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Assignment 6 - IPsec

Section 1: Goals of the Experiment

The goal of this experiment is to learn how IP security protects data on the network layer by comparing Wireshark captures with and without an implemented VPN application. The steps to achieving this goal is to construct a website that is locally hosted, acting as the server, connect a client to the server and capture the communication between client (through VPN) and server using Wireshark.

Section 2: Experiment Setup

Step 1: Download a VPN tunneling application: TunnelBear (Figure1)

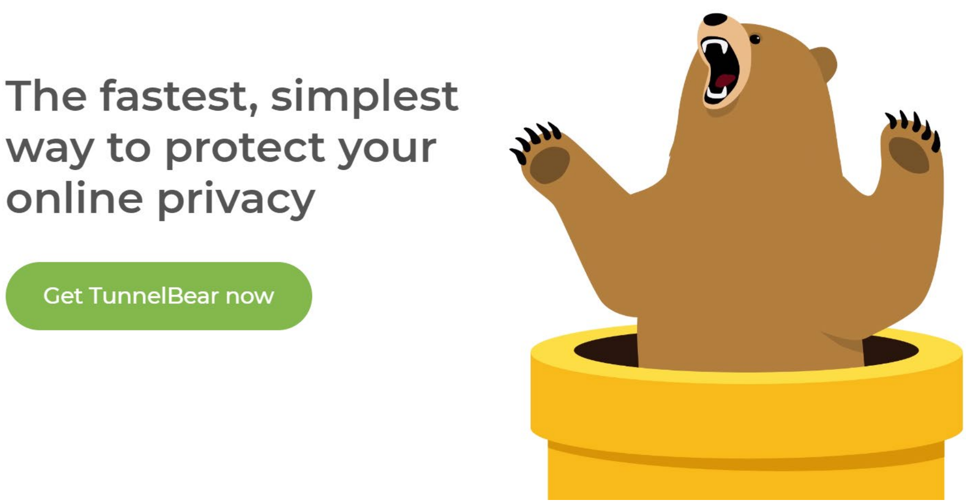

Figure1 : The website to download TunnelBear

An example when browsing from a secure tunnel in France.(Figure 2)

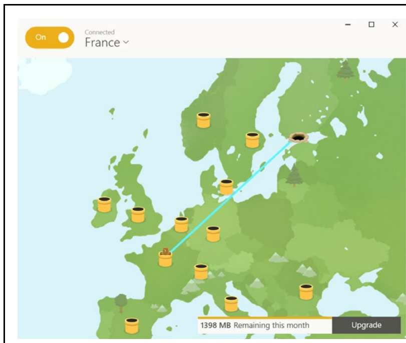

Figure 2a:Using TunnelBear to switch the location to France.

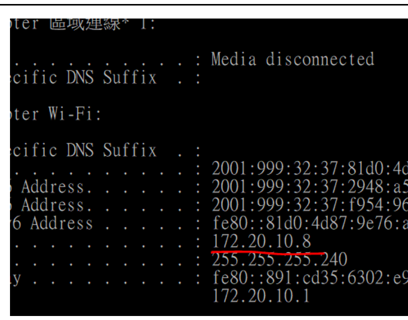

Figure 2b: Internal IP address (Private)

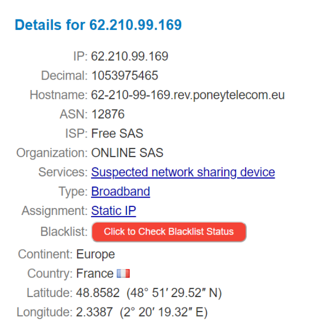

Figure 2c:External IP address (Public)

Step 2: Access the website we made in assignment 5 without using VPN.

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This step is included to show the difference between browsing normally and with a VPN. First we ran the program using command line as seen in Figure 3 on the laptop acting as the server. The code can be found in Appendices A-C.

```
C:\Users\sarah\AppData\Local\Programs\Python\Python37-32\Assignments - Copy>py app.py
 * Serving Flask app "app" (lazy loading)
 * Environment: production
   WARNING: Do not use the development server in a production environment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Restarting with stat
 * Debugger is active!
 * Debugger PIN: 951-006-426
 * Running on http://0.0.0.0:5000/ (Press CTRL+C to quit)
127.0.0.1 - - [07/Apr/2019 14:54:35] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [07/Apr/2019 14:54:36] "GET /favicon.ico HTTP/1.1" 404 -
```

Figure 3: Running web server

The client was able to access the web page by typing in server's internal IP address since both the server and client were on the same network (aalto open).

```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:708:150:10::2998
   Link-local IPv6 Address . . . . . : fe80::6dca:20bc:46e:ea06%20
   IPv4 Address. . . . . . . . . . . : 10.100.2.213
   Subnet Mask . . . . . . . . . . . : 255.255.192.0
   Default Gateway . . . . . . . . . : fe80::32f7:dff:fefa:4000%20
                                       10.100.0.1

C:\Users\sarah\AppData\Local\Programs\Python\Python37-32\Assignments>
```

Figure 4a: IP address of server

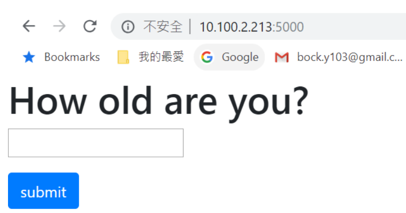

Figure 4b: Client accessing web page

Step 3: Use Wireshark to capture traffic.
While the client was accessing the site, we ran Wireshark on the server laptop and received TCP and HTTP packets. The capture is normally what we would see when browsing a website without an SSL certificate.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.100.2.213	40.67.248.104	TLSv1.2	97	Application Data
2	0.066264	40.67.248.104	10.100.2.213	TLSv1.2	179	Application Data
3	0.114465	10.100.2.213	40.67.248.104	TCP	54	2860 → 443 [ACK] Seq=44 Ack=126 Win=256 Len=0
4	1.542758	10.100.38.106	10.100.2.213	TCP	66	49909 → 5000 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
5	1.543042	10.100.2.213	10.100.38.106	TCP	66	5000 → 49909 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 WS=256 S…
6	1.544848	10.100.38.106	10.100.2.213	HTTP	540	GET / HTTP/1.1
7	1.546142	10.100.38.106	10.100.2.213	TCP	54	49909 → 5000 [ACK] Seq=1 Ack=1 Win=65536 Len=0
8	1.546351	10.100.2.213	10.100.38.106	TCP	71	5000 → 49906 [PSH, ACK] Seq=1 Ack=487 Win=254 Len=17 [TCP segment of …
9	1.546829	10.100.2.213	10.100.38.106	HTTP	692	HTTP/1.0 200 OK (text/html)
10	1.561190	10.100.38.106	10.100.2.213	TCP	54	49906 → 5000 [ACK] Seq=487 Ack=657 Win=254 Len=0
11	1.563072	10.100.38.106	10.100.2.213	TCP	54	49906 → 5000 [FIN, ACK] Seq=487 Ack=657 Win=254 Len=0
12	1.563155	10.100.2.213	10.100.38.106	TCP	54	5000 → 49906 [ACK] Seq=657 Ack=488 Win=254 Len=0
13	7.181176	10.100.2.213	40.67.248.104	TLSv1.2	97	Application Data
14	7.249186	40.67.248.104	10.100.2.213	TLSv1.2	179	Application Data
15	7.305737	10.100.2.213	40.67.248.104	TCP	54	2867 → 443 [ACK] Seq=44 Ack=126 Win=253 Len=0
16	7.520537	10.100.38.106	10.100.2.213	HTTP	685	POST / HTTP/1.1 (application/x-www-form-urlencoded)

```
> Hypertext Transfer Protocol
v Line-based text data: text/html (17 lines)
    <!DOCTYPE html>\n
    <html>\n
    <head>\n
    <link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap.min.css" integrity="sha384-ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcW…
```

Figure 5: Normal Browsing Wireshark Capture

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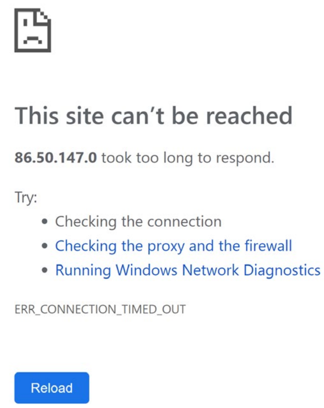
<u>Step 4</u>: Access the website again with VPN.

We kept the website running but the client accessed the site with the VPN but when putting in the external IP address of the server the site was unreachable. With further research, we found that this is because locally hosted websites are inaccessible to computers outside of the network it is being hosted on. This is because when the client sends the packet with the external IP and port number, the router isn't configured to accept the packet at the port. To solve this issue, we utilized ngrok, an application that "exposes local servers behind NATs and firewalls to the public internet over secure tunnels," to forward the client request to the server.



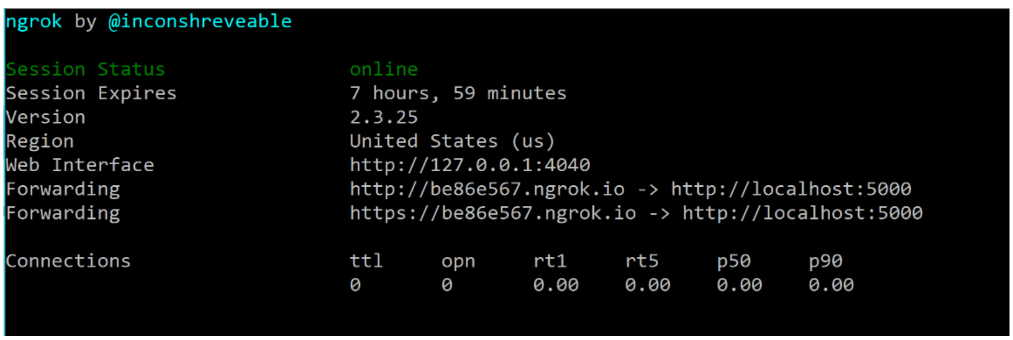


Figure 6b: Ngrok application

To start the port forwarding, we ran ngrok on the server laptop and entered the command "`ngrok http 5000`". The application will assign a temporary uniform resource locator (URL) that the client can use to access the website. Once we fixed this process, the client laptop was able to access the website outside of the network with the VPN as seen in Figure 6e.

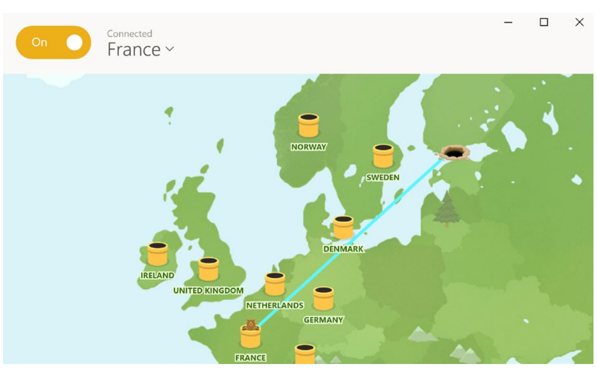


Figure 6c: Turning on TunnelBear VPN on client laptop

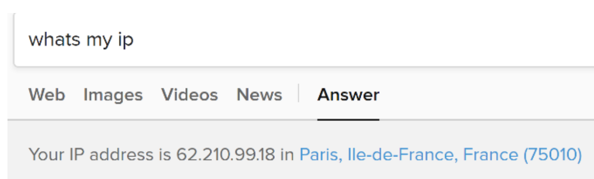


Figure 6d: Client IP address with VPN

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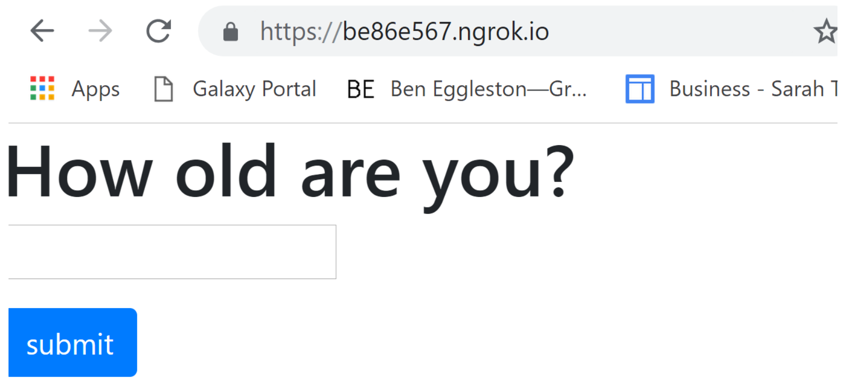

Figure 6e: Client accessing website with VPN after port forwarding

<u>Step 5</u>: Use Wireshark to capture traffic
While the client was connected to the server, we ran Wireshark on the server side but there were no packets that had an IP address that matched the client's VPN assigned IP address. Objectively, we were looking for a packet that has the VPN assigned IP of the client (62.210.99.18) and the external IP of the server (86.50.147.0) to show that the client successfully connected to the server. Figure 7a is a screen capture of the Wireshark trace on the server side while the client was accessing the website.

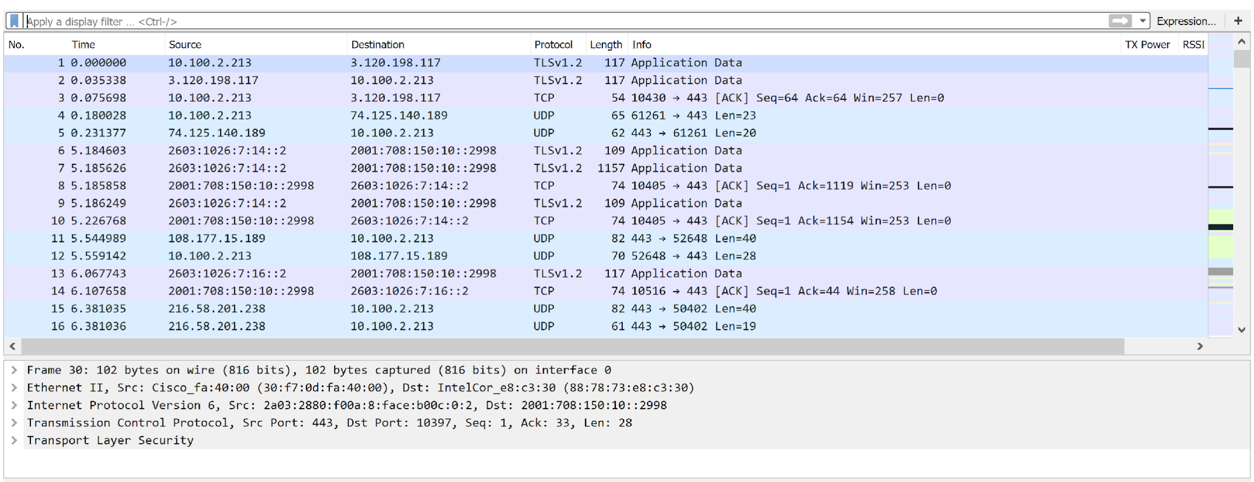

Figure 7a: Server side Wireshark capture

On the client side, we also ran Wireshark and only saw communication between the VPN server(62.210.99.18) and the client's internal IP address(10.100.16.141). Figure 7b does show that the Wireshark trace captured the Encapsulated Secure Payload(ESP) packets but only between the VPN server and client.

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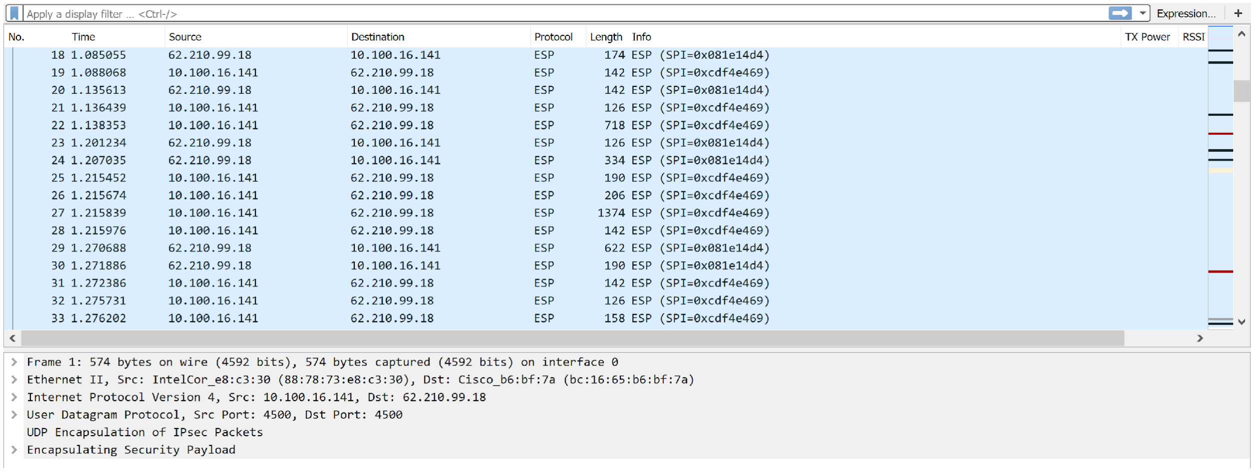

Figure 7b: Client Side Wireshark trace

Section 3: Results and Conclusion

In addition to the experiment detailed above, we tried running the server through the VPN to see if that would make a difference but got the same results as the client VPN. The Wireshark traces show no communication between the client (with VPN IP address) and server. This is due to the limited functions of Wireshark on a Windows computer since we can only track traffic coming in and out of the laptop. After searching for some information, we found that since Wireshark uses WinPcap(windows packet capture) on Windows, and some third-party (or even some standard) VPN software doesn't work with WinPcap. This might be the problem. We suspect that with a Linux based operating system that has “monitor” mode we could possibly track more traffic on the network. Despite this problem, we were still able to see the ESP packet on the client side and learned how secure the using VPN can be.

Section 4: Appendices

Appendix A - Unsecure Backend Python Code (app.py)

```
from flask import Flask, render_template, request
app = Flask(__name__)

@app.route("/", methods=['GET','POST'])
def send():
    if request.method == 'POST':
        age = request.form['age']

        return render_template('age.html', age=age)

    return render_template('index.html')

if __name__ == "__main__":
    app.run(debug=True, host='0.0.0.0')
```

Appendix B - Index.html

```
<!DOCTYPE html>
<html>
<head>
```

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```
<link rel="stylesheet"
href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap
.min.css" integrity="sha384-
ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
crossorigin="anonymous">
<title>Page Title</title>
</head>
<body>

<h1>How old are you?</h1>
<form method = "POST" action="/">
      <div class = "form-group">
            <input type = "text" name="age">
      </div>
      <input class="btn btn-primary" type="submit" value="submit">
</form>
</body>
</html>
```

Appendix C - age.html

```
<!DOCTYPE html>
<html>
<head>
<link rel="stylesheet"
href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap
.min.css" integrity="sha384-
ggOyR0iXCbMQv3Xipma34MD+dH/1fQ784/j6cY/iJTQUOhcWr7x9JvoRxT2MZw1T"
crossorigin="anonymous">
<title>Page Title</title>
</head>
<body>

      <h1> Your age is {{ age }}</h1>
</body>
</html>
```