Malware Detection

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Lecture 12

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- Virus detection is undecidable
- Anti-virus (more generally anti-malware) is a great business model
  - Need regular updates
  - Infinite supply of new malware
- Malware can be stealthy
- Malware can be really stealthy
Malware Detection Techniques

Malware Detection Techniques

Misuse Detection
- Signature-based
  - static
  - dynamic
  - hybrid

Behavior-Based Detection
- Anomaly-based
  - static
  - dynamic
  - hybrid

Specification-based
  - static
  - dynamic
  - hybrid

Nwokedi Idika and Aditya Mathur, A Survey of Malware Detection Techniques, Purdue University, Feb 2007.
Signature Limitations

\[ U = \text{set of all malicious behavior} \]
\[ S = \text{set of all known signatures} \]

S needs regular updates

Nwokedi Idika and Aditya Mathur, A Survey of Malware Detection Techniques, Purdue University, Feb 2007.
Anomaly Based

Training Phase

Detection Phase

Infer patterns

Infer specifications
Anomaly Based Limitations

\[ A = \text{set of all behaviors} \]
\[ V = \text{set of all valid behaviors} \]
\[ V_{\text{approx}} = \text{approximation to } V \]

Blue area is false positives
If white area extends outside blue area we have false negatives

Nwokedi Idika and Aditya Mathur, A Survey of Malware Detection Techniques, Purdue University, Feb 2007.
Defeat signature-based detection

- Encrypted malware
- Polymorphic malware
- Metamorphic malware

- Rootkit can misrepresent the existence or content of executable files

Encrypted Malware

- Encrypted Main Body
- Key
- Decryptor

.execute malware

propagate malware

reveals signature

Cleartext Main Body
Polymorphic Malware

encrypted Main Body | Key | Decryptor | execute malware | Cleartext Main Body

encrypted Main Body | Key’ | Obfuscated Decryptor | propagate malware

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Polymorphic Malware

- Encrypted Main Body
- Key
- Decryptor
  - execute malware
  - propagate malware
  - no signature

- Encrypted Main Body
- Key’
- Obfuscated Decryptor

Cleartext Main Body
Polymorphic Malware

execute malware

propagate malware

no signature

Encryptected Main Body Key Decryptor

Cleartext Main Body

Encryptected Main Body Key’ Obfuscated Decryptor

Execute in a sandbox and detect the signature after decryption

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Polymorphic Malware

encrypted main body → key → decryptor → cleartext main body

Execute in a sandbox and detect the signature after decryption

Mutation Engines automate this construction

execute malware

propagate malware

no signature
Metamorphic Malware

Original Main Body

propagate malware

Obfuscated Main Body

execute malware

Original Main Body

propagate malware

Obfuscated Main Body

execute malware

Obfuscated Main Body

execute malware

Obfuscated Main Body

Obfuscated Main Body

no signature
Obfuscation Techniques

- Dead-Code Insertion
- Register Reassignment
- Subroutine Reordering
- Instruction substitution
- Code transposition
- Code Integration
Really Stealthy Malware

- Not visible in source code
- Reappears in binary code due to malware infected compiler
- In theory could reappear in binary code due to other components in binary execution workflow
  - Loader
  - Linker
  - OS
  - BIOS

Malicious Compiler Inserts a Backdoor

OS Login module

Malicious Compiler Binary

Infected Login Binary
Assumption:
Malicious behavior cannot be detected in binary, but may be detectable in compiler source.
Self-Compiler

Compiler source for language L

Compiler binary for language L

Compiler binary for language L
Malicious Self-Compiler in Binary and Source

- Malicious Compiler source for language L
  - Compiler binary for language L
  - Malicious Compiler binary for language L
Malicious Self-Compiler in Binary and Source

Source code analysis will reveal malicious behavior
Doubly Malicious Self-Compiler in Binary and Source

Source code analysis will reveal doubly malicious behavior

- Doubly Malicious Compiler source for language L
- Compiler binary for language L
- Doubly Malicious Compiler binary for language L
Doubly Malicious Compiler Binary Behavior

OS Login module

Doubly Malicious Compiler binary for language L

Infected Login Binary

Compiler source for language L

Doubly Malicious Compiler binary for language L

Doubly Malicious Compiler binary for language L
Doubly Malicious Compiler Binary Behavior

OS Login module

Doubly Malicious Compiler binary for language L

Infected Login Binary

Compiler source for language L

Doubly Malicious Compiler binary for language L

Doubly Malicious Compiler binary for language L

No trace of malicious behavior in source code
Malicious Self-Compiler in Binary but not in Source

Compiler source for language L

Malicious Compiler binary for language L

Malicious Compiler binary for language L

partial countermeasure