Gaining Insight Through Security Visualization

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Saâd Kadhi -- HAPSIS

Agenda

★ Introducing Security Visualization

★ From Data to Graphs

★ Firemen For Firewalls

★ Visual Vulnerability Management

★ A Few Things To Know

Introducing Security Visualization

What Is Security Visualization?

★ "A picture is worth a thousand log records" (Raffael Marty)

★ It's a process

★ Generating a picture (or graph) from log records (or security events in the broader sense)

From Events to Picture

★ SecViz takes security events as input and (should) produce a worthy visual representation

★ A worthy visual representation is a visual representation that provides insight and support decision-making

From Data To Insight

★ Visualization allows us to move from data to information and then move from information to insight

★ And insight is paramount! (Cluebats have yet to be invented)

1. cluebat

A metaphorical bat used to 'beat some sense into' someone who is blatantly stupid

some guy just tried to install 'crack_hotmail_passwords.exe' and he wonders why his machine is full of crap. someone needs to beat him with a cluebat.

But Hey, We Have Text!

★ Ever tried to analyze a log file of 529083 lines to try to understand why there's a sudden surge of tcp/25 connections that are about to take down your front-line defenses?

★ No? Then be my guest...

But Seriously, Why?

- ★ Because of the human visual system!
- ★ Pattern seeker
- ★ Massive, high-bandwidth, parallel processor
- ★ The human brain has a hard time processing text

More Sources, More Data, More Everything

- ★ Databases, documents, emails, websites...
- ★ Huge amount of data in this information-oriented era (and growing...)
- ★ We need new ways of sorting this mess out

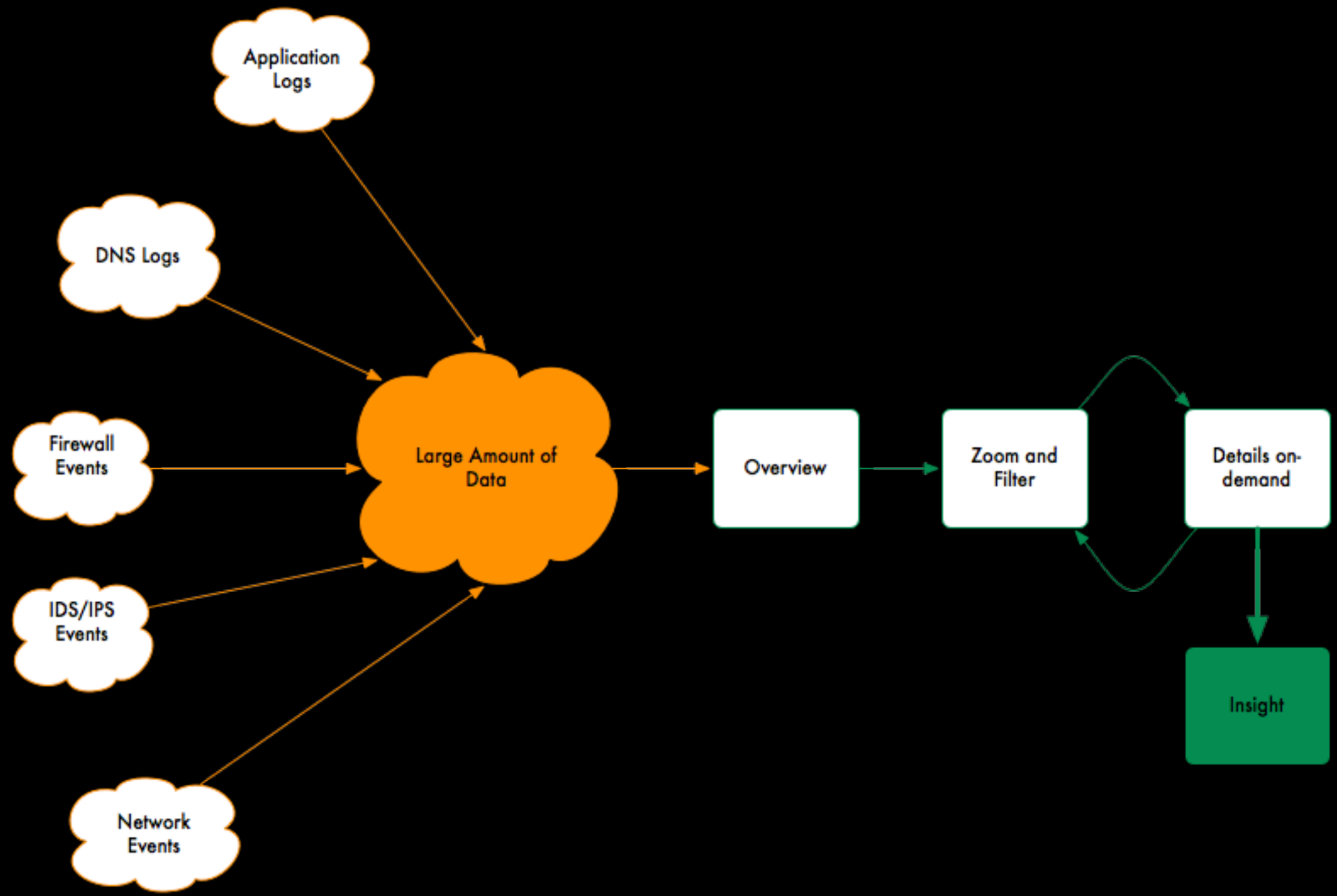
Visualization Can Be One Answer

★ Display relevant information graphically to aid in understanding the data

★ Discover "hidden" relationships

★ Analyze a large amount of data very quickly

SecViz Mantra



From Data To Graphs

It's Not a Perfect World (far from it...)

★ Visualization of data is not a straightforward process

★ ... well, not always

★ First, we need to define the problem and the objective (very, very clearly)

It's Not a Perfect World (reloaded)

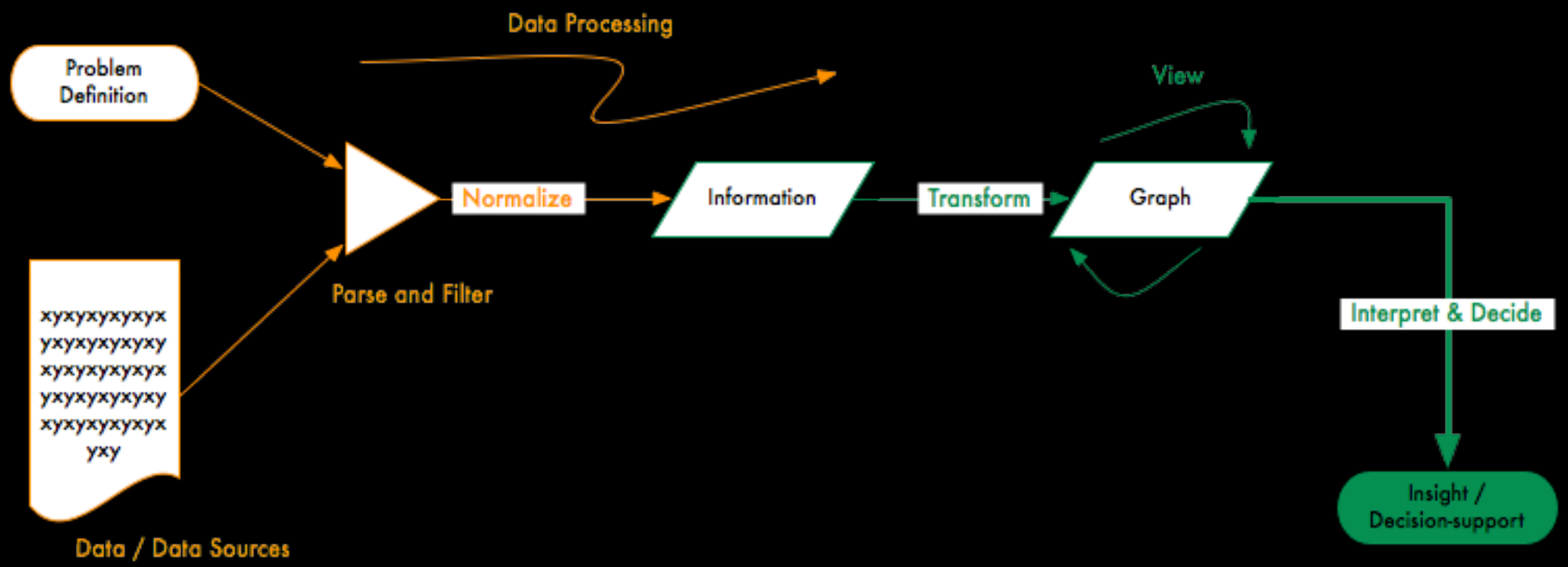
★ We also need to think about some choices to make: color assignments, type of graph to use...

★ These choices depend on the problem and the objective

Yes, We Need a Process

1. Define the problem
2. Assess available data / data sources
3. Parse/Filter data
4. Transform to visual representation
5. View visual representation
6. Interpret and decide

Process, Pictured



Define The Problem

★ What are you looking for?

★ What are you trying to find an answer for?

★ Example: Who is trying to connect to my SSH server?

Assess Available Data / Data Sources

★ What data is available? Log files?

★ Do we need any additional data

★ Example: /var/log/auth.log + GeoIP information

Parse & Filter

★ Parse and filter the data / data sources to extract the necessary information

★ The information needs to be normalized in order to be fed to the graph generating tool

Parse & Filter Example

```
Jan 11 12:06:00 skin sshd[8846]: error: PAM: authentication error for illegal us
er test1 from 220.162.241.11
Jan 11 12:06:00 skin sshd[8846]: Failed keyboard-interactive/pam for invalid use
r test1 from 220.162.241.11 port 45239 ssh2
Jan 11 12:06:20 skin sshd[8851]: Invalid user ts from 59.108.230.130
Jan 11 12:06:23 skin sshd[8853]: Invalid user ts from 59.108.230.130
Jan 11 12:06:25 skin sshd[8855]: Invalid user ts from 59.108.230.130
Jan 11 12:06:27 skin sshd[8857]: Invalid user ts from 59.108.230.130
Jan 11 12:06:29 skin sshd[8859]: Invalid user ts from 59.108.230.130
Jan 11 12:06:32 skin sshd[8861]: Invalid user ts from 59.108.230.130
Jan 11 12:06:34 skin sshd[8863]: Invalid user ts from 59.108.230.130
Jan 11 12:06:37 skin sshd[8865]: Invalid user ts from 59.108.230.130
Jan 11 12:06:39 skin sshd[8867]: Invalid user ts from 59.108.230.130
Jan 11 12:06:41 skin sshd[8869]: Invalid user ts from 59.108.230.130
Jan 11 12:06:43 skin sshd[8871]: Invalid user ts from 59.108.230.130
Jan 11 12:06:46 skin sshd[8873]: Invalid user ts from 59.108.230.130
Jan 11 12:06:48 skin sshd[8875]: Invalid user teamspeak from 59.108.230.130
Jan 11 12:06:50 skin sshd[8877]: Invalid user teamspeak from 59.108.230.130
Jan 11 12:06:53 skin sshd[8879]: Invalid user teamspeak from 59.108.230.130
Jan 11 12:06:55 skin sshd[8881]: Invalid user teamspeak from 59.108.230.130
Jan 11 12:06:57 skin sshd[8883]: Invalid user teamspeak from 59.108.230.130
Jan 11 12:07:00 skin sshd[8885]: Invalid user teamspeak from 59.108.230.130
Jan 11 12:07:02 skin sshd[8887]: Invalid user ts1 from 59.108.230.130
Jan 11 12:07:05 skin sshd[8889]: Invalid user ts1 from 59.108.230.130
Jan 11 12:07:07 skin sshd[8891]: Invalid user ts2 from 59.108.230.130
```

Parse & Filter Example

```
SrcIP;NumConn
148.233.140.193;1
190.34.172.5;1
193.27.193.74;1
200.13.253.122;1
204.213.57.35;1
212.243.41.9;3
220.162.241.11;2
58.247.222.163;1
58.60.106.24;1
59.108.230.130;38
94.23.203.221;2345
```

```
SrcIP;NumConn;CountryISO;CountryName
148.233.140.193;1;MX;Mexico
190.34.172.5;1;PA;Panama
193.27.193.74;1;SE;Sweden
200.13.253.122;1;CO;Colombia
204.213.57.35;1;US;United States
212.243.41.9;3;CH;Switzerland
220.162.241.11;2;CN;China
58.247.222.163;1;CN;China
58.60.106.24;1;CN;China
59.108.230.130;38;CN;China
94.23.203.221;2345;FR;France
```

Transform & View

★ What properties do we need in the resulting graph? (i.e. choosing the right graph)

★ How about color, size, shape?

★ How about scale, layout, zooming in/out?

★ It's time to introduce graph types!

Graph Types

★ There are far too many types (and variations)

★ Of particular interest are: pie charts, bar charts, histograms, link graphs and Treemaps

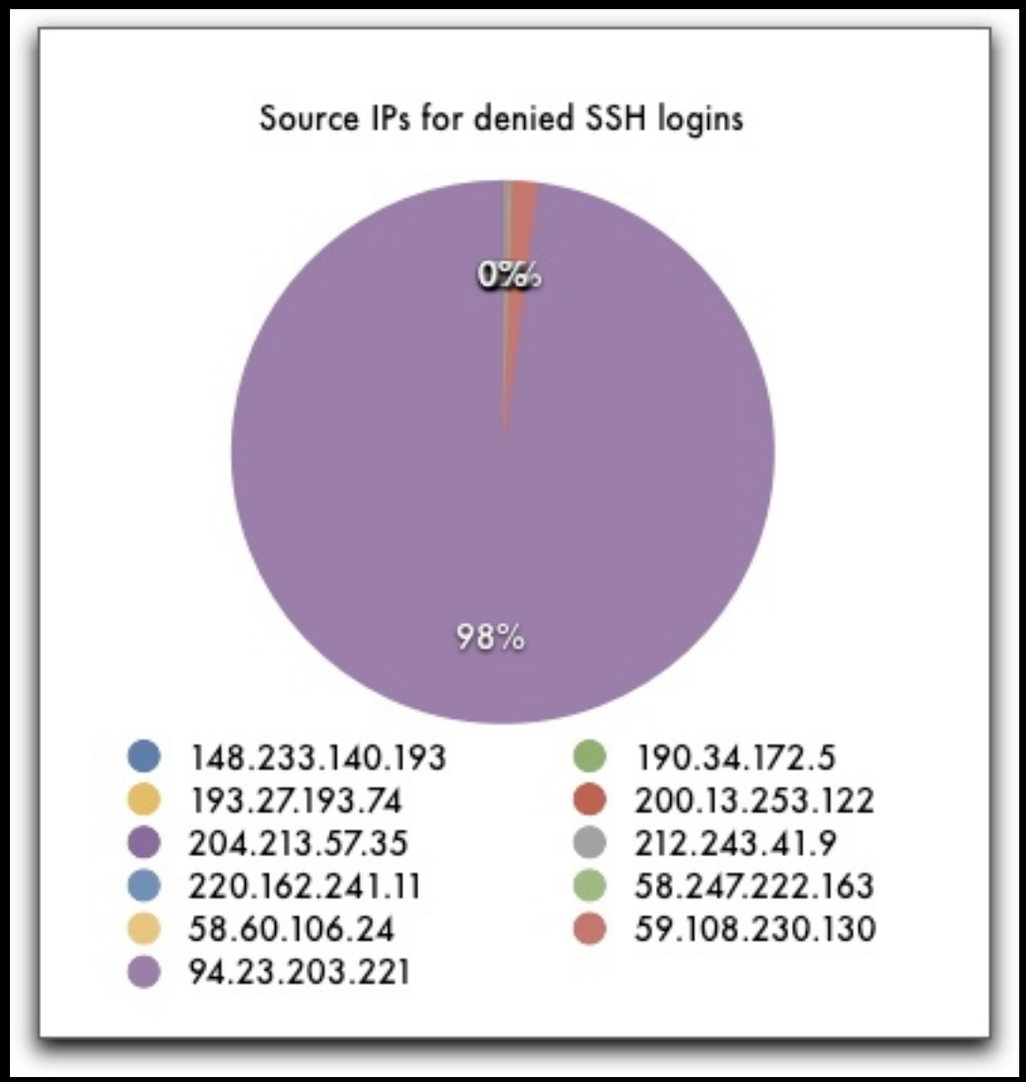
Pie Charts

★ Well you know about these... your boss (and salespeople) crave them

★ Compare single-dimensional values as parts / % of a whole

★ Only a small number of different values at a time

Pie Charts


Source IPs for denied SSH logins
0%
98%
148.233.140.193
193.27.193.74
204.213.57.35
220.162.241.11
58.60.106.24
94.23.203.221
190.34.172.5
200.13.253.122
212.243.41.9
58.247.222.163
59.108.230.130

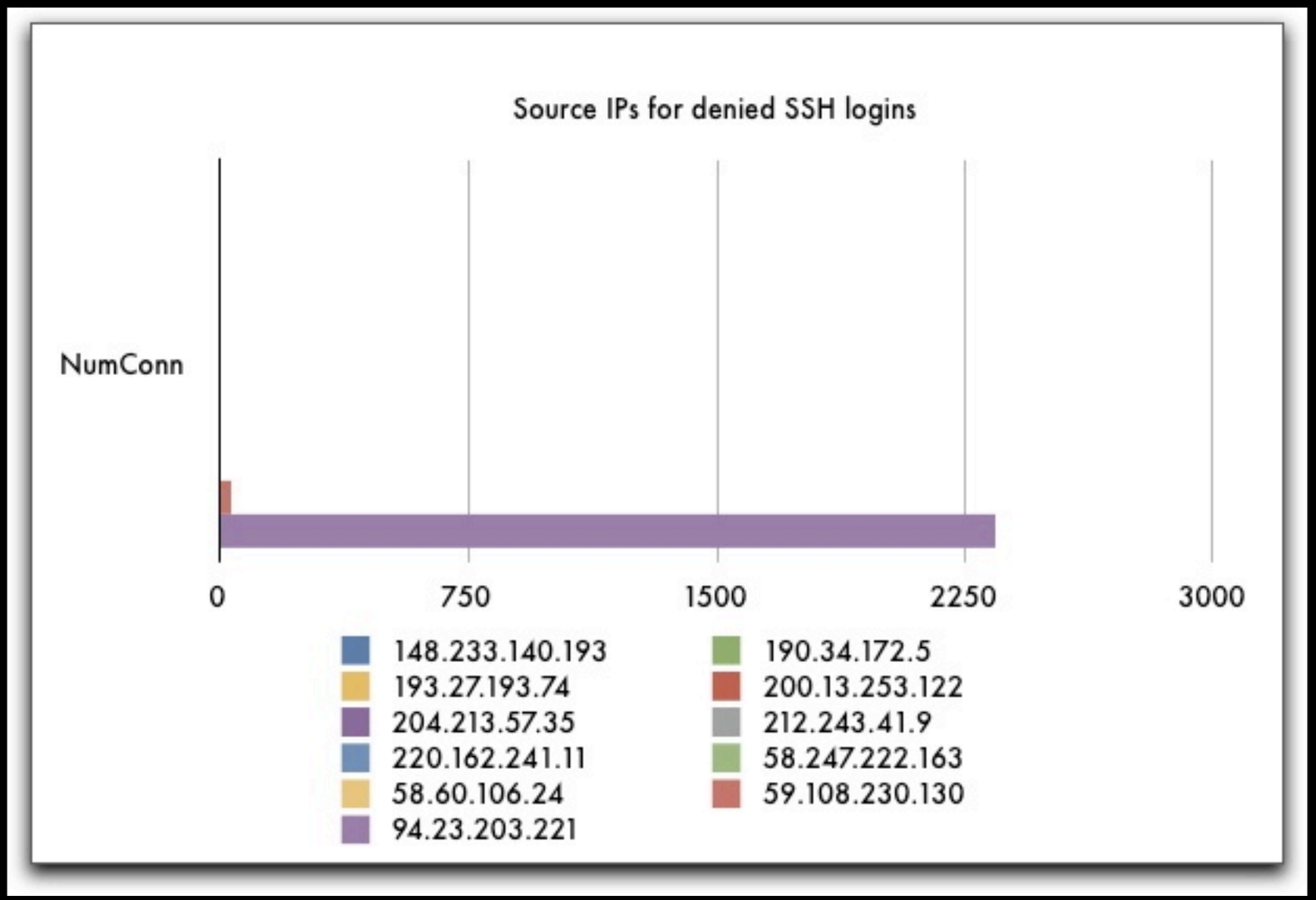
Bar Charts

★ Used to show the frequency of one-dimensional values

★ Each bar represents a value

★ The bar's height represents the frequency count

Bar Charts


Source IPs for denied SSH logins
NumConn
0
750
1500
2250
3000
148.233.140.193
193.27.193.74
204.213.57.35
220.162.241.11
58.60.106.24
94.23.203.221
190.34.172.5
200.13.253.122
212.243.41.9
58.247.222.163
59.108.230.130

Histograms

★ Histograms look like bar charts

★ Bar charts are not suitable for continuous data while histograms are (ex. number of logins on any given day)

★ We can group thousand of values

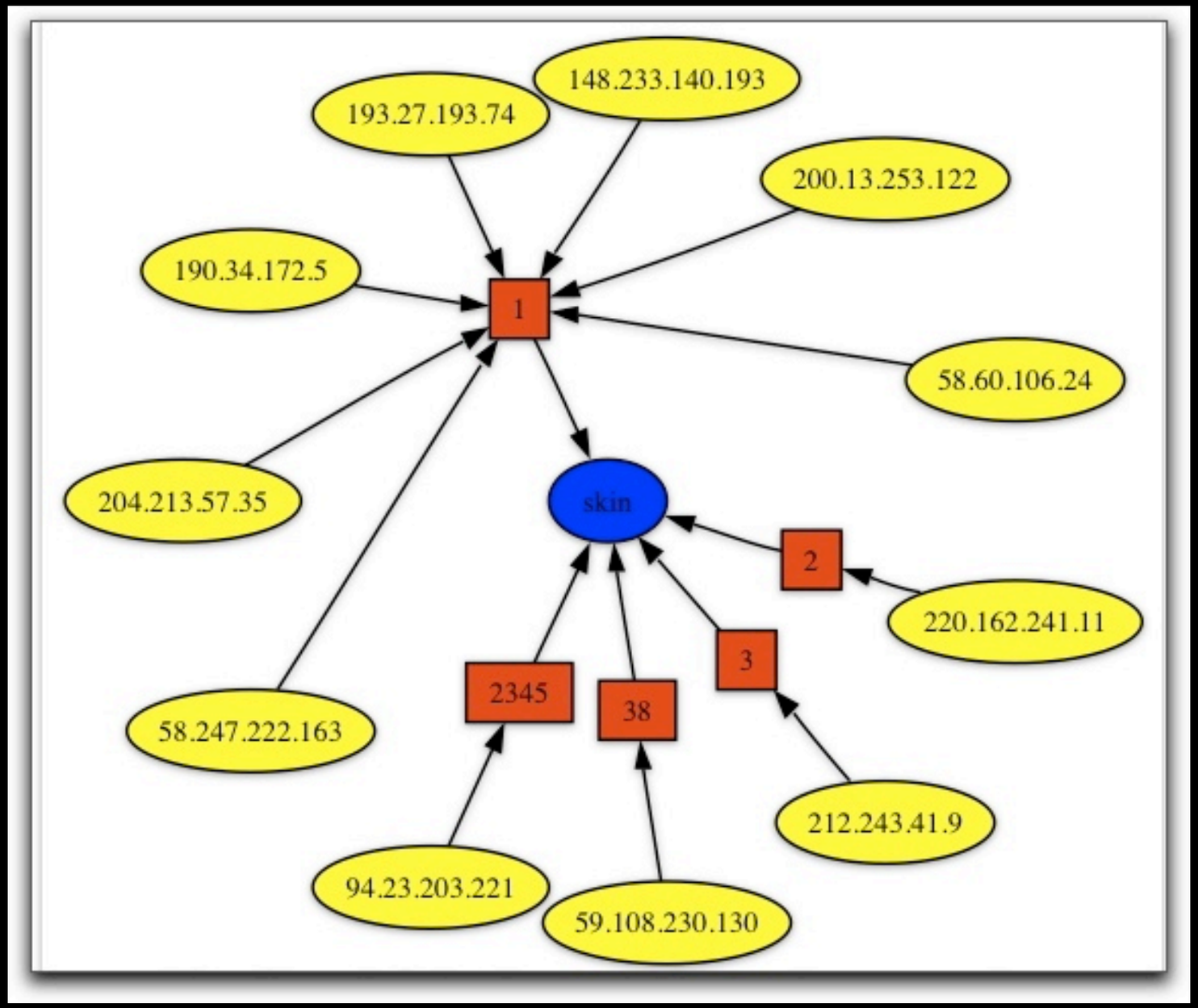
Link Graphs

★ Best-suited for visualizing relationships

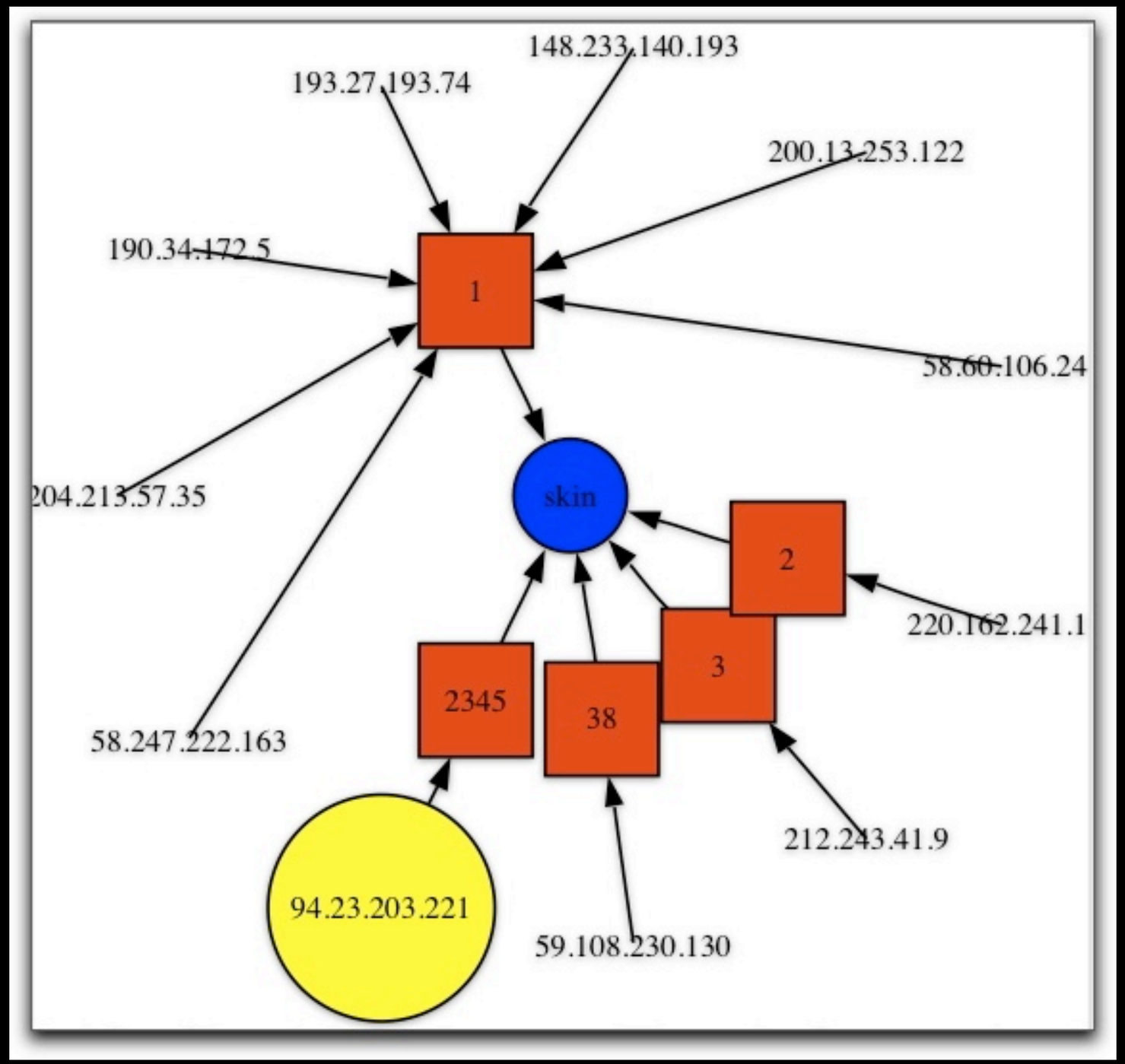
★ two dimensions (ex. source IP, destination IP)

★ three dimensions (ex. source IP, destination port, destination IP)

Link Graphs


148.233.140.193
193.27.193.74
200.13.253.122
190.34.172.5
1
58.60.106.24
204.213.57.35
skin
2
220.162.241.11
3
2345
38
58.247.222.163
212.243.41.9
94.23.203.221
59.108.230.130

Link Graphs


148.233.140.193
193.27.193.74
200.13.253.122
190.34.172.5
1
58.60.106.24
204.213.57.35
skin
2
220.162.241.1
3
2345
38
58.247.222.163
212.243.41.9
94.23.203.221
59.108.230.130

TreeMaps

★ Best-suited for visualizing multi-dimensional, hierarchical data

★ Use size and color to encode specific properties

★ Extremely practical for visualizing large data sets

TreeMaps

Interpret & Decide

★ So, what is the answer to the initial problem?

★ What actions shall be performed (if any)?

Firemen For Firewalls

Firewall Overload

★ On Aug 27th, 2009, Internet-facing firewalls got overloaded all of a sudden

★ legitimate traffic came to a halt

★ After some time, the firewalls felt better

The Problem

★ An MRTG-like graph tells us there is a spike in 25/tcp (SMTP?) connections to our mail relays

★ What happened?

★ What can we do to prevent it from happening again?

Available Data / Data Sources

- ★ Firewall log files
- ★ Mail relay log files
- ★ GeoIP

Firewall Log Files

★Very valuable

★Date and time, action, source IP, source port, destination IP, destination port, protocol...

★The spike was seen for about 2h

★That`s a 110MB, 529083 lines file

Mail Relay Log Files

- ★ Worthless
- ★ It took a rocket scientist (well, almost...) to figure out that these "best-of-breed" anti-spam appliances don't record incoming connections but incoming connections once they passed the first stage of SPAM clearance!

The Quest Begins

★ How to make something out of that 110MB firewall log file?

★ Which IP connected to our mail relays, how many times, to which country does it belong and is it a legitimate MTA?

★ Secondary mail relays? botnet?...

Parse and Filter

★ A quick "grep | sort -u" etc... gives us some initial information

★ 529083 lines translate into 125859 unique source IPs (uh oh...)

★ A Perl script tells us 119812 IPs made 10 connections or less

On The Way To Visualization

★ We want to see visually the source IPs and the number of connections each one made

★ What graph type shall we choose?

Preparing The Transformation

★ We need to normalize the data

★ Depending on the TreeMap tool, we must either use a specific format (TM3 files for HCIL TreeMap) or a more general-purpose one (CSV,...)

★ CSV is a good choice (and HCIL TreeMap is a nice piece of bloatware)

From TXT Log File To CSV

★ The log file we received was in TXT

★ Quite trivial to parse and transform into CSV

★ We can also add GeoIP information

From TXT Log File To CSV

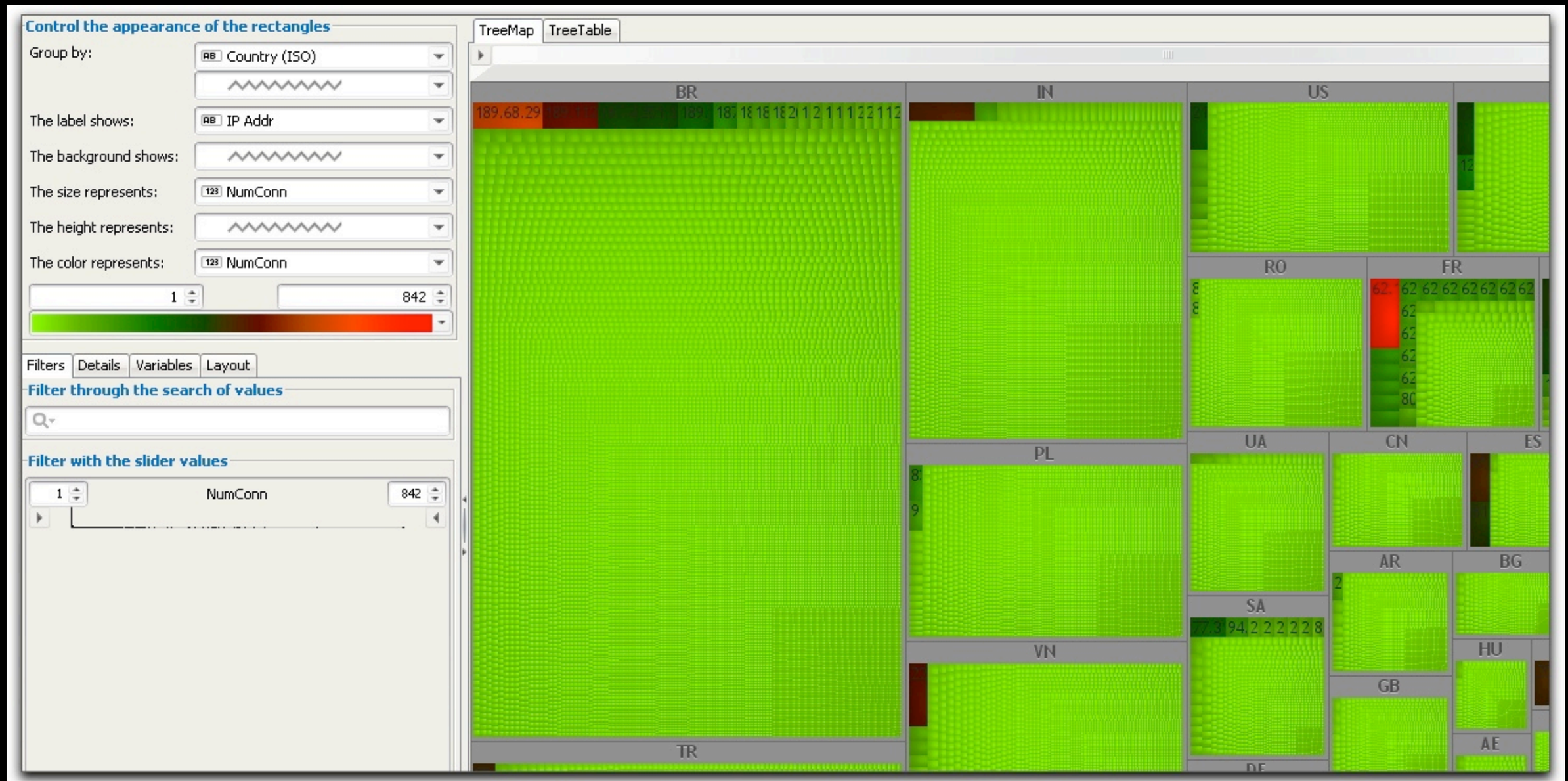
```
"Number" "Date" "Time" "Interface" "Origin" "Type" "Action" "Service" "Source Po
rt" "Source" "Destination" "Protocol" "Rule" "Rule Name" "Current Rule Number" "
User" "Information" "Product"
"13" "27Aug2009" "13:58:28" "eth-s1p4c0" "mainsite-f1es1p4-c003" "Log" "Accept"
"tcp-25" "1538" "117.204.18.22" "mainsite-mailrelay1-dmz" "tcp" "17" "" "17-dn"
"" "service_id: tcp-25" "VPN-1 Power/UTM"
"15" "27Aug2009" "13:58:28" "eth-s1p4c0" "mainsite-f1es1p4-c003" "Log" "Accept"
"tcp-25" "35187" "76.215.109.27" "mainsite-mailrelay2-dmz" "tcp" "17" "" "17-dn"
 "" "service_id: tcp-25" "VPN-1 Power/UTM"
"24" "27Aug2009" "13:58:28" "eth-s1p4c0" "mainsite-f1es1p4-c003" "Log" "Accept"
"tcp-25" "4823" "200.43.109.166" "mainsite-mailrelay1-dmz" "tcp" "17" "" "17-dn"
 "" "service_id: tcp-25" "VPN-1 Power/UTM"
```

```
IP Addr;NumConn;Country (ISO);Country (Name);
110.10.163.173;2;KR;Korea, Republic of;
110.10.249.70;4;KR;Korea, Republic of;
110.10.50.208;2;KR;Korea, Republic of;
110.11.217.209;2;KR;Korea, Republic of;
110.11.27.99;1;KR;Korea, Republic of;
110.12.108.16;4;KR;Korea, Republic of;
110.12.148.248;1;KR;Korea, Republic of;
110.12.84.77;2;KR;Korea, Republic of;
110.137.108.101;1;ID;Indonesia;
110.137.110.115;4;ID;Indonesia;
110.137.111.167;1;ID;Indonesia;
110.137.111.67;1;ID;Indonesia;
110.137.160.14;6;ID;Indonesia;
110.137.160.47;6;ID;Indonesia;
110.137.161.37;2;ID;Indonesia;
110.137.166.231;2;ID;Indonesia;
```

Viewing The Results

★To put it otherwise, let`s load the 125k line CSV in the Macrofocus TreeMap tool (way better than HCIL TreeMap)

★We need to fiddle a bit with the color, shape, grouping etc. to get the best from our data


Control the appearance of the rectangles
Group by:
Country (ISO)
The label shows:
IP Addr
The background shows:
The size represents:
NumConn
The height represents:
The color represents:
NumConn
1
842
Filters
Details
Variables
Layout
Filter through the search of values
Filter with the slider values
1
NumConn
842
TreeMap
TreeTable
BR
IN
US
RO
FR
UA
CN
ES
PL
AR
BG
SA
HU
VN
GB
AE
TR

Interpret & Decide

★ Doesn't sound like legitimate business, does it?

★ 25/tcp probe of all those 125k unique IPs: 96912 filtered, 7836 open, 21098 closed

★ Only 6.23% answer on 25/tcp

Visual Vulnerability Management

A Real Situation

★ Company with many business units located worldwide

★ In order to keep the attack surface as small as possible, a vulnerability discovery service is offered

★ Regular vulnerability scanning

Trade-offs & Design

★ Local contacts in business units have (very) limited time and sometimes basic security knowledge

★ Vulnerability scanner reports only on highly-critical, remotely-exploitable vulnerabilities

Deliverables

★ After each scan campaign, the local contacts receive HTML (yes, Web 2.0-style!) reports, scoring, and Excel spreadsheet giving an overview of which assets are more or less vulnerable

★ But a spreadsheet is still text...

Taking It To The Next Level

★ We need to prioritize actions more efficiently

★ i.e concentrate efforts on the more valuable assets with the highest number of vulnerabilities

★ Let`s get visual with TreeMaps!

Enriching Data

★ The vulnerability scanner gives us the number of vulnerabilities for each asset

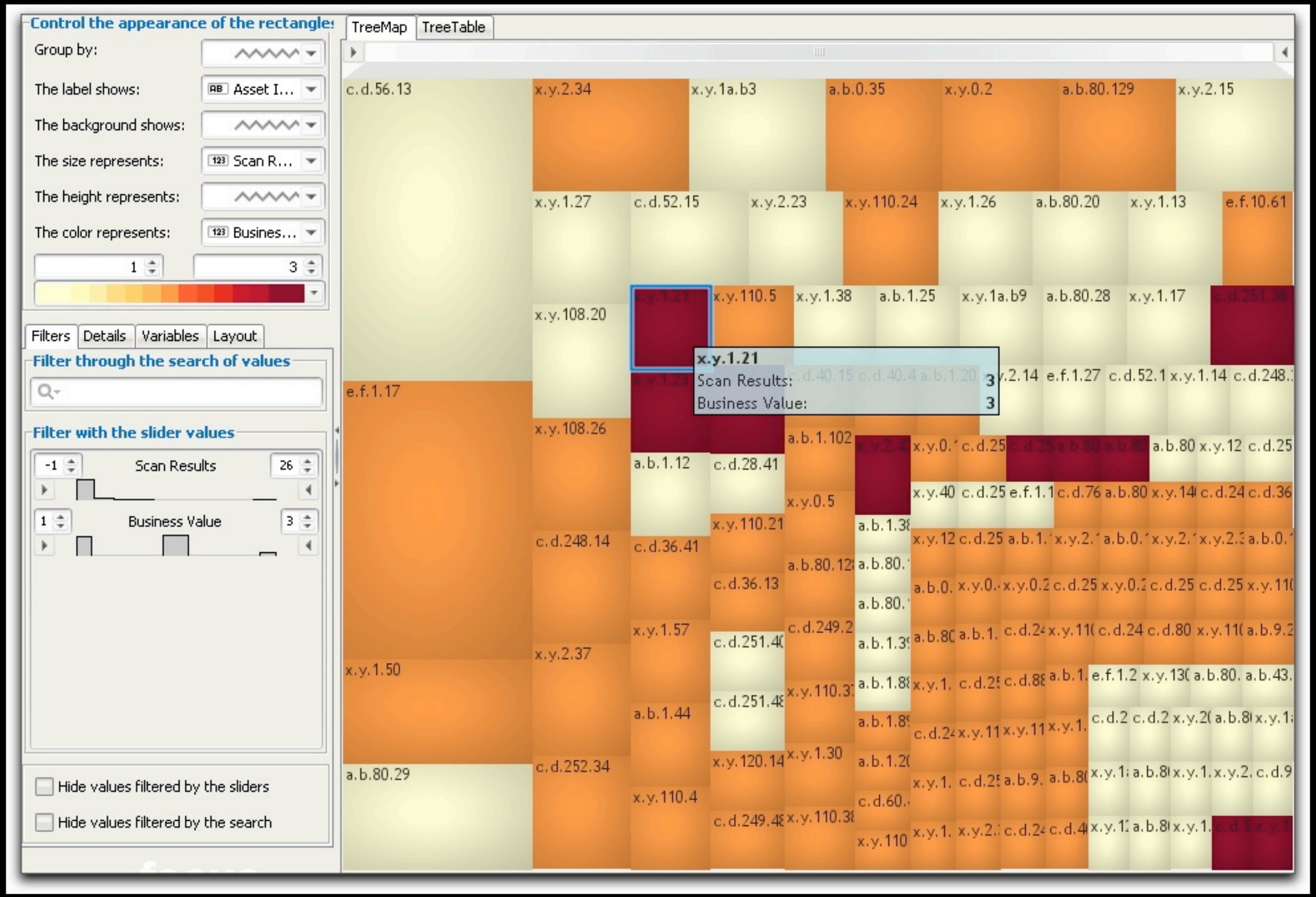
★ We need to add the "business value"

★ Scale from 1 to 3. The higher the value, the more valuable an asset is

In The Beginning There Was Text

```
Asset IP addr;Scan Results;Business Value
x.y.2.23;4;1
x.y.5.131;0;1
x.y.35.4;0;1
c.d.28.41;2;1
a.b.80.112;0;1
a.b.43.166;0;1
x.y.5.132;0;1
x.y.35.5;0;1
x.y.105.20;0;1
a.b.43.167;0;1
x.y.5.133;0;1
a.b.1.38;1;1
x.y.35.6;0;1
a.b.80.161;1;1
x.y.105.21;0;1
e.f.1.35;0;1
c.d.28.42;0;1
a.b.80.114;1;1
a.b.43.168;0;1
x.y.5.134;0;1
a.b.1.39;-1;1
x.y.35.7;0;1
x.y.75.2;0;1
x.y.105.22;0;1
a.b.8.160;0;1
x.y.5.135;0;1
x.y.75.3;0;1
x.y.105.23;0;1
a.b.8.161;0;1
a.b.43.76;0;1
x.y.35.9;0;1
x.y.105.24;0;1
a.b.80.117;0;1
x.y.125.10;0;1
```

And a TreeMap Appeared



A Few Things To Know

Still a Young Field

★ SecViz is not really mature at this point

★ It picked up some momentum in 2007 and some active research is being conducted since then

Common Pitfalls

★ There are very few industrial-grade tools

★ Time spent parsing, filtering and normalizing data can be a hurdle

★ The problem of filtering too much / not enough

Tools of The Trade

★ Data capture: tshark

★ Classic Unix tools (grep, sed, awk, perl, ruby...)

★ Linkgraphs: AfterGlow, GraphViz

★ TreeMaps: Macrofocus TreeMap

★ DAVIX Linux Distribution

Reference

★ SecViz Web community

★ Conti G., Security Data Visualization.

★ Marty R., Applied Security Visualization.

Thanks!

★ OSSIR

★ HAPSIS

★ and of course to you for listening to my babble

Get The Slides

★ You can get the slides from the OSSIR website

★ Questions ? Comments ?

- saad.kadhi@hapsis.fr

Speaker

★ Saâd Kadhi, I.S. Security Consultant, HAPSIS (http://www.hapsis.fr/)

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