Getting started

Wireshark

Michael Muratov, Darien Ho, Joshua Mazariegos

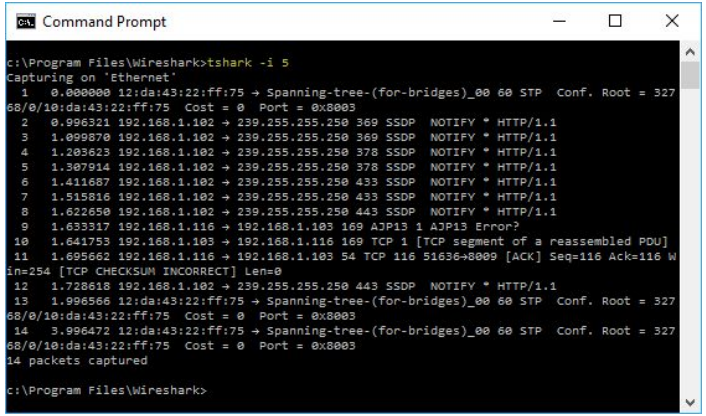
Wireshark

Cross-platform, open-source Packet Analyzer written in C, C++.

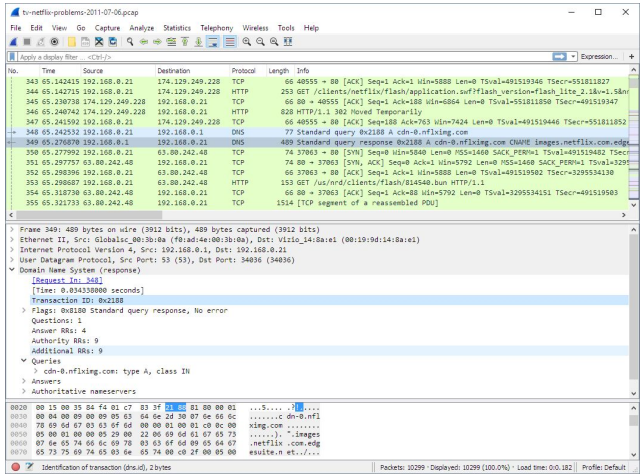
Used for monitoring networks, troubleshooting, and testing security.

Available on many operating systems (including Linux, Mac, & Windows).

TShark



Wireshark



Brief History

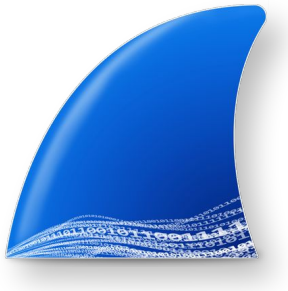
Invented by Gerald Combs in the 1990s.

Open sourced.

Released in 1998 as Ethereal.

Heavily extended by the cyber security community.

WIRESHARK



- v0.99:(2006)
  - TCP, UDP, SSL streams
  - SSL decryption support
  - I/O Graphs
  - AirPcap support
- V1.0 (2009)
  - Usability bug fixes
- V1.2 (2010)
  - Protocol support expansion
- V1.4 (2011)
  - Protocol support expansion
- V1.6 (2013)
  - SSL session key export
- V2.0 (2017)
  - Update to statistics capabilities
- V3.0 (2019)
  - IP Map

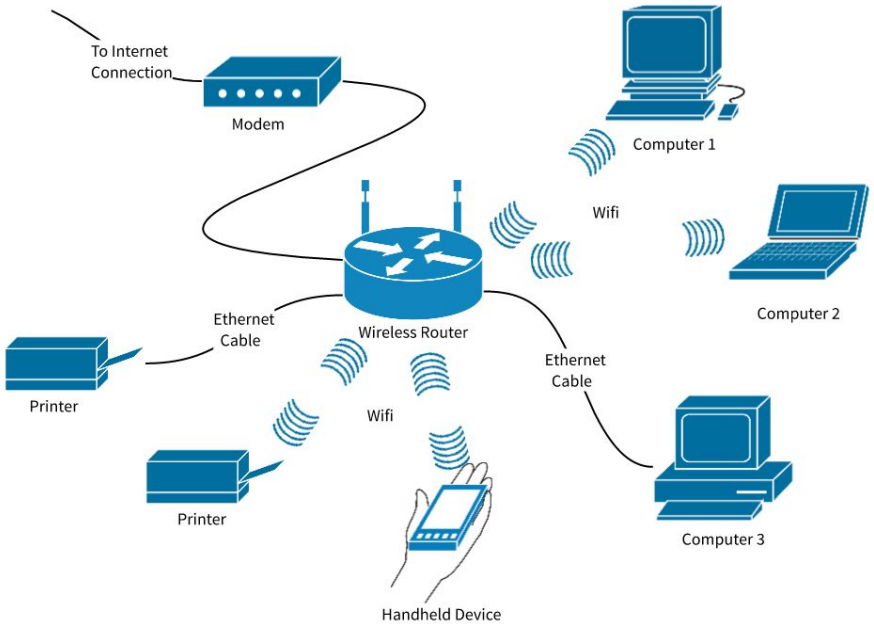
Source:
https://www.wireshark.org/docs/relnotes/

Wireshark

Captures packets going through a network.

Similar to tcpdump with a GUI and extended toolset:

- Searching/filtering packets
- Promiscuous mode
- Graphs
- Bluetooth traffic
- USB traffic
- Usage statistics
- ...



Source: https://www.lucidchart.com/pages/templates/network-diagram/wireless-network-diagram-template

Wireshark

Tools & Features

Tools & Features

Capabilities of Wireshark

Capture Packets

Monitor & promiscuous mode.

Filters

Control which packets are captured or displayed.

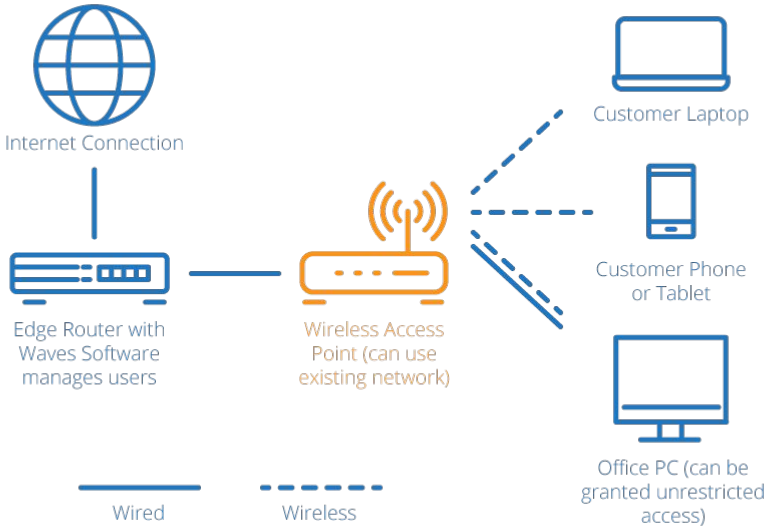
Analysis

On the toolbar, the `Statistics` menu contain many ways to analyze packets.

- Conversations—between two endpoints
- Flow Graph—sequential streams
- I/O Graph—packets over time

Monitor Mode

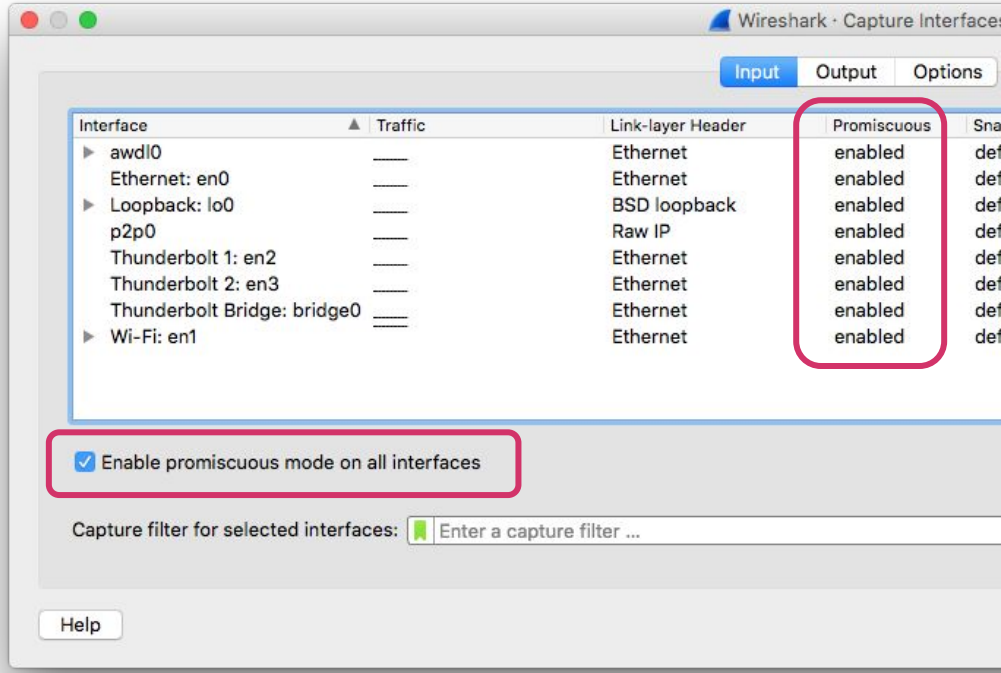
- In normal operation, devices on a wireless network ignore traffic not directed to it
- In monitor mode, all visible wireless traffic is processed
- Monitor mode is limited to wireless traffic only



Source:
https://www.waveswifi.com/how-does-waves-work

Promiscuous Mode

- Captures all visible packets including those of other devices
- Requires support from your device's network interface card
- In non-promiscuous mode, devices can only read packets directed to them



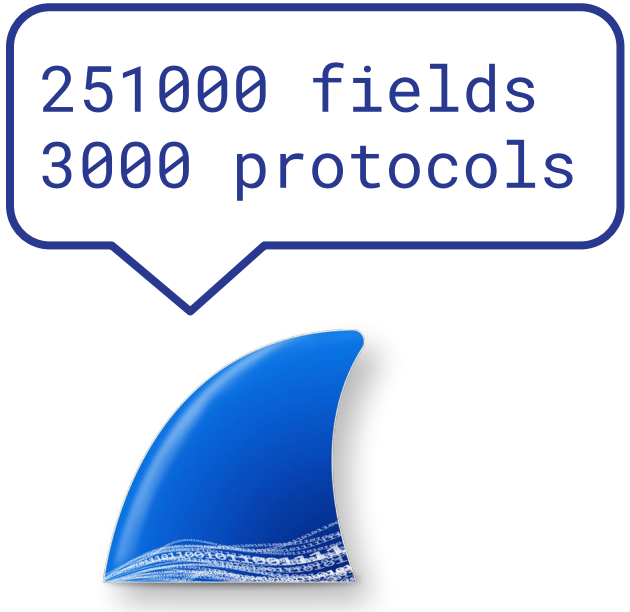
Source: https://medium.com/@debookee/promiscuous-vs-monitoring-mode-d603601f5fa

Filters

We might only be interested in a small subset of all network traffic. For instance, we might be interested in a particular:

- Source, Destination, Port, ...
- Request method (GET, POST, PUT, ...)
- Protocol (ARP, HTTP, TCP, UDP, ...)
- ...

We can filter packets during *capture* or during *display*.



Capture Filters

Capture Filters

Only packets that satisfy these filters will be captured.

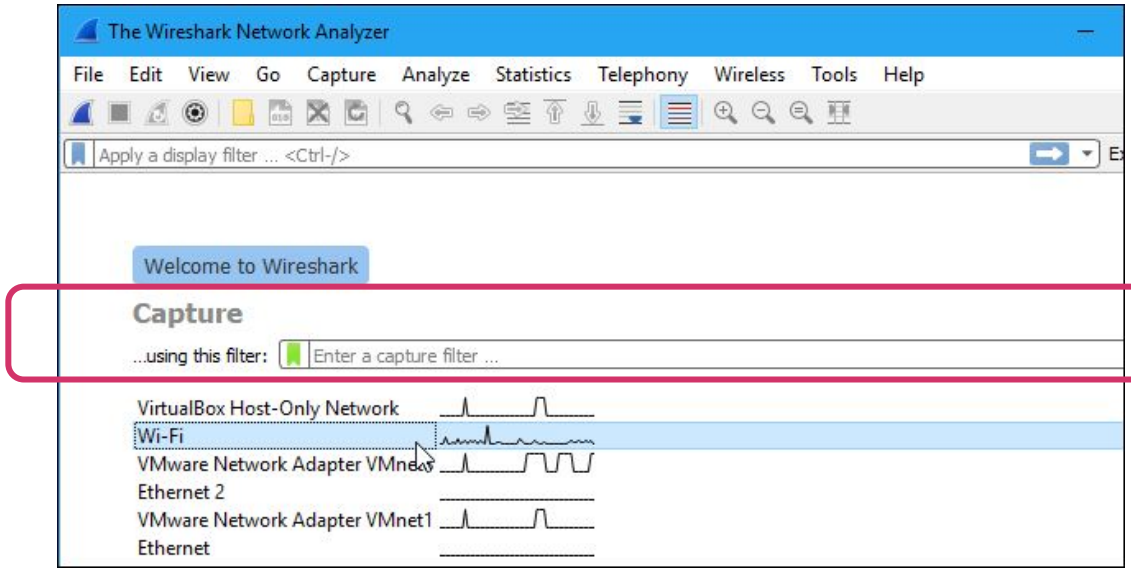
Example

`host 192.168.1.1`

Only traffic to or from 192.168.1.1

Reference

https://wiki.wireshark.org/CaptureFilters



Source: https://www.howtogeek.com/104278/how-to-use-wireshark-to-capture-filter-and-inspect-packets/

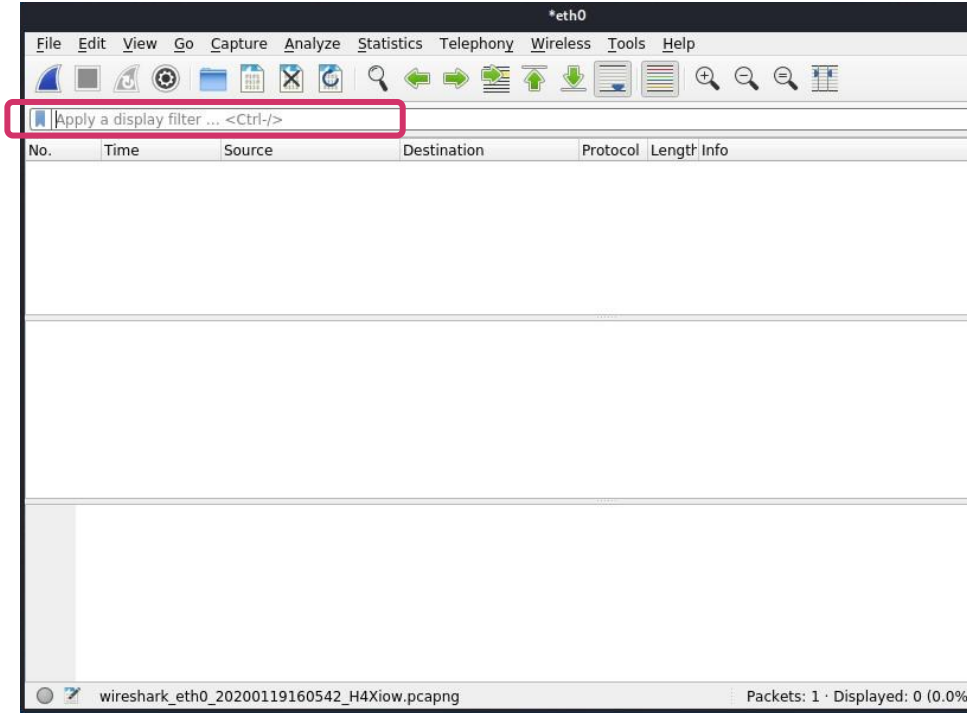
Display Filters

Display Filters

Controls which captured packets are displayed. Will not prevent packets from being captured.

Reference

https://www.wireshark.org/docs/dfref/



Statistics

Understanding network activity and the flow of packets

Acquire insight by visualizing the flow and relations of packets.

Tools emphasize different properties of network traffic.

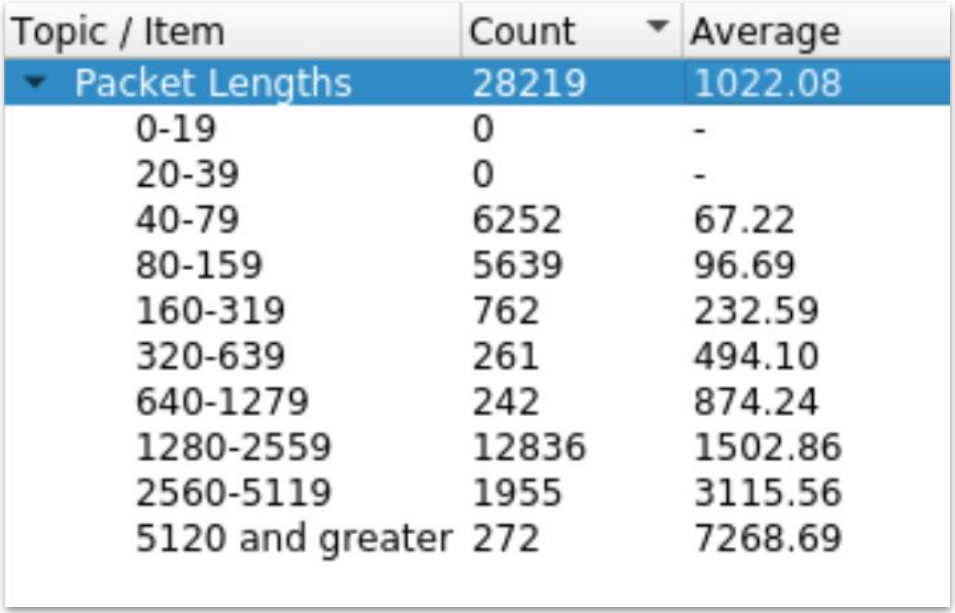
Packet Lengths

`Statistics > Packet Lengths`

Number of packets belonging to different size ranges.

Provides information about each group, such as:

- Average size
- Minimum/maximum size
- Distribution of packets



Topic / Item	Count	Average
Packet Lengths	28219	1022.08
0-19	0	-
20-39	0	-
40-79	6252	67.22
80-159	5639	96.69
160-319	762	232.59
320-639	261	494.10
640-1279	242	874.24
1280-2559	12836	1502.86
2560-5119	1955	3115.56
5120 and greater	272	7268.69

Graphs

`Statistics > I/O Graph`

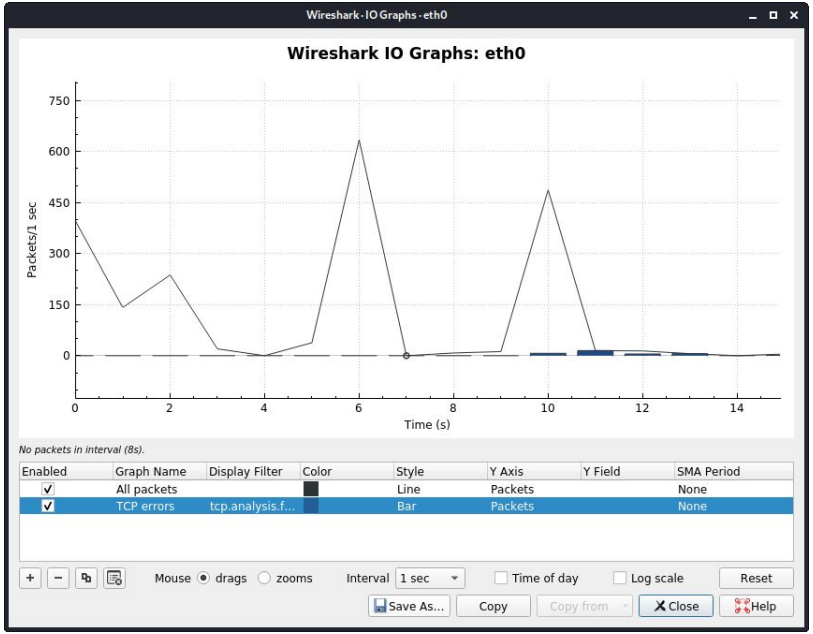
Visualize the flow of packets over time.

Customizable

- Plot type (line, bar, dot, …)
- Use filters to choose which packets to plot
- Show plots of different filters in a single graph

Example: Load Balancer

Plot lines corresponding to traffic going to each server. This could expose unequal distribution of traffic.



Endpoints

Endpoints

The end of a specific protocol layer. For example, an IP endpoint sends and receives traffic to/from a specific IP address.

Reference

https://wiki.wireshark.org/Endpoint

`Statistics > Endpoints`

Lists endpoints encountered in the captured traffic.

Example

- IPv4
- IPv6
- Ethernet
- 802.11

Conversations

`Statistics > Conversations`

Lists “conversations” between pairs of endpoints within the captured traffic.

Displays the amount of data sent between the two hosts and how long they were communicating.

`Statistics > Flow Graph`

Useful for visualizing the interaction between two hosts (e.g., handshake protocols).

Example Usage:

1. Right click a packet
2. Follow > TCP Stream
3. Statistics > Flow Graph
4. Flow Type: TCP Flows
5. Limit to display filter

The Big Picture

Drawing conclusions about network activity

It can be difficult to make sense of hundreds of thousands of packets.

Wireshark offers many tools for filtering and analyzing important or relevant traffic.

Wireshark

Applications

Applications

Uses of Wireshark

Use Cases:

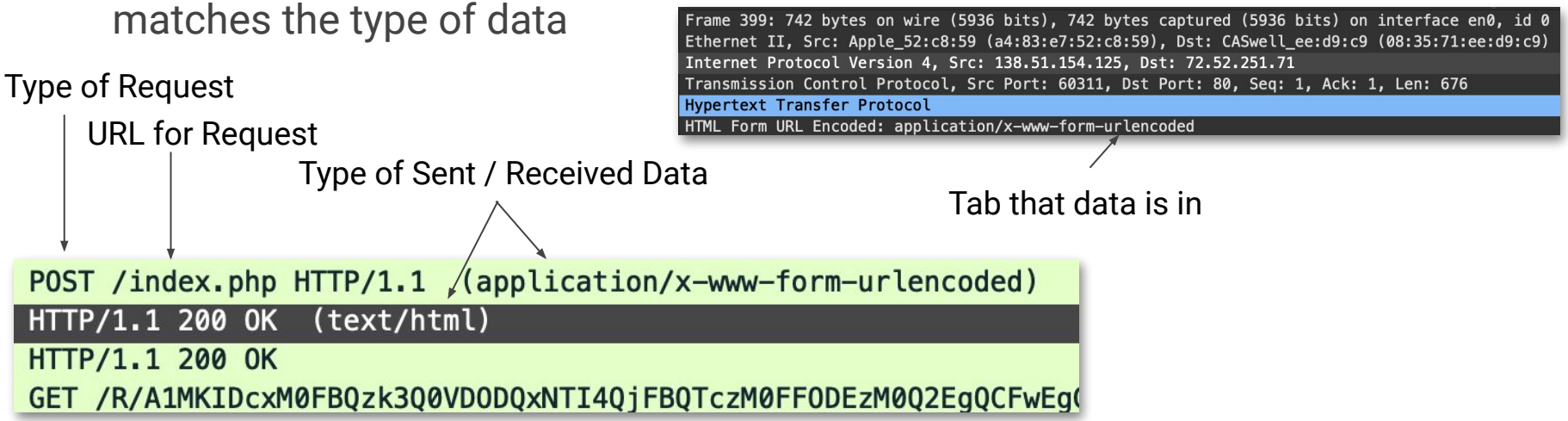
- Troubleshoot networks
- Analyze network traffic
- Develop network protocols
- Debug programs that uses networks
- Education - learning how networks work

Used By:

- System administrators
- Security professionals
- Software developers/engineers

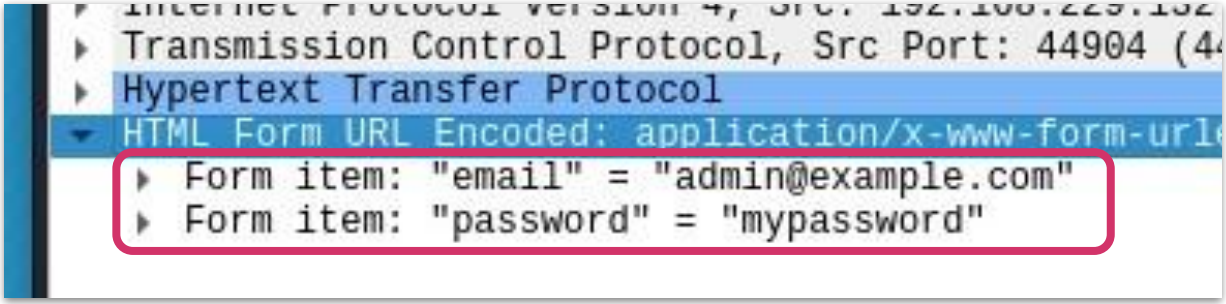
Capture Network Traffic

- Type of request or response can be seen in the info tab
- Also shows the type of data that was sent or received
- Any data sent or received can be seen as well through the last tab that matches the type of data



HTTP Traffic

- No TLS/SSL layer used to encrypt traffic
- Packets might be transmitted as plaintext
- Eavesdroppers can capture these packets and view sensitive information



Plaintext credentials captured by Wireshark

Filter for HTTP/HTTPS Traffic

Display HTTP/HTTPS Traffic

- Filter for `http` to show traffic using HTTP
- Filter for specific ports:
  - `tcp.port==80` (Internet traffic)
  - `tcp.port==443` (HTTPS traffic)
- Filter for `ssl` or `tls` to find secure traffic

tcp.port == 443 tcp.port == 80 http

Filter by Domain Name

```
http.host=="example.com"
```

Filter by Request Method

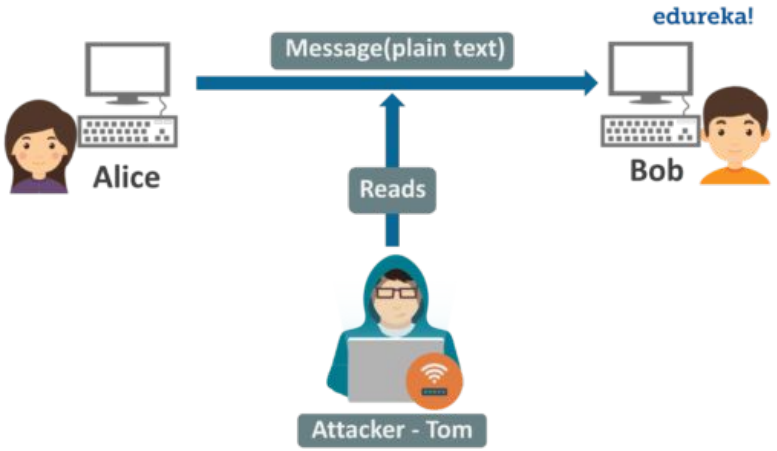
```
http.request.method=="GET"
```

Reference

https://www.wireshark.org/docs/wsug_html_chunked/ChWorkBuildDisplayFilterSection.html

Insecure Traffic

- Insecure packets are not properly encrypted
- Plaintext sent over a network can be intercepted and read
- Problematic for websites possessing private/sensitive user data



Source: https://www.edureka.co/blog/what-is-network-security/

Secure Traffic

- Secure packets contain encrypted data
- Data in secure traffic is protected from network analyzers
- HTTPS is used to provide a secure communication channel
  - Data is encrypted before transmission
  - Secure as long as the decryption key is not made available to the public

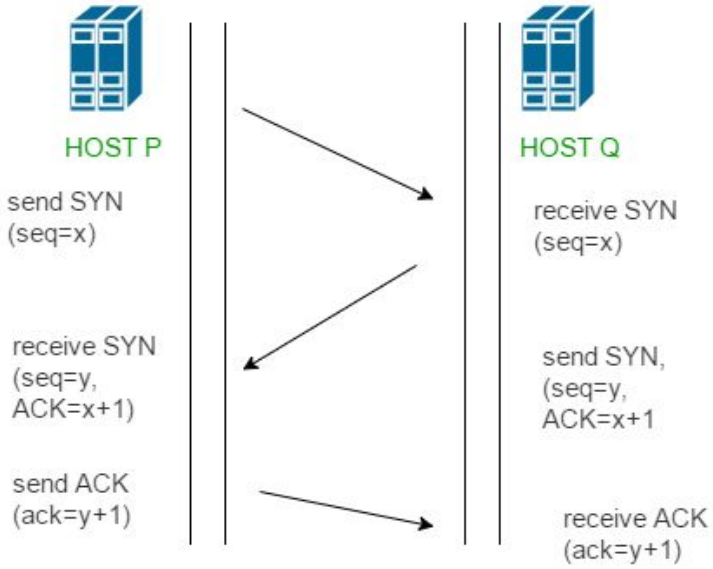
Decrypting Secure Traffic

When users want to see human-readable data

HTTPS Decryption

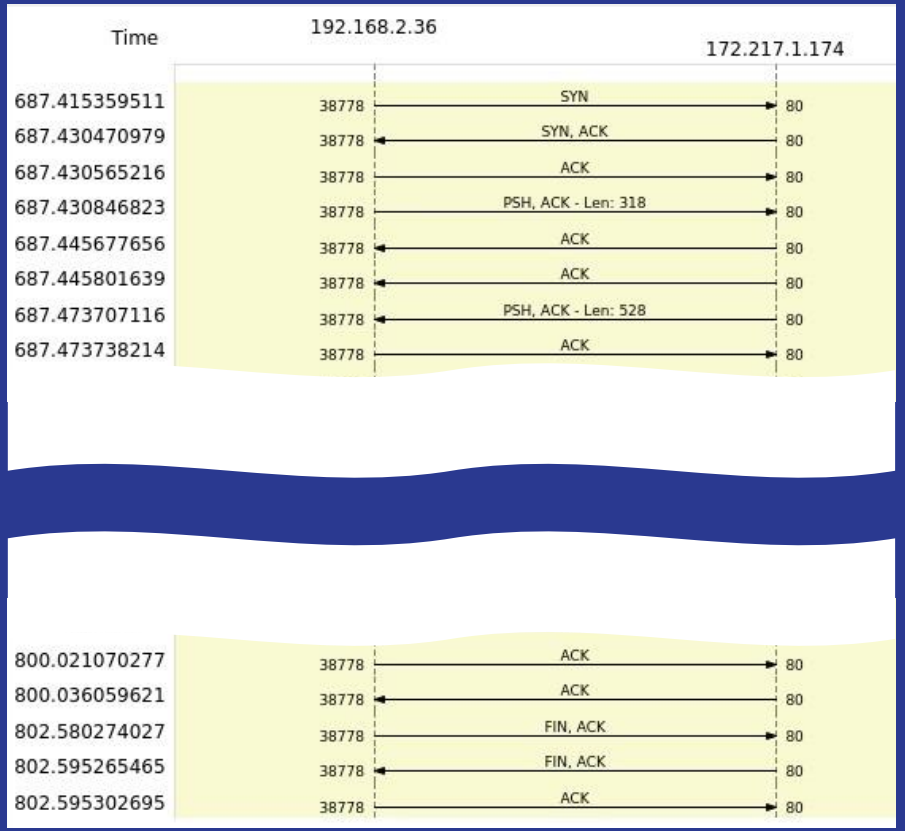
Cannot be done without the corresponding private key. Those who possess the decryption key can provide it to Wireshark.

Handshake Protocol



Source: https://www.geeksforgeeks.org/tcp-3-way-handshake-process/

Statistics > Flow Graph



Network Troubleshooting

Understanding a network

Isolating Traffic

`Statistics > Conversations`

Details about traffic between two endpoints.

Troubleshooting

Analyze content and flow of packets

- HTTP headers, methods, parameters, etc.
- HTML responses
- TCP Errors

HTTPS Overview

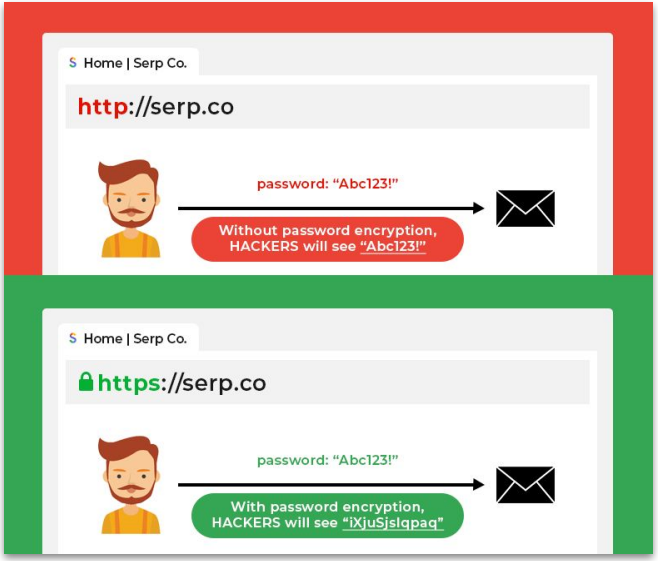
HTTP and HTTPS

HyperText Transfer Protocol (HTTP)

A request-response protocol where client sends requests and receives responses from a server. Data could be sent as plaintext over the wire.

HyperText Transfer Protocol Secure (HTTPS)

A request-response protocol where TLS or SSL is layered over HTTP. Traffic is encrypted before transmission so that plaintext will not be intercepted.



Source: https://serp.co/blog/http-vs-https/

TLS and SSL

Transport Layer Security (TLS)

- Asymmetric encryption used to establish trust between client and server
- TLS Handshake generates a shared secret for symmetric encryption
- Trusted certificates contain public key to the host

Secure Sockets Layer (SSL)

- Predecessor of TLS
- Weaker encryption algorithms
- Susceptible to man-in-the-middle attacks
    - POODLE vulnerability - attackers were able to decrypt SSL traffic

Certificates

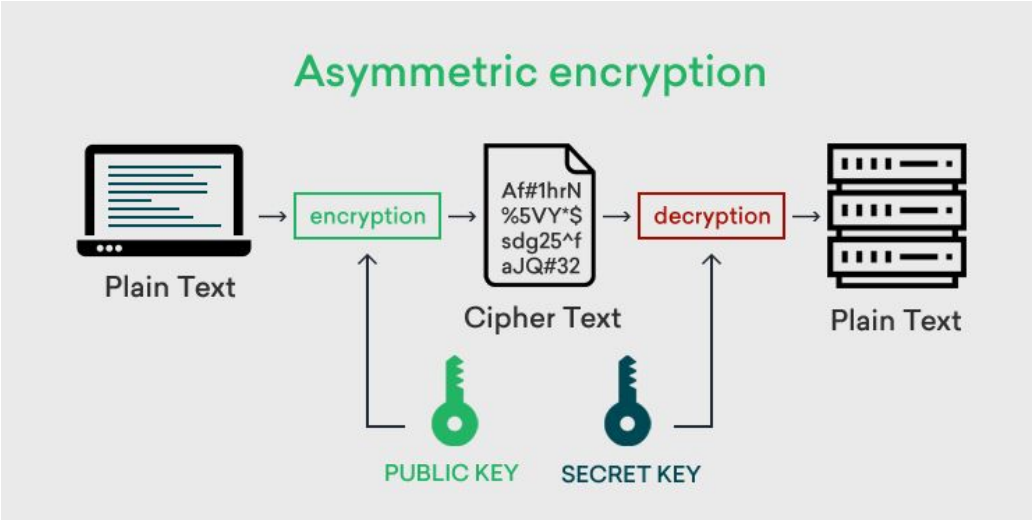
Certificates provide information about the organization and the certificate itself.

Users can use trusted certificates to establish a secure connection.

Source: https://www.cloudflare.com/learning/ssl/why-is-http-not-secure/

Certificates

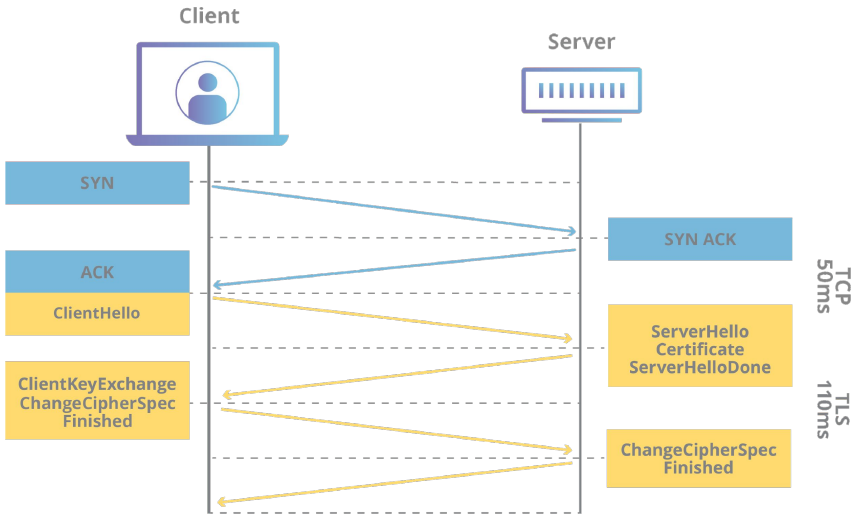
- Issued by trusted certificate authorities (CA)
  - Browsers are often preinstalled with known CAs
- Contains a public key for encrypting traffic
- Server possesses the corresponding private key
- Eavesdropper can only capture encrypted traffic



Source: https://www.clickssl.net/blog/symmetric-encryption-vs-asymmetric-encryption

TLS Handshake

- First request-response messages act as “hello” to ensure they can communicate
- Then the next is for sending any information needed about the client’s or server’s TLS and the certificate
- Lastly it authenticates the certificate using the issuer and both do a test send to make sure that they are who they say they are then finish



Source: https://www.cloudflare.com/learning/ssl/what-happens-in-a-tls-handshake/

HTTPS Traffic

- Wireshark can see HTTPS traffic but cannot expose plaintext on its own
- If the decryption key is provided, Wireshark can decrypt HTTPS traffic
  - Useful for developers or system administrators who want to see plaintext and not pseudorandom strings when debugging or troubleshooting
- Wireshark can still see parts of HTTPS packets like source/destination IP

Source: https://medium.com/@kasunpdh/ssl-handshake-explained-4dabb87cdce

Network Monitoring

Network Monitoring

Other Devices' Traffic

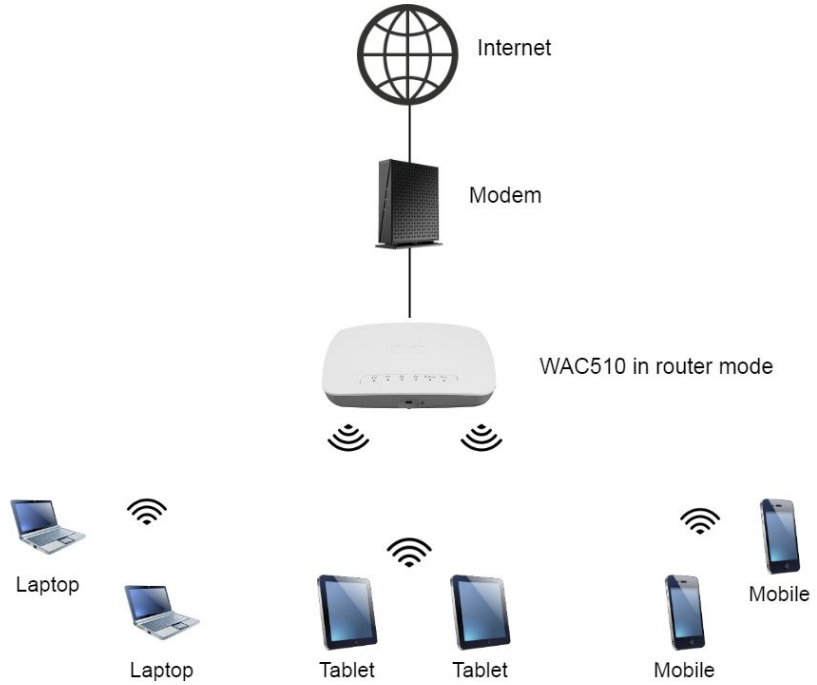
Capturing only your own device's traffic is not very interesting.

Promiscuous Mode

Capture traffic from other devices depending on device and network configuration.

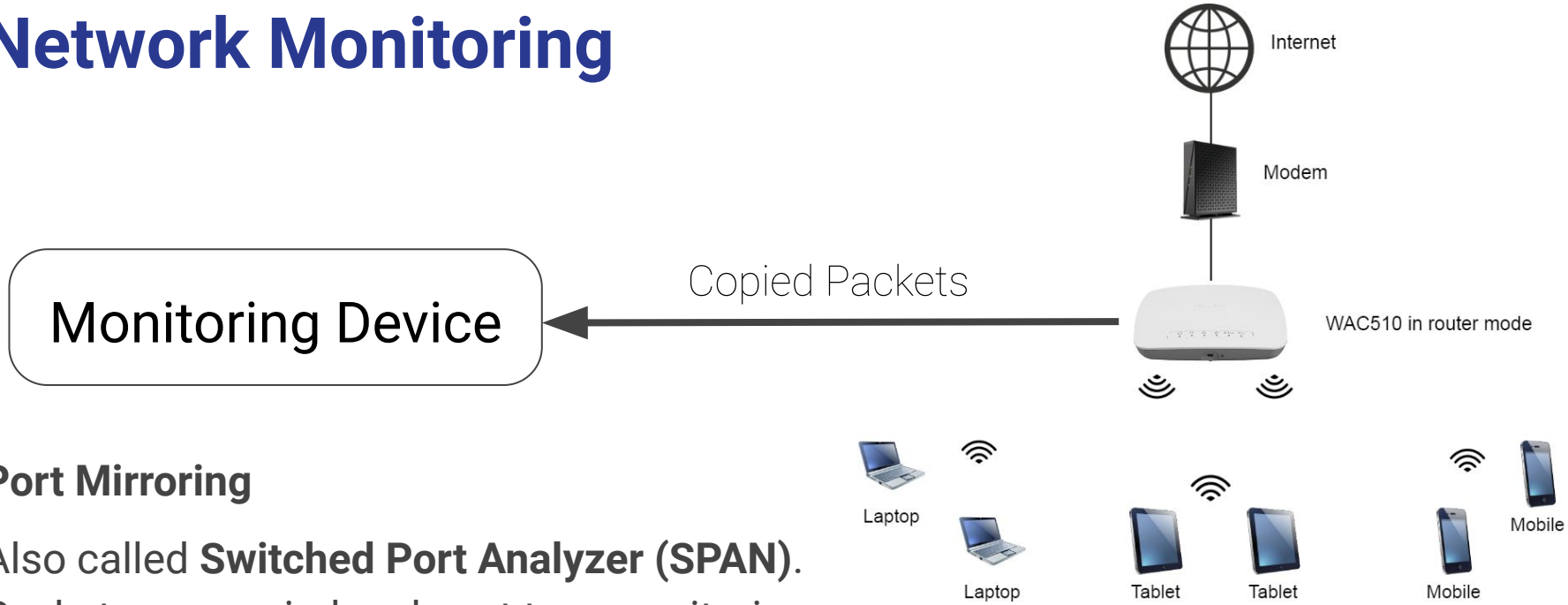
Other Options

Send traffic to a monitoring device.



Source: https://kb.netgear.com/000058849/What-do-I-need-to-know-about-using-my-NETGEAR-WAC510-access-point-in-router-mode

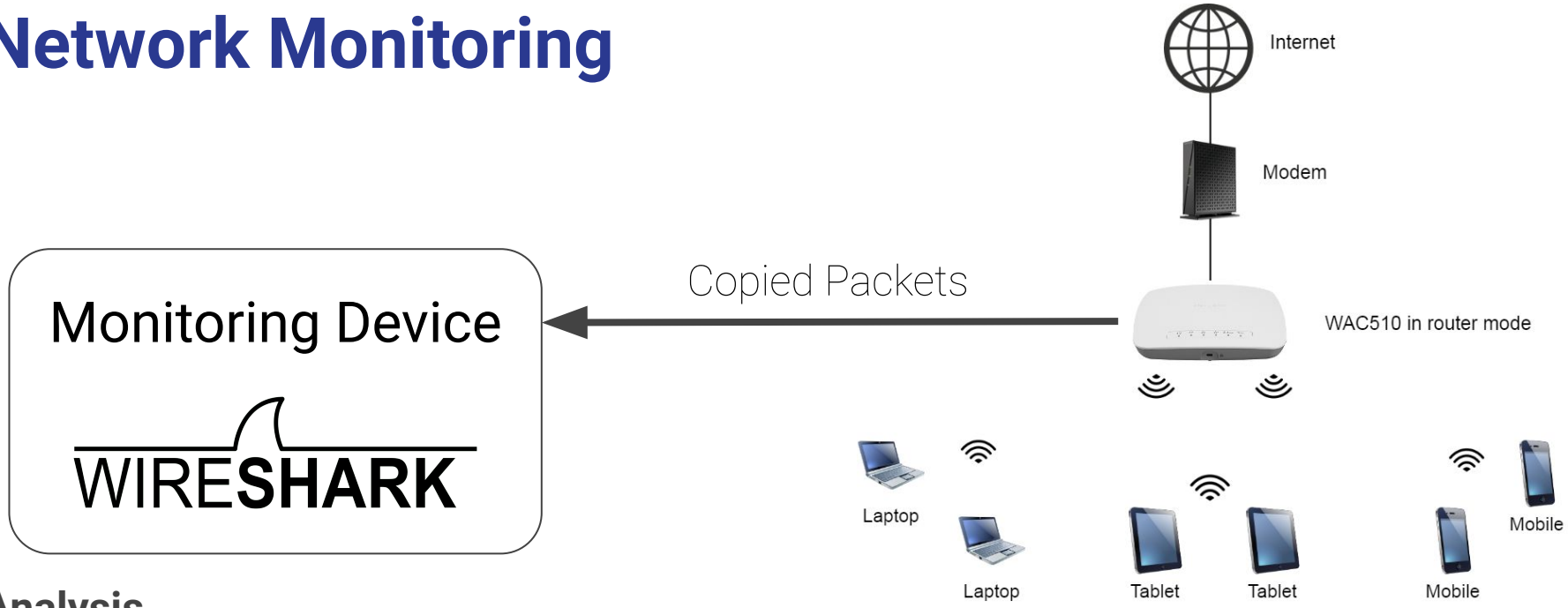
Network Monitoring



Port Mirroring

Also called **Switched Port Analyzer (SPAN)**. Packets are copied and sent to a monitoring device.

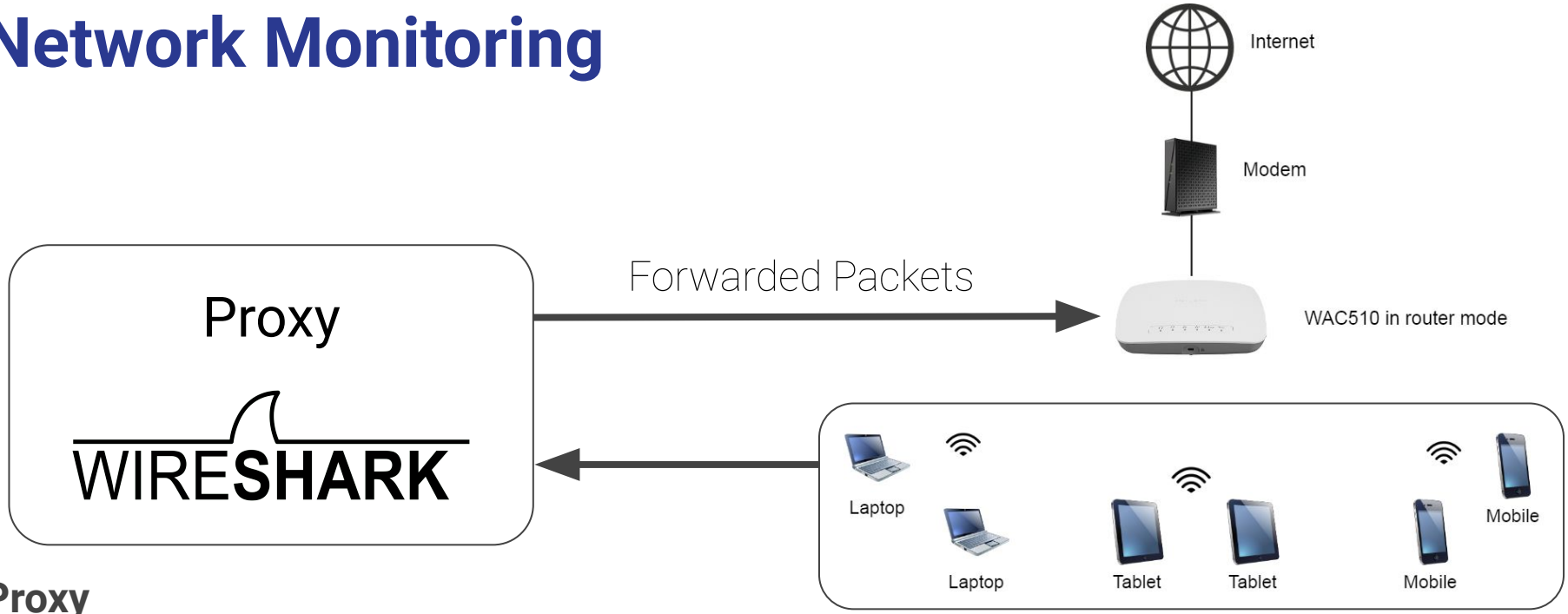
Network Monitoring



Analysis

Use tools provided by Wireshark to analyze the traffic.

Network Monitoring



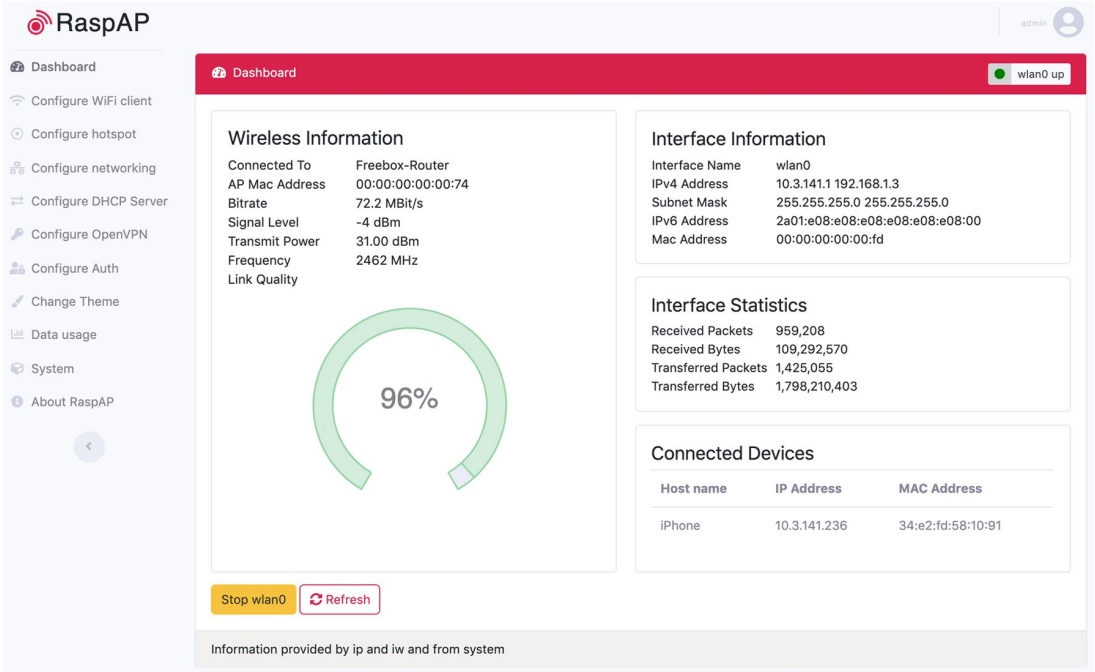
Proxy

Wireshark can see all traffic that goes through a device.

Raspberry Pi Proxy

RaspAP

WiFi Configuration Portal



WiFi proxy forwarding

Collects usage statistics

Enables the capturing of packets from connected devices

Source: https://raspap.com/

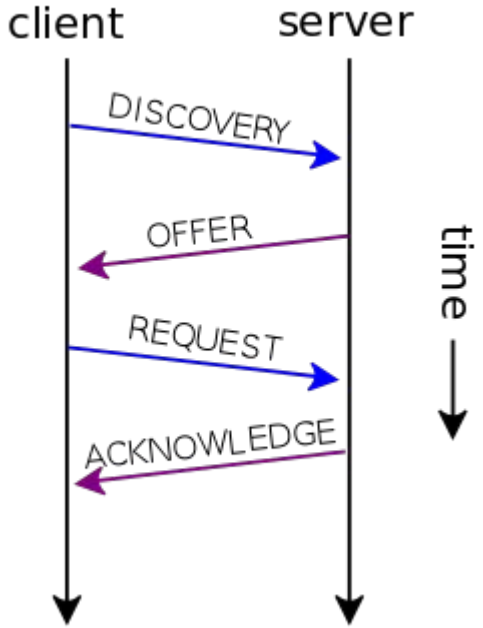
DHCP

Dynamic Host Configuration Protocol

Centralized protocol for assigning IP addresses to devices connecting to the network

Four Phases

1. Discovery
2. Offer
3. Request
4. Acknowledgement



Source: https://en.wikipedia.org/wiki/Dynamic_Host_Configuration_Protocol

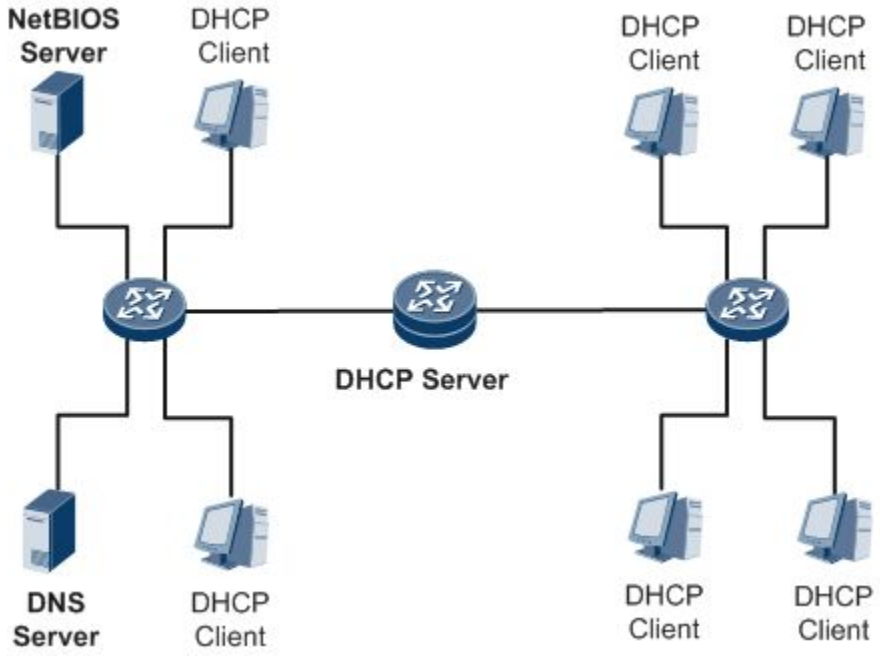
DHCP

Dynamic Host Configuration Protocol

Clients send a broadcast to request information from the DHCP server

Server responds with available IP addresses and client configuration:

- Default gateway
- Domain name
- Name servers
- Time servers



Source: https://support.huawei.com/enterprise/en/doc/EDOC1100059438/93af6f6a/configuring-a-dhcp-server

iptables

```
sudo iptables -A FORWARD -i eth0 -o wlan0 -m state --state RELATED,ESTABLISHED -j ACCEPT
sudo iptables -A FORWARD -i wlan0 -o eth0 -j ACCEPT
sudo iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
sudo iptables -t nat -A PREROUTING -i wlan0 -p tcp -m tcp --dport 80 -j REDIRECT --to-ports 8080
sudo iptables -t nat -A PREROUTING -i wlan0 -p tcp -m tcp --dport 443 -j REDIRECT --to-ports 8080
```

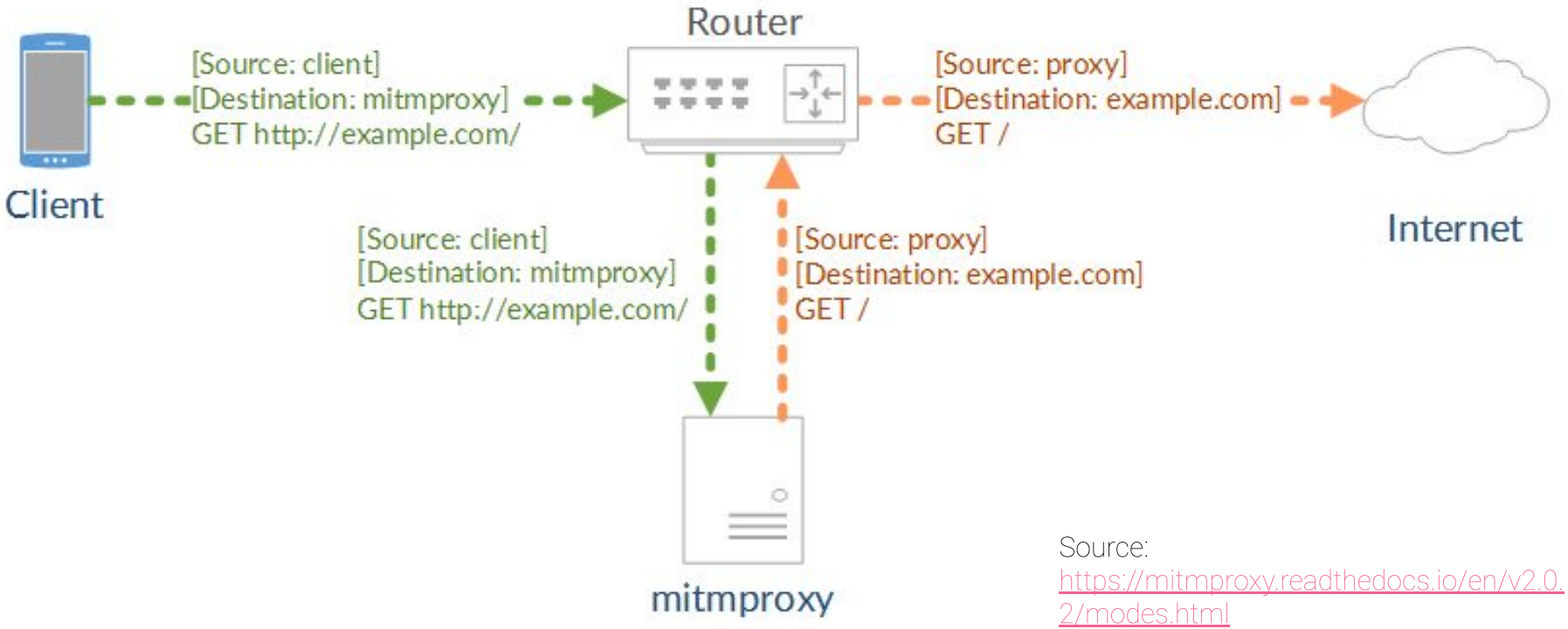
Send ethernet network traffic to our wireless network

Send the wireless network traffic back to ethernet

Save traffic from ports 80 and 443 to port 8080

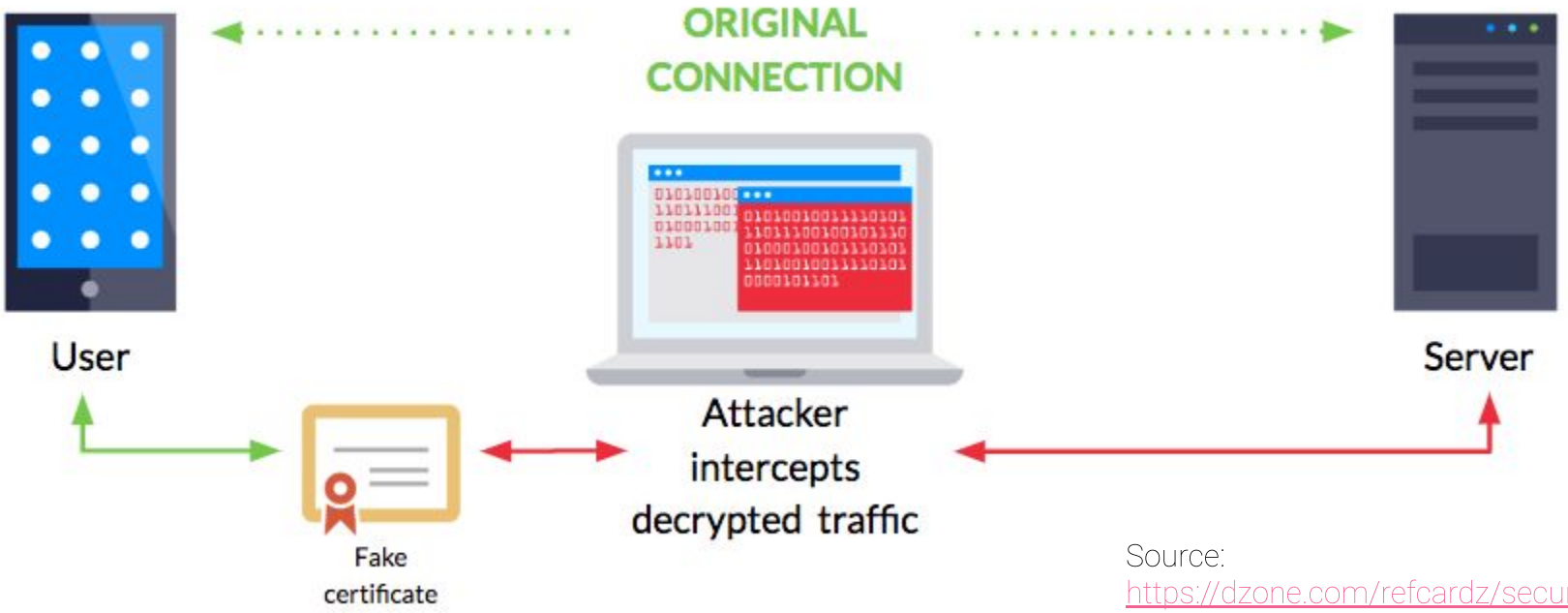
Our proxy will read from port 8080

mitmproxy



Source: https://mitmproxy.readthedocs.io/en/v2.0.2/modes.html

Certificate Authority Replacement



Source:
https://dzone.com/refcardz/securing-mobile-applications-with-cert-pinning

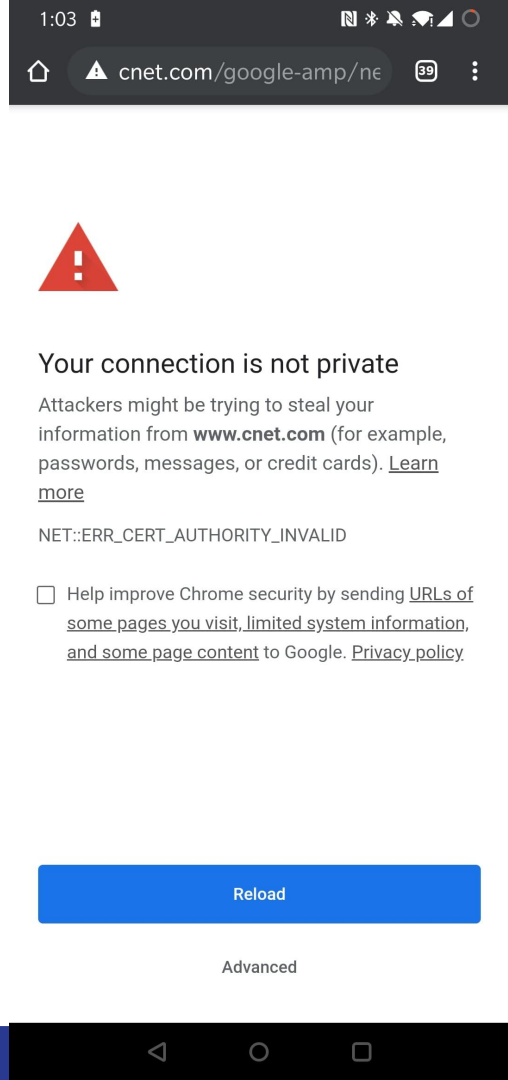
Built In Protection

Browsers will check a list of trusted authorities to see if the website certificate came from a trusted source

If the source is not trusted (public key not in its database) the website will be flagged

User have the option to disregard the message and continue to the site

This leaves the users vulnerable to the man in the middle attack

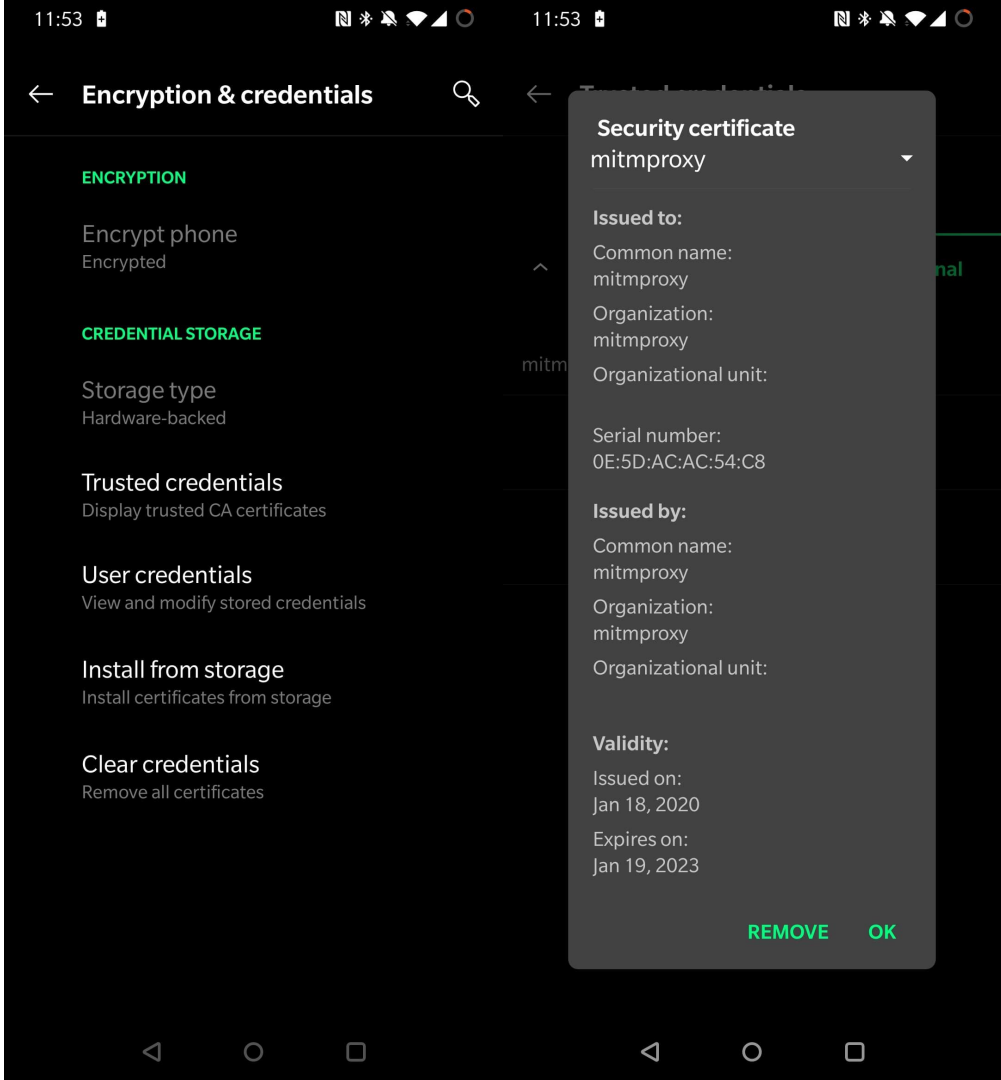


Compromising the User

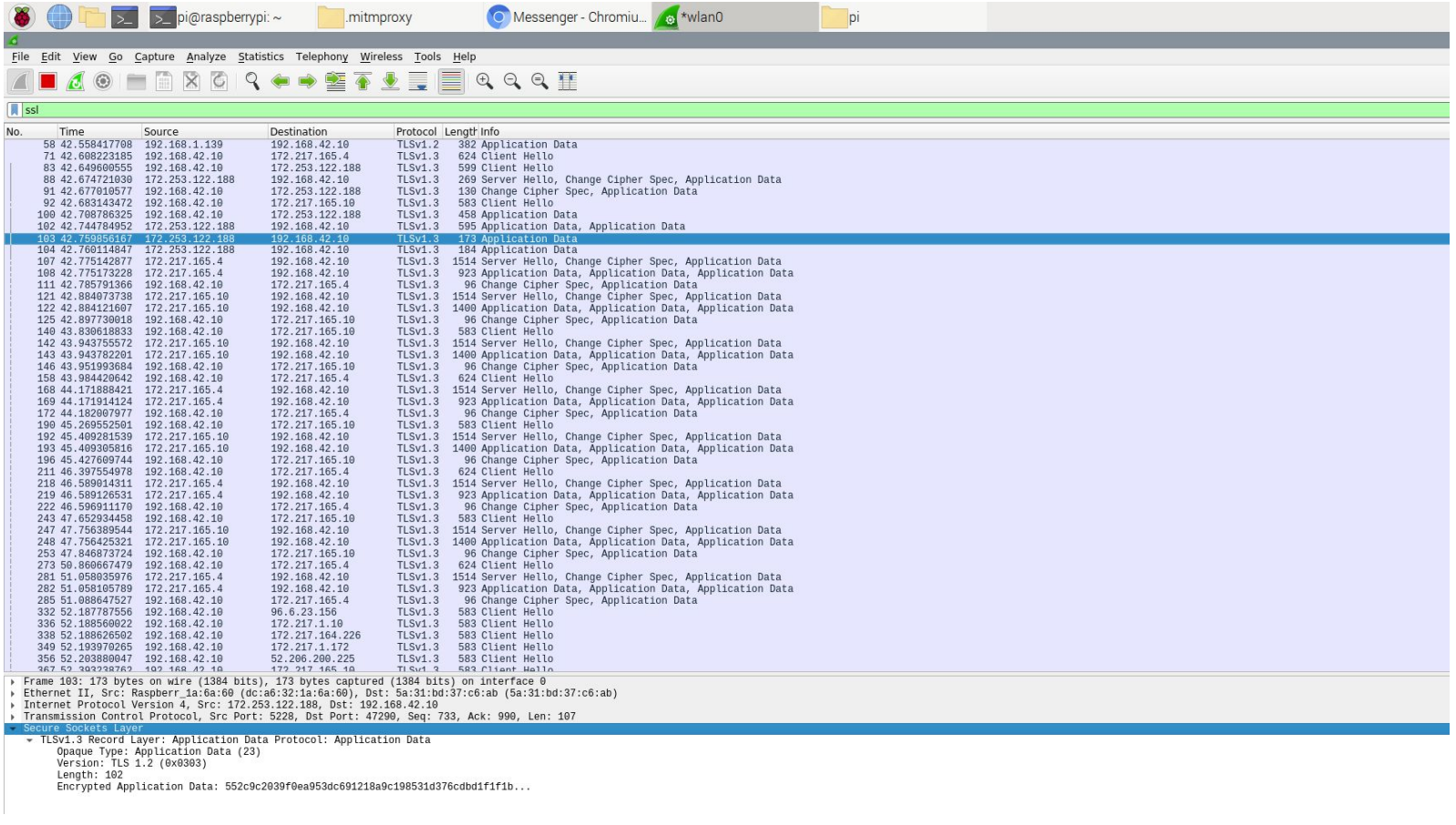
Add MITM proxy authority to list of trusted authorities

On page visit the browser will check the certificate

Certificate will be deemed acceptable



Secure Website without Proxy



Secure Website with Proxy

More information is made available

MITM decrypts ciphertext encrypted with its certificate public key

Request | Response | Details

```
GET https://opensource.com/article/20/1/wireshark-linux-tshark HTTP/2.0
```

:authority	opensource.com
cache-control	max-age=0
save-data	on
upgrade-insecure-requests	1
user-agent	Mozilla/5.0 (Linux; Android 10; ONEPLUS A6013) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/79.0.3945.116 Mobile Safari/537.36
sec-fetch-user	?1
accept	text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9
sec-fetch-site	none
sec-fetch-mode	navigate
referer	https://www.googleapis.com/auth/chrome-content-suggestions
accept-encoding	gzip, deflate, br
accept-language	en-US,en;q=0.9,ru;q=0.8
cookie	has_js=1; _ga=GA1.2.32918463.1579543743; _gid=GA1.2.729685603.1579543743; check=true; AMCVS_945D02BE532957400A490D4C%40AdobeOrg=1; rh_omni_tc=701f2000001OH7nAAG; sat_prevInternalCampaign=; sat_prevExtCmp=no%20value; scCidHist=701f2000001OH7nAAG; s_cc=true; mbox=session#b1a9fd8ecb44491ea809e51c2036cc78#1579549244|PC#b1a9fd8ecb44491ea809e51c2036cc78.17_0#1642792183; dtm_prevURL=https%3A%2F%2Fopensource.com%2Farticle%2F20%2F1%2Fwireshark-linux-tshark%2520my; sat_ppv=54; _CT_RS_=Recording; WRUIDCD=2612870918439262; __CT_Data=gpv=2&ckp=tld&dm=opensource.com&apv_25612_www14=4&cpv_25612_www14=2&rpv_25612_www14=1; AMCV_945D02BE532957400A490D4C%40AdobeOrg=1075005958%7CMCIDTS%7C18282%7CMCMID%7C23417381787794176430122423514770256766%7CMCAAMLH-1580152184%7C7%7CMCAAMB-1580152184%7CRKhpRz8krg2tLO6pguXWp5olkAcUniQYPHaMWWgdJ3xzPWQmdj0y%7CMCOPTOUT-1579554584s%7CNONE%7CMCAID%7CNONE%7CvVersion%7C4.4.1%7CMCCIDH%7C1332280493; _cs_ex=1; _cs_c=1; rh_elqCustomerGUID=4e25e161-4417-42ac-8fb0-1c4003e4368d; ctm=eydwZ3YnOjE4NzIwMTEzMTg4NzEzOTB8J3ZzdCc6Njg3NDM1NDI3MjEzMzM2OHwndnN0cic6NDU1Njg4NDEwMzQ5NTExMHwnaW50cic6MTU3OTU0NzUyODM5OXwndic6MX0=

Request content missing.

Wireshark and SSL/TLS Master Secrets

The SSL/TLS master keys can be logged by mitmproxy so that external programs can decrypt SSL/TLS connections both from and to the proxy. Recent versions of Wireshark can use these log files to decrypt packets. See the Wireshark wiki for more information.

Key logging is enabled by setting the environment variable `SSLKEYLOGFILE` so that it points to a writable text file:

```
SSLKEYLOGFILE="$PWD/.mitmproxy/sslkeylogfile.txt" mitmproxy
```

You can also `export` this environment variable to make it persistent for all applications started from your current shell session.

You can specify the key file path in Wireshark via `Edit -> Preferences -> Protocols -> SSL -> (Pre)-Master-Secret log filename`. If your SSLKEYLOGFILE does not exist yet, just create an empty text file, so you can select it in Wireshark (or run mitmproxy to create and collect master secrets).

Note that `SSLKEYLOGFILE` is respected by other programs as well, e.g., Firefox and Chrome. If this creates any issues, you can use `MITMPROXY_SSLKEYLOGFILE` instead without affecting other applications.

Source: https://docs.mitmproxy.org/stable/howto-wireshark-tls/

Man-in-the-Middle

Raspberry Pi

Takeaways

Wireshark offers a suite of tools for capturing and analyzing network traffic

HTTP is not secure - plaintext can be captured by an eavesdropper

HTTPS is secure - the traffic is visible but the data is encrypted

On an unsecure network connection, even HTTPS can be not enough to protect your credentials

If a user’s devices can be physically compromised, the user can be made unaware of a surveyed network

Questions?