Rethinking Antivirus:
Executable Analysis in the Network Cloud

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August 7, 2007

HOTSEC '07
Limitations of Antivirus

Antivirus is the predominate method of detecting and stopping malicious software

- AV fails to detect modern threats
  - Worst: 54.9% Best: 86.6% Avg: ~76%
- AV host software is complex
  - Maintenance overhead
  - Frequent signature updates
  - Risk of security vulnerabilities
  - Rinbot – Symantec remote exploit

<table>
<thead>
<tr>
<th>Antivirus</th>
<th>Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avast</td>
<td>84.7%</td>
</tr>
<tr>
<td>ClamAV</td>
<td>59.7%</td>
</tr>
<tr>
<td>F-Prot</td>
<td>79.9%</td>
</tr>
<tr>
<td>F-Secure</td>
<td>86.6%</td>
</tr>
<tr>
<td>Kaspersky</td>
<td>85.3%</td>
</tr>
<tr>
<td>McAfee</td>
<td>54.9%</td>
</tr>
<tr>
<td>Symantec</td>
<td>81.9%</td>
</tr>
<tr>
<td>Trend Micro</td>
<td>82.0%</td>
</tr>
</tbody>
</table>

AML dataset of 5066 samples (Sept '06 – May '07)
Attributes of an in-cloud antivirus network service

- Parallel analysis with multiple detection engines
- Simplified host agent software
- Centralized management and network-wide visibility
- Information sharing between detection engines
More is Better

- Multiple detection engines
  - Parallel, scalable analysis
  - Heterogeneous engines
  - Increased detection coverage

- Detection engine classes
  - Antivirus products
  - Behavioral simulators
  - Other detectors
    - Static and dynamic analysis
    - Easily extended for new engines
Keep It Simple Stupid

- Simplified host agent software
  - Eliminate frequent updates
  - Mobile and other resource-constrained devices
  - Reduce vulnerability profile

- Centralized management
  - Network-wide visibility
    - Malicious threats
    - Legitimate executable usage
Sharing is Caring

- Detection engines can share info
  - Correlation enables greater detection coverage
  - Caching mechanisms enable performance enhancements
- Example scenario
  - Malicious executable not detected by antivirus engines
  - Behavioral engine finds behavior identical to a previous executable detected by antivirus
  - Executable flagged as malicious

Share Bear says...  

*Sharing is caring! Stop that malware!*
Implementation: Overview

Executable Analysis as a Network Service

Network service component

Host agent component

notepad.exe: OK
outlook.exe: OK
mobile.exe: OK

BAD
Don't Execute

worm.exe
Implementation: Overview

- The *host agent* detects a new *executable* on host
- The *host agent* blocks access to the *executable*
- *Executable* checked against local black/white lists
- The *host agent* sends hash of the *executable* to the *network service*
- The *network service* checks the hash against its black/white lists
- The *host agent* sends the *executable* to the *network service* for analysis
- The *network service* analyzes the *executable* and sends a threat report back to the *host agent*
Implementation: Host Agent

- Win32 Implementation
  - Local black/white list cache
  - File system notifications
  - CreateProcess API hooking

- Disconnected operation
  - Mobile, DoS, outage
  - Policy decision
    - Fail-over local AV
Implementation: Network Service

- In-cloud network service
  - Virtualized detection engines
    - VMware-based containers
    - Scalability and security
  - Remote black/white list caching
  - Multiple engines running in cluster
    - Antivirus products
    - Behavioral engines
      - Norman Sandbox Analyzer
      - VMware/VTrace Profiler
    - Extensible to new engines
## Initial Results: Coverage

<table>
<thead>
<tr>
<th>#</th>
<th>Antivirus Products Run in Parallel</th>
<th>Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F-Secure</td>
<td>86.59%</td>
</tr>
<tr>
<td>2</td>
<td>Trend, Avast</td>
<td>92.93%</td>
</tr>
<tr>
<td>3</td>
<td>Trend, F-Secure, Avast</td>
<td>94.63%</td>
</tr>
<tr>
<td>4</td>
<td>ClamAV, Symantec, Trend, Avast</td>
<td>95.34%</td>
</tr>
<tr>
<td>5</td>
<td>ClamAV, Symantec, Trend, F-Secure, Avast</td>
<td>95.85%</td>
</tr>
<tr>
<td>6</td>
<td>F-Prot, ClamAV, Symantec, Trend, F-Secure, Avast</td>
<td>96.15%</td>
</tr>
<tr>
<td>7</td>
<td>Mcafee, F-Prot, ClamAV, Symantec, Trend, Kaspersky, Avast</td>
<td>96.23%</td>
</tr>
<tr>
<td>8</td>
<td>Mcafee, F-Prot, ClamAV, Symantec, Trend, F-Secure, Kaspersky, Avast</td>
<td>96.23%</td>
</tr>
</tbody>
</table>

- Multiple AV engines detect 4875 of 5066, 191 undetected
- Correlation with behavioral analysis
  - 92 of 191 have identical behavior to known malicious samples

Total detection coverage of over 98%
Initial Results: Performance

- Local Network Assumptions
  - Low-latency (<100ms)
  - High-speed (>=100Mbps)
- Analysis times of legitimate and malicious samples:

<table>
<thead>
<tr>
<th></th>
<th>Legitimate Dataset</th>
<th>Malicious Dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executables</td>
<td>472</td>
<td>5066</td>
</tr>
<tr>
<td>Avg Size</td>
<td>183 KB</td>
<td>366 KB</td>
</tr>
<tr>
<td>Avg AV Time</td>
<td>0.05s</td>
<td>0.48s</td>
</tr>
<tr>
<td>Worst AV Avg</td>
<td>0.14s</td>
<td>0.91s</td>
</tr>
</tbody>
</table>

Reasonable analysis times (<1 second)
Initial Results: Caching

- Are black/white list caches an effective optimization to eliminate redundant analysis?

- Dataset from mwcollect Alliance
  - /18 network, 2 month period
  - 213 distinct executables
    - seen over 2.5 million times
    - 49 seen once, 164 seen multiple

Preliminary results indicate effective hit rates
Wrap-up

• Initial prototype feasibility
  • Coverage: increased!
    • Over 98% in dataset
  • Performance: acceptable!
    • Potentially increased perf w/caching
  • Deployability: positive!
    • Better management/visibility

• Future developments and evaluation
  • Production-grade implementation
  • University deployment (~1k hosts)

• In-cloud network security service
  • enterprise cloud, organizational networks, upstream ISP
QUESTIONS?