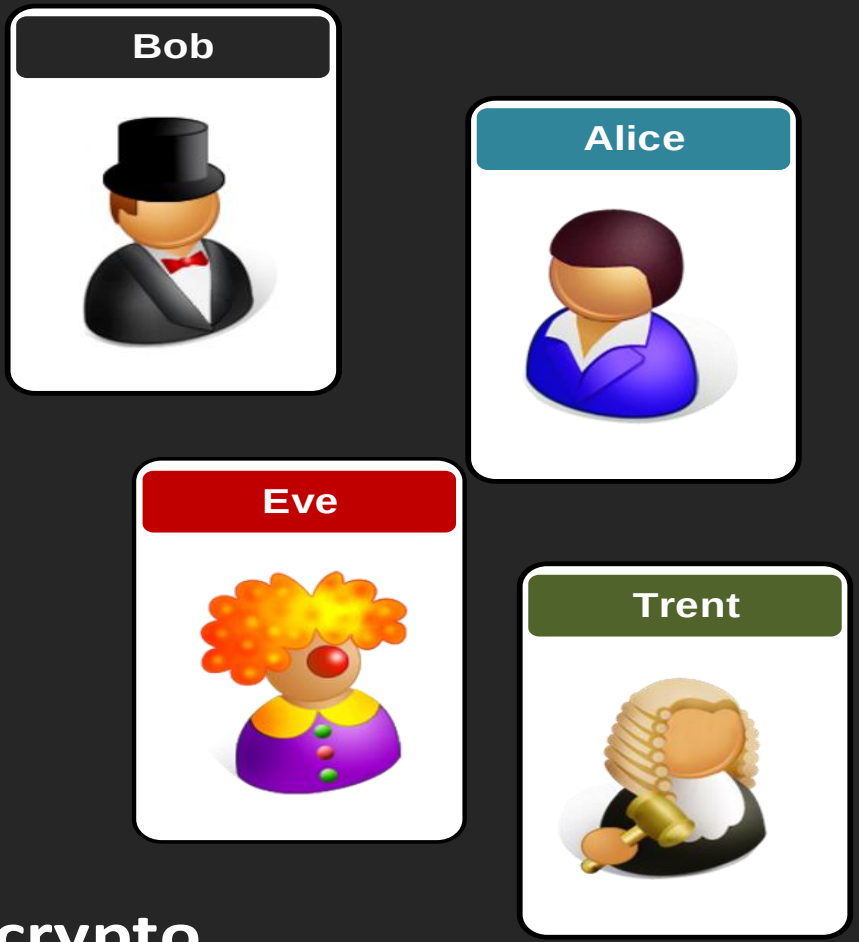
Advanced Crypto

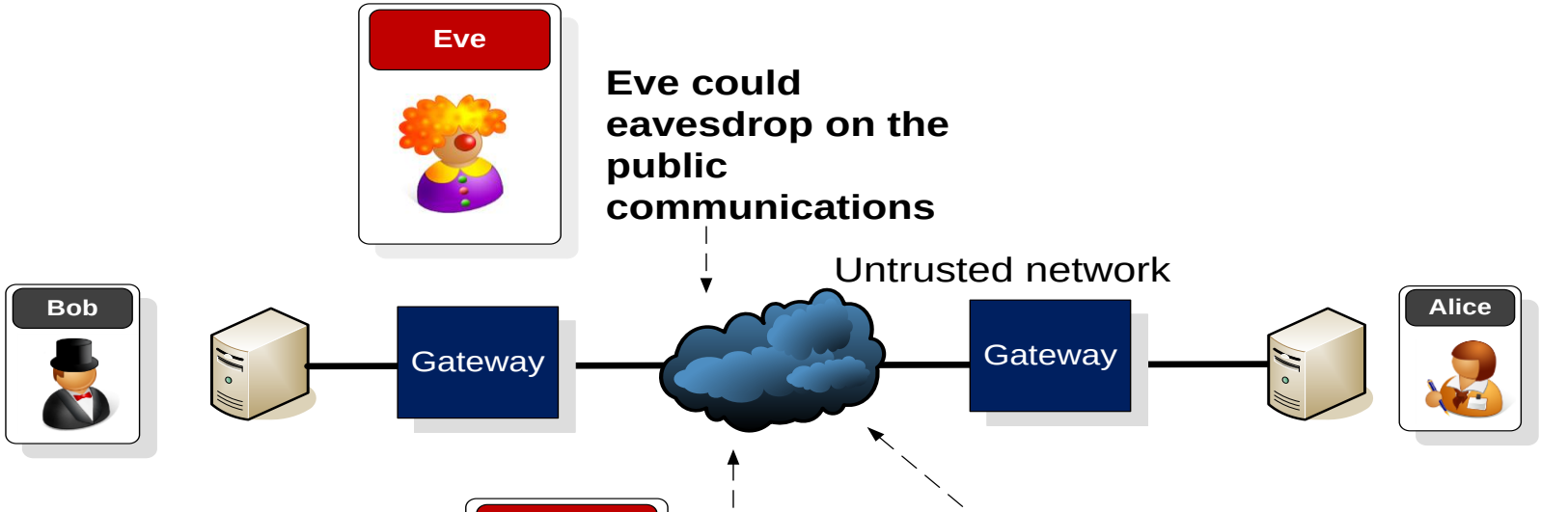
6. Tunnelling

Introduction



http://asecuritysite.com/crypto

Author: Prof Bill Buchanan



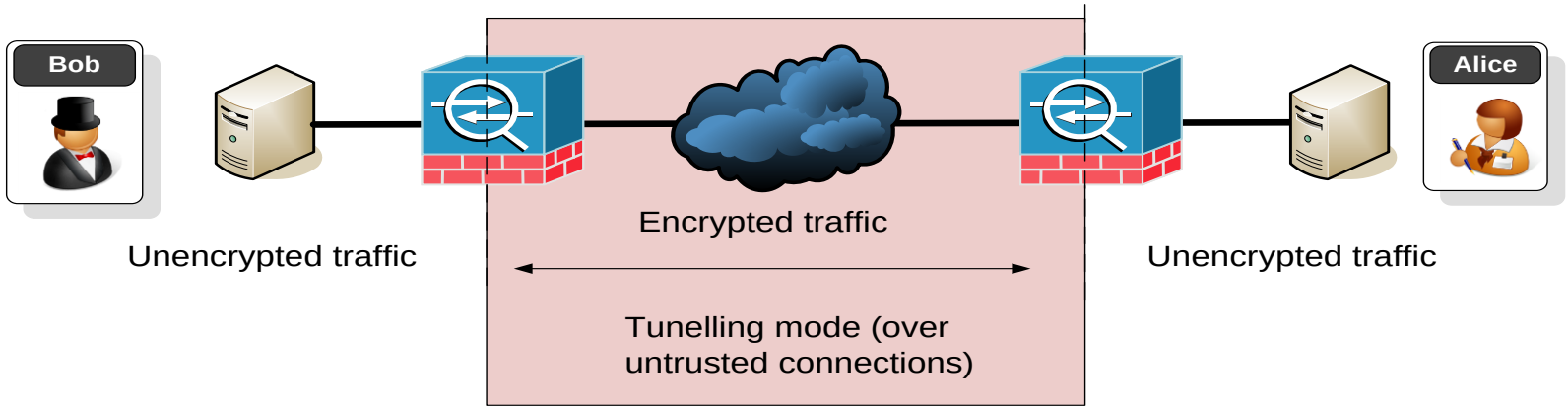
What is required is:

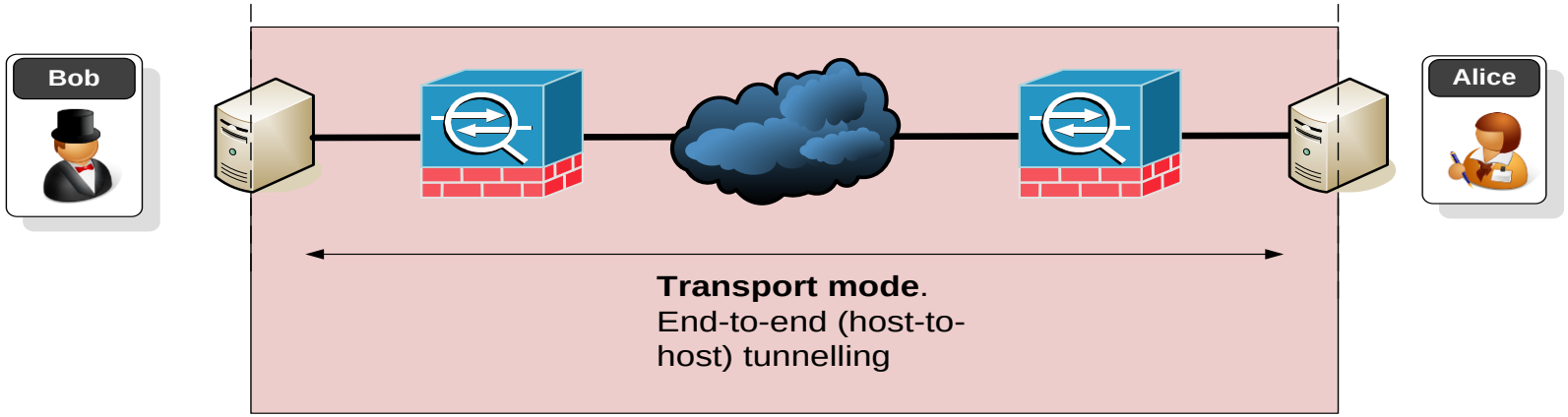
- Encryption.
- Authentication of devices (to overcome spoofing)
- Authentication of packets (for integrity)

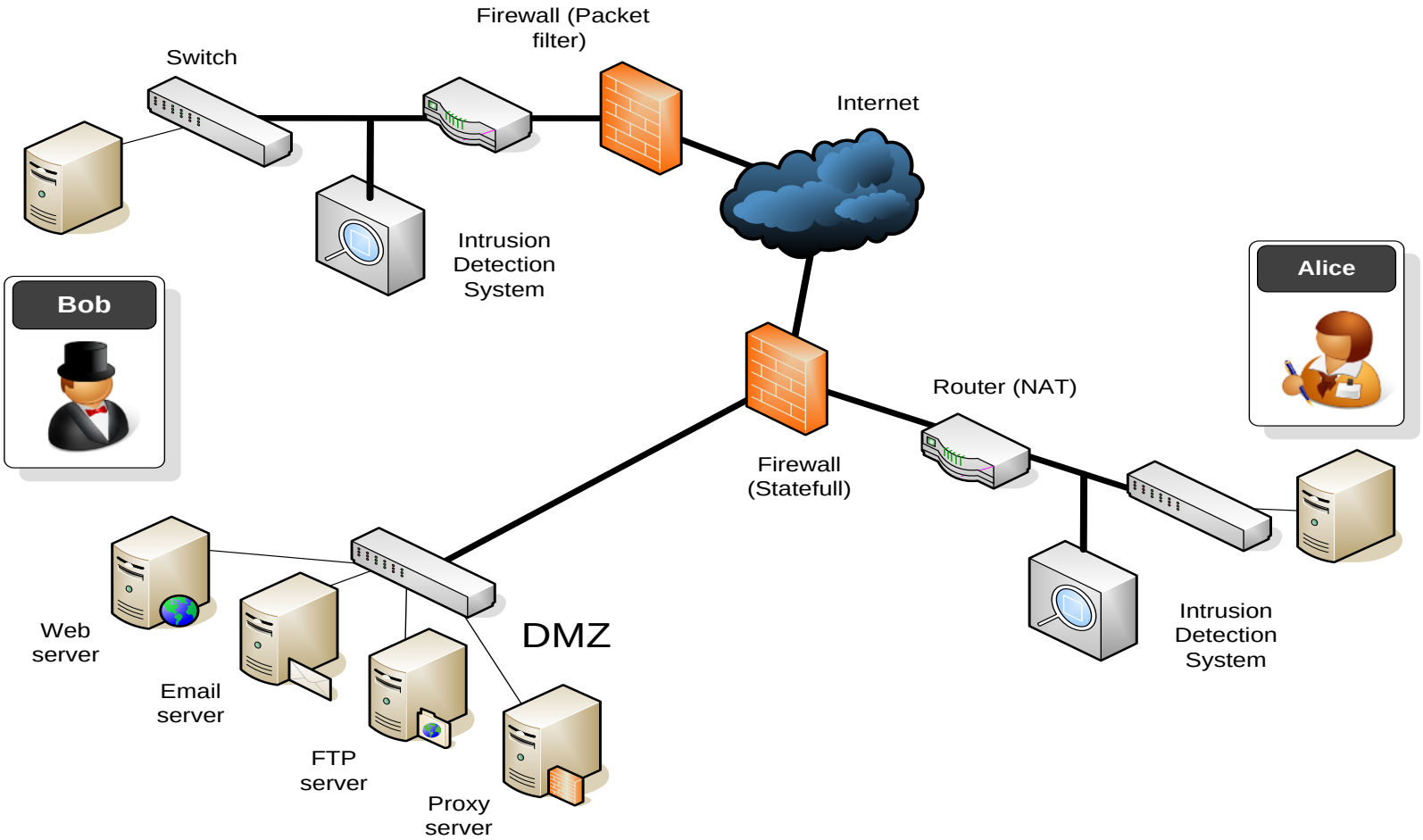
Eve could change the data packets

Eve could setup an alternative gateway

Traffic is encrypted over the untrusted network.

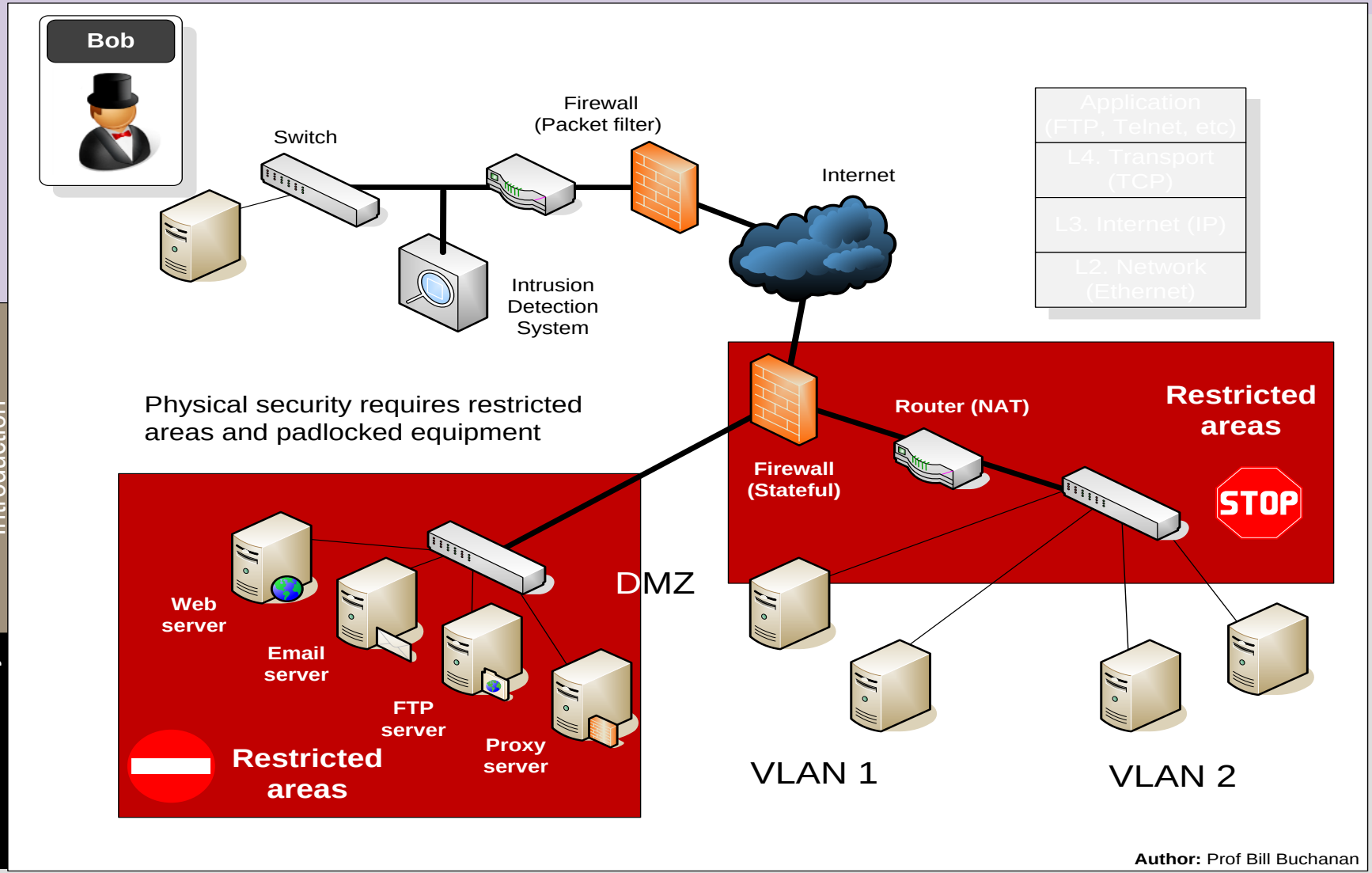






Author: Prof Bill Buchanan

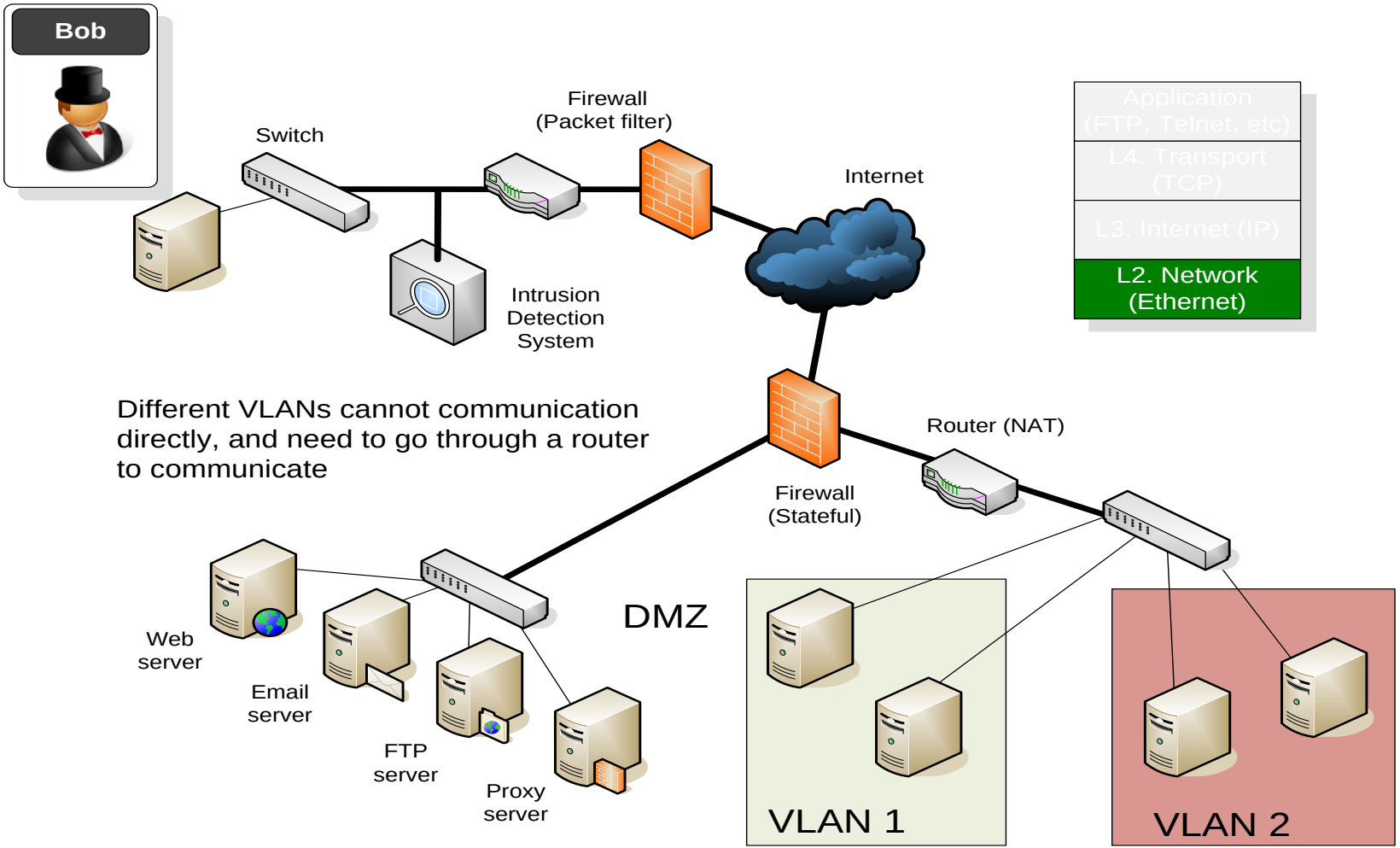
Example Infrastructure



Introduction

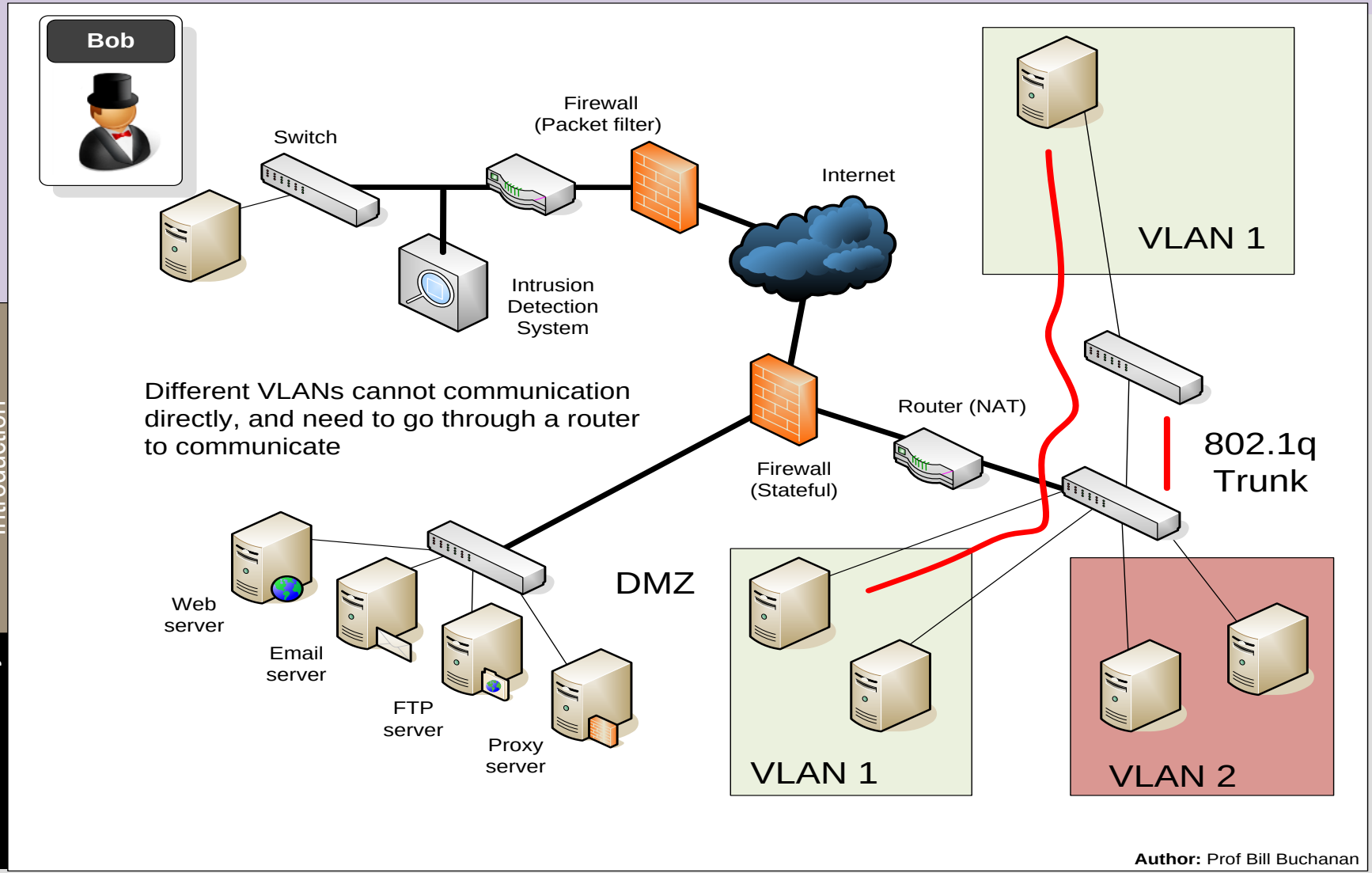
Network Security

Example Infrastructure

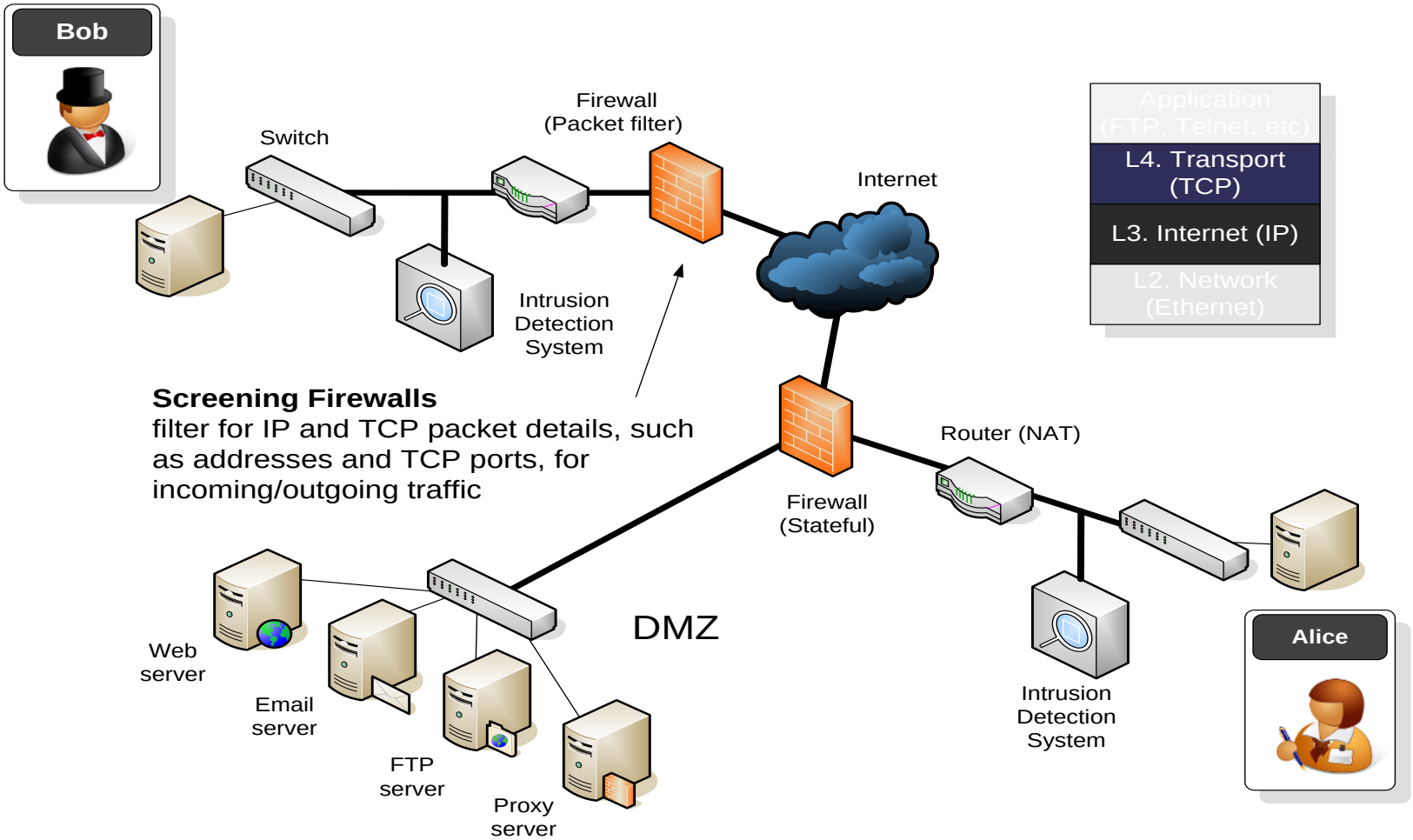


Author: Prof Bill Buchanan

Example Infrastructure



Example Infrastructure

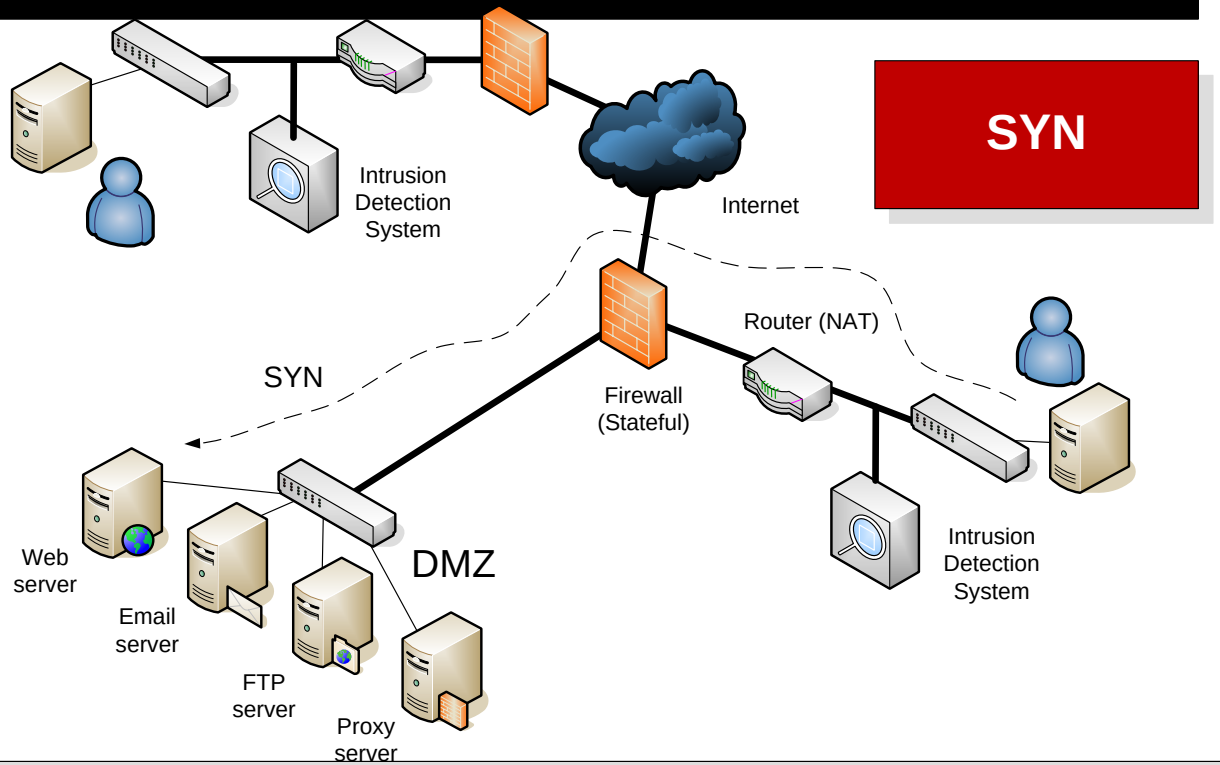


Author: Prof Bill Buchanan

Example Infrastructure

Originator		Recipient
1. CLOSED		LISTEN
2. SYN-SENT	**<SEQ=999><CTL=SYN>**	**SYN-RECEIVED**
3. ESTABLISHED	<SEQ=100><ACK=1000><CTL=SYN,ACK>	SYN-RECEIVED
4. ESTABLISHED	<SEQ=1000><ACK=101><CTL=ACK>	ESTABLISHED
5. ESTABLISHED	<SEQ=1000><ACK=101><CTL=ACK><DATA>	ESTABLISHED

SYN



Originator		Recipient
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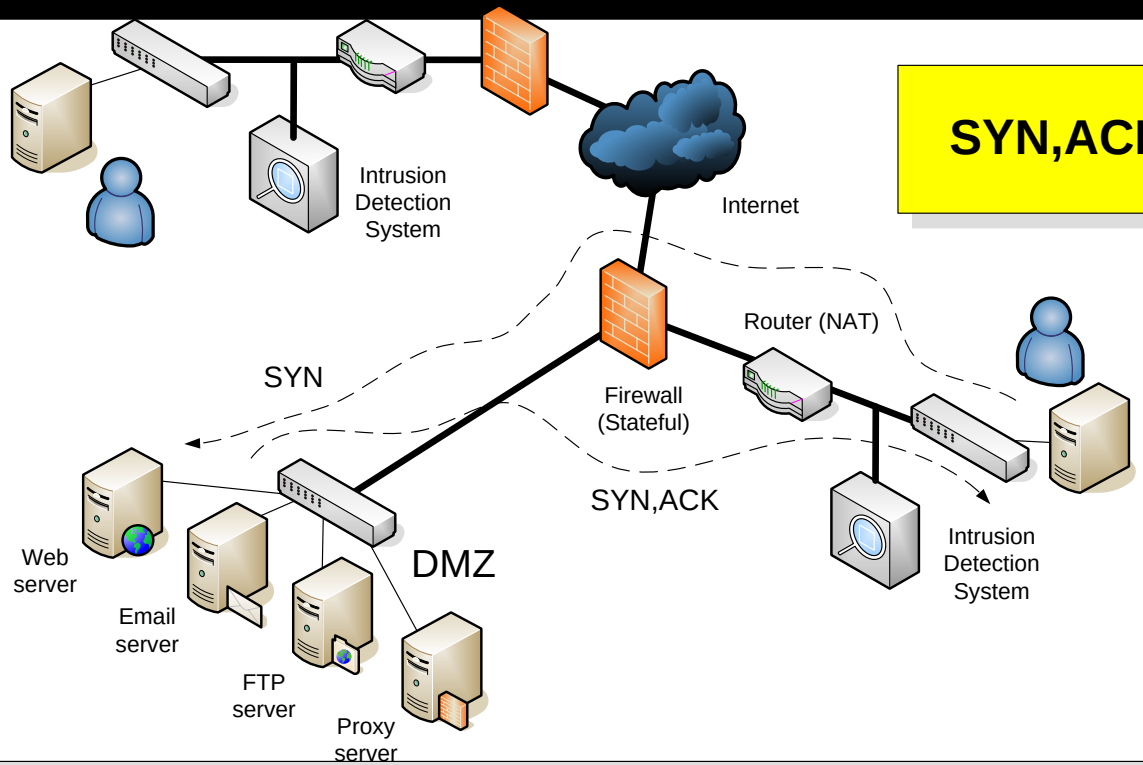
4. ESTABLISHED	<SEQ=1000><ACK=101><CTL=ACK>	ESTABLISHED
5. ESTABLISHED	<SEQ=1000><ACK=101><CTL=ACK><DATA>	ESTABLISHED

SYN

SYN,ACK



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2. SYN-SENT	<SEQ=999><CTL=SYN>	SYN-RECEIVED
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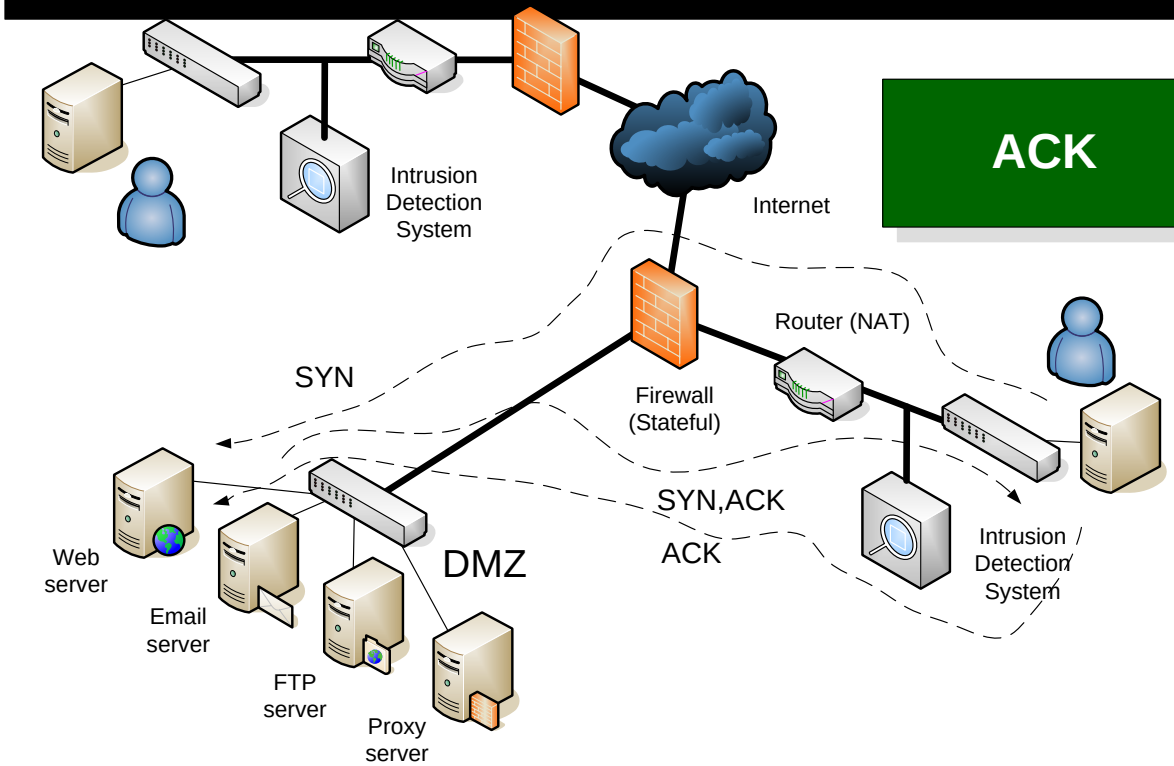
SYN
SYN,ACK
ACK



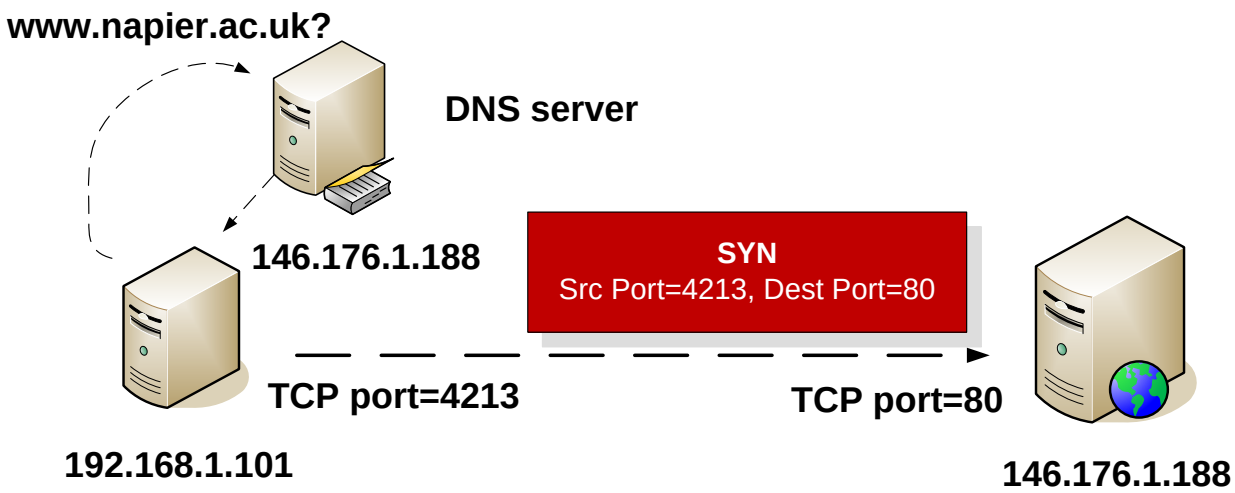
68	9.980194	192.168.1.101	resolver2.svr.pol.	DNS	Standard query PTR 255.1.168.192.in-addr.arpa
69	10.005697	resolver2.svr.pol.	192.168.1.101	DNS	Standard query response, No such name
70	14.477532	192.168.1.101	resolver2.svr.pol.	DNS	Standard query A www.napier.ac.uk
71	14.503727	resolver2.svr.pol.	192.168.1.101	DNS	Standard query response A 146.176.1.188
72	14.512705	192.168.1.101	www.napier.ac.uk	TCP	4213 > http [SYN] Seq=0 Ack=0 Win=16384 Len=0 MSS=1260
73	14.515118	192.168.1.1	192.168.1.255	SNMP	TRAP-V1 SNMPv2-SMI::enterprises.3955.1.1.0
74	14.553506	www.napier.ac.uk	192.168.1.101	TCP	http > 4213 [SYN, ACK] Seq=0 Ack=1 Win=16384 Len=0 MSS=1352
75	14.553533	192.168.1.101	www.napier.ac.uk	TCP	4213 > http [ACK] Seq=1 Ack=1 Win=17640 Len=0
76	14.553687	192.168.1.101	www.napier.ac.uk	HTTP	GET / HTTP/1.1

```
ame 72 (62 bytes on wire, 62 bytes captured)
hernet II, Src: 00:15:00:34:02:f0, Dst: 00:0c:41:f5:23:d5
iternet Protocol, Src Addr: 192.168.1.101 (192.168.1.101), Dst Addr: www.napier.ac.uk (146.176.1.188)
ansmission Control Protocol, Src Port: 4213 (4213), Dst Port: http (80), Seq: 0, Ack: 0, Len: 0
Source port: 4213 (4213)
Destination port: http (80)
Sequence number: 0    (relative sequence number)
Header length: 28 bytes
Flags: 0x0002 (SYN)
Window size: 16384
Checksum: 0x3c0c (correct)
Options: (8 bytes)
```

SYN

Stateful fi

Network Security



Stateful firewall

```
68 9.980194  192.168.1.101      resolver2.svr.pol. DNS   Standard query PTR 255.1.168.192.in-addr.arpa
69 10.005697 resolver2.svr.pol. 192.168.1.101      DNS   Standard query response, No such name
70 14.477532 192.168.1.101      resolver2.svr.pol. DNS   Standard query A www.napier.ac.uk
71 14.503727 resolver2.svr.pol. 192.168.1.101      DNS   Standard query response A 146.176.1.188
72 14.512705 192.168.1.101      www.napier.ac.uk   TCP   4213 > http [SYN] Seq=0 Ack=0 Win=16384 Len=0 MSS=1260
73 14.515118 192.168.1.1        192.168.1.255      SNMP  TRAP-V1 SNMPv2-SMI::enterprises.3955.1.1.0
74 14.553506 www.napier.ac.uk   192.168.1.101      TCP   http > 4213 [SYN, ACK] Seq=0 Ack=1 Win=16384 Len=0 MSS=1352
75 14.553533 192.168.1.101      www.napier.ac.uk   TCP   4213 > http [ACK] Seq=1 Ack=1 Win=17640 Len=0
76 14.553687 192.168.1.101      www.napier.ac.uk   HTTP  GET / HTTP/1.1

ame 74 (62 bytes on wire, 62 bytes captured)
thernet II, Src: 00:0c:41:f5:23:d5, Dst: 00:15:00:34:02:f0
nternet Protocol, Src Addr: www.napier.ac.uk (146.176.1.188), Dst Addr: 192.168.1.101 (192.168.1.101)
ransmission Control Protocol, Src Port: http (80), Dst Port: 4213 (4213), Seq: 0, Ack: 1, Len: 0
 Source port: http (80)
 Destination port: 4213 (4213)
 Sequence number: 0    (relative sequence number)
 Acknowledgement number: 1    (relative ack number)
 Header length: 28 bytes
 Flags: 0x0012 (SYN, ACK)
 Window size: 16384
 Checksum: 0xa97c (correct)
 Options: (8 bytes)
```

SYN,ACK

Network Security

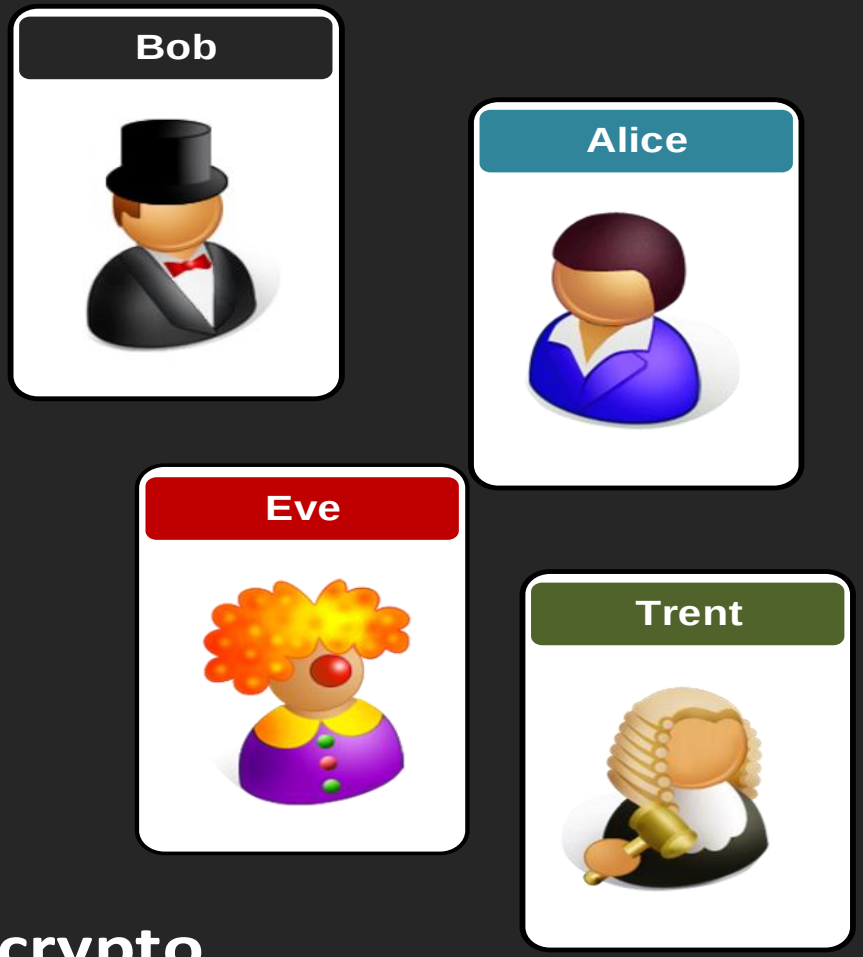
```
69 10.005697 resolver2.svr.pol. 192.168.1.101      DNS   Standard query response, No such name
70 14.477532 192.168.1.101      resolver2.svr.pol. DNS   Standard query A www.napier.ac.uk
71 14.503727 resolver2.svr.pol. 192.168.1.101      DNS   Standard query response A 146.176.1.188
72 14.512705 192.168.1.101      www.napier.ac.uk   TCP   4213 > http [SYN] Seq=0 Ack=0 Win=16384 Len=0 MSS=1260
73 14.515118 192.168.1.1        192.168.1.255      SNMP  TRAP-V1 SNMPv2-SMI::enterprises.3955.1.1.0
74 14.553506 www.napier.ac.uk   192.168.1.101      TCP   http > 4213 [SYN, ACK] Seq=0 Ack=1 Win=16384 Len=0 MSS=1352
75 14.553533 192.168.1.101      www.napier.ac.uk   TCP   4213 > http [ACK] Seq=1 Ack=1 Win=17640 Len=0
76 14.553687 192.168.1.101      www.napier.ac.uk   HTTP  GET / HTTP/1.1

ame 75 (54 bytes on wire, 54 bytes captured)
thernet II, Src: 00:15:00:34:02:f0, Dst: 00:0c:41:f5:23:d5
nternet Protocol, Src Addr: 192.168.1.101 (192.168.1.101), Dst Addr: www.napier.ac.uk (146.176.1.188)
ransmission Control Protocol, Src Port: 4213 (4213), Dst Port: http (80), Seq: 1, Ack: 1, Len: 0
 Source port: 4213 (4213)
 Destination port: http (80)
 Sequence number: 1    (relative sequence number)
 Acknowledgement number: 1    (relative ack number)
 Header length: 20 bytes
 Flags: 0x0010 (ACK)
 Window size: 17640
 Checksum: 0xd0ec (correct)
 [SEQ/ACK analysis]
```

ACK

Advanced Crypto

6. Tunnelling

SSL/TLS



http://asecuritysite.com/crypto

Author: Prof Bill Buchanan

4	0.000602	192.168.75.132	192.168.75.1	TCP	78	http > mgcp-gateway [SYN, ACK] Seq=0 Ack=1 W
5	0.000681	192.168.75.1	192.168.75.132	TCP	66	mgcp-gateway > http [ACK] Seq=1 Ack=1 Win=66
6	0.000835	192.168.75.1	192.168.75.132	HTTP	475	GET / HTTP/1.1
7	0.055477	192.168.75.132	192.168.75.1	TCP	1514	[TCP segment of a reassembled PDU]

```
⊞ Destination: Vmware_0f:71:a3 (00:0c:29:0f:71:a3)
⊞ Source: Vmware_c0:00:08 (00:50:56:c0:00:08)
  Type: IP (0x0800)
⊟ Internet Protocol Version 4, Src: 192.168.75.1 (192.168.75.1), Dst: 192.168.75.132 (192.168.75.132)
  Version: 4
  Header length: 20 bytes
⊞ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
  Total Length: 461
  Identification: 0x011e (286)
⊞ Flags: 0x02 (Don't Fragment)
  Fragment offset: 0
  Time to live: 128
  Protocol: TCP (6)
⊞ Header checksum: 0xe036 [validation disabled]
  Source: 192.168.75.1 (192.168.75.1)
  Destination: 192.168.75.132 (192.168.75.132)
  [Source GeoIP: Unknown]
  [Destination GeoIP: Unknown]
⊟ Transmission Control Protocol, Src Port: mgcp-gateway (2427), Dst Port: http (80), Seq: 1, Ack: 1, Len: 409
  Source port: mgcp-gateway (2427)
  Destination port: http (80)
  [Stream index: 0]
  Sequence number: 1    (relative sequence number)
  [Next sequence number: 410    (relative sequence number)]
  Acknowledgment number: 1    (relative ack number)
  Header length: 32 bytes
⊞ Flags: 0x018 (PSH, ACK)
  Window size value: 16652
  [Calculated window size: 66608]
  [Window size scaling factor: 4]
⊞ Checksum: 0xf834 [validation disabled]
⊞ Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
⊞ [SEQ/ACK analysis]
⊟ Hypertext Transfer Protocol
  GET / HTTP/1.1\r\n
  User-Agent: Opera/9.80 (Windows NT 6.0; U; en) Presto/2.2.15 Version/10.01\r\n
```

Stack

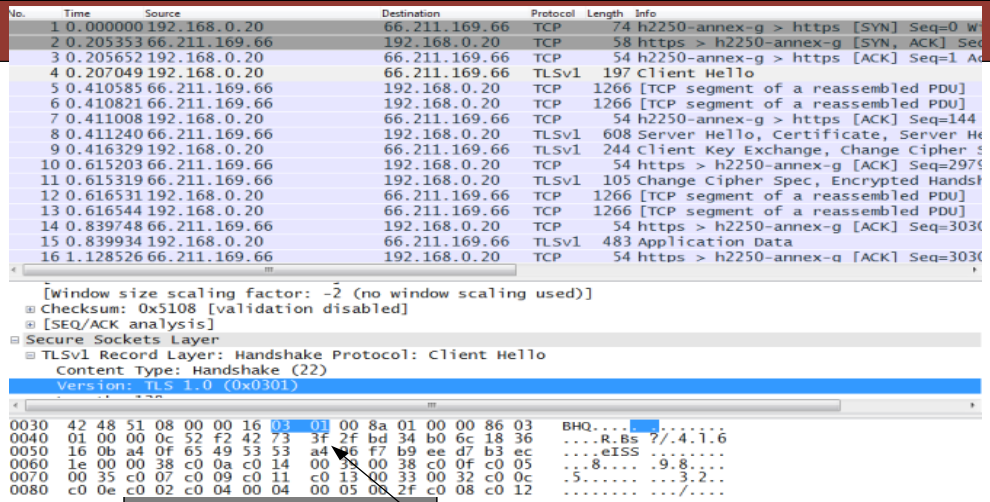
Tunnelling

HTTP, FTP Telnet, POP-3 IMAP, SMTP	Application
TCP, UDP, SPX	Transport
IP, IPX, ARP, ICMP	Network
Ethernet, PPP, HDLC	Data Link
Cables, Signals	Physical

Author: Prof Bill Buchanan

Ports

HTTP	80	HTTPs	443
TELNET	23	SSH	22
SMTP	25	SMTPs	465
POP-3	110	POP-3s	995



Stack

Tunnelling

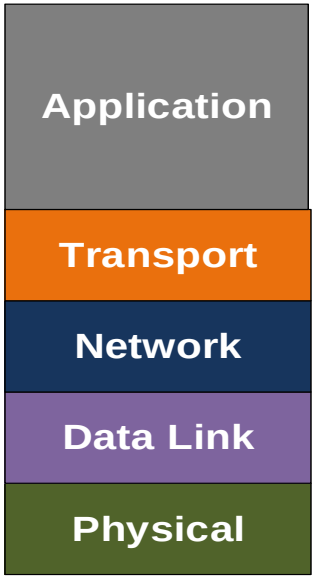
HTTP, FTP
Telnet, POP-3
IMAP, SMTP

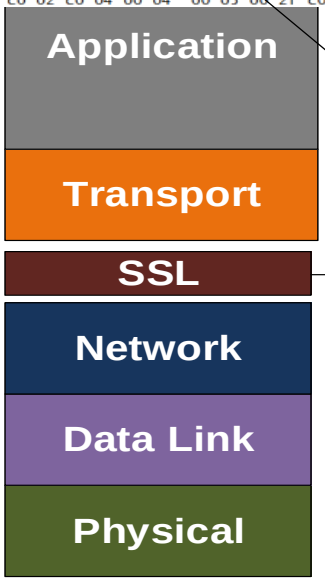
TCP, UDP, SPX

IP, IPX, ARP,
ICMP

Ethernet,
PPP, HDLC

Cables, Signals



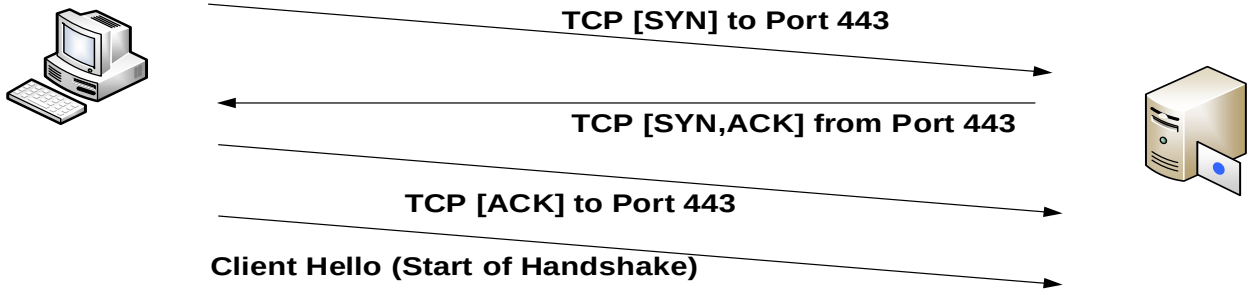


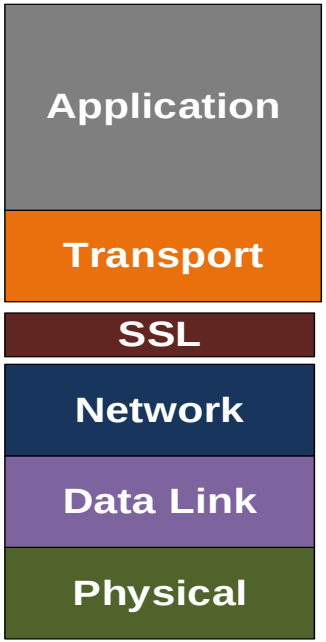
HTTPS (HTTP + SSL)
FTP (FTP+SSL)
SSH (Telnet+SSL)

SSL 1.0
SSL 2.0
SSL 3.0 [0x0300]
SSL 3.1 (TLS 1.0) [0x0301]
TLS 1.1 and 1.2 [0x0302]

Secure Socket Layer
Transport Layer Socket

Author: Prof Bill Buchanan





ssl.pcap [Wireshark 1.10.7 (v1.10.7-0-g6b931a1 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.20	66.211.169.66	TCP	74	h2250-annex-g > https [SYN] Seq=0 Win=8
2	0.205353	66.211.169.66	192.168.0.20	TCP	58	https > h2250-annex-g [SYN, ACK] Seq=0
3	0.205652	192.168.0.20	66.211.169.66	TCP	54	h2250-annex-g > https [ACK] Seq=1 Ack=1
4	0.207049	192.168.0.20	66.211.169.66	TLSv1	197	Client Hello
5	0.410585	66.211.169.66	192.168.0.20	TCP	1266	[TCP segment of a reassembled PDU]
6	0.410821	66.211.169.66	192.168.0.20	TCP	1266	[TCP segment of a reassembled PDU]
7	0.411008	192.168.0.20	66.211.169.66	TCP	54	h2250-annex-g > https [ACK] Seq=144 Ack
8	0.411240	66.211.169.66	192.168.0.20	TLSv1	608	Server Hello, Certificate, Server Hello
9	0.416329	192.168.0.20	66.211.169.66	TLSv1	244	Client Key Exchange, Change Cipher Spec
10	0.615203	66.211.169.66	192.168.0.20	TCP	54	https > h2250-annex-g [ACK] Seq=2979 Ac
11	0.615319	66.211.169.66	192.168.0.20	TLSv1	105	Change Cipher Spec, Encrypted Handshake
12	0.616531	192.168.0.20	66.211.169.66	TCP	1266	[TCP segment of a reassembled PDU]

```
⊞ Frame 4: 197 bytes on wire (1576 bits), 197 bytes captured (1576 bits)
⊞ Ethernet II, Src: IntelCor_4f:30:1d (00:1f:3c:4f:30:1d), Dst: Netgear_b0:d6:8c (00:18:4d:b0:d6:8c)
⊞ Internet Protocol Version 4, Src: 192.168.0.20 (192.168.0.20), Dst: 66.211.169.66 (66.211.169.66)
⊞ Transmission Control Protocol, Src Port: h2250-annex-g (2099), Dst Port: https (443), Seq: 1, Ack: 1,
⊟ Secure Sockets Layer
  ⊟ TLSv1 Record Layer: Handshake Protocol: Client Hello
      Content Type: Handshake (22)
      Version: TLS 1.0 (0x0301)
      Length: 138
    ⊟ Handshake Protocol: Client Hello
        Handshake Type: Client Hello (1)
        Length: 134
```

```
0000  00 18 4d b0 d6 8c 00 1f  3c 4f 30 1d 08 00 45 00   ..M..... <O0...E.
0010  00 b7 0b ba 40 00 80 06  41 b5 c0 a8 00 14 42 d3   ....@... A.....B.
0020  a9 42 08 33 01 bb 42 d6  54 ce d7 ae 1a f7 50 18   .B.3..B. T.....P.
0030  42 48 51 08 00 00 16 03  01 00 8a 01 00 00 86 03   BHQ..... ........
0040  01 00 00 0c 52 f2 42 73  3f 2f bd 34 b0 6c 18 36   ....R.Bs ?/.4.l.6
0050  16 0b a4 0f 65 49 53 53  a4 96 f7 b9 ee d7 b3 ec   ....eISS ........
```

Frame (frame), 197 bytes | Packet... | Profile: Default

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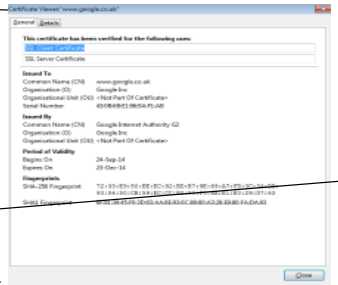
192.168.0.20

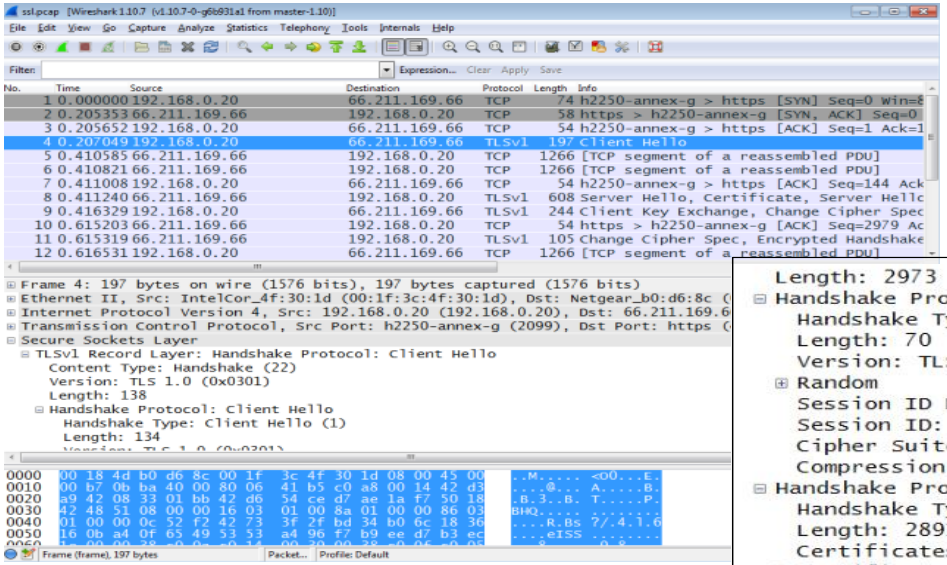
Client Hello

66.211.169.66



Server Hello

```
Content Type: Handshake (22)
Version: TLS 1.0 (0x0301)
Length: 138
Handshake Protocol: Client Hello
  Handshake Type: Client Hello (1)
  Length: 134
  Version: TLS 1.0 (0x0301)
  Random
  Session ID Length: 0
  Cipher Suites Length: 56
  Cipher Suites (28 suites)
    Cipher Suite: TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA (0xc00a)
    Cipher Suite: TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA (0xc014)
    Cipher Suite: TLS_DHE_RSA_WITH_AES_256_CBC_SHA (0x0039)
    Cipher Suite: TLS_DHE_DSS_WITH_AES_256_CBC_SHA (0x0038)
```

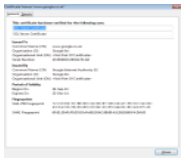


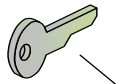
```
Length: 2973
Handshake Protocol: Server Hello
  Handshake Type: Server Hello (2)
  Length: 70
  Version: TLS 1.0 (0x0301)
  Random
  Session ID Length: 32
  Session ID: ed2175399c8f02d916e58afdbbd46317564a98a1d985632a...
  Cipher Suite: TLS_RSA_WITH_3DES_EDE_CBC_SHA (0x000a)
  Compression Method: null (0)
Handshake Protocol: Certificate
  Handshake Type: Certificate (11)
  Length: 2891
  Certificates Length: 2888
  Certificates (2888 bytes)
```

Stack

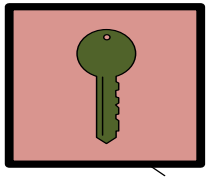
Tunnelling

Author: Prof Bill Buchanan

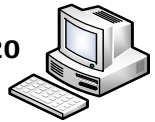




Public key



192.168.0.20

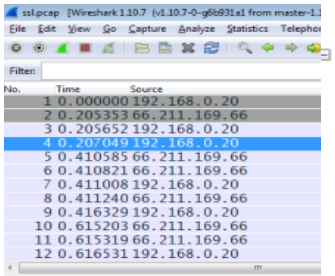


Client Hello

66.211.169.66

Server Hello

Client Key Exchange



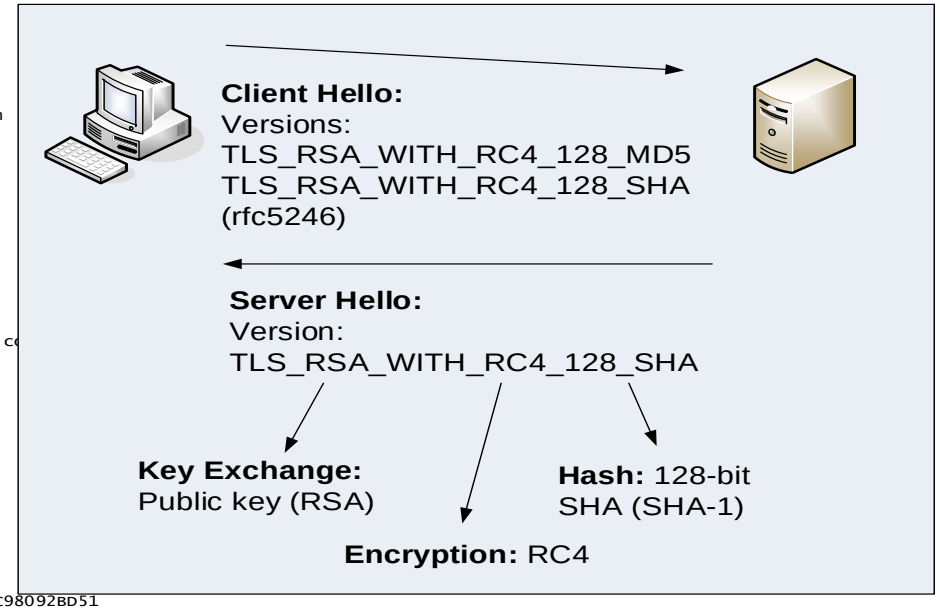
```
[Window size scaling factor: -2 (no window scaling used)]
⊞ Checksum: 0x2a30 [validation disabled]
⊞ [SEQ/ACK analysis]
Secure Sockets Layer
⊟ TLSv1 Record Layer: Handshake Protocol: Client Key Exchange
    Content Type: Handshake (22)
    Version: TLS 1.0 (0x0301)
    Length: 134
  ⊟ Handshake Protocol: Client Key Exchange
      Handshake Type: Client Key Exchange (16)
      Length: 130
    ⊟ RSA Encrypted PreMaster Secret
        Encrypted PreMaster length: 128
        Encrypted PreMaster: 07d26b83aa8129bd8c48462627a1d3f67f34e2745959fce2...
⊟ TLSv1 Record Layer: Change Cipher Spec Protocol: Change Cipher Spec
    Content Type: Change Cipher Spec (20)
    Version: TLS 1.0 (0x0301)
```

Stack

Tunnelling

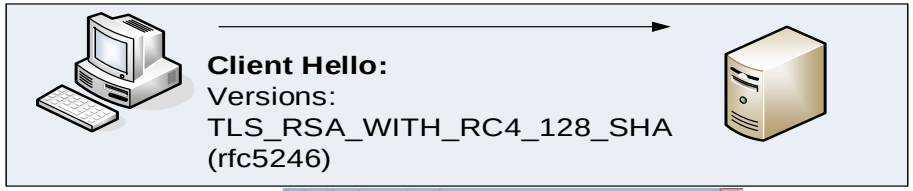
Author: Prof Bill Buchanan

```
billbuchanan@Bills-MacBook-Pro:~$ openssl s_client -connect www.google.com:443
CONNECTED(00000003)
depth=2 C = US, O = GeoTrust Inc., CN = GeoTrust Global CA
verify error:num=20:unable to get local issuer certificate
verify return:0
---
Certificate chain
 0 s:/C=US/ST=California/L=Mountain View/O=Google Inc/CN=www.google.com
   i:/C=US/O=Google Inc/CN=Google Internet Authority G2
 1 s:/C=US/O=Google Inc/CN=Google Internet Authority G2
   i:/C=US/O=GeoTrust Inc./CN=GeoTrust Global CA
 2 s:/C=US/O=GeoTrust Inc./CN=GeoTrust Global CA
   i:/C=US/O=Equifax/OU=Equifax Secure Certificate Authority
---
Server certificate
-----BEGIN CERTIFICATE-----
MIIEdjCCA16gAwIBAgIISVyALWN+akUwDQYJKoZIhvcNAQEFBQAwSTELMAkGA1UE
---
SOx4I5L0D0jZYqKfJuImGcFwdIETq0EpCmkhJfGNHjVdzC/h/T61TmaY
-----END CERTIFICATE-----
subject=/C=US/ST=California/L=Mountain View/O=Google Inc/CN=www.google.c
issuer=/C=US/O=Google Inc/CN=Google Internet Authority G2
---
No client certificate CA names sent
---
SSL handshake has read 3719 bytes and written 446 bytes
---
New, TLSv1/SSLv3, Cipher is ECDHE-RSA-AES128-GCM-SHA256
Server public key is 2048 bit
Secure Renegotiation IS supported
Compression: NONE
Expansion: NONE
SSL-Session:
    Protocol  : TLSv1.2
    Cipher    : ECDHE-RSA-AES128-GCM-SHA256
    Session-ID: 9D92CEC32FA9F86C6D902081EE186C4FC68234FFF7B903D6621A86C98092BD51
    Session-ID-ctx:
    Master-Key:
B8A14DB1D3021E80B53F30EA94D2EEA155A995B926879B08E3D971EB16873D16F62929899E2FA368D374716DB14A412
B
    Key-Arg   : None
    PSK identity: None
    PSK identity hint: None
    SRP username: None
    TLS session ticket lifetime hint: 100800 (seconds)
    TLS session ticket:
    0000 - fa 8d cb 50 53 3d 99 c8-b4 11 20 0c ca 53 e9 bd   ...PS=.... ..S..
    0010 - f8 8e 15 14 ec 82 c1 56-ab d9 9b 36 c2 56 b0 db   .......V...6.V..
    0020 - 2b d4 07 56 a5 02 ac 1f-34 fa 72 21 fd 7c ba 97   +..V....4.r!.|..
    0030 - 2a ae e9 20 04 ef 8a e5-a0 57 28 3a c7 67 04 ac   *.. .....W(:.g..
    0040 - 7d 14 bf b0 6d 96 9f cb-eb 0c 0a 40 07 5f a6 84   }...m......@._..
    0050 - e2 3b 98 0b e7 f4 b1 e1-04 be 15 6b 36 a5 57 b3   .;.........k6.W.
    0060 - 11 98 f2 f4 20 fe b5 7f-6b 10 4e 7a f9 b5 6d 02   .... ...k.Nz..m.
    0070 - 30 ec 07 e6 f0 c0 49 81-31 6b 30 f9 b0 d3 c4 25   0.....I.1k0....%
    0080 - 62 f3 92 33 e8 25 cc 22-32 84 54 e6 0e 76 b1 45   b..3.%."2.T..v.E
    0090 - 3a 60 83 cf 1b b0 97 7d-05 03 47 20 29 12 d9 8d   :`.....}..G )...
    00a0 - 6f 5a b4 f2                                       oZ..

    Start Time: 1413136351
    Timeout   : 300 (sec)
    Verify return code: 20 (unable to get local issuer certificate)
```



TLS_RSA_WITH_AES_256_CBC_SHA256
Key: RSA Enc: AES_256_CBC Hash: SHA256
TLS_DH_DSS_WITH_3DES_EDE_CBC_SHA
Key ex: DH_DSS Enc: 3DES_EDE_CBC Hash: SHA

Author: Prof Bill Buchanan

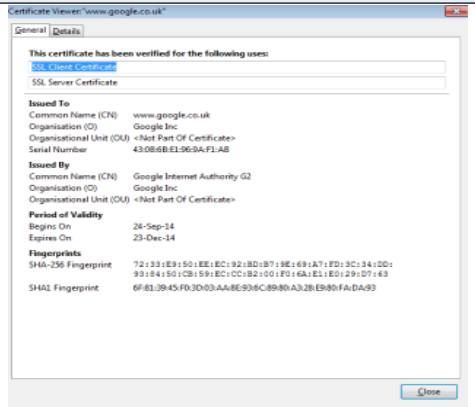


Server Hello:
Version:
TLS_RSA_WITH_RC4_128_SHA

Key Exchange:
Public key (RSA)

Encryption: RC4

Hash: 128-bit
SHA (SHA-1)



Session key

Public key

Private key

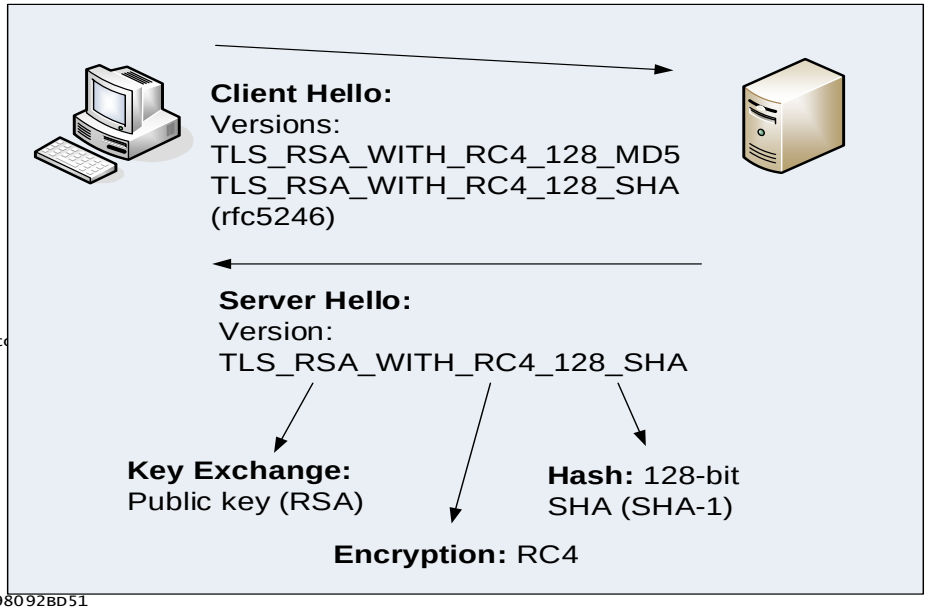
Tunnel created (RC4, Hash: SHA-1)

SSL

Tunnelling

Author: Prof Bill Buchanan

```
billbuchanan@Bills-MacBook-Pro:~$ openssl s_client -connect www.google.com:443
CONNECTED(00000003)
depth=2 C = US, O = GeoTrust Inc., CN = GeoTrust Global CA
verify error:num=20:unable to get local issuer certificate
verify return:0
---
Certificate chain
 0 s:/C=US/ST=California/L=Mountain View/O=Google Inc/CN=www.google.com
   i:/C=US/O=Google Inc/CN=Google Internet Authority G2
 1 s:/C=US/O=Google Inc/CN=Google Internet Authority G2
   i:/C=US/O=GeoTrust Inc./CN=GeoTrust Global CA
 2 s:/C=US/O=GeoTrust Inc./CN=GeoTrust Global CA
   i:/C=US/O=Equifax/OU=Equifax Secure Certificate Authority
---
Server certificate
-----BEGIN CERTIFICATE-----
MIIEdjCCA16gAwIBAgIISVyALWN+akUwDQYJKoZIhvcNAQEFBQAwSTELMAkGA1UE
---
SOx4I5LODOjZYqKfJuImGcFwdIETqOEpCmkhJfGNHjVdzC/h/T61TmaY
-----END CERTIFICATE-----
subject=/C=US/ST=California/L=Mountain View/O=Google Inc/CN=www.google.c
issuer=/C=US/O=Google Inc/CN=Google Internet Authority G2
---
No client certificate CA names sent
---
SSL handshake has read 3719 bytes and written 446 bytes
---
New, TLSv1/SSLv3, Cipher is ECDHE-RSA-AES128-GCM-SHA256
Server public key is 2048 bit
Secure Renegotiation IS supported
Compression: NONE
Expansion: NONE
SSL-Session:
    Protocol  : TLSv1.2
    Cipher    : ECDHE-RSA-AES128-GCM-SHA256
    Session-ID: 9D92CEC32FA9F86C6D902081EE186C4FC68234FFF7B903D6621A86C98092BD51
    Session-ID-ctx:
    Master-Key:
B8A14DB1D3021E80B53F30EA94D2EEA155A995B926879B08E3D971EB16873D16F62929899E2FA368D374716DB14A412
B
    Key-Arg   : None
    PSK identity: None
    PSK identity hint: None
    SRP username: None
    TLS session ticket lifetime hint: 100800 (seconds)
    TLS session ticket:
    0000 - fa 8d cb 50 53 3d 99 c8-b4 11 20 0c ca 53 e9 bd   ...PS=.... ..S..
    0010 - f8 8e 15 14 ec 82 c1 56-ab d9 9b 36 c2 56 b0 db   .......V...6.V..
    0020 - 2b d4 07 56 a5 02 ac 1f-34 fa 72 21 fd 7c ba 97   +..V....4.r!.|..
    0030 - 2a ae e9 20 04 ef 8a e5-a0 57 28 3a c7 67 04 ac   *.. .....W(:.g..
    0040 - 7d 14 bf b0 6d 96 9f cb-eb 0c 0a 40 07 5f a6 84   }...m......@._..
    0050 - e2 3b 98 0b e7 f4 b1 e1-04 be 15 6b 36 a5 57 b3   .;.........k6.W.
    0060 - 11 98 f2 f4 20 fe b5 7f-6b 10 4e 7a f9 b5 6d 02   .... ...k.Nz..m.
    0070 - 30 ec 07 e6 f0 c0 49 81-31 6b 30 f9 b0 d3 c4 25   0.....I.1k0....%
    0080 - 62 f3 92 33 e8 25 cc 22-32 84 54 e6 0e 76 b1 45   b..3.%."2.T..v.E
    0090 - 3a 60 83 cf 1b b0 97 7d-05 03 47 20 29 12 d9 8d   :`.....}..G )...
    00a0 - 6f 5a b4 f2                                       oZ..

    Start Time: 1413136351
    Timeout   : 300 (sec)
    Verify return code: 20 (unable to get local issuer certificate)
```



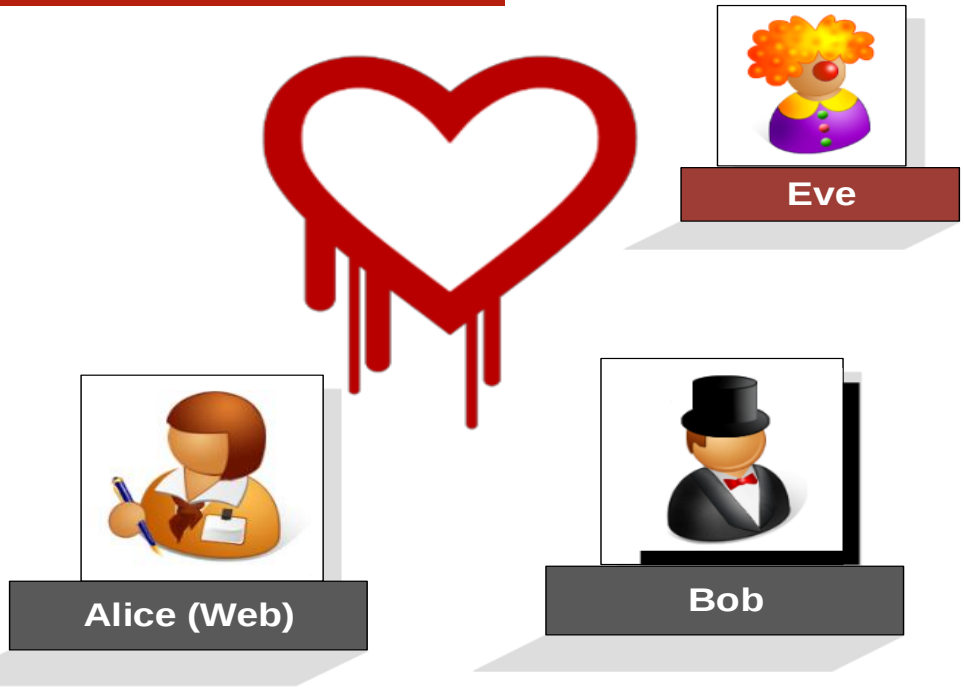
TLS_RSA_WITH_AES_256_CBC_SHA256
Key: RSA Enc: AES_256_CBC Hash: SHA256
TLS_DH_DSS_WITH_3DES_EDE_CBC_SHA
Key ex: DH_DSS Enc: 3DES_EDE_CBC Hash: SHA

Author: Prof Bill Buchanan

Heartbleed … A Short History

Edinburgh Napier UNIVERSITY

- Outline
- OpenSSL
- Heartbeat
- Heartbleed
- Timeline

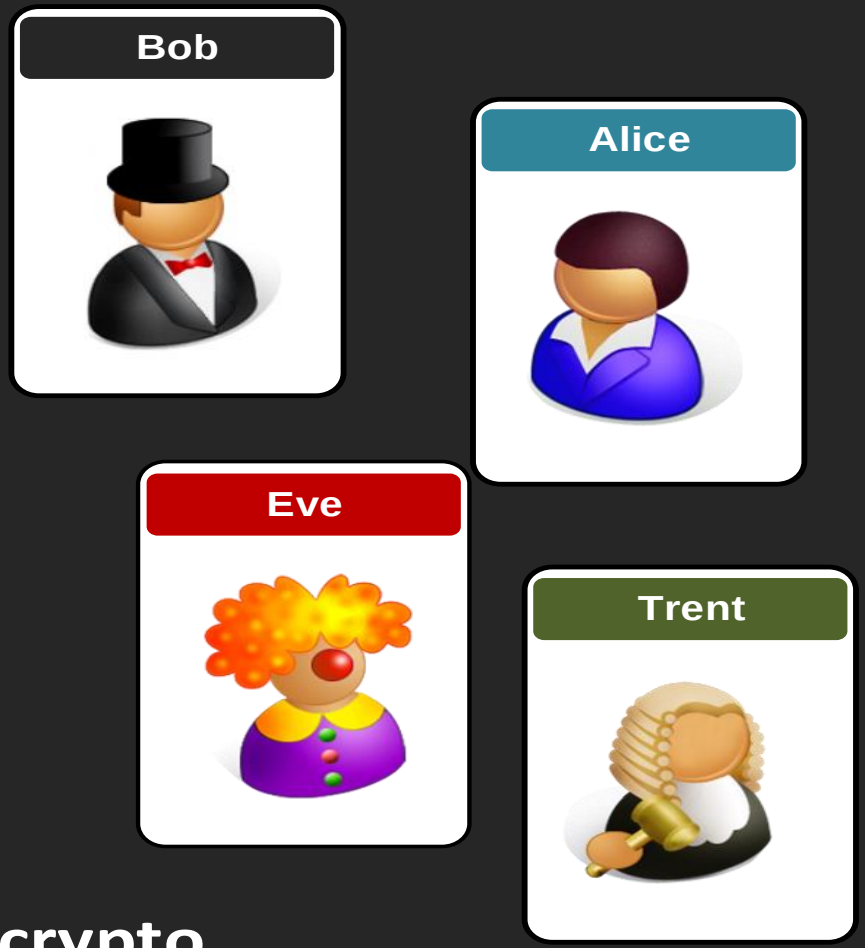


Prof Bill Buchanan
Web: asecuritysite.com, Twitter: billatnapier

Advanced Crypto

6. Tunnelling

Heartbleed



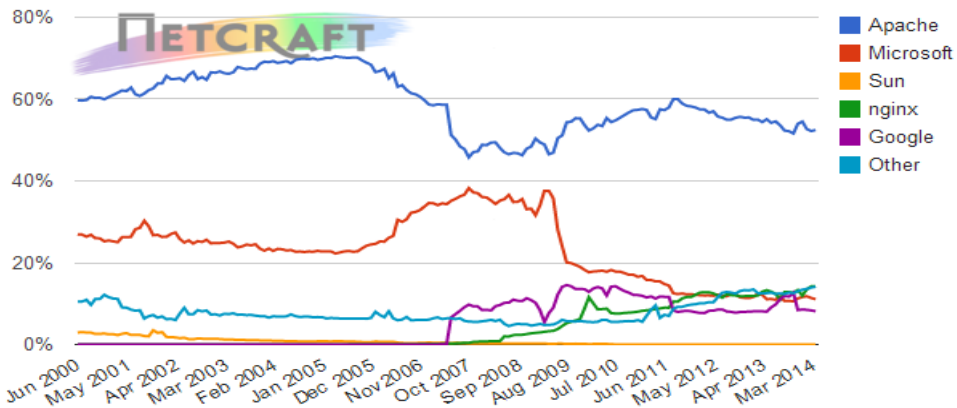
http://asecuritysite.com/crypto

Author: Prof Bill Buchanan

"On the scale of 1 to 10, this is an 11. Half a million sites are vulnerable, including my own."

Has anyone looked at all the low-margin non-upgradable embedded systems that use OpenSSL? An upgrade path that involves the trash, a visit to Best Buy, and a credit card isn't going to be fun for anyone.

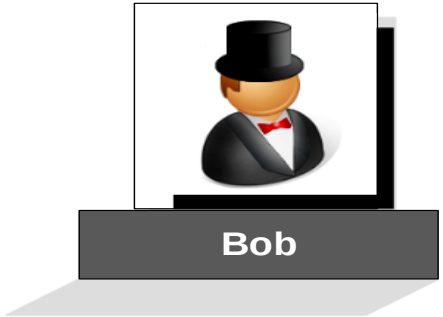
… a 'catastrophic' revelation and suggested it could have been created deliberately to help snoop through firms' data.



I'm hearing that the CAs are completely clogged, trying to reissue so many new certificates. And I'm not sure we have anything close to the infrastructure necessary to revoke half a million certificates.

Author: Prof Bill Buchanan

```
# cat /etc/shadow
root:$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1:15651:0:99999:7:::
# openssl passwd -1 -salt Etg2ExUZ redhat
$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1
```



SSL/TLS

OpenSSL Software Foundation (OSF):

- Steve Marquess (US) and Stephen Henson (UK) + 8 volunteer devs.
- <$1million per year.
- Funded by donations eg United States Department of Homeland Security and the United States Department of Defense.

Eric Young and Tim Hudson

SSLeay (165K)	OpenSSL 0.9.1	OpenSSL 0.9.8	OpenSSL 1.0.0	OpenSSL 1.0.1a (500K)	OpenSSL 1.0.1f	OpenSSL 1.0.1g
Dec 1998	23 Dec 1998	5 July 2005	29 Mar 2010	1 Jan 2012	1 April 2014	7 Apr 2014

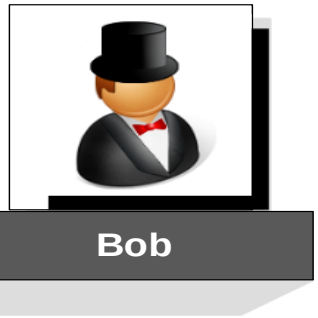
eay (Eric A Young)

14 Mar 2012
Support TLS v1.2 and TLS v1.1.
RFC 6520 TLS/DTLS heartbeat support.

Timeline

```
# cat /etc/shadow
root:$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1:15651:0:99999:7:::
# openssl passwd -1 -salt Etg2ExUZ redhat
$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1
```

SSL/TLS



Stephen Henson

- Only full-time developer.
- UK-based Mathematical.
- 60% of all code.
- 31 Dec 2011, Bug introduced by German developer Robin Seggelmann and okayed.

OpenSSL Software Foundation (OSF):

- Steve Marquess (US) and Stephen Henson (UK) + 8 volunteer devs.
- <$1million per year.
- Funded by donations eg United States Department of Homeland Security and the United States Department of Defense.

Steve Marquess

- “no money going toward reviewing the code or performing audits.“
- $9K since Heartbleed. Where are all the Fortune 1000 companies who use it for free?

OSF

OpenSSL
Cryptography and SSL/TLS Toolkit

```
# cat /etc/shadow
root:$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1:15651:0:99999:7:::
# openssl passwd -1 -salt Etg2ExUZ redhat
$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1
```

```
#else
     /*
      * XXXX just disable all digests for now, because it sucks.
      * we need a better way to decide this - i.e. I may not
      * want digests on slow cards like hifn on fast machines,
      * but might want them on slow or loaded machines, etc.
      * will also want them when using crypto cards that don't
      * suck moose gonads - would be nice to be able to decide something
      * as reasonable default without having hackery that's card dependent.
      * of course, the default should probably be just do everything,
      * with perhaps a sysctl to turn algoritms off (or have them off
      * by default) on cards that generally suck like the hifn.
      */
     *nids = NULL;
     return (0);
#endif
}
```

```
static long ssl_callback_ctrl(BIO *b, int cmd, bio_info_cb *fp)
       {
       SSL *ssl;
       BIO_SSL *bs;
       long ret=1;

       bs=(BIO_SSL *)b->ptr;
       ssl=bs->ssl;
       switch (cmd)
              {
       case BIO_CTRL_SET_CALLBACK:
              {
/* FIXME: setting this via a completely different prototype
                  seems like a crap idea */
              SSL_set_info_callback(ssl,(void (*)(const SSL *,int,int))fp);
              }
              break;
       default:
              ret=BIO_callback_ctrl(ssl->rbio,cmd,fp);
              break;
              }
       return(ret);
       }
```

```
#else
       /* EEK! Experimental code starts */
       if(iterator) return iterator;
       /* Prevent infinite recusrion if we're looking for the dynamic engine. */
       if (strcmp(id, "dynamic"))
              {
#ifdef OPENSSL_SYS_VMS
              if((load_dir = getenv("OPENSSL_ENGINES")) == 0) load_dir = "SSLROOT:[ENGINES]";
#else
              if((load_dir = getenv("OPENSSL_ENGINES")) == 0) load_dir = ENGINESDIR;
#endif
              iterator = ENGINE_by_id("dynamic");
              if(!iterator || !ENGINE_ctrl_cmd_string(iterator, "ID", id, 0) ||
                           !ENGINE_ctrl_cmd_string(iterator, "DIR_LOAD", "2", 0) ||
                           !ENGINE_ctrl_cmd_string(iterator, "DIR_ADD",
                                  load_dir, 0) ||
                           !ENGINE_ctrl_cmd_string(iterator, "LOAD", NULL, 0))
                           goto notfound;
              return iterator;
              }
notfound:
       ENGINE_free(iterator);
       ENGINEerr(ENGINE_F_ENGINE_BY_ID,ENGINE_R_NO_SUCH_ENGINE);
       ERR_add_error_data(2, "id=", id);
       return NULL;
       /* EEK! Experimental code ends */
#endif
       }
```

```
# cat /etc/shadow
root:$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1:15651:0:99999:7:::
# openssl passwd -1 -salt Etg2ExUZ redhat
$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1
```

```
$ openssl version
OpenSSL 1.0.1f 6 Jan 2014

$ openssl dgst -md5  file
MD5(file)= b1946ac92492d2347c6235b4d2611184

$ openssl genrsa -out mykey.pem 1024
Generating RSA private key, 1024 bit long modulus
.....................................................................++++++
...++++++
e is 65537 (0x10001

$ openssl rsa -in mykey.pem -pubout > mykey.pub
writing RSA key

$ cat mykey.pub
-----BEGIN PUBLIC KEY-----
MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQDXv9HSFkpM+ZoOQcpdHBZiUwX8
EzIKm0nsgjc5ZTYVaF9CMLtmKoTzep7aQX9o9nKepFt1kQ73Ta9vOPd6CX61/cgY
Xy2tShw0imrtFaVDFjX+7kLmc0uWbFFCoZMtJxIaXaa9SV2kARxOCTJ2uOjRTCCe
XUO9IJGHnIhSNJeIJQIDAQAB
-----END PUBLIC KEY-----

$ cat /etc/shadow
root:$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1:15651:0:99999:7:::

$ openssl passwd -1 -salt Etg2ExUZ redhat
$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1
```

Heartbleed … A Short History

Edinburgh Napier UNIVERSITY

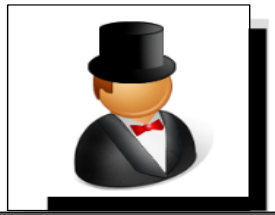
Eve

Heartbeat

Heartbleed

Timeline

Alice (Web)



Bob

Prof Bill Buchanan
Web: asecuritysite.com, Twitter: billatnapier

OpenSSL
Cryptography and SSL/TLS Toolkit

```
# cat /etc/shadow
root:$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1:15651:0:99999:7:::
# openssl passwd -1 -salt Etg2ExUZ redhat
$1$Etg2ExUZ$F9NTP7omafhKIlqaBMqng1
```

Internet Engineering Task Force (IETF)
Request for Comments: 6520
Category: Standards Track
ISSN: 2070-1721

R. Seggelmann
M. Tuexen
Muenster Univ. of Appl. Sciences
M. Williams
GWhiz Arts & Sciences
February 2012

Transport Layer Security (TLS) and
Datagram Transport Layer Security (DTLS) Heartbeat Extension

Abstract

This document describes the Heartbeat Extension for the Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS) protocols.

The Heartbeat Extension provides a new protocol for TLS/DTLS allowing the usage of keep-alive functionality without performing a renegotiation and a basis for path MTU (PMTU) discovery for DTLS.

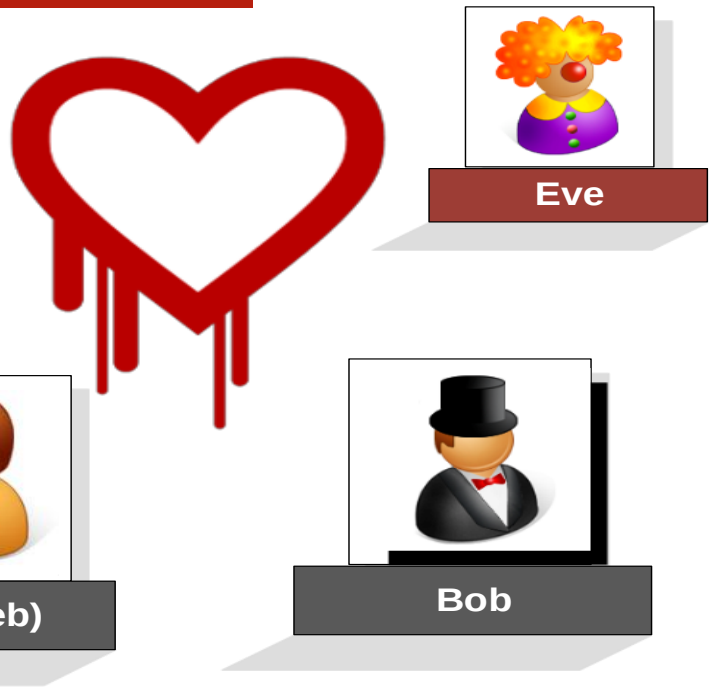
```
struct {
   HeartbeatMessageType type;
   uint16 payload_length;
   opaque payload[HeartbeatMessage.payload_length];
   opaque padding[padding_length];
} HeartbeatMessage;
```

64KB max

payload: The payload consists of arbitrary content.

Heartbleed … A Short History

Edinburgh Napier UNIVERSITY

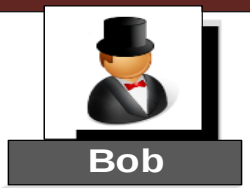


Heartbleed

Timeline

Prof Bill Buchanan
Web: asecuritysite.com, Twitter: billatnapier

```
        /* Read type and payload length first */
        hbtype = *p++;
        n2s(p, payload);
        pl = p;

        if (s->msg_callback)
                s->msg_callback(0, s->version, TLS1_RT_HEARTBEAT,
                        &s->s3->rrec.data[0], s->s3->rrec.length,
                        s, s->msg_callback_arg);

        if (hbtype == TLS1_HB_REQUEST)
                {
                unsigned char *buffer, *bp;
                int r;

                /* Allocate memory for the response, size is 1 bytes
                 * message type, plus 2 bytes payload length, plus
                 * payload, plus padding
                 */
                buffer = OPENSSL_malloc(1 + 2 + payload + padding);
                bp = buffer;

                /* Enter response type, length and copy payload */
                *bp++ = TLS1_HB_RESPONSE;
                s2n(payload, bp);
                memcpy(bp, pl, payload);

                r = ssl3_write_bytes(s, TLS1_RT_HEARTBEAT, buffer, 3
+ payload + padding);

+       /* Read type and payload length first */
+       if (1 + 2 + 16 > s->s3->rrec.length)
+           return 0; /* silently discard */
+       hbtype = *p++;
+       n2s(p, payload);
+       if (1 + 2 + payload + 16 > s->s3->rrec.length)
+           return 0; /* silently discard per RFC 6520 sec. 4 */
+       pl = p;
```



Bob

Never Trust User Input!!!!

Allocate an area of memory based on payload size defined by request

My Payload is 64K

Payload (8 bytes)

Copy payload into memory

Payload (8 bytes)

64KB Memory

Payload (8 bytes)

64KB Memory

Data leakage

Alice (Web)

Author: Prof Bill Buchanan

Heartbleed Request

heart.pcap [Wireshark 1.10.7 (v1.10.7-0-g6b931a1 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: tcp matches "\x18\x03" Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
38	24.35351	172.16.121.1	172.16.121.150	TLSv1.	74	Heartbeat Request
39	24.35400	172.16.121.150	172.16.121.1	TCP	1514	[TCP segment of a reassembled PDU]

```
⊞ Frame 38: 74 bytes on wire (592 bits), 74 bytes captured (592 bits)
⊞ Ethernet II, Src: Vmware_c0:00:08 (00:50:56:c0:00:08), Dst: Vmware_15:f3:e9 (00:0c:29:15:f3:e9)
⊞ Internet Protocol Version 4, Src: 172.16.121.1 (172.16.121.1), Dst: 172.16.121.150 (172.16.121.150)
⊞ Transmission Control Protocol, Src Port: 64667 (64667), Dst Port: https (443), Seq: 226, Ack: 1126, Len: 8
⊟ Secure Sockets Layer
  ⊟ TLSv1.1 Record Layer: Heartbeat Request
      Content Type: Heartbeat (24)
      Version: TLS 1.1 (0x0302)
      Length: 3
    ⊟ Heartbeat Message
        Type: Request (1)
        Payload Length: 16384
⊞ [Malformed Packet: SSL]
```

```
0000  00 0c 29 15 f3 e9 00 50  56 c0 00 08 08 00 45 00   ..)....P V.....E.
0010  00 3c 58 eb 40 00 40 06  97 18 ac 10 79 01 ac 10   .<X.@.@. ....y...
0020  79 96 fc 9b 01 bb ee e0  a5 10 d2 3b 4b d2 80 18   y....... ...;K...
0030  20 00 3c fa 00 00 01 01  08 0a 2a 72 9e b8 00 24    .<..... ..*r...$
0040  f8 50 18 03 02 00 03 01  40 00                     .P...... @.
```

Payload Length (ssl.heartbeat_message.payl... | Packets: 60 · Displayed: 2 (3.3%) · Load ti... | Profile: Default

No payload

My Payload is 64K

18	03 02	00 03	1	40 00
Heartbeat	TLS 1.1	Length	Request	Payload length

Little Endian: 0x4000 -> 16,384

Author: Prof Bill Buchanan

Heartbleed Reply

heart.pcap [Wireshark 1.10.7 (v1.10.7-0-g6b931a1 from master-1.10)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: tcp matches "\x18\x03" Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
38	24.35351	172.16.121.1	172.16.121.150	TLSv1.	74	Heartbeat Request
39	24.35400	172.16.121.150	172.16.121.1	TCP	1514	[TCP segment of a reassembled PDU]

```
⊞ Frame 39: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits)
⊞ Ethernet II, Src: Vmware_15:f3:e9 (00:0c:29:15:f3:e9), Dst: Vmware_c0:00:08 (00:50:56:c0:00:08)
⊞ Internet Protocol Version 4, Src: 172.16.121.150 (172.16.121.150), Dst: 172.16.121.1 (172.16.121.1)
⊟ Transmission Control Protocol, Src Port: https (443), Dst Port: 64667 (64667), Seq: 1126, Ack: 234, Len: 1448
    Source port: https (443)
    Destination port: 64667 (64667)
    [Stream index: 2]
    Sequence number: 1126    (relative sequence number)
    [Next sequence number: 2574    (relative sequence number)]
    Acknowledgment number: 234    (relative ack number)
    Header length: 32 bytes
  ⊞ Flags: 0x010 (ACK)
    Window size value: 235
    [Calculated window size: 30080]
    [Window size scaling factor: 128]
```

443 – Should be encrypted

```
0120  00 01 01 2d 4c 61 6e 67  75 61 67 65 3a 20 65 6e   ...-Lang uage: en
0130  2d 55 53 2c 65 6e 3b 71  3d 30 2e 35 0d 0a 41 63   -US,en;q =0.5..Ac
0140  63 65 70 74 2d 45 6e 63  6f 64 69 6e 67 3a 20 67   cept-Enc oding: g
0150  7a 69 70 2c 20 64 65 66  6c 61 74 65 0d 0a 43 6f   zip, def late..Co
0160  6e 6e 65 63 74 69 6f 6e  3a 20 6b 65 65 70 2d 61   nnection : keep-a
0170  6c 69 76 65 0d 0a 49 66  2d 4d 6f 64 69 66 69 65   live..If -Modifie
0180  64 2d 53 69 6e 63 65 3a  20 54 75 65 2c 20 31 35   d-Since:  Tue, 15
0190  20 41 70 72 20 32 30 31  34 20 31 39 3a 32 34 3a    Apr 201 4 19:24:
01a0  34 38 20 47 4d 54 0d 0a  49 66 2d 4e 6f 6e 65 2d   48 GMT.. If-None-
01b0  4d 61 74 63 68 3a 20 22  62 31 2d 34 66 37 31 39   Match: " b1-4f719
```

Memory copy from server – Non-encrypted!

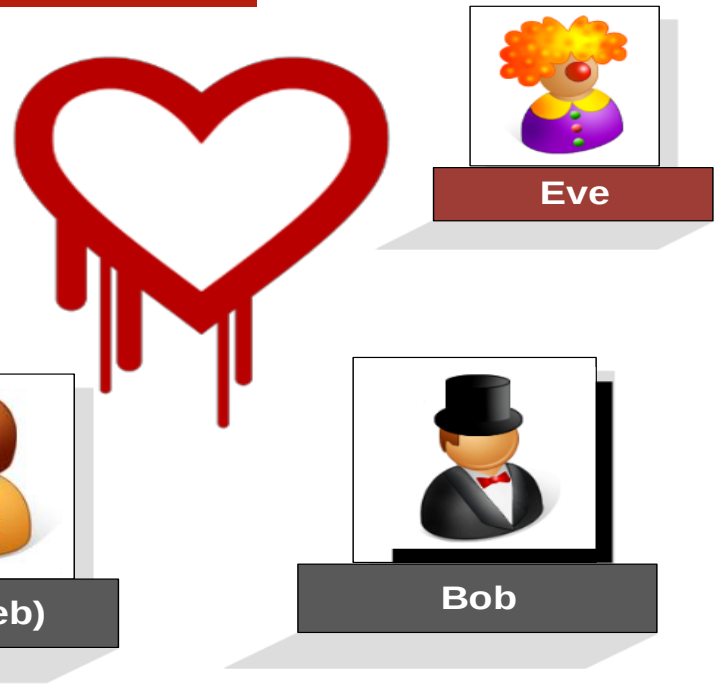
File: "C:\Users\BILLBU~1\AppData\Local\Te... Packets: 60 · Displayed: 2 (3.3%) · Load ti... Profile: Default

Author: Prof Bill Buchanan

Live Demo …
perhaps?

Heartbleed … A Short History

Edinburgh Napier UNIVERSITY



Timeline

Prof Bill Buchanan
Web: asecuritysite.com, Twitter: billatnapier

Day Zero Minus 7 (1 April) | **Day Zero (7 April)** | **Day Zero +1 (8 April)** | **Day Zero +2 (9 April)**

New Year's Eve 2011. Robin Seggelmann commits Heartbeat code.

Robin Seggelmann

Stephen Henson

1 April 2014. Google inform OpenSSL about vulnerability found by Neel Mehta.

Google

Finnish security company Codenomicon dub it "Heartbleed."

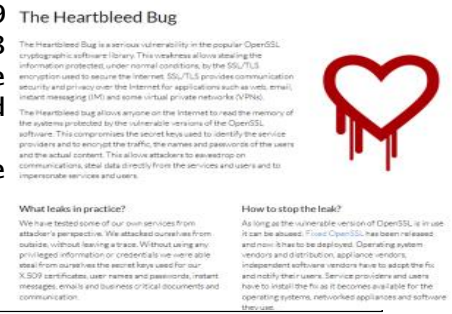
CODENOMICON

April 8, half of which had no SSL encryption at all. Of those that did, 15% were exposed to the vulnerability.


```
Re: heartbleed OpenSSL bug CVE-2014-0160
From: Andrew Case <atcuno () gmail com>
Date: Mon, 07 Apr 2014 19:35:47 -0500
its 64KB per request so you can read much more than that
through
multiple requests
Thanks,
Andrew (@attrc)
On 4/7/2014 7:10 PM, Kirils Solovjovs wrote:
We are doomed.
Description: http://www.openssl.org/news/vulnerabilities.html
Article dedicated to the bug: http://heartbleed.com/
Tool to check if TLS heartbeat extension is supported:

http://possible.lv/tools/hb/

A missing bounds check in the handling of the TLS heartbeat
extension
can be used to reveal up to 64kB of memory to a connected
client or server.
1.0.1[ abcdef] affected.
P.S. Happy Monday!
```

```
IP Addresses are: [54.230.19.147]
[54.240.160.39] [54.240.160.40] [54.230.17.45]
[54.230.17.192] [54.230.17.201] [54.230.18.79]
[54.230.19.102]
Domain Name: HEARTBLEED.COM
Registrar: GODADDY.COM, LLC
Whois Server: whois.godaddy.com
Referral URL: http://registrar.godaddy.com
Name Server: NS-1338.AWSDNS-39.ORG
Name Server: NS-1621.AWSDNS-10.CO.UK
Name Server: NS-473.AWSDNS-59
Name Server: NS-697.AWSDNS-23
Status: clientDeleteProhibite
Status: clientRenewProhibited
Status: clientTransferProhibi
Status: clientUpdateProhibite
Updated Date: 07-apr-2014
Creation Date: 05-apr-2014
Expiration Date: 05-apr-2015
```

CODENOMICON


The Heartbleed Bug

The Heartbleed Bug is a serious vulnerability in the popular OpenSSL cryptographic software library. This weakness allows stealing the information protected, under normal conditions, by the SSL/TLS encryption used to secure the Internet. SSL/TLS provides communication security and privacy over the Internet for applications such as web, email, instant messaging (IM) and some virtual private networks (VPNs).

The Heartbleed bug allows anyone on the Internet to read the memory of the systems protected by the vulnerable versions of the OpenSSL software. This compromises the secret keys used to identify the service providers and to encrypt the traffic, the names and passwords of the users and the actual content. This allows attackers to eavesdrop on communications, steal data directly from the services and users and to impersonate services and users.

What leaks in practice?

We have tested some of our own services from attacker's perspective. We attacked ourselves from outside, without leaving a trace. Without using any privileged information or credentials we were able steal from ourselves the secret keys used for our X.509 certificates, user names and passwords, instant messages, emails and business critical documents and communication.

How to stop the leak?

As long as the vulnerable version of OpenSSL is in use it can be abused. Fixed OpenSSL has been released and now it has to be deployed. Operating system vendors and distribution, appliance vendors, independent software vendors have to adopt the fix and notify their users. Service providers and users have to install the fix as it becomes available for the operating systems, networked appliances and software they use.

21 March. Neel Mehta discovers

Google

21 March (10:23). Google patches

31 March. CloudFare Patch. “Friend says it’s messy!”

CLOUDFLARE

1 April. Google inform OpenSSL team

OpenSSL

1 April (4pm). OpenSSL distributed to rest of the team.

2 April (9:30) Codenomicon discover bug

3 April Codenomicon tell National Cyber Security Centre Finland (NCSC-FI)

CODENOMICON

Akamai

Finnish Communications Regulatory Authority
National Cyber Security Centre

6 April. National Cyber Security Centre Finland asks CERT for CVE number: “on a critical OpenSSL issue”

5 April. Codenomicon register Heartbleed.com

4 April. Rumours abound in Open Source Community

4 April. Akami.com patch servers.

5 April. Codenomicon register Heartbleed.com

Present

The Heartbleed Bug

The Heartbleed Bug is a serious vulnerability in the popular OpenSSL cryptographic software library. This weakness allows stealing the information protected, under normal conditions, by the SSL/TLS encryption used to secure the Internet. SSL/TLS provides communication security and privacy over the Internet for applications such as web, email, instant messaging (IM) and some virtual private networks (VPNs).

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be_emo_ava1.jpg be_emo_ava2.jpg be_emo_ava3.jpg

All brushes used were downloaded from www.bittbox.com

Filed under: Avatars, wallpapers | 21 Comments

The red bubble

11Mar07

This update brings you the wallpaper just right for you. I also made 2 avatars t
You can download your version in the wallpaper section.

ava20.jpg ava18.jpg

Filed under: Avatars, wallpapers | 28 Comments

Heartbleed.com (2005)

CODENOMICON

The Heartbleed Bug

op the leak?

he vulnerable version of OpenSSL is in use
used. Fixed OpenSSL has been released
as to be deployed. Operating system
l distribution, appliance vendors,
it software vendors have to adopt the fix
heir users. Service providers and users
all the fix as it becomes available for the
ystems, networked appliances and software

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8pm, 7 April 2014

6 April. Mark Cox (OpenSSL and Red Hat) notifies Red Hat and private bug fix added.

7 April (before this date). Facebook “Informed through a friend.” and patch systems.

7 April. The National Cyber Security Centre Finland reports bug to OpenSSL core team members Ben Laurie (who works for Google) and Mark Cox (Red Hat) via encrypted email.

7 April (10:30) OpenSSL fix bug and posts bug.

CLOUDFLARE.

11am: CloudFlare publish details

Google

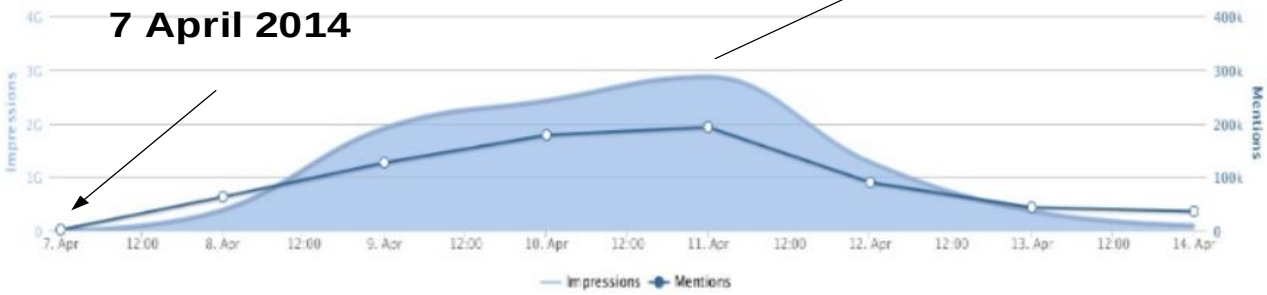
12:35: Neel tweets details

CODENOMICON

13:13: Codenomicon tweet details

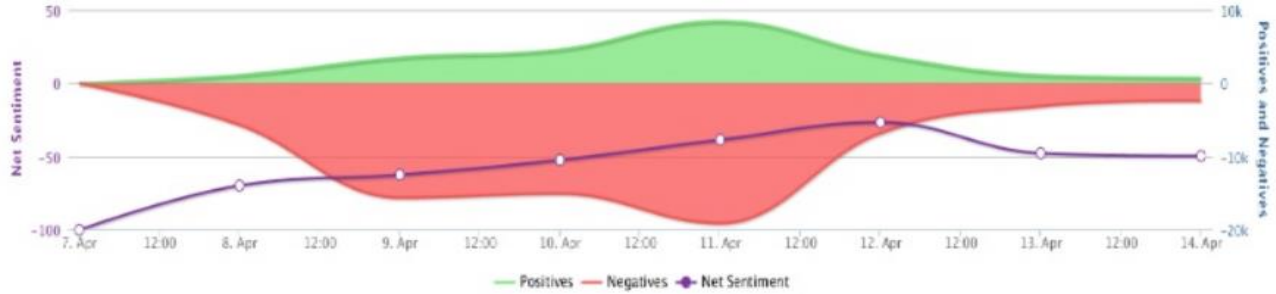
Mentions And Reach

Mentions, which refers to the number of times "Heartbleed" appeared on a website or social media post, peaked on April 11, four days after the news broke.



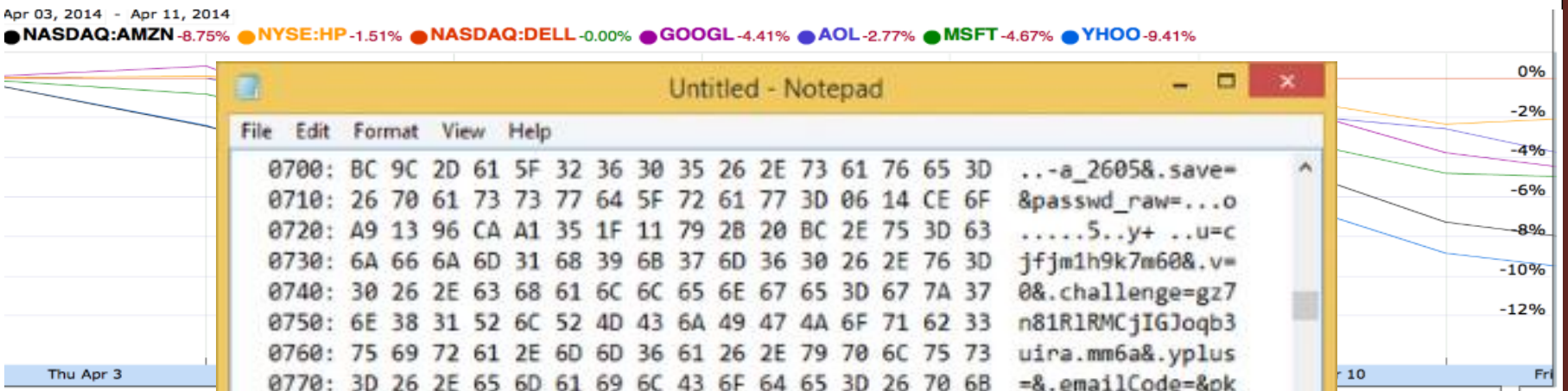
Sentiment

Despite the ebb and flow of conversation volume, sentiments of relevant dialogue continued to be extremely negative.



Source: NetBase Aggregated Social Listening Data, April 7 to April 14, 2014 (Global)

Author: Prof Bill Buchanan



Untitled - Notepad

File Edit Format View Help

```
0700: BC 9C 2D 61 5F 32 36 30 35 26 2E 73 61 76 65 3D  ..-a_2605&.save=
0710: 26 70 61 73 73 77 64 5F 72 61 77 3D 06 14 CE 6F  &passwd_raw=...o
0720: A9 13 96 CA A1 35 1F 11 79 2B 20 BC 2E 75 3D 63  .....5..y+ ..u=c
0730: 6A 66 6A 6D 31 68 39 6B 37 6D 36 30 26 2E 76 3D  jfjm1h9k7m60&.v=
0740: 30 26 2E 63 68 61 6C 6C 65 6E 67 65 3D 67 7A 37  0&.challenge=gz7
0750: 6E 38 31 52 6C 52 4D 43 6A 49 47 4A 6F 71 62 33  n81RlRMCjIGJoqb3
0760: 75 69 72 61 2E 6D 6D 36 61 26 2E 79 70 6C 75 73  uira.mm6a&.yplus
0770: 3D 26 2E 65 6D 61 69 6C 43 6F 64 65 3D 26 70 6B  =&.emailCode=&pk
0780: 67 3D 26 73 74 65 70 69 64 3D 26 2E 65 76 3D 26  g=&stepid=&.ev=&
0790: 68 61 73 4D 73 67 72 3D 30 26 2E 63 68 6B 50 3D  hasMsgr=0&.chkP=
07a0: 59 26 2E 64 6F 6E 65 3D 68 74 74 70 25 33 41 25  Y&.done=http%3A%
07b0: 32 46 25 32 46 6D 61 69 6C 2E 79 61 68 6F 6F 2E  2F%2Fmail.yahoo.
07c0: 63 6F 6D 26 2E 70 64 3D 79 6D 5F 76 65 72 25 33  com&.pd=ym_ver%3
07d0: 44 30 25 32 36 63 25 33 44 25 32 36 69 76 74 25  D0%26c%3D%26ivt%
07e0: 33 44 25 32 36 73 67 25 33 44 26 2E 77 73 3D 31  3D%26sg%3D&.ws=1
07f0: 26 2E 63 70 3D 30 26 6E 72 3D 30 26 70 61 64 3D  &.cp=0&nr=0&pad=
0800: 36 26 61 61 64 3D 36 26 6C 6F 67 69 6E 3D 61 67  6&aad=6&login=ag
0810: 6E 65 73 61 64 75 62 6F 61 74 65 6E 67 25 34 30  nesaduboateng%40
0820: 79 61 68 6F 6F 2E 63 6F 6D 26 70 61 73 73 77 64  yahoo.com&passwd
0830: 3D 30 32 34                                      =024          &.pe
```

Majo
compa
informed

Users are being encouraged to change their passwords on sites that have tackled the bug

Several tech firms are urging people to change all their passwords after the discovery of a major security flaw.

Related Stories

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Stallholder's son

Agnes Adu Boateng

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0277-442491		hayford.king@gmail.com
0244-624648		adoboemensah@yahoo.co.uk
0302-256224/5		aak@ghana.com
0248418422		agnesaduboateng@yahoo.com
277495932		safarihost@yahoo.com
020812525		kbadusei@hotmail.com/kbadusei@gmail.com
0244174956	0208120068	ralak58@yahoo.com

agnesaduboateng@yahoo.com

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File Edit Format View Help

```
0700: BC 9C 2D 61 5F 32 36 30 35 26 2E 73 61 76 65 3D  ..-a_2605&.save=
0710: 26 70 61 73 73 77 64 5F 72 61 77 3D 06 14 CE 6F  &passwd_raw=...o
0720: A9 13 96 CA A1 35 1F 11 79 2B 20 BC 2E 75 3D 63  .....5..y+ ..u=c
0730: 6A 66 6A 6D 31 68 39 6B 37 6D 36 30 26 2E 76 3D  jfjm1h9k7m60&.v=
0740: 30 26 2E 63 68 61 6C 6C 65 6E 67 65 3D 67 7A 37  0&.challenge=gz7
0750: 6E 38 31 52 6C 52 4D 43 6A 49 47 4A 6F 71 62 33  n81RlRMCjIGJoqb3
0760: 75 69 72 61 2E 6D 6D 36 61 26 2E 79 70 6C 75 73  uira.mm6a&.yplus
0770: 3D 26 2E 65 6D 61 69 6C 43 6F 64 65 3D 26 70 6B  =&.emailCode=&pk
0780: 67 3D 26 73 74 65 70 69 64 3D 26 2E 65 76 3D 26  g=&stepid=&.ev=&
0790: 68 61 73 4D 73 67 72 3D 30 26 2E 63 68 6B 50 3D  hasMsgr=0&.chkP=
07a0: 59 26 2E 64 6F 6E 65 3D 68 74 74 70 25 33 41 25  Y&.done=http%3A%
07b0: 32 46 25 32 46 6D 61 69 6C 2E 79 61 68 6F 6F 2E  2F%2Fmail.yahoo.
07c0: 63 6F 6D 26 2E 70 64 3D 79 6D 5F 76 65 72 25 33  com&.pd=ym_ver%3
07d0: 44 30 25 32 36 63 25 33 44 25 32 36 69 76 74 25  D0%26c%3D%26ivt%
07e0: 33 44 25 32 36 73 67 25 33 44 26 2E 77 73 3D 31  3D%26sg%3D&.ws=1
07f0: 26 2E 63 70 3D 30 26 6E 72 3D 30 26 70 61 64 3D  &.cp=0&nr=0&pad=
0800: 36 26 61 61 64 3D 36 26 6C 6F 67 69 6E 3D 61 67  6&aad=6&login=ag
0810: 6E 65 73 61 64 75 62 6F 61 74 65 6E 67 25 34 30  nesaduboateng%40
0820: 79 61 68 6F 6F 2E 63 6F 6D 26 70 61 73 73 77 64  yahoo.com&passwd
0830: 3D 30 32 34                                      =024          &.pe
```

bi

Chartered Institute of Taxation (Ghana)

(ESTABLISHED IN 1980)

THE PROFESSIONAL BODY FOR TAX PROFESSIONALS

http://www.taxghana.org

List of Members in Good Standing at 2013

bible@gospelhall.org

How much do you need for open source?

Apache Software Foundation ($905,732- 2013)	Linux Foundation ($6.25 million - 2014)	Mozilla Foundation ($311 million - 2012)

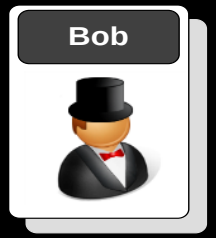
OpenSSL? Marquess … “A few million a year would do grandly. There should be half a dozen guys working full-time, plus support.”

24 April 2104

Linux Foundation defines Core Infrastructure Initiative, - multimillion-dollar project funding critical path - $3.9 million for three years, … Top of List … OpenSSL.

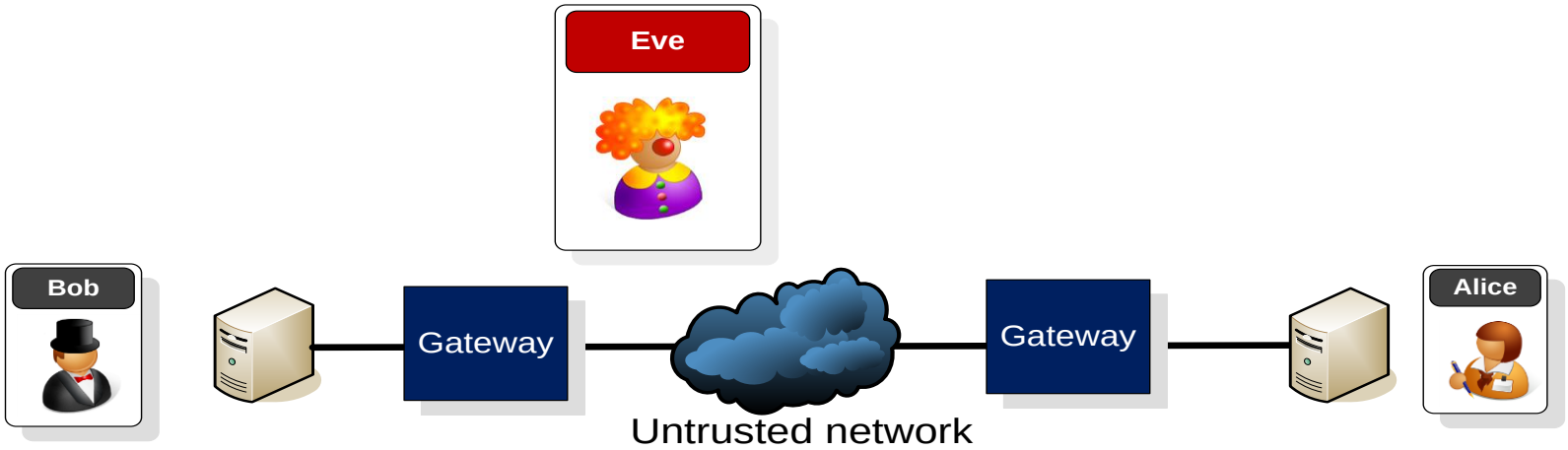
Author: Prof Bill Buchanan

Network Security



VPNs

Author: Prof Bill Buchanan



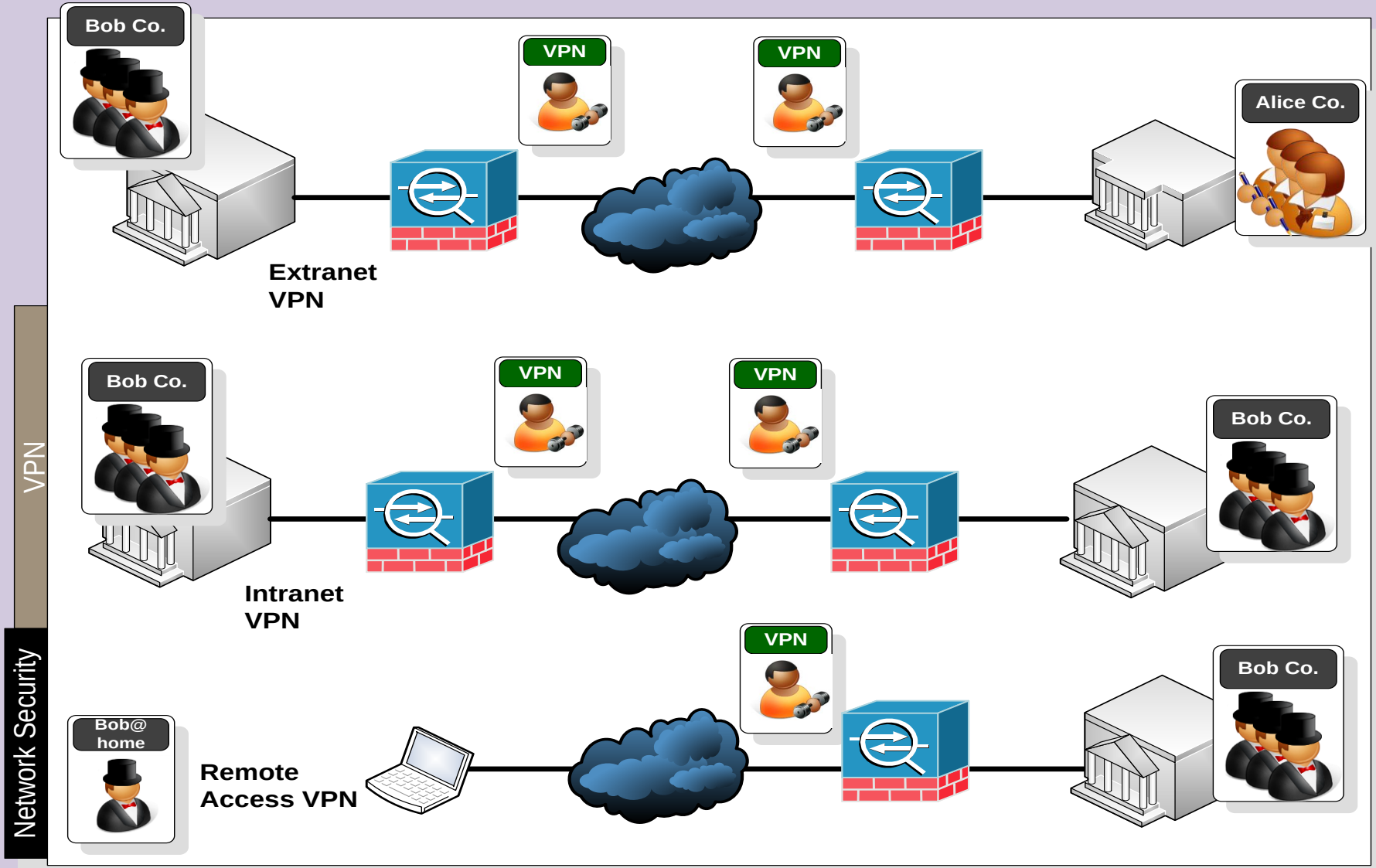
What is required is:

- Encryption.
- Authentication of devices (to overcome spoofing)
- Authentication of packets (for integrity)

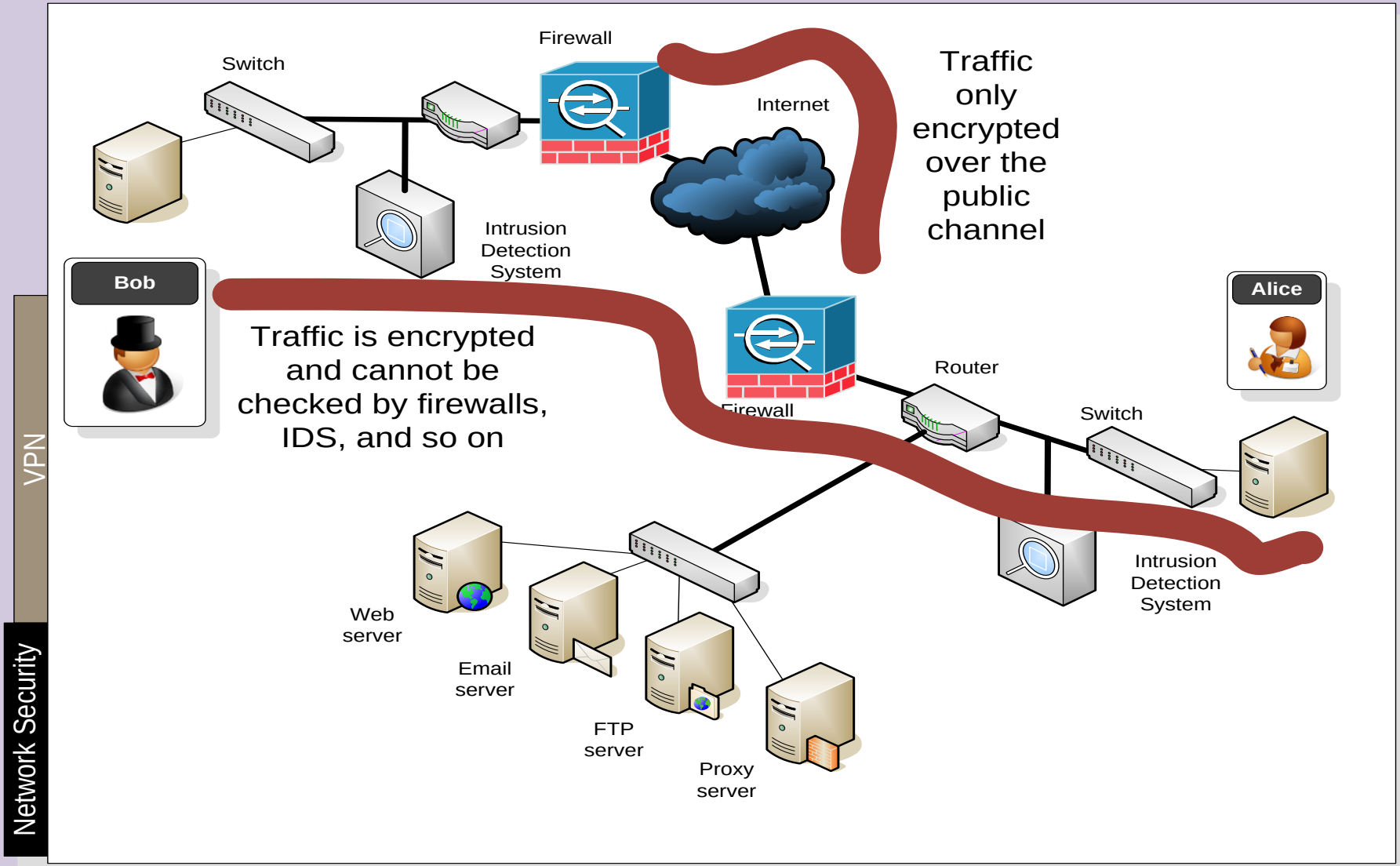
PPTP (Point-to-point Tunneling Protocol). Created by Microsoft and is routable. It uses MPPE (Microsoft Point-to-point Encryption) and user authentication.

L2TP (Layer 2 Tunneling Protocol). Works at Layer 2 to Forward IP, IPX and AppleTalk (RFC2661). Cisco, Microsoft, Ascent and 3Com developed it. User and machine authentication, but no encryption (but can be used with L2TP over IPSec).

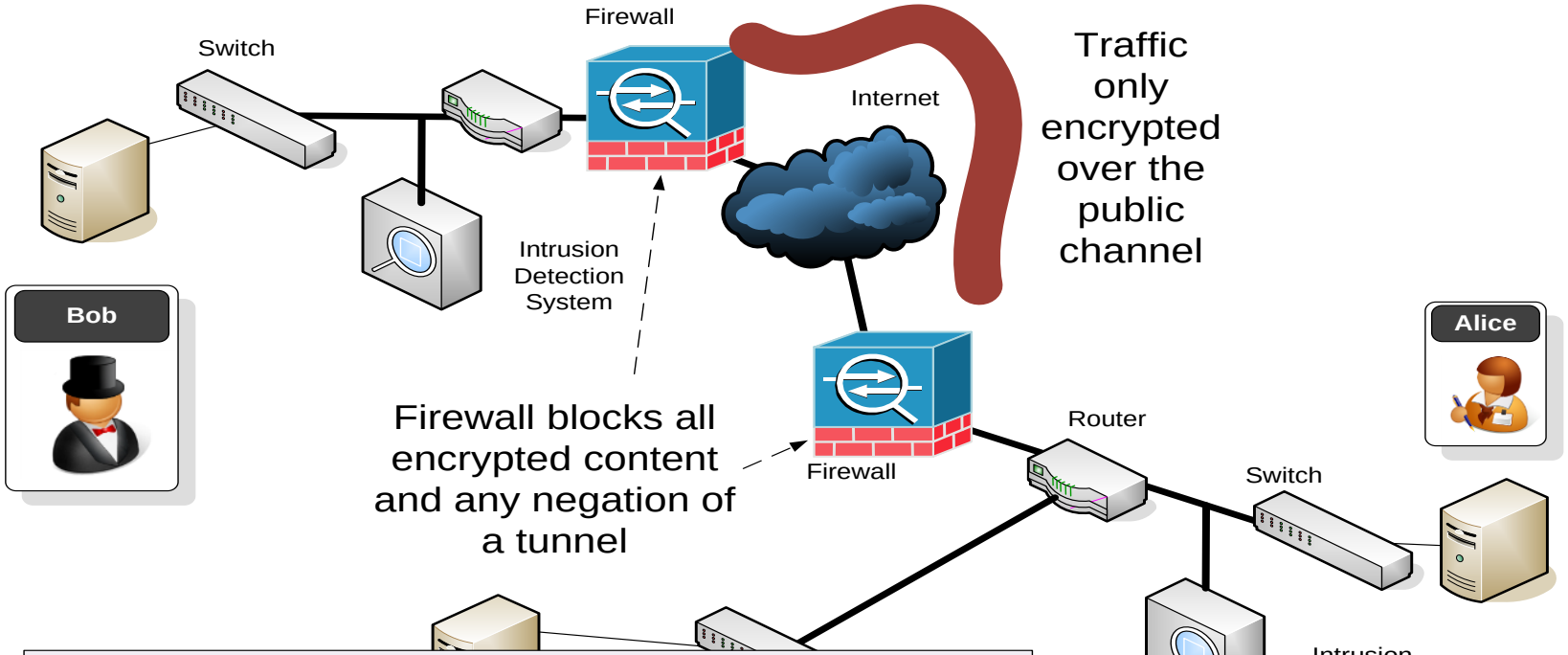
IPSec. An open standard. Includes both encryption and Authentication.


Bob Co.
VPN
VPN
Alice Co.
Extranet
VPN
Bob Co.
VPN
VPN
Bob Co.
Intranet
VPN
VPN
Bob Co.
Bob@
home
Remote
Access VPN
VPN
Network Security

VPN types



Tunnelling mode or transport mode

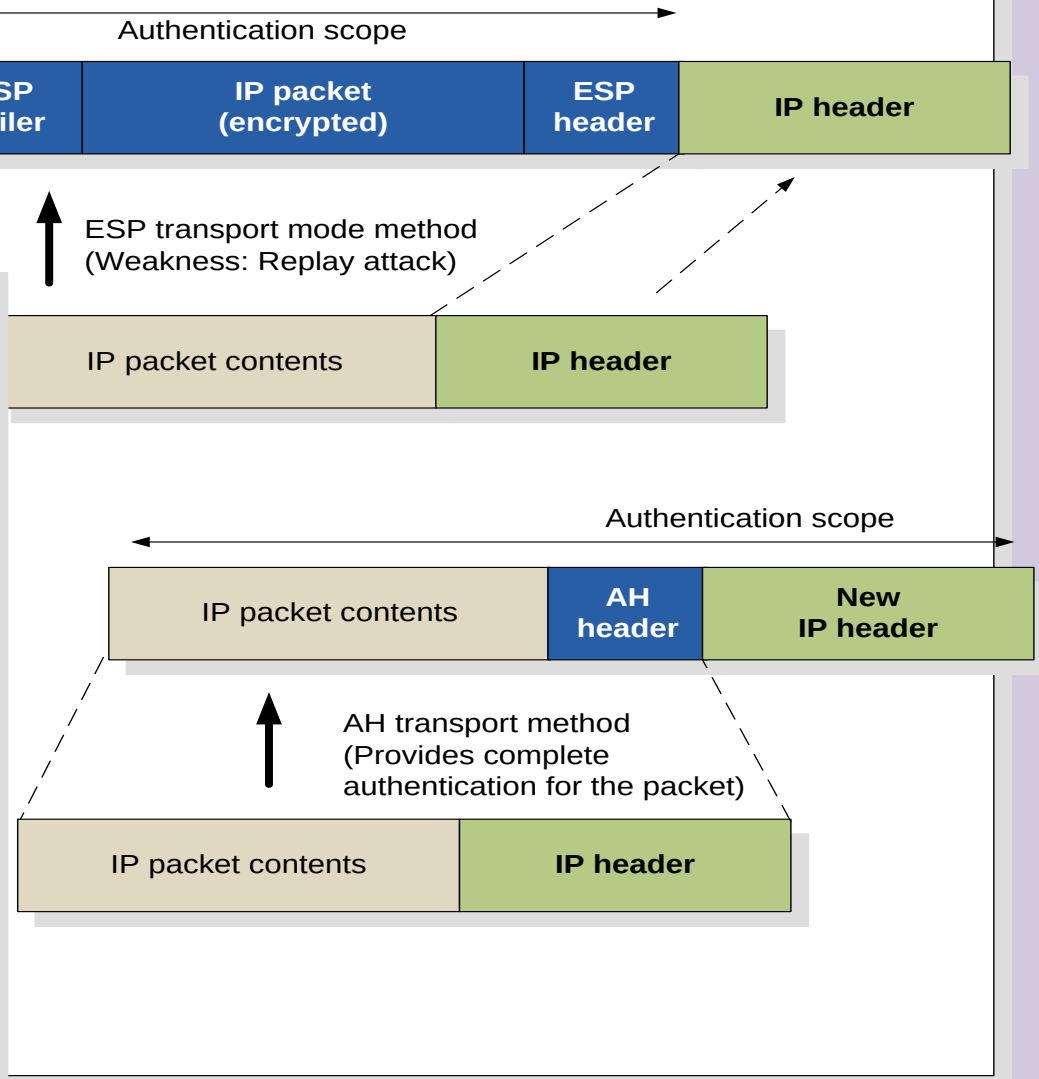


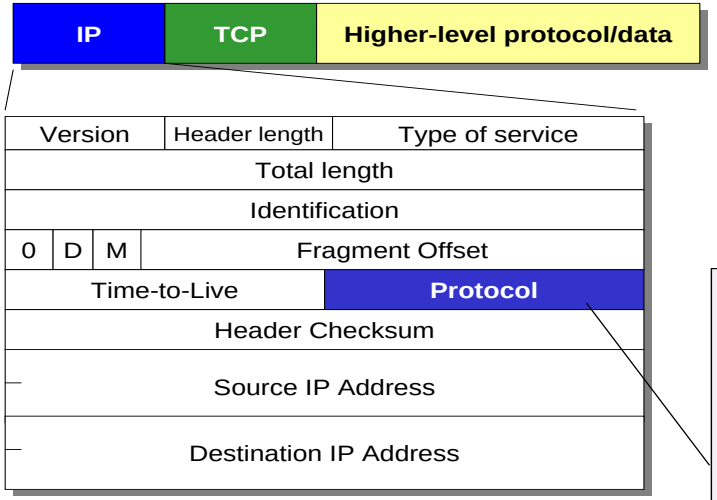
For IPSec (one of the most popular tunnelling methods):

- UDP Port 500 is the key exchange port. If it is blocked there can be no tunnel.
- TCP Port 50 for IPSec ESP (Encapsulated Security Protocol).
- TCP Port 51 for IPSec AH (Authentication Header)

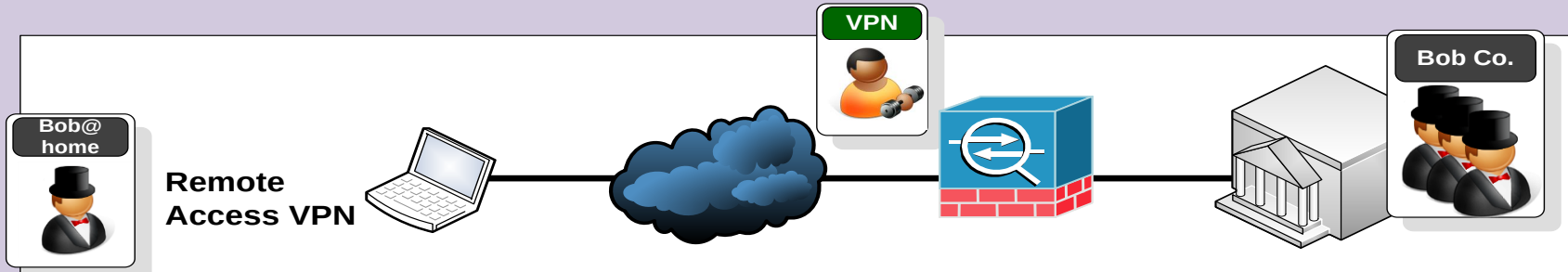
The IPSec protocol has:

- **ESP (Encapsulated Security Protocol)**. ESP takes the original data packet, and breaks off the IP header. The rest of the packet is encrypted, with the original header added at the start, along with a new ESP field at the start, and one at the end. It is important that the IP header is not encrypted as the data packet must still be read by routers as it travels over the Internet. Only the host at the other end of the IPSec tunnel can decrypt the contents of the IPSec data packet.
- **AH (Authentication Header)**. This encrypts the complete contents of the IP data packet, and adds a new packet header. ESP has the weakness that an intruder can replay previously sent data, whereas AH provides a mechanism of sequence numbers to reduce this problem.





1 ICMP Internet Control Message [RFC792]
6 TCP Transmission Control [RFC793]
8 EGP Exterior Gateway Protocol [RFC888]
9 IGP any private interior gateway [IANA]
47 GRE General Routing Encapsulation (PPTP)
50 ESP Encap Security Payload [RFC2406]
51 AH Authentication Header [RFC2402]
55 MOBILE IP Mobility
88 EIGRP EIGRP [CISCO]
89 OSPFIGP OSPFIGP [RFC1583]
115 L2TP Layer Two Tunneling Protocol



Phase 1 (IKE – Internet Key Exchange)

UDP port 500 is used for IKE

Define the policies between the peers

IKE Policies

- Hashing algorithm (SHA/MD5)
- Encryption (DES/3DES)
- Diffie-Hellman agreements
- Authentication (pre-share, RSA nonces, RSA sig).

```
isakmp enable outside
isakmp key ABC&FDD address 176.16.0.2 netmask
255.255.255.255
isakmp identity address
isakmp policy 5 authen pre-share
isakmp policy 5 encrypt des
isakmp policy 5 hash sha
isakmp policy 5 group 1
isakmp policy 5 lifetime 86400
sysopt connection permit-ipsec
```

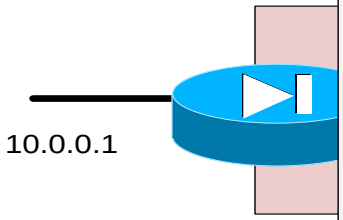
Phase 2

Defines the policies for transform sets, peer IP addresses/hostnames and lifetime settings.

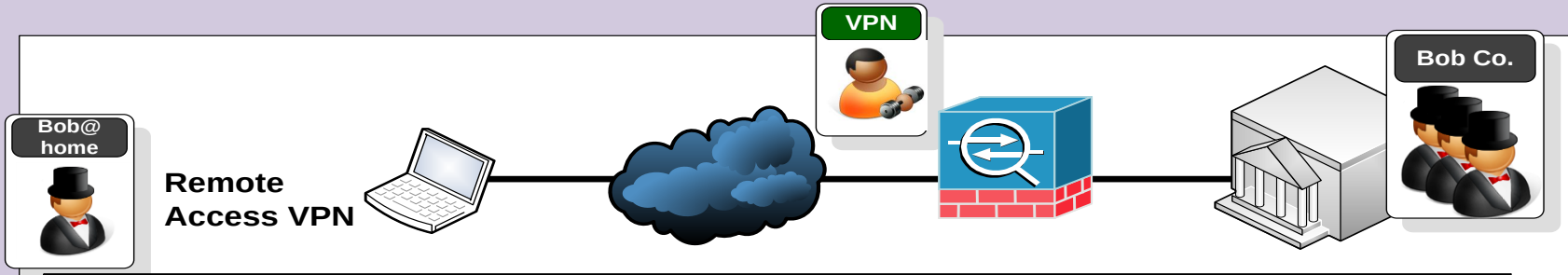
Crypto maps are exchanged

- AH, ESP (or both)
- Encryption (DES, 3DES)
- ESP (tunnel or transport)
- Authentication (SHA/MD5)
- SA lifetimes defined
- Define the traffic of interest

```
crypto ipsec transform-set MYIPSECFORMAT esp-des esp-sha-hmac
crypto map MYIPSEC 10 ipsec-isakmp
access-list 111 permit ip 10.0.0.0  255.255.255.0  176.16.0.0
255.255.255.0
crypto map MYIPSEC 10 match address 111
crypto map MYIPSEC 10 set peer 176.16.0.2
crypto map MYIPSEC 10 set transform-set MYIPSECFORMAT
crypto map MYIPSEC interface outside
```




```
No.     Time        Source                Destination           Protocol Info
81 5.237402    192.168.0.3           146.176.210.2         ISAKMP   Aggressive

Frame 81 (918 bytes on wire, 918 bytes captured)
Ethernet II, Src: IntelCor_34:02:f0 (00:15:20:34:62:f0), Dst: Netgear_b0:d6:8c
(00:18:4d:b0:d6:8c)
Internet Protocol, Src: 192.168.0.3 (192.168.0.3), Dst: 146.176.210.2 (146.176.210.2)
User Datagram Protocol, Src Port: isakmp (500), Dst Port: isakmp (500)
    Source port: isakmp (500)
    Destination port: isakmp (500)
    Length: 884
    Checksum: 0xd89d [correct]
Internet Security Association and Key Management Protocol
    Initiator cookie: 5ABABE2D49A2D42A
    Responder cookie: 0000000000000000
    Next payload: Security Association (1)
    Version: 1.0
    Exchange type: Aggressive (4)
    Flags: 0x00
    Message ID: 0x00000000
    Length: 860
    Security Association payload
        Next payload: Key Exchange (4)
        Payload length: 556
        Domain of interpretation: IPSEC (1)
        Situation: IDENTITY (1)
        Proposal payload # 1
            Next payload: NONE (0)
            Payload length: 544
            Proposal number: 1
            Protocol ID: ISAKMP (1)
            SPI Size: 0
            Proposal transforms: 14
            Transform payload # 1
                Next payload: Transform (3)
                Payload length: 40
                Transform number: 1
                Transform ID: KEY_IKE (1)
                Encryption-Algorithm (1): AES-CBC (7)
                Hash-Algorithm (2): SHA (2)
                Group-Description (4): Alternate 1024-bit MODP group (2)
                Authentication-Method (3): XAUTHInitPreShared (65001)
                Life-Type (11): Seconds (1)
                Life-Duration (12): Duration-Value (2147483)
                Key-Length (14): Key-Length (256)
```

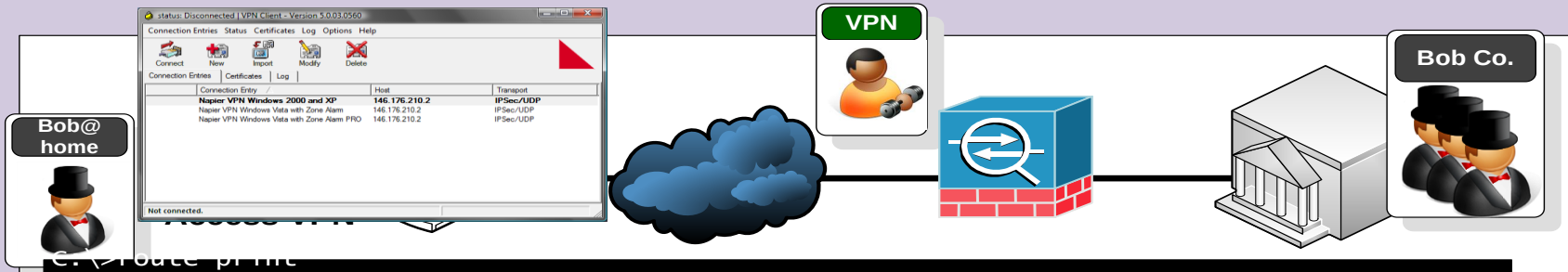



```
C:\>route print
===========================================================================
Interface List
 10 ...00 1d 09 3f 49 8d ......Broadcom NetLink (TM) Fast Ethernet
  7 ...00 1f 3c 4f 30 1d ......Intel(R) PRO/Wireless 3945ABG Network Connection

  1 ........................... Software Loopback Interface 1
===========================================================================

IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0      192.168.0.1      192.168.0.3     25
        127.0.0.0        255.0.0.0         On-link         127.0.0.1    306
        127.0.0.1  255.255.255.255         On-link         127.0.0.1    306
  127.255.255.255  255.255.255.255         On-link         127.0.0.1    306
      192.168.0.0    255.255.255.0         On-link       192.168.0.3    281
      192.168.0.3  255.255.255.255         On-link       192.168.0.3    281
    192.168.0.255  255.255.255.255         On-link       192.168.0.3    281
        224.0.0.0        240.0.0.0         On-link         127.0.0.1    306
        224.0.0.0        240.0.0.0         On-link       192.168.0.3    281
  255.255.255.255  255.255.255.255         On-link         127.0.0.1    306
  255.255.255.255  255.255.255.255         On-link       192.168.0.3    281
===========================================================================
Persistent Routes:
  None
```

VPN

Network Security

Before connecting to the VPN

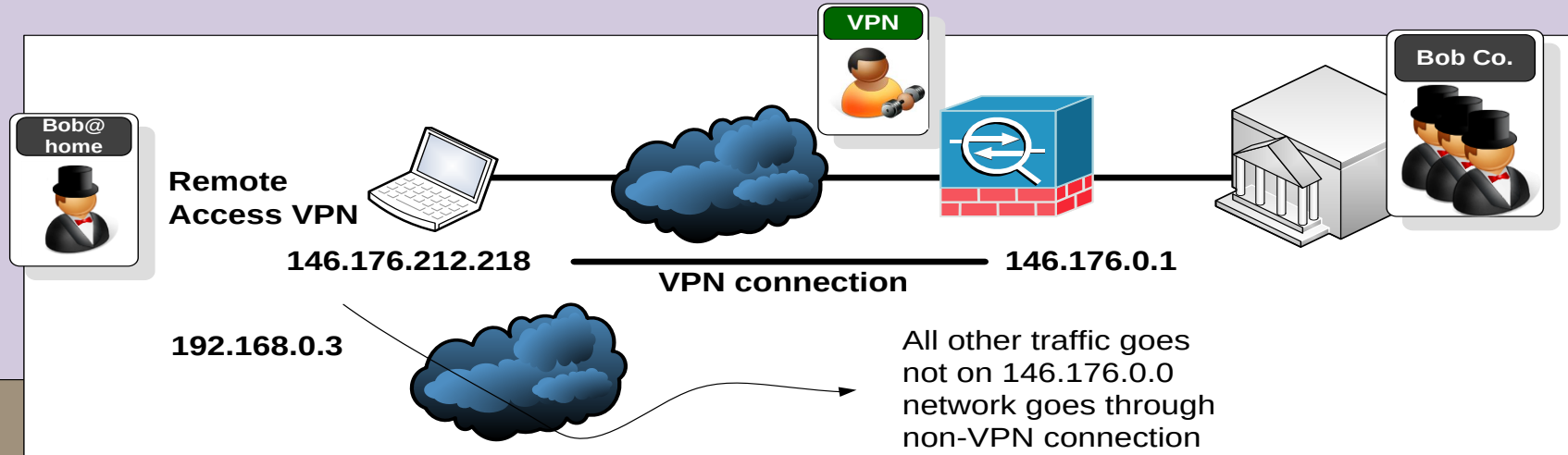



```
C:\>route print
===========================================================================
Interface List
 21 ...00 05 9a 3c 78 00 ......  Cisco Systems VPN Adapter
 10 ...00 1d 09 3f 49 8d ......  Broadcom NetLink (TM) Fast Ethernet
  7 ...00 1f 3c 4f 30 1d ......  Intel(R) PRO/Wireless 3945ABG Network Connectio

  1 ........................... Software Loopback Interface 1
===========================================================================

IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0      192.168.0.1      192.168.0.3     25
        127.0.0.0        255.0.0.0         On-link         127.0.0.1    306
        127.0.0.1  255.255.255.255         On-link         127.0.0.1    306
  127.255.255.255  255.255.255.255         On-link         127.0.0.1    306
      146.176.0.0      255.255.0.0         On-link   146.176.212.218    281
      146.176.1.0    255.255.255.0      146.176.0.1  146.176.212.218    100
      146.176.2.0    255.255.255.0      146.176.0.1  146.176.212.218    100
...
    146.176.210.2  255.255.255.255      192.168.0.1      192.168.0.3    100
    146.176.211.0    255.255.255.0      146.176.0.1  146.176.212.218    100
  146.176.212.218  255.255.255.255         On-link   146.176.212.218    281
...
  255.255.255.255  255.255.255.255         On-link         127.0.0.1    306
  255.255.255.255  255.255.255.255         On-link       192.168.0.3    281
  255.255.255.255  255.255.255.255         On-link   146.176.212.218    281
===========================================================================
Persist
```

VPN

Network Security

After connecting to the VPN

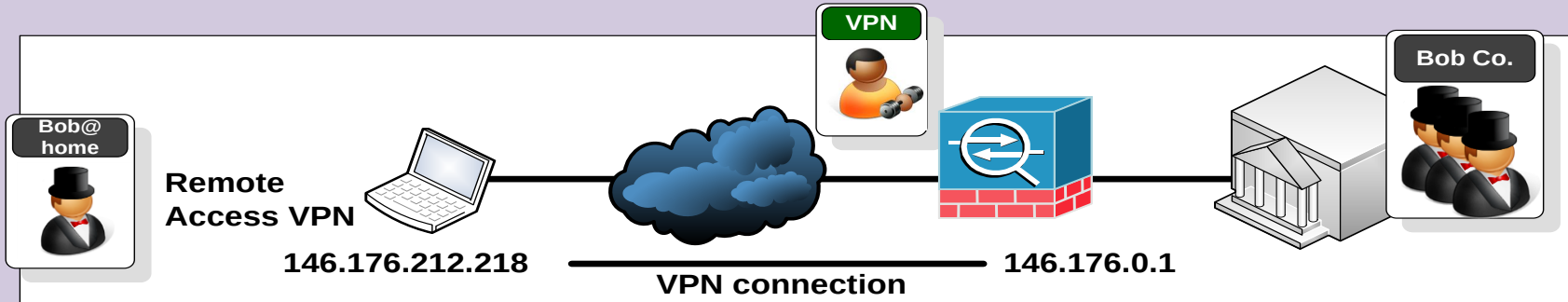


VPN

Network Security

```
===========================================================================
Interface List
 21 ...00 05 9a 3c 78 00 ......  Cisco Systems VPN Adapter
 10 ...00 1d 09 3f 49 8d ......  Broadcom NetLink (TM) Fast Ethernet
  7 ...00 1f 3c 4f 30 1d ......  Intel(R) PRO/Wireless 3945ABG Network Connectio

  1 ........................... Software Loopback Interface 1
===========================================================================

IPv4 Route Table
===========================================================================
Active Routes:
Network Destination        Netmask          Gateway       Interface  Metric
          0.0.0.0          0.0.0.0      192.168.0.1      192.168.0.3      25
        127.0.0.0        255.0.0.0         On-link         127.0.0.1     306
        127.0.0.1  255.255.255.255         On-link         127.0.0.1     306
  127.255.255.255  255.255.255.255         On-link         127.0.0.1     306
      146.176.0.0      255.255.0.0         On-link   146.176.212.218     281
      146.176.1.0    255.255.255.0      146.176.0.1  146.176.212.218     100
      146.176.2.0    255.255.255.0      146.176.0.1  146.176.212.218     100
...
===========================================================================
Persist
```

After connecting to the VPN



VPN

Before VPN connection

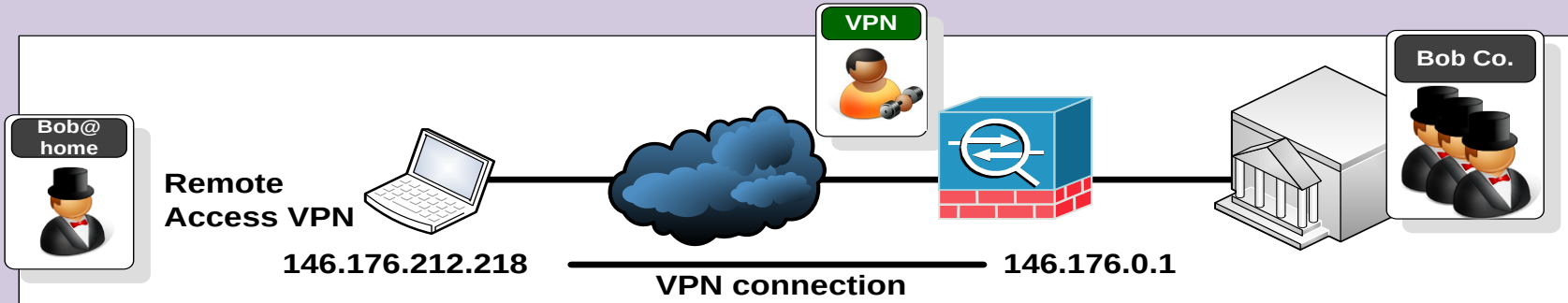
```
C:\>tracert www.napier.ac.uk

Tracing route to www.napier.ac.uk [146.176.222.174]
over a maximum of 30 hops:

  1     2 ms     2 ms     6 ms  192.168.0.1
  2    36 ms    38 ms    38 ms  cr0.escra.uk.easynet.net [87.87.249.224]
  3    31 ms    31 ms    30 ms  ip-87-87-146-129.easynet.co.uk [87.87.146.129]
  4    43 ms    43 ms    43 ms  be2.er10.thlon.ov.easynet.net [195.66.224.43]
  5    48 ms    45 ms    45 ms  linx-gw1.ja.net [195.66.224.15]
  6    45 ms    44 ms    45 ms  so-0-1-0.lond-sbr4.ja.net [146.97.35.129]
  7    49 ms    79 ms    49 ms  so-2-1-0.leed-sbr1.ja.net [146.97.33.29]
  8    58 ms    56 ms    56 ms  EastMAN-E1.site.ja.net [146.97.42.46]
  9    59 ms    57 ms    57 ms  vlan16.s-pop2.eastman.net.uk [194.81.56.66]
 10    57 ms    59 ms    58 ms  gi0-1.napier-pop.eastman.net.uk [194.81.56.46]
 11
```

Network Security

After VPN connection

```
C:\>tracert www.napier.ac.uk

Tracing route to www.napier.ac.uk [146.176.222.174]
over a maximum of 30 hops:

  1    57 ms    58 ms    57 ms  146.176.210.2
  2    58 ms    56 ms    57 ms  www.napier.ac.uk [146.176.222.174]
  3    58 ms    59 ms    56 ms  www.napier.ac.uk [146.176.222.174]
```

Traceroute for VPN



Before VPN connection

```
C:\>tracert www.intel.com

Tracing route to a961.g.akamai.net [90.223.246.33]
over a maximum of 30 hops:

  1     3 ms     1 ms     1 ms  192.168.0.1
  2    35 ms    43 ms    36 ms  cr0.escra.uk.easynet.net [87.87.249.224]
  3    32 ms    31 ms    32 ms  ip-87-87-146-129.easynet.co.uk [87.87.146.129]
  4    46 ms    45 ms    45 ms  te7-0-0.sr0.enlcs.ov.easynet.net [89.200.132.109]
  5    46 ms    47 ms    47 ms  5adff621.bb.sky.com [90.223.246.33]
```

After VPN connection

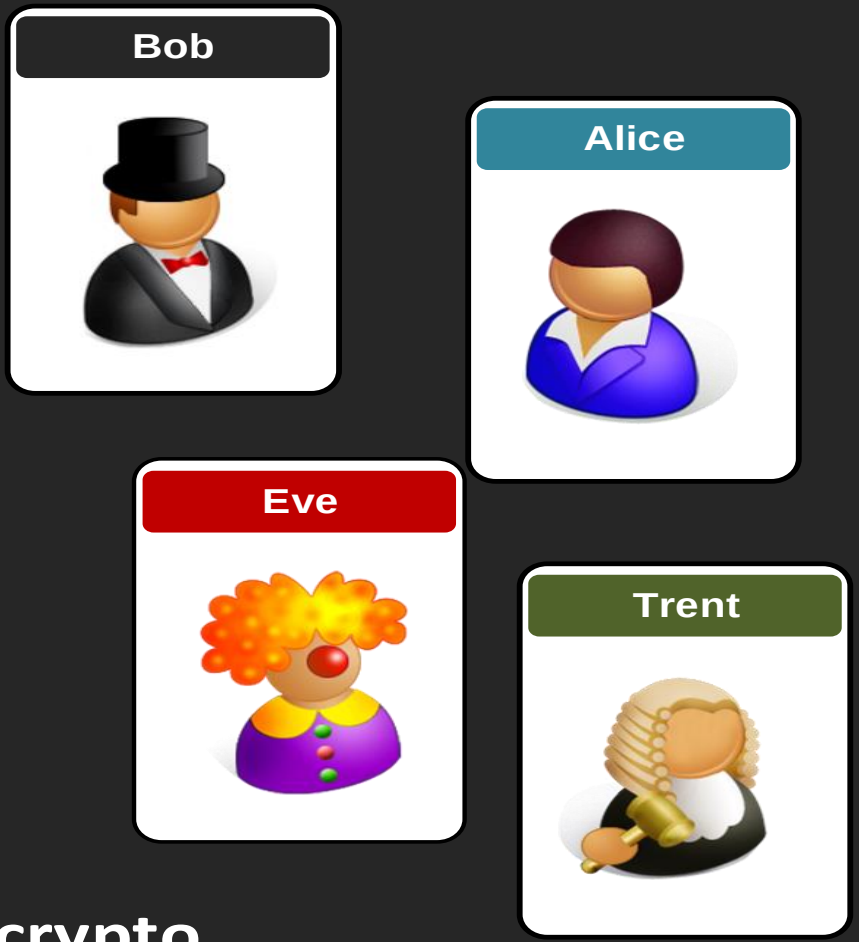
```
C:\>tracert www.intel.com

Tracing route to a961.g.akamai.net [90.223.246.33]
over a maximum of 30 hops:

  1     3 ms     1 ms     1 ms  192.168.0.1
  2    35 ms    43 ms    36 ms  cr0.escra.uk.easynet.net [87.87.249.224]
  3    32 ms    31 ms    32 ms  ip-87-87-146-129.easynet.co.uk [87.87.146.129]
  4    46 ms    45 ms    45 ms  te7-0-0.sr0.enlcs.ov.easynet.net [89.200.132.109]
  5    46 ms    47 ms    47 ms  5adff621.bb.sky.com [90.223.246.33]
```


Traceroute for VPN

Advanced Crypto

6. Tunnelling

Introduction



http://asecuritysite.com/crypto

Author: Prof Bill Buchanan