SECURITY MONITORING OF HTTP TRAFFIC USING EXTENDED FLOWS

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Introduction

- HTTP is the new IP and we want keep an eye on it.
- Large-scale monitoring of HTTP traffic was problematic:
  - Traditional flow-based monitoring processes only L3/L4 headers.
  - DPI is not scalable for large and high-speed networks.
- Extended flows combine the benefits of both methods.
- Can we use large-scale HTTP monitoring for security purposes?
- What types of incidents can we detect using extended flows?
Flow Monitoring

- Passive method of network monitoring.
- Suitable for large-scale and high-speed networks.
- Only the L3/L4 headers are processed.
- Aggregation of network traffic to flows.
- Network flow is a series of packets sharing 5-tuple of elements:
  - L3 protocol, source IP, destination IP, source port, destination port.
Flow Monitoring

HTTP Request
FROM 172.16.96.48:15094
TO 209.85.135.147:80

HTTP Response
FROM 209.85.135.147:80
TO 172.16.96.48:15094

SRC and DST IP addr
SRC and DST port
Protocol number

Lifetime
Number of packets
Sum of bytes
TCP flags

Others

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Extended Flow Monitoring

- Extension of traditional flow monitoring.
- Modules parse additional information from packets.
- Additional data are stored along the network flow.
- Modules are optimized to parse specific protocol/data.
- Overhead is acceptable, even for monitoring 10 Gbps links.
Research Questions

**Question I.**
What classes of HTTP traffic relevant to security can be observed at network level and what is their impact on attack detection?

**Question II.**
What is the added value of extended flow compared to traditional flow monitoring from a security point of view?
Measurement Tools and Environment

- FlowMon probes deployed in campus network of Masaryk University (/16).
- 10 Gbps links, 40,000 users, and 15,000 active IPs per day.
- NetFlow and IPFIX export protocols.
- Extension modules for parsing HTTP headers.
- Over 10 G network flows containing over 1 G HTTP requests were processed.
Data Elements

- Key flow elements:
  - L3Proto, srcIP, dstIP, L4Proto, srcPort, dstPort.
- Additional elements:
  - timeStart, timeEnd, packets, octets, TCPflags, ToS, srcAS, dstAS.
- HTTP elements:
  - hostname, path, userAgent, requestMethod, referrer.
  - responseCode, contentType.
Results

Traffic of interest was found in the three classes:

I. Repeated request on a single host.
II. Similar requests on many hosts.
III. Multiple varying requests on multiple hosts.
## Class I: Repeated Requests

<table>
<thead>
<tr>
<th>Guest</th>
<th>Host</th>
<th>HTTP Path</th>
<th>#Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>H1</td>
<td>/wp-login.php</td>
<td>46,031</td>
</tr>
<tr>
<td>G2</td>
<td>H2</td>
<td>/administrator/index.php</td>
<td>27,965</td>
</tr>
<tr>
<td>G3</td>
<td>H2</td>
<td>/administrator/index.php</td>
<td>27,798</td>
</tr>
<tr>
<td>G4</td>
<td>H3</td>
<td>/wp-login.php</td>
<td>25,316</td>
</tr>
<tr>
<td>G5</td>
<td>H4</td>
<td>/pub/linux/slax/Slax-7.x/7.0.8/slax-Chinese-Simplified-7.0.8-i486.iso</td>
<td>5,921</td>
</tr>
<tr>
<td>G6</td>
<td>H5</td>
<td>/proxy/libproxy.pac</td>
<td>5,036</td>
</tr>
<tr>
<td>G7</td>
<td>H6</td>
<td>/node/</td>
<td>4,286</td>
</tr>
<tr>
<td>G8</td>
<td>H4</td>
<td>/pub/linux/slax/Slax-7.x/7.0.8/slax-English-US-7.0.8-i486.zip</td>
<td>4,170</td>
</tr>
<tr>
<td>G9</td>
<td>H7</td>
<td>/wp-login.php</td>
<td>3,632</td>
</tr>
<tr>
<td>G10</td>
<td>H7</td>
<td>/polit/wp-login.php</td>
<td>3,632</td>
</tr>
</tbody>
</table>
Brute-forcing and proxy servers

Two interesting subclasses were identified:

- Brute-force password attacks.
- Clients connecting to proxy servers.

Both subclasses can be recognized by repeating patterns in URLs.

<table>
<thead>
<tr>
<th>Subclass</th>
<th>Path regular expression</th>
<th>Portion [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proxy</strong></td>
<td>*.libproxy.pac</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td>*.sviproxy.pac</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>*.proxy.php</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td><strong>49.4</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Brute-force</strong></td>
<td><em>.admin.</em></td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td><em>.login.</em></td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td><strong>10.6</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>*</td>
<td><strong>40.0</strong></td>
</tr>
</tbody>
</table>
## Class II: Similar requests on many hosts

<table>
<thead>
<tr>
<th>Guest</th>
<th>HTTP Path</th>
<th>#Hosts</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>/myadmin/scripts/setup.php</td>
<td>497</td>
<td>100</td>
</tr>
<tr>
<td>G1</td>
<td>/pma/scripts/setup.php</td>
<td>497</td>
<td>100</td>
</tr>
<tr>
<td>G1</td>
<td>/wootwoot.at.blackhats.romanian.anti-sec:)</td>
<td>497</td>
<td>100</td>
</tr>
<tr>
<td>G1</td>
<td>/phpmyadmin/scripts/setup.php</td>
<td>495</td>
<td>99</td>
</tr>
<tr>
<td>G1</td>
<td>/phpMyAdmin/scripts/setup.php</td>
<td>494</td>
<td>99</td>
</tr>
<tr>
<td>G1</td>
<td>/MyAdmin/scripts/setup.php</td>
<td>491</td>
<td>99</td>
</tr>
<tr>
<td>G2</td>
<td>/manager/html</td>
<td>118</td>
<td>24</td>
</tr>
</tbody>
</table>
HTTP Scanners

- Hosts appearing in Class II.
- HTTP scanner requests the same URL from more hosts.
- Typically preceded by or accompanying TCP SYN scan.
  - Lower number of flows is needed to detect a HTTP scan.
- The adversaries are searching for popular vulnerable resources, e.g., older versions of phpMyAdmin.
- Simultaneous search for more resources is common.
Class III: Varying requests on multiple hosts

<table>
<thead>
<tr>
<th>Guest</th>
<th>Domain Name</th>
<th>#Hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>207.46.13.62</td>
<td>msnbot-207-46-13-62.search.msn.com</td>
<td>7</td>
</tr>
<tr>
<td>137.110.244.137</td>
<td>bnsserver2.sdsc.edu</td>
<td>4</td>
</tr>
<tr>
<td>157.55.39.6</td>
<td>msnbot-157-55-39-156.search.msn.com</td>
<td>4</td>
</tr>
<tr>
<td>37.187.28.19</td>
<td>z3.sentience.com</td>
<td>4</td>
</tr>
<tr>
<td>137.110.244.139</td>
<td>integromedbcrawler.integromedb.org</td>
<td>3</td>
</tr>
<tr>
<td>5.135.154.106</td>
<td>nks02.sentience.com</td>
<td>3</td>
</tr>
<tr>
<td>5.135.154.98</td>
<td>nks03.sentience.com</td>
<td>3</td>
</tr>
<tr>
<td>77.75.73.32</td>
<td>fulltextrobot-77-75-73-32.seznam.cz</td>
<td>3</td>
</tr>
<tr>
<td>77.75.77.17</td>
<td>fulltextrobot-77-75-77-17.seznam.cz</td>
<td>3</td>
</tr>
</tbody>
</table>
Web crawlers

- Web crawlers are mostly legitimate and welcome in the network.
- Two reasons to include them in the analysis:
  - Malicious crawlers, e.g., e-mail harvesters discovering spam recipients.
  - The large number of flows they generate.
- Legitimate crawlers can be identified by reverse DNS records or well-known User-Agent in HTTP field.
- Lack of such data indicates suspicious crawler.
- All detection methods have to deal with false positive alerts.
- Identification of legitimate crawler can reduce number of FPs.
Conclusion

- Extended flows enable large-scale analysis of HTTP traffic.
- Traffic of interest was found in three classes:
  - Repeated requests - brute-force password attack or proxy server.
  - HTTP scanning.
  - Activity of web crawlers.
- Straightforward implementation of detection methods.
  - Lower thresholds are needed, e.g., for HTTP scan detection.
  - Clearer evidence of malicious intent.
- Not limited to aggregation-based methods.
  - Detection of accesses to a phishing website.
  - Communication with suspicious domains.
THANK YOU FOR YOUR ATTENTION!

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