Introduction to Bro Network Security Monitor

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Overview

- Introduction to Bro
- Bro Architecture
- Bro Events and Logs
- Bro Signatures
- Bro Scripting
- Bro and ELK

Introductory Workshop!

- This is an introductory workshop
- You probably won't hear/see new things if you have:
  - Already used Bro;
  - Followed SANS SEC 503;
- **If you are stuck, please do not suffer in silence!**

Workshop VM

- Bro_2.5.5_ELK_6.4.1_ubuntu-16.04.5-desktop-amd64
- VMware Workstation, Player, or Fusion
  - You can try VirtualBox too, but you are on your own with that… sorry! ☺
- 4 GB RAM
- 30 GB disk space
- Workshop VM (Ubuntu) user/pass: **user / Workshop1234%**
  - Normally, it should not require password for login and sudo

About Eva

- Managing partner and CEO at Alzette Information Security
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Introduction to Bro

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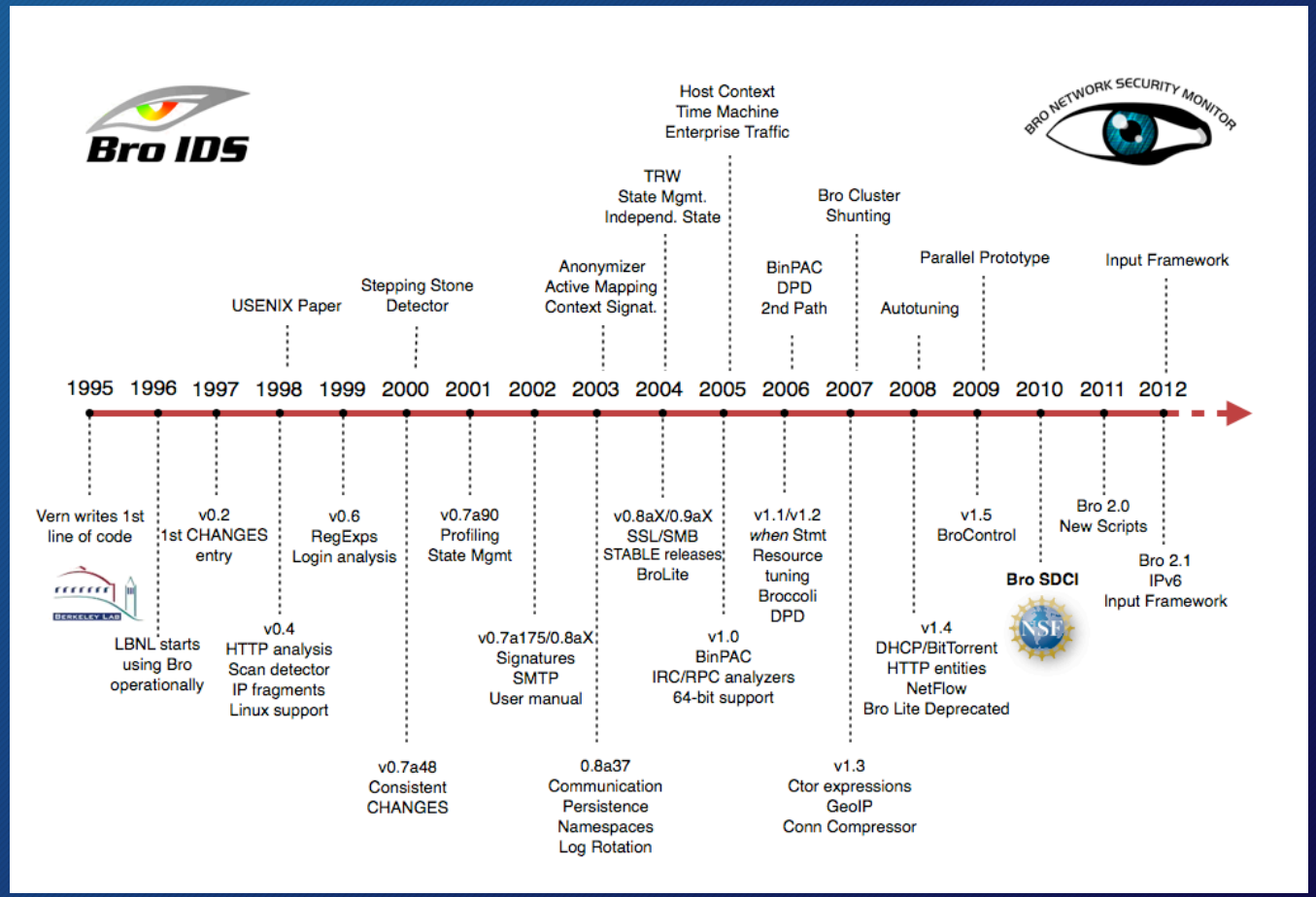
About Bro

- What is Bro?
- Passive, open-source network traffic analyzer
- Event/data-driven NIDS
- Platform for traffic analysis: fully customizable and extensible
- Runs on commodity hardware (can be up to 10GbE or even 100GbE links)

- Why Bro?
- Network Intrusion Detection Systems (NIDS)
  - Alert data only
- Network Security Monitoring (NSM)
  - NSM datatypes
    - Alert data
    - Flow (or Session) data
    - Transaction data
    - Packet data
    - Statistical data
    - Correlated data

Bro's History

- 1995 - Vern Paxson: initial version
- 1996 - Berkeley Lab deployment
- 2003 - National Science Foundation (NSF) began supporting Bro R&D
- 2010 - National Center for Supercomputing Applications (NCSA) joined the team as a core partner



Source: https://www.bro.org/sphinx/_images/history.png

Bro Architecture

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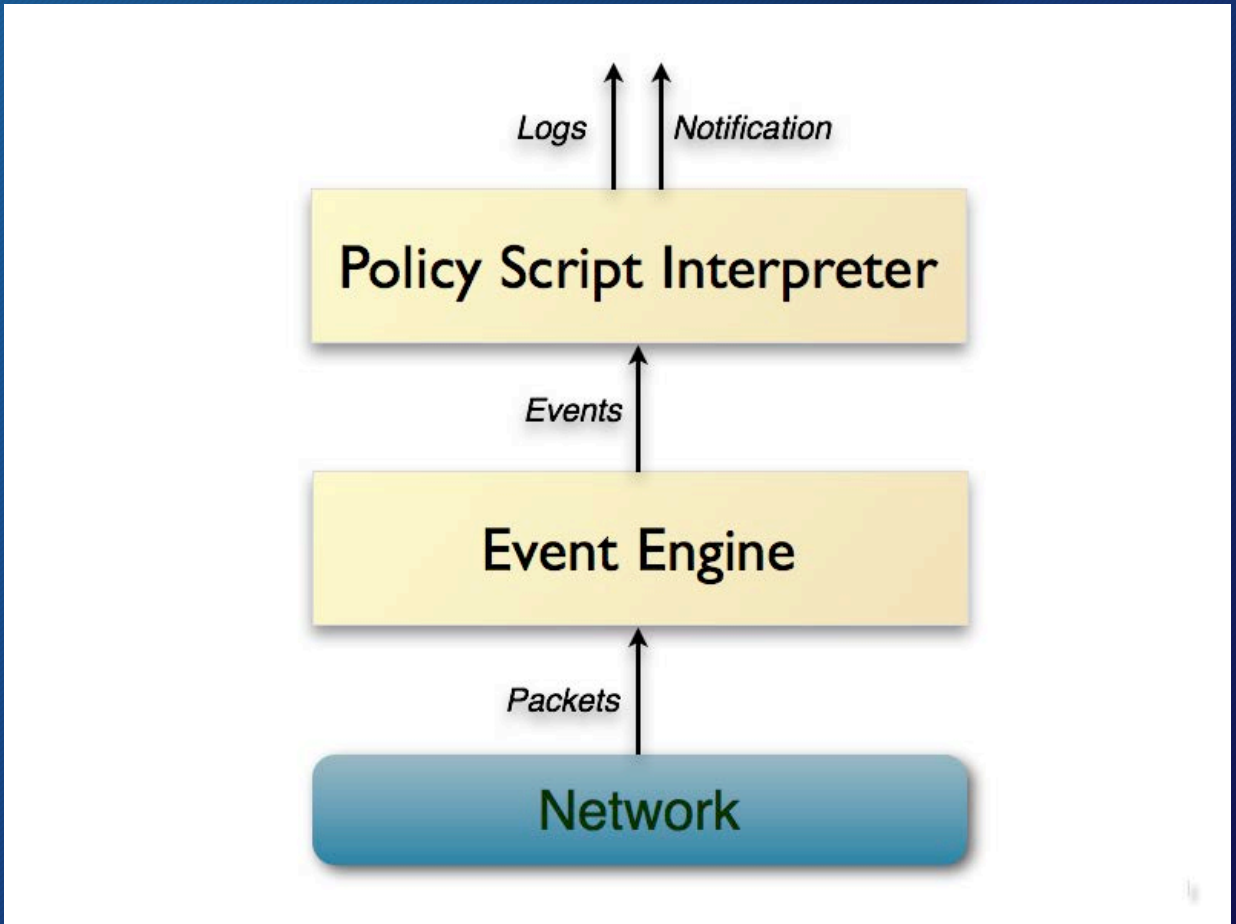
Bro's Internal Architecture

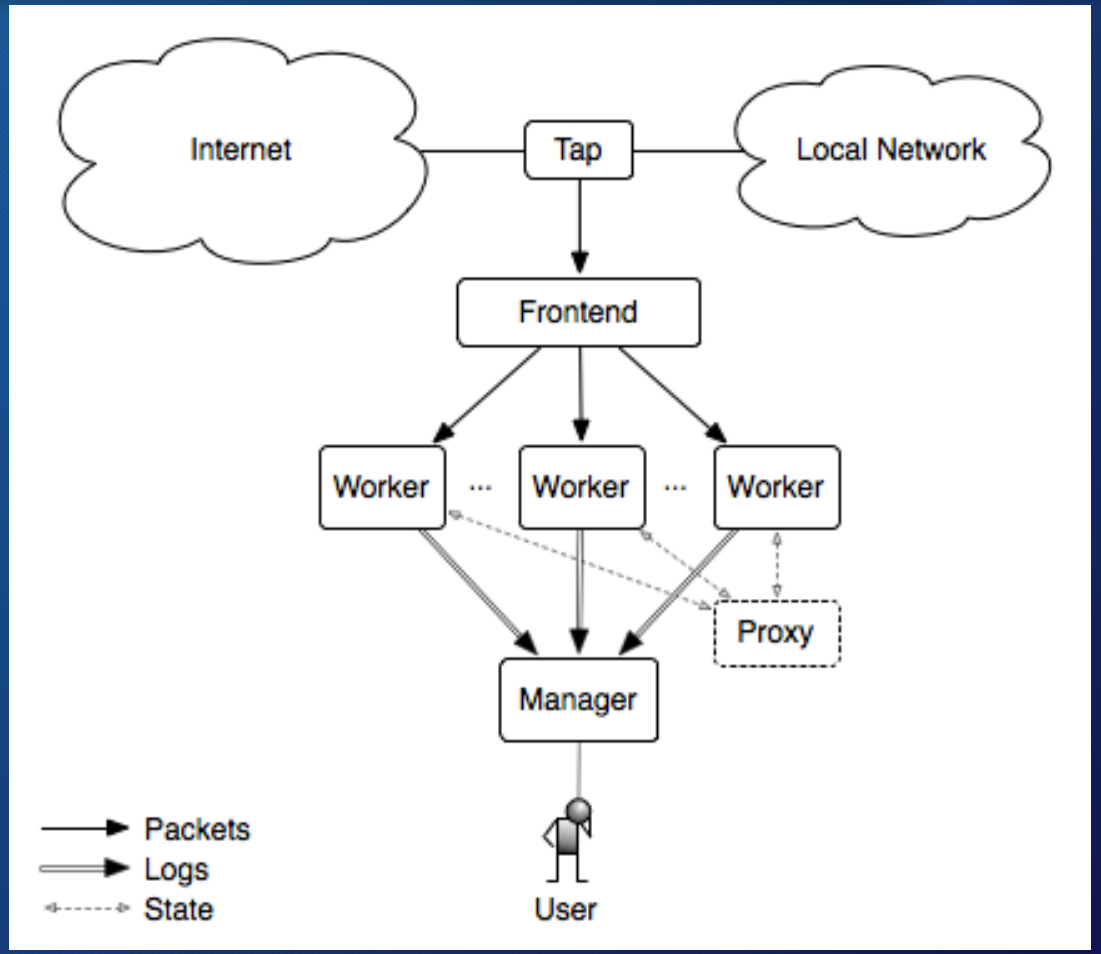
- **Event Engine**: protocol analyzer, generates network events
- **Policy Script Interpreter**: perform action/write output



Source: https://www.bro.org/sphinx/_images/architecture.png

Bro Cluster Architecture

- **Network Frontend**:
  - hardware flow balancers
  - on-host flow balancing (PF_RING)
- **Manager**: central log collector
- **Worker**: traffic inspection, stream reassembly, protocol analysis
- **Proxy**: synchronizing Bro state
- **Logger** (optional): receives log messages from nodes
- Standalone or cluster mode



Source: https://www.bro.org/sphinx/_images/deployment.png

Directory Hierarchy

Directory	Content
$(PREFIX)/bro/bin/	Executables: bro,broctl,bro-cut,capstats
$(PREFIX)/bro/etc/	Configuration: node.cfg, networks.cfg, broctl.cfg, broccoli,conf
$(PREFIX)/bro/logs/	Logs: current, <date>
$(PREFIX)/bro/spool/	Logs, error logs: tmp
$(PREFIX)/bro/share/bro/	/base: initialization – init-bare.bro, init-default.bro /broxigen: documentation /broctl: scripts for broctl /site: extensions and local.bro /policy: tuning, protocol policies
$(PREFIX)/bro/lib/bro/	Plugins: AMQP Writer, Kafka Writer, etc.
$(PREFIX)/bro/lib/broctl/	Broctl and broctl plugins

Bro Events and Logs

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Bro Events

- Bro’s event engine (or core):
  - Reduces the incoming packet stream into a series of higher-level events
  - Places events into an ordered "event queue“
- Events can be:
  - State change (new_connection, signature_match)
  - Protocol specific (http_response, dns_request)
  - Data availability (http_entity_data)
  - Etc.

Bro Logs (a few examples)

Log File	Description
conn.log	TCP/UDP/ICMP connections
dhcp.log	DHCP leases
dns.log	DNS activity
ftp.log	FTP activity
http.log	HTTP requests and replies
rdp.log	RDP
smb_cmd.log	SMB commands
smb_files.log	SMB files
ssh.log	SSH connections

Log File	Description
ssl.log	SSL/TLS handshake info
files.log	File analysis results
x509.log	X.509 certificate info
intel.log	Intelligence data matches
notice.log	Bro notices
signatures.log	Signature matches
known_hosts.log	Hosts seen (TCP handshakes)
software.log	Software seen on the network
weird.log	Unexpected network activity

Complete list: https://www.bro.org/sphinx/script-reference/log-files.html

Using bro-cut

- bro-cut utility can be used in place of other tools to build terminal commands
- Parsing the header in each file
- User can refer to specific columns

```
$ cat conn.log | bro-cut id.orig_h id.orig_p id.resp_h id.resp_p
192.168.1.102       68        192.168.1.1         67
192.168.1.103       137       192.168.1.255       137
192.168.1.102       137       192.168.1.255       137
192.168.1.103       138       192.168.1.255       138
192.168.1.102       138       192.168.1.255       138
192.168.1.104       137       192.168.1.255       137
192.168.1.104       138       192.168.1.255       138
192.168.1.103       68        192.168.1.1         67
192.168.1.102       138       192.168.1.255       138
192.168.1.104       68        192.168.1.1         67
192.168.1.102       1170      192.168.1.1         53
192.168.1.104       1174      192.168.1.1         53
192.168.1.1         5353      224.0.0.251         5353
fe80::219:e3ff:fee7:5d23      5353      ff02::fb  5353
192.168.1.103       137       192.168.1.255       137
```

Using Timestamps

- bro-cut accepts the flag -d to convert the epoch time values in the log files to a human-readable format.

```
$ bro-cut -d ts uid host < http.log
2009-11-18T10:14:13+0100      CmBOWT297WuJIENdwl    download.windowsupdate.com
```

- Converting the timestamp from a log file to UTC can be accomplished with the -u option.

```
$ bro-cut -u ts uid host < http.log
2009-11-18T09:14:13+0000      CmBOWT297WuJIENdwl    download.windowsupdate.com
```

- The default format can be altered by using the -D and -U flags, using the standard strftime syntax.

```
$ bro-cut -D %d-%m-%YT%H:%M:%S%z ts uid host < http.log
18-11-2009T10:14:13+0100      CmBOWT297WuJIENdwl    download.windowsupdate.com
```

Using UIDs

- Unique identifier (UID): correlating a session across multiple log files

```
$ cat conn.log | bro-cut uid id.resp_h resp_bytes | sort -nrk3 | head -5
CSjNSg2PjautayFDCk    199.7.51.190   314640
CHHYy23JnTWsOPjoee    69.147.86.184  244265
Ce17F52e1L5egkZi07    151.207.243.129        174678
CSjqes3Hu7SxsWq4x5    198.189.255.75 95603
CsTFmw4tqZOMNjwc4b    198.189.255.75 95598
```

- Generally included in any log file entry associated with that connection

```
$ cat http.log | bro-cut uid id.resp_h method status_code host | grep CSjNSg2PjautayFDCk
CSjNSg2PjautayFDCk    199.7.51.190   GET    200    SVRSecure-crl.verisign.com
```

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Bro Logs Hands-On

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Bro Signatures

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Signature Framework

- Independent signature language
- Low-level, regexp-based pattern matching
- Signatures are **not** Bro's preferred detection tool

```
signature example-sig {
  ip-proto == tcp
  dst-port == 80
  tcp-state established,originator
  http-request-header /.*redditmedia\.com/
  http-request-header /.*\/ads\//
  event "Found hostname!“
}
```

```
event signature_match(state:
signature_state, msg: string, data:
string)
```

Signature Language

- Signature has the format:

```
signature <id> { <attributes> }
```

- Two types of attributes:
  - Conditions: define when the signature matches
  - Actions: declare what to do in the case of a match

Signature Conditions

- **Header**: header fields such as IP, port, protocol
- **Content**: regular expression raw payload (payload statement) or an analyzer-specific label (http-request, http-request-header, ftp, etc. statements)
- **Dependency**: define dependencies between signatures (requires-signature, requires-reverse-signature)
- **Context**: passes the match decision on to other components of Bro (eval, payload-size, same-ip, tcp-state)

Signature Actions

- **Event** <string>:
  - Raises a signature_match event
  - The given string is passed in as msg
- **Enable** <string>:
  - Enables the protocol analyzer <string> for the matching connection ("http", "ftp", etc.).
  - This is used by Bro's dynamic protocol detection to activate analyzers on the fly.

Bro Signatures Hands-On

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Bro Scripting

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Bro Scripting Overview

- Event-driven
- Domain-specific
- Turing-complete scripting language
- Based on ML (LISP-like)
- Basically, all Bro output is generated by Bro scripts

Types (1)

Name	Description
bool	boolean (T = true, F = false)
count, int, double	count = unsigned int
time, **interval**	temporal types (e.g. 3.5mins)
string	string
pattern	regular expression (flex lexical analyzer, e.g. /foo|bar/)
port, addr, subnet	network types (e.g. 80/tcp, 192.168.0.1, 10.0.0.0/8)

Source: https://www.bro.org/sphinx-git/script-reference/types.html

Types (2)

Name	Description
enum	enumeration (user-defined type)
table, set, vector, record	Container types (table = hash, record = structure)
function, event, hook	Executable types
file	File type (only for writing)
opaque	Opaque type (for some built-in functions)
any	Any type (for functions or containers)

Source: https://www.bro.org/sphinx-git/script-reference/types.html

Operators (1)

- Relational operators

Name	Syntax
Equality	a == b
Inequality	a != b
Less than	a < b
Less than or equal	a <= b
Greater than	a > b
Greater than or equal	a >= b

- Logical operators

Name	Syntax
Logical AND	a && b
Logical OR	a || b
Logical NOT	!a

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Source: https://www.bro.org/sphinx-git/script-reference/operators.html

Operators (2)

- Arithmetic operators

Name	Syntax
Addition	a + b
Subtraction	a - b
Multiplication	a * b
Division	a / b
Modulo	a % b

Name	Syntax
Unary plus	+a
Unary minus	-a
Pre-increment	++a
Pre-decrement	--a
Absolute value	|a|

Source: https://www.bro.org/sphinx-git/script-reference/operators.html

Operators (3)

- Assignment operators

Name	Syntax
Assignment	a = b
Addition assignment	a += b
Subtraction assignment	a -= b

- Record field operators

Name	Syntax
Field access	a$b
Field value existence test	a?$b

Source: https://www.bro.org/sphinx-git/script-reference/operators.html

Operators (4)

- Other operators

Name	Syntax
Membership test	a in b
Non-membership test	a !in b
Table or vector element access	a[b]
Substring extraction	a[b:c]

Name	Syntax
Create a deep copy	copy(a)
Module namespace access	a::b
Conditional	a ? b : c

Source: https://www.bro.org/sphinx-git/script-reference/operators.html

Attributes (the most important ones)

Name	Description
&redef	Redefine a global constant or extend a type.
&priority	Specify priority for event handler or hook.
&log	Mark a record field as to be written to a log.
&optional	Allow a record field value to be missing.
&default	Specify a default value.

Source: https://www.bro.org/sphinx-git/script-reference/attributes.html

Declarations

Name	Description
module	Change the current module
export	Export identifiers from the current module
local	Declare a local variable
global	Declare a global variable
const	Declare a constant
type	Declare a user-defined type
redef	Redefine a global value /extend user-defined type
function/event/hook	Declare a function, event handler, or hook

Source: https://www.bro.org/sphinx-git/script-reference/statements.html

Statements

Name	Description
add, delete	Add/delete elements
print	Print to stdout/file
if, else if, else	Evaluate boolean expression
switch, case, break, fallthrough	Evaluate expression and execute

Name	Description
for, while, next, break	Loop over each element
event, schedule	Invoke or schedule an event handler
return	Return from function, hook, or event handler

Source: https://www.bro.org/sphinx-git/script-reference/statements.html

Namespaces and Directives

- Namespaces

Name	Scope
Local	Local block
Module global	Global in the module
Global	All Modules

- Directives
  - Evaluated before script execution
  - Like pre-processor macros in C/C++
- Examples

Name	Scope
@load	Load Bro script
@load-plugin	Load Bro plugin
@load-sigs	Load Bro signature
@DIR	Directory pathname
@FILENAME	Script filename

Frameworks

Framework	Description
File Analysis Framework	Generalized presentation of file-related information.
GeoLocation Framework	Requires libGeoIP with GeoLite city database installed.
Input Framework	Allows users to import data into Bro.
Intelligence Framework	Consume data and make it available for matching.
Logging Framework	Fine-grained control of what and how is logged.
NetControl Framework	Flexible, unified interface for active response.
Notice Framework	Detect potentially interesting situations and take action.
Signature Framework	Signature language for low-level pattern matching.
Summary Statistics Framework	Measuring aspects of network traffic.
Broker-Enabled Communication Framework	Exchange information with other Bro processes.

And a Bunch of Other Things...

- Hooks
- Analyzers
- Bro script debugging
- Bro frameworks in depth
- Broccoli: The Bro Client Communications Library
- Bro Plugins
- Go check the documentation: https://www.bro.org/documentation/index.html

Bro Scripting Hands-On

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Bro and ELK

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Bro and Syslog-ng Configuration

- Bro node configuration:
  - /opt/bro/etc/node.cfg

```
[bro]
type=standalone
host=localhost
interface=ens34
```

- Bro output configuration:
  - /opt/bro/share/bro/site/local.bro

```
#@load tuning/defaults
@load tuning/json-logs
```

- Syslog-ng configuration:
  - /etc/syslog-ng/syslog-ng.conf

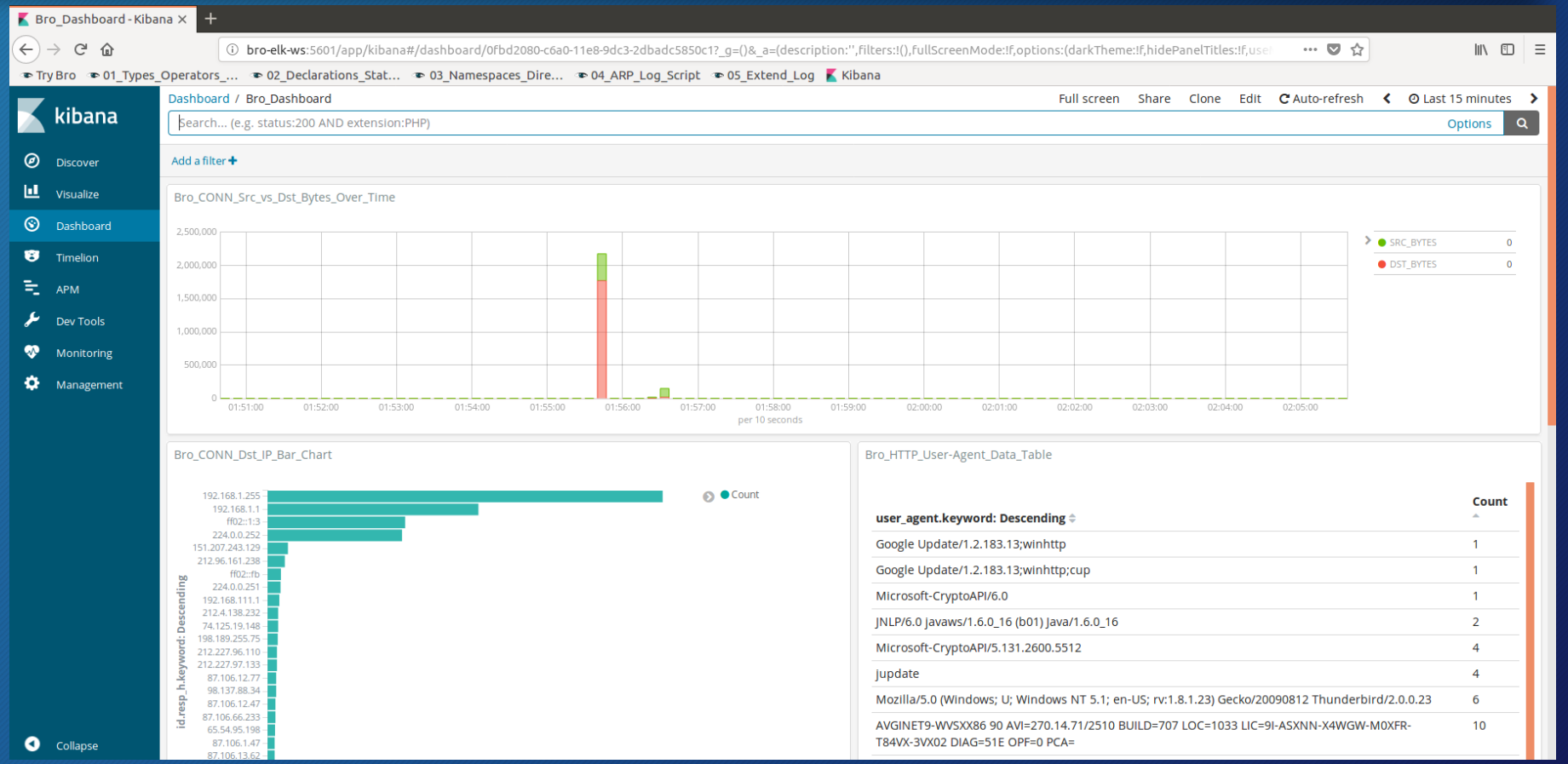
```
source s_bro_conn { file("/opt/bro/logs/current/conn.log"
flags(no-parse) program_override("bro_conn")); };
source s_bro_http { file("/opt/bro/logs/current/http.log"
flags(no-parse) program_override("bro_http")); };
...

destination d_bro { network("127.0.0.1" port(5514)); };

log {
  source(s_bro_conn);
  source(s_bro_http);
  ...
  destination(d_bro);
};
```

Logstash Pipeline Configuration

- Create file:
  - /etc/logstash/conf.d/bro.conf
- /etc/logstash/logstash.yml has:
  - config.reload.automatic: true
  - config.reload.interval: 5s

```
input {
  syslog {
    port => "5514“
  }
}
filter {
  json {
    source => "message“
  }
  mutate {
    remove_field => ["message"]
  }
}
output {
  elasticsearch {
    hosts => ["localhost:9200"]
  }
}
```

Kibana Visualizations and Dashboard



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Questions and Answers

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References

- Bro Documentation
  - https://www.bro.org/documentation/index.html
- Install Bro
  - https://www.bro.org/sphinx/install/install.html
- Bro on DockerHub
  - https://hub.docker.com/u/broplatform/
- Try Bro Online
  - http://try.bro.org