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Building Analytics for Network Flow Records

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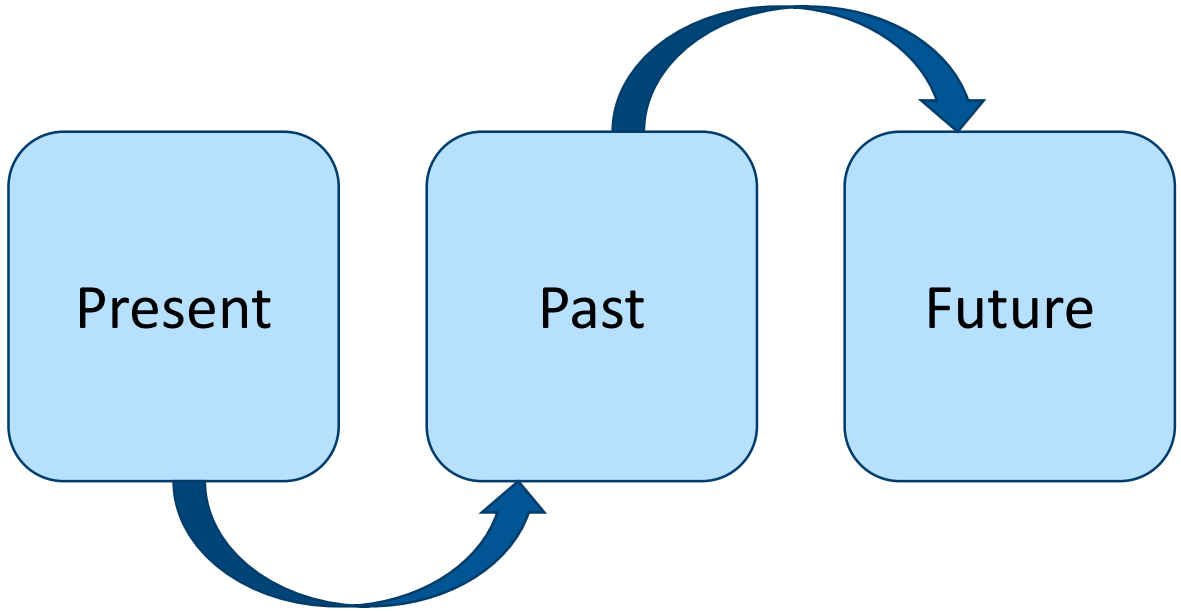
Poll on Automated Analysis

How is your organization automating analysis for network situational awareness or network security?

- Uncertain: We don’t do network situational awareness
- Outsourced: We have a good managed security solution
- Feeds: We merge several external threat feeds to develop analytics (data-centric, not directed)
- Heroes: We hire good people and leave it in their hands
- Repeatable: We have a process, but have little management support
- Optimized: We have a process and a focus on continuing to improve it (mission-focused)
- Other (please explain)

Business Value Perspective



Present – current operational system

- Created
- Referenced / Modified
- Deleted

Past – data from repository

Future – proactive security

N. Sheikh, Implementing Analytics, Morgan Kaufmann, Boston, MA, 2013

What we won’t cover

Information security basics

- C.I.A. or Kill Chain or CAPEC
- Indicator analysis

Implementation details

- The basics of network flow analysis
- SiLK tool suite command syntax
- Scripting languages

Capability Maturity Models

Building Analytics for Network Flow Records

Analytic Development Process

Process

Explore

Model

Test

Analyze

Refine

Explore

Needs analysis – is there a prior analytic that addresses this?

Research analytic

- vendor documentation
- published papers
- data feeds

Identify unique attributes

- ports
- protocols
- associations
- behaviors

Model

Lessons learned from prior analytics

Build model

- identified behavior
- similar behavior

Program model

- Shell
- Python
- other

Test

Execute programmed model

- monitor progress
- debug

Save test results

- ‘raw’ files
- ‘set’ files
- ‘bag’ files
- other formats

Analyze

Review test results.

Reduce false positives.

Reduce false negatives.

Identify improvements.

Refine

Apply improvements

Update programs

Repeat

Mature the process

Maturing the process

Templates

- Common input / output options
- Documentation content
- Common style (and in-script documentation)
  - Invoking commonly-used tools in conventional way
  - Describing common aspects in conventional way

Test suite

- Data with known content
- Regression tests
- Example output for documentation

Source control with versioning (code and documentation)

Poll on Examples

Which analytic are you most interested in?

- Host characterization: what mix of services per address?
- Backwards: what hosts either send or receive traffic that appears reversed?
- Scanners: what external addresses are mapping our network?
- Profiling Popular Usage: what are our popular services and protocols?
- Profiling Active Talkers: what are the active addresses on our network?
- Profiling Inventory Assets: what assets are using/serving what services?

Building Analytics for Network Flow Records

Example Analytics

Understanding Host Roles

Explore: Characterize hosts that seem to act as email servers

- Of the hosts communicating on TCP port 25 (SMTP), how much non-SMTP traffic does each generate?
- Changes over time? After event?

Model:

- Input:
  - Assume small population of interesting hosts (specified as IP set)
  - Pre-retrieve traffic of interest (as rw file)
- Use rwfilter with rwuniq to pull out SMTP vs non-SMTP flow counts
- Output: Table of behavior per IP address

Test, Analyze, and Refine:

- Include test cases for addresses with known and unknown roles
- Reliability / performance / interpretable results
- How about non-SMTP email activity? (e.g., POP, IMAP)
- How about non-SMTP related to email? (e.g. DNS)

Initial Host Characterization Script

```
#!/bin/bash
rm -f  more-mail-saddr.txt more-nomail-saddr.txt more-nomail.rw
rwfilter in_month.rw --sipset=interest.set --pass=stdout \
      | rwfilter stdin --protocol=6 --aport=25 \
         --fail=more-nomail.rw --pass=stdout \
      | rwuniq --field=sIP --no-titles --ip-format=zero-padded \
         --sort-output --output-path=more-mail-saddr.txt
rwuniq more-nomail.rw --field=sIP --ip-format=zero-padded \
     --no-titles --sort-output --output-path=more-nomail-saddr.txt
echo '              sIP|      mail||  not mail|' \
      ; join more-mail-saddr.txt more-nomail-saddr.txt \
      | sort -t'|' -nrk2,2 \
      | head -n 5
```

Using SiLK for Network Traffic Analysis (Example 3.37)

Identifying Backwards Traffic

Explore: Identify hosts for which sensors record traffic that appears reversed (possible forged addresses).

- Of the hosts sending or receiving TCP traffic, for which do sensors record traffic that is “inbound” but from local hosts, or “outbound” and going to local hosts?
- Changes over time? Related to event?

Model:

- Assume we have hosts of interest, expressed as IP set
- Assume we have date/time range of interest, expressed as parameters
- Use rwfilter to pull traffic into files for later analysis

Test, Analyze, and Refine:

- Test against normal traffic and traffic engineered to be reverse
- Reliability / Interpretable results
- Traffic not completely reversed? Traffic observed in both groups?

Initial Backwards Traffic Script

```
#!/bin/bash
START=2009/4/20T12
END=2009/4/20T13
SENNAME=SEN1
rm -f strange_in.rw strange_out.rw
rwfilter --sensor=$SENNAME --type=in,inweb --start-date=$START \
             --end-date=$END --protocol=6 --bytes-per-packet=65- \
             --sipset=mynetwork.set --flags-all=SAF/SAFR,SAR/SAFR,SAFR/SAFR \
             --packets=4- --pass=strange_in.rw
rwfilter --sensor=$SENNAME --type=out,outweb --start-date=$START \
             --end-date=$END --dipset=mynetwork.set --not-sipset=mynetwork.set\
             --pass=strange_out.rw
exit 0
```

Using SiLK for Network Traffic Analysis (Example 4.22)

Finding Scanners

Explore: Identify external addresses that are mapping our network

- Much existing work in literature (Gates, Jung, etc.)
- Simple approach exploits attacker workflow (minimal advance knowledge)
  - Of quick TCP traffic with relatively few bytes per packet, which have flags that could reflect scanning? Are the sources frequent enough?

Model:

- Assume a date of interest, expressed as parameters
- Use rwfilter to isolate TCP traffic with few bytes per packet, then to split out flag combinations.
- Use rwbag to count sources per bag combinations
- Use rwbagtool to manipulate counts and isolate frequent sources
- Use rwbagtool to produce set of IP addresses for sources

Test, Analyze, and Refine:

- Use test cases with known scans and without known scans
- False positives and false negatives
- Trends over time?

Gates, C. et. al., “Detecting Scans at the ISP level”, http://resources.sei.cmu.edu/library/asset-view.cfm?assetid=8073

Jung, J. et. al., “Fast Portscan Detection Using Sequential Hypothesis Testing”, http://nms.lcs.mit.edu/papers/portscan-oakland04.pdf

Initial Scanner Detection Script

```
#!/bin/bash
rm -f fastfile.rw fast-{low,high}.{set,bag} scan.set
rwfilter --start=2009/04/20 --sensor=S0 --type=in,inweb --bytes-per=40-65 \
   --protocol=6 --duration=0-1199 --pass=fastfile.rw
rwfilter fastfile.rw --flags-all=S/SRF --packets=1-3 --pass=stdout \
      | rwbag --sip-flows=fast-low.bag
rwfilter fastfile.rw --flags-all=SAF/SARF,SR/SRF --pass=stdout \
      | rwbag --sip-flows=fast-high.bag
rwbagtool fast-high.bag --maxcounter=10 --coverset --output-path=fast-high.set
rwbagtool fast-low.bag --mincounter=10 --coverset --output-path=fast-low.set
rwsettool --difference fast-low.set fast-high.set --output-path=scan.set
exit 0
```

Using SiLK for Network Traffic Analysis (Example 4.33)

Profiling Top Five Services and Protocols

Explore: Characterize traffic on our network by protocols and services

- What protocols are being used? What services are we requesting? What services are we providing?
- Changes over time? Anomalies?

Model:

- Input:
  - Pre-retrieve traffic for some time period, typically a full days worth.
- Use rwfilter with rwstats to generate top 5 statistics
- Output: Multiple tables containing summarizations of traffic

Test, Analyze, and Refine:

- Include test cases for how to handle large sets of data
- Reliability / **performance** / interpretable results
- Would a list of top 10's provide more value for the performance hit?
- Is generating a table of all protocols and services then filtering text, rather than SiLK binary, feasible?
- Inbound vs. Outbound traffic?

Profiling Top Five Services and Protocols Script

```
#!/bin/bash
echo Initial dataset:
rwfilter --type=out,outweb --start-date=2011/09/28:00 \
   --end-date=2011/09/28:23 --protocol=0- --pass=sample.rw
echo -e “\nTop protocols:”
rwstats sample.rw --fields=protocol --count=5
echo -e “\nTop services being requested:”
rwstats sample.rw --count=5 --fields=dport
echo -e “\nTop services being provided:”
rwstats sample.rw --count=5 --fields=sport
```

Network Profiling Using Flow(Section 3 Script)

Profiling Active Addresses

Explore: Identify addresses that have actively talked during a given time period

- How many active addresses are using TCP? What about other protocols? Are there addresses that are merely passing through our network (transiting)
- Awareness of network address topology. Changes over time? Anomalies?

Model:

- Input:
  - Pre-retrieve traffic for some time period, typically a full days worth.
- Use rwfilter with rwset tools to generate and understand address lists
- Output: Multiple tables containing summarizations of active addresses, Multiple set files

Test, Analyze, and Refine:

- Include test cases for how to handle large sets of data
- Reliability / **performance** / interpretable results
- What about separating out UDP and ICMP from other IP protocols?
- What about traffic heading into the network from an internal host?

Profiling Active Addresses Script

```
#!/bin/bash
echo Number of TCP talkers:
rwfilter sample.rw --type=out,outweb  --protocol=6 --packets=4- --ack-flag=1 \
    --pass=stdout | rwset --sip-file=tcp_talkers.set
rwsetcat tcp_talkers.set --count
echo -e “\nNumber of talkers on other protocols:"
rwfilter sample.rw --type=out --protocol=0-5,7- --pass=stdout \
| rwset --sip-file=other_talkers.set
rwsetcat other_talkers.set --count
rwsettool --union tcp_talkers.set other_talkers.set --output-path=talkers.set
rwsetcat talkers.set --network-structure
echo -e “\n\nClass C network blocks:"
rwsetcat talkers.set --network-structure=C
echo -e "Transit traffic:"
rwfilter sample.rw  --type=out,outweb  --not-sipset=talkers.set --pass=stdout \
| rwtotal --sip-first-8 --summation --skip-zeroes  --no-titles | cut -f 2 -d “|”
rwfilter sample.rw  --type=out,outweb  --dipset=talkers.set --pass=stdout \
| rwtotal --sip-first-8 --summation --skip-zeroes --no-titles | cut -f 2 -d “|”
```

Network Profiling Using Flow(Section 4 Script)

Profiling Assets by Service

Explore: Identify assets in our network by popular services

- What assets are running web servers? DNS Servers? Telnet servers? What assets are telnet clients?
- Changes over time? Policy Violations?

Model:

- Input:
  - Pre-retrieve traffic for some time period, typically a full days worth.
- Use rwfilter, rwstats, rwuniq, and rwset tools to generate asset lists and statistics
- Output: Multiple tables containing summarizations of traffic, Multiple set files

Test, Analyze, and Refine:

- Include test cases for how to handle large sets of data
- Reliability / **performance** / interpretable results
- What additional services are of interest?
- Do we have to limit our output in some manner? (e.g.: > 1% of packets)

Profiling Assets by Service Script

Network Profiling Using Flow(Section 5 Script)

Furthering Your SiLK Analysis Skills

SiLK tools site

- http://tools.netsa.cert.org

Using SiLK for Network Traffic Analysis

- http://tools.netsa.cert.org/silk/analysis-handbook.pdf

Tool Tips

- https://tools.netsa.cert.org/confluence/display/tt/Tooltips

Flow analysis research and advanced techniques

- http://www.cert.org/netsa

FloCon (January 2017, San Diego CA)

- http://www.cert.org/flocon