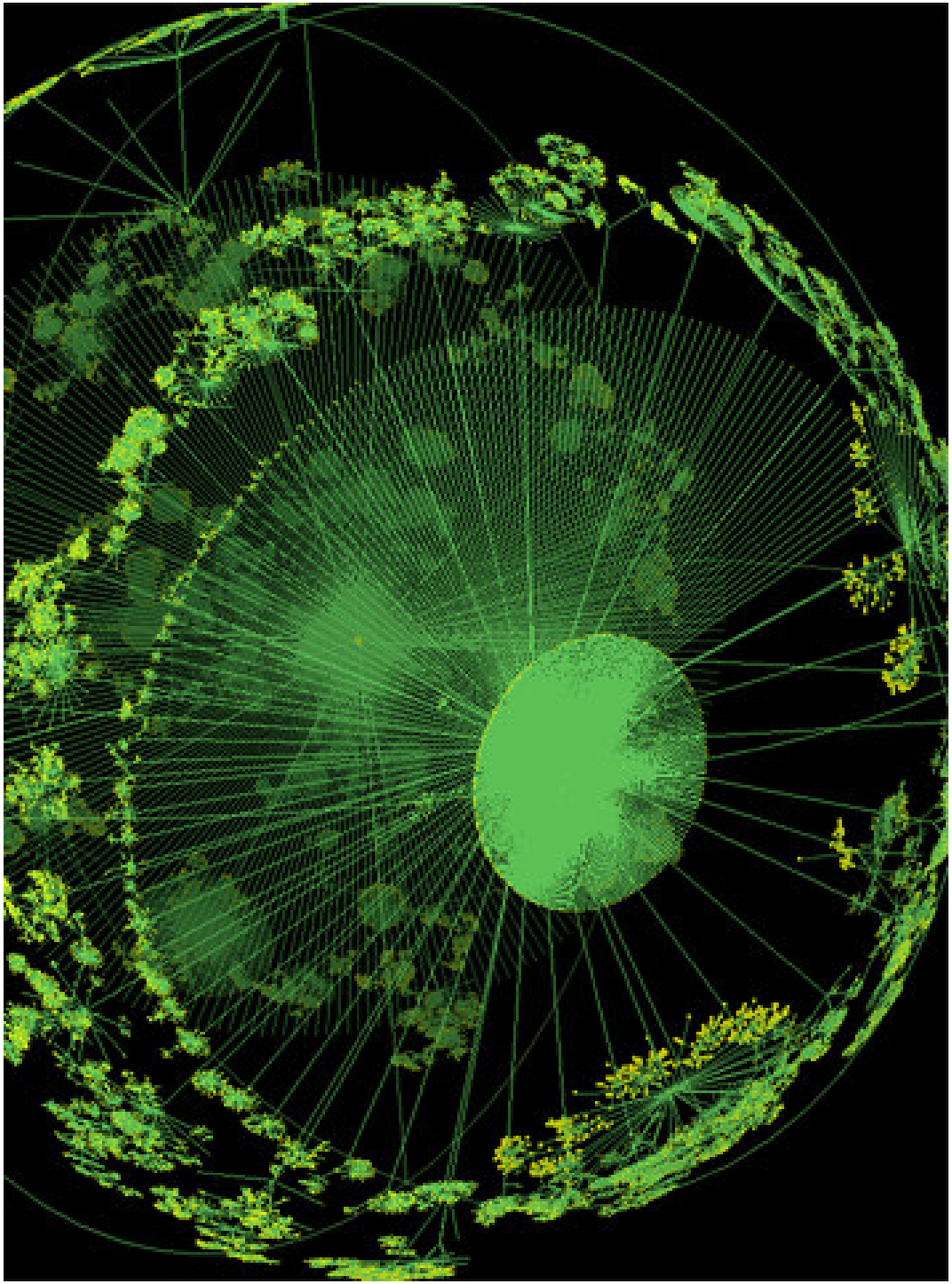


Network Security Data Visualization

Greg Conti

www.cc.gatech.edu/~conti

http://www.cybergeography.org/atlas/walrus1_large.gif

Disclaimer

The views expressed in this presentation are those of the author and do not reflect the official policy or position of the United States Military Academy, the Department of the Army, the Department of Defense or the U.S. Government.

image: http://www.leavenworth.army.mil/usdb/standard%20products/vtdefault.htm

information visualization *is the use of interactive, sensory representations, typically visual, of abstract data to reinforce cognition.*

http://en.wikipedia.org/wiki/Information_visualization

Why InfoVis?

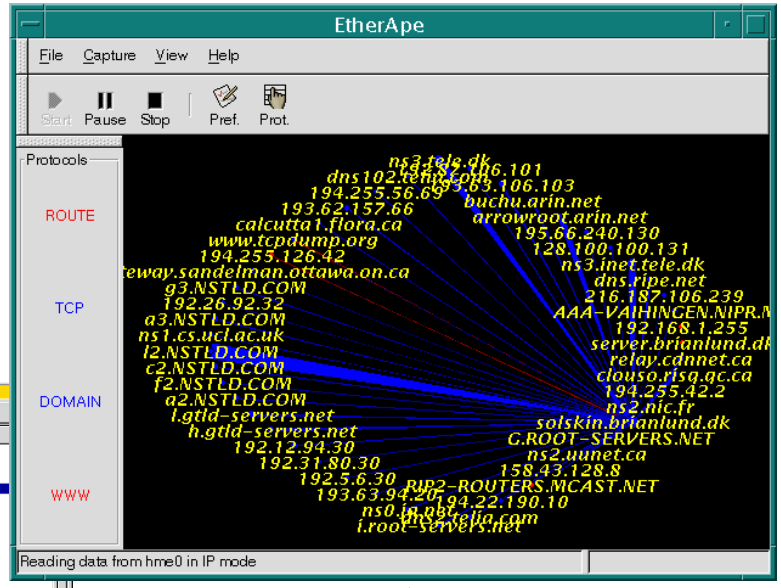
- Helps find patterns
- Helps reduce search space
- Aids efficient monitoring
- Enables interaction (what if)
- Help prevent overwhelming the user

So What?

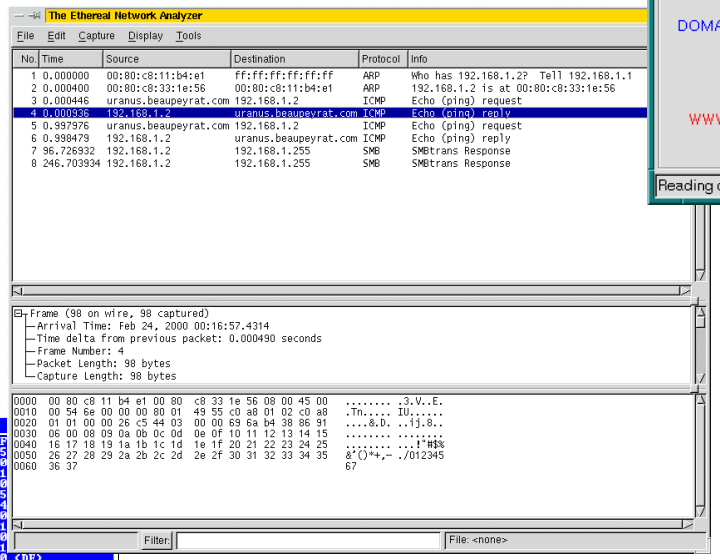
- Go Beyond the Algorithm
- Help with detecting and understand some 0 day attacks
- Make Root Wars & CTF a Spectator Sport
- Help find insider threats
- Stealth might not be so stealthy
- Help visually fingerprint attacks/tools

What tasks do you need help with?

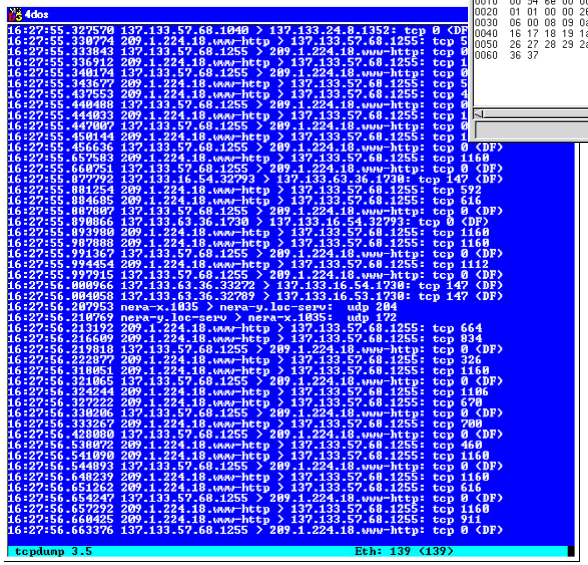
Packet Capture Visualizations



EtherApe



Ethereal



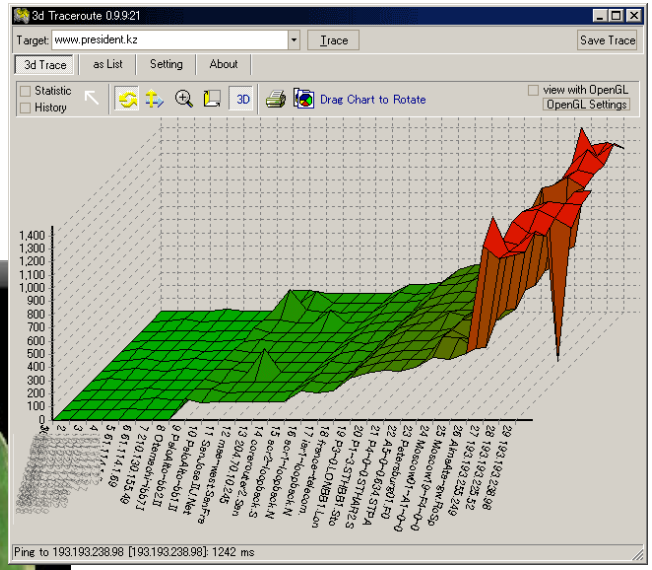
TCP Dump

Tcpdump image: http://www.bgnett.no/~giva/pcap/tcpdump.png
TCPDump can be found at http://www.tcpdump.org/

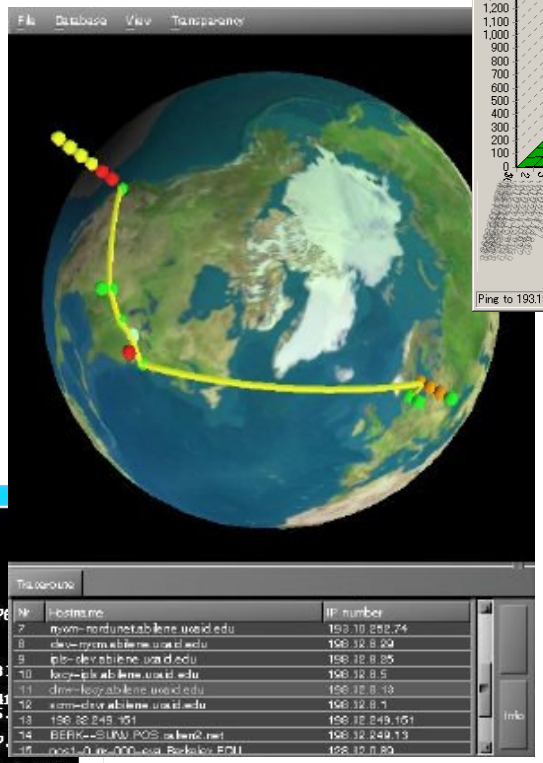
Ethereal image: http://www.linux-france.org/prj/edu/archinet/AMSI/index/images/ethereal.gif
Ethereal by Gerald Combs can be found at http://www.ethereal.com/

EtherApe image: http://www.solaris4you.dk/sniffersSS.html
Etherape by Juan Toledo can be found at http://etherape.sourceforge.net/

traceroute Visualizations



3D TraceRoute



Xtraceroute

```
C:\WINNT\System32\command.com

C:\>tracert jefferypsanders.com

Tracing route to jefferypsanders.com [66.218.65.125]
over a maximum of 30 hops:

  1     1 ms     1 ms     1 ms  192.168.0.1
  2    12 ms    13 ms    14 ms  cdm-66-105-1-pine.cox-internet.com [66.76

  3    15 ms    15 ms    16 ms  172.16.110.1
  4    20 ms    18 ms    18 ms  12.119.71.133
  5    26 ms    25 ms    26 ms  gbr2-p59.hs1tx.ip.att.net [12.123.212.18
  6    29 ms    33 ms    30 ms  gbr3-p40.dlstx.ip.att.net [12.122.2.97]
  7    30 ms    27 ms    31 ms  ggr1-p360.dlstx.ip.att.net [12.123.16.24
  8    29 ms    30 ms    29 ms  pos1-3.core1.Dallas1.Level3.net [209.245.
]
  9    29 ms    31 ms    29 ms  so-4-0-0.mp2.Dallas1.Level3.net [209.247.

 10    69 ms    70 ms    69 ms  so-3-0-0.mp2.SanJose1.Level3.net [64.159.1.130]

 11    71 ms    71 ms    69 ms  gige10-0.ipcolo4.SanJose1.Level3.net [64.159.2.4
2]
 12    70 ms    71 ms    70 ms  cust-int.level3.net [64.152.69.18]
 13    69 ms    72 ms    73 ms  ge-1-3-0.msr1.pao.yahoo.com [216.115.100.150]
 14    72 ms    71 ms    73 ms  vl10.bas1.scd.yahoo.com [66.218.64.134]
 15    71 ms    72 ms    71 ms  pweb1.geo.vip.scd.yahoo.com [66.218.65.125]

Trace complete.
```

basic traceroute/tracert

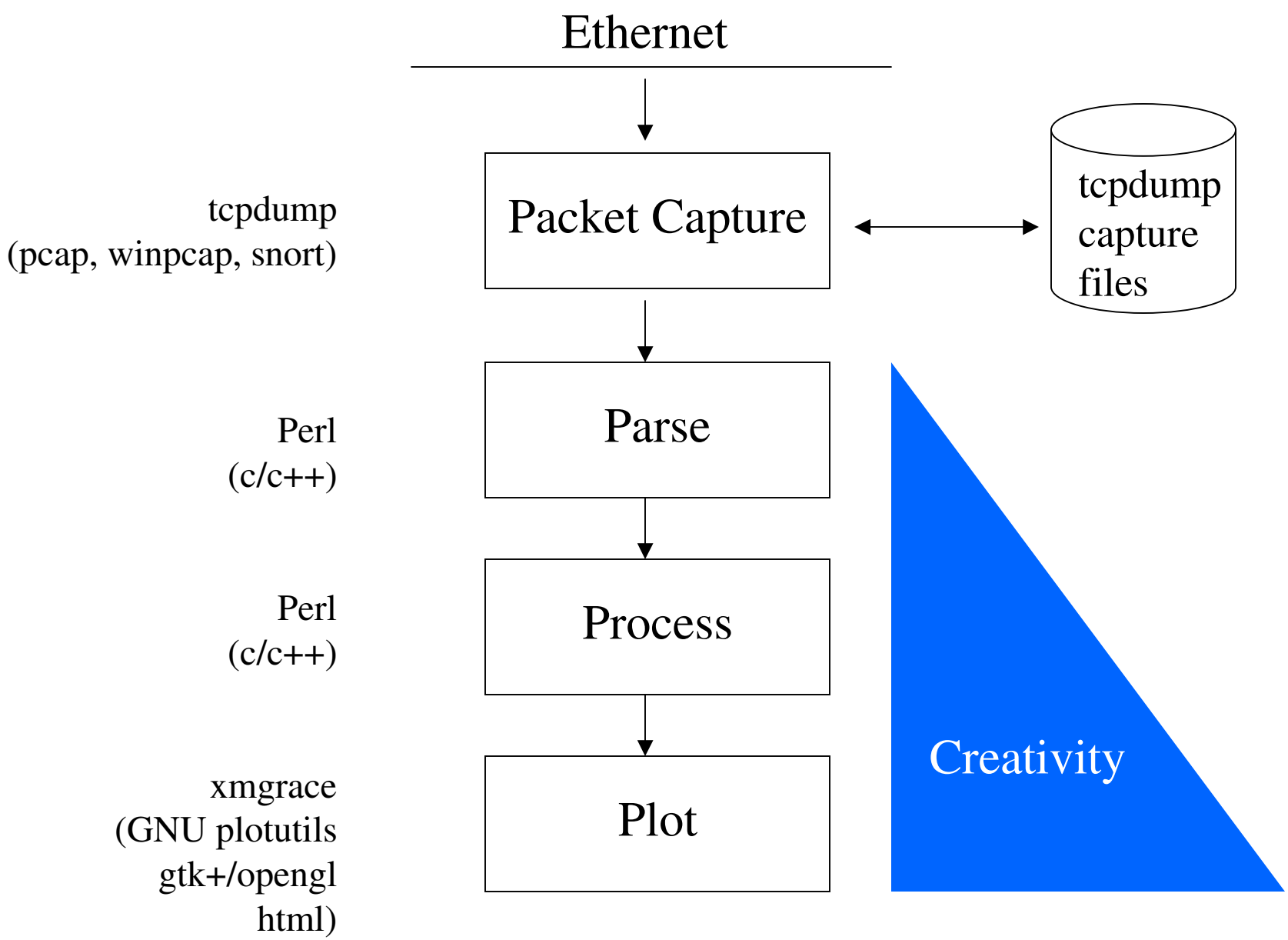
3D TraceRoute Developer: http://www.hlembke.de/prod/3dtraceroute/
XTraceRoute Developer: http://www.dtek.chalmers.se/~d3august/xt/

Intrusion Detection System Types

- ***Host-based intrusion-detection*** is the art of detecting malicious activity within a single computer by using
  - host log information
  - system activity
  - virus scanners

- A ***Network intrusion detection system*** is a system that tries to detect malicious activity such as denial of service attacks, port-scans or other attempts to hack into computers by reading all the incoming packets and trying to find suspicious patterns.

http://en2.wikipedia.org/wiki/Host-based_intrusion-detection_system
http://en2.wikipedia.org/wiki/Network_intrusion_detection_system


Ethernet
tcpdump
(pcap, winpcap, snort)
Packet Capture
tcpdump
capture
files
Perl
(c/c++)
Parse
Perl
(c/c++)
Process
xmgrace
(GNU plotutils
gtk+/opengl
html)
Plot
Creativity

Information Visualization Mantra

Overview First,

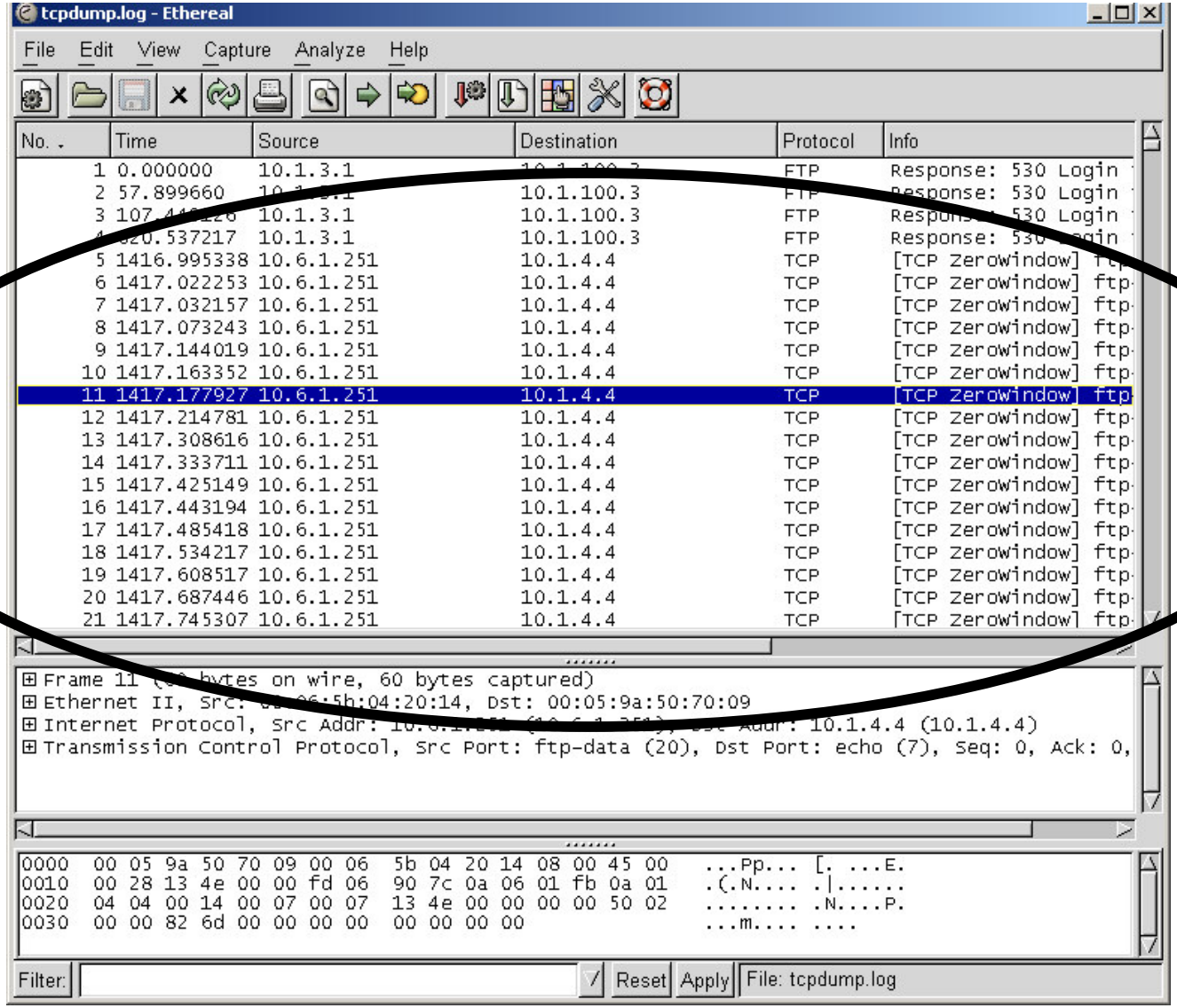
Zoom & Filter,

Details on Demand

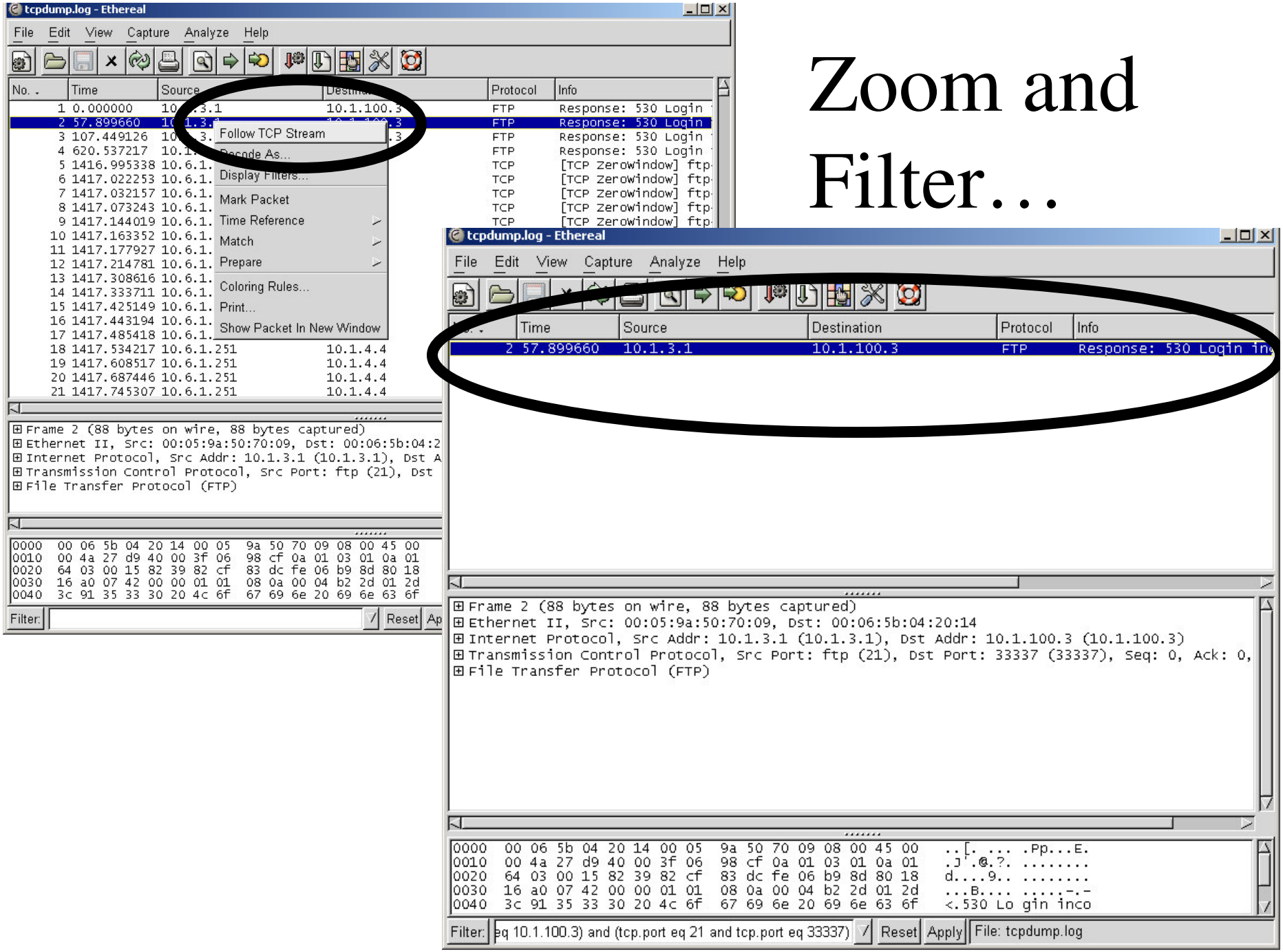
- Ben Shneiderman

http://www.cs.umd.edu/~ben/

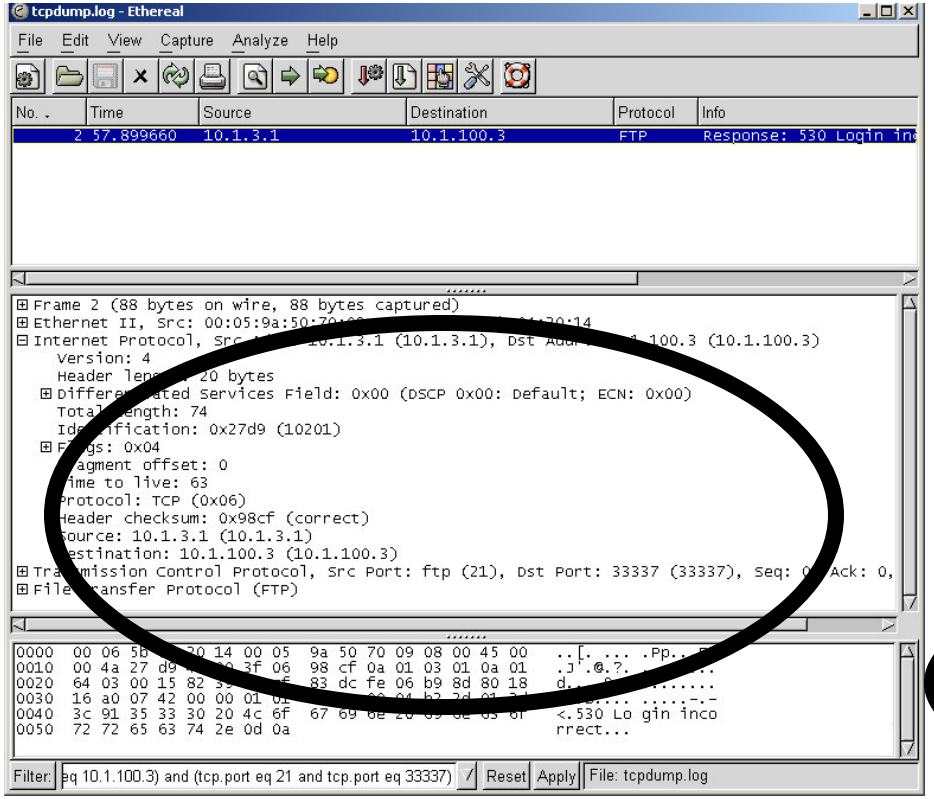
Overview First…

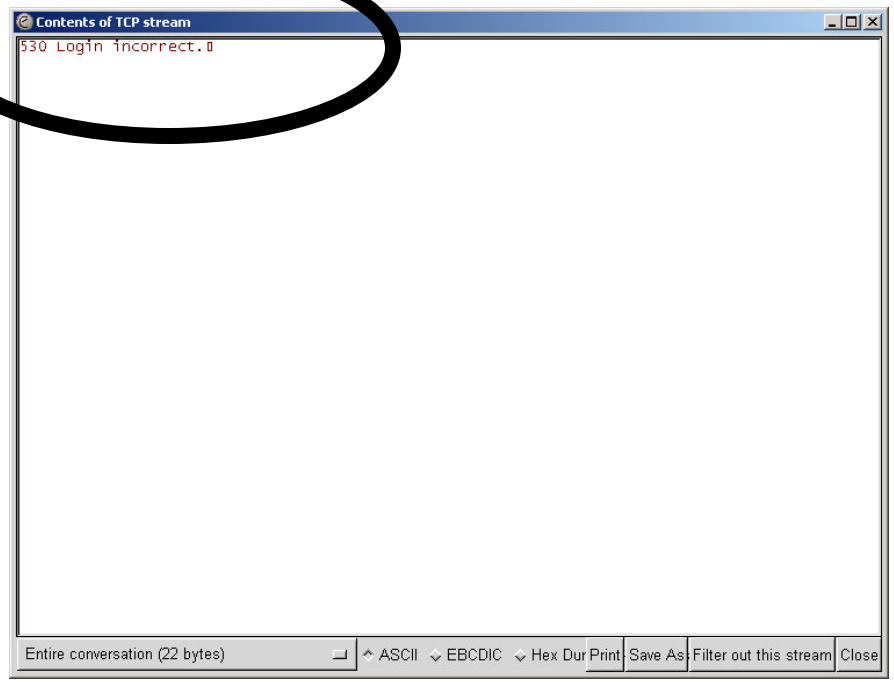


Zoom and Filter…



Details on Demand…





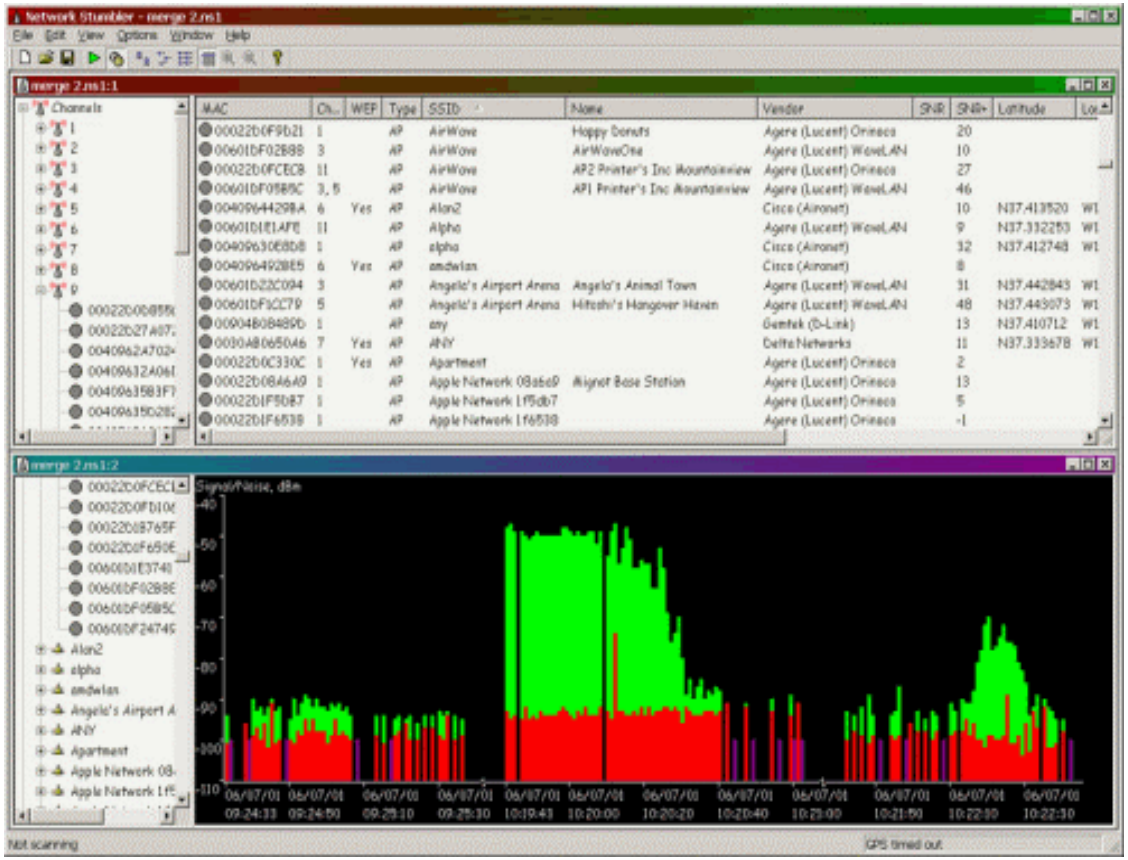
What Tools are at Your Disposal…

Tools

- Color
- Size
- Sequence
- Filtering
- Interactivity

What InfoVis can help you see

- Relationships between X & Y & Z…
- Extremes
- Comparisons and Differences
- Trends



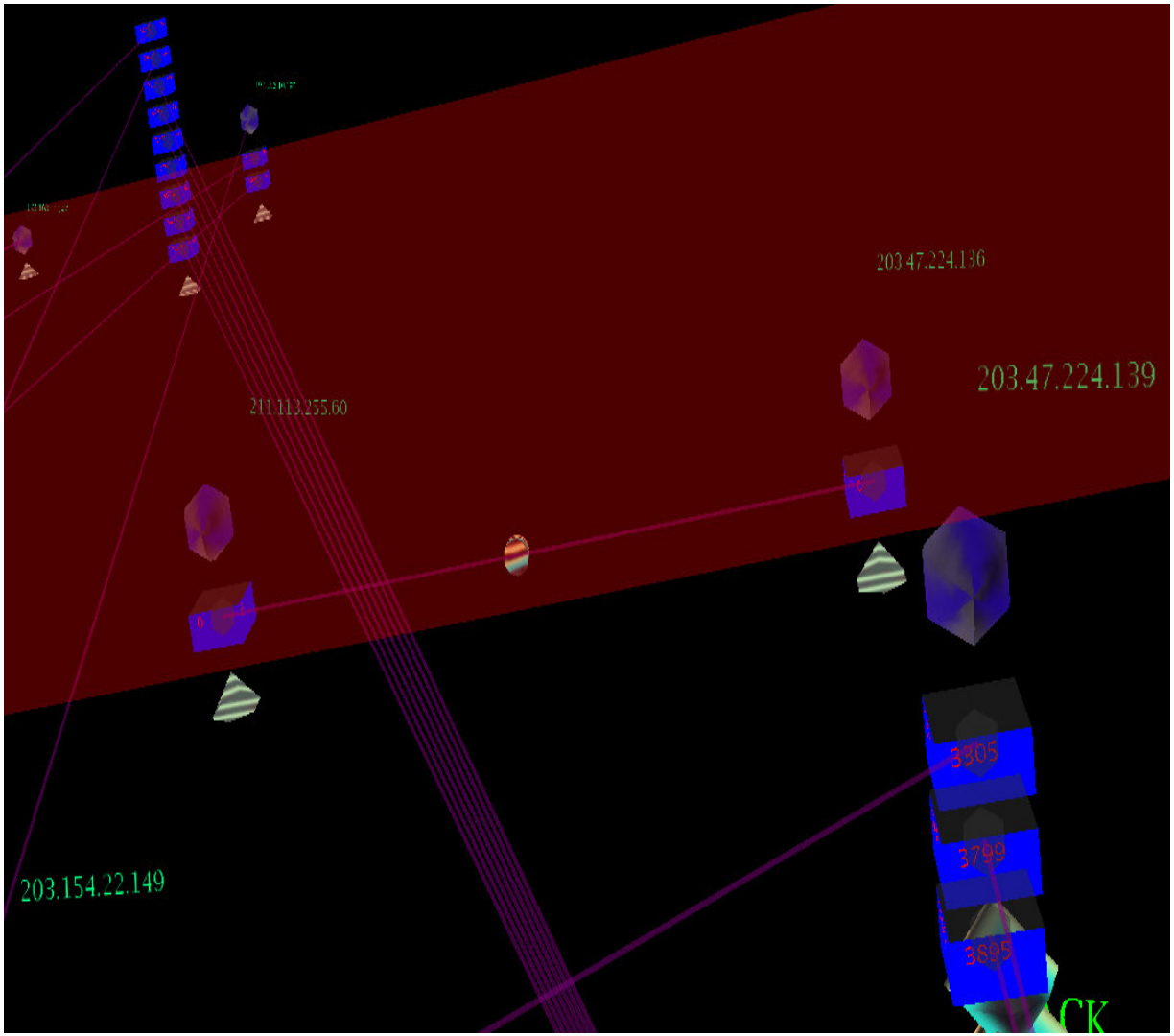
http://www.netstumbler.com/
Image: http://images.webattack.com/screenfiles/netstumbler.gif

More tools

- Shape
- Orientation
- Scale
- Perspective

What InfoVis can help you see

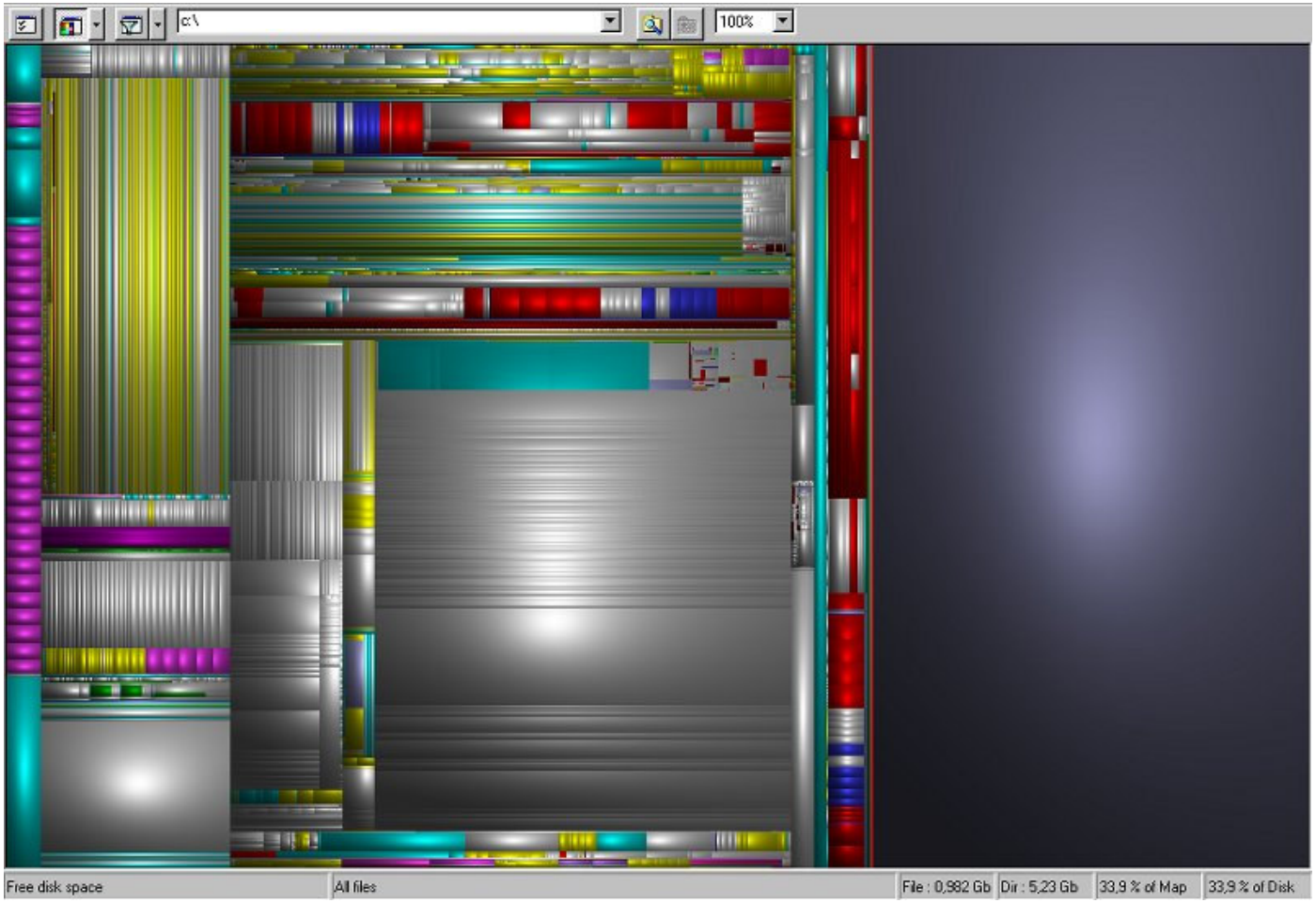
- Anomalies
- Outliers
- Patterns



http://scanmap3d.sourceforge.net/

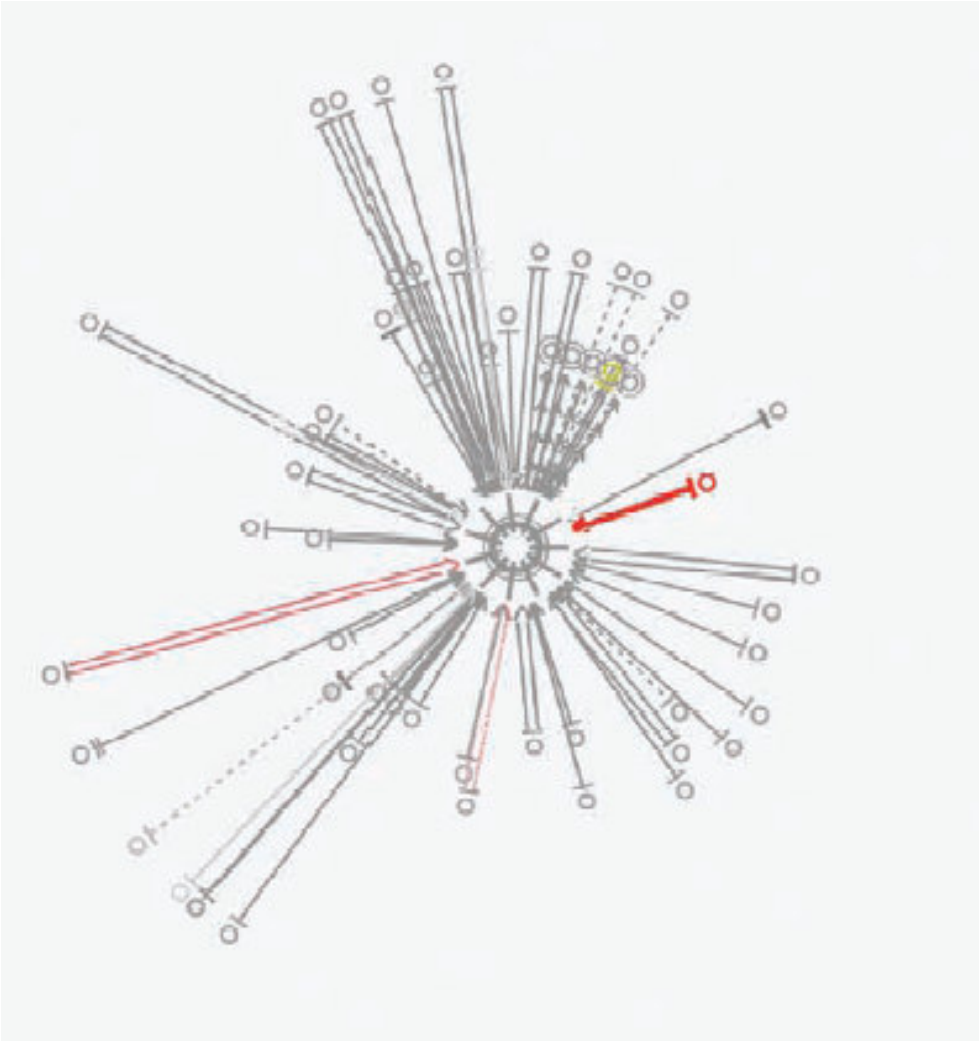
Representative Current Research

SequoiaView



Demo

http://www.win.tue.nl/sequoiaview/



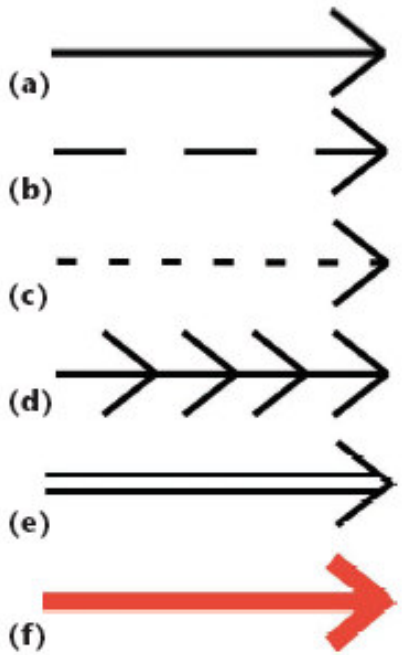
Observing Intruder Behavior

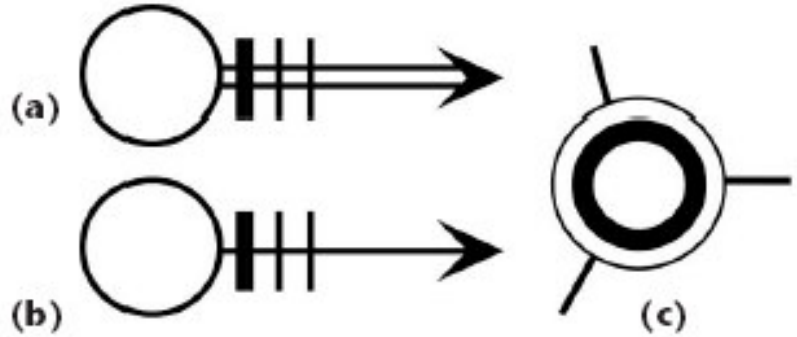
Dr. Rob Erbacher

- Visual Summarizing and Analysis Techniques for Intrusion Data
- Multi-Dimensional Data Visualization
- A Component-Based Event-Driven Interactive Visualization Software Architecture

http://otherland.cs.usu.edu/~erbacher/

3 Line appearances and their relationships. (a) Telnet and rlogin connections as solid lines, (b) privileged FTPs as long dashed lines, (c) anonymous FTPs as short dashed lines, (d) Network file system (NFS) accesses as solid lines with many arrows, (e) initial inetd port connection, and (f) port scan.



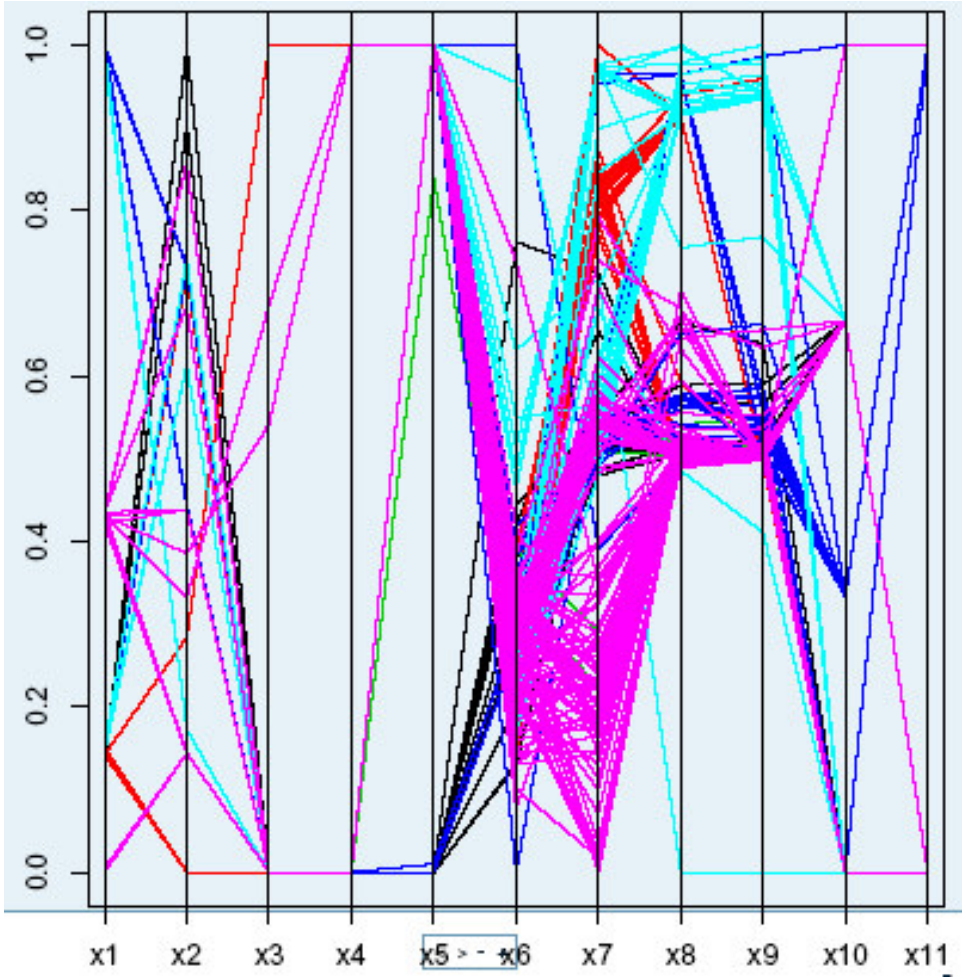


2 Basic glyph organization. (a) The initial inetd connection to the system. (b) The resulting connection after authentication. (a) and (b) also represent the number of users with connections from the given remote host and the number of connections by said users through the use of the cross hatches. The monitored system, (c) showing number of users and load.

Demo

http://otherland.cs.usu.edu/~erbacher/

Operating System Fingerprinting

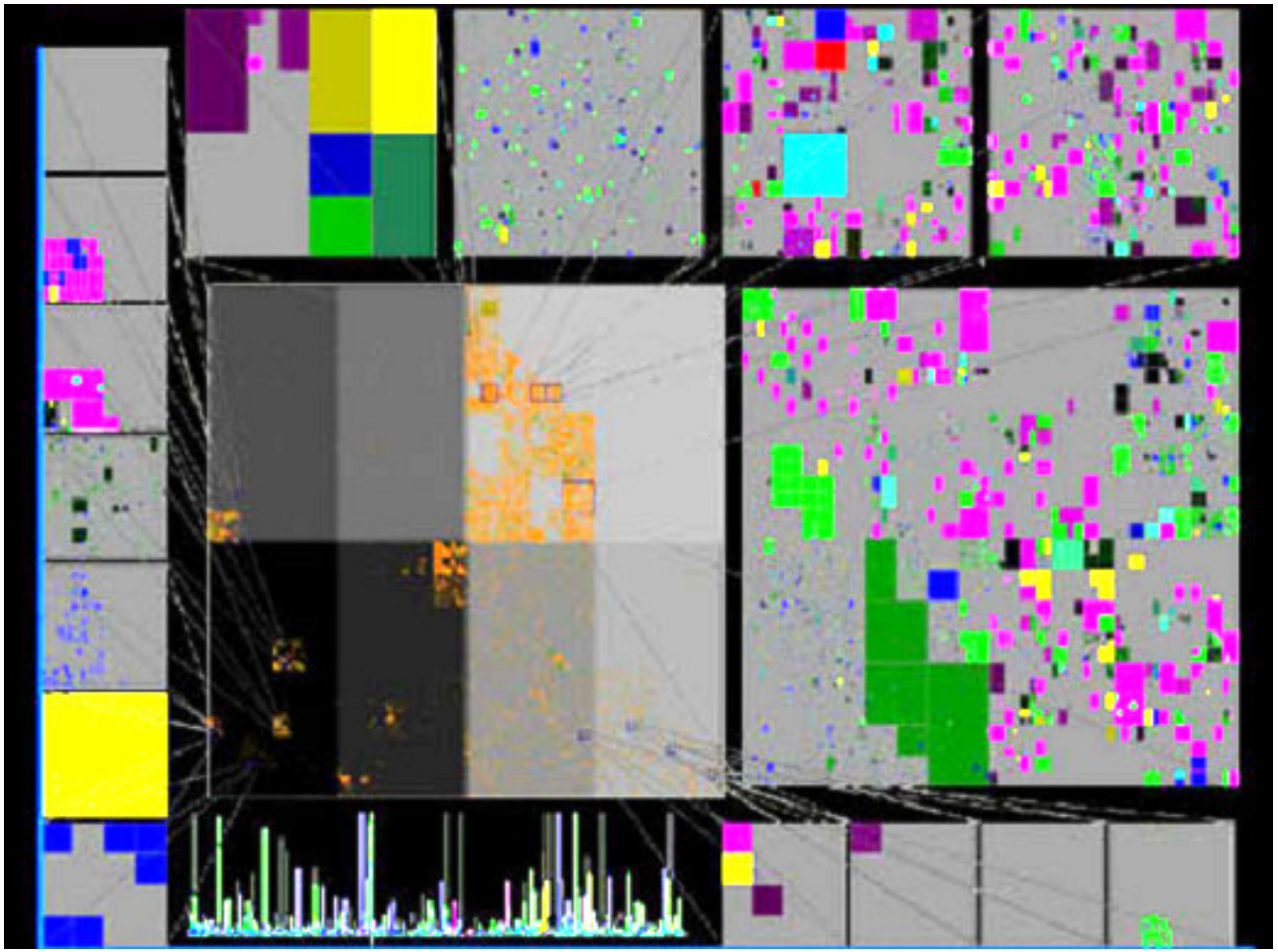


Dr. David Marchette

- Passive Fingerprinting
- Statistics for intrusion detection

http://www.mts.jhu.edu/~marchette/

Visualizing Internet Routing Data

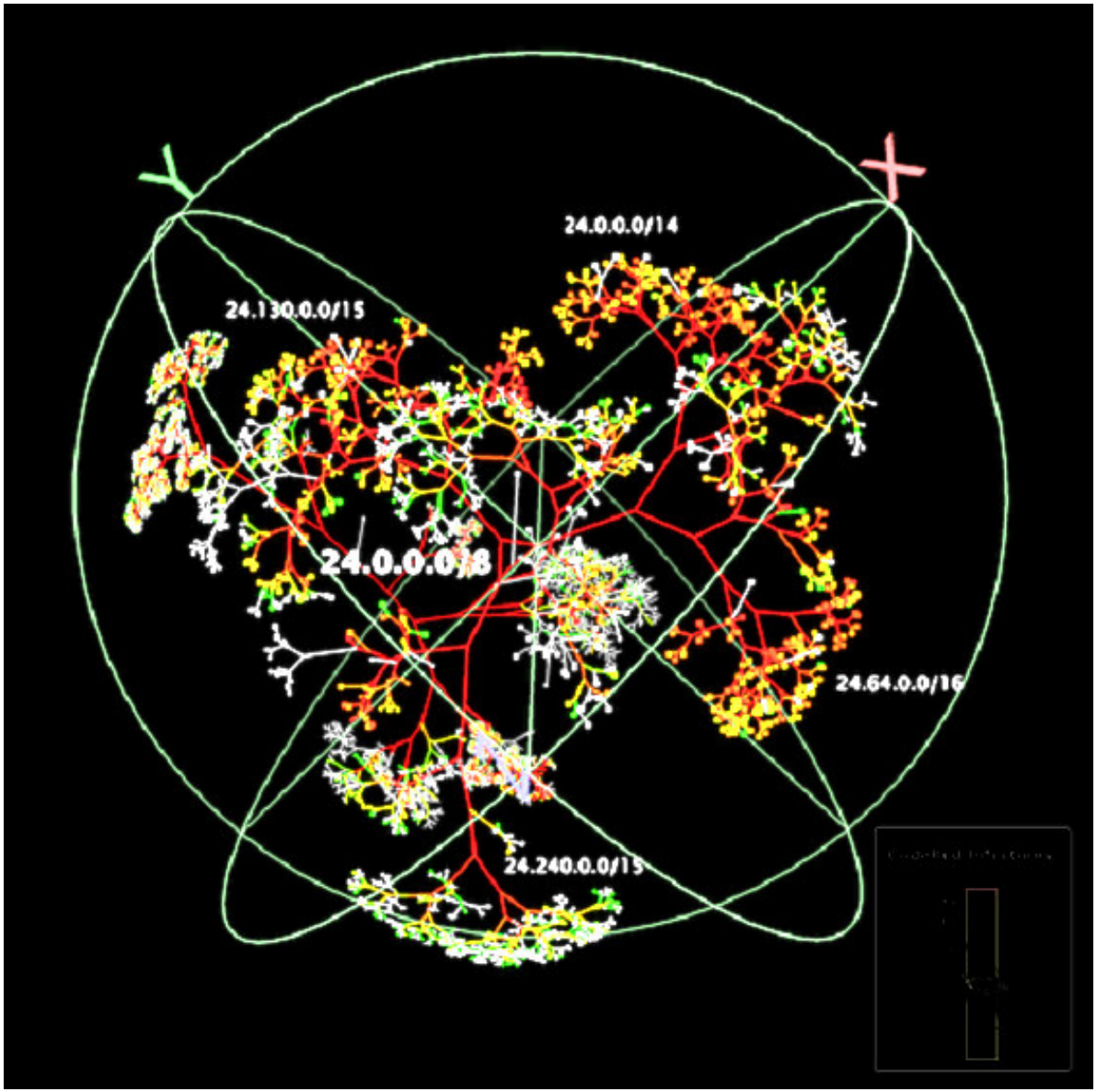


Soon Tee Teoh

Demo

http://graphics.cs.ucdavis.edu/~steoh/

See also treemap basic research: http://www.cs.umd.edu/hcil/treemap-history/index.shtml

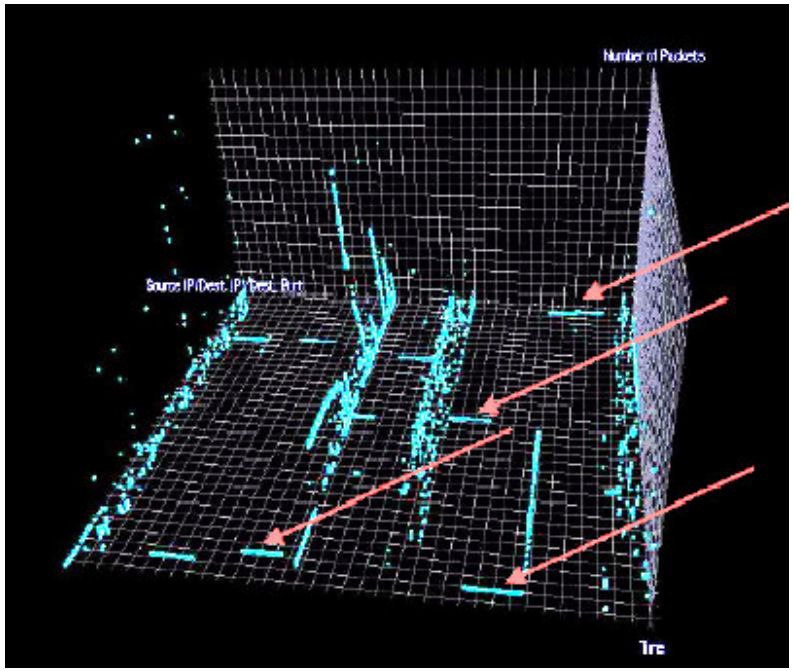


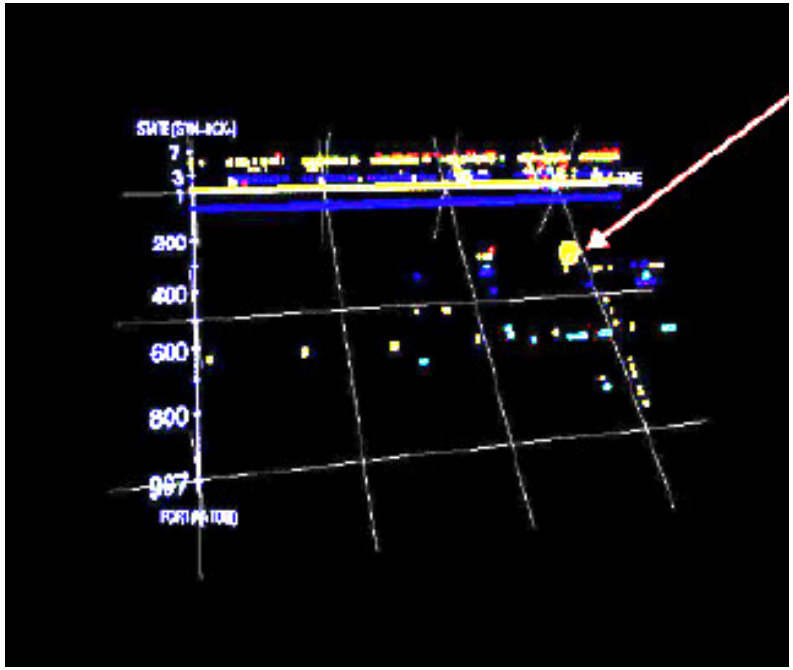
Worm Propagation

- CAIDA

- Young Hyun
- David Moore
- Colleen Shannon
- Bradley Huffaker

http://www.caida.org/tools/visualization/walrus/examples/codered/





Intrusion Detection and Visualization Using Perl

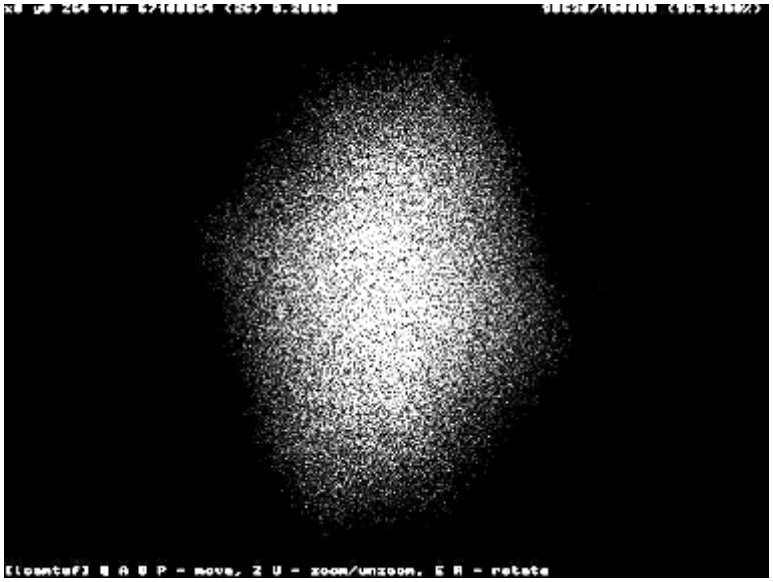
Jukka Juslin

3D plot of:

- Time
- SDP (Source-Destination-Port)
- Number of Packets

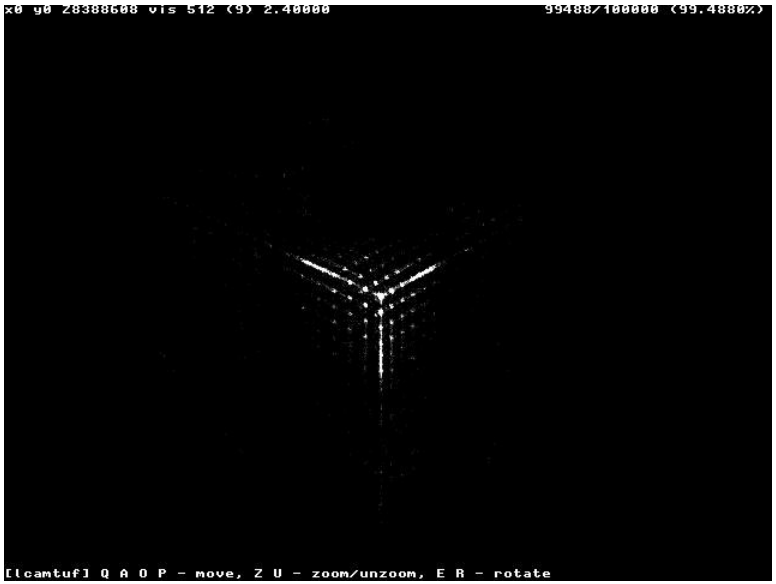
Data stored in Perl hashes
Output piped to GNUplot

http://www.cs.hut.fi/~jtjuslin/



TCP/IP Sequence Number Generation

Michal Zalewski



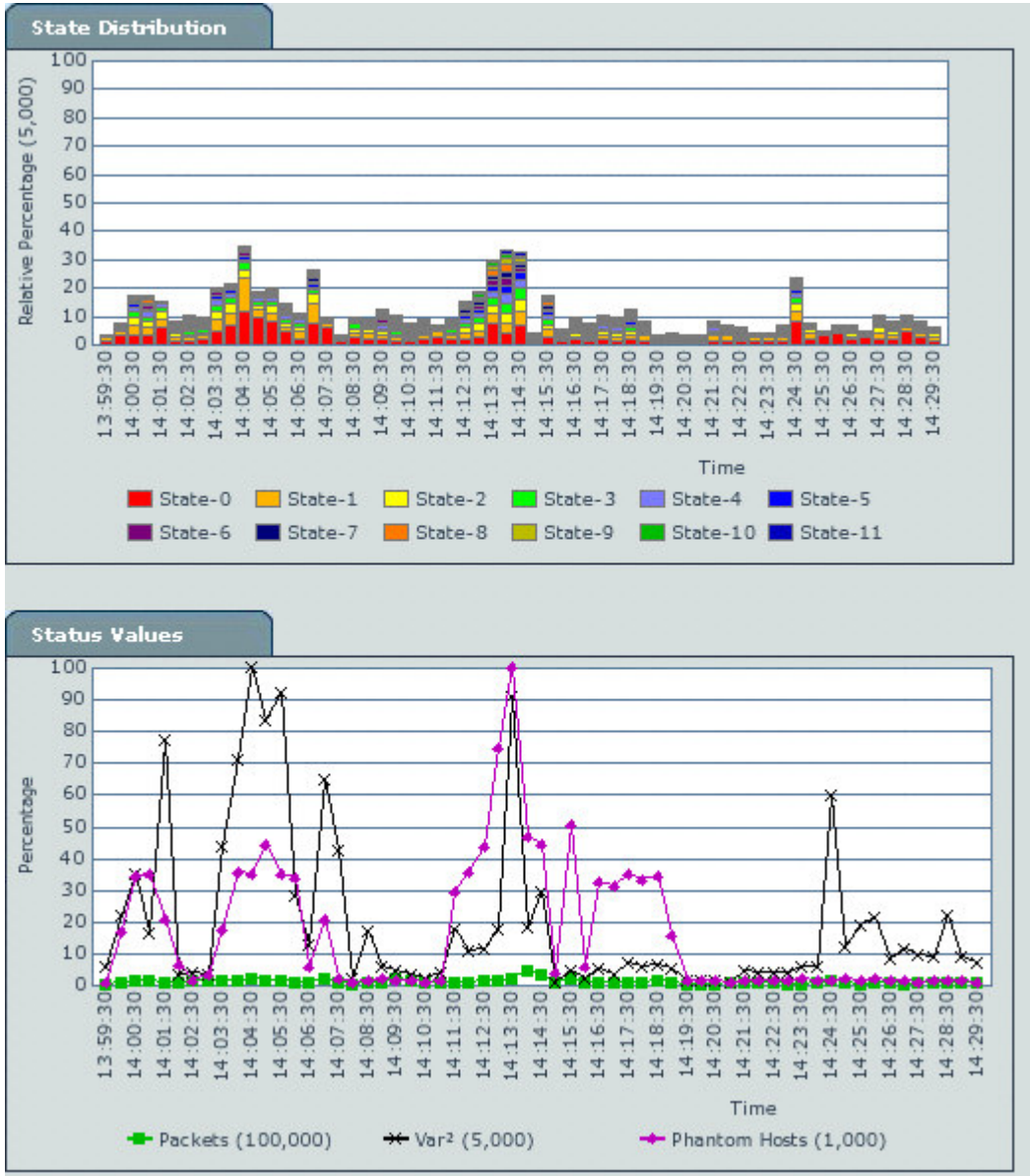
$$x[n] = s[n-2] - s[n-3]$$

$$y[n] = s[n-1] - s[n-2]$$

$$z[n] = s[n] - s[n-1]$$

Follow-up paper - http://lcamtuf.coredump.cx/newtcp/

Initial paper - http://razor.bindview.com/publish/papers/tcpseq/print.html

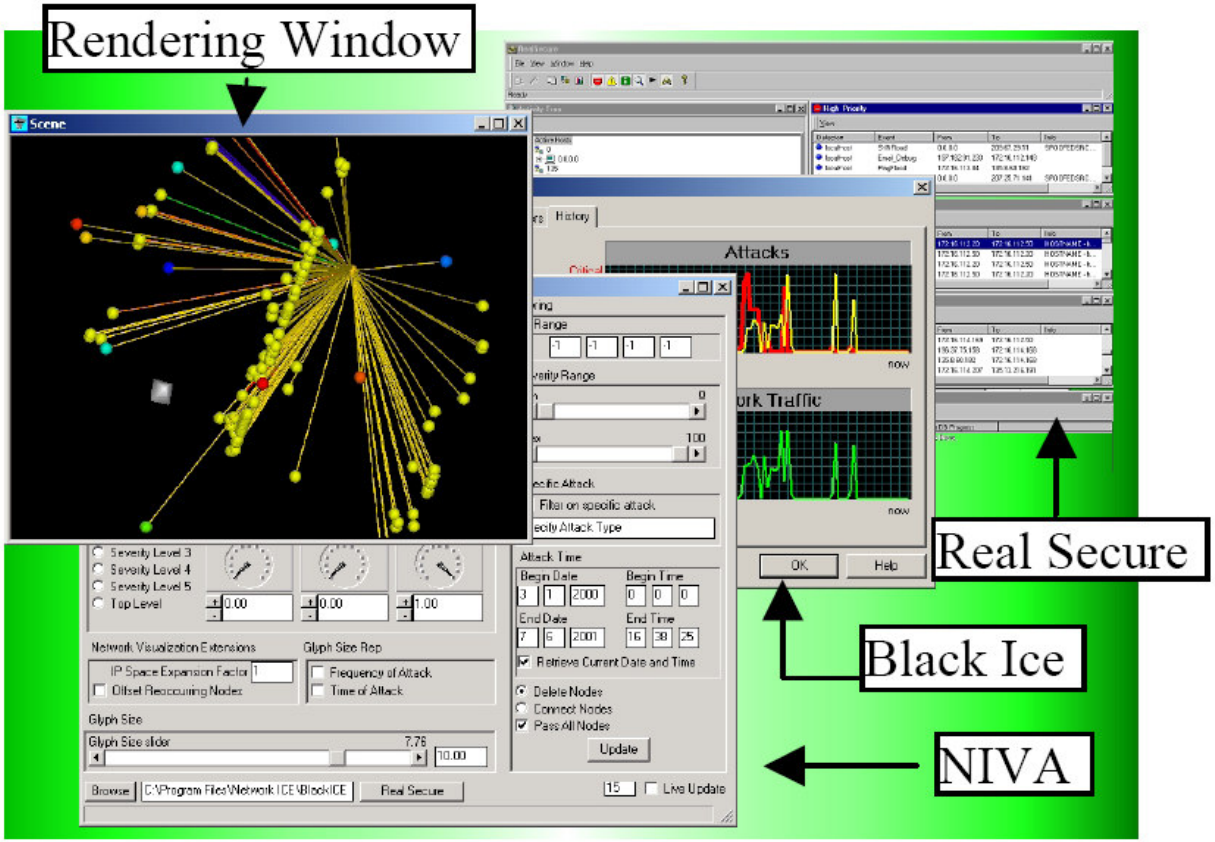


High Speed Data Flow Visualization

Therminator technology watches the data stream and illustrates categories of data as colored bars that are proportional in height to the quantity of data at a given time. The process is repeated to form a stacked bar graph that moves across a computer screen to show current and past data traffic composition.

http://www.fcw.com/fcw/articles/2002/1209/web-nsa-12-13-02.asp

Haptic and Visual Intrustion Detection



NIVA System

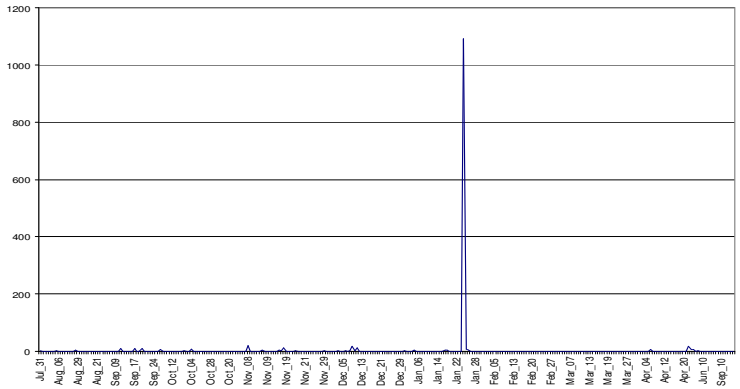
- Craig Scott
- Kofi Nyarko
- Tanya Capers
- Jumoke Ladeji-Osias

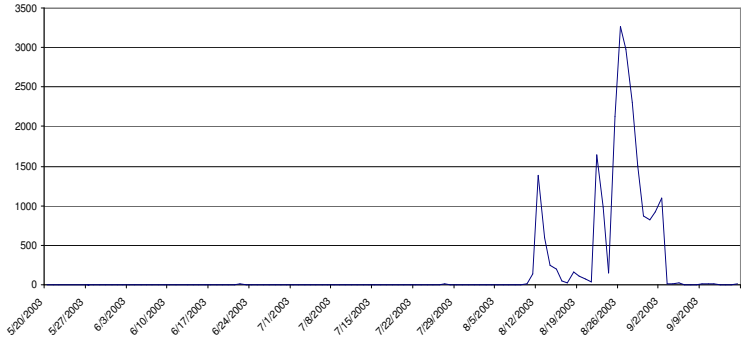
http://portal.acm.org/citation.cfm?id=952873&dl=ACM&coll=GUIDE

Atlas of Cyber Space

http://www.cybergeography.org/atlas/atlas.html

Honeynets



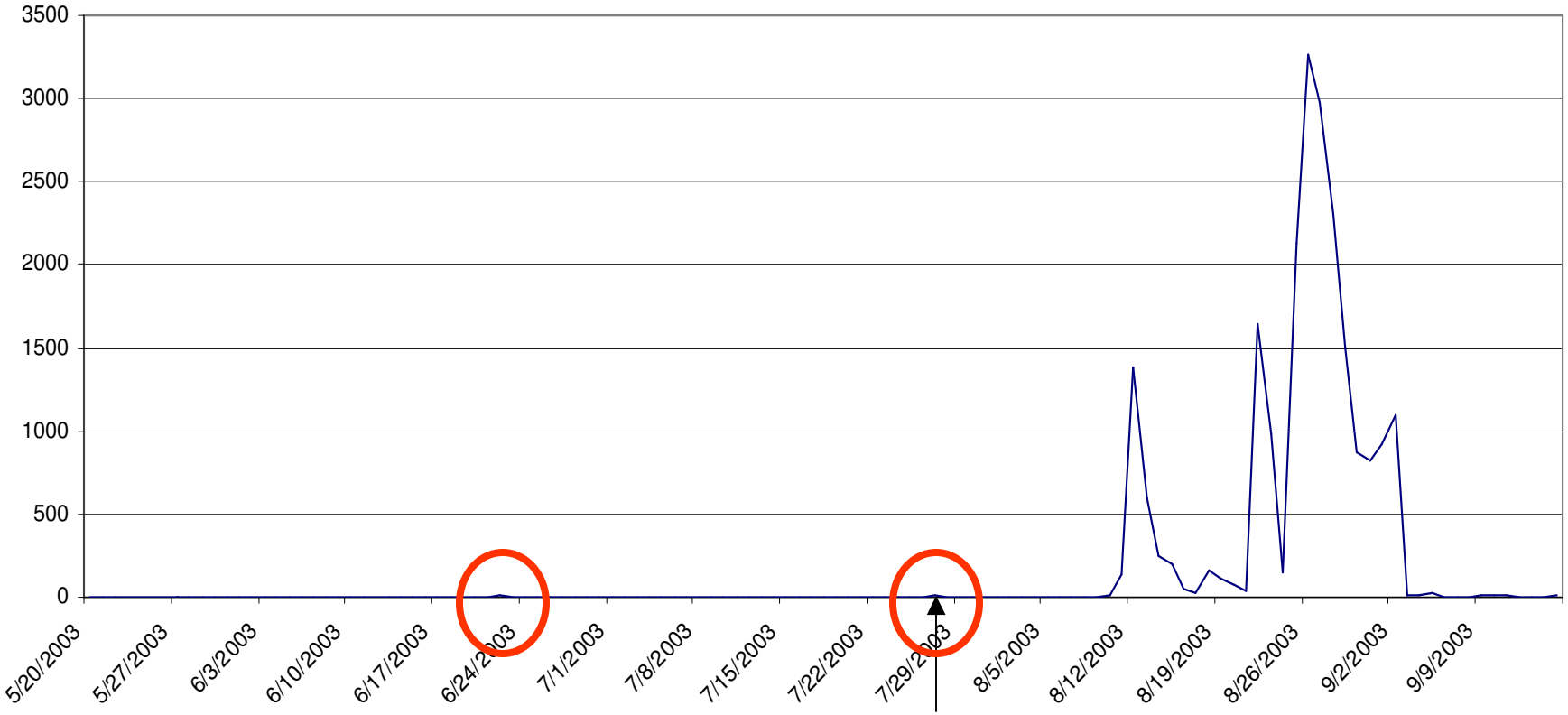


John Levine

- The Use of Honeynets to Detect Exploited Systems Across Large Enterprise Networks
- Interesting look at detecting zero-day attacks

http://users.ece.gatech.edu/~owen/Research/Conference%20Publications/honeynet_IAW2003.pdf

Port 135 MS BLASTER scans



Date Public: 7/16/03 Date Attack: 8/11/03

Georgia Tech Honeynett

Source: John Levine, Georgia Tech

Hot Research Areas…

- visualizing vulnerabilities
- visualizing IDS alarms (NIDS/HIDS)
- visualizing worm/virus propagation
- visualizing routing anamolies
- visualizing large volume computer network logs
- visual correlations of security events
- visualizing network traffic for security
- visualizing attacks in near-real-time
- security visualization at line speeds
- dynamic attack tree creation (graphic)
- forensic visualization

http://www.cs.fit.edu/~pkc/vizdmsec04/

More Hot Research Areas…

- feature selection and construction
- incremental/online learning
- noise in the data
- skewed data distribution
- distributed mining
- correlating multiple models
- efficient processing of large amounts of data
- correlating alerts
- signature and anomaly detection
- forensic analysis

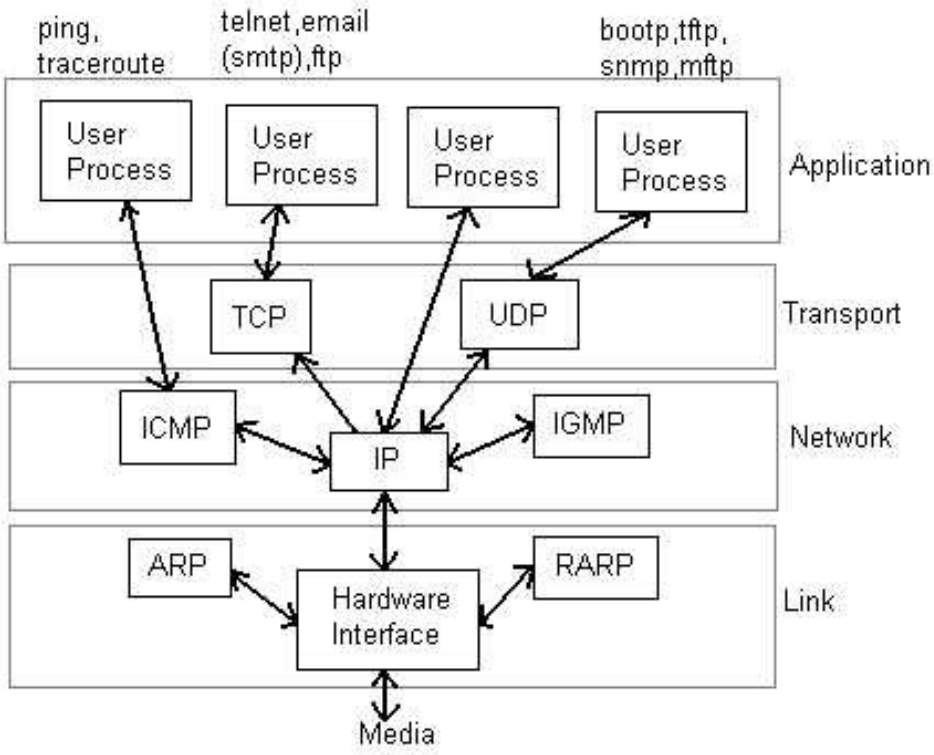
http://www.cs.fit.edu/~pkc/vizdmsec04/

One Approach…

- Look at TCP/IP Protocol Stack Data (particularly header information)
- Find interesting visualizations
- Throw some interesting traffic at them
- See what they can detect
- Refine

Information Available On and Off the Wire

- Levels of analysis
- External data
  - Time
  - Size
  - Protocol compliance
  - Real vs. Actual Values
- Matrices of options
- Header slides



http://ai3.asti.dost.gov.ph/sat/levels.jpg

Examining Available Data…

DA	SA	PTY	DATA	CRC

Link Layer (Ethernet)

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  IHL  |Type of Service|          Total Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Identification        |Flags|      Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live |    Protocol   |         Header Checksum       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Source Address                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Address                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                    |    Padding    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Network Layer (IP)

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Source Port          |       Destination Port        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Sequence Number                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Acknowledgment Number                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Data |           |U|A|P|R|S|F|                               |
| Offset| Reserved  |R|C|S|S|Y|I|            Window             |
|       |           |G|K|H|T|N|N|                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Checksum            |         Urgent Pointer        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                    |    Padding    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             data                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Transport Layer (TCP)

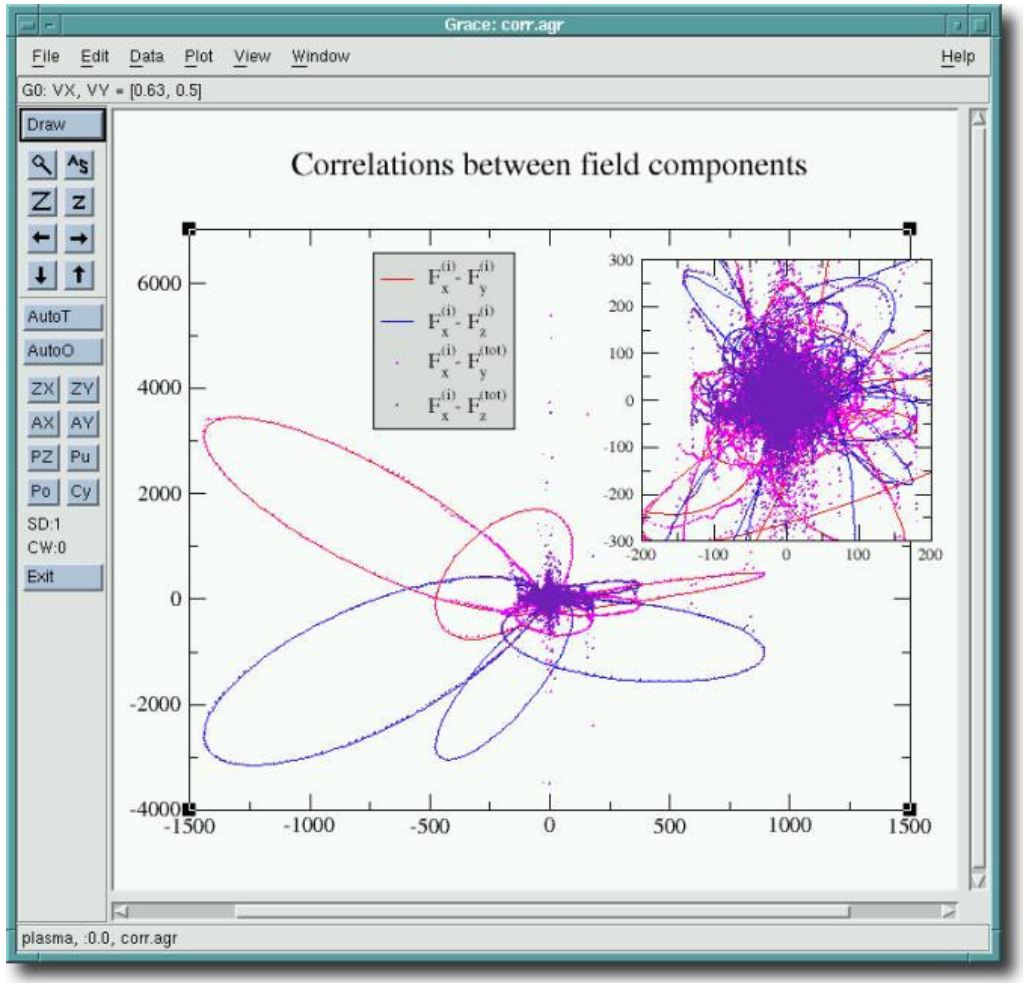
```
 0      7 8     15 16    23 24    31
+--------+--------+--------+--------+
|     Source      |   Destination   |
|      Port       |      Port       |
+--------+--------+--------+--------+
|                 |                 |
|     Length      |    Checksum     |
+--------+--------+--------+--------+
|
|          data octets ...
+---------------- ...
```

Transport Layer (UDP)

IP: http://www.ietf.org/rfc/rfc0791.txt
UDP: http://www.ietf.org/rfc/rfc0768.txt
TCP: http://www.ietf.org/rfc/rfc793.txt
Ethernet: http://www.itec.suny.edu/scsys/vms/OVMSDOC073/V73/6136/ZK-3743A.gif

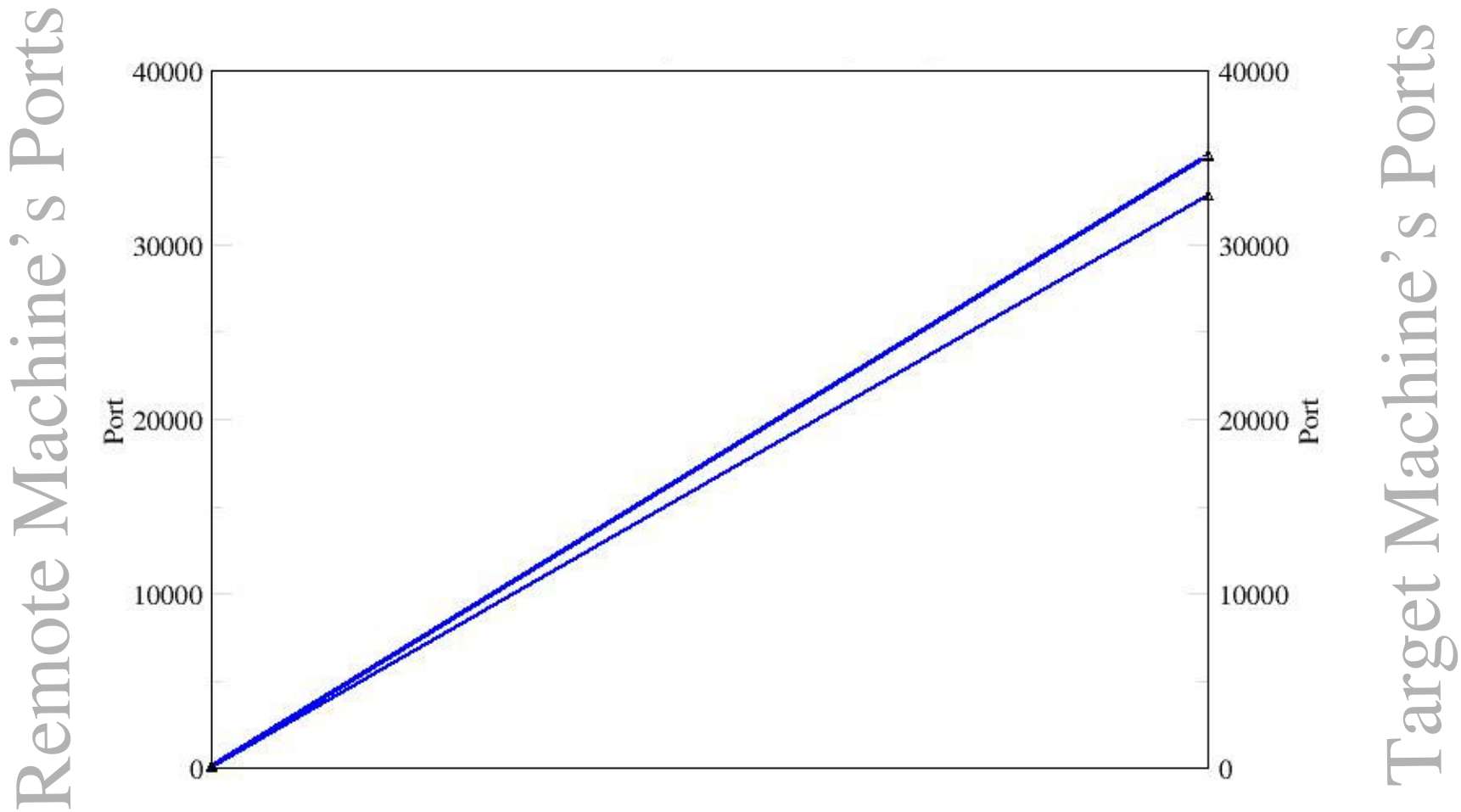
Grace

"**Grace** is a WYSIWYG 2D plotting tool for the X Window System and M*tif. Grace runs on practically any version of Unix-like OS. As well, it has been successfully ported to VMS, OS/2, and Win9*/NT/2000/XP"



http://plasma-gate.weizmann.ac.il/Grace/

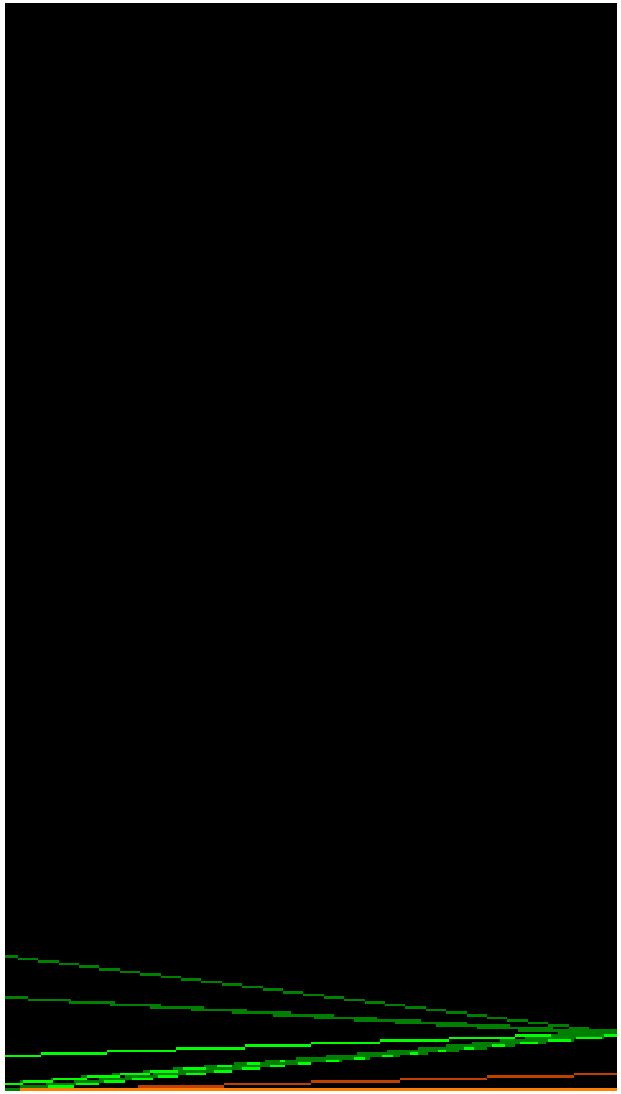
Parallel Plot



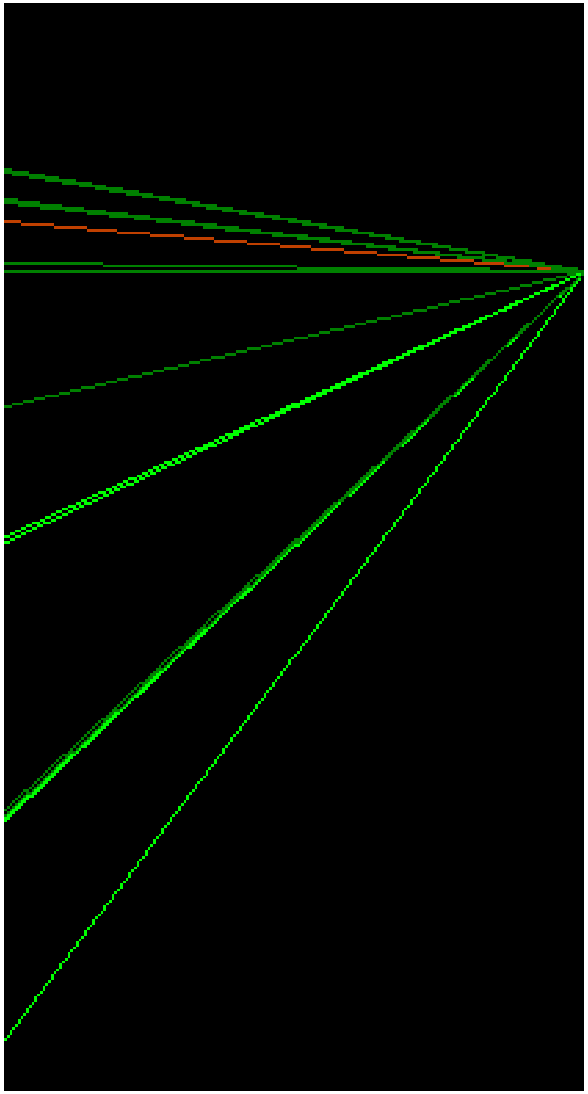
Results

Example 1 - Baseline with Normal Traffic
Example 2 - Port Scan
Example 3 - Port Scan “Fingerprinting”
Example 4 - Vulnerability Scanner
Example 5 - Wargame

Example 1: Baseline

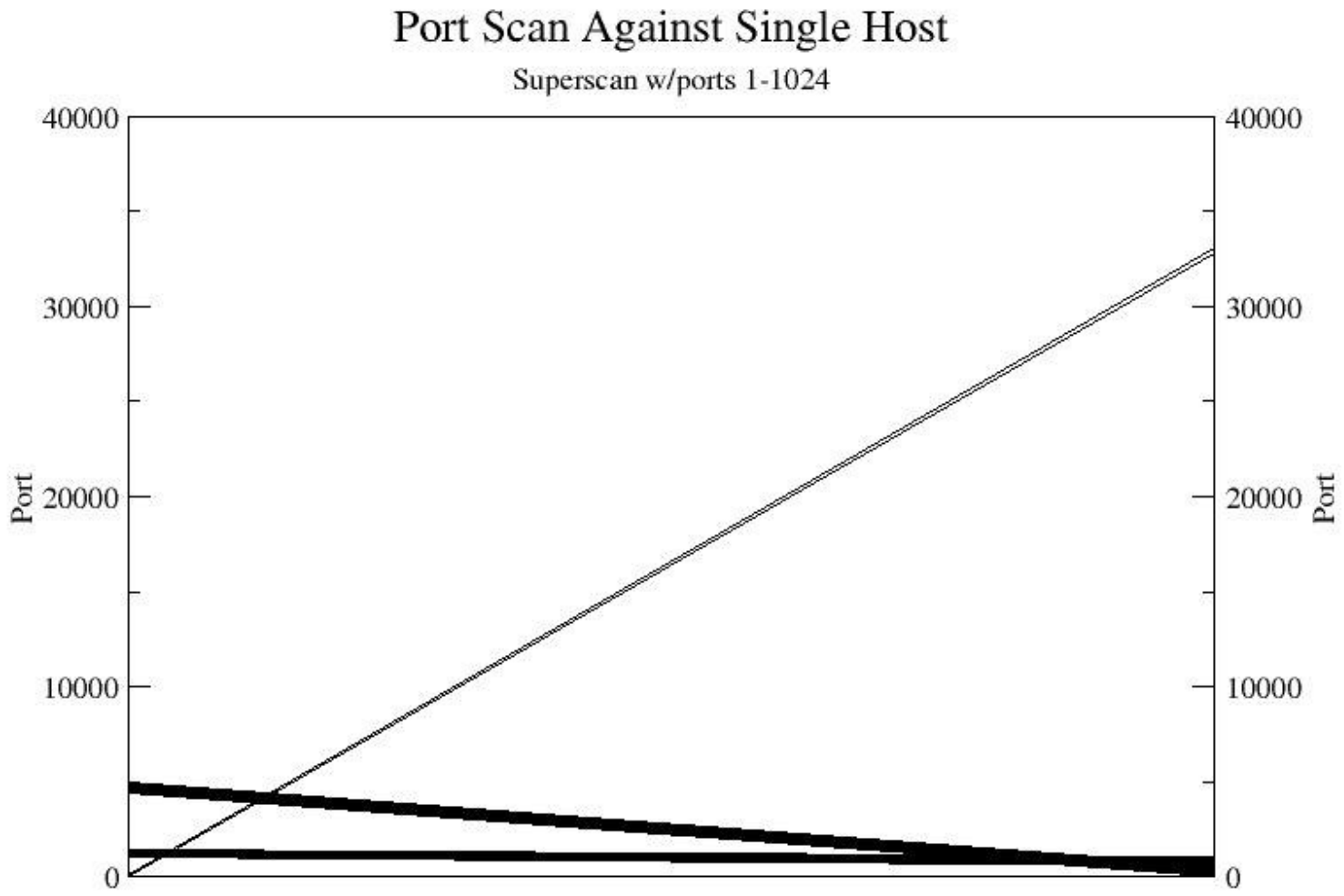


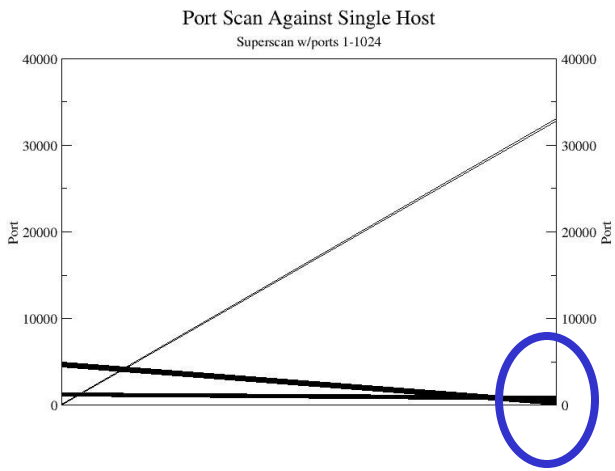
External Port Internal Port

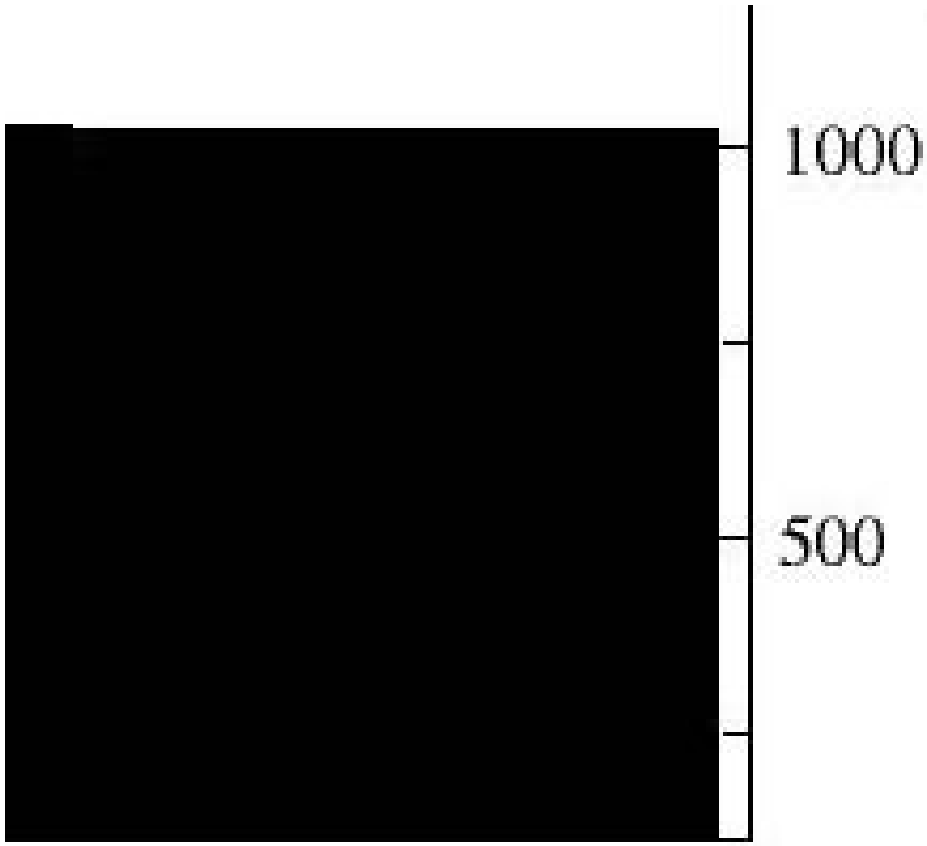


External IP Internal IP

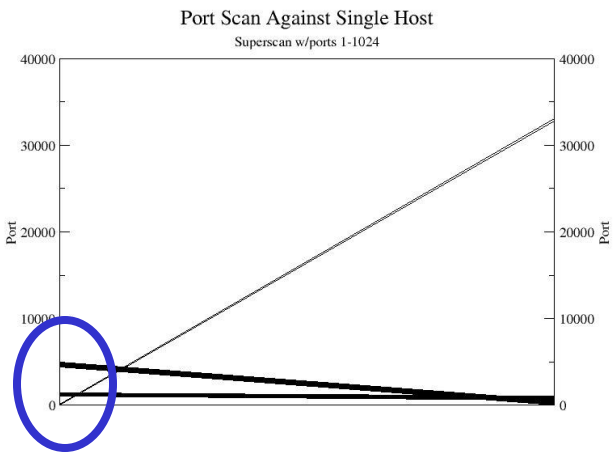
Example 2 - PortScan

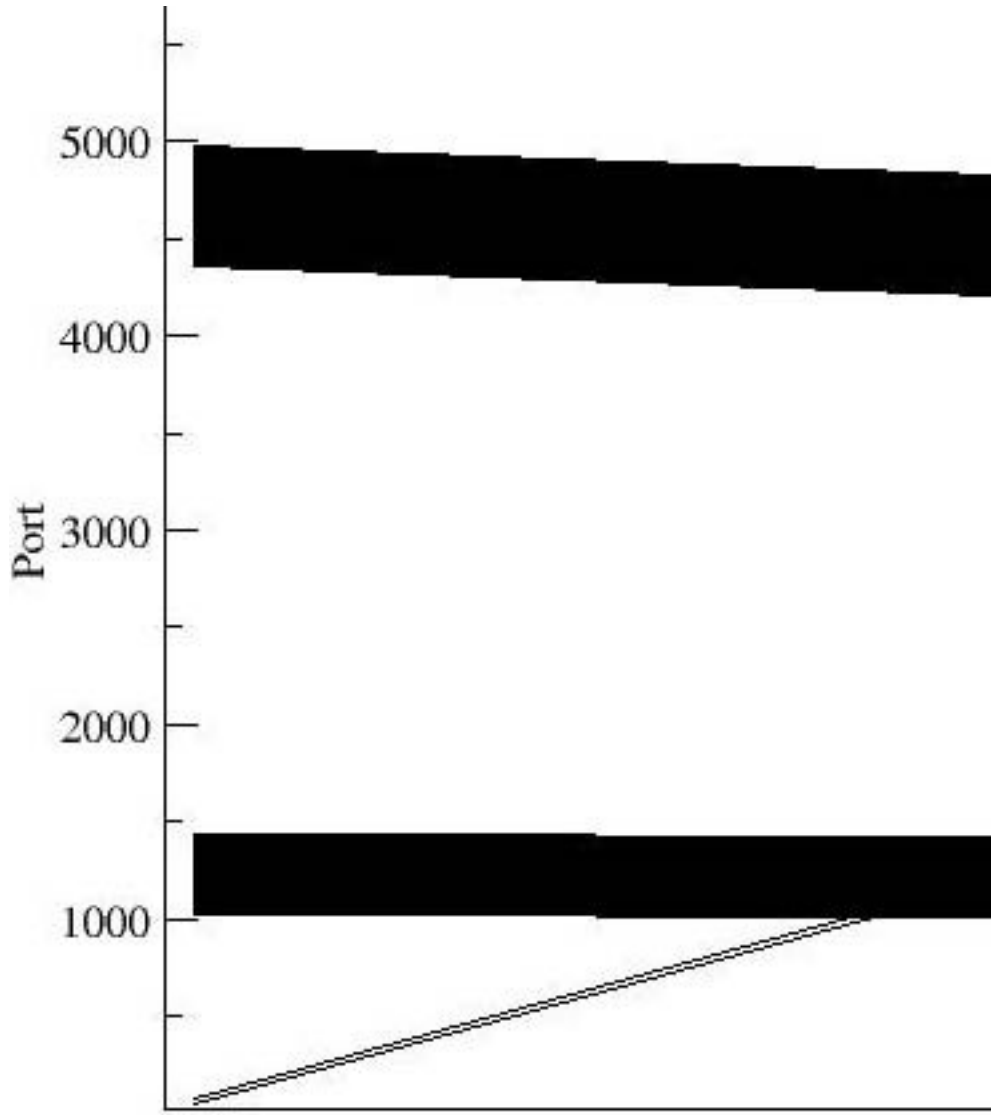



Port Scan Against Single Host
Superscan w/ports 1-1024
40000
30000
20000
10000
0
Port


1000
500

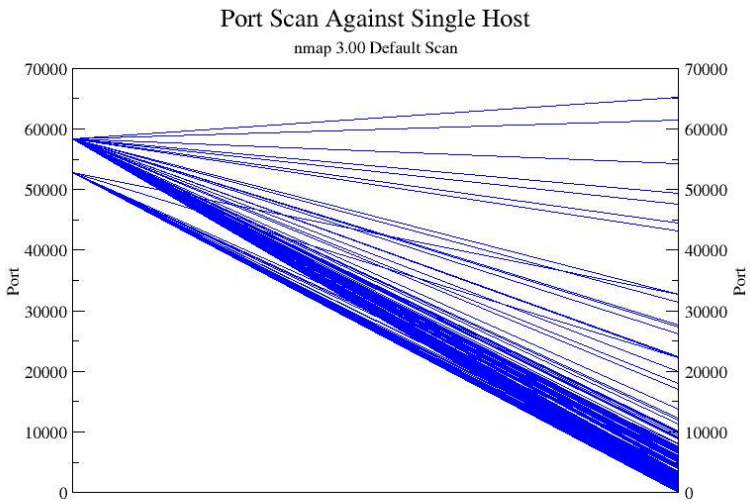
Defender


Port Scan Against Single Host
Superscan w/ports 1-1024
40000
30000
20000
10000
0
Port

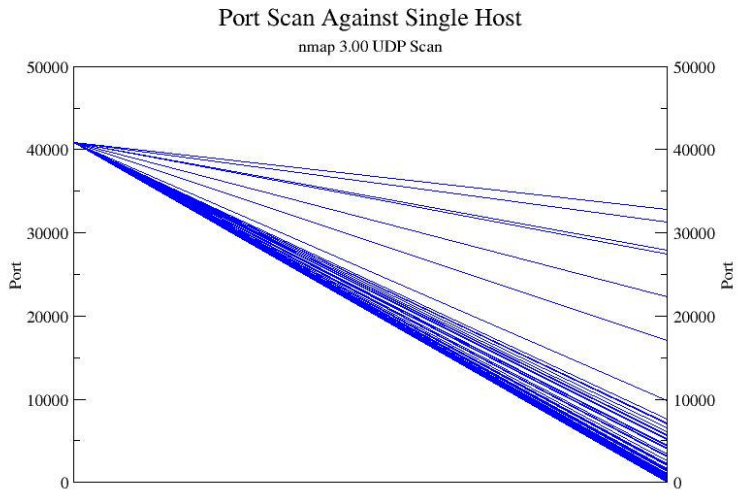

5000
4000
3000
2000
1000
Port

Attacker

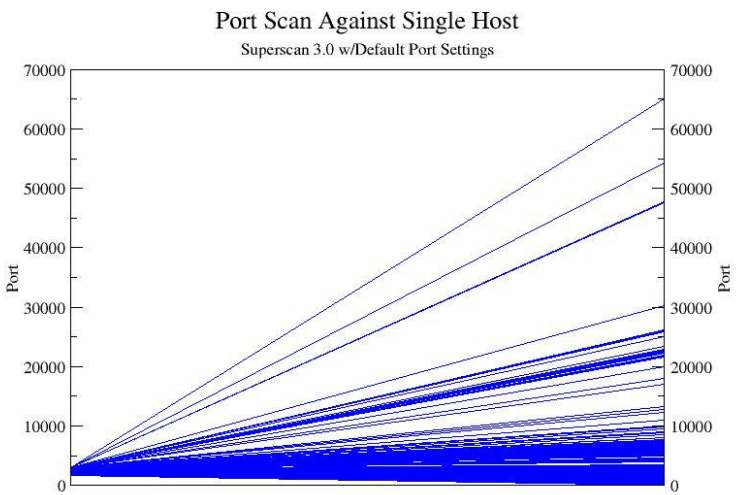
Example 3- PortScan “Fingerprinting”



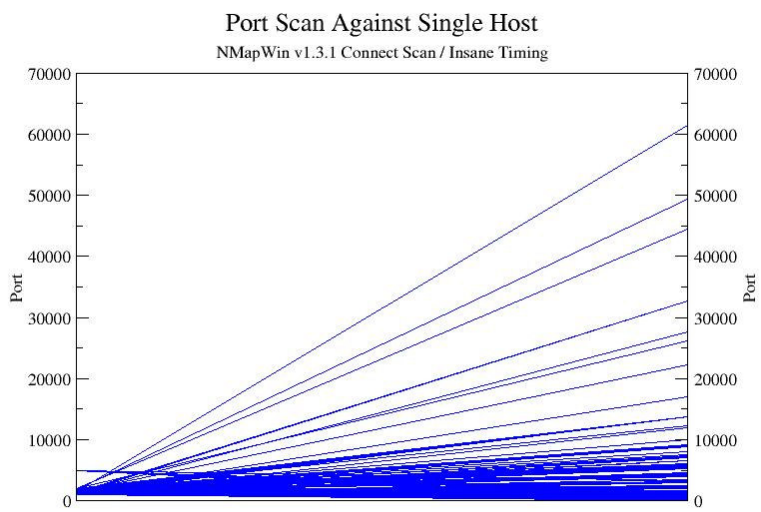
nmap 3.00 default (RH 8.0)



nmap 3.00 udp scan (RH 8.0)

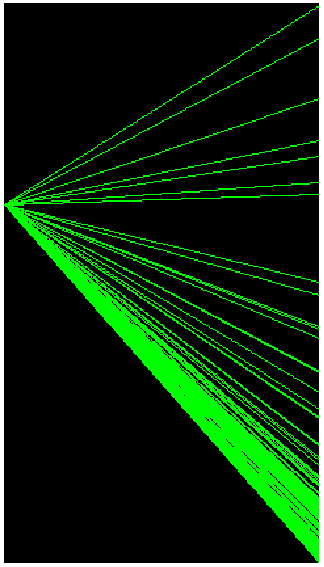


Superscan 3.0

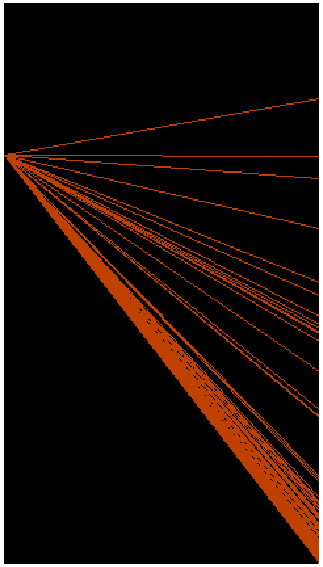


Nmap Win 1.3.1

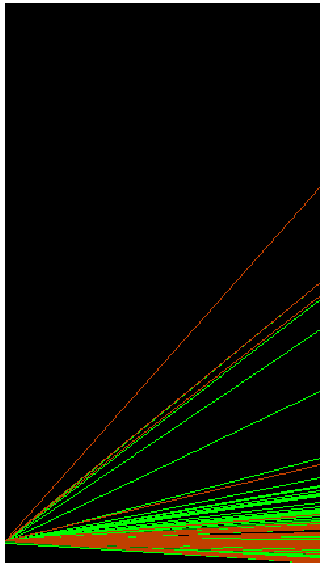
http://www.wire-fu.com/adept/
Brian McLachlan
Used with permission



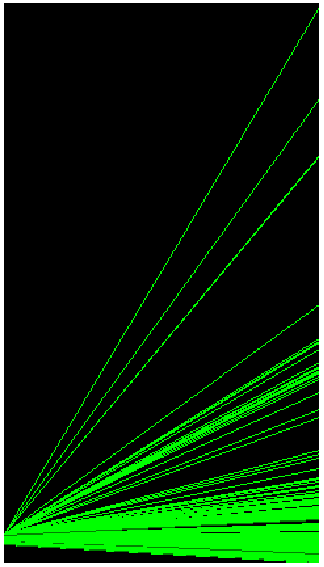
nmap 3 (RH8)



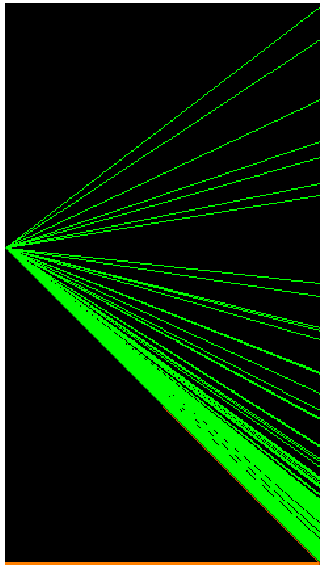
nmap 3 UDP (RH8)



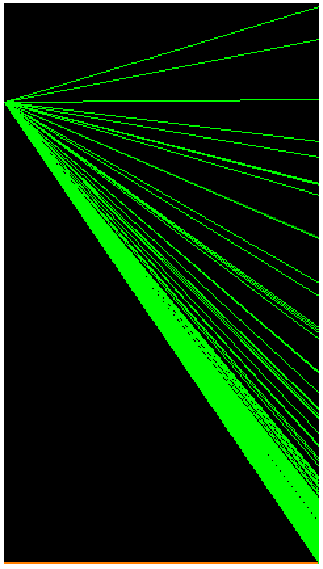
scanline 1.01 (XP)



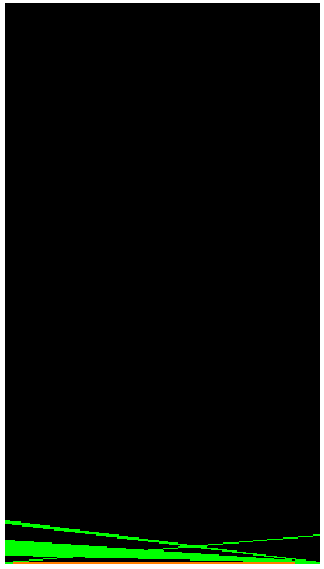
SuperScan 3.0 (XP)



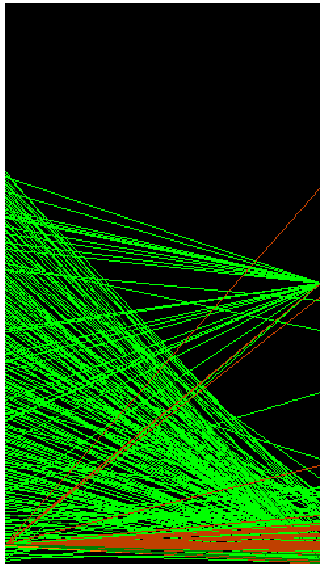
NMapWin 3 (XP)



nmap 3.5 (XP)



nikto 1.32 (XP)

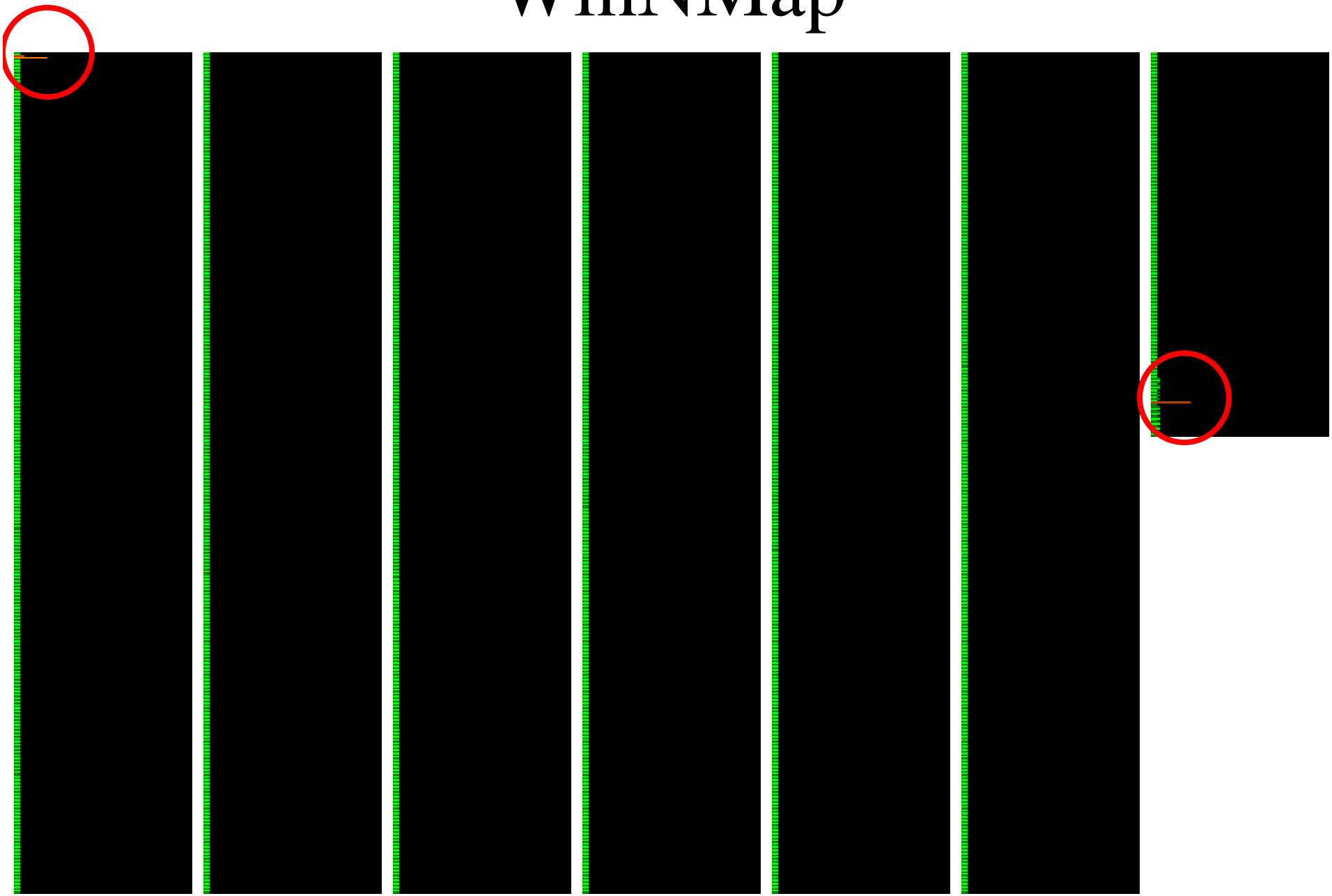


SuperScan 4.0 (XP)

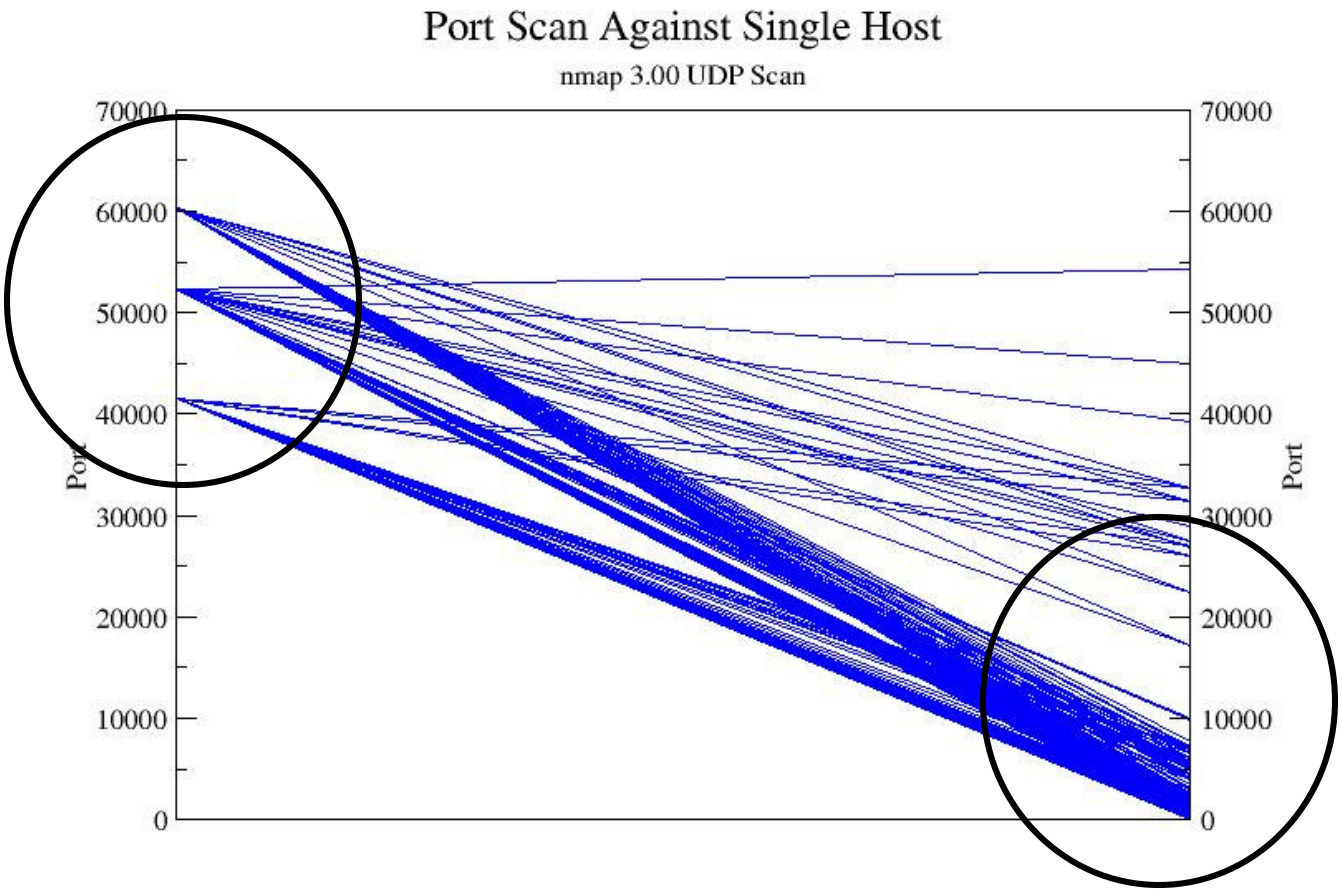
Demo

SuperScan 4.0

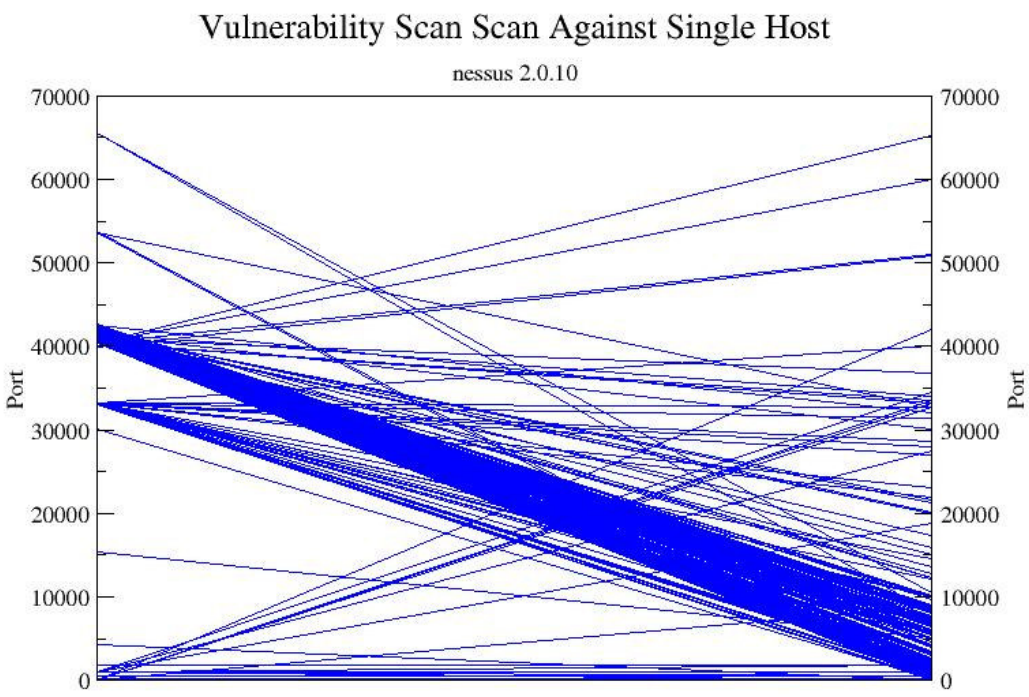
WinNMap

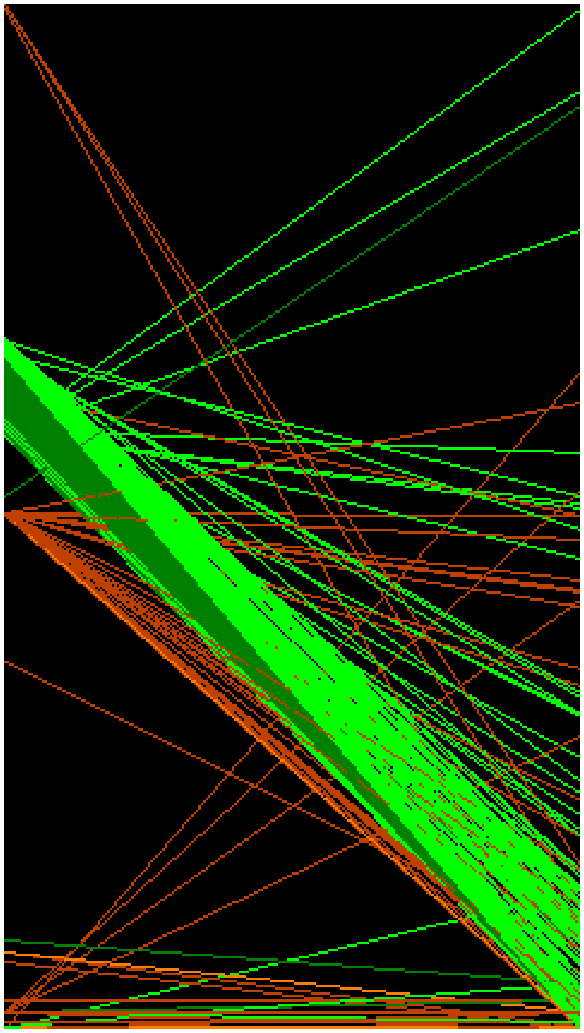


Three Parallel Scans

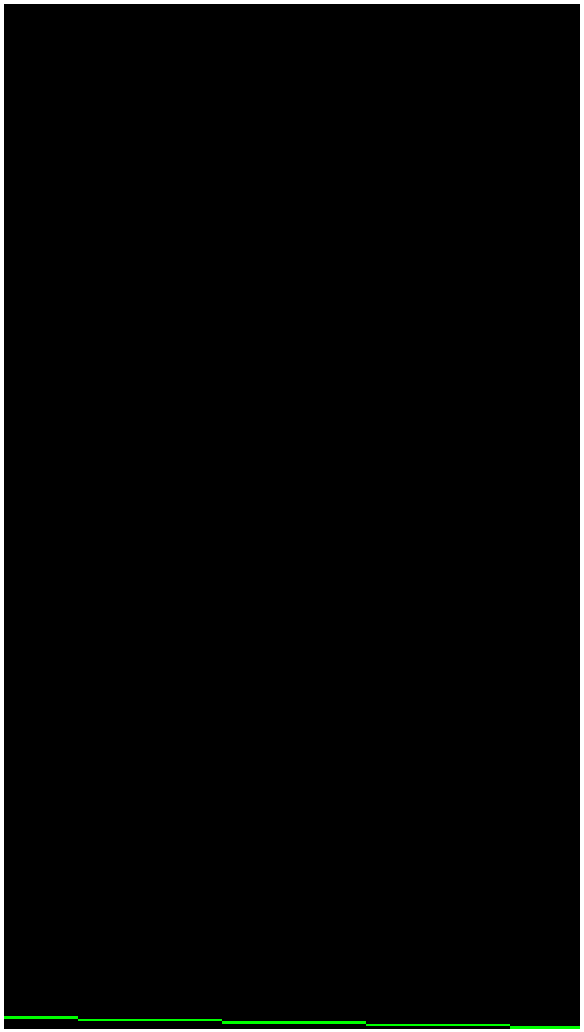


Example 4: Vulnerability Scanner Nessus 2.0.10

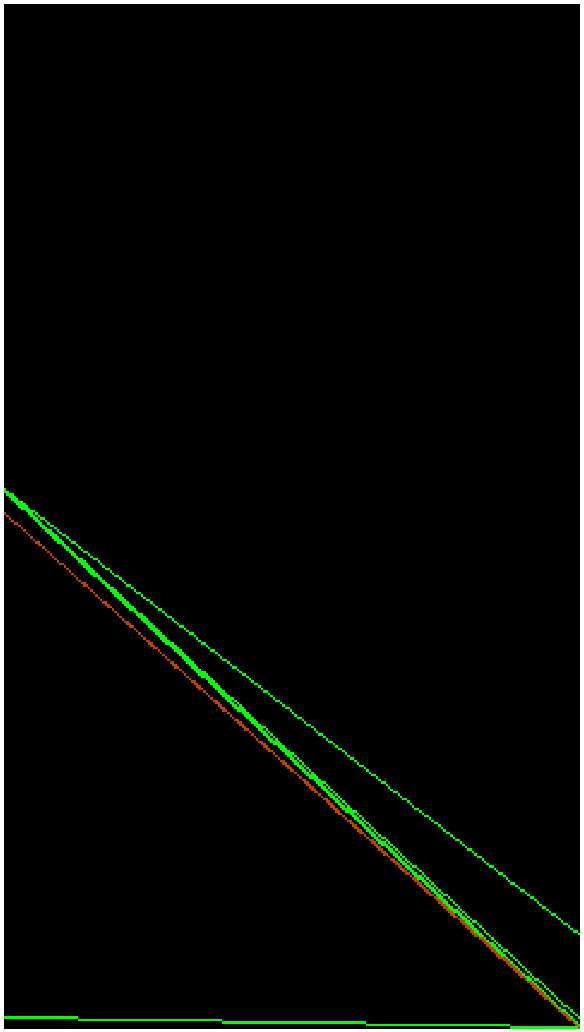




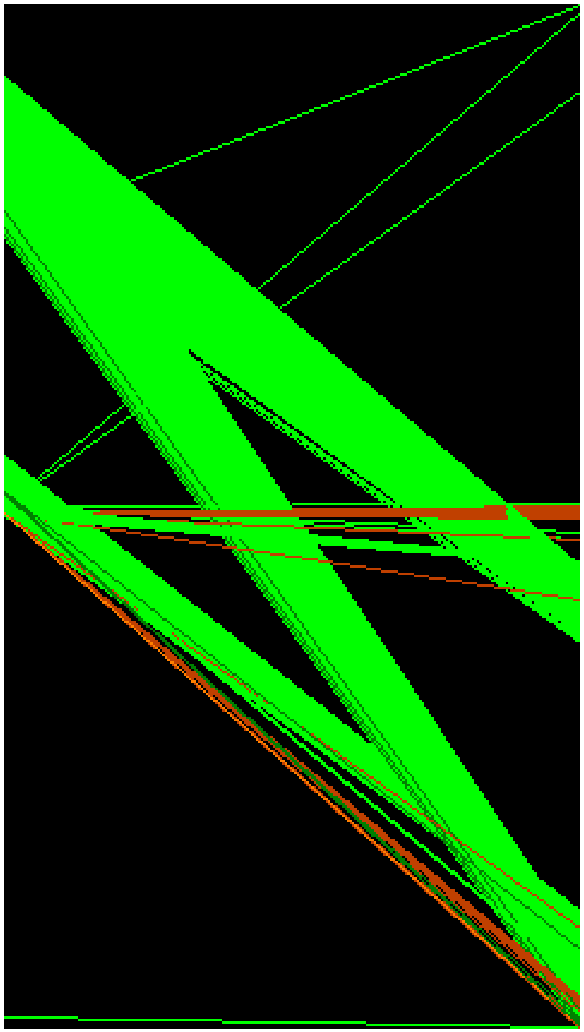
Sara 5.0.3



Light

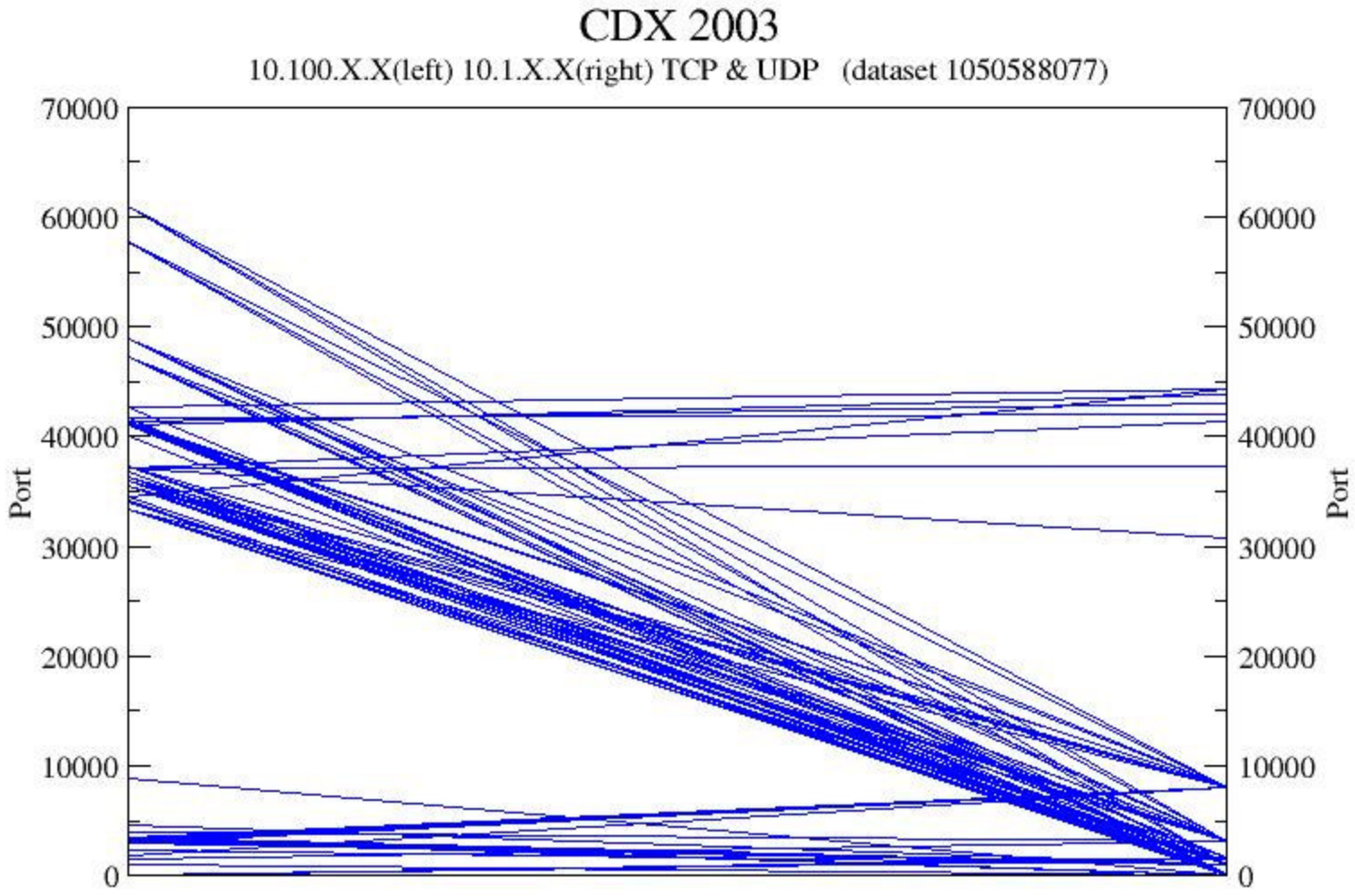


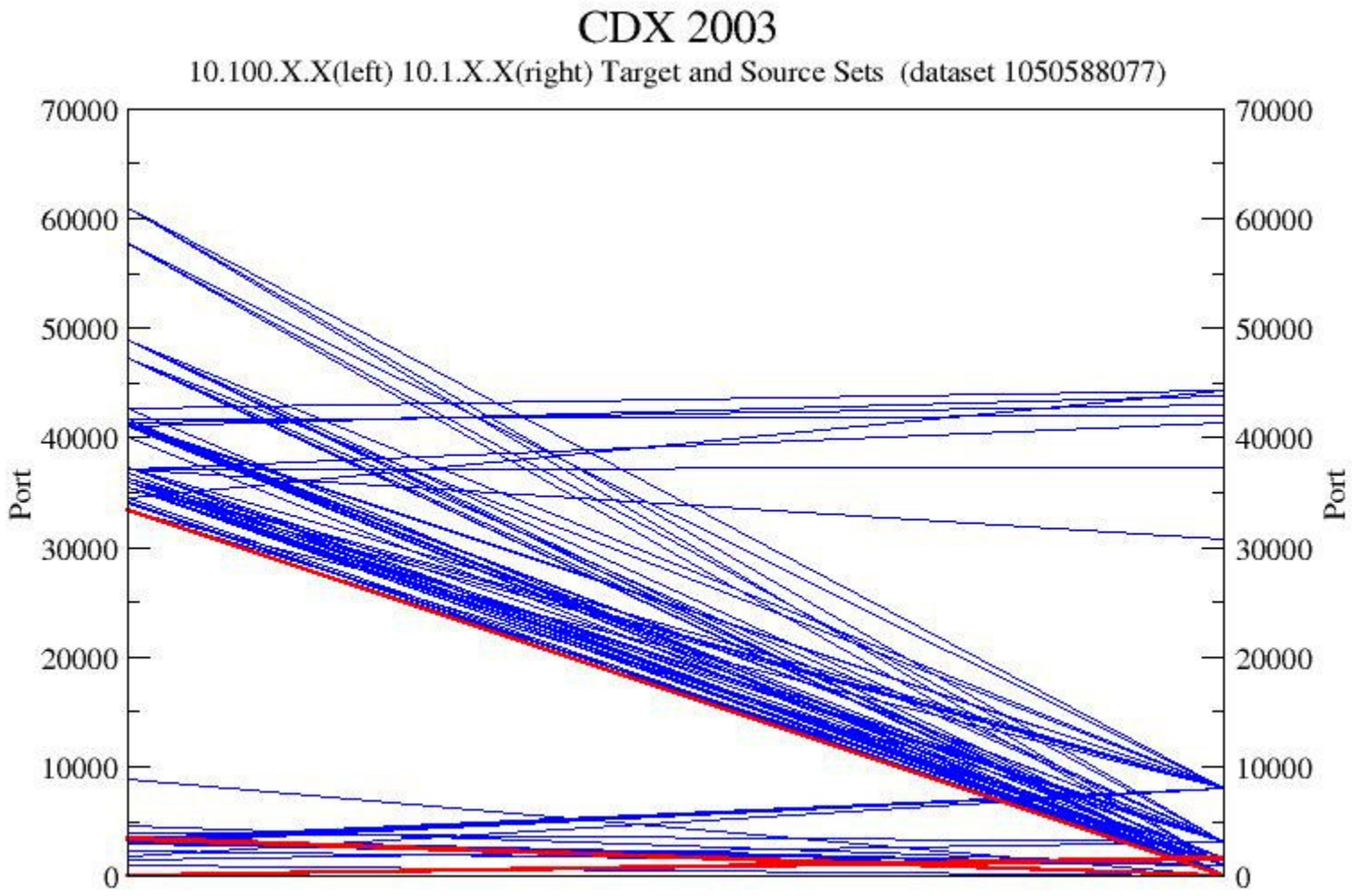
Medium



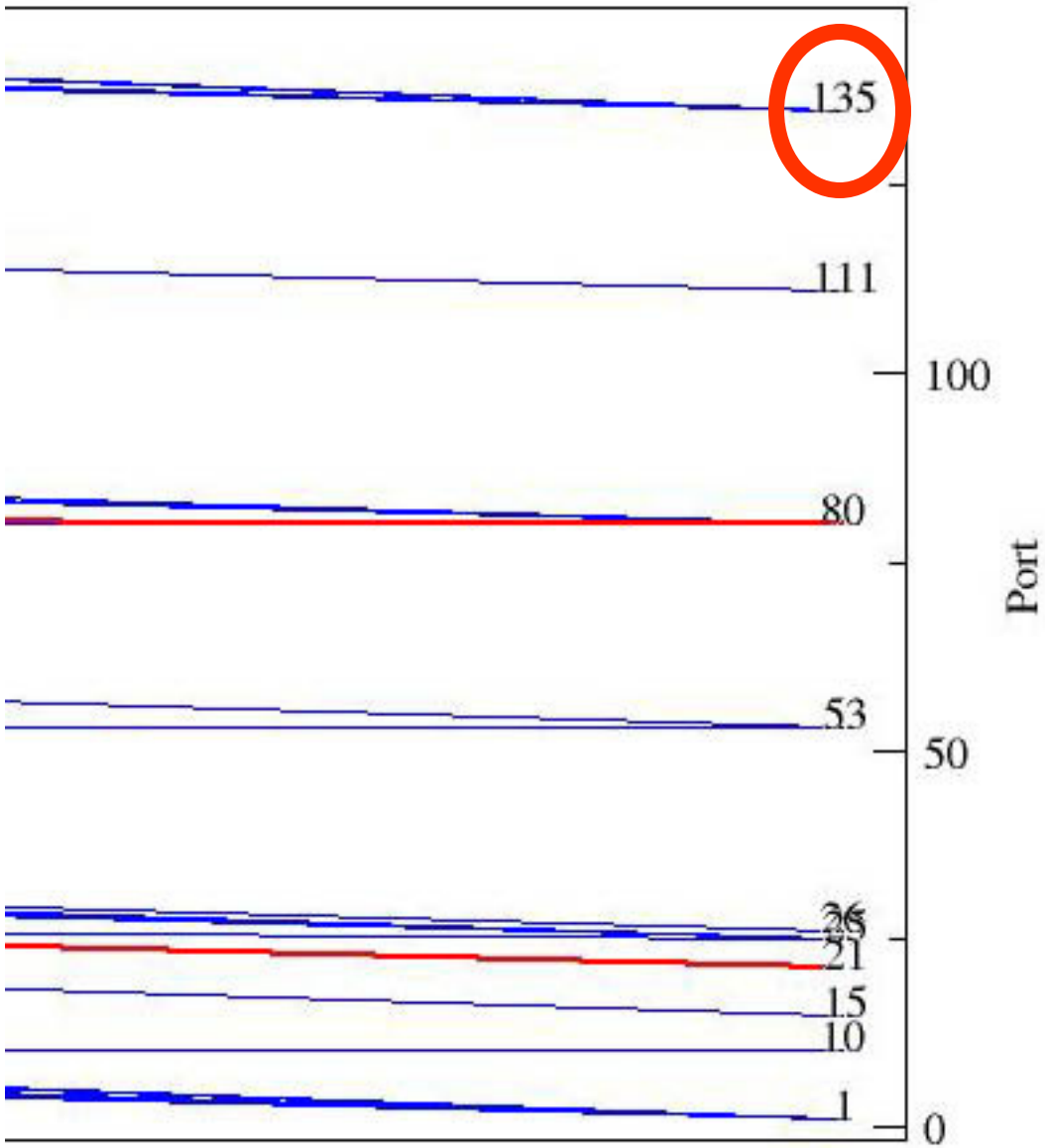
Heavy

Example 5: Wargame




CDX 2003
10.100.X.X(left) 10.1.X.X(right) Target and Source Sets (dataset 1050588077)
Port
70000
60000
50000
40000
30000
20000
10000
0

Demo


135
111
100
80
Port
53
50
26
25
21
15
10
1
0

Port 135

CAN-2003-0605 tcp any 135

The RPC DCOM interface in Windows 2000 SP3 and SP4 allows remote attackers to cause a denial of service (crash), and local attackers to use the DoS to hijack the epmapper pipe to gain privileges, via certain messages to the __RemoteGetClassObject interface that cause a NULL pointer to be passed to the PerformScmStage function.

CAN-2003-0352 6 any 135

Buffer overflow in a certain DCOM interface for RPC in Microsoft Windows NT 4.0, 2000, XP, and Server 2003 allows remote attackers to execute arbitrary code via a malformed message, as exploited by the Blaster/MSblast/LovSAN worm.

http://isc.incidents.org/port_details.html?port=135

Conclusions

- Limited fingerprinting of tools is possible
- Visualization can help drive better algorithms
- Some attacker techniques can be identified
- Some vulnerabilities can be identified

Where to go for files…

www.rumint.com/interz0ne3

Questions?

http://carcino.gen.nz/images/index.php/04980e0b/53c55ca5

Backup Slides

Data Format

- tcpdump outputs somewhat verbose output

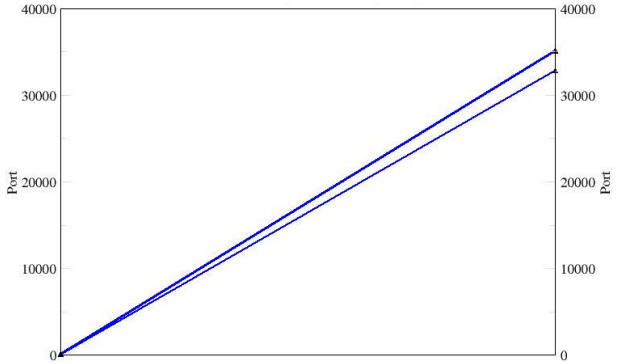
```
09:02:01.858240 0:6:5b:4:20:14 0:5:9a:50:70:9 62:
10.100.1.120.4532 > 10.1.3.0.1080: tcp 0 (DF)
```

- parse.pl cleans up output

```
09 02 01 858240 0:6:5b:4:20:14 0:5:9a:50:70:9
10.100.1.120.4532 10.100.1.120 4532 10.1.3.0.1080 10.1.3.0
1080 tcp
```

- analyze.pl extracts/formats for Grace.

```
0 4532
1 1080
0 4537
1 1080
0 2370
1 1080
```



Required Files

Perl, tcpdump and grace need to be installed.

- http://www.tcpdump.org/
- http://www.perl.org/
- http://plasma-gate.weizmann.ac.il/Grace/

to install grace...

Download RPMs (or source)
ftp://plasma-gate.weizmann.ac.il/pub/grace/contrib/RPMS

The files you want
grace-5.1.14-1.i386.rpm
pdflib-4.0.3-1.i386.rpm

Install
#rpm -i pdflib-4.0.3-1.i386.rpm
#rpm -i grace-5.1.14-1.i386.rpm

Hello World Example

```
# tcpdump -lnnq -c10 | perl parse.pl | perl analyze.pl
  |outfile.dat
# xmgrace outfile.dat &
```

Optionally you can run xmgrace with an external format language file…

```
# xmgrace outfile.dat -batch formatfile
```

See ppt file for more detailed howto information

Hello World Example (cont)

Optionally you can run xmgrace with an external format language file…

```
xmgrace outfile.dat -batch formatfile
```

formatfile is a text file that pre-configures Grace e.g.

```
title "Port Scan Against Single Host"
subtitle "Superscan w/ports 1-1024"
yaxis label "Port"
yaxis label place both
yaxis ticklabel place both
xaxis ticklabel off
xaxis tick major off
xaxis tick minor off
autoscale
```

To Run Demo

See readme.txt

Two demo scripts…

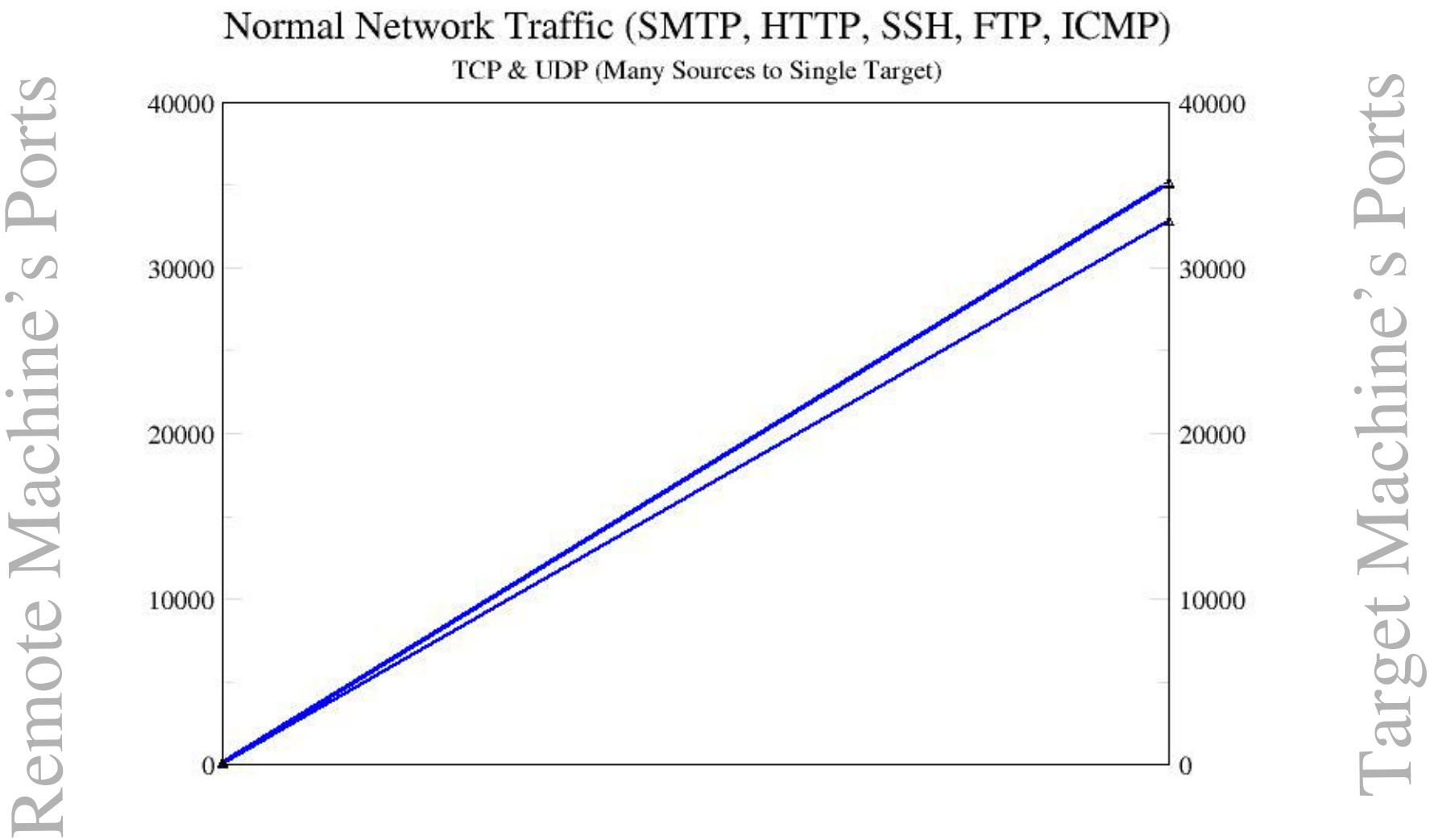
- runme.bat (uses sample dataset)
- runme_sniff.bat (performs live capture, must be root)

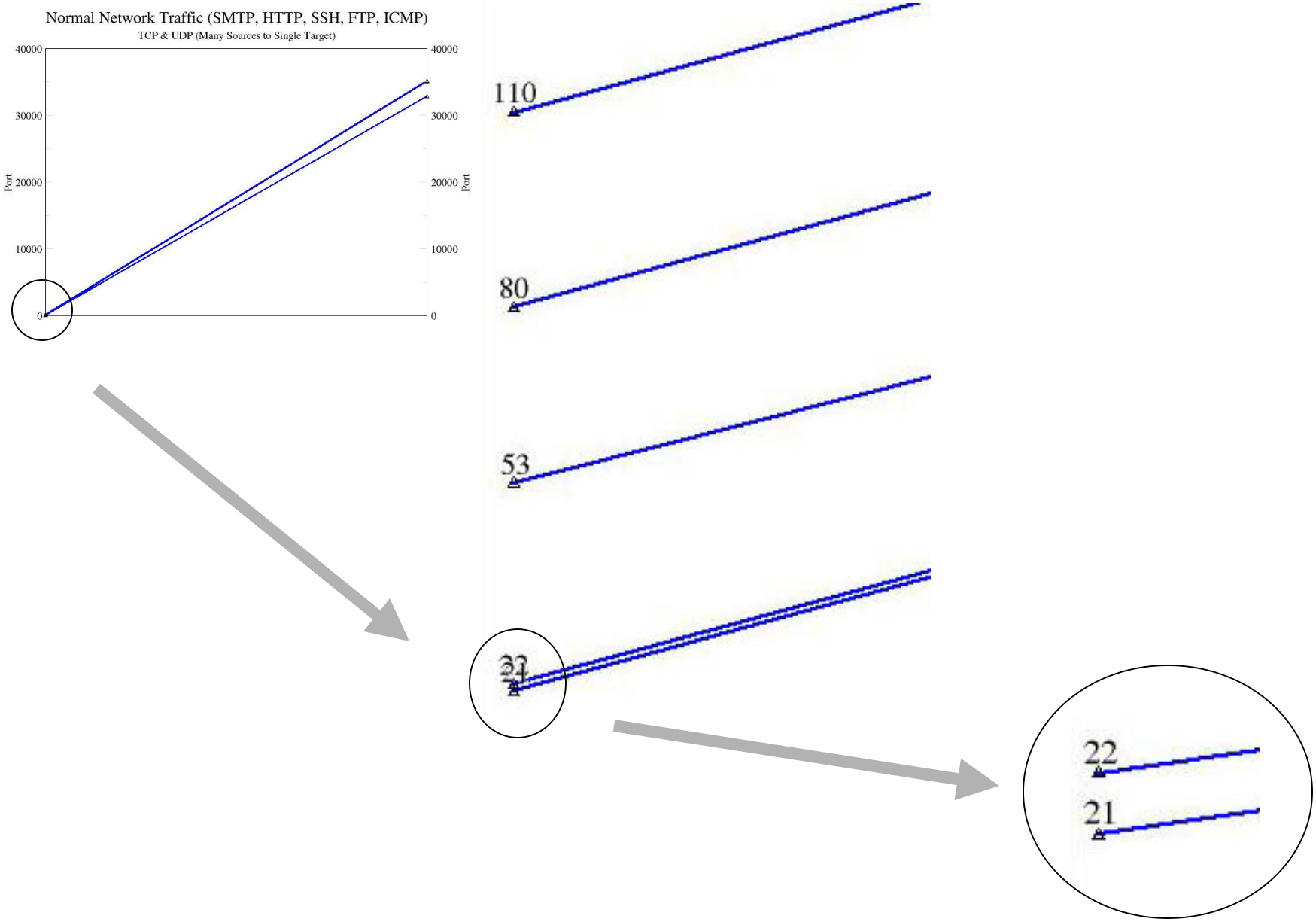
Note: you must modify the IP address variable in the Analyzer script. (See analyzer2.pl for example)

Example 1 - Baseline

- Normal network traffic
  - FTP, HTTP, SSH, ICMP…
- Command Line
  - Capture Raw Data
    - `tcpdump -l -nnqe -c 1000 tcp or udp | perl parse.pl > exp1_outfile.txt`
  - Run through Analysis Script
    - `cat exp1_outfile.txt | perl analyze_1a.pl > output1a.dat`
  - Open in Grace
    - `xmgrace output1a.dat &`

Example 1 - Baseline




Normal Network Traffic (SMTP, HTTP, SSH, FTP, ICMP)
TCP & UDP (Many Sources to Single Target)
Port
40000
30000
20000
10000
0
110
80
53
22
21

Example 2 - PortScan

- Light “normal” network traffic (HTTP)
- Command Line
  - Run 2a.bat (chmod +x 2a.bat)

```
echo running experiment 2
echo 1-1024 port scan

tcpdump -l -nnqe -c 1200 tcp or udp > raw_outfile_2.txt
cat raw_outfile_2.txt | perl parse_2a.pl > exp2_outfile.txt
cat exp2_outfile.txt | perl analyze_2a.pl > output_2a.dat
xmgrace output_2a.dat &

echo experiment 2 completed
```

Example 3- PortScan “Fingerprinting”

Tools Examined:

- Nmap Win 1.3.1 (on top of Nmap 3.00)
  XP Attacker
  (http://www.insecure.org/nmap/)

- Nmap 3.00
  RH 8.0 Attacker
  (http://www.insecure.org/nmap/)

- Superscan 3.0
  RH 8.0 Attacker
  (http://www.foundstone.com/index.htm?subnav=resources/navigation.htm&subcontent=/resources/proddesc/superscan.htm)

Example 4: Vulnerability Scanner

- Attacker: RH 8.0 running Nessus 2.0.10
- Target: RH 9.0

Example 5: Wargame

- Attackers: DoD Red Team
- Defenders: US Service Academies

Defenders lock down network, but must provide certain services

Dataset - http://www.itoc.usma.edu/cdx/2003/logs.zip