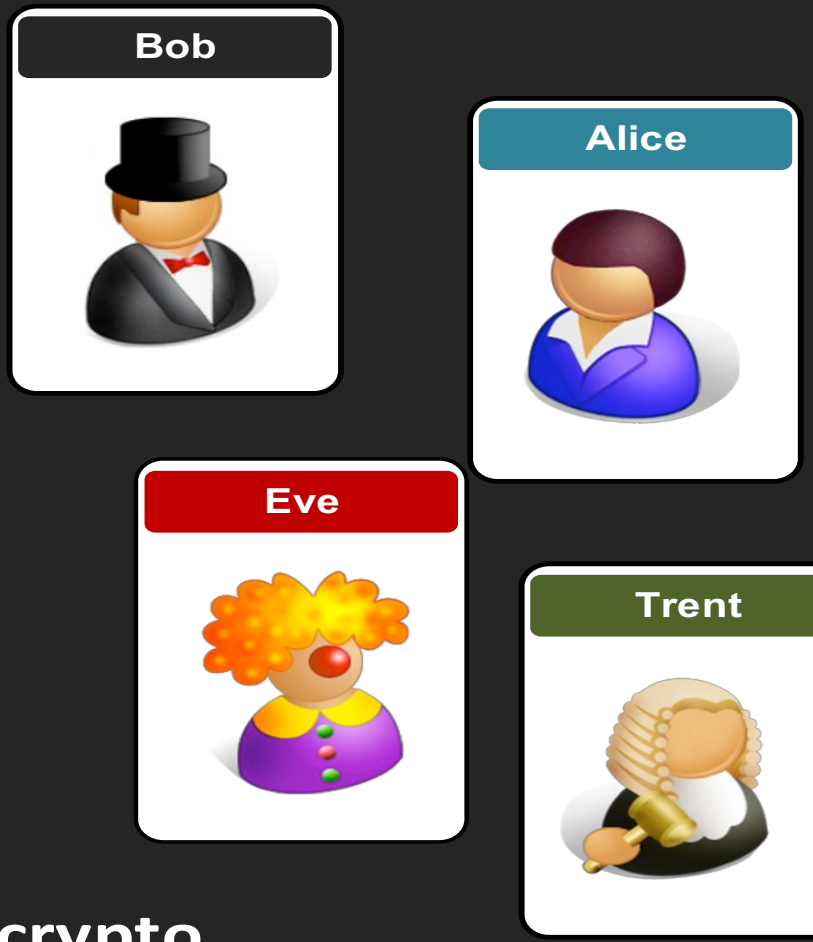
Advanced Crypto

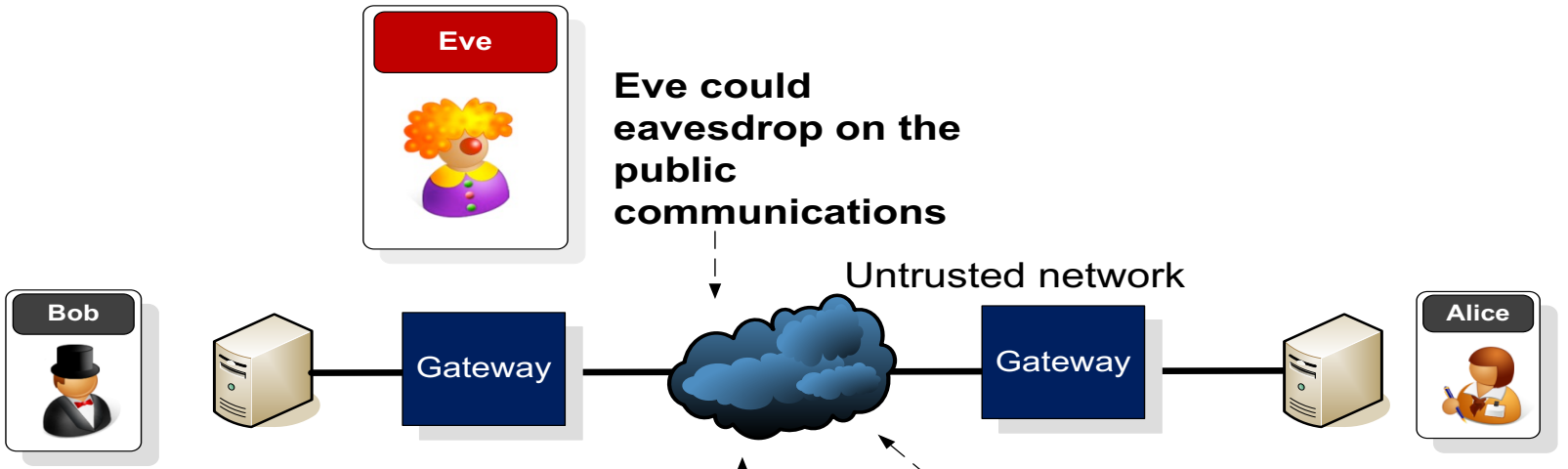
6. Tunnelling

Introduction



http://asecuritysite.com/crypto

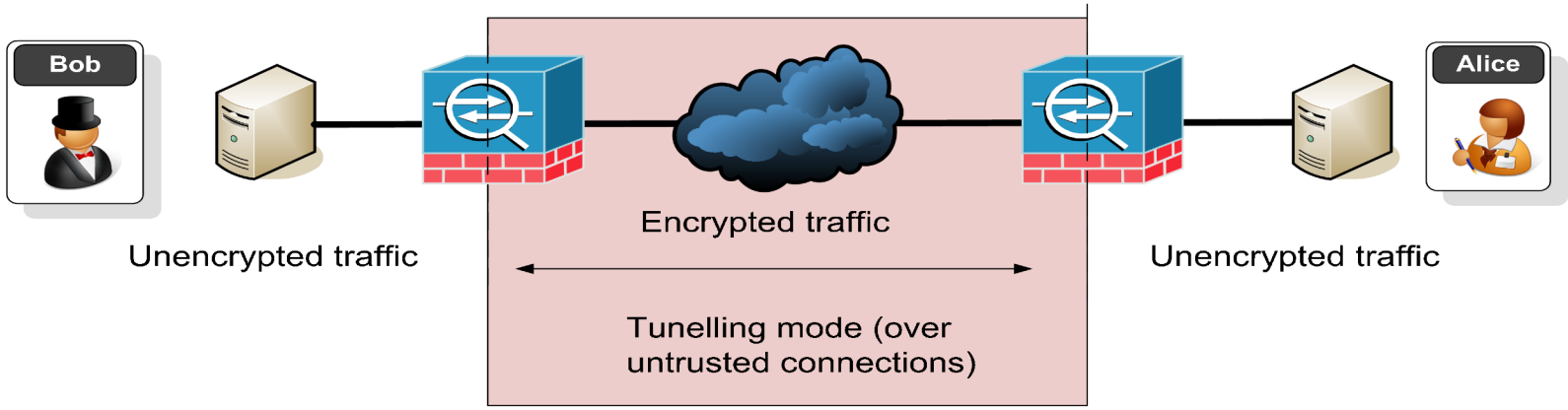
Author: Prof Bill Buchanan

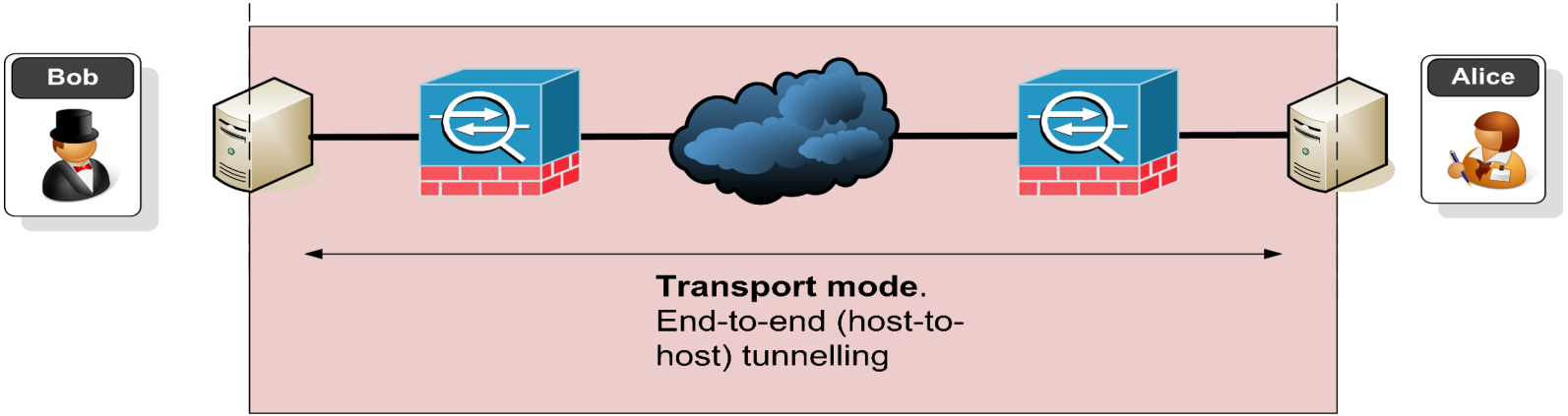


What is required is:

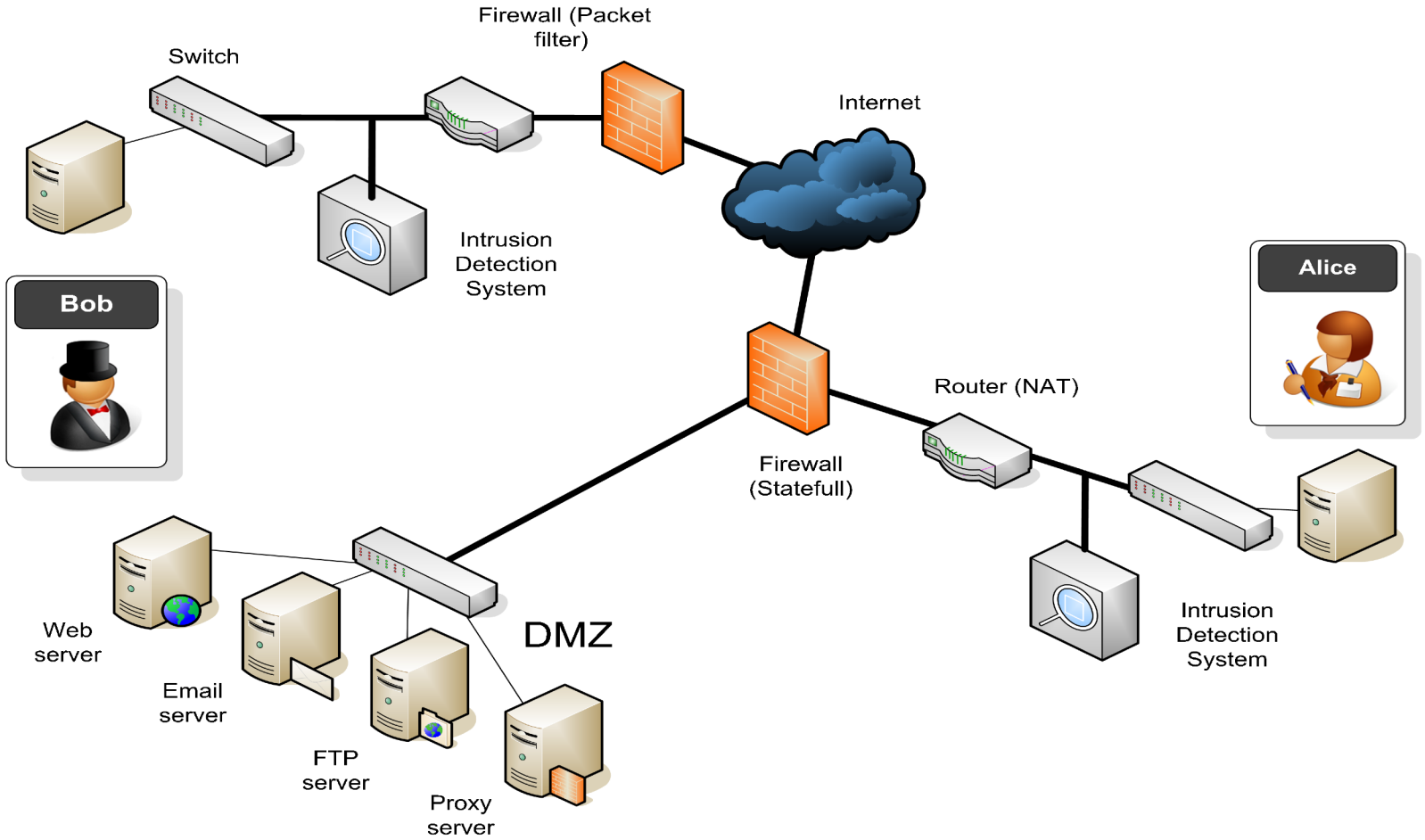
- Encryption.
- Authentication of devices (to overcome spoofing)
- Authentication of packets (for integrity)

Traffic is encrypted over the untrusted network.



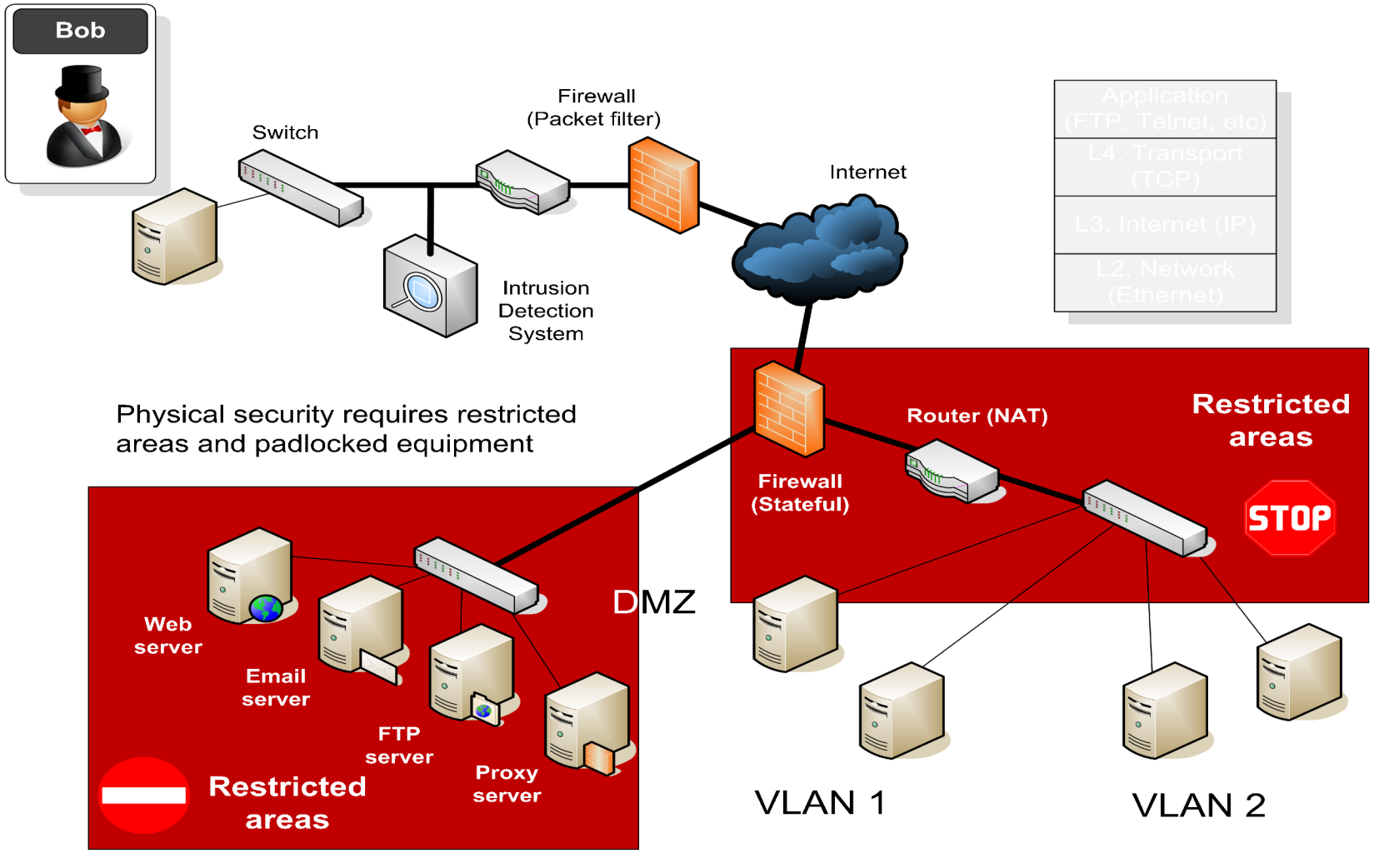


Tunnelling mode or transport mode

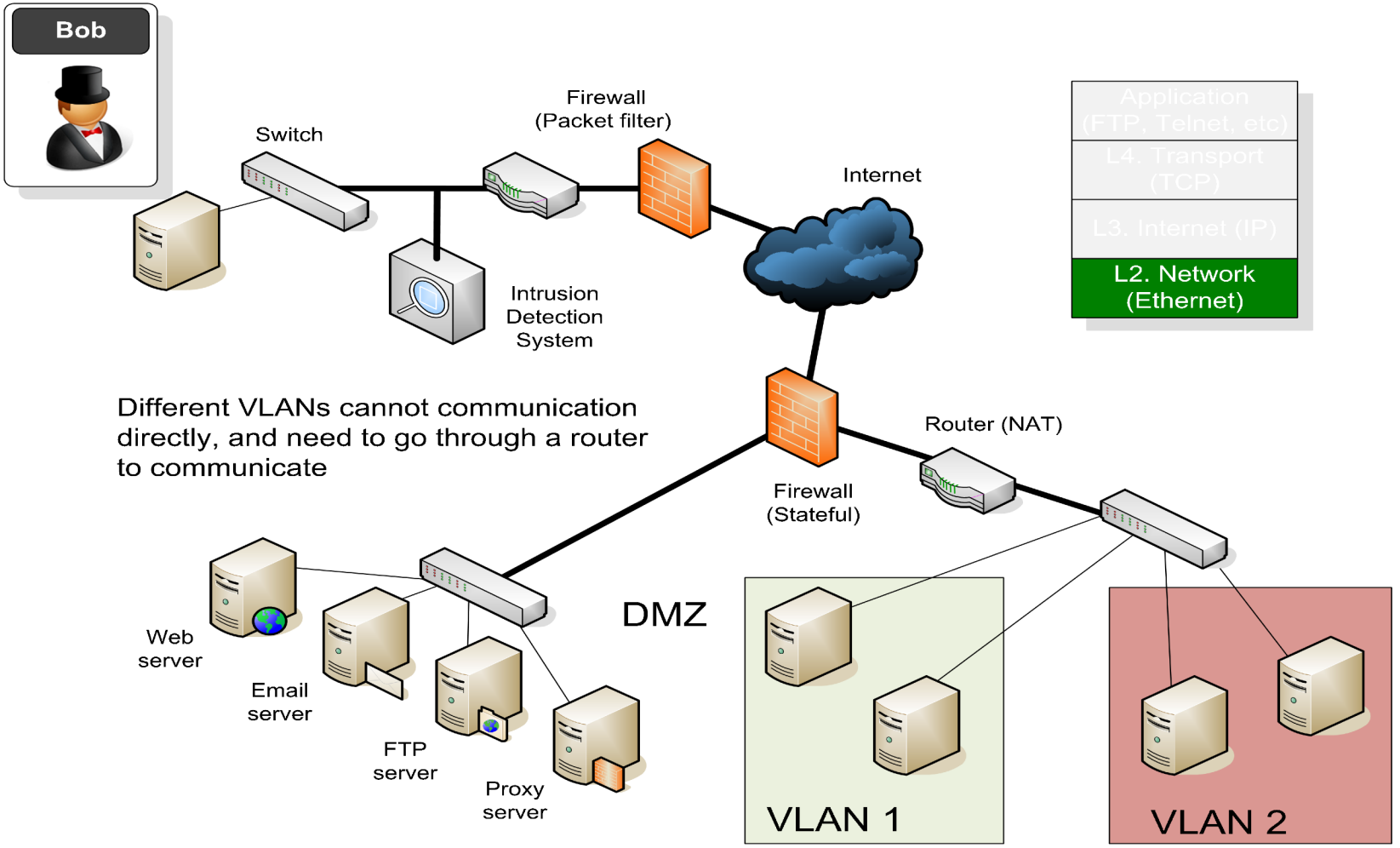


Author: Prof Bill Buchanan

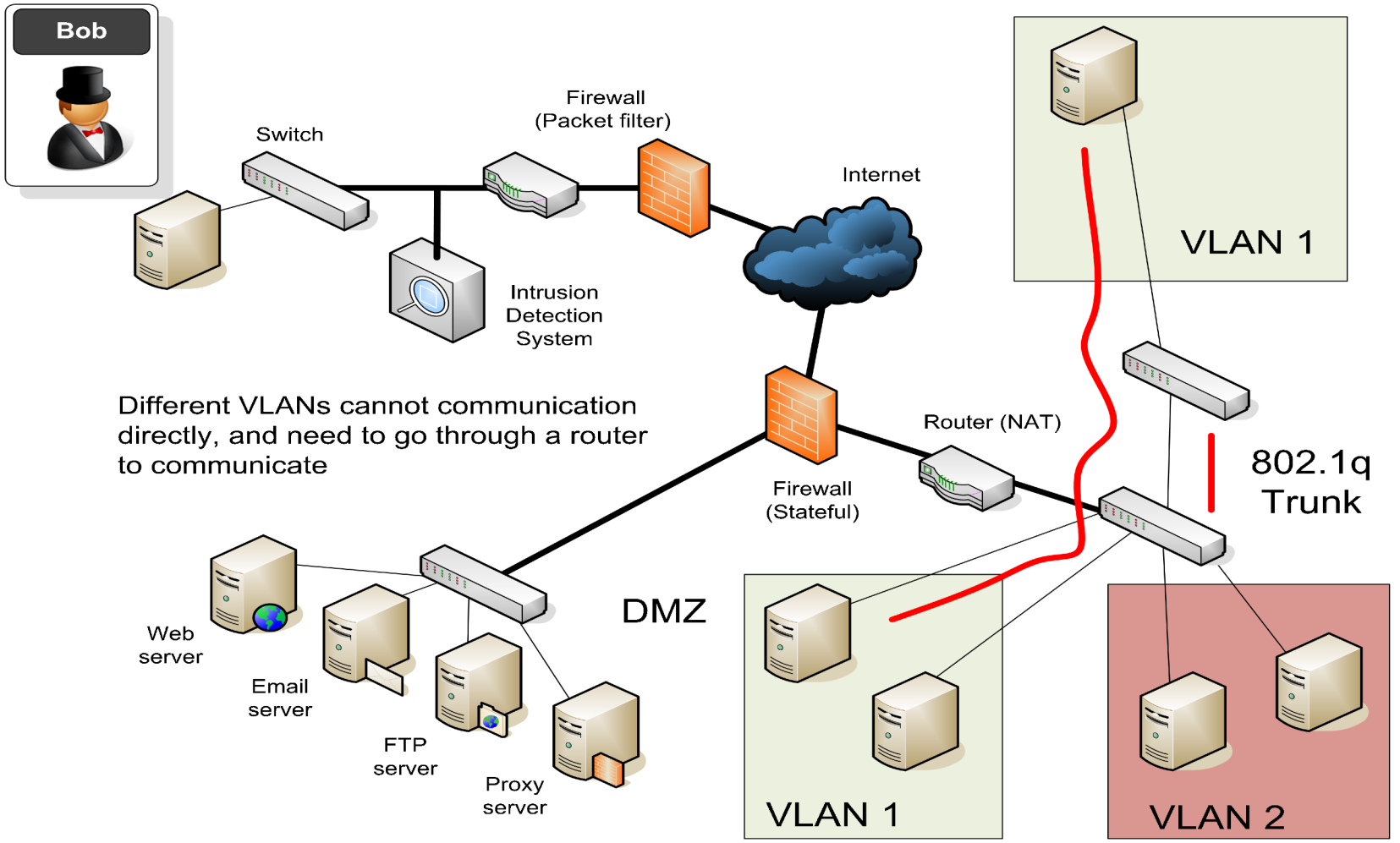
Example Infrastructure



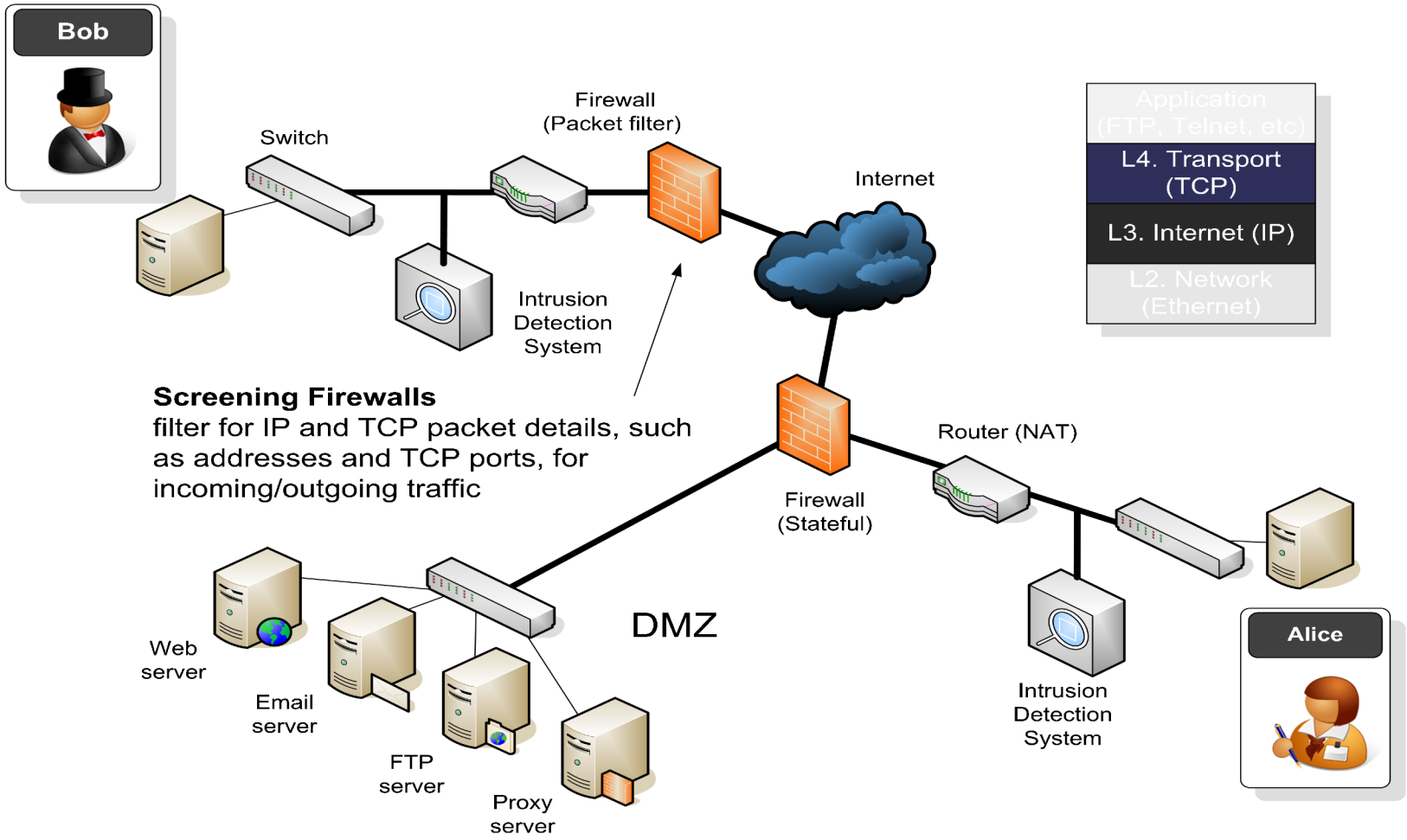
Author: Prof Bill Buchanan



Author: Prof Bill Buchanan



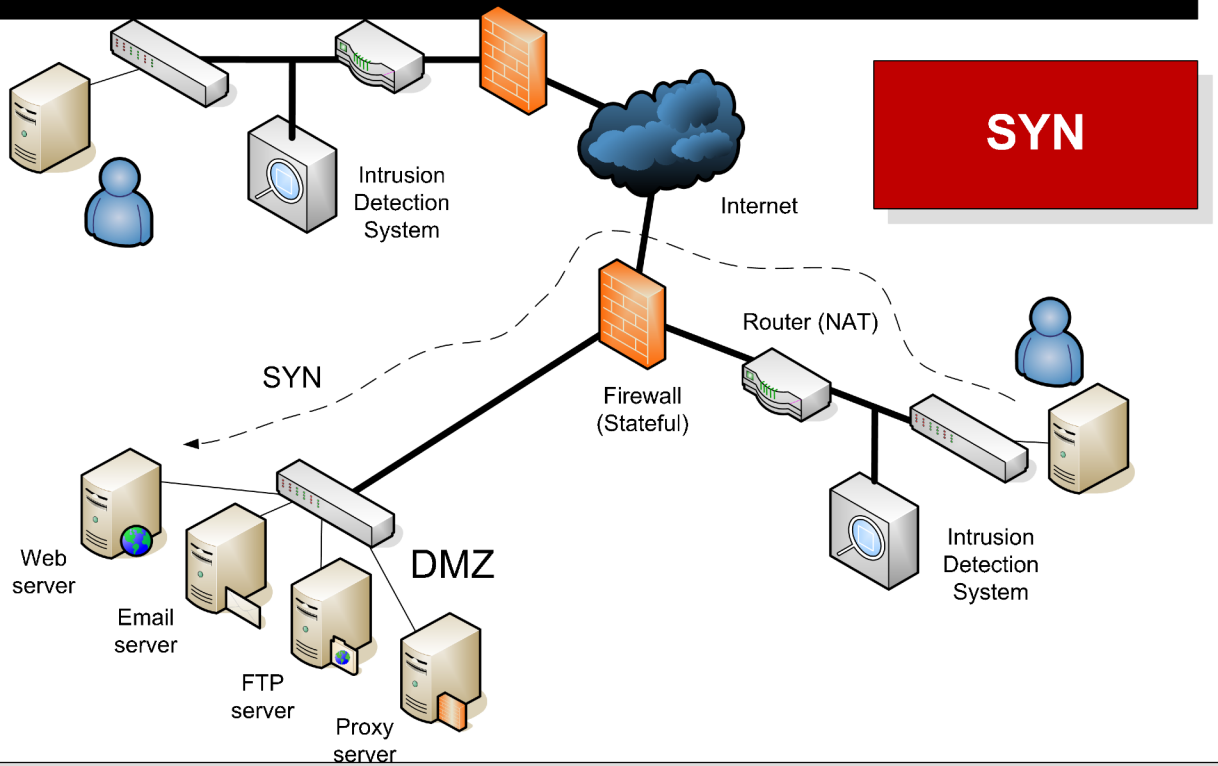
Author: Prof Bill Buchanan



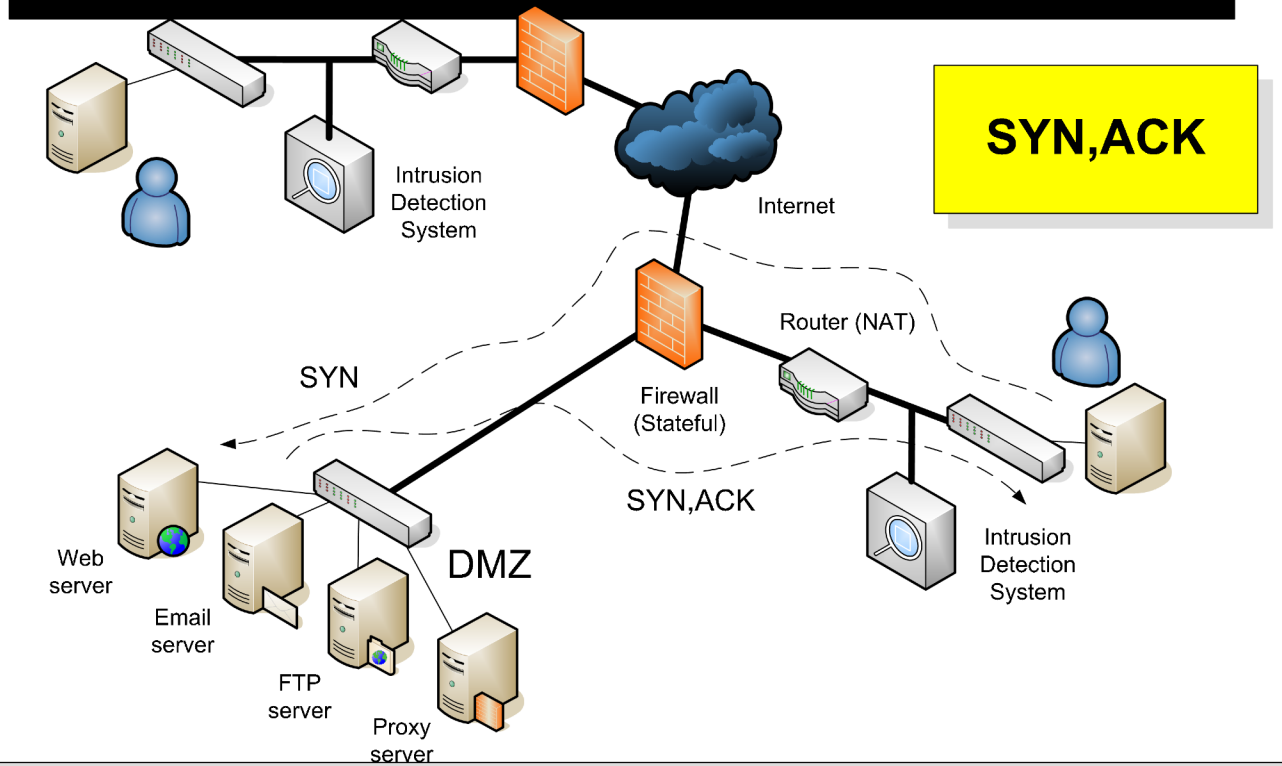
Author: Prof Bill Buchanan

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

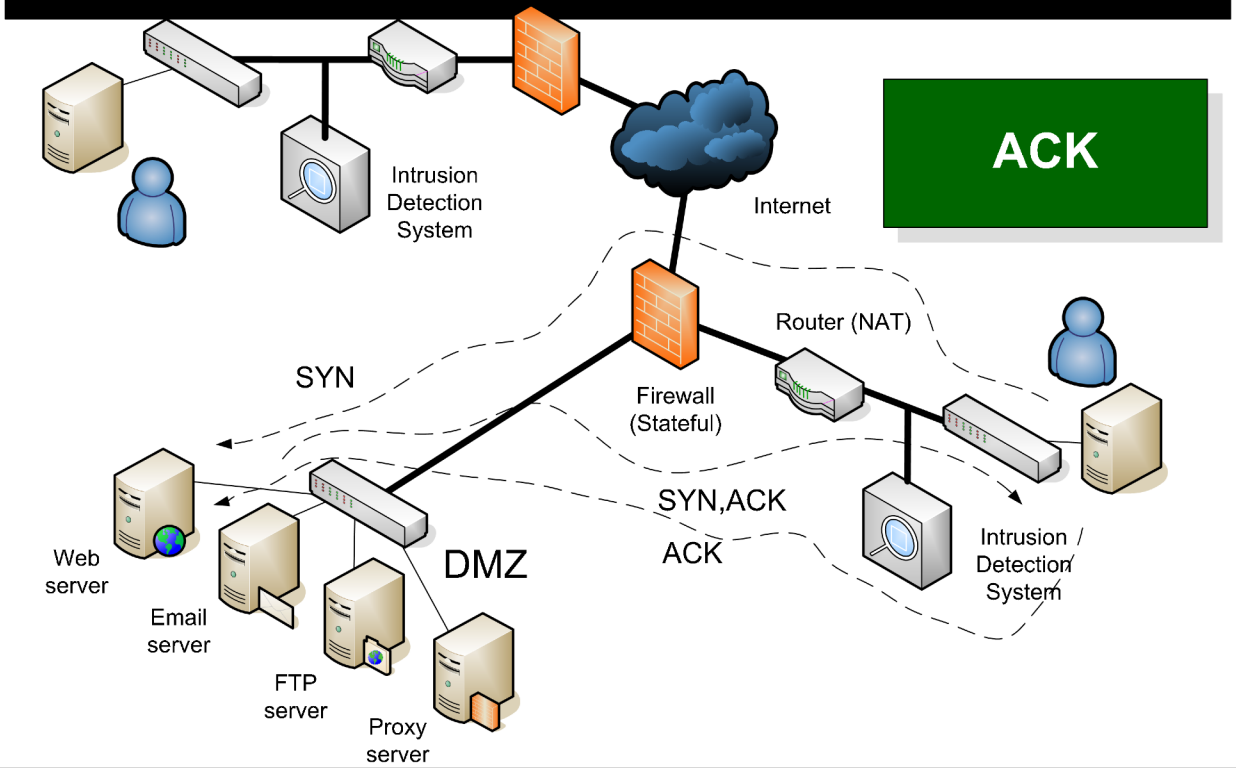
SYN



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



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



```
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
ternet 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

www.napier.ac.uk?

DNS server

146.176.1.188

SYN
Src Port=4213, Dest Port=80

TCP port=4213

TCP port=80

192.168.1.101

146.176.1.188

Stateful firewall

Network Security

```
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)
ansmission 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)
 [SEQ/ACK analysis]
```

SYN,ACK

```
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)
ansmission 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

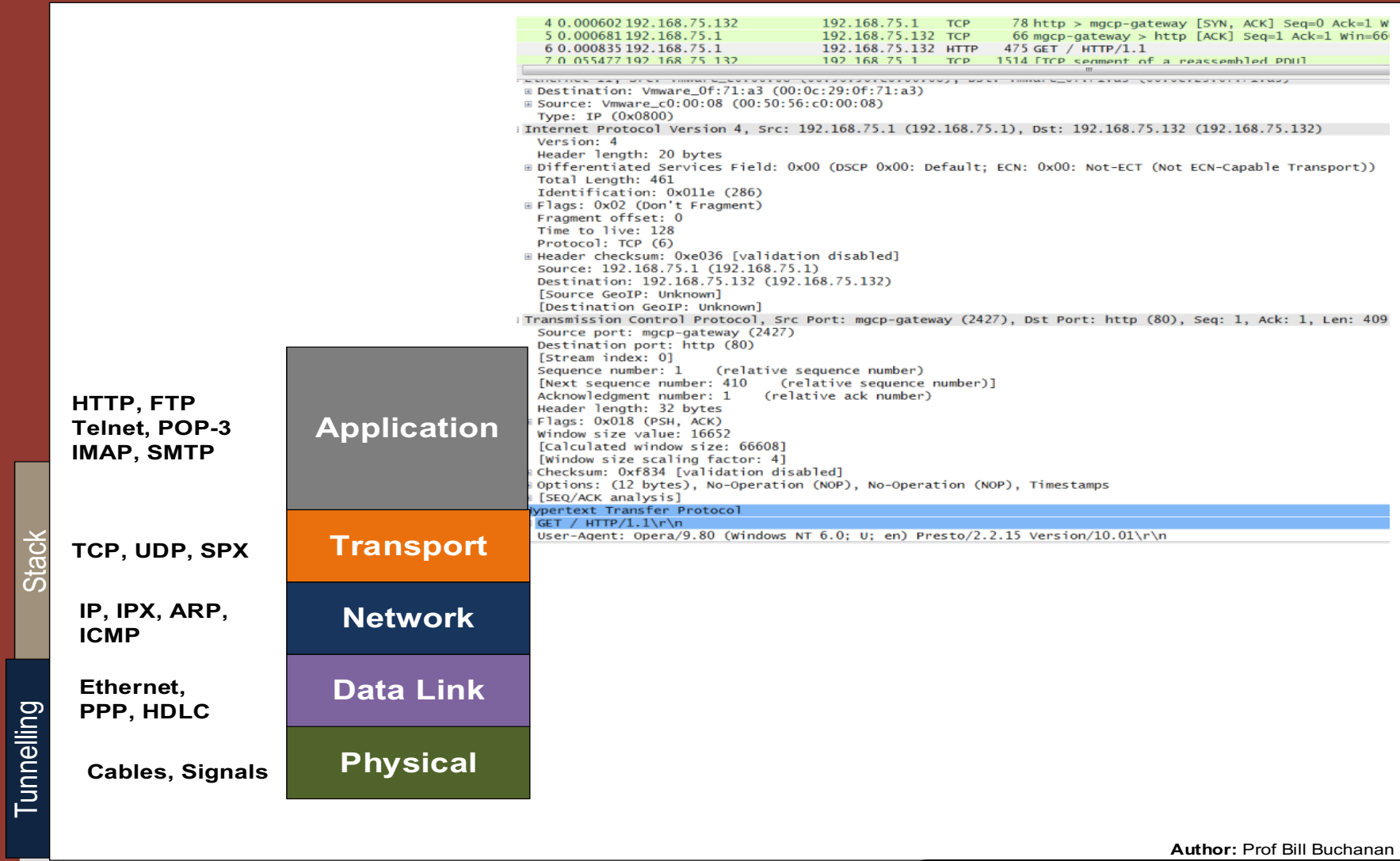
Advanced Crypto

6. Tunnelling

SSL/TLS

http://asecuritysite.com/crypto

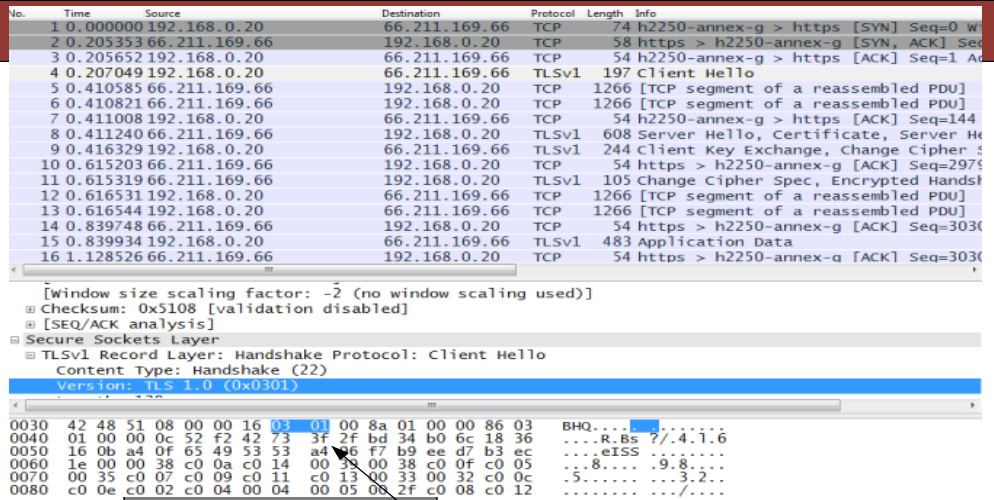
Author: Prof Bill Buchanan



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

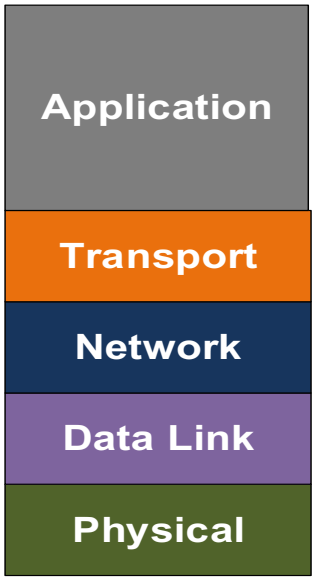
HTTP, FTP
Telnet, POP-3
IMAP, SMTP

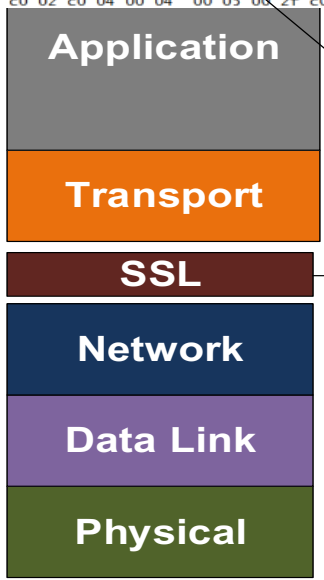
TCP, UDP, SPX

IP, IPX, ARP, ICMP

Ethernet, PPP, HDLC

Cables, Signals



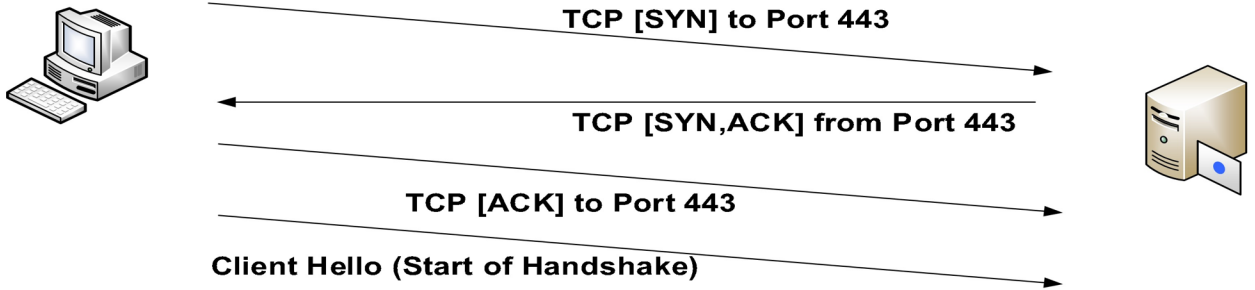


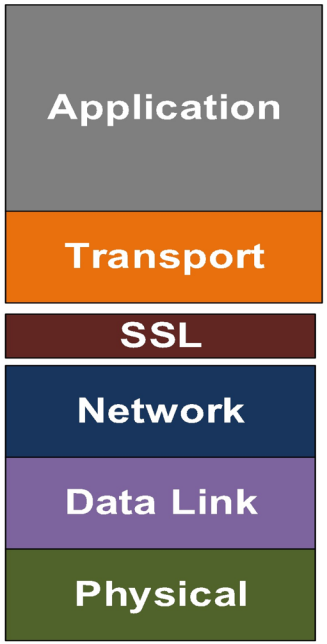
HTTPS (HTTP + SSL)
FTP (FTP+SSL)
SSH (Telnet+SSL)

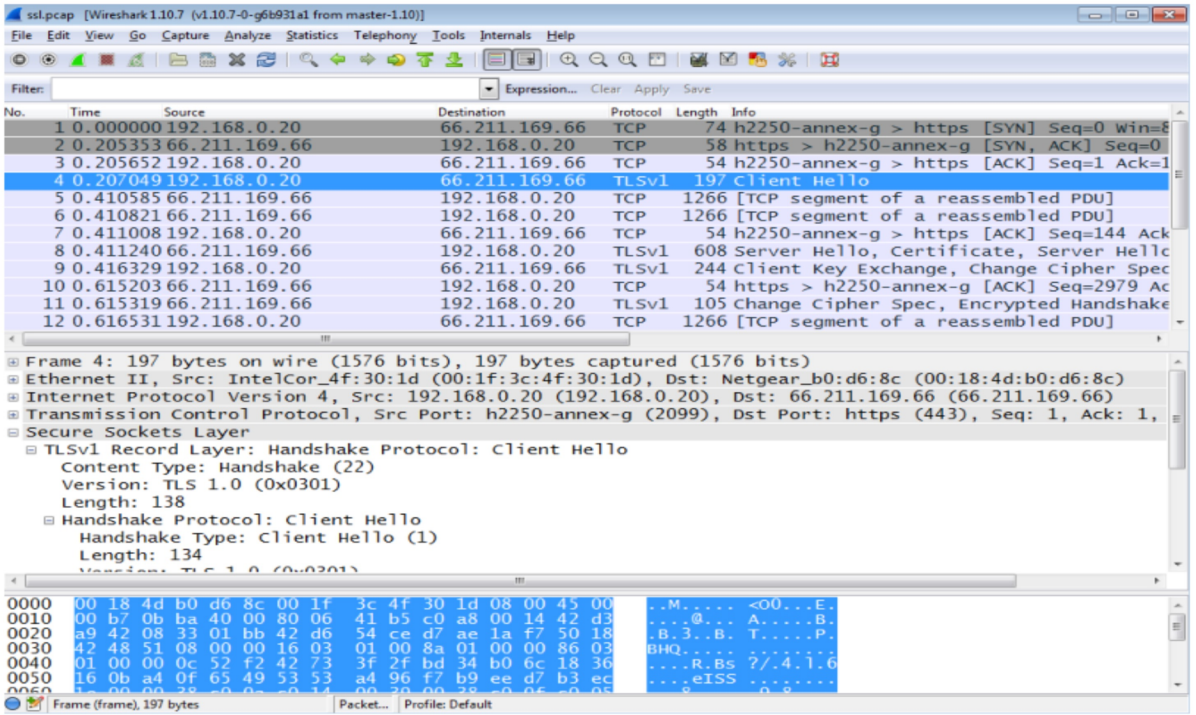
SSL 1.0
SSL 2.0
SSL 3.0 [0x0300]
SSL 3.1 (TLS 1.0) [0x0301]
TLS 1.1 and 1.2 [0x0302]

Secure Socket Layer
Transport Layer Socket

Author: Prof Bill Buchanan







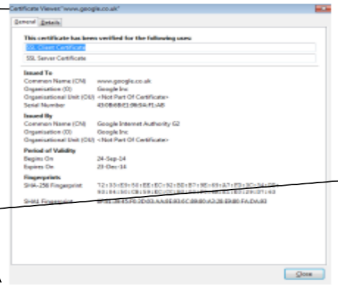
Author: Prof Bill Buchanan

192.168.0.20

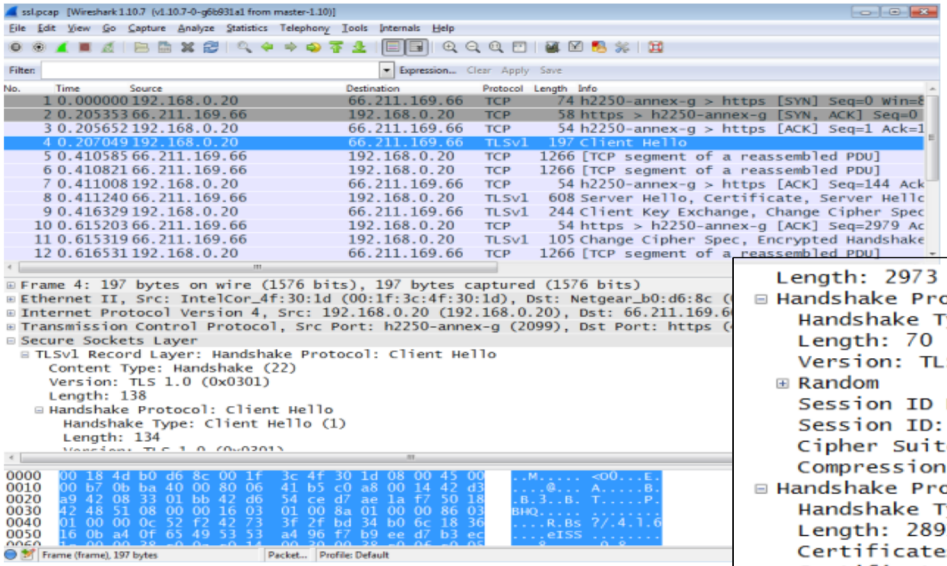
Client Hello

66.211.169.66

```
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)
```



Server Hello



```
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 (
Internet Protocol Version 4, Src: 192.168.0.20 (192.168.0.20), Dst: 66.211.169.6
Transmission Control Protocol, Src Port: h2250-annex-g (2099), Dst Port: https (
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
```

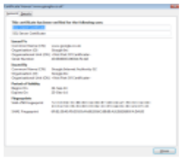
```
0000  00 18 4d b0 d6 8c 00 1f  3c 4f 30 1d 08 00 45 00   ..M..... <O0...E.
0010  00 b7 0b ba 40 00 80 06  41 b5 c0 a8 00 14 42 d3   ....@... A.....B.
0020  a9 42 08 33 01 bb 42 d6  54 ce d7 ae 1a f7 50 18   .B.3..B. T.....P.
0030  42 48 51 08 00 00 16 03  01 00 8a 01 00 00 86 03   BHQ..... ........
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 ........
```

```
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

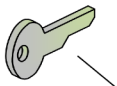
Author: Prof Bill Buchanan



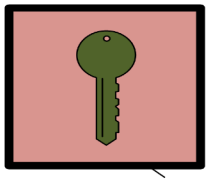
Client Hello

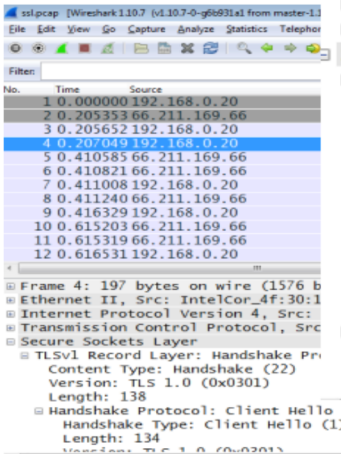
Server Hello

Client Key Exchange

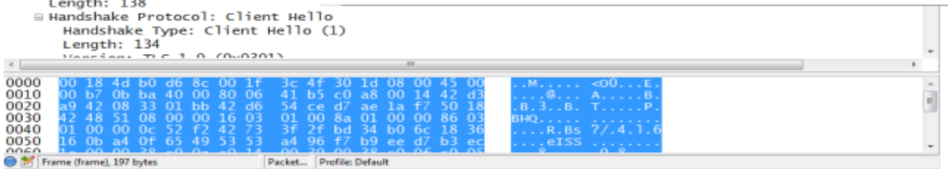


Public key





```
    [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)
```

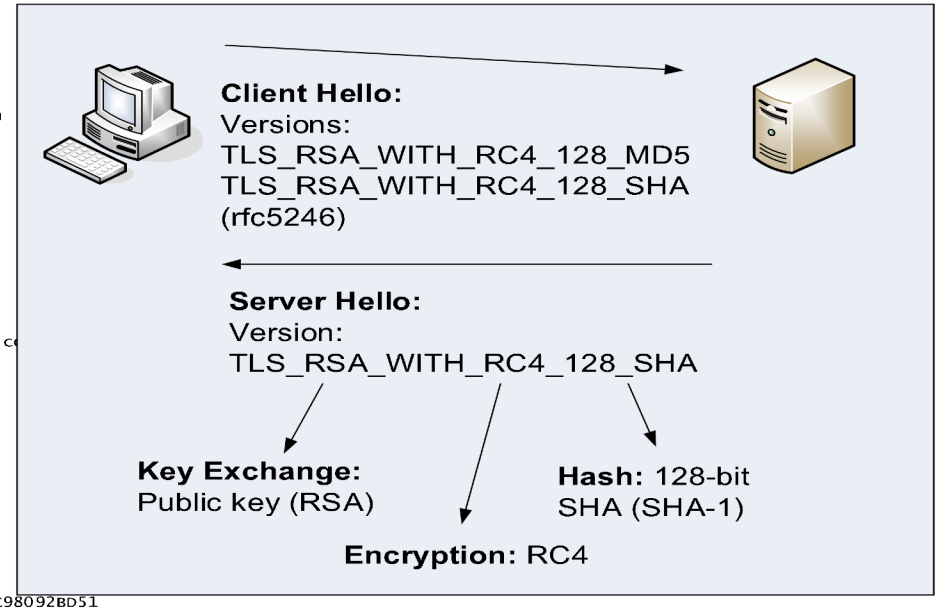


Stack

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)
```

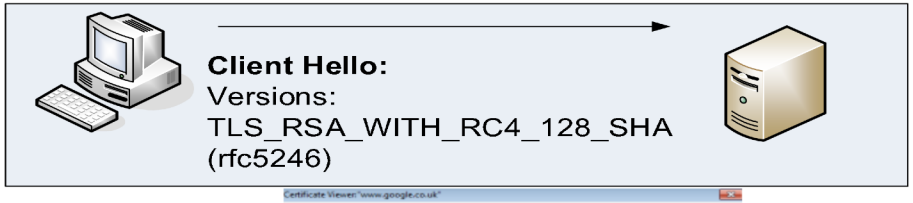



```
TLS_RSA_WITH_AES_256_CBC_SHA256
Key: RSA Enc: AES_256_CBC  Hash: SHA256
TLS_DH_DSS_WITH_3DES_EDE_CBC_SHA
Key ex: DH_DSS Enc: 3DES_EDE_CBC Hash: SHA
```

TC

Disk Encryption

Author: Prof Bill Buchanan

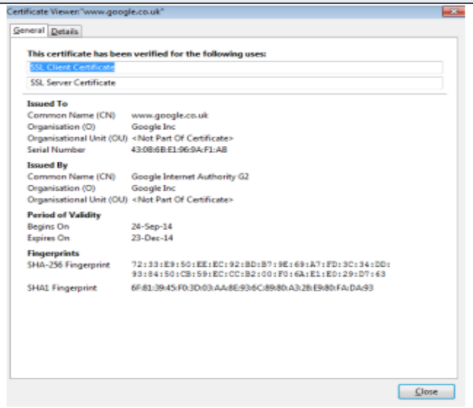


Server Hello:
Version:
TLS_RSA_WITH_RC4_128_SHA

Key Exchange:
Public key (RSA)

Encryption: RC4

Hash: 128-bit
SHA (SHA-1)



Session key

Public key

Private key

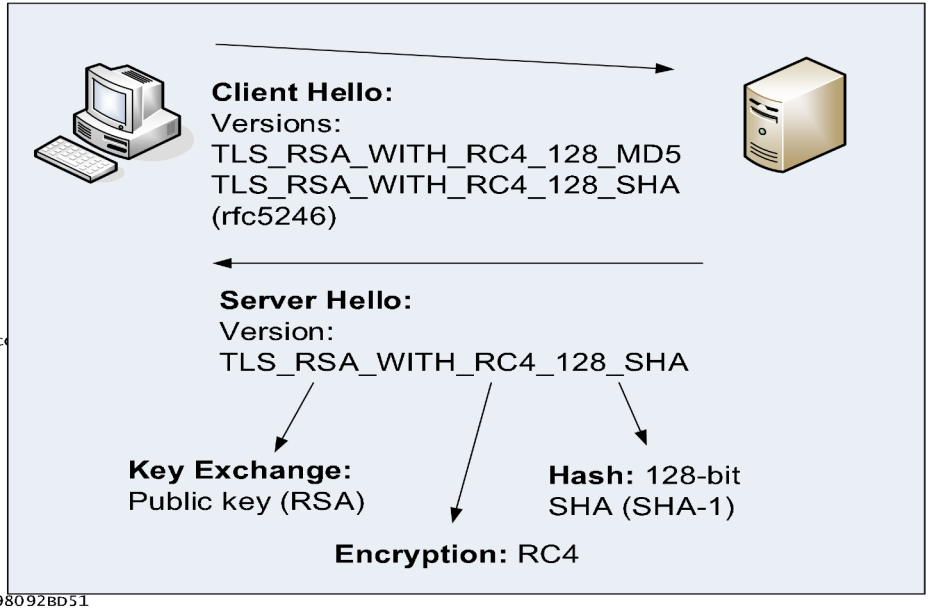
Tunnel created (RC4, Hash: SHA-1)

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
---
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
```

TC

Disk Encryption

Author: Prof Bill Buchanan

Advanced Crypto

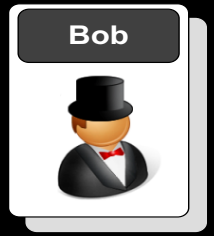
6. Tunnelling

Heartbleed

http://asecuritysite.com/crypto

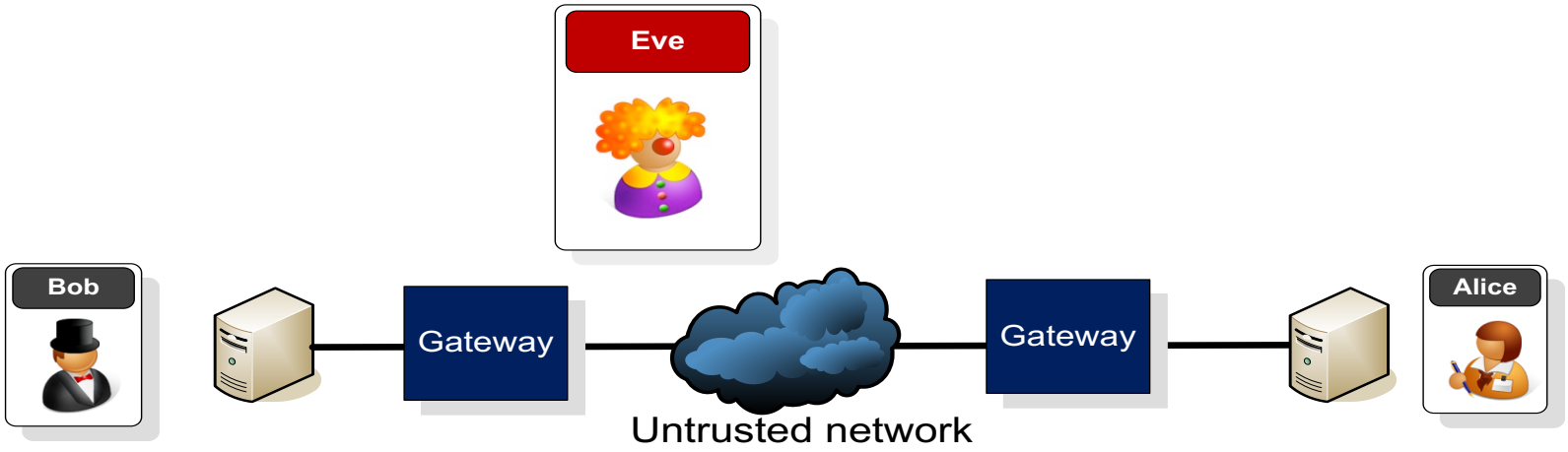
Author: Prof Bill Buchanan

Network Security



VPNs

Author: Prof Bill Buchanan



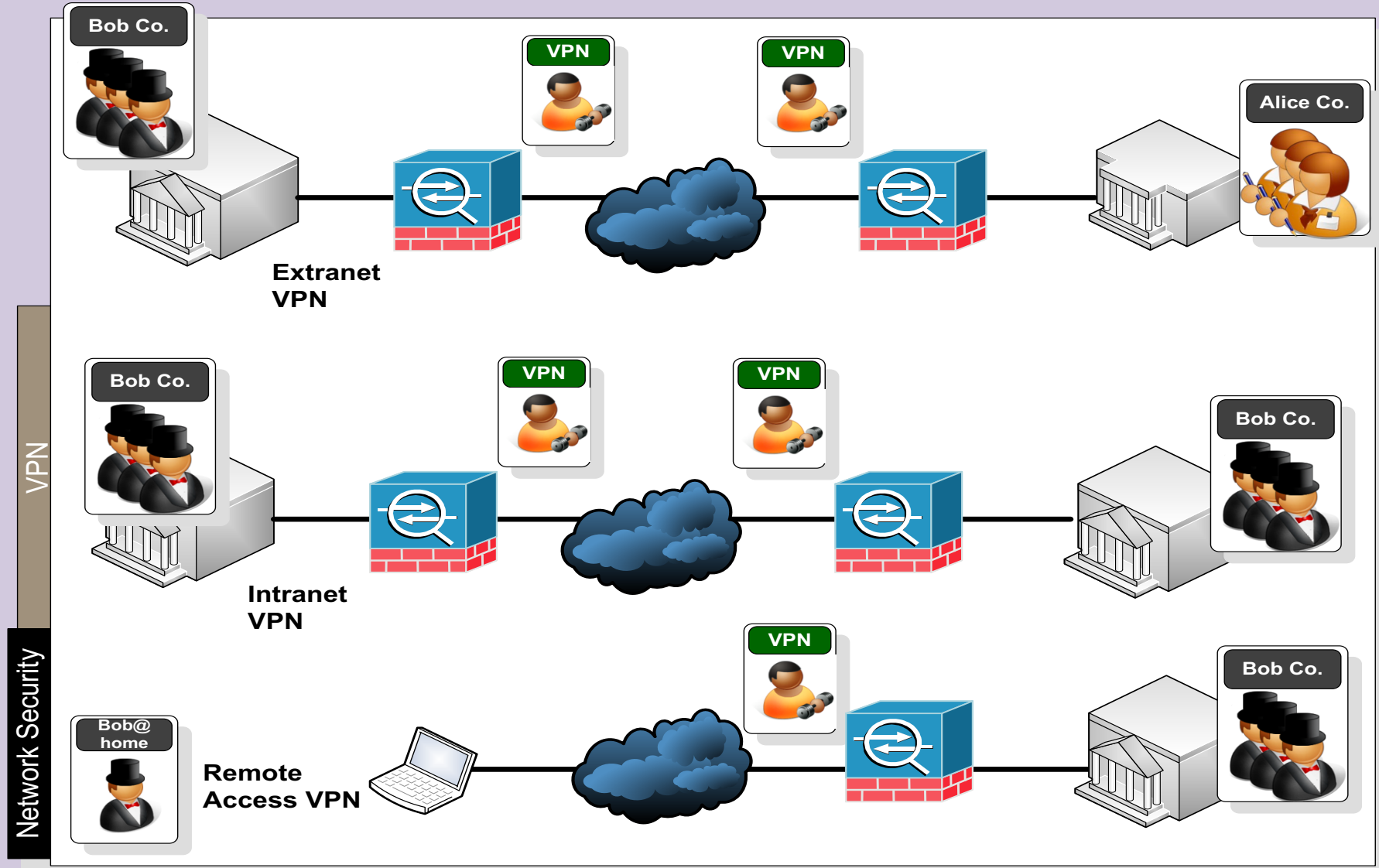
What is required is:

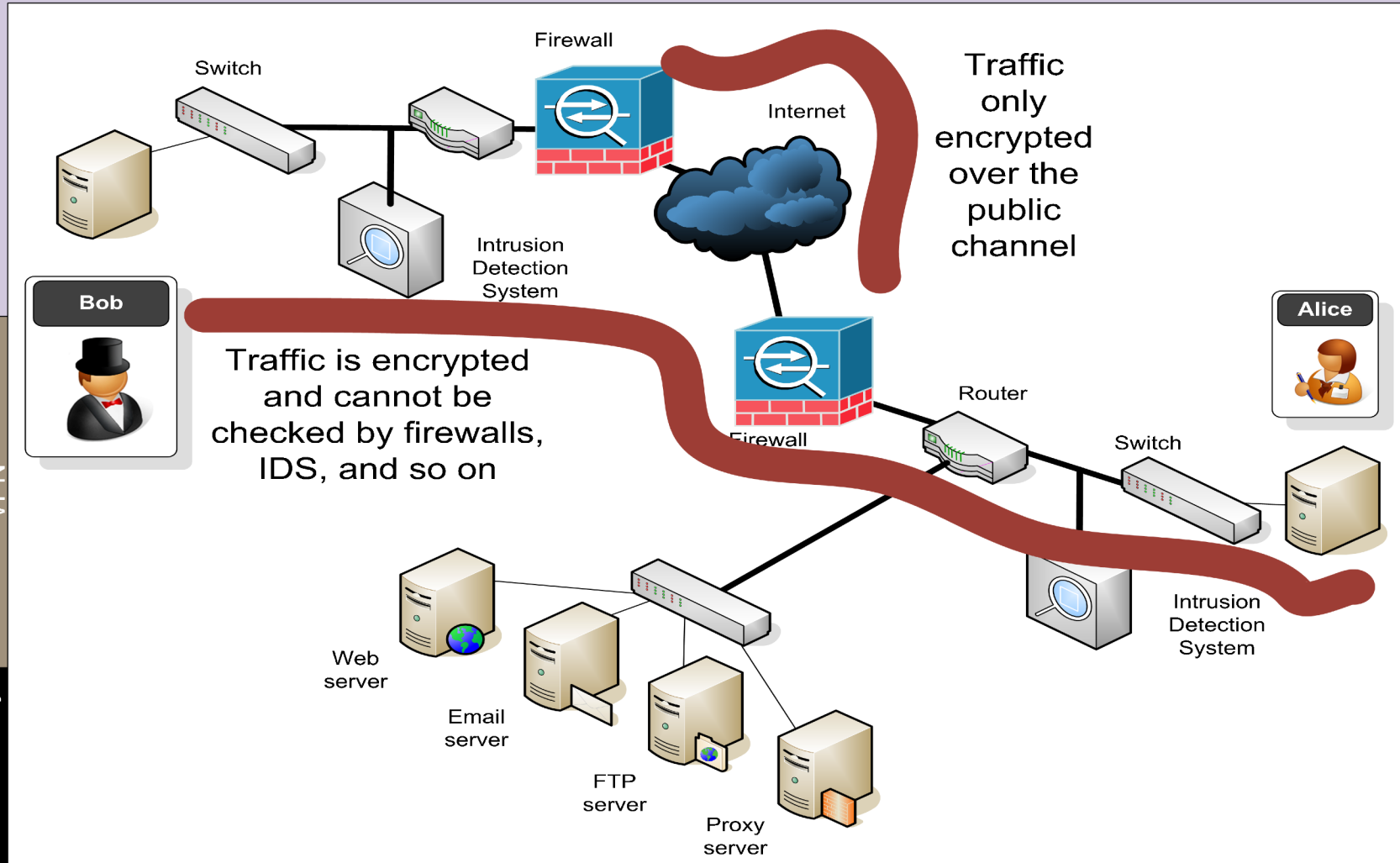
- Encryption.
- Authentication of devices (to overcome spoofing)
- Authentication of packets (for integrity)

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

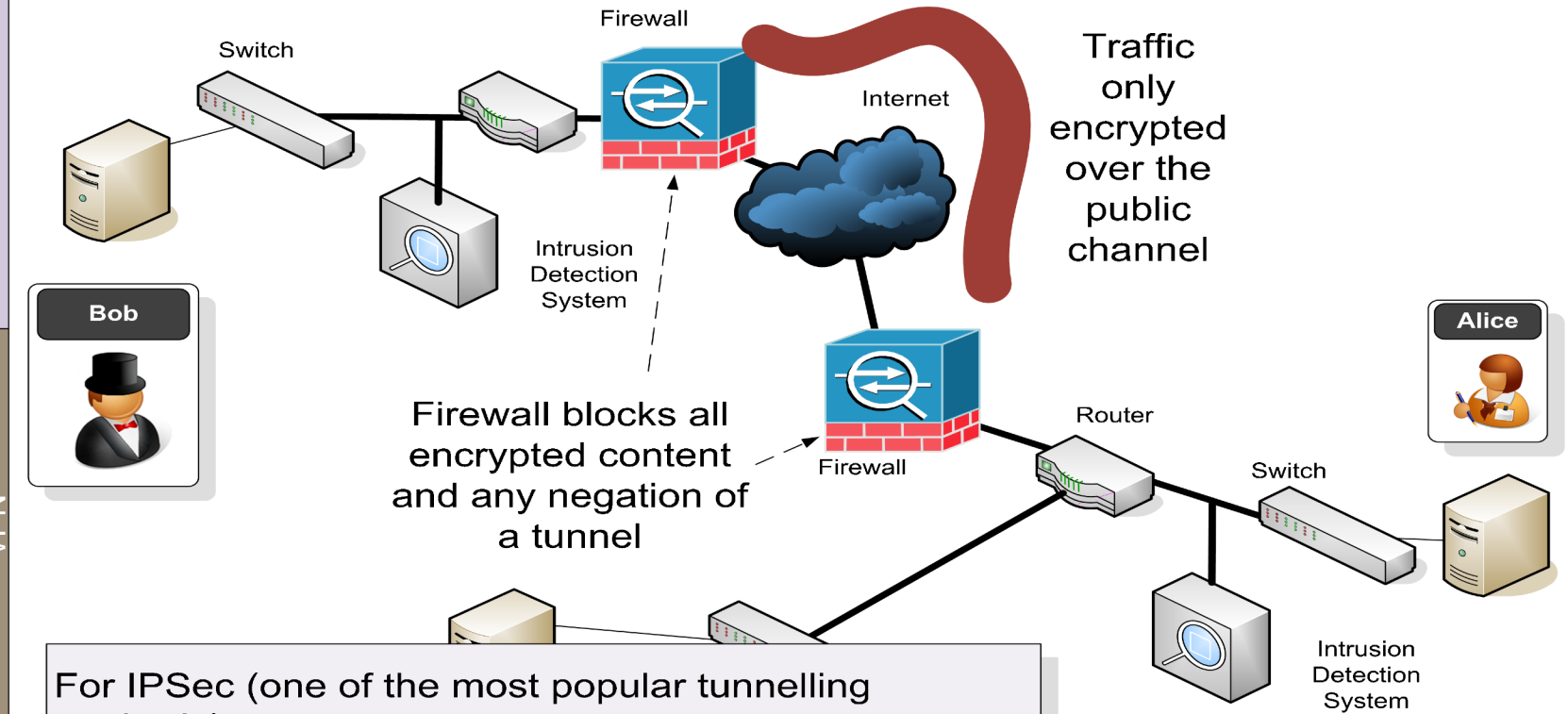
L2TP (Layer 2 Tunneling Protocol). Works at Layer 2 to Forward IP, IPX and AppleTalk (RFC2661). Cisco, Microsoft, Ascent and 3Com developed it. User and machine authentication, but no encryption (but can be used with L2TP over IPSec).

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@
home
Remote
Access VPN
Bob Co.
VPN
Network Security
VPN types



Tunnelling mode or transport mode

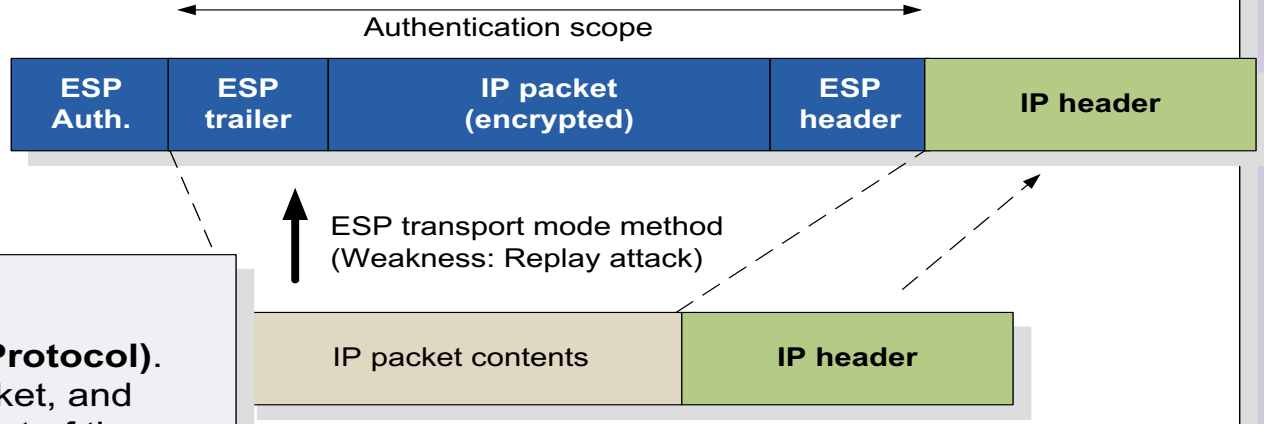


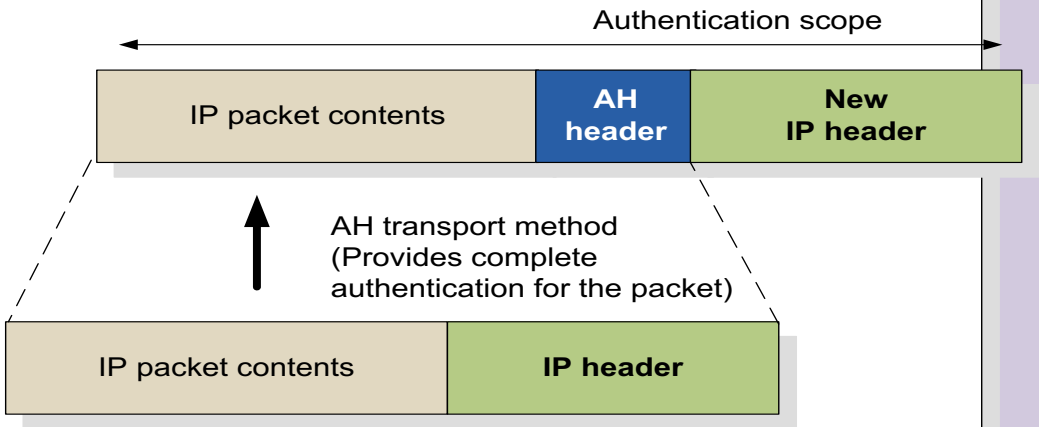
For IPSec (one of the most popular tunnelling methods):

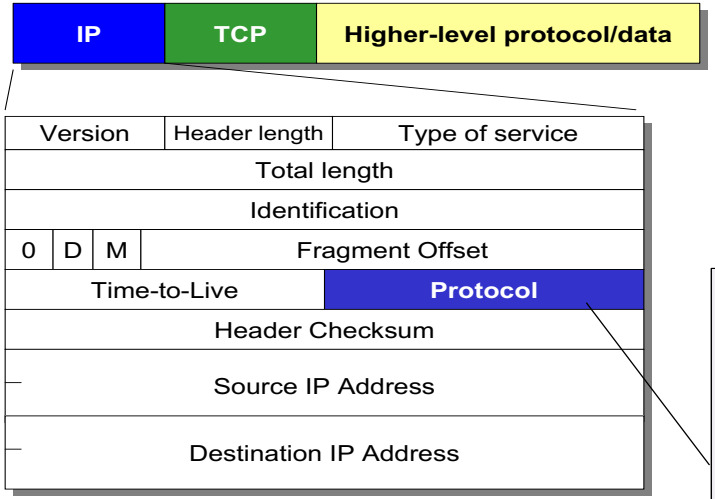
- UDP Port 500 is the key exchange port. If it is blocked there can be no tunnel.
- TCP Port 50 for IPSec ESP (Encapsulated Security Protocol).
- TCP Port 51 for IPSec AH (Authentication Header)

The IPSec protocol has:

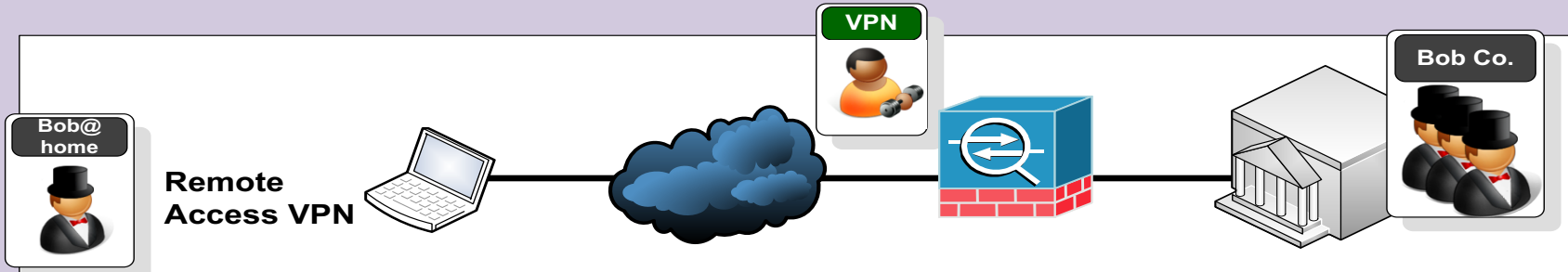
- **ESP (Encapsulated Security Protocol)**. ESP takes the original data packet, and breaks off the IP header. The rest of the packet is encrypted, with the original header added at the start, along with a new ESP field at the start, and one at the end. It is important that the IP header is not encrypted 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
```

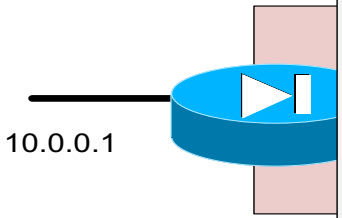
Phase 2

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

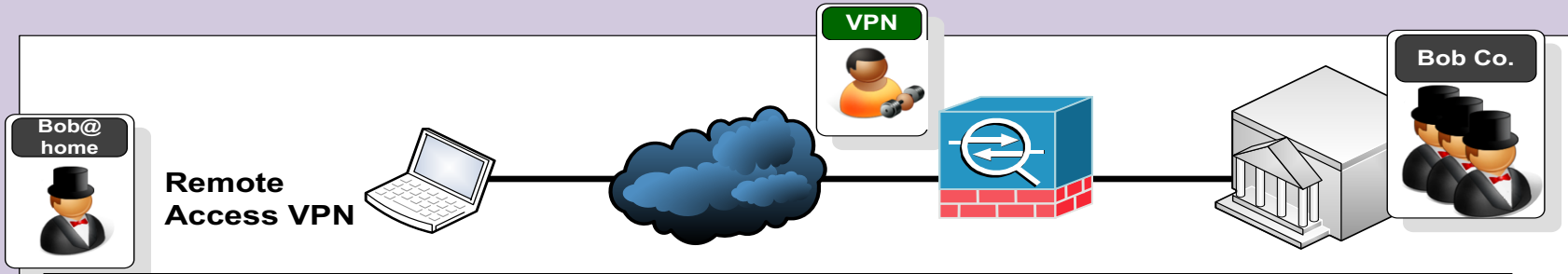
Crypto maps are exchanged

- 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
```

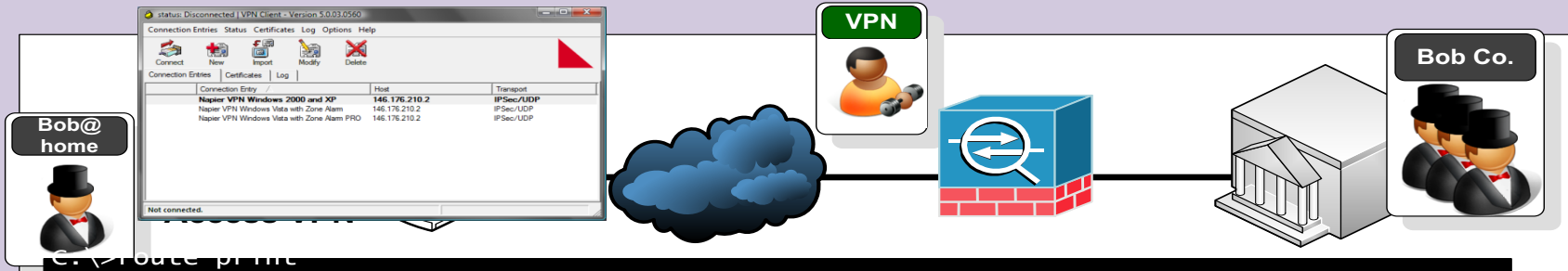



```
No.     Time        Source                Destination           Protocol Info
81 5.237402    192.168.0.3           146.176.210.2         ISAKMP   Aggressive

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
```


Before connecting to the VPN

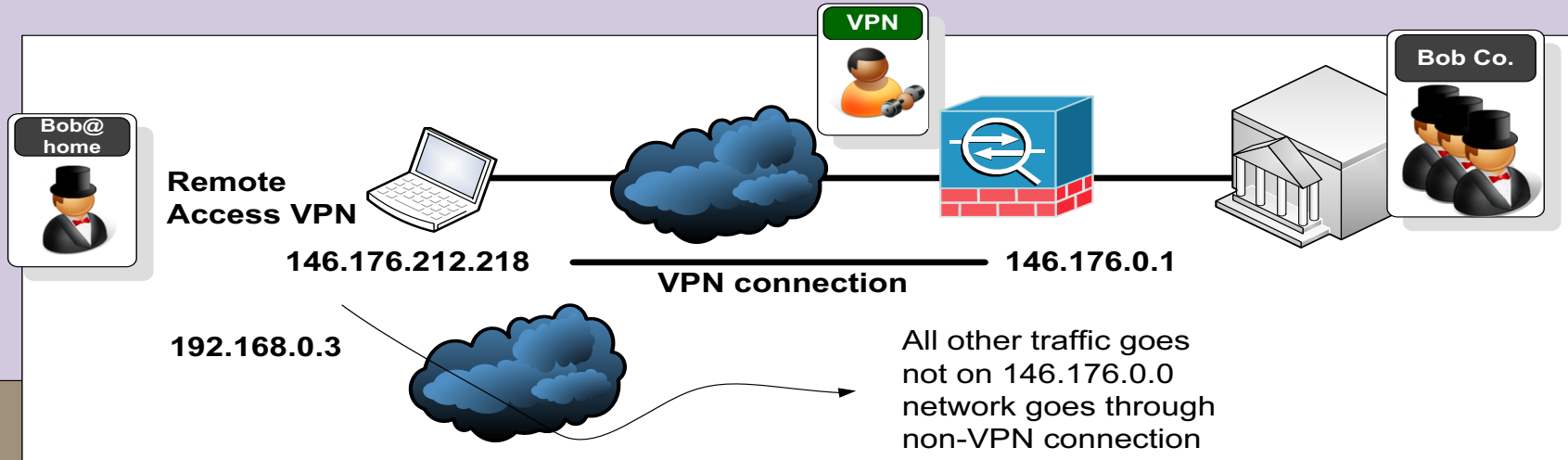


VPN

Network Security

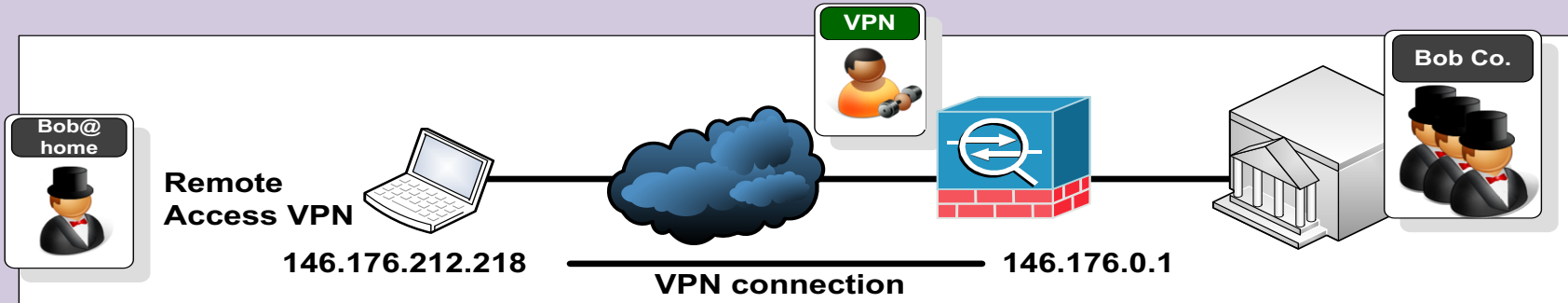
```
C:\>route print
===========================================================================
Interface List
 21 ...00 05 9a 3c 78 00 ......  Cisco Systems VPN Adapter
 10 ...00 1d 09 3f 49 8d ......  Broadcom NetLink (TM) Fast Ethernet
  7 ...00 1f 3c 4f 30 1d ......  Intel(R) PRO/Wireless 3945ABG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

After connecting to the VPN




```
===========================================================================
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

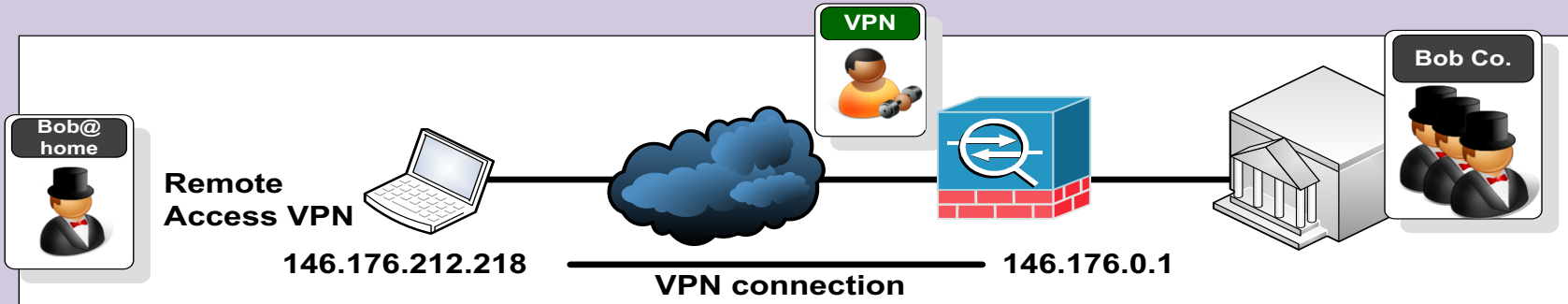



```
C:\>tracert www.napier.ac.uk

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
```

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    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]
```

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]
```

Before VPN connection

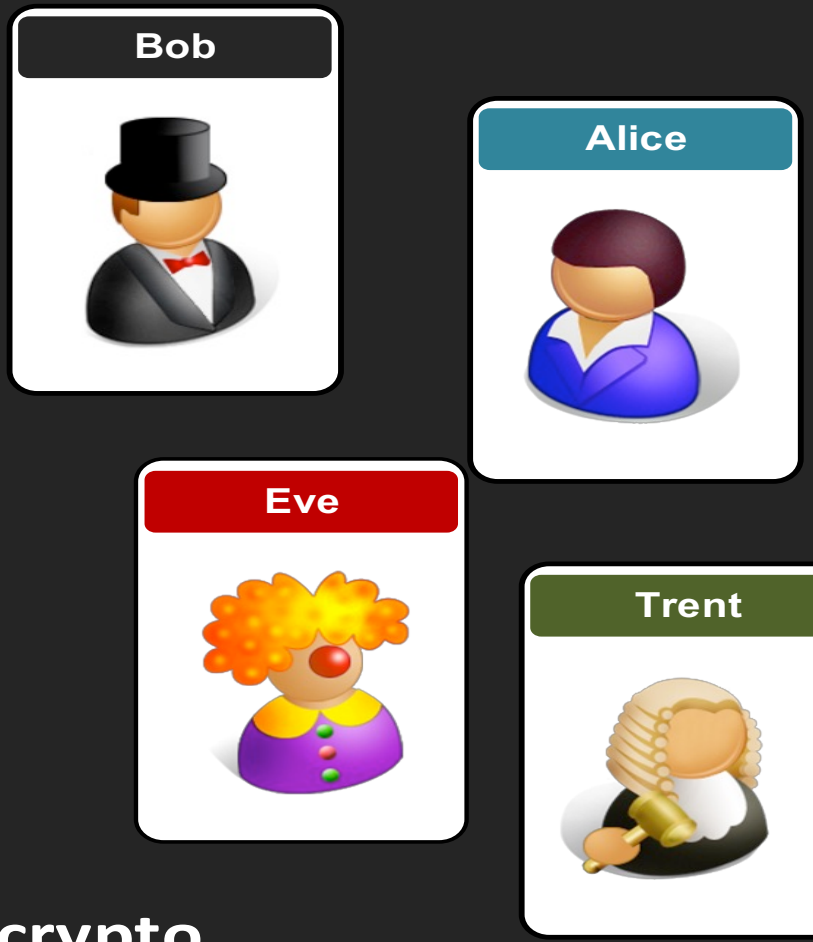
```
C:\>tracert www.intel.com

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

Advanced Crypto

6. Tunnelling

Introduction



http://asecuritysite.com/crypto

Author: Prof Bill Buchanan