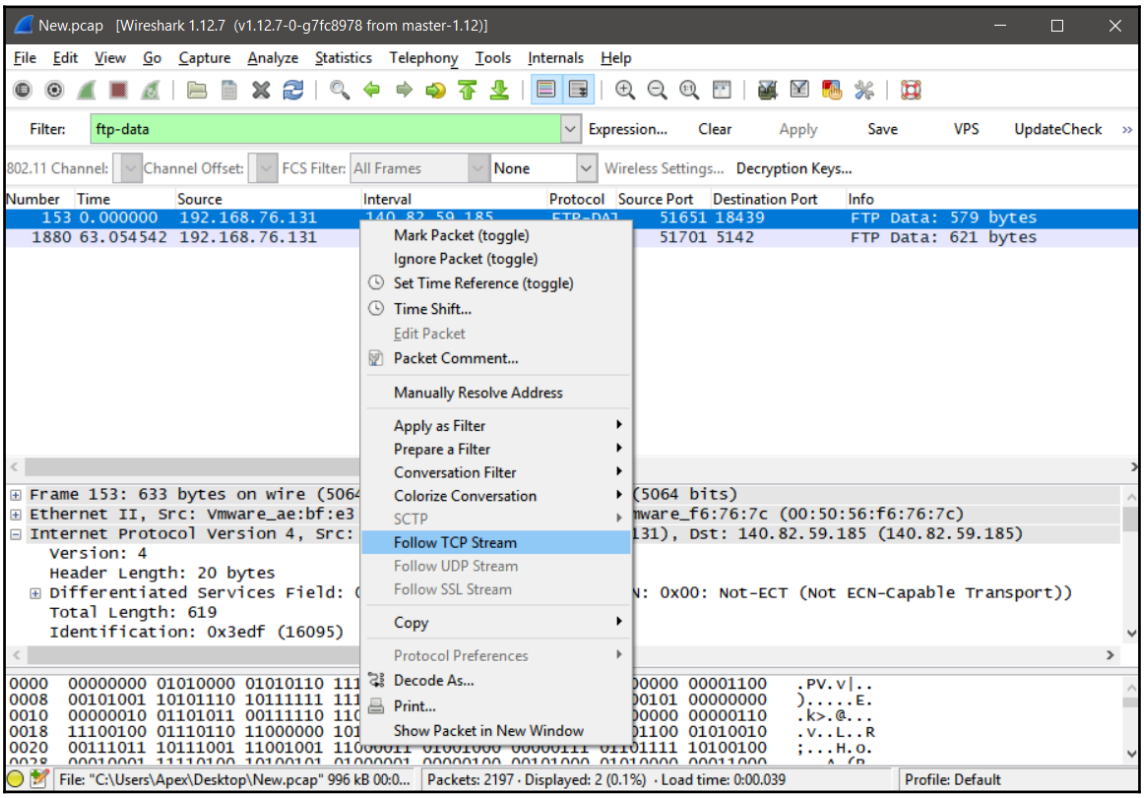
Let's try FTP as well, as shown in the following screenshot:



FTP

Well, we have plenty of activity on the FTP! We can see that the FTP packets contain the `USER` and `PASS` commands in the capture, which denotes a login activity to the server. Of course, this can be either the keylogger or a legitimate login from any user on the network. Additionally, we can see a `STOR` command that is used to store files on the FTP server. However, let's note down the credentials and filenames of the uploaded files for our reference and investigate further. Since, we know that the `STOR` command is used to store data on the server.

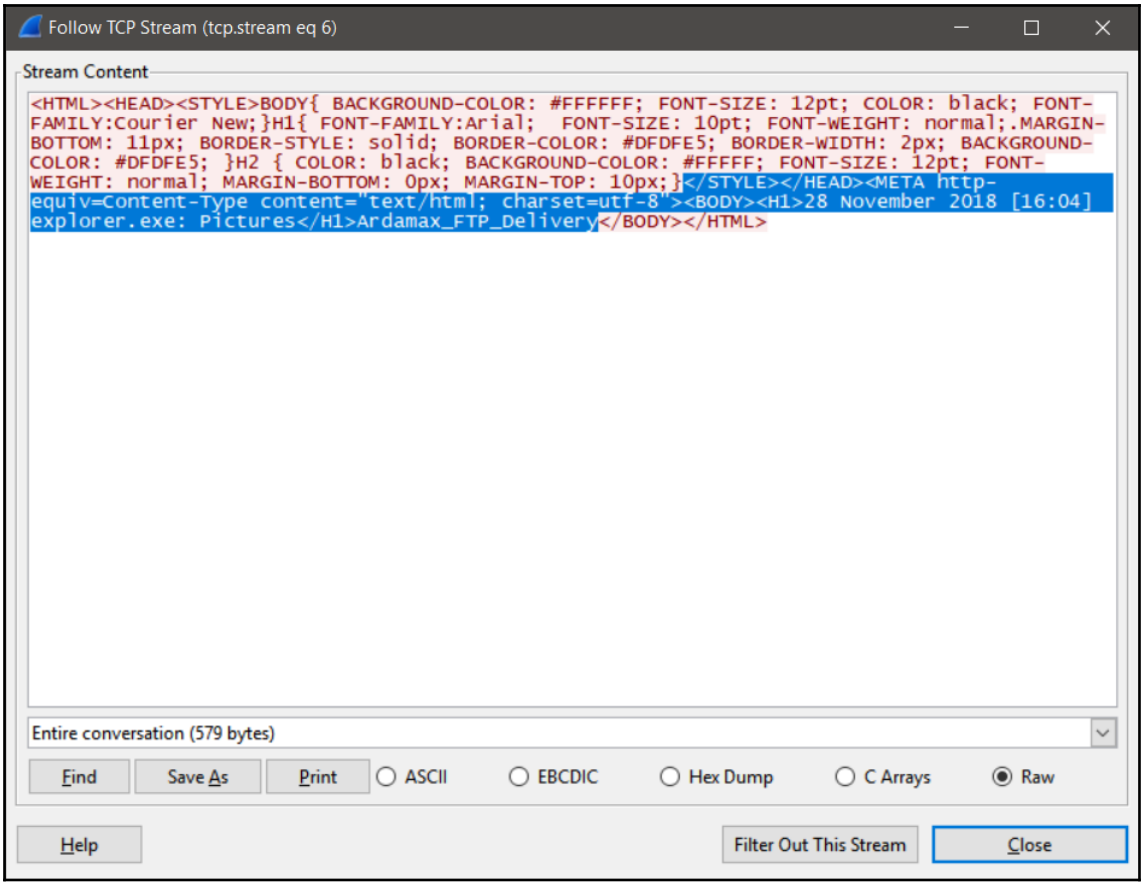
Let's view these data packets by changing filter to `ftp-data`, as shown in the following screenshot:



Changing filter to ftp-data

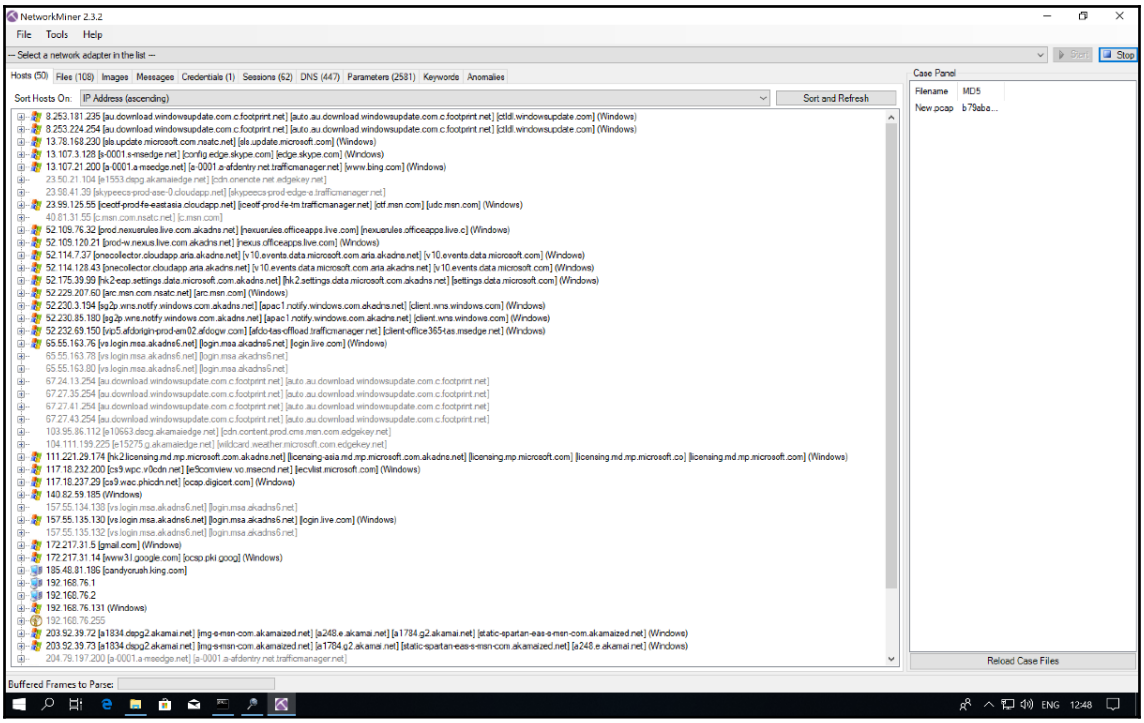
`ftp-data` will only contain mostly the files and data transferred rather that all the other FTP commands

Let's see what we get when we follow the TCP stream of the packet, we can see that we have the following data being posted to the server:



We can see that the data being transmitted contains the word `Ardamax`, which is the name of a common piece of keylogger software that records keystrokes from the system it has infected and sends it back to the attacker. Let's save the packet capture in PCAP format by selecting **File** | **Save As** and choosing the `.pcap` format. We will be using the `.pcap` format only since the free version of NetworkMiner support only PCAP files and not the `pcapng` format.

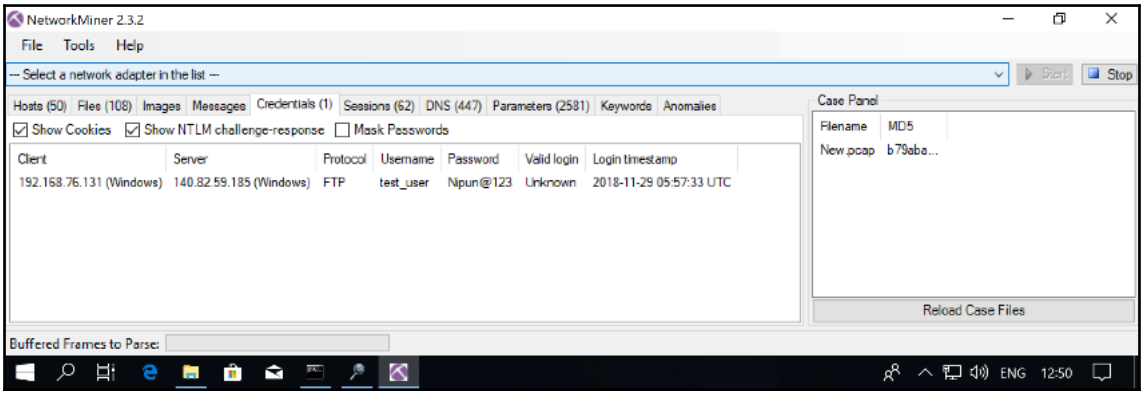
Let's open the saved file using NetworkMiner as shown in the following screenshot:



Opening the saved file using network miner

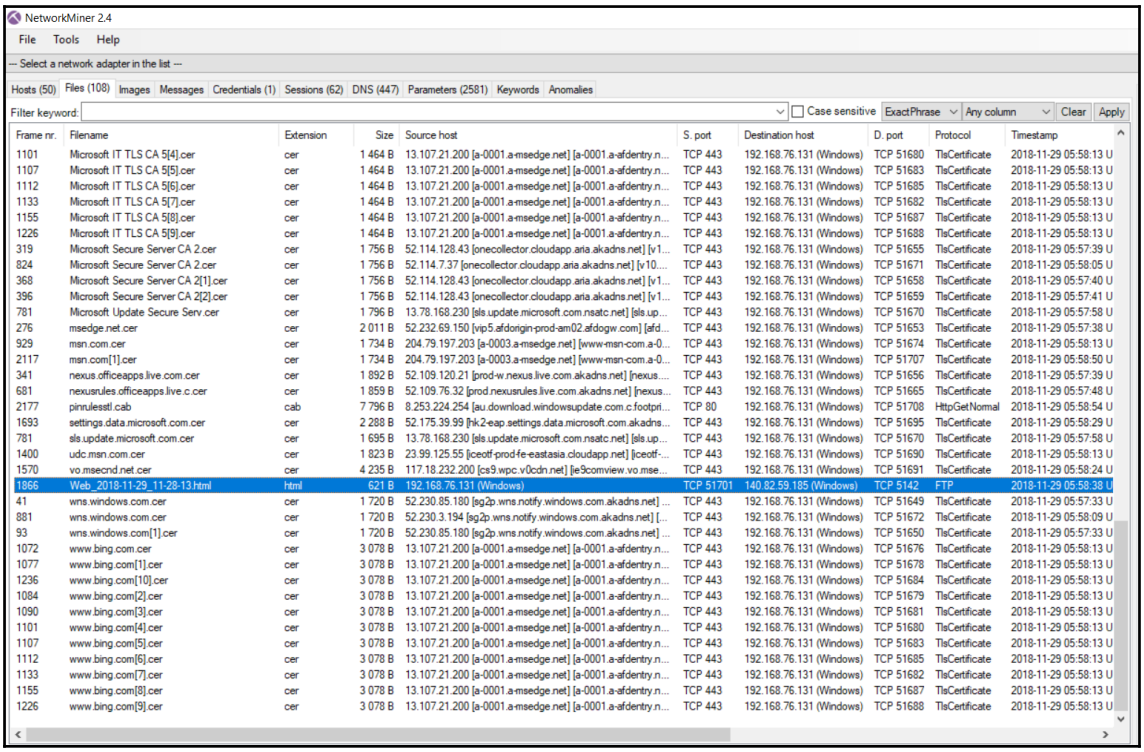
We can see we have a number of hosts present in the network capture.

Let's navigate to the **Credentials** tab, as shown in the following screenshot:



We can see that we have the username and password captured in the PCAP file displayed under **Credentials** tab in NetworkMiner. We previously saw the `STOR` command, which is commonly used in uploading files to an FTP from the Wireshark dump.

Let's browse to the **Files** tab and see the files that we are interested in:



Files tab

We can see plenty of files. Let's open the files that we found using the `STOR` command in the browser, as shown in the following screenshot:

The attacker was not only keylogging, but was also fetching details such as the active window title along with the key logs. So, to sum this up, we have the following answers to the questions that we asked at the beginning of the exercise:

- **Find the infected system**: `192.168.76.131`
- **Trace the data to the server**: `140.82.59.185`
- **Find the frequency of the data that is being sent**: The difference between two consecutive `STOR` commands for a similar file type is 15 seconds
- **Find what other information is carried alongside the keystrokes**: Active window titles
- **Try to uncover the attacker**: Not yet found
- **Extract and reconstruct the files sent to the attacker**: `Keys_2018-11-28_16-04-42.html`

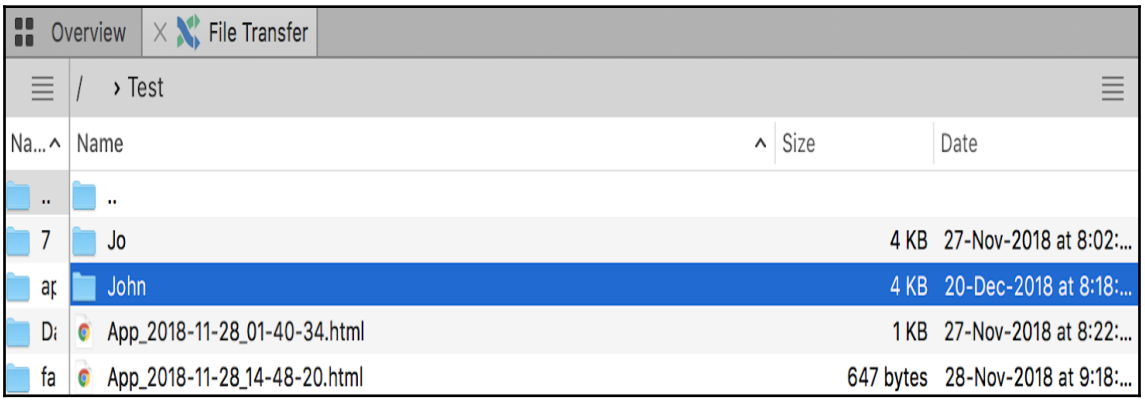
We have plenty of information regarding the hacker. At this point, we can provide the details we found in our analysis in the report, or we can go one step further and try to uncover the identity of the attacker. If you chose to do so, then let's get started in finding out how to uncover this information.

Logging into a computer that you're not authorized to access can result in criminal penalties (fines, imprisonment, or both).

We already found their credentials in the server. Let's try logging into the FTP server and try to find something of interest, as shown in the following screenshot:

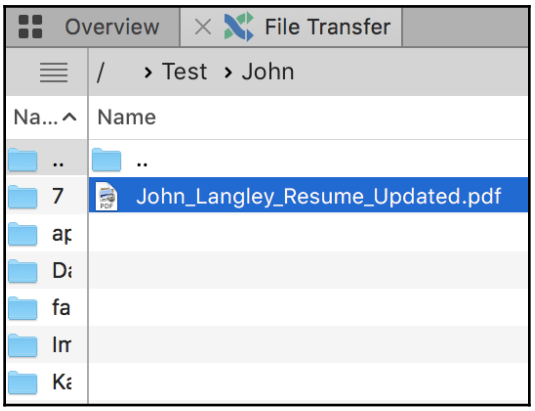
```
root@kali:~/fbctf# nc 140.82.59.185 21
220 (vsFTPd 3.0.3)
help
530 Please login with USER and PASS.
USER test_user
331 Please specify the password.
PASS Nipun@123
230 Login successful.
```

We can see that we are easily able to log into the server. Let's use an FTP client, such as Royal TSX in Mac (FileZilla for Windows), to view the files that reside on the server, as shown in the following screenshot:



Wow! So much information has been logged; however, we can see two directories named `John` and `Jo`. The directory `Jo` is empty but we may have something in the directory named `John`.

Let's view the contents of `John`, as shown in the following screenshot:



It looks as though the attacker is applying for jobs and keeps their updated resume on their server. The case-study analysis proves that the keylogger is a newbie. In answering the last question regarding the identity of the attacker, we have successfully conducted our first network forensic analysis exercise. The resume we found might have been stolen from someone else as well. However, this is just the tip of the iceberg. In the upcoming chapters, we will look at a variety of complex scenarios; this was an easy one.

In the next example, we will look at TCP packets and try figuring out what were the event causing such network traffic.

Exercise 2 – two too many

Let's analyze the given capture file that we currently don't know any details about and try reconstructing the chain of events.

We will open the PCAP in Wireshark, as follows:

9 0.001913	172.16.0.8	64.13.134.52	TCP	58	36050 53	36050 → 53 [SYN] Seq=0 Win=3072 Len=0 MSS=1460
10 0.001965	172.16.0.8	64.13.134.52	TCP	58	36050 5900	36050 → 5900 [SYN] Seq=0 Win=1024 Len=0 MSS=1460
11 0.063797	64.13.134.52	172.16.0.8	TCP	60	53 36050	53 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
12 0.065271	172.16.0.8	64.13.134.52	TCP	58	36050 21	36050 → 21 [SYN] Seq=0 Win=4096 Len=0 MSS=1460
13 0.065341	172.16.0.8	64.13.134.52	TCP	58	36050 113	36050 → 113 [SYN] Seq=0 Win=4096 Len=0 MSS=1460
14 0.126832	64.13.134.52	172.16.0.8	TCP	60	113 36050	113 → 36050 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
15 0.129000	172.16.0.8	64.13.134.52	TCP	58	36050 80	36050 → 80 [SYN] Seq=0 Win=3072 Len=0 MSS=1460
16 0.129075	172.16.0.8	64.13.134.52	TCP	58	36050 139	36050 → 139 [SYN] Seq=0 Win=1024 Len=0 MSS=1460
17 0.189975	64.13.134.52	172.16.0.8	TCP	60	80 36050	80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
18 0.191518	172.16.0.8	64.13.134.52	TCP	58	36050 3389	36050 → 3389 [SYN] Seq=0 Win=3072 Len=0 MSS=1460

From the preceding screenshot, we can see that numerous SYN packets are being sent out to the `64.13.134.52` IP address. However, looking closely, we can see that most of the packets are being sent every so often from a single port, which is `36050` and `36051`, to almost every port on `64.13.134.52`. Yes, you guessed right: this looks like a port scan. Initially the SYN packet is sent out, and on receiving a SYN/ACK, the port is considered open.

We know that the originating IP address, `172.16.0.8`, is an internal one and the server being contracted is `64.13.134.52`. Can you figure out the following?:

- Scan type
- Open ports

Answering the first question requires a more in-depth understanding of a TCP-oriented communication and its establishment, TCP works on a three-way handshake, which means that on receiving a **synchronize** (**SYN**) packet from the source IP address, the destination IP address sends out a **synchronize/ acknowledgment** (**SYN/ACK**) packet that is followed by a final **acknowledgment** (**ACK**) packet from the source IP address to complete the three-way handshake. However, as we can see from the preceding screenshot, only a SYN/ACK is sent back from port `80`, and there hasn't been an ACK packet sent out by the source IP address.

This phenomenon means that the ACK packet was never sent to the destination by the source, which means that only the first two steps of the three-way handshake were completed. This two step half open mechanism causes the destination to use up resources as the port will be help open for a period of time. Meanwhile, this is a popular technique leveraged by a scan type called **SYN scan** or **half-open scan**, or sometimes the **stealth scan**. Tools such as Nmap make use of such techniques to lower the number of network packets on the wire. Therefore, we can conclude that the type of scan we are dealing with is a SYN scan.

Nmap uses RST packet in half open scan periodically to prevent resource exhaustion at the destination.

ip.src==64.13.134.52

No.	Time	Source	Destination	Protocol	Length	Source Port	Port	New Column
11	0.063797	64.13.134.52	172.16.0.8	TCP	60	53	36050	53 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
14	0.126832	64.13.134.52	172.16.0.8	TCP	60	113	36050	113 → 36050 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
17	0.189975	64.13.134.52	172.16.0.8	TCP	60	80	36050	80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
46	1.465661	64.13.134.52	172.16.0.8	TCP	60	22	36050	22 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
47	1.465899	64.13.134.52	172.16.0.8	TCP	60	25	36050	25 → 36050 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
118	1.818507	64.13.134.52	172.16.0.8	TCP	60	31337	36050	31337 → 36050 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
529	3.063375	64.13.134.52	172.16.0.8	TCP	60	53	36050	[TCP Retransmission] 53 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
571	3.132131	64.13.134.52	172.16.0.8	TCP	60	113	36061	113 → 36061 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
632	3.187263	64.13.134.52	172.16.0.8	TCP	60	80	36050	[TCP Retransmission] 80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
1233	4.077986	64.13.134.52	172.16.0.8	TCP	60	70	36050	70 → 36050 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0
1963	5.063418	64.13.134.52	172.16.0.8	TCP	60	22	36050	[TCP Retransmission] 22 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
2006	9.071680	64.13.134.52	172.16.0.8	TCP	60	53	36050	[TCP Retransmission] 53 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
2007	9.387931	64.13.134.52	172.16.0.8	TCP	60	80	36050	[TCP Retransmission] 80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
2008	11.064190	64.13.134.52	172.16.0.8	TCP	60	22	36050	[TCP Retransmission] 22 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
2009	21.093215	64.13.134.52	172.16.0.8	TCP	60	53	36050	[TCP Retransmission] 53 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
2010	21.401180	64.13.134.52	172.16.0.8	TCP	60	80	36050	[TCP Retransmission] 80 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380
2011	23.085343	64.13.134.52	172.16.0.8	TCP	60	22	36050	[TCP Retransmission] 22 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1380

Applying the filer `ip.src==64.13.134.5`, we can see the responses sent by `64.13.134.52`. It is evident that we have received the SYN/ACK from ports `53`, `80`, and `22`, which are open ports. We can also see that there has been network loss, and the sender has sent the packets again. Additionally, we can see **Reset Acknowledgment Packets** (**RST**) that denote misconfigurations or the application running on the not willing to connect: the reasons for such behavior can differ.

Summary

Over the course of this chapter, we learned about the basics of network forensics. We used Wireshark to analyze a keylogger and packets from a port scan. We discovered various types of network evidence sources and also learned the basics methodology that we should follow when performing network forensics.

In the next chapter, we will look at the basics of protocols and other technical concepts and strategies that are used to acquire evidence, and we will perform hands-on exercises related to them.

All credits for this above capture file goes to Chris Sanders GitHub repository at `https://github.com/chrissanders/packets`.

Questions and exercises

To improve your confidence in your network forensics skills, try answering the following questions:

1. What is the difference between the `ftp` and `ftp-data` display filter in Wireshark?
2. Can you build an `http` filter for webpages with specific keywords?
3. We saved files from the PCAP using NetworkMiner. Can you do this using Wireshark? (Yes/No)
4. Try repeating these exercises with Tshark.

Further reading

Read more and watch videos on Wireshark