An Overview of the Bro Intrusion Detection System

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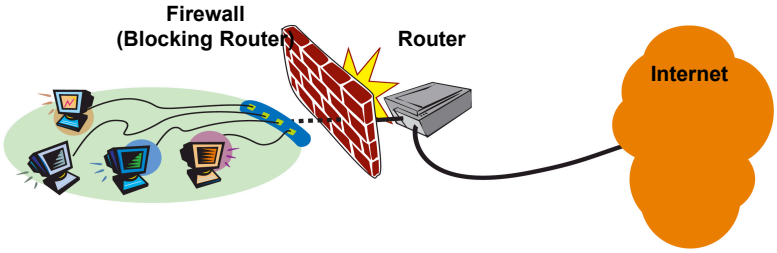
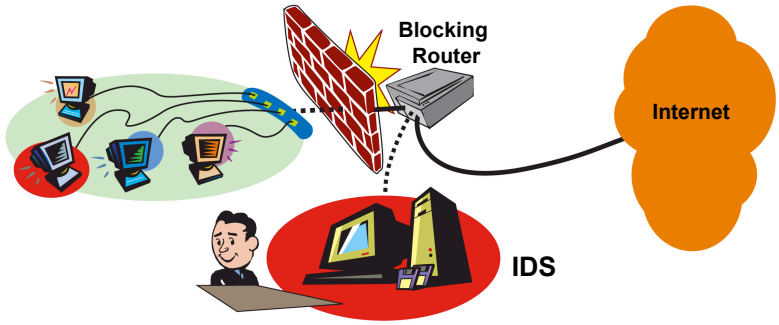
Typical Approach: Firewall with "default deny" policy

- **A blocking router is a type of firewall**
- **Blocks individual services (ports) inbound and possibly outbound**
- **Blocks address ranges inbound and possibly outbound**



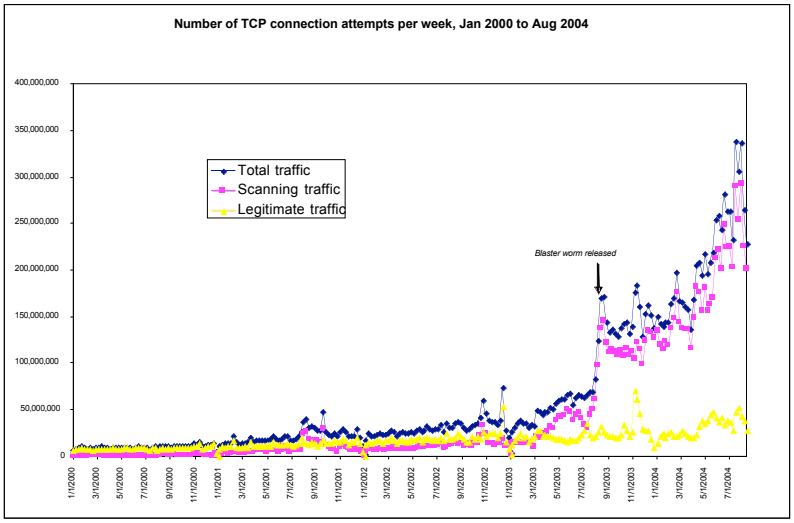
LBNL approach: IDS with Blocking Router

- IDS controls a blocking router
- IDS blocks dynamically when an intrusion attempt is detected or alerts upon suspicious activity
- Router blocks statically like a firewall
- "Intrusion Prevention"



Bro

LBNL Inbound (from Internet) TCP Traffic



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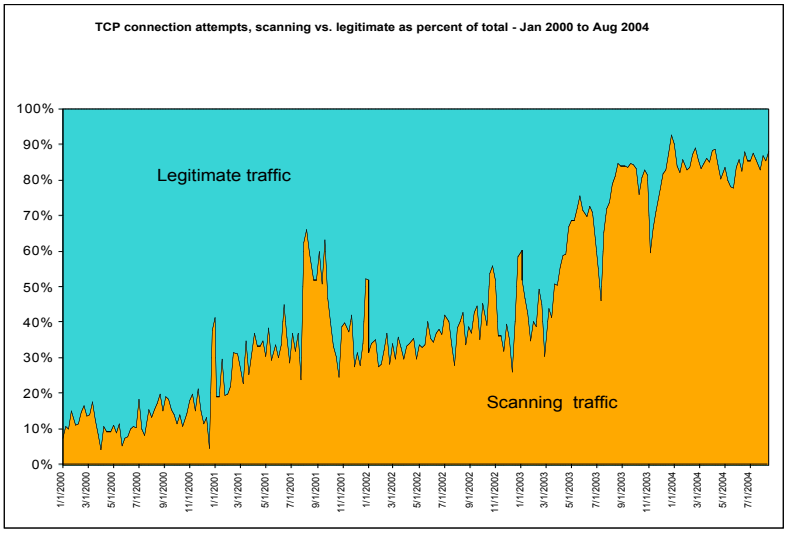


Bro's Use at LBL

- Operational 24×7 since 1996
- Monitors traffic for suspicious behavior or policy violations: incoming/outgoing/internal
- In conjunction with blocking routers, Bro *acts* as a dynamic and intelligent firewall
  - Blocks access from offending IP addresses
  - Blocks high risk ports
  - Blocks known high-risk activity
  - Terminates connections and/or sends alarms
- Very high performance: GigEther
- Award winning research

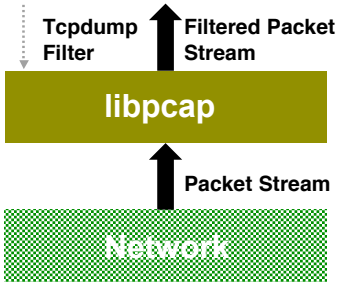
Bro Goals & Requirements (1995)

- Ability to monitor traffic in a very high performance environment
- Real-time detection and response
- Separation of mechanism from policy
- Ready extensibility of both mechanism and policy
- Resistant to evasion

How Bro Works

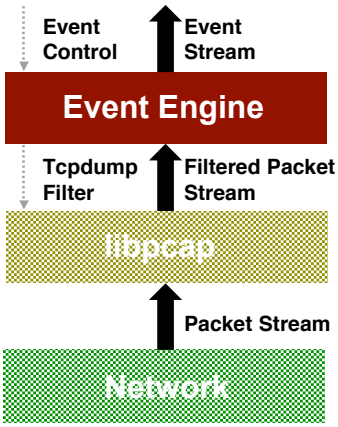
- Taps GigEther fiber link passively, sends up a copy of all network traffic.

How Bro Works



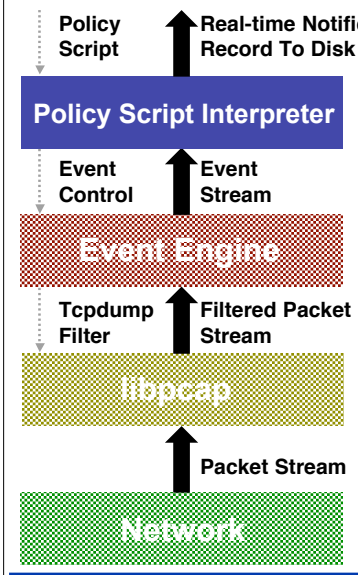
- Kernel filters down high-volume stream via standard *libpcap* packet capture library.

How Bro Works



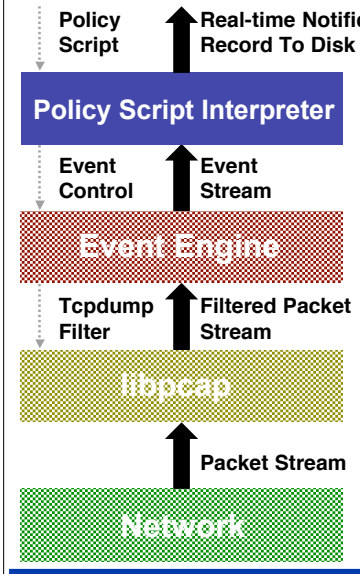
- "Event engine" distills filtered stream into high-level, *policy-neutral* events reflecting underlying network activity
  - E.g. Connection-level:
    - connection attempt
    - connection finished
  - E.g. Application-level:
    - ftp request
    - http_reply
  - E.g. Activity-level:
    - login success

How Bro Works



- "Policy script" processes event stream, incorporates:
  - Context from past events
  - Site's particular policies

How Bro Works



- "Policy script" processes event stream, incorporates:
  - Context from past events
  - Site's particular policies
- … and *takes action*:
  - Records to disk
  - Generates alerts via *syslog*, paging, etc.
  - Executes programs as a form of response

Signature Engine

- Bro also includes a *signature engine* for matching specific patterns in packet streams:
  - Conceptually simple
  - Easy to share
  - Compatible with *Snort* (widely used freeware IDS)
    - E.g., can run on *Snort's* default set of 2,500+ signatures
- As with other Bro analysis, signature matches generate events amenable to high-level policy script processing, rather than direct alerts

Examples of Bro's Contextual Signatures ("Rules")

- HTTP server attack
  - Snort signature: simple pattern matching on MS ISS attack
  - Bro rule: additional check to see if, e.g., host is running Apache ⇒ ignore alarm
- Error code checking
  - Snort signature: no checking of reply
  - Bro rule: Looks at return code for HTTP/FTP/SMTP,
    - signature match + error code = no alert
- Multi-stage attacks
  - Easy in Bro to express "signature A but only if followed by signature B" or "A unless followed by B"
  - Easy to express "generate alarms if given host triggers N or more signatures" or "triggers against N or more local hosts"
- *Greatly reduces number of false positives!*

Bro as a Tool for Network Analysis/Forensics

- Bro supports extensive long-term logging
- We have a record of every TCP connection in/out of LBNL going back to 1994
  - Time, size, duration, who, protocol, status
  - Plus specifics of apps analyzed by Bro:
    - Usernames, filenames, URLs
- Invaluable for forensic analysis
- Also invaluable for trending, retrospective analysis, longitudinal studies

Example: Bro dropping an IP source address

ISS Server attack:

Nov 5 00:04:07 140.138.148.222/2142 > cindy/http %63654: attack URI GET /scripts/..%5c..%5cwinnt/system32/cmd.exe?/c+copy+c:\winnt\system32\cmd.exe+c:\inetpub\scripts\script.exe, dropping

Policy: Drop this host:

Nov 5 00:04:07 AddressDropped dropping address 140.138.148.222 (attack URI /scripts/..%5c..%5cwinnt /system32/cmd.exe?/c+copy+c:\winnt\system32\cmd.exe+c:\inetpub\scripts\script.exe)

WU-FTP buffer overflow attack

Alarm:

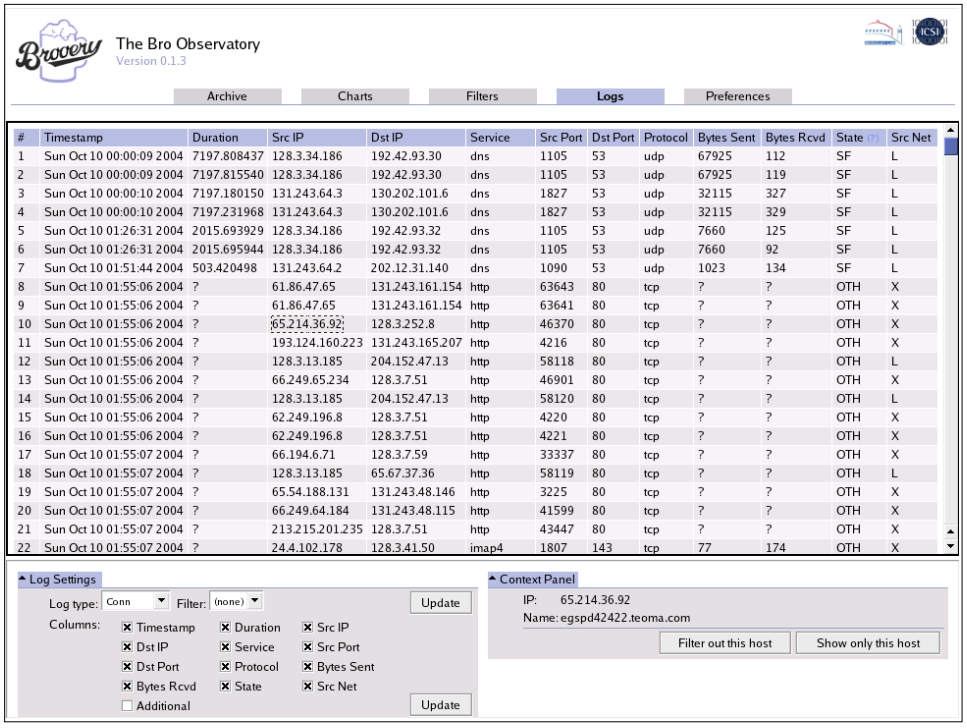
```
Jan 21 01:31:56 ssl.hawera.de/1540 > obsidian/ftp #18 excessive
   filename: 000000000000000000000000000000000..[495]..
```

Details from FTP log file:

```
Feb 21 00:53:15 #4733 clydesdale.cacc.ncsu.edu/2564 >
   obsidian.lbl.gov/ftp start
Feb 21 00:53:15 #4733 response (220 obsidian.lbl.gov FTP server
   (Version wu-2.6.1(1) Sat Jan 24 01:43:53 GMT 2001) ready.)
Feb 21 00:53:16 #4733 USER ftp/mozilla@ (logged in)
Feb 21 00:53:16 #4733 RNFR ././ (350 File exists, ready for
   destination name)
Feb 21 00:53:22 #4733 PWD (done)
Feb 21 00:53:22 #4733 CWD 000000000000000000000000000000000..[495]..
   (unavail)
Feb 21 00:53:22 #4733 CWD ~/{.,.,.,.} (ok)
```


Sample Bro Alarms

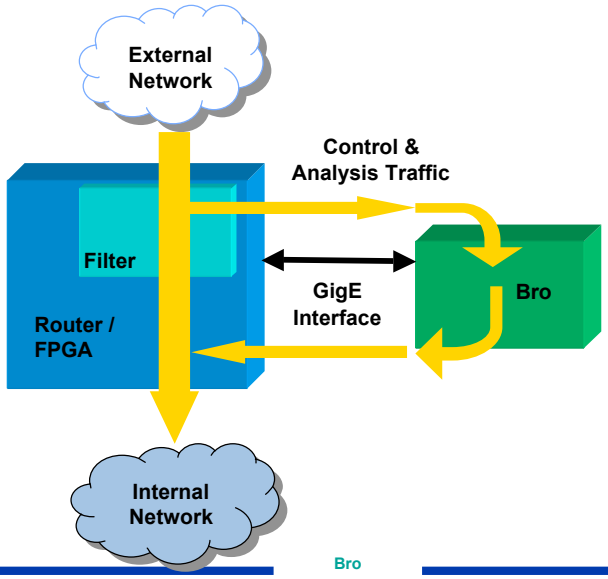
```
Nov 16 03:31:23 AddressDropped low port trolling a213-22-132-
   227.netcabo.pt 258/tcp
Nov 16 06:25:23 SensitivePortmapperAccess rpc: cs4/917 >
   guacamole.cchem.berkeley.edu/portmap pm_dump: (done)
Nov 16 06:30:49 AddressScan 66.243.211.244 has scanned 10000
   hosts (445/tcp)
Nov 16 06:30:50 SensitiveConnection hot: neutrino 200b >
   147.8.137.149/telnet 463b 14.2s "root"
Nov 16 06:30:50 OutboundTFTP outbound TFTP:
   sip000d28083467.dhcp -> inoc-dba.pch.net
Nov 16 06:30:52 SensitiveConnection hot: 198.128.27.21 560b >
   208.254.3.160/https 4202b 0.5s <IRC source sites>
Nov 16 06:30:53 WormPhoneHome worm phone-home signature mcr-88-
   4 -> 218.146.108.51/9900
Nov 16 06:30:56 FTP_Sensitive ftp: fun.ee/3766 >
   soling.cs.vu.nl/ftp #1537 RETR nfsshell.tar.gz (complete)
Nov 16 06:32:38  HTTP_SensitiveURI scan1/34462 >
   198.128.27.212/http %988: GET /admin/file_manager.php?action=
   download& filename=./../../../../../../etc/passwd <no reply>
```



Related Research

- Bro serves as platform for
  - Developing new methods of analyzing high-level network activity
    - Detecting scans, "stepping stones", "backdoors"
  - "Independent state"
    - Sharing context between Bro's across time & space
  - Efficient hardware to support intrusion detection
  - Investigating defenses against evasion
  - Hardware assist - "Shunting"
- Operation at LBNL produces ongoing bonanza of intrusion detection research data
  - Rich, challenging environment

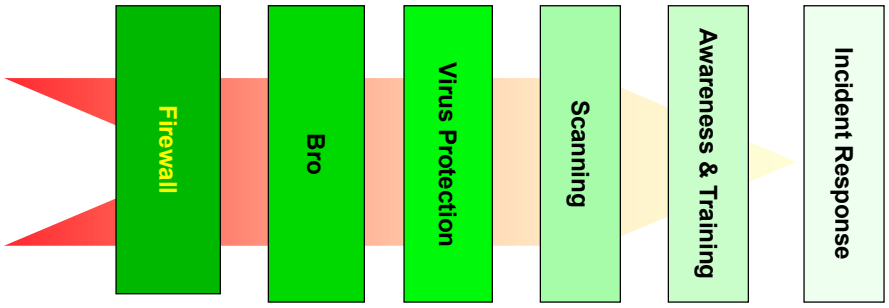
New Project: *Shunting*



Bro vs. Bro-Lite

- Bro and Bro-Lite are the exact same set of software
  - All Bro-Lite work is going into the main Bro distribution
- Bro-Lite refers to a specific default policy configuration
- Bro-Lite is a project name

Bro is a part of a Overall Cyber Security Strategy



For more Information

- New Web site: http://www.bro-ids.org/
- Bro-Lite “alpha” release now available
  - http://www.bro-ids.org/alpha/
- Bro-Lite “beta” release coming soon
- Send email to bro@bro-ids.org