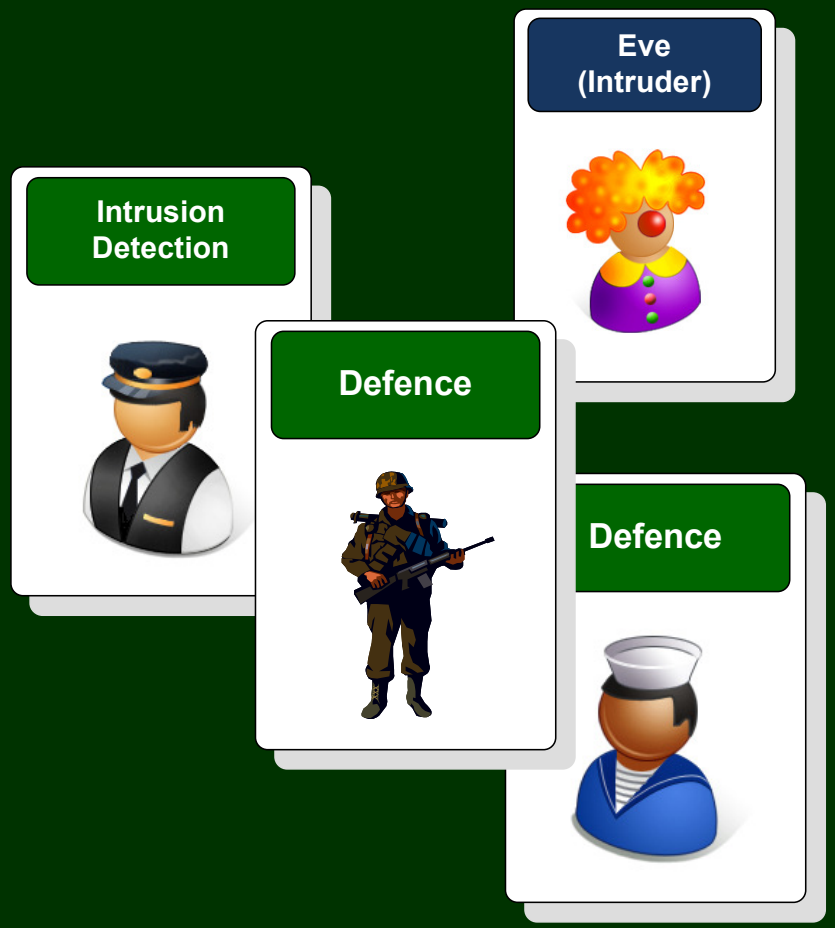
Intrusion Detection Systems

Introduction
Threats
Types
Host or Network?
Agent-based
Snort
A simple rule
A few intrusions
User profiling
Honeypots
IPS
Conclusions



Author: Prof Bill Buchanan

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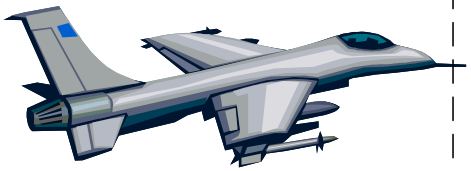
Introduction

IDS

Author: Prof Bill Buchanan

Enemy takes some time to breach each of the levels of defence

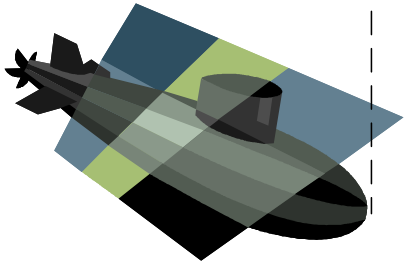


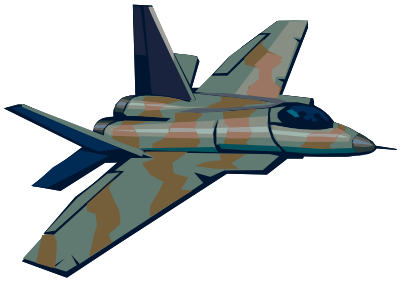
Defence

Defence

Defence

Defence





Forth-level defence

Third-level defence

Second-level defence

First-level defence

Author: Prof Bill Buchanan

Trusted (our side)

DMZ – an area where military actions are prohibited

Untrusted (their side)

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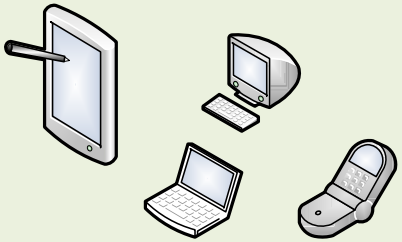
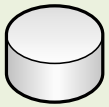
Users

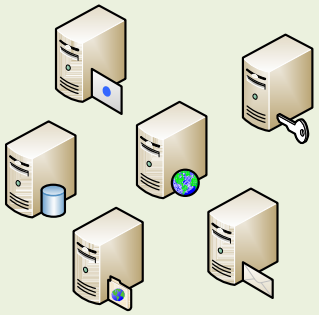


Assets

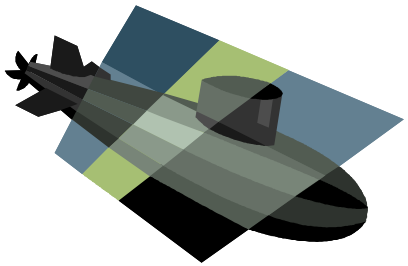


Hello. How are you? Is this okay?

Data



Systems



Even with the best defences, intruders can penetrate them

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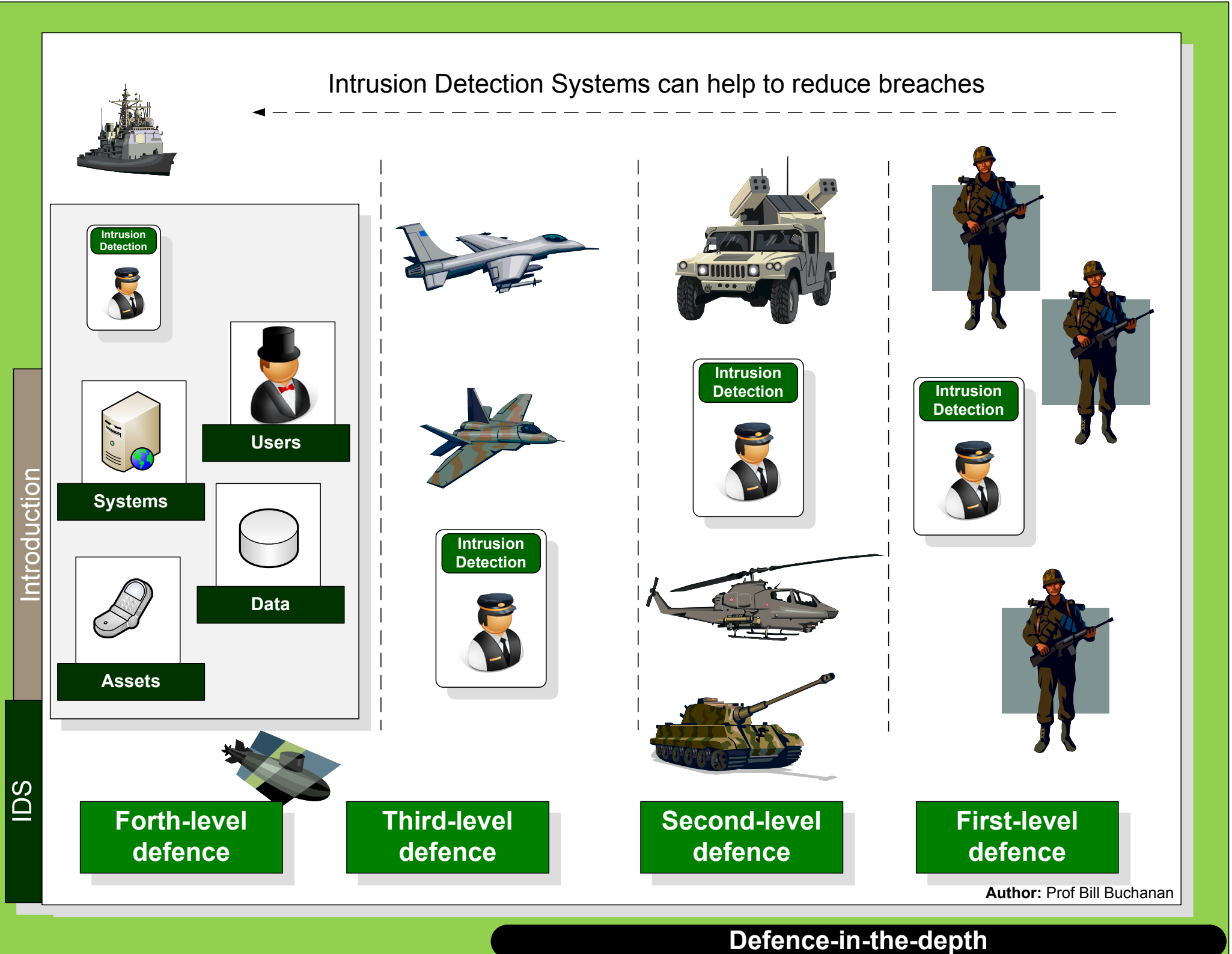
Intrusion Detection Systems can help to reduce breaches
Intrusion Detection
Users
Systems
Data
Assets
Intrusion Detection
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Forth-level defence
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Second-level defence
First-level defence
Author: Prof Bill Buchanan
Defence-in-the-depth

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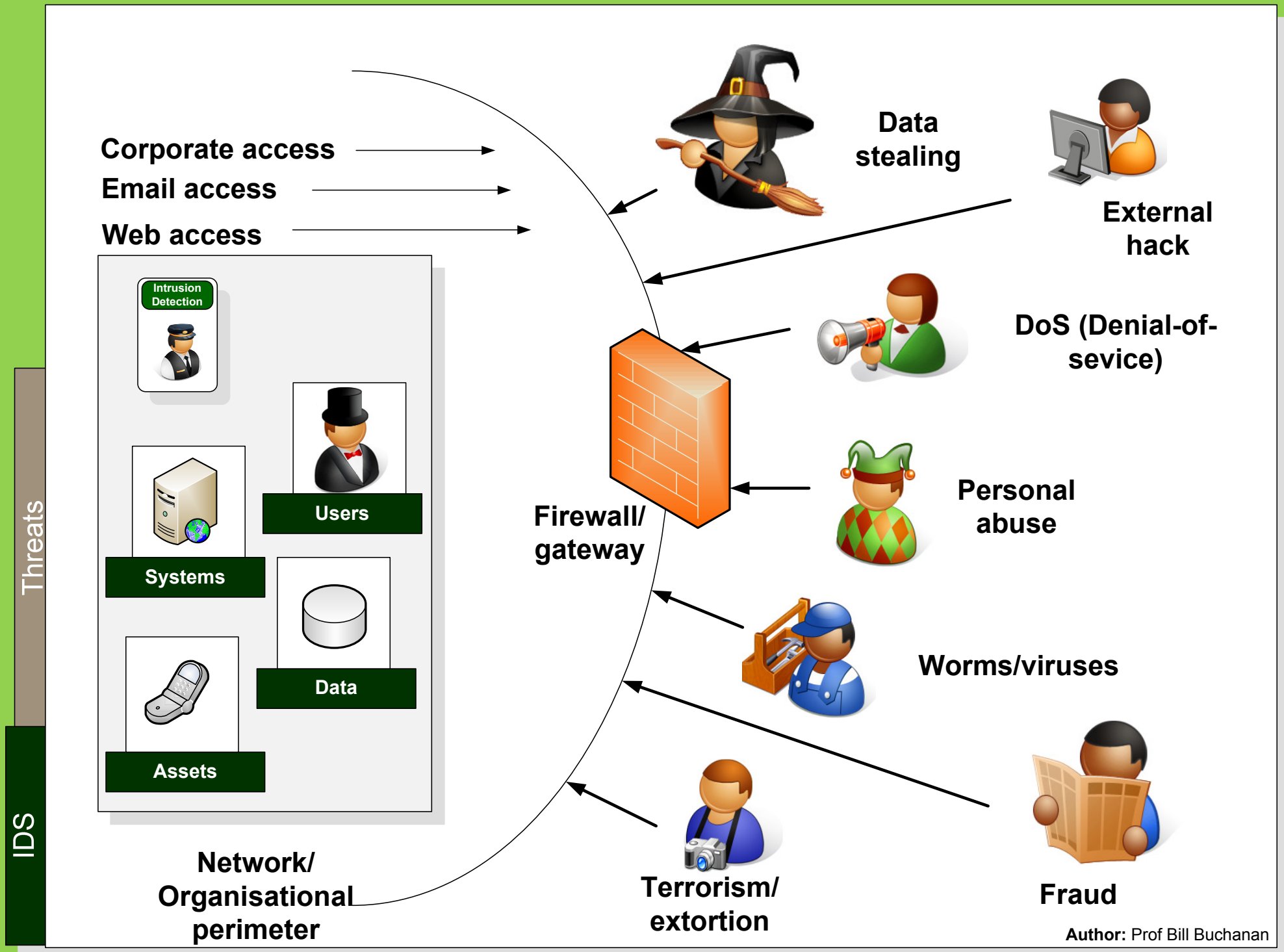
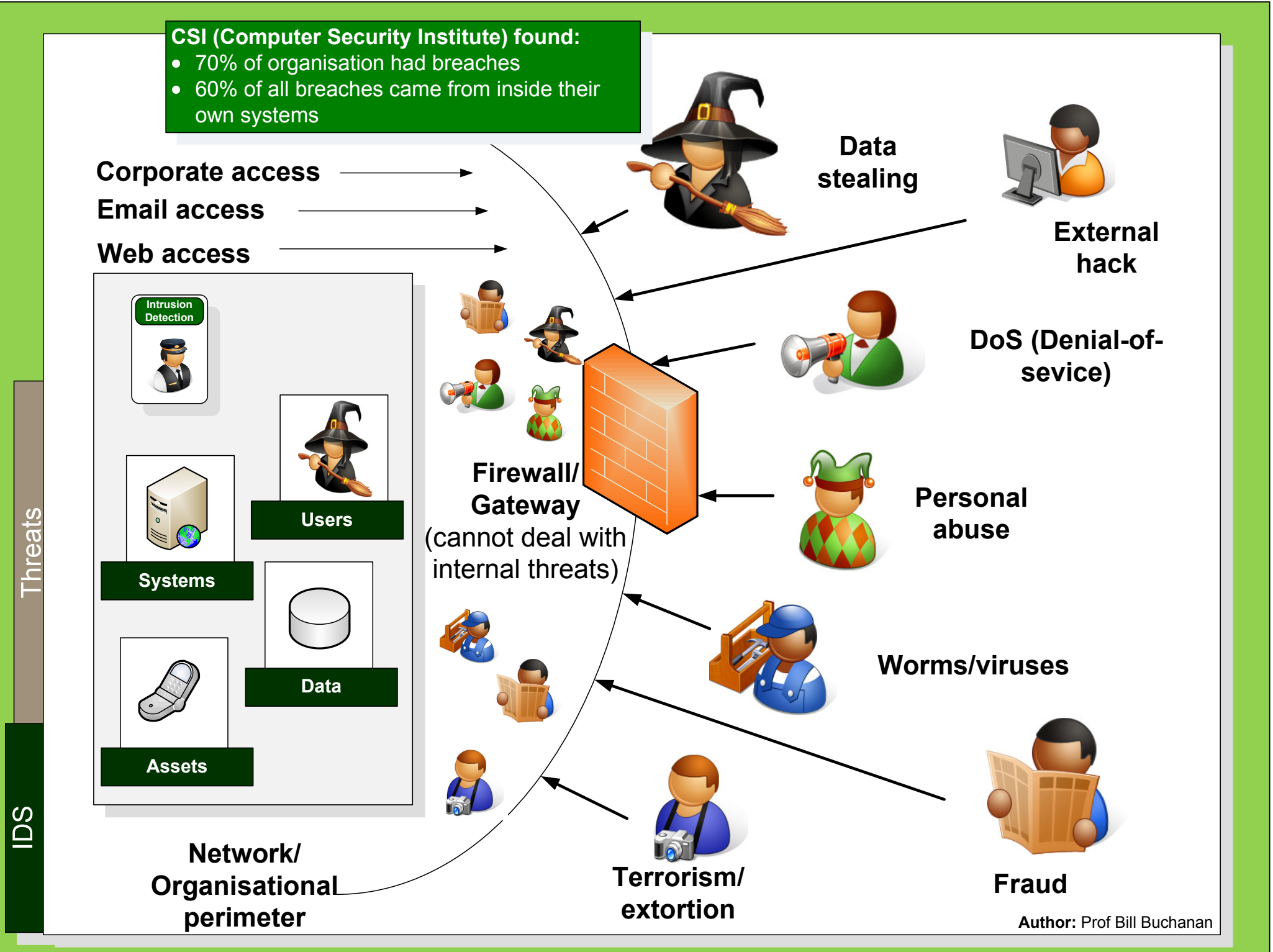


Outside threats

CSI (Computer Security Institute) found:

- 70% of organisation had breaches
- 60% of all breaches came from inside their own systems



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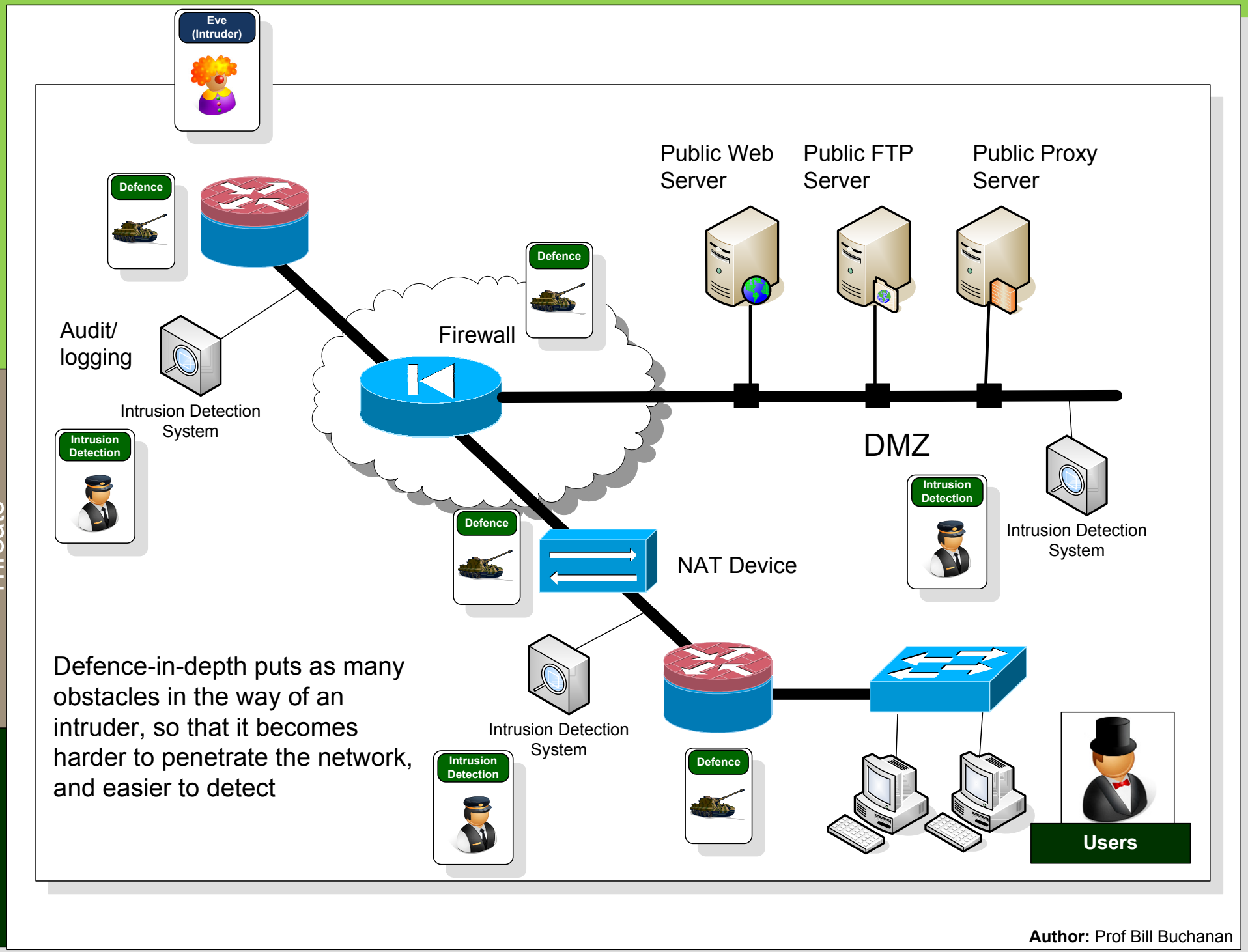
Internal threats (often a great threat than from outside)



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Defence-in-depth (multiple obstacles)

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Types

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Misuse Detection
This attempts to model attacks on a system as specific patterns, and then scans for occurrences of these. Its disadvantage is that it struggles to detect new attacks.

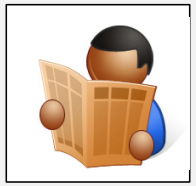
Anomaly Detection.
This assumes that abnormal behaviour by a user can be correlated with an intrusion. Its advantage is that it can typically react to new attacks, but can often struggle to detect variants of known attacks, particularly if they fit into the normal usage pattern of a user. Another problem is that the intruder can mimic the behavioural pattern of the user.

Viruses/Worms

External hack (scripting)

Denial-of-Service

Personal abuse



Fraud

External hack (human)

Data stealing

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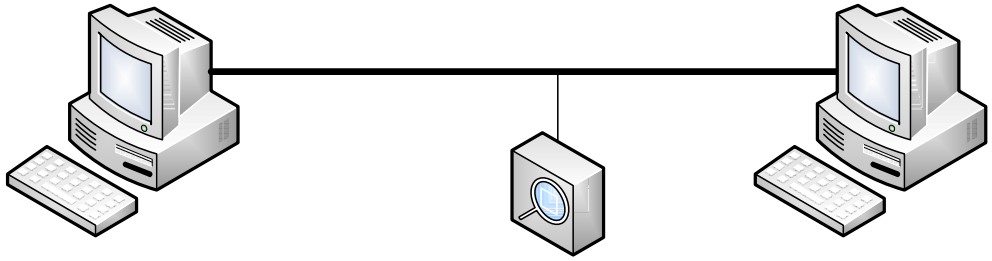
IDS types

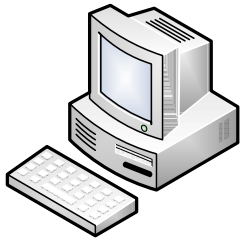


Network intrusion detection systems (NIDS)

These **monitor packets** on the network and tries to determine an intrusion. This is either host base (where it runs on a host), or can listen to the network using a hub, router or probe.

System Integrity Verifier

These **monitor system files** to determine if an intruder has changed them (a backdoor attack). A good example of this is **Tripwire**. It can also watch other key system components, such as the Windows registry and root/ administrator level privileges.

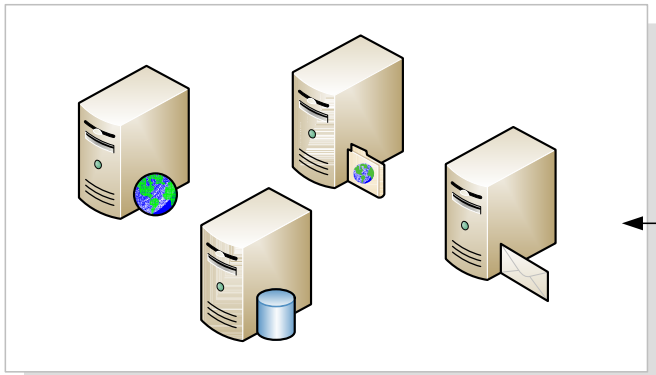


User profiling

```
29/05/2008  19:57          603 zhp1020.log
04/08/2007  12:00      337,920 zipfldr.dll
21/07/2008  03:00      102,400 zLhp1020.dll
13/03/2008  15:46       53,248 zlib.dll
21/07/2008  03:00       28,672 zlm.dll
```

Log file monitors (LFM)

These monitor **log files** which are generated by network services, and look for key patterns of change. **Swatch** is a good example.

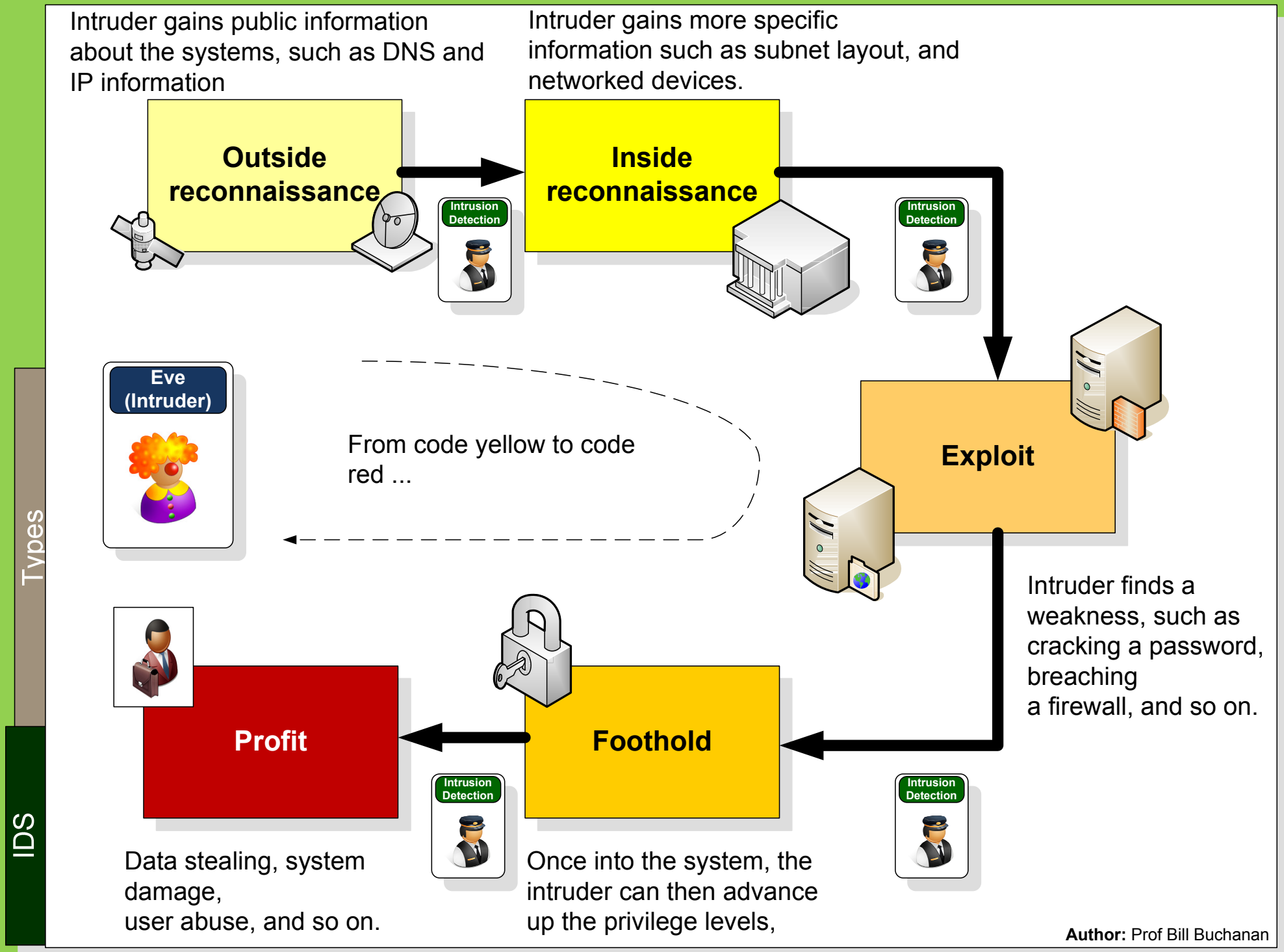


Types

IDS

Author: Prof Bill Buchanan

IDS Types

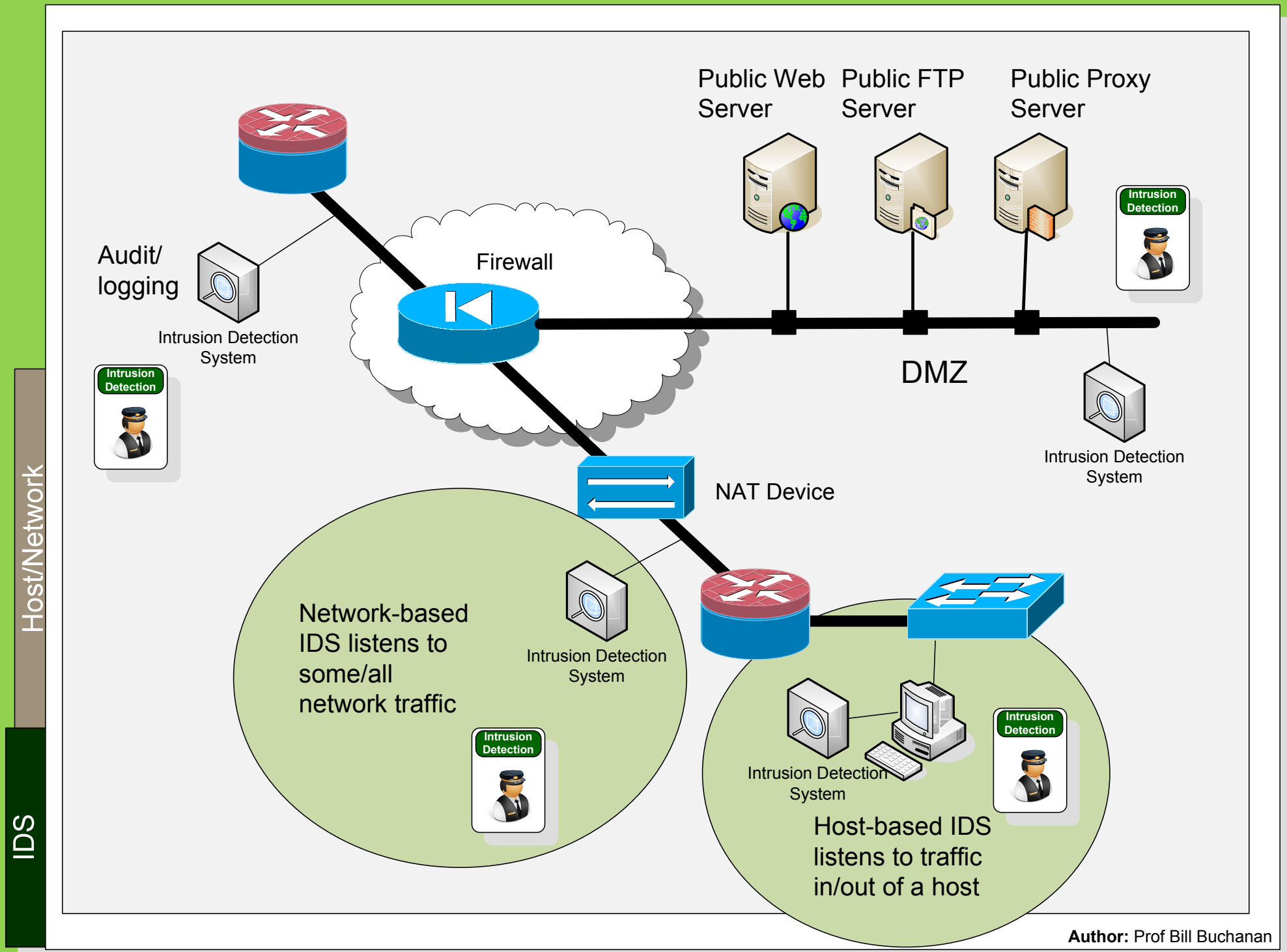


Typical pattern of intrusion ...

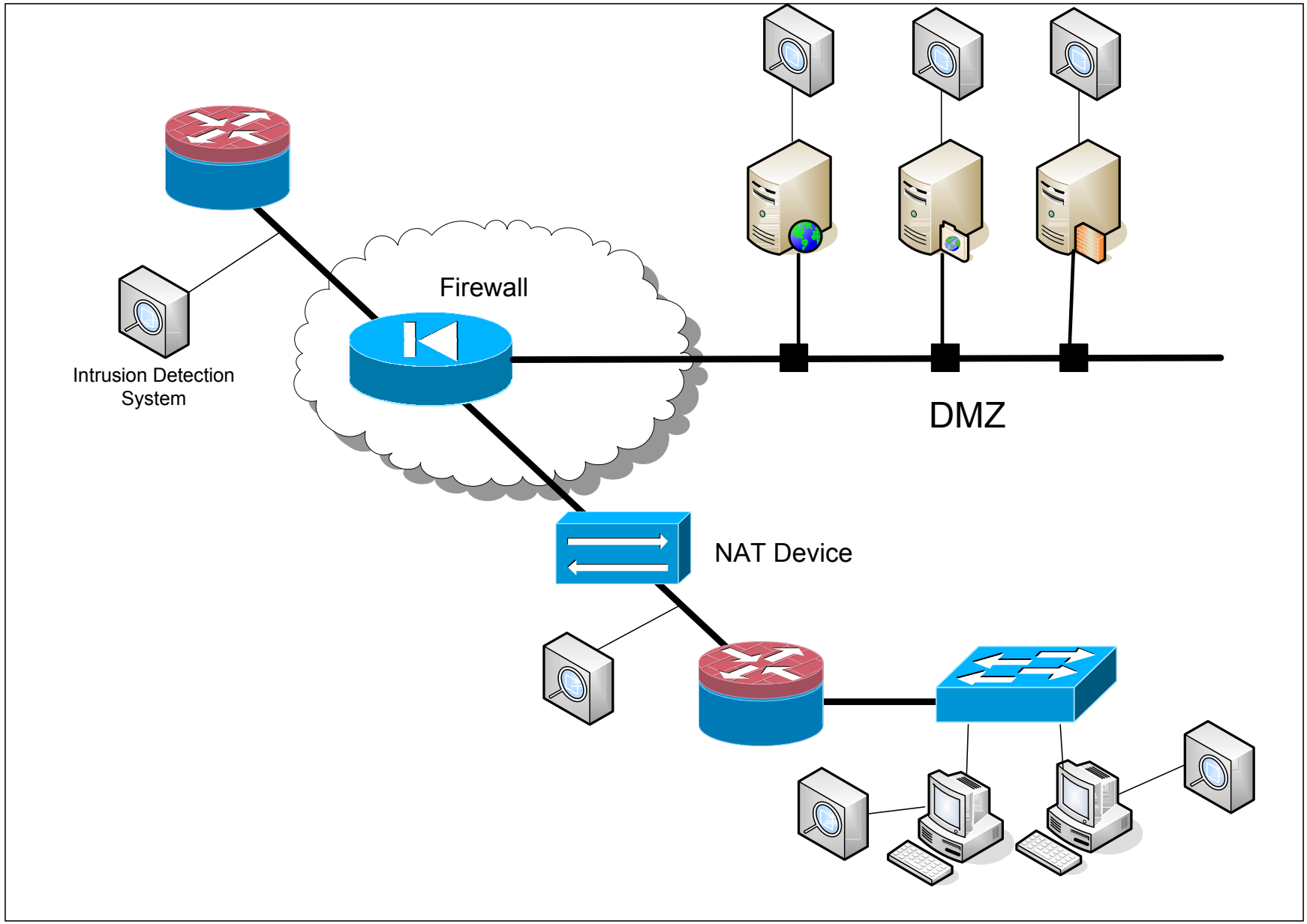
Intrusion Detection Systems

Host or Network?

Author: Prof Bill Buchanan



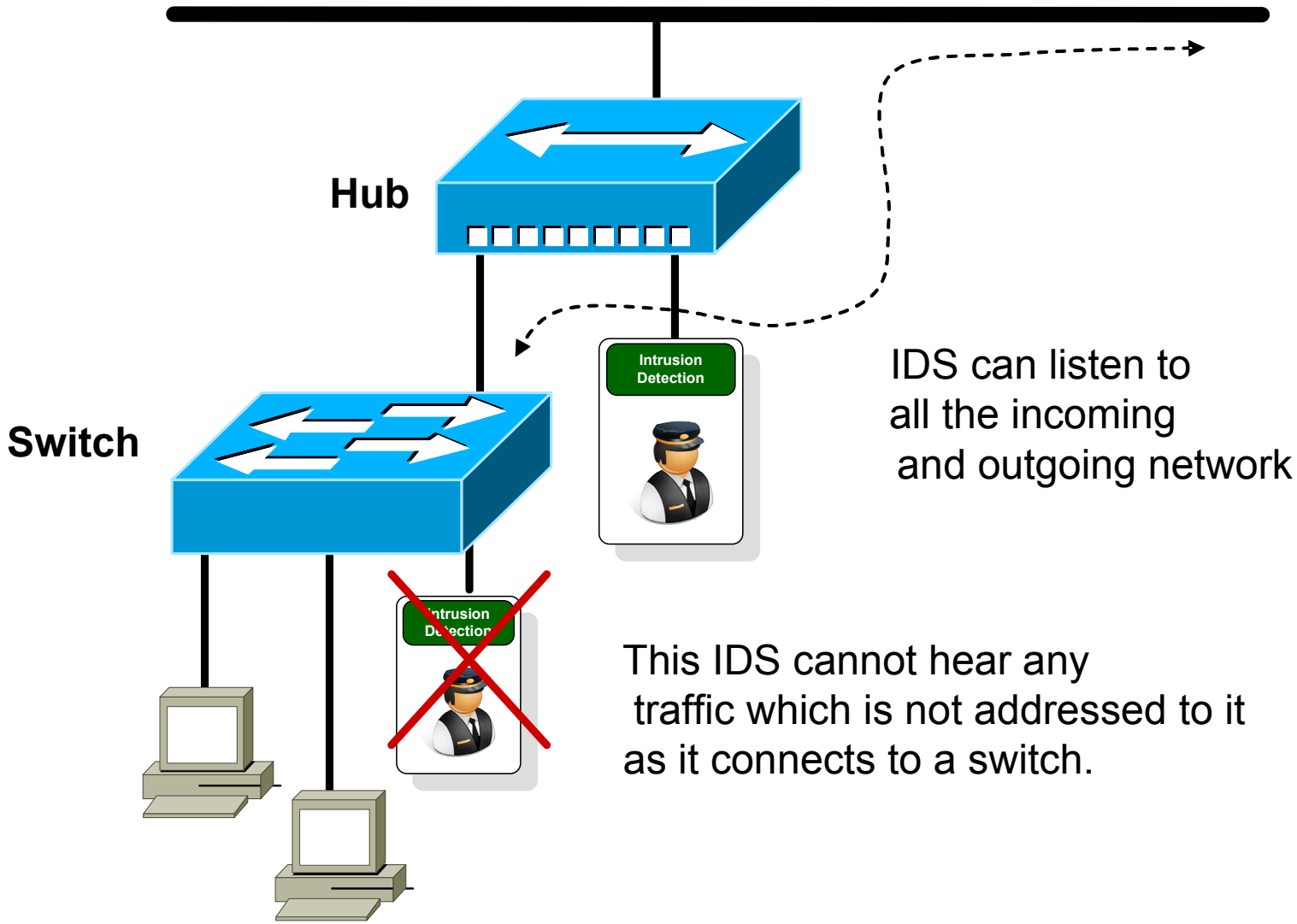
Host or network?



Host/Network

IDS

Author: Prof Bill Buchanan



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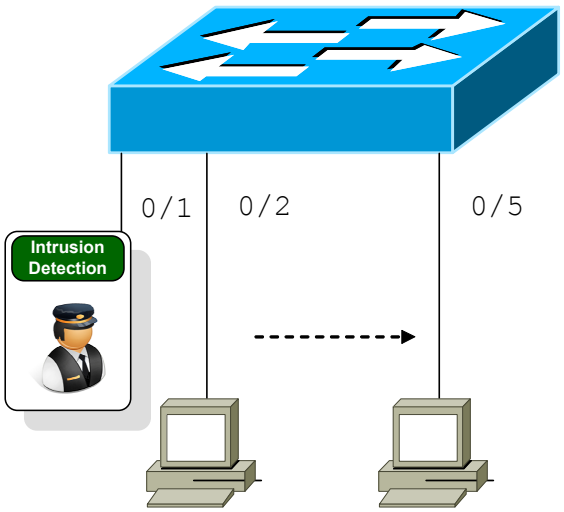
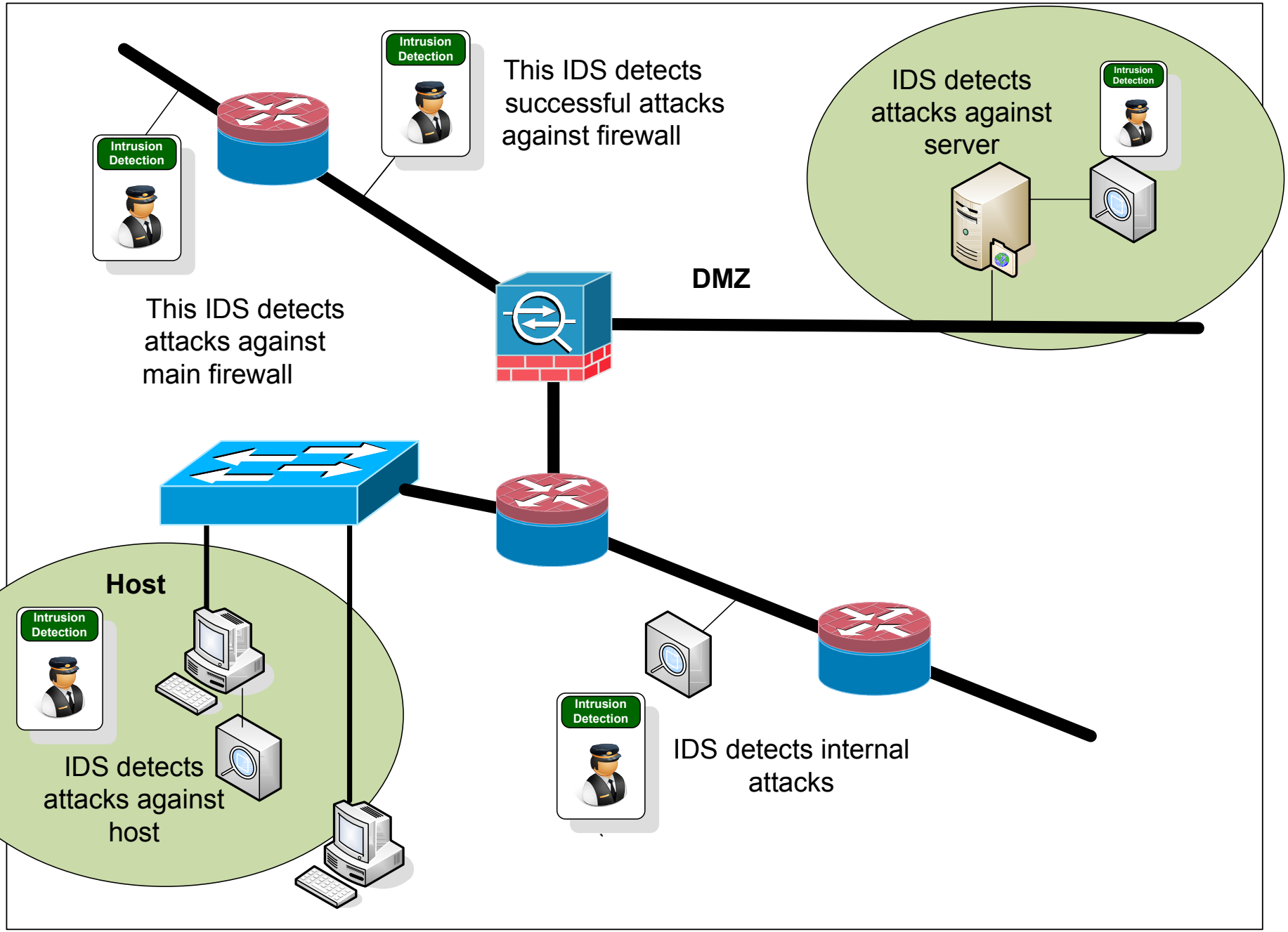
IDS location




```
interface FastEthernet0/1
 port monitor FastEthernet0/2
 port monitor FastEthernet0/5
 port monitor VLAN2
!
interface FastEthernet0/2
!
interface FastEthernet0/3
 switchport access vlan 2
!
interface FastEthernet0/4
 switchport access vlan 2
!
interface FastEthernet0/5
!
interface VLAN1
 ip address 192.168.0.1 255.255.255.0
 no ip directed-broadcast
 no ip route-cache
!
```

Author: Prof Bill Buchanan

Using the span port



Host/Network

IDS

Author: Prof Bill Buchanan

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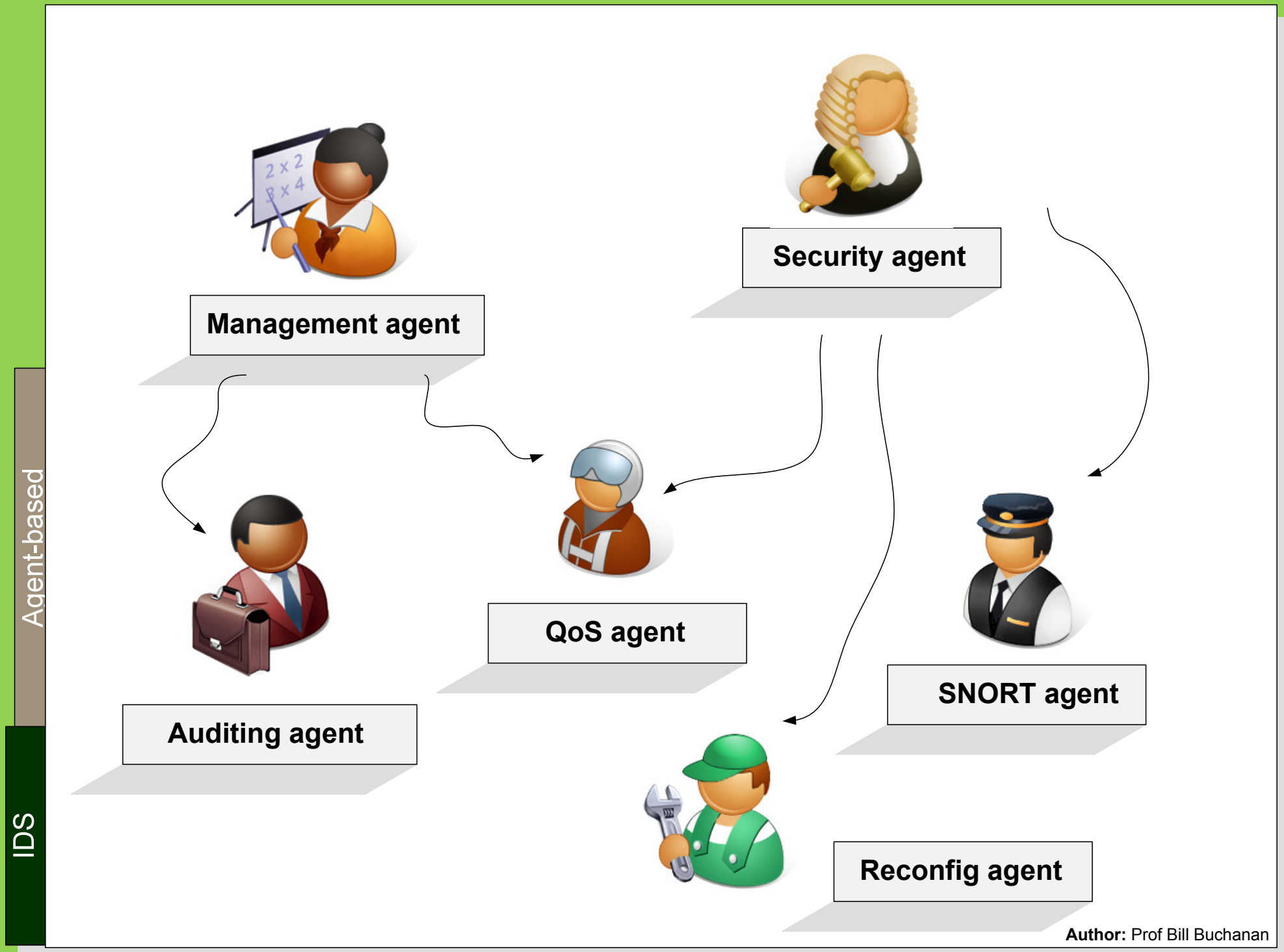
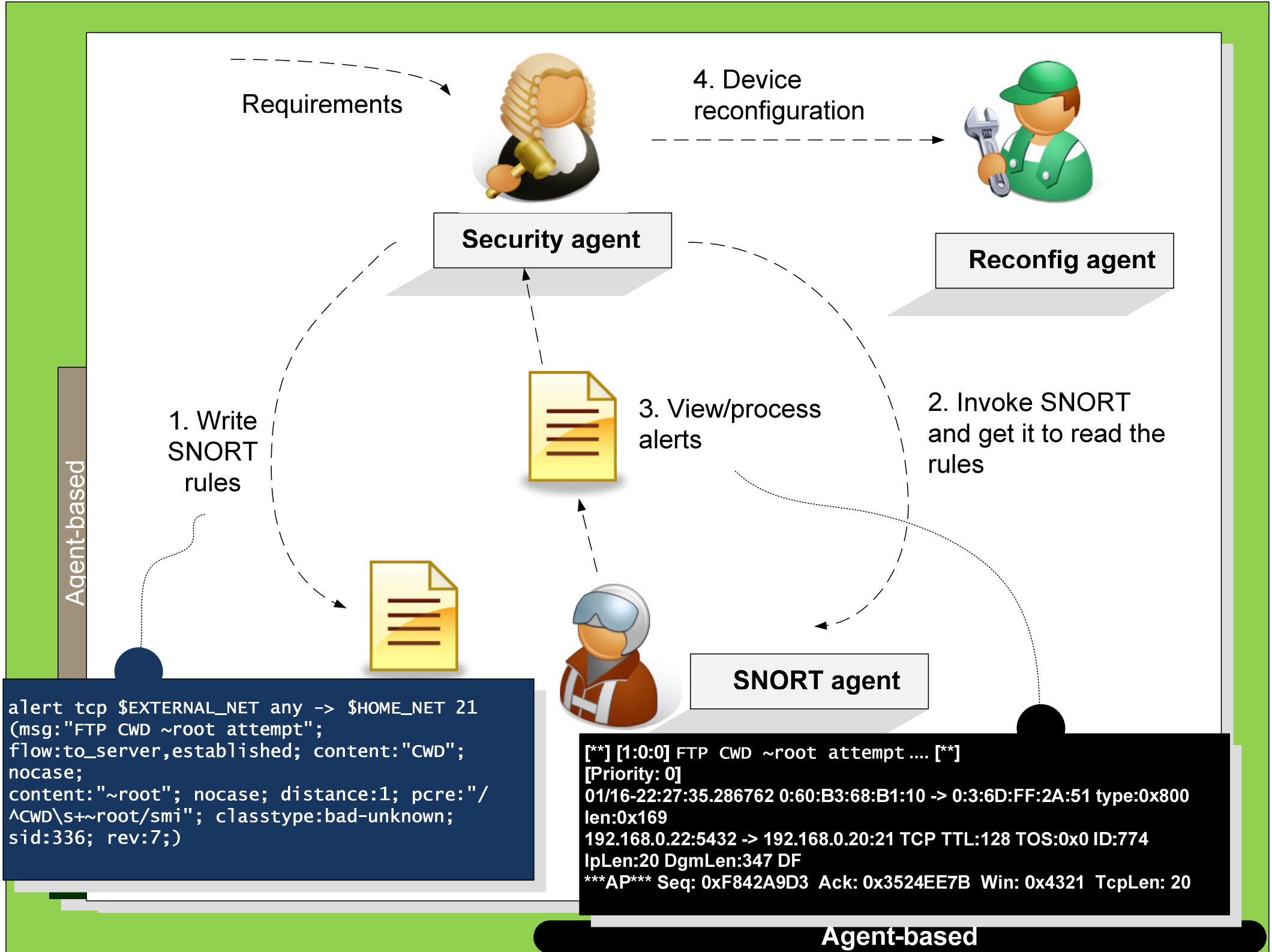
Agent-based

Author: Prof Bill Buchanan



Agent-based system allows for distributed security


Requirements
4. Device reconfiguration
Security agent
Reconfig agent
1. Write SNORT rules
3. View/process alerts
2. Invoke SNORT and get it to read the rules
Agent-based
SNORT agent
alert tcp $EXTERNAL_NET any -> $HOME_NET 21
(msg:"FTP CWD ~root attempt";
flow:to_server,established; content:"CWD";
nocase;
content:"~root"; nocase; distance:1; pcre:"/
^CWD\s+~root/smi"; classtype:bad-unknown;
sid:336; rev:7;)
[**] [1:0:0] FTP CWD ~root attempt .... [**]
[Priority: 0]
01/16-22:27:35.286762 0:60:B3:68:B1:10 -> 0:3:6D:FF:2A:51 type:0x800
len:0x169
192.168.0.22:5432 -> 192.168.0.20:21 TCP TTL:128 TOS:0x0 ID:774
IpLen:20 DgmLen:347 DF
AP Seq: 0xF842A9D3 Ack: 0x3524EE7B Win: 0x4321 TcpLen: 20
Agent-based

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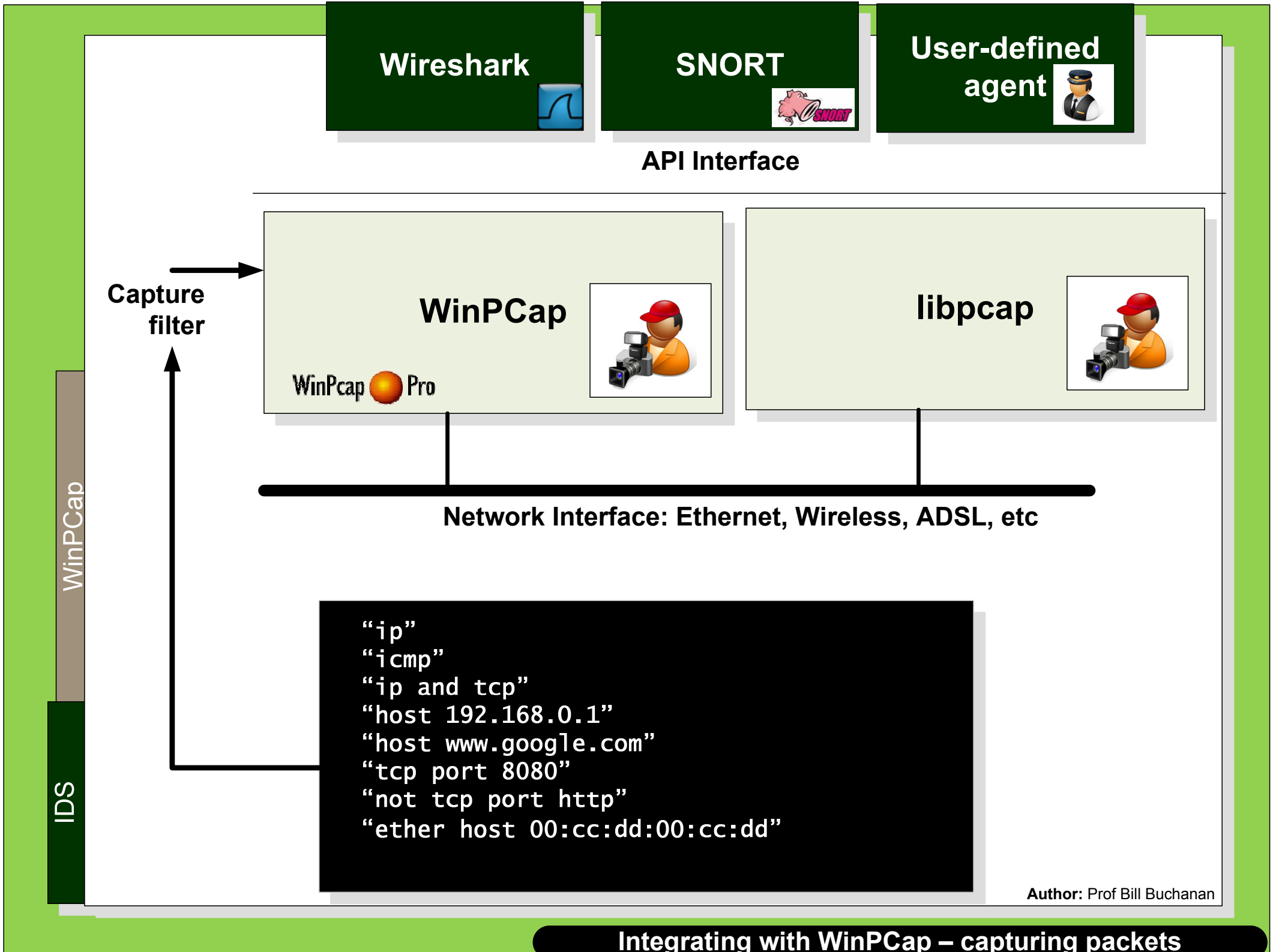
WinPCap

Author: Prof Bill Buchanan



Integrating with WinPCap – capturing packets

```
"ip"
"icmp"
"ip and tcp"
"host 192.168.0.1"
"host www.google.com"
"tcp port 8080"
"not tcp port http"
"ether host 00:cc:dd:00:cc:dd"
```

Capture filter

User-defined agent

API Interface

Tamir Code Wrapper (.NET interface)

WinPCap

WinPcap Pro

WinPCap

IDS

Network Interface: Ethernet, Wireless, ADSL, etc

Author: Prof Bill Buchanan

Integrating with WinPCap – capturing packets

```
using System;
using Tamir.IPLib;
namespace NapierCapture
{
   public class ShowDevices
   {
      public static void Main(string[] args)
      {
         string verWinPCap =null;
         int count=0;
         verWinPCap= Tamir.IPLib.Version.GetVersionString();
         PcapDeviceList getNetConnections = SharpPcap.GetAllDevices();
         Console.WriteLine("WinPCap Version: {0}", verWinPCap);
         Console.WriteLine("Connected devices:\r\n");
         foreach(PcapDevice net in getNetConnections)
         {
            Console.WriteLine("{0}) {1}",count,net.PcapDescription);
            Console.WriteLine("\tName:\t{0}",net.PcapName);
            Console.WriteLine("\tMode:\t\t\t{0}",net.PcapMode);
            Console.WriteLine("\tIP Address: \t\t{0}",net.PcapIpAddress);
            Console.WriteLine("\tLoopback: \t\t{0}",net.PcapLoopback);
            Console.WriteLine();
            count++;
         }
         Console.Write("Press any <RETURN> to exit");
         Console.Read();
      }
   }
```

WinPCap

```
WinPCap Version: 1.0.2.0
Connected devices:

0) Realtek RTL8169/8110 Family Gigabit Ethernet NIC
    (Microsoft's Packet Scheduler)
        Name:    \Device\NPF_{A22E93C1-A78D-4AFE-AD2B-517889CE42D7}
        Mode:                    Capture
        IP Address:              192.168.2.1
        Loopback:                False

1) Intel(R) PRO/Wireless 2200BG Network Connection (Microsoft's Packet Scheduler)
        Name:    \Device\NPF_{044B069D-B90A-4597-B99E-A68C422D5FE3}
        Mode:                    Capture
        IP Address:              192.168.1.101
        Loopback:                False
```

Tamir Code Wrapper (.NET interface)

WinPCap

WinPcap Pro

Author: Prof. Bill Buchanan

rating with WinPCap – showing the interface

```
namespace NapierCapture
{
   public class CapturePackets
   {
      public static void Main(string[] args)
      {
         PcapDeviceList getNetConnections = SharpPcap.GetAllDevices();

         NetworkDevice netConn = (NetworkDevice)getNetConnections[1];
         PcapDevice device = netConn;
         device.PcapOnPacketArrival +=
         new SharpPcap.PacketArrivalEvent(device_PcapOnPacketArrival);
         Console.WriteLine("Network connection: {0}",
            device.PcapDescription);
         device.PcapStartCapture();
         Console.Write("Press any <RETURN> to exit");
         Console.Read();
         device.PcapStopCapture();
         device.PcapClose();
      }
      private static void device_PcapOnPacketArrival(object sender,
                                                     Packet packet)
      {
         DateTime time = packet.PcapHeader.Date;
         int len = packet.PcapHeader.PacketLength;
         Console.WriteLine("{0}:{1}:{2},{3} Len={4}",time.Hour,
          time.Minute, time.Second, time.Millisecond, len);
      }
   }
}
```

WinPCap

```
13:17:56,990 Len=695
13:17:57,66 Len=288
13:17:57,68 Len=694
13:18:4,363 Len=319
13:18:4,364 Len=373
13:18:4,364 Len=371
13:18:4,365 Len=375
13:18:4,366 Len=367
```

Tamir Code Wrapper (.NET interface)

WinPCap

WinPcap Pro

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Snort

Author: Prof Bill Buchanan

Other tools:
Tcptrace. Identity TCP streams.
Tcpflow. Reconstruct TCP streams.

SNORT rules file

SNORT agent

Event data

Log data

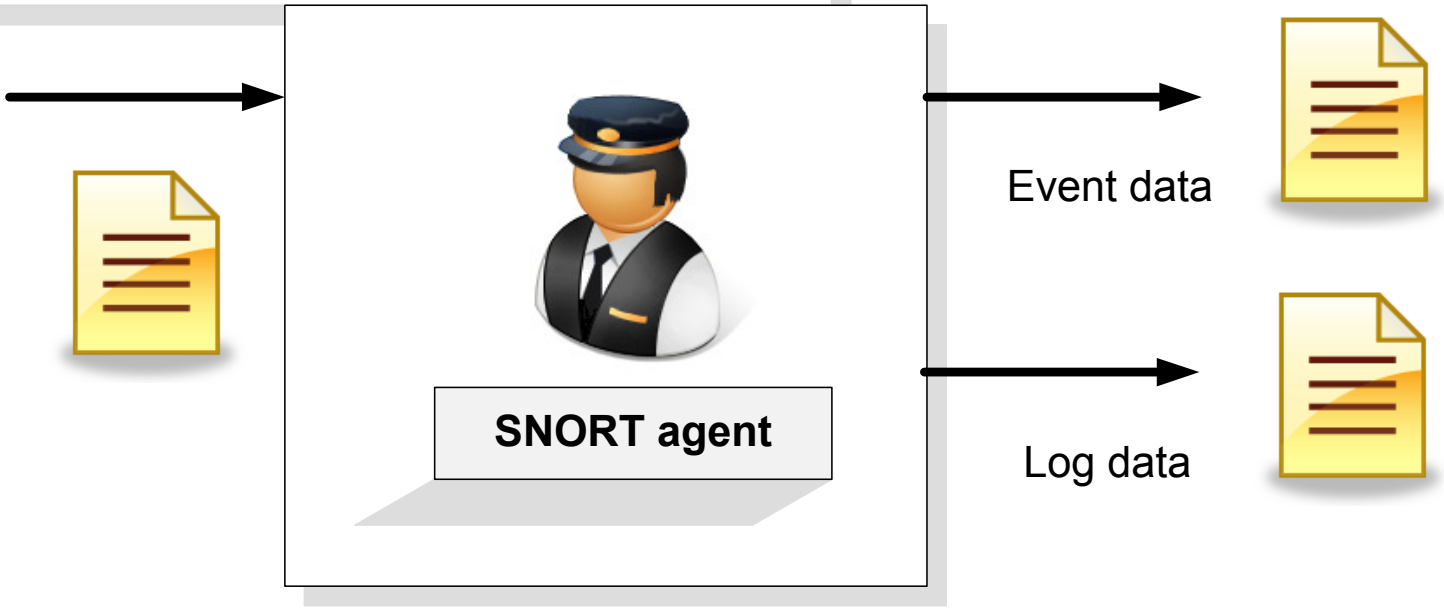
Signature detection.
Identify well-known patterns of attack.

Anomaly detection.
Statistical anomalies, such as user logins, changes to files, and so on.

Author: Prof Bill Buchanan

alert tcp any any -> 192.168.1.0/24 111 (content:"|00 01 86 a5|"; msg:"mountd access";)

`alert`	Generate an alert and log packet
`log`	Log packet
`pass`	Ignore the packet
`activate`	Alert and activate another rule
`Dynamic`	Remain idle until activated by an activate rule



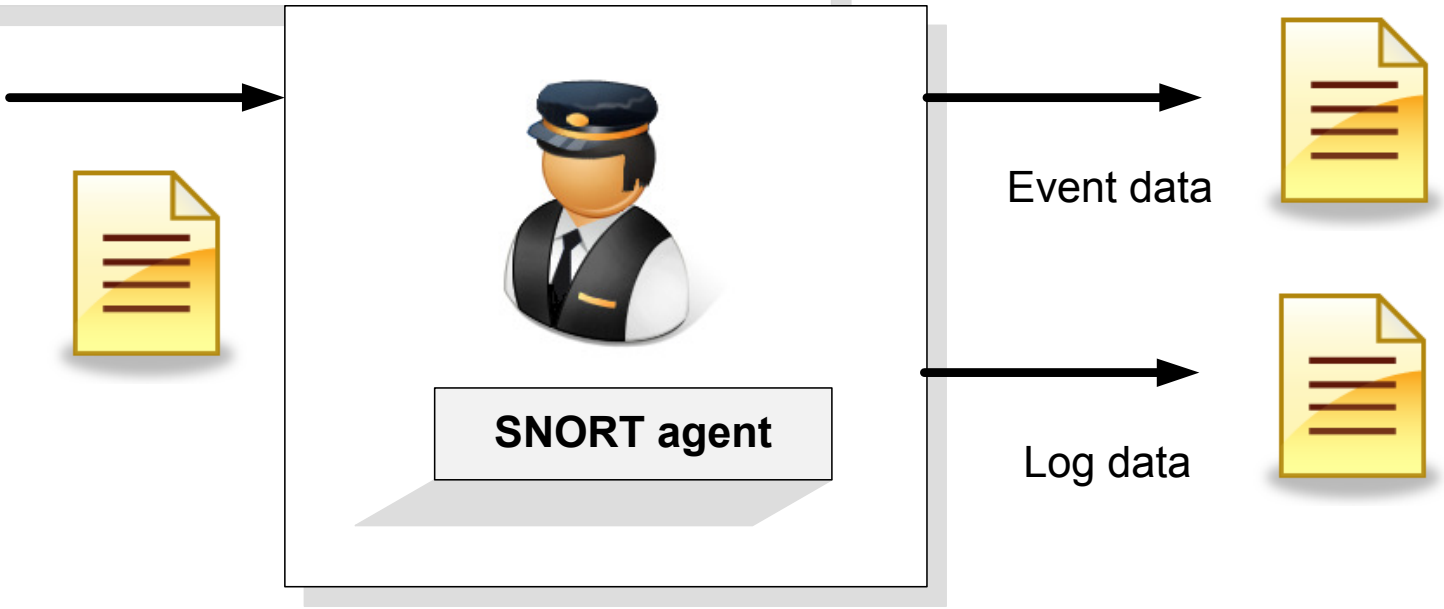
Snort

IDS

Author: Prof Bill Buchanan

```
alert tcp any any -> 192.168.1.0/24 111 (content:"|00 01 86 a5|"; msg:"mountd access";)
```

[Source IP] [Port] [Destination IP] [Port]



Snort

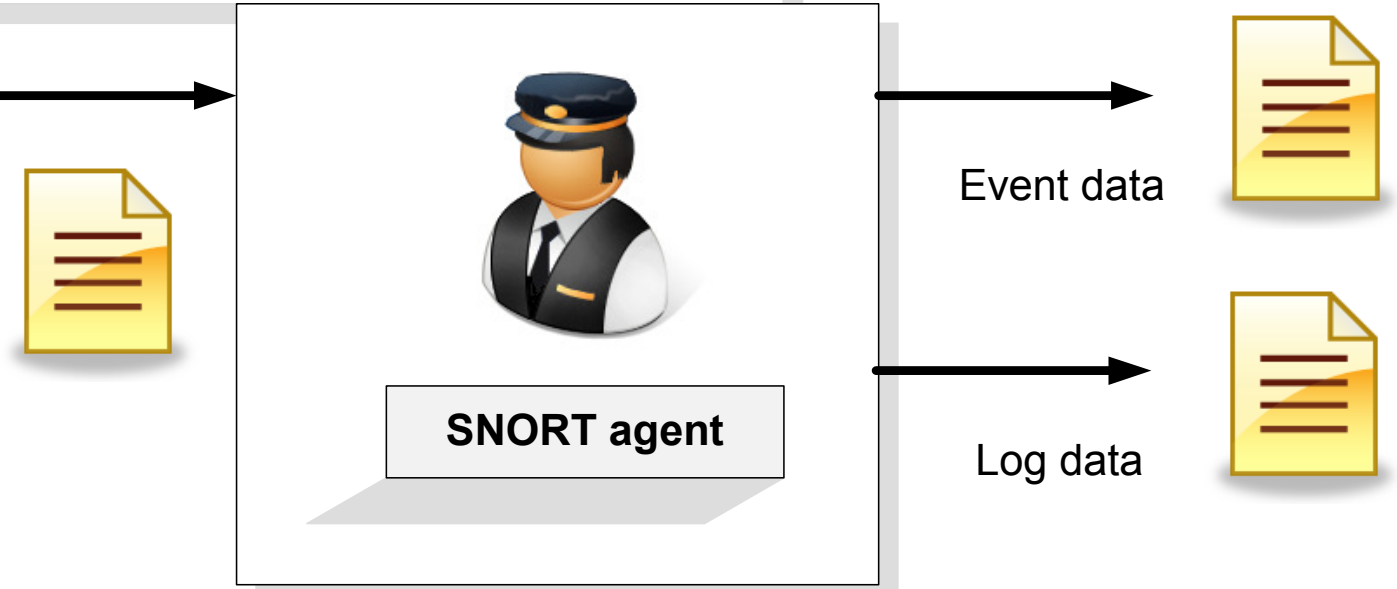
IDS

Author: Prof Bill Buchanan

alert tcp any any -> 192.168.1.0/24 111 (content:"|00 01 86 a5|"; msg:"mountd access";)

Payload detection:
Hex sequence `"|00 01 86 a5|"`
Text sequence `"USER root"`

Modifiers:
rawbytes
offset
distance
within
uricontent
bytejump



Snort

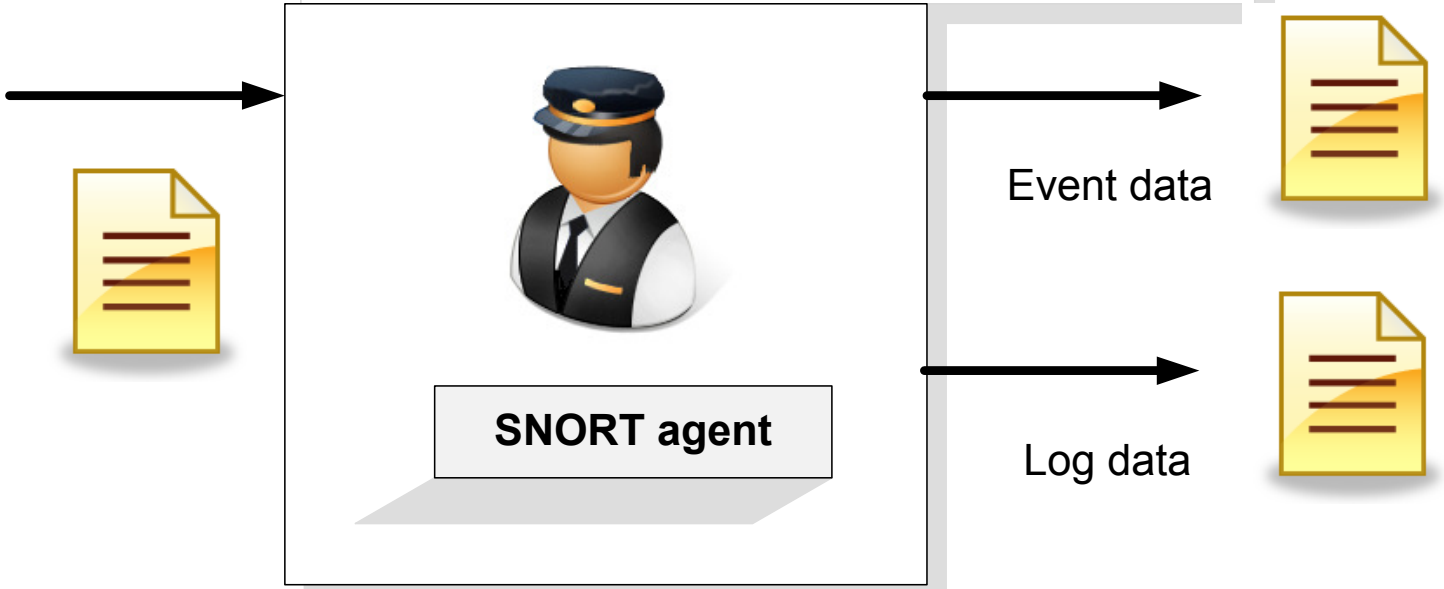
IDS

Author: Prof Bill Buchanan

Payload detection

```
alert tcp any any -> 192.168.1.0/24 111 (content:"|00 01 86 a5|"; msg:"mountd access";)
```

Message-to-display

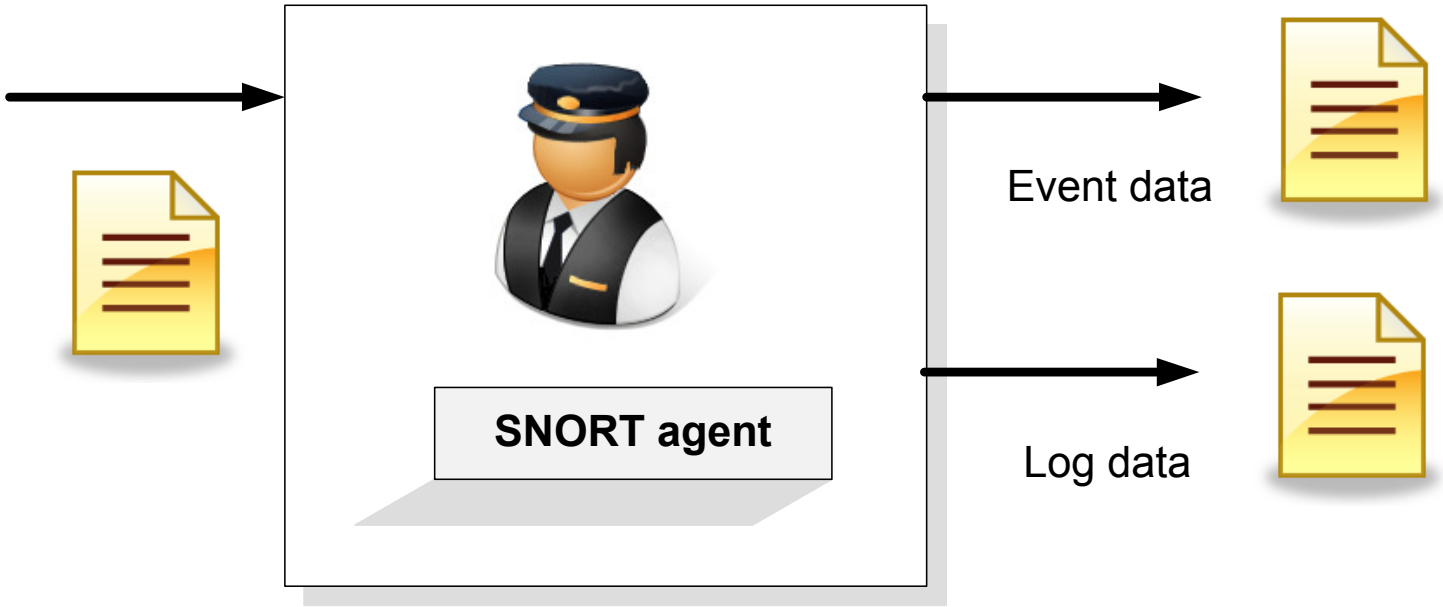


Snort

IDS

Author: Prof Bill Buchanan

```
alert tcp $HOME_NET any -> $EXTERNAL_NET 1863
(msg:"CHAT MSN login attempt";  flow:to_server,established; content:"USR "; depth:4;
nocase; content:" TWN "; distance:1;  nocase;
classtype:policy-violation; sid:1991; rev:1;)
```



The SID and REV represent know Snort rules:

- Less 100 Reserved for future use
- Between 100 and 1,000,000 are rules included with the Snort distribution
- More than 1,000,000 is for local rules

For example: **sid:336; rev:7;** represents an attempt to change to the system administrator's account in FTP.

Author: Prof Bill Buchanan

Intrusion Detection Systems

A simple rule

Author: Prof Bill Buchanan

```
alert tcp any any -> any any (content:"the"; msg:"The found ....";)
```

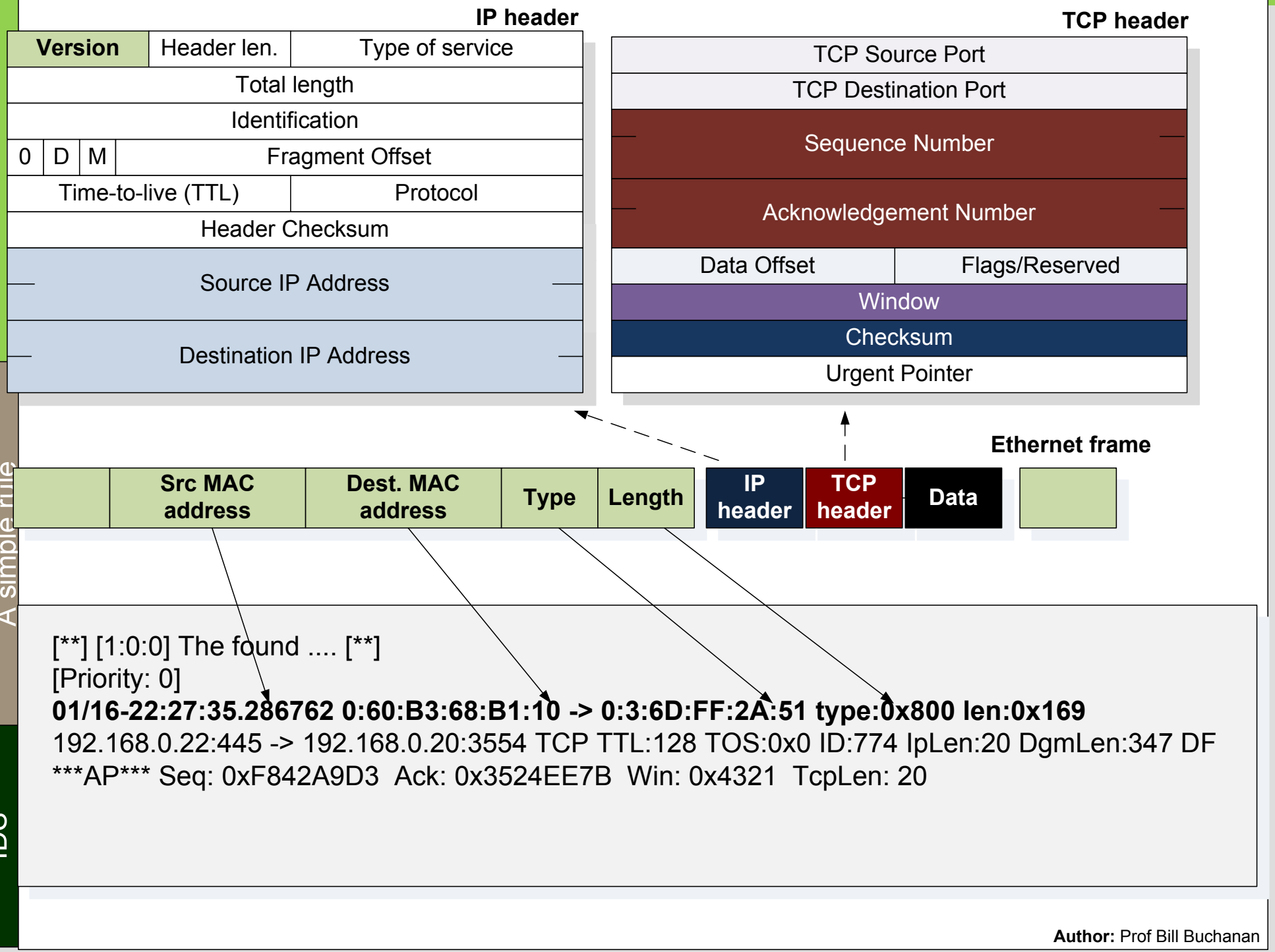
```
Snort -v -c bill.rules -l /log
```

Alert.ids
(in \log)

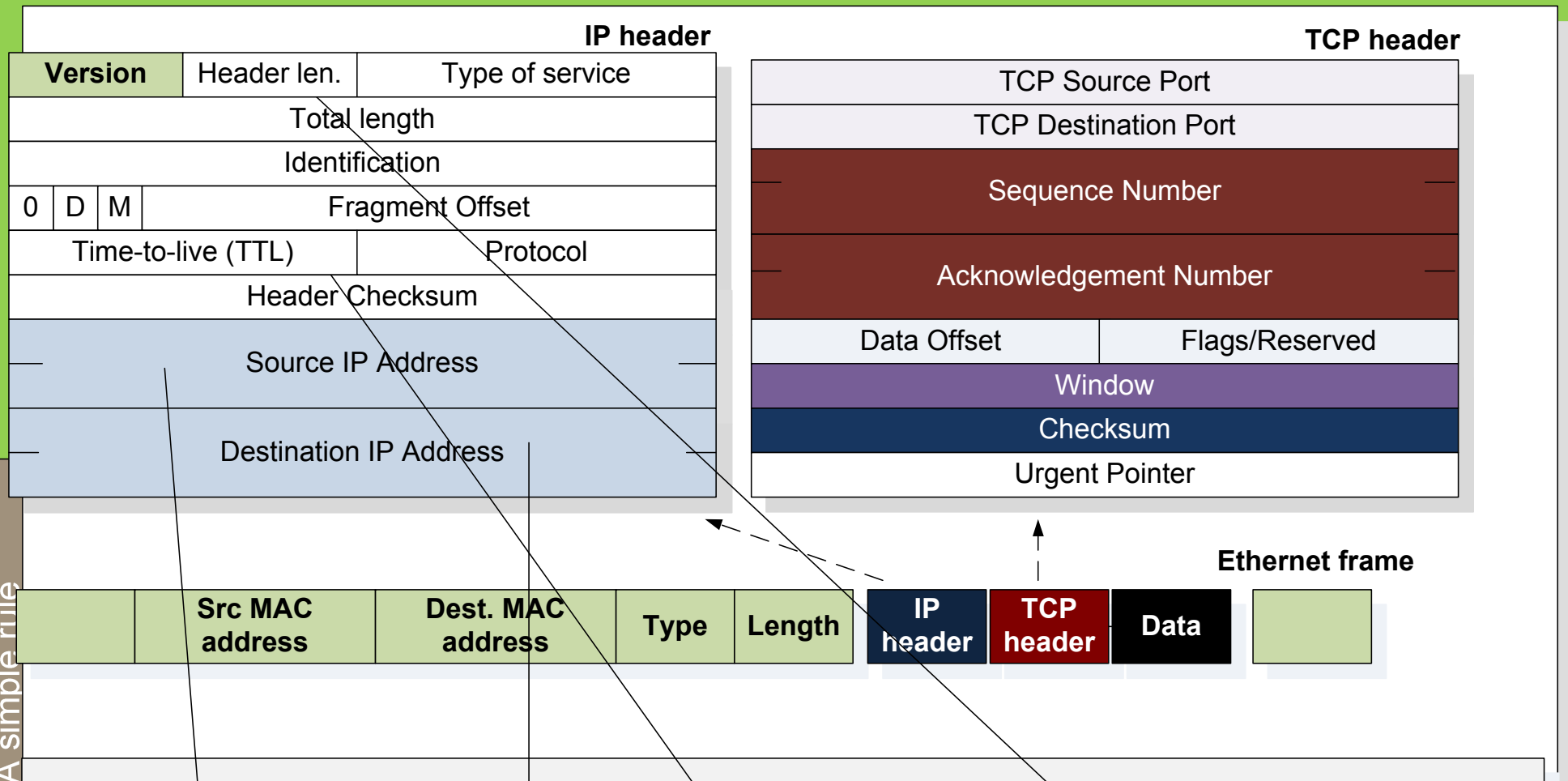
16 January 10:27pm

```
[**] [1:0:0] The found .... [**]
[Priority: 0]
01/16-22:27:35.286762 0:60:B3:68:B1:10 -> 0:3:6D:FF:2A:51 type:0x800 len:0x169
192.168.0.22:445 -> 192.168.0.20:3554 TCP TTL:128 TOS:0x0 ID:774 IpLen:20
DgmLen:347 DF
***AP*** Seq: 0xF842A9D3  Ack: 0x3524EE7B  Win: 0x4321  TcpLen: 20

[**] [1:0:0] The found .... [**]
[Priority: 0]
01/16-22:27:35.287084 0:3:6D:FF:2A:51 -> 0:60:B3:68:B1:10 type:0x800 len:0x198
192.168.0.20:3554 -> 192.168.0.22:445 TCP TTL:128 TOS:0x0 ID:1086 IpLen:20
DgmLen:394 DF
***AP*** Seq: 0x3524EE7B  Ack: 0xF842AB06  Win: 0x42E4  TcpLen: 20

[**] [1:0:0] The found .... [**]
[Priority: 0]
01/16-22:27:35.290026 0:60:B3:68:B1:10 -> 0:3:6D:FF:2A:51 type:0x800 len:0x5D
192.168.0.22:445 -> 192.168.0.20:3554 TCP TTL:128 TOS:0x0 ID:775 IpLen:20
DgmLen:79 DF
***AP*** Seq: 0xF842AB06  Ack: 0x3524EFDD  Win: 0x41BF  TcpLen: 20
```

Author: Prof Bill Buchanan



Payload detection



A simple rule

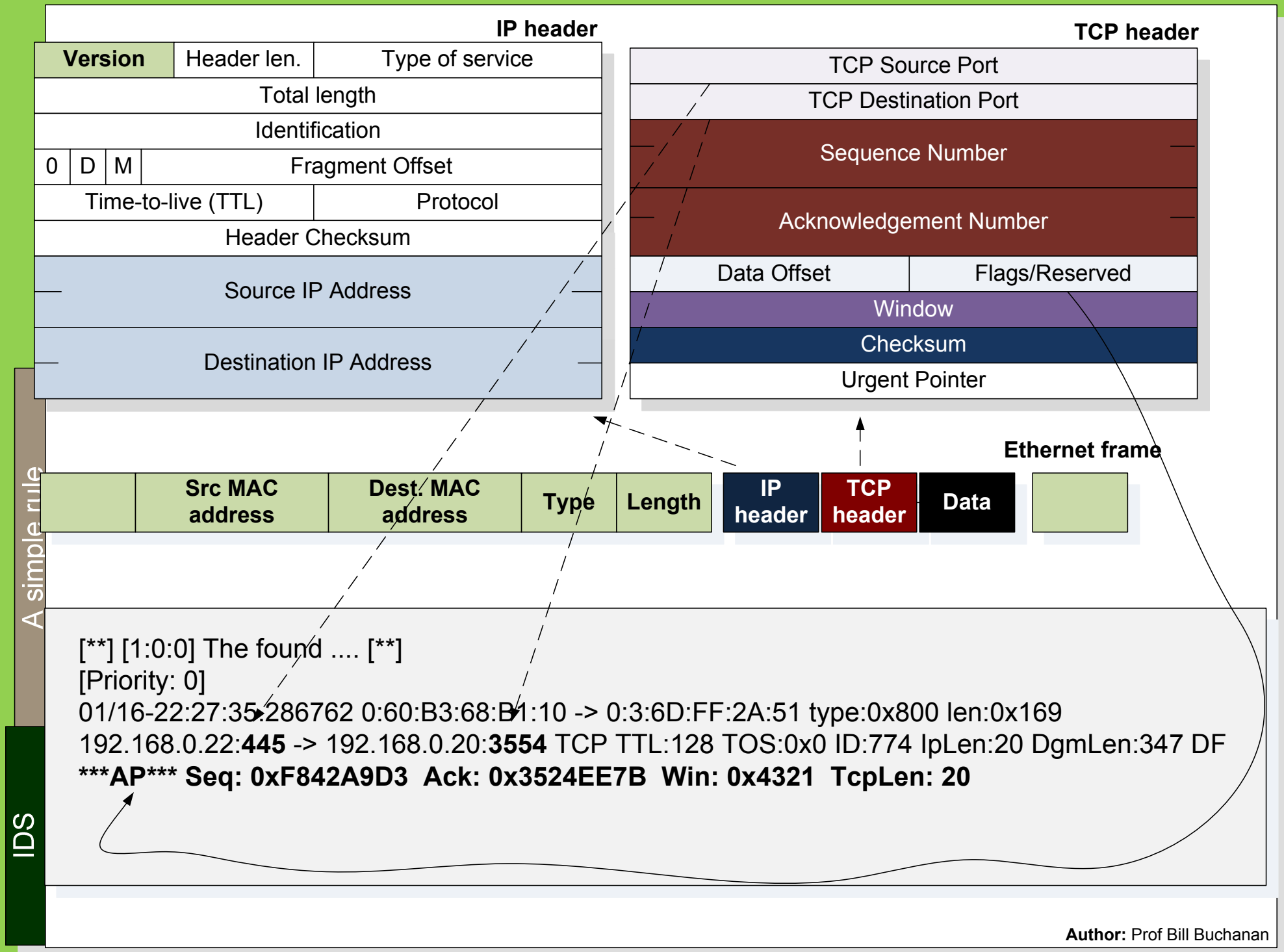
IDS

[**] [1:0:0] The found .... [**]
[Priority: 0]
01/16-22:27:35.286762 0:60:B3:68:B1:10 -> 0:3:6D:FF:2A:51 type:0x800 len:0x169
192.168.0.22:445 -> 192.168.0.20:3554 TCP TTL:128 TOS:0x0 ID:774 IpLen:20 DgmLen:347 DF
AP Seq: 0xF842A9D3 Ack: 0x3524EE7B Win: 0x4321 TcpLen: 20

Protocol
1 ICMP
6 TCP
8 EGP
41 IPv6 over IPv4
46 RSVP
50 ESP
51 AH

Author

Payload detection



Payload detection

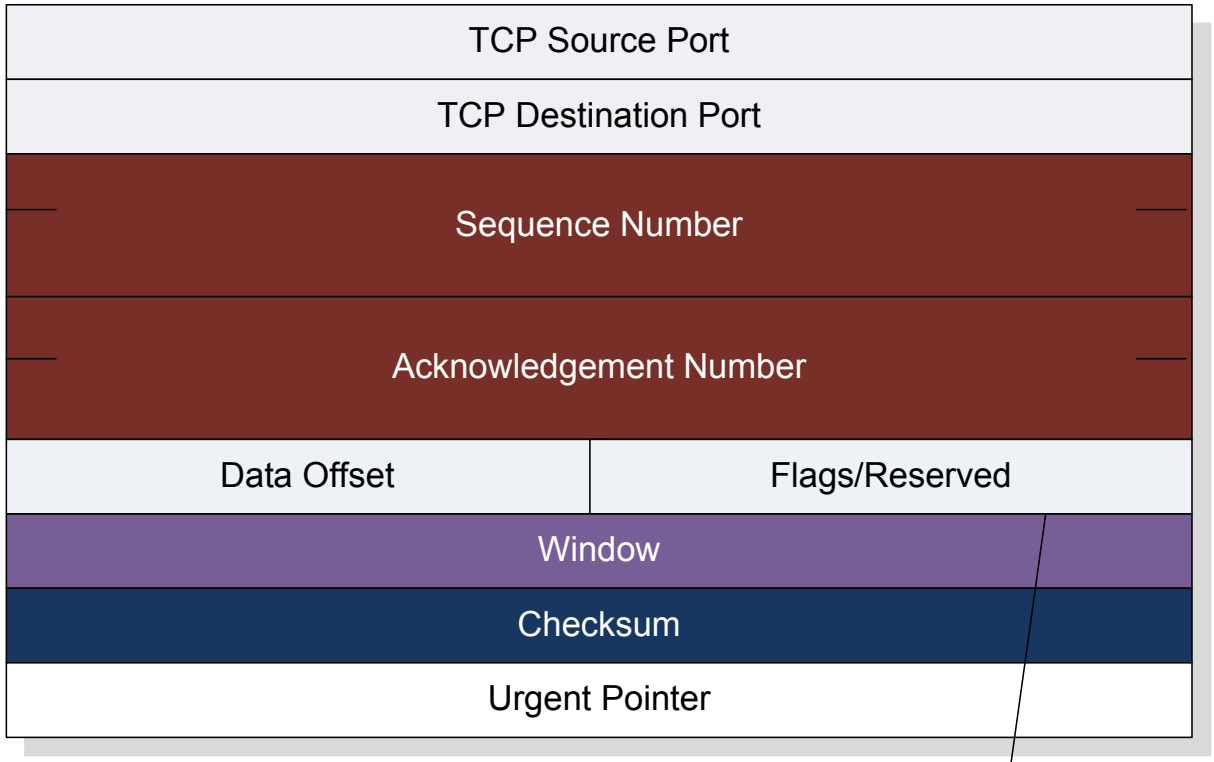
- log
  - 192.168.0.1
  - 192.168.0.2
  - 192.168.0.3
  - 192.168.0.20
    - TCP_3423-445.ids
    - TCP_3424-139.ids
    - TCP_3521-445.ids
    - TCP_3529-139.ids
    - TCP_3554-445.ids
    - TCP_3566-445.ids
  - 192.168.0.21
  - 192.168.0.24
  - 192.168.0.25
  - 192.168.0.60

Log of traffic between port 3423 and 455 to/from 192.168.0.20

```
01/16-22:11:15.833440 192.168.0.20:3423 -> 192.168.0.22:445
TCP TTL:128 TOS:0x0 ID:975 IpLen:20 DgmLen:48 DF
******S* Seq: 0x26885B8B  Ack: 0x0  Win: 0x4000  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

01/16-22:11:15.835497 192.168.0.22:445 -> 192.168.0.20:3423
TCP TTL:128 TOS:0x0 ID:653 IpLen:20 DgmLen:48 DF
***A**S* Seq: 0xE9A4004C  Ack: 0x26885B8C  Win: 0x4470  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

01/16-22:11:15.835571 192.168.0.20:3423 -> 192.168.0.22:445
TCP TTL:128 TOS:0x0 ID:977 IpLen:20 DgmLen:40 DF
***A**** Seq: 0x26885B8C  Ack: 0xE9A4004D  Win: 0x4470  TcpLen: 20
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```

Author: Prof Bill Buchanan

TCP header



Flags – the flag field is defined as UAPRSF,

- U is the urgent flag (URG).
- A the acknowledgement flag (ACK).
- P the push function (PSH).
- R the reset flag (RST).
- S the sequence synchronize flag (SYN).
- F the end-of-transmission flag (FIN).

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

The SYN flag identifies a connection

Flags – the flag field is defined as UAPRSF,

- U is the urgent flag (URG).
- A the acknowledgement flag (ACK).
- P the push function (PSH).
- R the reset flag (RST).
- S the sequence synchronize flag (SYN).
- F the end-of-transmission flag (FIN).

Author: Prof Bill Buchanan

An incoming SYN flag is important in detecting the start of a connection. The main flags are:

F FIN
S SYN
R RST
P PSH
A ACK
U URG

The following modifiers can be set to change the match criteria:

+ match on the specified bits, plus any others
* match if any of the specified bits are set
! match if the specified bits are not set

Example to test for SYN flag:

alert tcp any any -> any any (flags:S;)

It is often important to know the flow direction. The main flow rules options are:

- to_client. Used for server responses to client.
- to_server Used for client requests to server.
- from_client. Used on client responses.
- from_server. Used on server responses.
- established . Established TCP connections.

Example to test for an FTP connection to the users computer:

```
alert tcp any any -> $HOME_NET 21 (flow: from_client;
                                   content: "CWD incoming"; nocase;
```

IP header

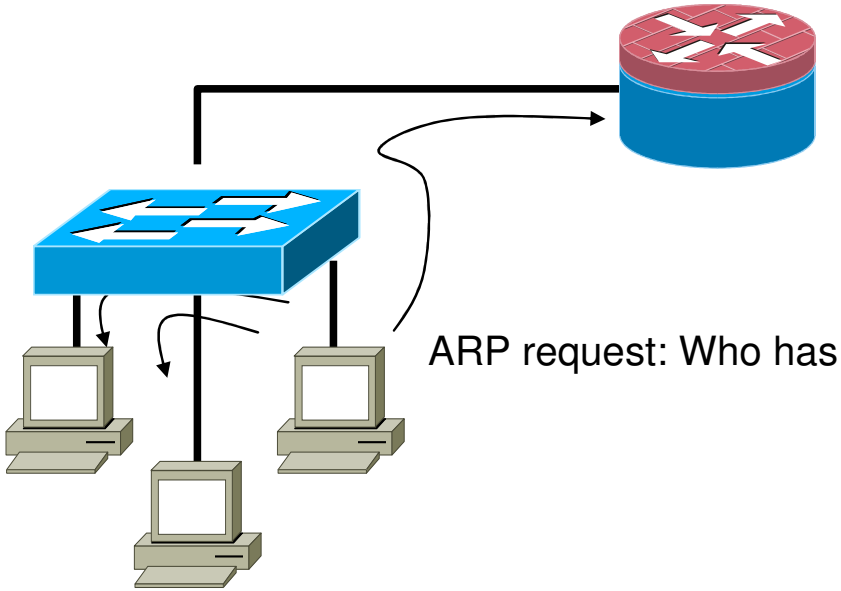
Version	Header len.	Type of service	
Total length			
Identification			
0	D	M	Fragment Offset
Time-to-live (TTL)		Protocol	
Header Checksum			
Source IP Address			
Destination IP Address			

TCP header

TCP Source Port	
TCP Destination Port	
Sequence Number	
Acknowledgement Number	
Data Offset	Flags/Reserved
Window	
Checksum	
Urgent Pointer	

```
01/16-22:11:15.833440 192.168.0.20:3423 -> 192.168.0.22:445
TCP TTL:128 TOS:0x0 ID:975 IpLen:20 DgmLen:48 DF
******S* Seq: 0x26885B8B  Ack: 0x0  Win: 0x4000  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

01/16-22:11:15.835497 192.168.0.22:445 -> 192.168.0.20:3423
TCP TTL:128 TOS:0x0 ID:653 IpLen:20 DgmLen:48 DF
***A**S* Seq: 0xE9A4004C  Ack: 0x26885B8C  Win: 0x4470  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

01/16-22:11:15.835571 192.168.0.20:3423 -> 192.168.0.22:445
TCP TTL:128 TOS:0x0 ID:977 IpLen:20 DgmLen:40 DF
***A**** Seq: 0x26885B8C  Ack: 0xE9A4004D  Win: 0x4470  TcpLen: 20
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```

Author: Prof Bill Buchanan



Devices can only communicate directly if they have they have the MAC address and IP address.

ARP request: Who has 192.168.0.168?

ARP request is broadcast to the network

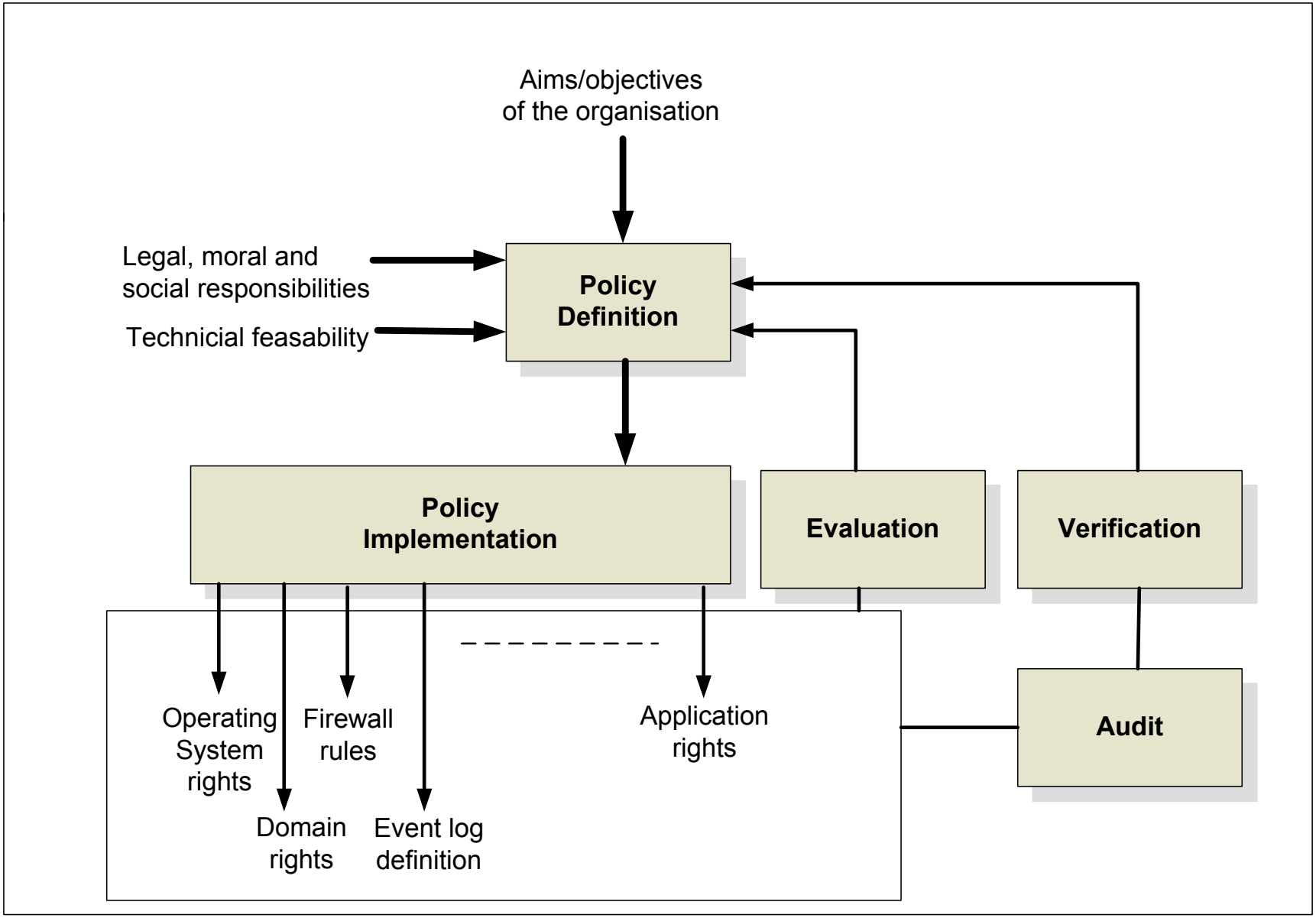
```
01/16-09:31:08.785149 ARP who-has 192.168.0.168 tell 192.168.0.22
01/16-09:45:59.458607 ARP who-has 192.168.0.42 tell 192.168.0.216
01/16-09:45:59.459159 ARP reply 192.168.0.42 is-at 0:20:18:38:B8:63
01/16-09:46:03.857325 ARP who-has 192.168.0.104 tell 192.168.0.198
01/16-09:46:10.125715 ARP who-has 192.168.0.15 tell 192.168.0.38
01/16-09:46:10.125930 ARP who-has 192.168.0.38 tell 192.168.0.15
```

Author: Prof Bill Buchanan

Intrusion Detection Systems

A few intrusions

Author: Prof Bill Buchanan



A few intrusions

IDS

Author: Prof Bill Buchanan

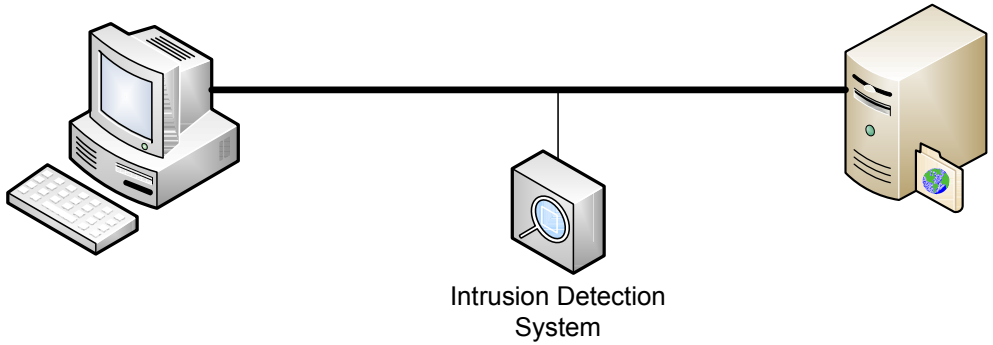
```
alert tcp $HOME_NET any -> $EXTERNAL_NET 1863
(msg:"CHAT MSN login attempt";  flow:to_server,established; content:"USR "; depth:4;
nocase; content:" TWN "; distance:1;  nocase;
classtype:policy-violation; sid:1991; rev:1;)
```

No.	Source	Destination	Protocol	Info
1	192.168.0.3	207.46.28.93	TCP	5398 > 1863 [SYN] Seq=0 Len=0 MSS=1460
2	192.168.0.3	207.46.28.93	TCP	5398 > 1863 [SYN] Seq=0 Len=0 MSS=1460
3	207.46.28.93	192.168.0.3	TCP	1863 > 5398 [SYN, ACK] Seq=0 Ack=1 Win=5840
4	192.168.0.3	207.46.28.93	TCP	5398 > 1863 [ACK] Seq=1 Ack=1 Win=17520
5	192.168.0.3	207.46.111.39	MSNMS	USR 2 TWN I test@hotmail.com
6	207.46.111.39	192.168.0.3	MSNMS	USR 26 OK test@hotmail.com 1 0

```
private static void device_PcapOnPacketArrival(…)
{
  if(packet is TCPPacket)
  {
   TCPPacket tcp = (TCPPacket)packet;
   int destPort = tcp.SourcePort; byte [] b = tcp.Data;
   ASCIIEncoding format = new ASCIIEncoding();
   string s = format.GetString(b); s=s.ToLower();
   if (destPort==1863 && (s.StartsWith("usr ")) && s.IndexOf(" twn ")>0 )
     Console.WriteLine("MSN Messenger Login");
  }
}
```

Author: Prof Bill Buchanan

```
alert tcp $EXTERNAL_NET any -> $HOME_NET 21
(msg:"FTP CWD ~root attempt"; flow:to_server,established; content:"CWD";
nocase; content:"~root"; nocase; distance:1; pcre:"/^CWD\s+~root/smi";
classtype:bad-unknown; sid:336; rev:7;)
```

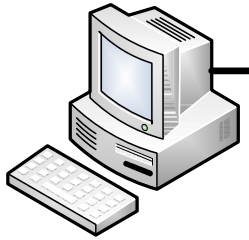


FTP server
(listening on port 21)

```
private static void device_PcapOnPacketArrival(..)
{
     if(packet is TCPPacket)
     {
   TCPPacket tcp = (TCPPacket)packet;
   int destPort = tcp.SourcePort;
   byte [] b = tcp.Data;
   ASCIIEncoding format = new ASCIIEncoding();
   string s = format.GetString(b); s=s.ToLower();
   if (destPort==21 && s.IndexOf("cwd")>0 && s.IndexOf("~root")>0 )
     Console.WriteLine("FTP CWD ~root attempt");
  }
}
```


Author: Prof Bill Buchanan

```
alert tcp $EXTERNAL_NET any
(msg:"FTP CWD ~root attempt
nocase; content:"~root"; no
classtype:bad-unknown; sid:
```



```
> telnet ftp.test.com 21
220-Microsoft FTP Service
220 NTXPW35
cwd
530 Please login with USER and PASS.
user bill
331 Password required for ******.
pass ******
230-FTP Server
230 User bill  logged in.
help
214-The following  commands are recognized
   ABOR        ACCT        ALLO        APPE    CDUP
   CWD         DELE        FEAT        HELP    LIST
   MDTM        MKD         MODE        NLST    NOOP
   OPTS        PASS        PASV        PORT    PWD
   QUIT        REIN        REST        RETR
   RMD         RNFR        RNTO        SITE
   SIZE        SMNT        STAT        STOR
   STOU        STRU        SYST        TYPE
   USER        XCUP        XCWD        XMKD
   XPWD        XRMD
214  HELP command successful.
pwd
257 "/bill" is current directory.
cwd /
250 CWD command successful.
pwd
257 "/" is current directory.
cwd ~root
250 CWD command successful.
list
150 Opening ASCII mode data connection for /bin/ls.
```

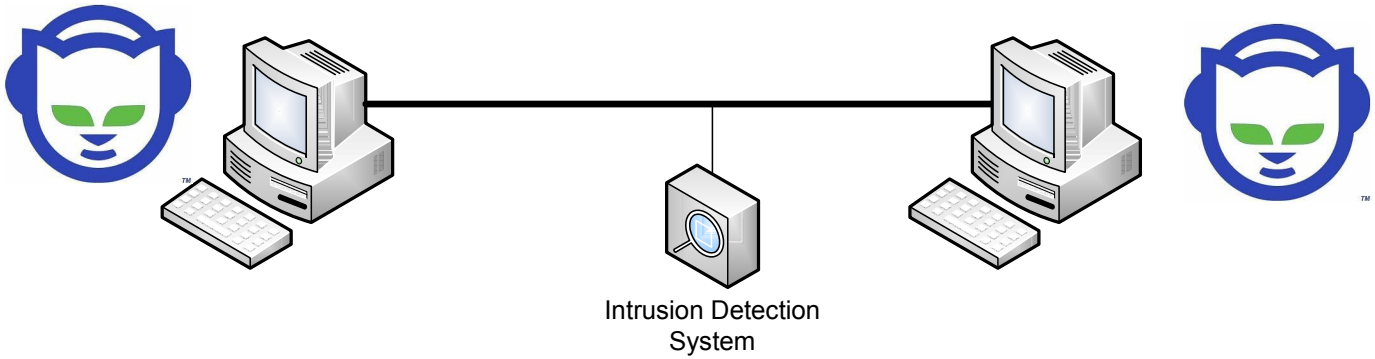
```
private static void device_Pcap
{
     if(packet is TCPPacket)
     {
   TCPPacket tcp = (TCPPacket)p
   int destPort = tcp.SourcePo
   byte [] b = tcp.Data;
   ASCIIEncoding format = new A
   string s = format.GetString(
   if (destPort==21 && s.Index(
     Console.WriteLine("FTP CWD
  }
}
```

A few intrusions

IDS

Author: Prof Bill Buchanan

```
alert tcp $HOME_NET any -> $EXTERNAL_NET 8888
(msg:"P2P napster login"; flow:to_server,established;
content:"|00 0200|"; offset:1; depth:3;
classtype:policy-violation; sid:549; rev:6;)
```




```
private static void device_PcapOnPacketArrival(…)
{
     if(packet is TCPPacket)
     {
   TCPPacket tcp = (TCPPacket)packet;
   int destPort = tcp.SourcePort;
   byte [] b = tcp.Data;
   if (destPort==8888 && b[0]==0x00 && b[1]==0x20 && b[2]==0x00)
     Console.WriteLine("P2P napster login");
  }
}
```

Author: Prof Bill Buchanan

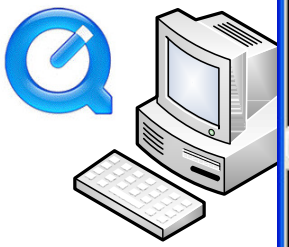
```
alert tcp $HOME_NET any -> $EXTERNAL_NET 80
(msg:"MULTIMEDIA Quicktime User Agent access"; flow:to_server,established;
content:"User-Agent\: Quicktime";
classtype:policy-violation; sid:1436;  rev:2;)
```

```
GET /napierstream
HTTP/1.0 User-Agent: QuickTime/7.1 (qtver=7.1;os=Windows NT 5.1)
Accept: application/x-rtsp-tunnelled
Pragma: no-cache Cache-Control: no-cache
```

```
private static void device_PcapOnPacketArrival(..)
{
     if(packet is TCPPacket)
     {
   TCPPacket tcp = (TCPPacket)packet;
   int destPort = tcp.SourcePort;
   byte [] b = tcp.Data;
   ASCIIEncoding format = new ASCIIEncoding();
   string s = format.GetString(b); s=s.ToLower();
   if (destPort==80 && s.StartsWith("User-Agent\\: Quicktime "))
     Console.WriteLine("MULTIMEDIA Quicktime User Agent access ");
  }
}
```

Author: Prof Bill Buchanan

```
alert tcp $HO
(msg:"MULTIME
content:"User-
classtype:pol
```



```
private static
{
     if(packet
     {
   TCPPacket t
   int destPor
   byte [] b =
   ASCIIEncodi
   string s =
   if (destPor
     Console.W
  }
}
```

(Untitled) - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: http contains "GET" && ip.addr == 192.168.0.3 Expression... Clear Apply

No.	Time	Source	Destination	Protocol	Info
295	13.610302	192.168.0.3	nwk-qtpix.apple.com	HTTP	GET /qtpix/qtpix_auto.mov HT
297	13.611322	192.168.0.3	nwk-qtpix.apple.com	HTTP	[TCP Out-Of-Order] GET /qtpix
400	15.735383	192.168.0.3	84.53.179.169	HTTP	GET /f/654/39/5m/qtpix.apple.
402	15.736462	192.168.0.3	84.53.179.169	HTTP	[TCP Out-Of-Order] GET /f/654

```
Frame 295 (248 bytes on wire, 248 bytes captured)
Ethernet II, Src: IntelCor_34:02:f0 (00:15:00:34:02:f0), Dst: Gvc_b7:5b:5a (00:c0:a8:b7:5b:5a)
Internet Protocol, Src: 192.168.0.3 (192.168.0.3), Dst: nwk-qtpix.apple.com (17.149.160.34)
Transmission Control Protocol, Src Port: 6213 (6213), Dst Port: http (80), Seq: 1, Ack: 1, Len: 194
Hypertext Transfer Protocol
  GET /qtpix/qtpix_auto.mov HTTP/1.1\r\n
    Request Method: GET
    Request URI: /qtpix/qtpix_auto.mov
    Request Version: HTTP/1.1
  User-Agent: QuickTimeWinInet\r\n
  Host: qtpix.apple.com\r\n
  Cache-Control: no-cache\r\n
```

```
0000  00 c0 a8 b7 5b 5a 00 15  00 34 02 f0 08 00 45 00   ....[Z.. .4....E.
0010  00 ea 0f 70 40 00 80 06  78 3b c0 a8 00 03 11 95   ...p@... x;......
0020  a0 22 18 45 00 50 c3 15  40 27 05 62 90 3e 50 18   ."E.P.. @'.b.>P.
0030  44 70 1f f6 00 00 47 45  54 20 2f 71 74 70 69 78   Dp....GE T /qtpix
0040  2f 71 74 70 69 78 5f 61  75 74 6f 2e 6d 6f 76 20   /qtpix_a uto.mov
0050  48 54 54 50 2f 31 2e 31  0d 0a 55 73 65 72 2d 41   HTTP/1.1 ..User-A
0060  67 65 6e 74 3a 20 51 75  69 63 6b 54 69 6d 65 57   gent: Qu ickTimeW
0070  69 6e 49 6e 65 74 0d 0a  48 6f 73 74 3a 20 71 74   inInet.. Host: qt
0080  70 69 78 2e 61 70 70 6c  65 2e 63 6f 6d 0d 0a 43   pix.appl e.com..C
0090  61 63 68 65 2d 43 6f 6e  74 72 6f 6c 3a 20 6e 6f   ache-Con trol: no
00a0  2d 63 61 63 68 65 0d 0a  43 6f 6f 6b 69 65 3a 20   -cache.. Cookie:
```

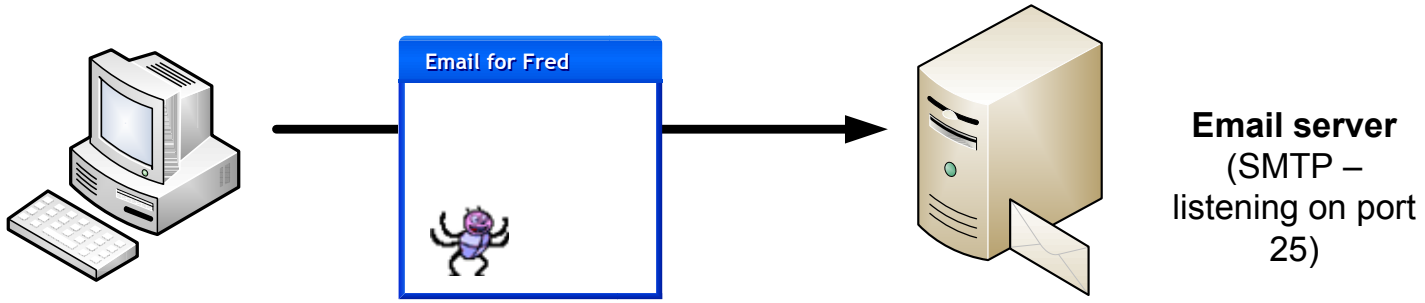
File: "C:\DOCUME~1\WILLIA~1\LOCALS~1\Temp\etherXXXXa03428" 1448 KB 00:03... P: 4415 D: 4 M: 3 Drops: 0

A few intrusions

IDS

Author: Prof Bill Buchanan

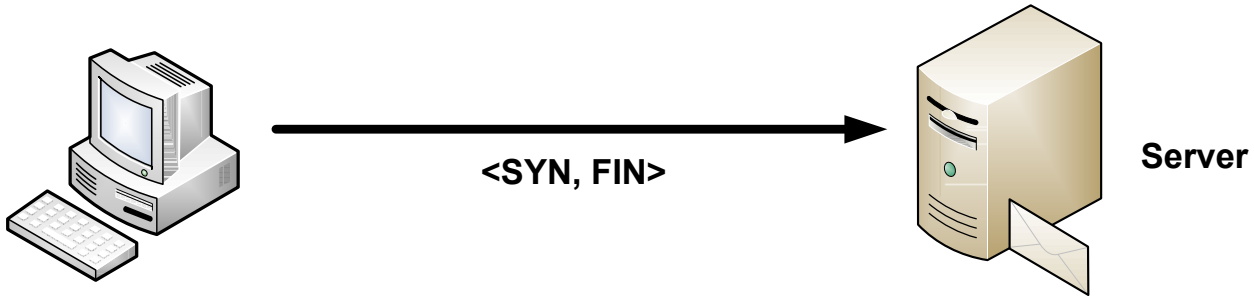
```
alert tcp $SMTP_SERVERS any -> $EXTERNAL_NET 25
(msg:"VIRUS OUTBOUND .exe file attachment";
flow:to_server,established; content:"Content-Disposition|3a|";
content:"filename=|22|"; distance:0; within:30;
content:".exe|22|"; distance:0; within:30; nocase;
classtype:suspicious-filename-detect; sid:2160; rev:1;)
```




```
private static void device_PcapOnPacketArrival(..)
{
 TCPPacket tcp = (TCPPacket)packet;
 if(packet is TCPPacket)
 {
  int destPort = tcp.SourcePort;   byte [] b = tcp.Data;
  ASCIIEncoding format = new ASCIIEncoding();
  string s = format.GetString(b); s=s.ToLower();
  if (destPort==25 && s.IndexOf("Content-Disposition;")>0
     && s.IndexOf("filename=\"")>0 && s.IndexOf(".exe\"")>0 )
        Console.WriteLine("VIRUS OUTBOUND .exe file attachment");
 }
}
```

Author: Prof Bill Buchanan

```
alert tcp any any -> any any (msg:"SYN FIN Scan"; flags: SF;)
 alert tcp any any -> any any (msg:"FIN Scan"; flags: F;)
 alert tcp any any -> any any (msg:"NULL Scan"; flags: 0;)
 alert tcp any any -> any any (msg:"XMAS Scan";flags: FPU;)
 alert tcp any any -> any any (msg:"FULL XMAS Scan";flags:SRAFPU;)
```




```
private static void device_PcapOnPacketArrival(…)
{
  if(packet is TCPPacket)
  {
   TCPPacket tcp = (TCPPacket)packet;
   if (tcp.Syn==true && tcp.Fin=true)
     Console.WriteLine("SYN FIN Scan");
  }
}
```

Author: Prof Bill Buchanan

```
alert tcp $TELNET_SERVERS 23 -> $EXTERNAL_NET
   any (msg:"TELNET root login";
   flow:from_server,established;
   content:"login|3A| root";
   classtype:suspicious-login; sid:719; rev:7;)
```

(Untitled) - Wireshark

File Edit View Go Capture Analyze Statistics Help

Filter: (ip.addr eq 192.168.0.4 and ip.addr eq 146.176 Expression... Clear Apply

No.	Time	Source	Destination	Protocol	Info
2069	77.297871	pc165229.napier.ac.uk	192.168.0.4	TCP	telnet > 2403 [ACK] Seq=41 Ack=41 Win=5840 Len=0
2070	77.298170	pc165229.napier.ac.uk	192.168.0.4	TELNET	Telnet Data ...
2071	77.298329	192.168.0.4	pc165229.napier.ac.uk	TELNET	Telnet Data ...
2073	77.386208	pc165229.napier.ac.uk	192.168.0.4	TCP	telnet > 2403 [ACK] Seq=53 Ack=44 Win=5840 Len=0
2074	77.386276	192.168.0.4	pc165229.napier.ac.uk	TELNET	Telnet Data ...
2077	77.438728	pc165229.napier.ac.uk	192.168.0.4	TCP	telnet > 2403 [ACK] Seq=53 Ack=53 Win=5840 Len=0
2078	77.439196	pc165229.napier.ac.uk	192.168.0.4	TELNET	Telnet Data ...
2079	77.439345	192.168.0.4	pc165229.napier.ac.uk	TELNET	Telnet Data ...
2084	77.491337	pc165229.napier.ac.uk	192.168.0.4	TELNET	Telnet Data ...
2085	77.491427	192.168.0.4	pc165229.napier.ac.uk	TELNET	Telnet Data ...

```
⊞ Frame 2084 (142 bytes on wire, 142 bytes captured)
⊞ Ethernet II, Src: Netgear_b0:d6:8c (00:18:4d:b0:d6:8c), Dst: IntelCor_34:02:f0 (00:15:00:34:02:f0)
⊞ Internet Protocol, Src: pc165229.napier.ac.uk (146.176.165.229), Dst: 192.168.0.4 (192.168.0.4)
⊞ Transmission Control Protocol, Src Port: telnet (23), Dst Port: 2403 (2403), Seq: 59, Ack: 56, Len: 88
⊟ Telnet
    Data: \r\n
    Data: Please login to NETLAB device.\r\n
    Data: Unauthorized access is prohibited.\r\n
    Data: \r\n
    Data: NETLAB user ID:
```

```
0000  00 15 00 34 02 f0 00 18  4d b0 d6 8c 08 00 45 00   ...4.... M.....E.
0010  00 80 b1 c2 40 00 34 06  9b 73 92 b0 a5 e5 c0 a8   ....@.4. .s......
0020  00 04 00 17 09 63 5a 60  4f bc 63 b2 ec 4f 50 18   .....cZ` O.c..OP.
0030  16 d0 aa 74 00 00 0d 0a  50 6c 65 61 73 65 20 6c   ...t.... Please l
0040  6f 67 69 6e 20 74 6f 20  4e 45 54 4c 41 42 20 64   ogin to  NETLAB d
0050  65 76 69 63 65 2e 0d 0a  55 6e 61 75 74 68 6f 72   evice... Unauthor
0060  69 7a 65 64 20 61 63 63  65 73 73 20 69 73 20 70   ized acc ess is p
0070  72 6f 68 69 62 69 74 65  64 2e 0d 0a 0d 0a 4e 45   rohibite d.....NE
0080  54 4c 41 42 20 75 73 65  72 20 49 44 3a 20         TLAB use r ID:
```

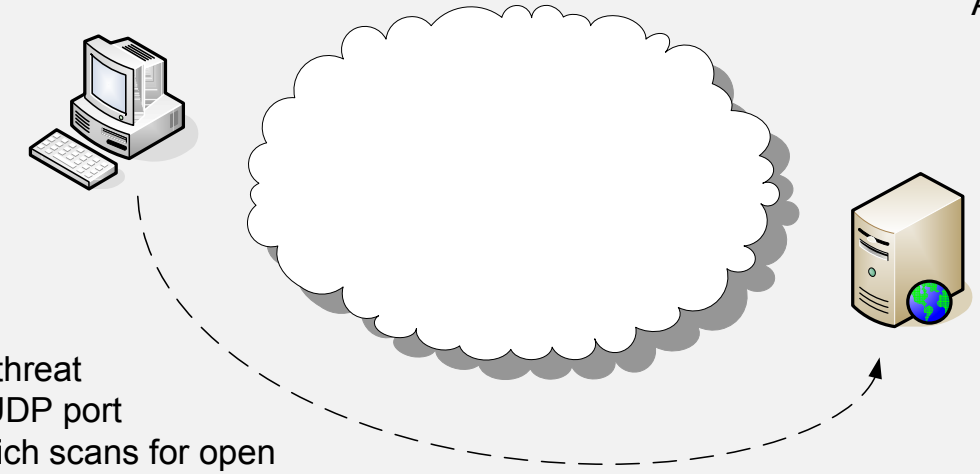
File: "C:\DOCUME~1\WILLIA~1\LOCALS~1\Temp\etherXXXXa02060" 3237 KB 00:01:57 | P: 4729 D: 64 M: 0 Drops: 0

A few intrusions

IDS

Open port 10?
Open port 11?
..
Open port 8888?

Typical scans:
Ping sweeps.
TCP scans.
UDP scans.
OS identification scans.
Account scans.



A particular threat is the TCP/UDP port scanner, which scans for open ports on a host.

If an intruder finds one, it may try and connect to it.

An open port is in the LISTEN state.

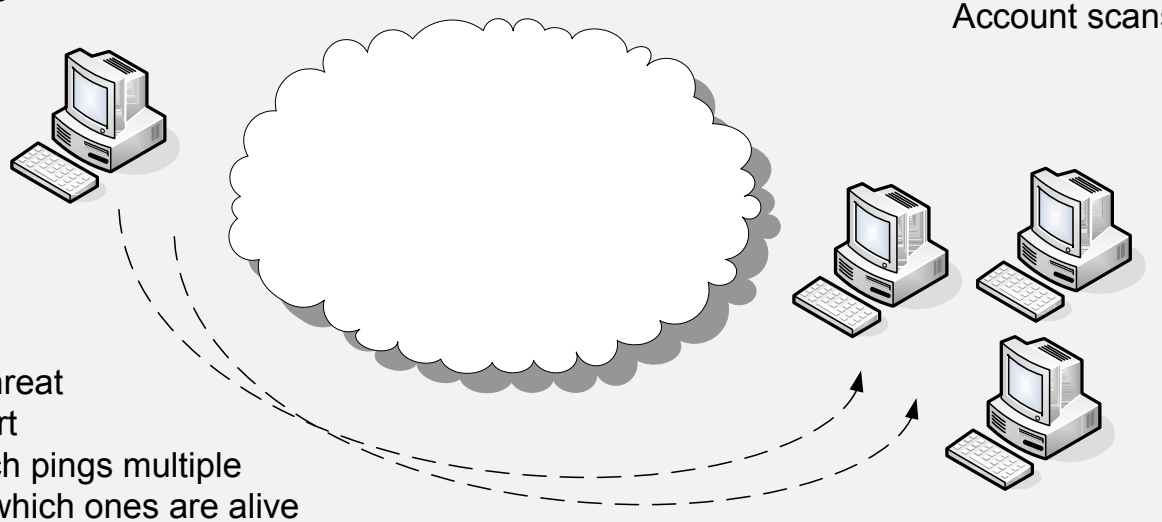
```
C:\log>netstat -a
Active Connections
Proto  Local Address          Foreign Address        State
TCP    bills:epmap            bills:0                LISTENING
TCP    bills:microsoft-ds     bills:0                LISTENING
TCP    bills:1035             bills:0                LISTENING
TCP    bills:3389             bills:0                LISTENING
```

Author: Prof Bill Buchanan

UDP/TCP Port Scans

Ping 192.168.0.1?
Ping 192.168.0.1?
..
Ping 192.168.0.253?
Ping 192.168.0.254?

Typical scans:
Ping sweeps.
TCP scans.
UDP scans.
OS identification scans.
Account scans.



A particular threat is the ping port scanner, which pings multiple hosts to see which ones are alive

If an intruder finds one, they may try and connect to it.

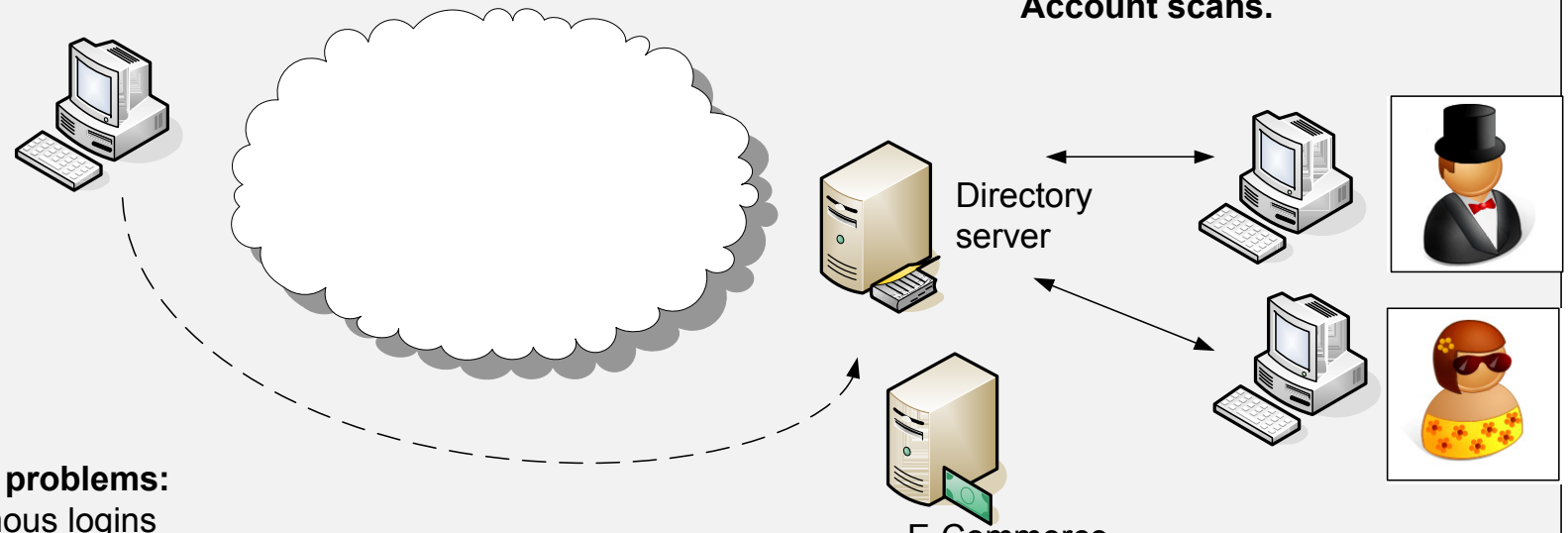
Often ping (ICMP) is blocked on the gateway of the network.

Author: Prof Bill Buchanan

Ping sweeps

Login anonymous
Login **fred fred**
Login user **password**
Login root
Login default

Typical scans:
Ping sweeps.
TCP scans.
UDP scans.
OS identification scans.
Account scans.



Typical problems:
Anonymous logins
Using the same password as user ID
Using password as password.
Using root login
Using system default logins
Weak passwords
Well-known passwords
Social Engineering

Author: Prof Bill Buchanan

User account scans

SCAN.RULE

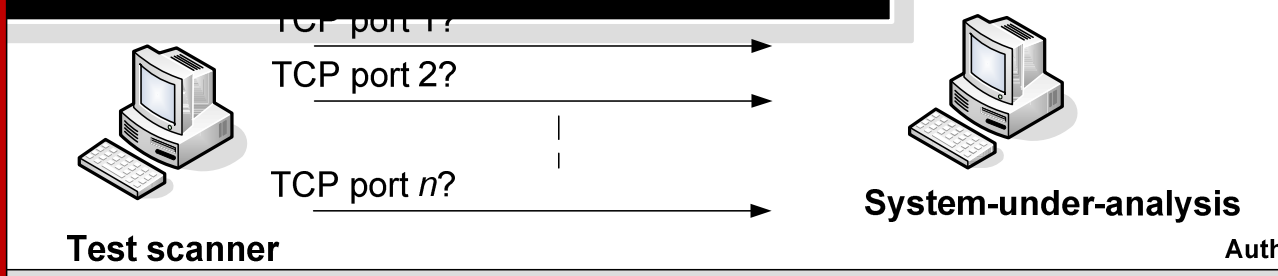
```
preprocessor flow: stats_interval 0 hash 2
preprocessor sfportscan: proto { all } scan_type { all }
                sense_level { low } logfile { portscan.log }
```

```
C:\> snort -c scan.rule -dev -i 3 -p -l c:\\bill -K ascii
Initializing Preprocessors!
Initializing Plug-ins!
Parsing Rules file scan.rule
,-----------[Flow Config]----------------------
| Stats Interval:  0
| Hash Method:     2
| Memcap:          10485760
| Rows   :         4096
| Overhead Bytes:  16388(%0.16)
`----------------------------------------------
Portscan Detection Config:
    Detect Protocols:  TCP UDP ICMP IP
    Detect Scan Type:  portscan portsweep decoy_portscan distributed_portscan
    Sensitivity Level: Low
    Memcap (in bytes): 1048576
    Number of Nodes:   3869
    Logfile:           c:\\bill/portscan.log

Tagged Packet Limit: 256
...
C:\>nmap -o -A 192.168.0.1
Starting Nmap 4.20 ( http://insecure.org ) at 2007-01-09 21:58 GMT Standard Tim
Interesting ports on 192.168.0.1:
Not shown: 1695 closed ports
PORT     STATE SERVICE
80/tcp   open  http
8888/tcp open  sun-answerbook
MAC Address: 00:0B:44:F5:33:D5 (The Linksys Group)
Nmap finished: 1 IP address (1 host up) scanned in 1.500 seconds
```

PORTSCAN.LOG

```
Time: 08/17-14:41:54.495296
event_ref: 0
192.168.0.3 -> 64.13.134.49 (portscan) TCP Portsweep
Priority Count: 5
Connection Count: 135
IP Count: 43
Scanned IP Range: 64.13.134.49:216.239.59.99
Port/Proto Count: 1
Port/Proto Range: 80:80

Time: 08/17-14:42:52.431092
event_ref: 0
192.168.0.3 -> 192.168.0.1 (portscan) TCP Portsweep
Priority Count: 5
Connection Count: 10
IP Count: 5
Scanned IP Range: 66.249.93.165:192.168.0.7
Port/Proto Count: 3
Port/Proto Range: 80:2869

Time: 08/17-14:42:52.434852
event_ref: 0
192.168.0.3 -> 192.168.0.1 (portscan) TCP Portscan
Priority Count: 5
Connection Count: 9
IP Count: 1
Scanner IP Range: 192.168.0.3:192.168.0.3
Port/Proto Count: 10
Port/Proto Range: 21:636
```

NOTE:
The NMAP program should only be used on machines which you are under control of, and in a local, and isolated environment. It should only be used to determine possible weaknesses and vulnerabilities.



Author: Prof Bill Buchanan

Port scanner pre-processor

Intrusion Detection Systems

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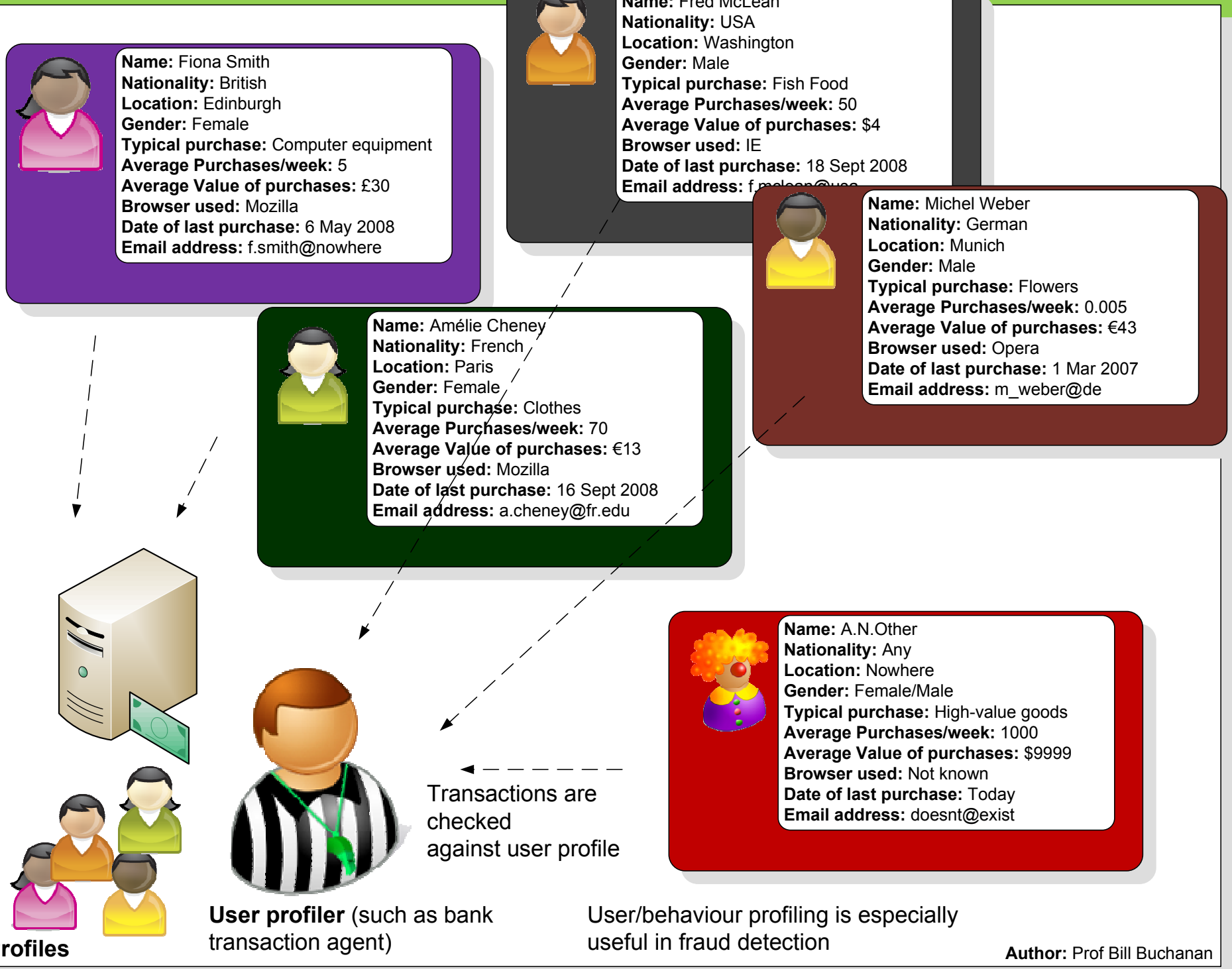
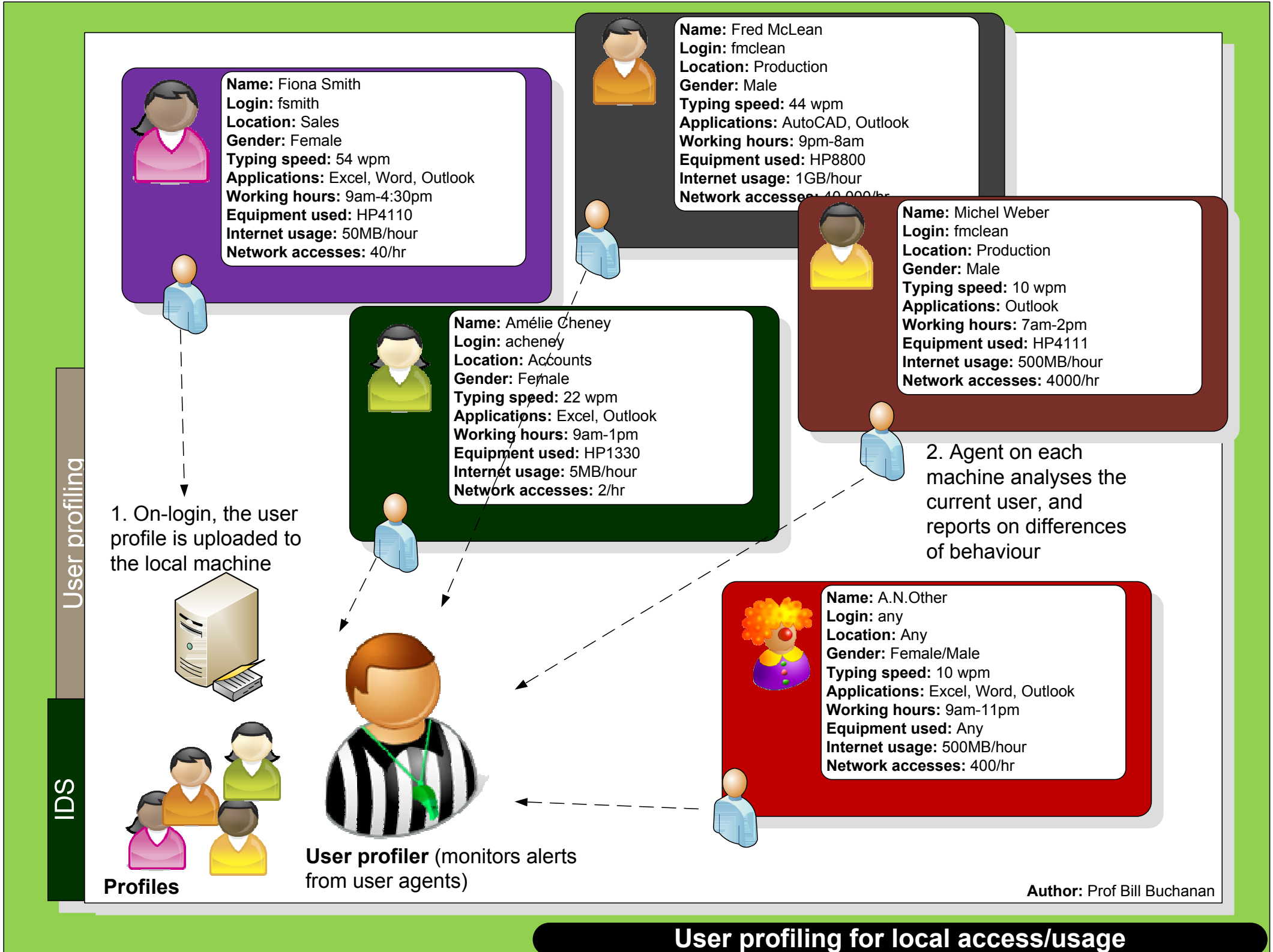
User Profiling

Author: Prof Bill Buchanan



User profiling for on-line purchases



User profiling for local access/usage

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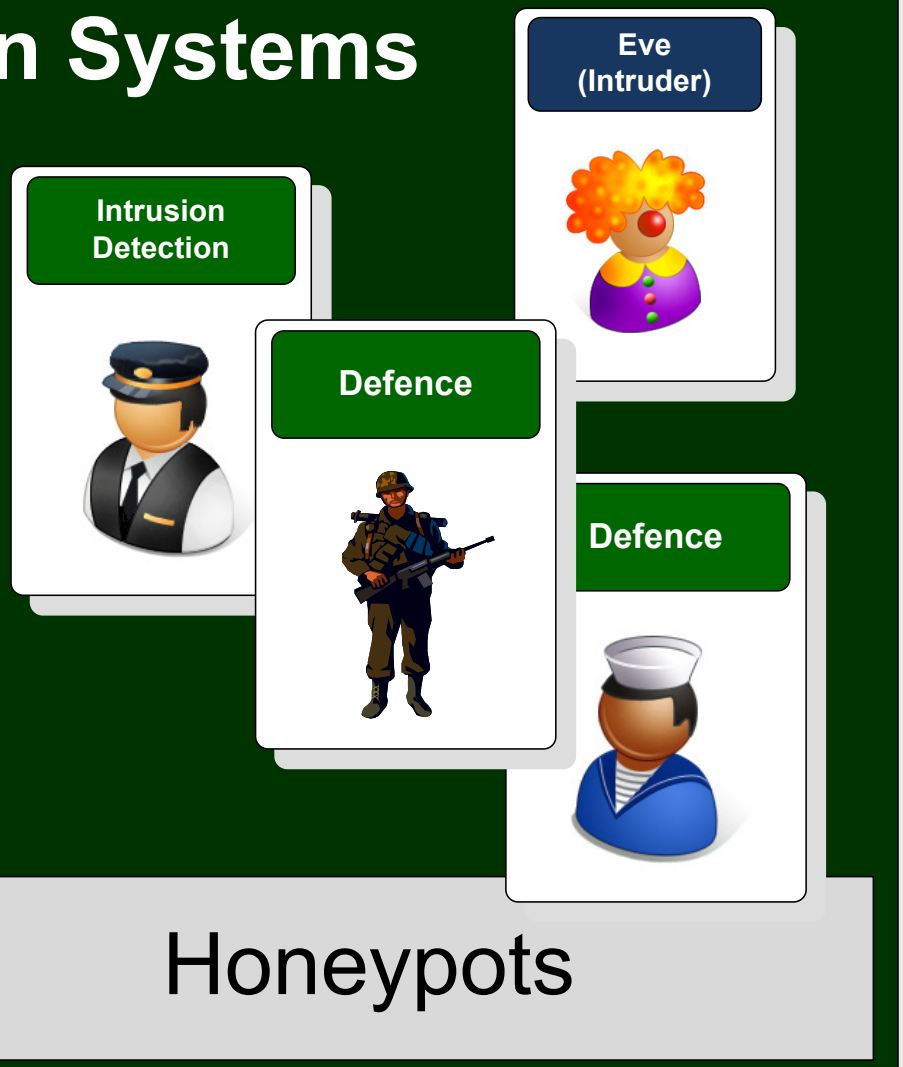


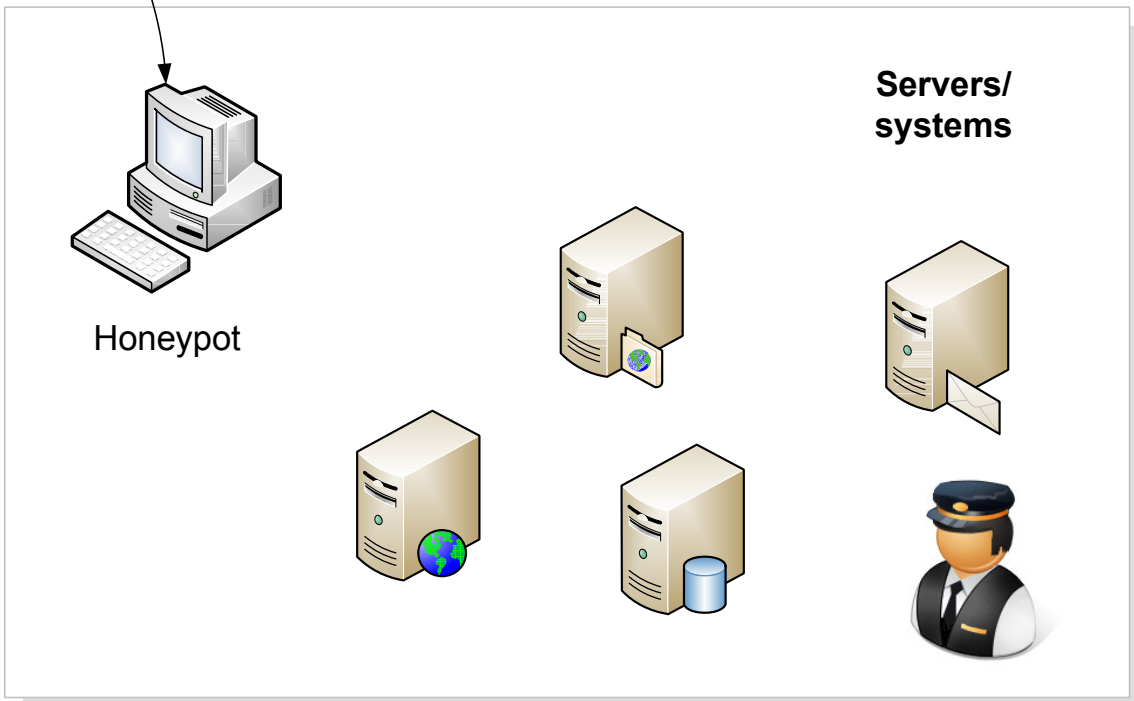
Honeypots

Author: Prof Bill Buchanan

This device has all the required weaknesses, such as:

- Default administrator/password.
- Dummy users with weak passwords.
- Ports open for connection.
- React to virus/worm systems (but simulate conditions).

Intruder



Author: Prof Bill Buchanan

Honeypots

IDS

High-interaction honeypot. This simulates all the aspects of the operating system

Open ports: 110 (POP-3), 80 (HTTP), 21 (FTP, 22 (SSH)

Low-interaction honeypot. This simulates only part of the network stack (such as for **Honeyd**)

- can be virtual (from a virtual machine) or simulated by another machine.

Honeyd.conf

```
create default
set default personality "Windows XP"
set default default tcp action reset
add default tcp port 110 "sh scripts/pop.sh"
add default tcp port 80 "perl scripts/iis-0.95/main.pl"
add default tcp port 25 block
add default tcp port 21 "sh scripts/ftp.sh"
add default tcp port 22 proxy $ipsrc:22
add default udp port 139 drop
set default uptime 3284460

### Cisco router
create router
set router personality "Cisco PIX Firewall (PixOS 5.2 -
6.1)"
add router tcp port 23 "/usr/bin/perl scripts/router-
telnet.pl"
set router default tcp action reset
set router uid 32767 gid 32767
set router uptime 1327650
# Bind specific templates to specific IP address
# If not bound, default to Windows template
bind 192.168.1.150 router
```

Author: Prof Bill Buchanan

Honeypot types

```
# Copyright 2002 Niels Provos <provos@citi.umich.edu>
# All rights reserved.
# For the license refer to the main source code of Honeyd.
# Don't echo Will Echo Will Surpress Go Ahead
$return = pack('ccccccccc', 255, 254, 1, 255, 251, 1, 255, 251, 3);
syswrite STDOUT, $return, 9;

$string =
"Users (authorized or unauthorized) have no explicit or\r
implicit expectation of privacy.  Any or all uses of this\r
system may be intercepted, monitored, recorded, copied,\r
audited, inspected, and disclosed to authorized site,\r
and law enforcement personnel, as well as to authorized\r
officials of other agencies, both domestic and foreign.\r
By using this system, the user consents to such\r
interception, monitoring, recording, copying, auditing,\r
inspection, and disclosure at the discretion of authorized\r
site.\r
\r
Unauthorized or improper use of this system may result in\r
administrative disciplinary action and civil and criminal\r
penalties.  By continuing to use this system you indicate\r
your awareness of and consent to these terms and conditions\r
 of use.  LOG OFF IMMEDIATELY if you do not agree to the\r
conditions stated in this warning.\r
\r
\r
\r
User Access Verification\r
";

syswrite STDOUT, $string;
$count = 0;
while ($count < 3) {
  do {
    $count++;
    syswrite STDOUT, "\r\n";
    $word = read_word("Username: ", 1);
  } while (!$word && $count < 3);
  if ($count >= 3 && !$word) {
    exit;
  }
  $password = read_word("Password: ", 0);
  if (!$password) {
    syswrite STDOUT, "% Login invalid\r\n";
  } else {
    syswrite STDERR, "Attempted login: $word/$password";
    syswrite STDOUT, "% Access denied\r\n";
  }
}
```

```
exit;
sub read_word {
  local $prompt = shift;
  local $echo = shift;
  local $word;

  syswrite STDOUT, "$prompt";

  $word = "";
  $alarmed = 0;
  eval {
    local $SIG{ALRM} = sub { $alarmed = 1; die; };
    alarm 30;
    $finished = 0;
    do {
      $nread = sysread STDIN, $buffer, 1;
      die unless $nread;
      if (ord($buffer) == 0) {
      ; #ignore
      } elsif (ord($buffer) == 255) {
      sysread STDIN, $buffer, 2;
      } elsif (ord($buffer) == 13 || ord($buffer) == 10) {
      syswrite STDOUT, "\r\n" if $echo;
      $finished = 1;
      } else {
      syswrite STDOUT, $buffer, 1 if $echo;
      $word = $word.$buffer;
      }
    } while (!$finished);
    alarm 0;
  };
  syswrite STDOUT, "\r\n" if $alarmed || ! $echo;
  if ($alarmed) {
    syswrite STDOUT, "% $prompt timeout expired!\r\n";
    return (0);
  }

  return ($word);
}
```

Example of router-telnet.pl

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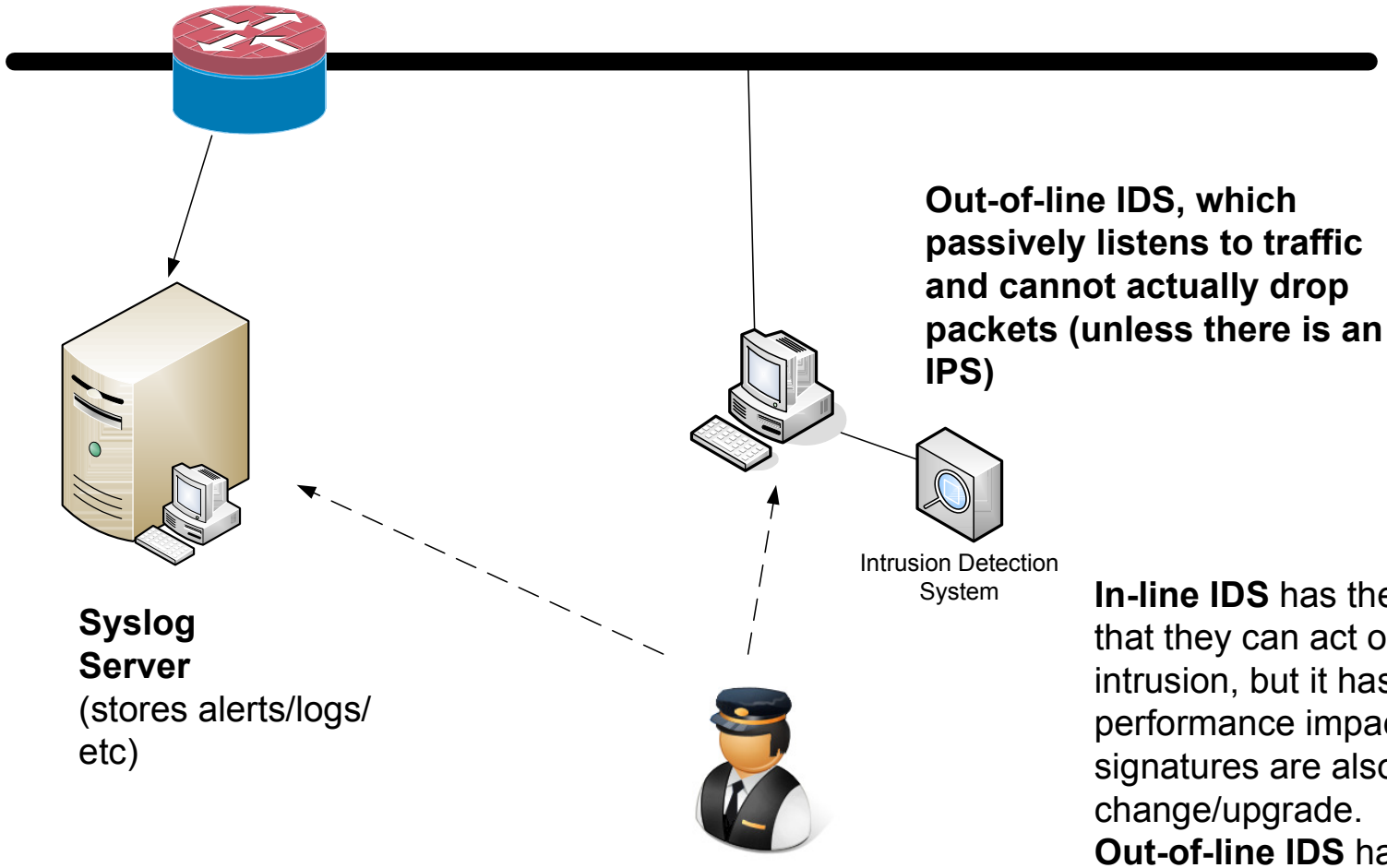
IPS and In/out-line

Author: Prof Bill Buchanan

IPS

IDS

In-line IDS, which can decide to drop a packet, alarm (send an alert/log) or reset a connection.



Out-of-line IDS, which passively listens to traffic and cannot actually drop packets (unless there is an IPS)

Syslog Server
(stores alerts/logs/ etc)

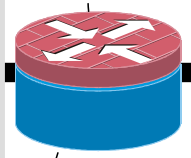
In-line IDS has the advantage that they can act on the intrusion, but it has a performance impact. The signatures are also difficult to change/upgrade.
Out-of-line IDS has the advantage of being able to more easily craft an IDS rule, but cannot take actions, directly.

Author: Prof Bill Buchanan

In-line and out-of-line IDS

Example Cisco IDS signatures

1001 – Bad IP Options (Info)
1100 – IP Fragment (Attack)
2000 - ICMP echo reply (Info)
2154 – Ping of death (Attack)
3041 – SYN/FIN Packet (Attack)
3040 – NULL TCP Packet (Attack)
3050 – Half open SYN (Attack)
3152 – CWD Root on FTP (Info)



Syslog Server (stores alerts/logs/ etc)

IPS

IDS

```
(config)# ip audit ?
  attack     Specify default action for attack signatures
  info       Specify default action for informational signatures
  name       Specify an IDS audit rule
  notify     Specify the notification mechanisms (nr-director or log) for the
             alarms
  po         Specify nr-director's PostOffice information (for sending events
             to the nr-directors
  signature  Add a policy to a signature
  smtp       Specify SMTP Mail spam threshold
(config)# ip audit notify ?
  log          Send events as syslog messages
  nr-director  Send events to the nr-director
(config)# ip audit notify log
(config)# logging 132.191.125.3
(config)# ip audit ?
  attack     Specify default action for attack signatures
  info       Specify default action for informational signatures
  name       Specify an IDS audit rule
  notify     Specify the notification mechanisms (nr-director or log) for the
             alarms
  po         Specify nr-director's PostOffice information (for sending events
             to the nr-directors
  signature  Add a policy to a signature
  smtp       Specify SMTP Mail spam threshold
(config)# ip audit info ?
  action  Specify the actions
(config)# ip audit info action ?
  alarm  Generate events for matching signatures
  drop   Drop packets matching signatures
  reset  Reset the connection (if applicable)
(config)# ip audit info action drop
(config)# ip audit attack action reset
(config)# ip audit signature ?
  <1-65535>  Signature to be configured
(config)# ip audit signature 1005 disable
(config)# ip audit smtp ?
  spam  Specify the threshold for spam signature
  <cr>
(config)# ip audit smtp spam ?
  <1-65535>  Threshold of correspondents to trigger alarm
(config)# ip audit smtp spam 4
```

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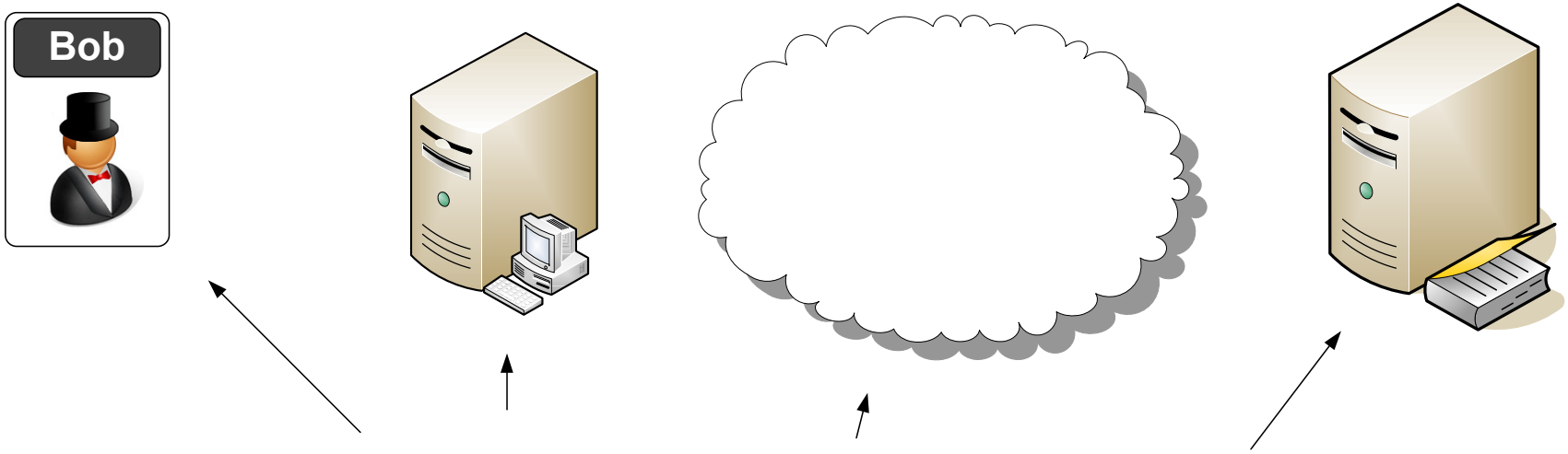
Anomaly Detection

Author: Prof Bill Buchanan

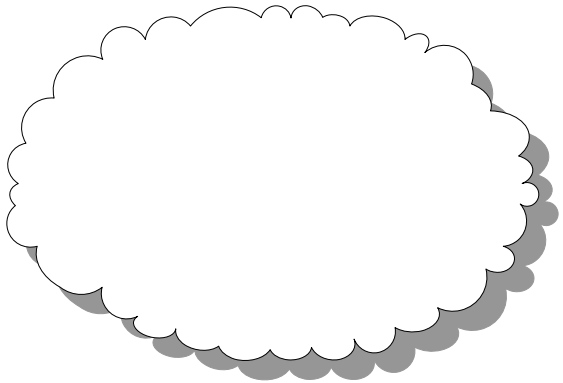


Anomaly detection:
Learn normal activity, such as:
User activity.
System activity
Server activity
Network activity
Application activity
And so on

Anomaly

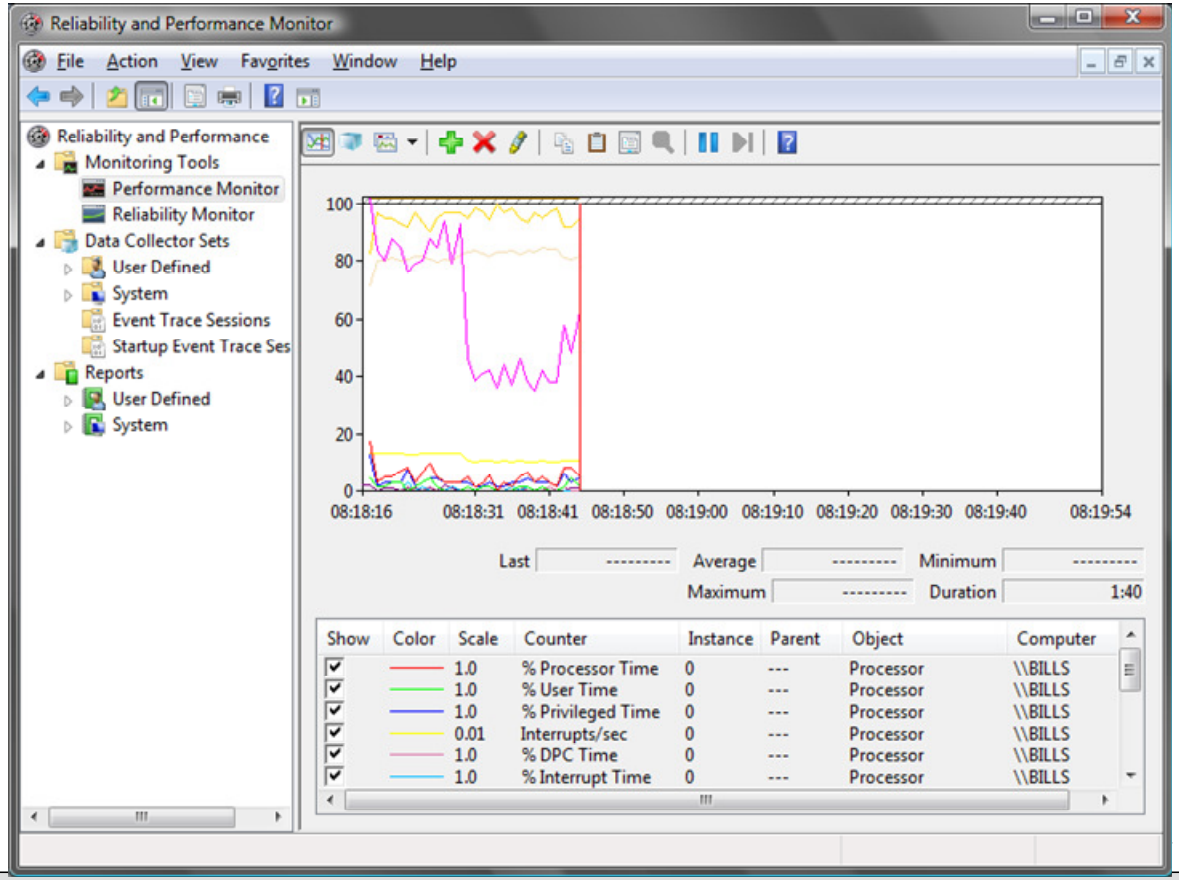
IDS

Author: Prof Bill Buchanan



User anomaly:
Typing speed
Packages used
Working hours
Emails sent/hr
Web sites visited

System anomaly:
CPU Usage/min
Threads/min
Disk writes/min

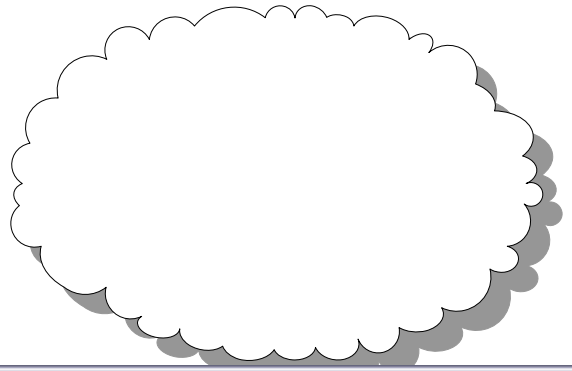


Anomaly

IDS

Bill Buchanan

User, system and network anomaly



Anomaly

IDS

Network anomaly
IP packets (%)
TCP packets (%)
HTTP (%)
FTP (%)

FTP threshold (2%)

Ethereal: Protocol Hierarchy Statistics

Protocol	% Packets	Packets	Bytes	Mbit/s	End Packets	End Bytes	End Mbit/s
Frame	100.00%	1108	774129	0.021	0	0	0.000
Ethernet	100.00%	1108	774129	0.021	0	0	0.000
Logical-Link Control	1.17%	13	1174	0.000	0	0	0.000
Internetwork Packet eXchange	1.17%	13	1174	0.000	0	0	0.000
IPX Routing Information Protocol	0.54%	6	348	0.000	6	348	0.000
NetBIOS over IPX	0.54%	6	588	0.000	6	588	0.000
Name Management Protocol over IPX	0.09%	1	238	0.000	0	0	0.000
SMB (Server Message Block Protocol)	0.09%	1	238	0.000	0	0	0.000
SMB MailSlot Protocol	0.09%	1	238	0.000	0	0	0.000
Microsoft Windows Browser Protocol	0.09%	1	238	0.000	1	238	0.000
Internet Protocol	98.65%	1093	772853	0.021	0	0	0.000
User Datagram Protocol	14.44%	160	44326	0.001	0	0	0.000
Hypertext Transfer Protocol	9.03%	100	34560	0.001	100	34560	0.001
Domain Name Service	3.79%	42	6718	0.000	42	6718	0.000
Simple Network Management Protocol	0.81%	9	1635	0.000	9	1635	0.000
NetBIOS Name Service	0.45%	5	460	0.000	5	460	0.000
NetBIOS Datagram Service	0.36%	4	953	0.000	0	0	0.000
SMB (Server Message Block Protocol)	0.36%	4	953	0.000	0	0	0.000
SMB MailSlot Protocol	0.36%	4	953	0.000	0	0	0.000
Microsoft Windows Browser Protocol	0.36%	4	953	0.000	4	953	0.000
Transmission Control Protocol	83.48%	925	727935	0.019	583	353311	0.009
Hypertext Transfer Protocol	27.89%	309	368157	0.010	298	360076	0.010
Line-based text data	0.36%	4	3301	0.000	0	0	0.000
Media Type	0.36%	4	2668	0.000	0	0	0.000
Compuserve GIF	0.27%	3	2112	0.000	3	2112	0.000
SSH Protocol	2.98%	33	6467	0.000	33	6467	0.000
Internet Control Message Protocol	0.72%	8	592	0.000	8	592	0.000
Address Resolution Protocol	0.18%	2	102	0.000	2	102	0.000

OK

nan

User, system and network anomaly

Intrusion Detection Systems

Conclusions

Author: Prof Bill Buchanan