Information Security CS 526

Topic 15

Malware Defense & Intrusion Detection

Anti-Virus Software

- Goal: Find malware programs on a system, in transmission, etc.

- Main deployed approach: Signature-based detection
  - Uses pattern matching
  - Searches for known patterns of data belonging to malwares in executable programs or other types of files
  - Maintains and updates a blacklist of signatures
- Problems
  - Cannot detect new malwares, variants of malwares, etc.
  - Hard to keep up with new malware
    - More malwares are created each day than benign programs

Polymorphic Malwares

- Uses a polymorphic engine (a mutation engine or mutating engine) to generate multiple copies of the same malware that look different
  - E.g., serve a different version to each computer subject to a drive-by download attack

- Typically encrypts the majority of the code, each time with a different key is used
- Weakness: decryption code often remains the same, and may be detected and/or used as signatures

Metamorphic Malware

- A malware automatically changes itself each time it propagates
- Each new version has different code, though the same functionality
- Uses techniques that include
  - Adding varying lengths of NOP instructions, permuting use of registers, add useless instructions, use functional equivalent instructions, reorder functions, reorder data structures, etc.

Semantic, or Heuristics Based Malware Detection

- Static approach: Looks for specific code behavior instead of specific strings
- Dynamic approach: Execute the program to identify potentially malicious behavior
- Main limitations
  - Performance overhead
  - Potential of high false positives

Application Whitelisting

- Instead of finding malwares and stop then, list all known good/allowed programs and only run them.
- Typically deployed by enterprise, who can afford to maintain a list of allowed programs

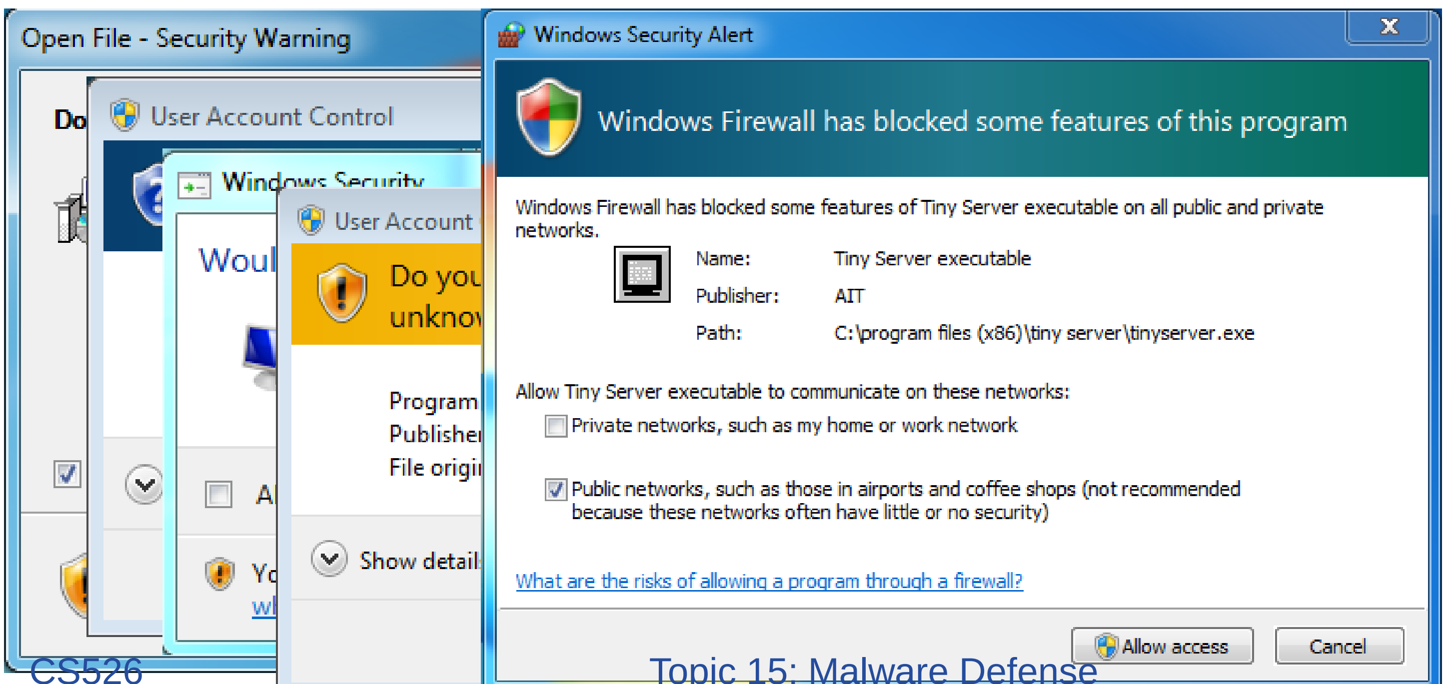
CodeShield: Personalized Application Whitelisting

- Goal: Practical Application Whitelisting on Windows desktops
  - Give the user flexibility
    - Allow the user to add software to the whitelist
  - Maintain the security advantage of whitelisting
    - New software isn't automatically allowed onto whitelist
    - Protect against certain types of Social Engineering attacks
- Not designed to stop all infection
  - Make persistence harder
  - Prevent most current attacks
- Focus on usability
  - A key challenge of many security mechanisms is the ability for a typical user to understand and use it

Christopher S. Gates, Ninghui Li, Jing Chen, Robert Proctor: **CodeShield: towards personalized application whitelisting.** ACSAC 2012

Analysis of Existing Security Interface

- Users are asked questions they do not know how to answer and presented with info that is difficult to understand
- Users are asked to make a decision too often
- Users are made to passively respond and provided an easy and insecure way out



Design Principles

- Reduce – decrease the number of times users are asked to make a decisions
- Simplify – ask questions that a user can understand
- Safe (Fail Safe Defaults) – do not provide an easy and insecure way out.
- Active – avoid passively respond to security prompts

Design of Personalized Whitelisting

Normal Mode	Installation Mode
• Only execute known software • Trusted Signatures = add to whitelist • Trusted Installers = add to whitelist • All else blocked	• Execute all software • Executed = added to whitelist • Written = added to whitelist • Try to exit installation mode quickly

- “Stopping” vs “Warning” approach
- The decision a user needs to make
  - “Do I want to install new software now”

Design Principles in Practice

- Reduce – there is a single security decision to make for installing any application
- Simplify – this paradigm more closely matches how typical users understand their actions. “I’m adding something new”
- Safe (Fail Safe Defaults) – Not allowing new code is the easiest action
- Active – In order to add new software, the user needs to actively participate and initiate the action.

Installation Mode vs Normal Mode

- This dual mode can more closely match the mental model of a typical user.
  – Users may not understand “Do you want to allow this program to make changes”
  – But most can be educated about “Do you want to add something new to your computer right now”

- Furthermore, users can be educated about when not to enter installation mode.

The Burden Benefit of Installation Mode

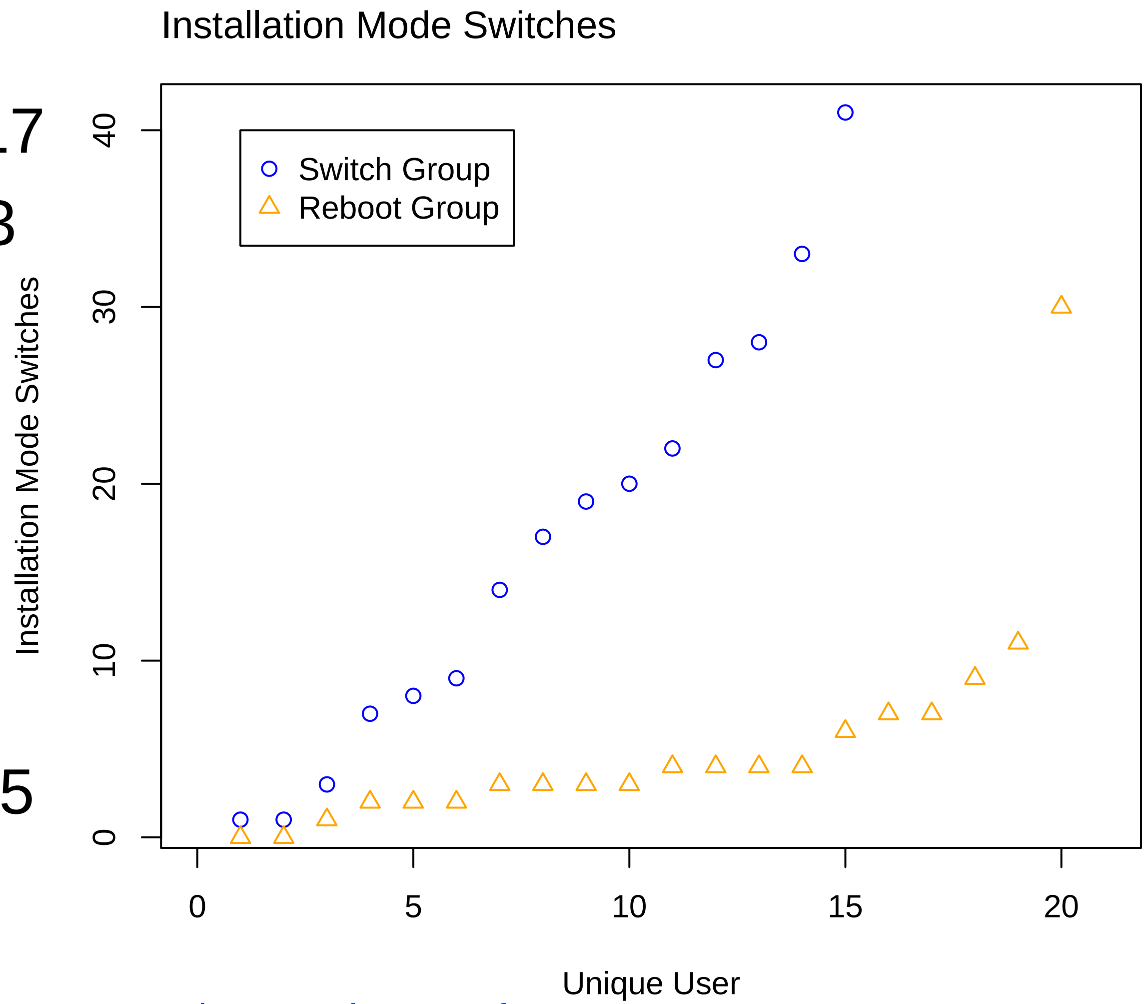
- Simple switch to installation mode
  - Advantage – it's easy
  - Disadvantage – user may enter installation mode often
- High overhead switch to installation mode (ex. reboot)
  - Advantage – it makes a user less likely to switch unless needed
  - Disadvantage – high overhead may lead to annoyance
- Advantage of reboot
  - Clear out memory, malware in memory can't take advantage of installation mode
  - Minimal number of applications active just after reboot

User Study

- 35 person user study running CodeShield for 6 weeks
- Longest use of CodeShield is 203 days (8 switches, 25 days/switch), next is 168 days (13 switches, 13 days/switch).
- Participants sat through a 30 minute training session
- Then installed CodeShield (standalone installer)
- Take a survey, Run for 6 weeks, Take a survey
- Uninstall if they want to
- 7 of 38 participants continued to use CodeShield at least 3 months after study ended.
  - 5 were using reboot only client
  - 2 using switch or reboot

Switches to Installation Mode

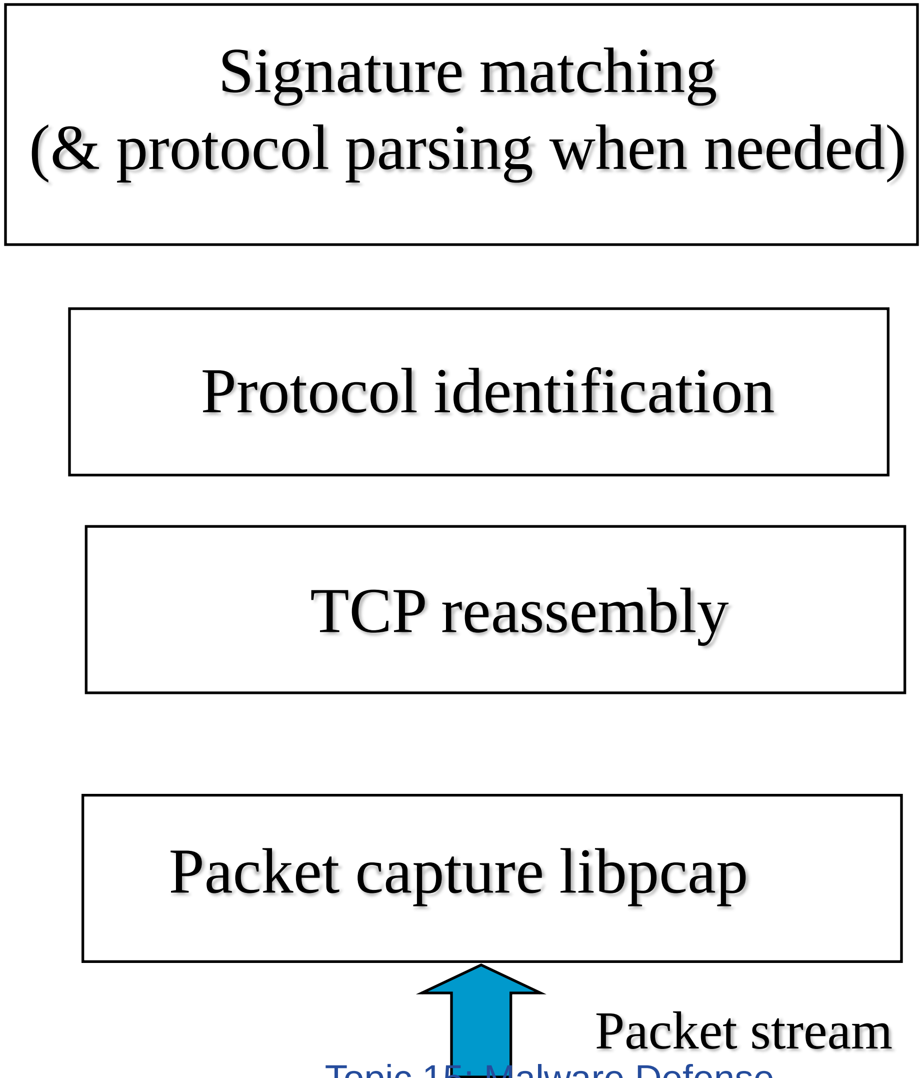
- Switch
  - Median - 17
  - Useful - 13
- Reboot
  - Median - 3.5
  - Useful - 3.5



Network IDSs

- Deploying sensors at strategic locations
  - E.G., Packet sniffing via *tcpdump* at routers
- Inspecting network traffic
  - Watch for violations of protocols and unusual connection patterns
- Monitoring user activities
  - E.g., look into the data portions of the packets for malicious code, or known exploits
- Inspection ability limited by encryption
  - Data portions and some header information can be encrypted
  - The decryption engine may still be there, especially for exploit

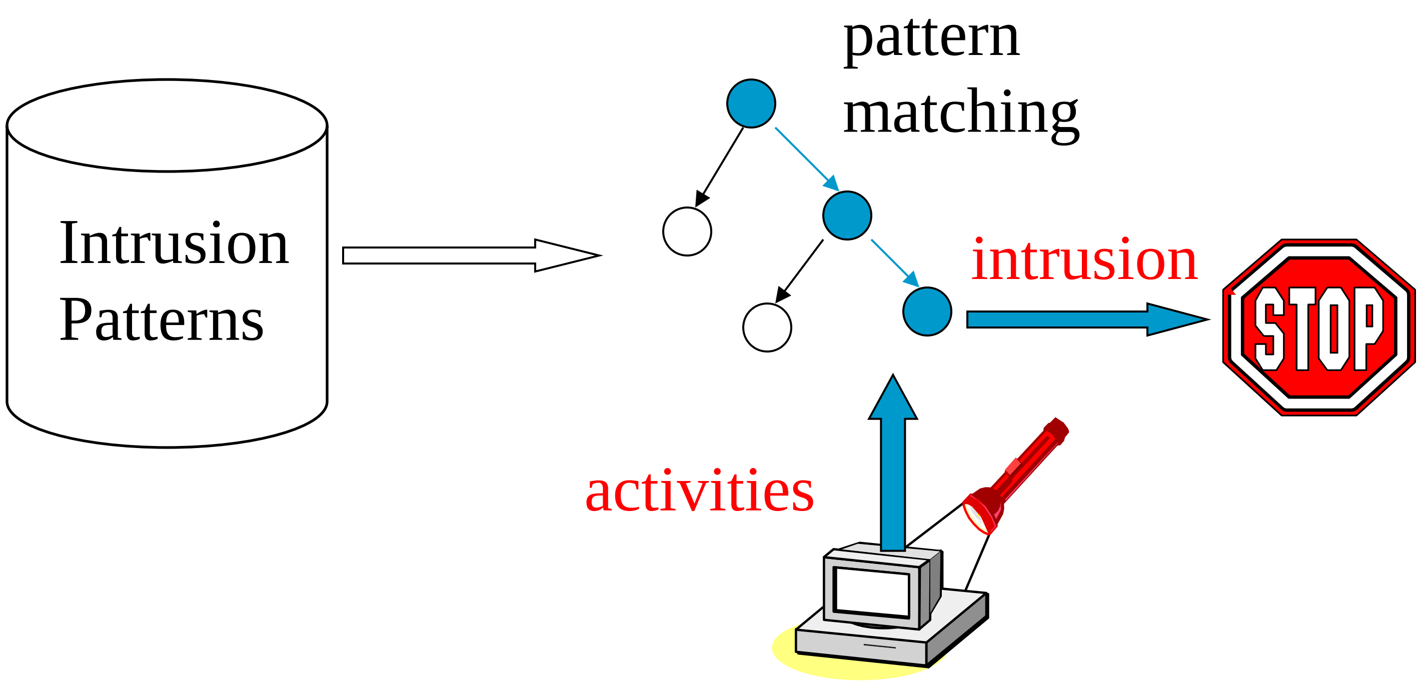
Architecture of Network IDS



Host-Based IDSs

- Running on a single host
- Monitoring
  - Shell commands
  - System call sequences
  - Etc.

Misuse Detection (aka Signature detection)

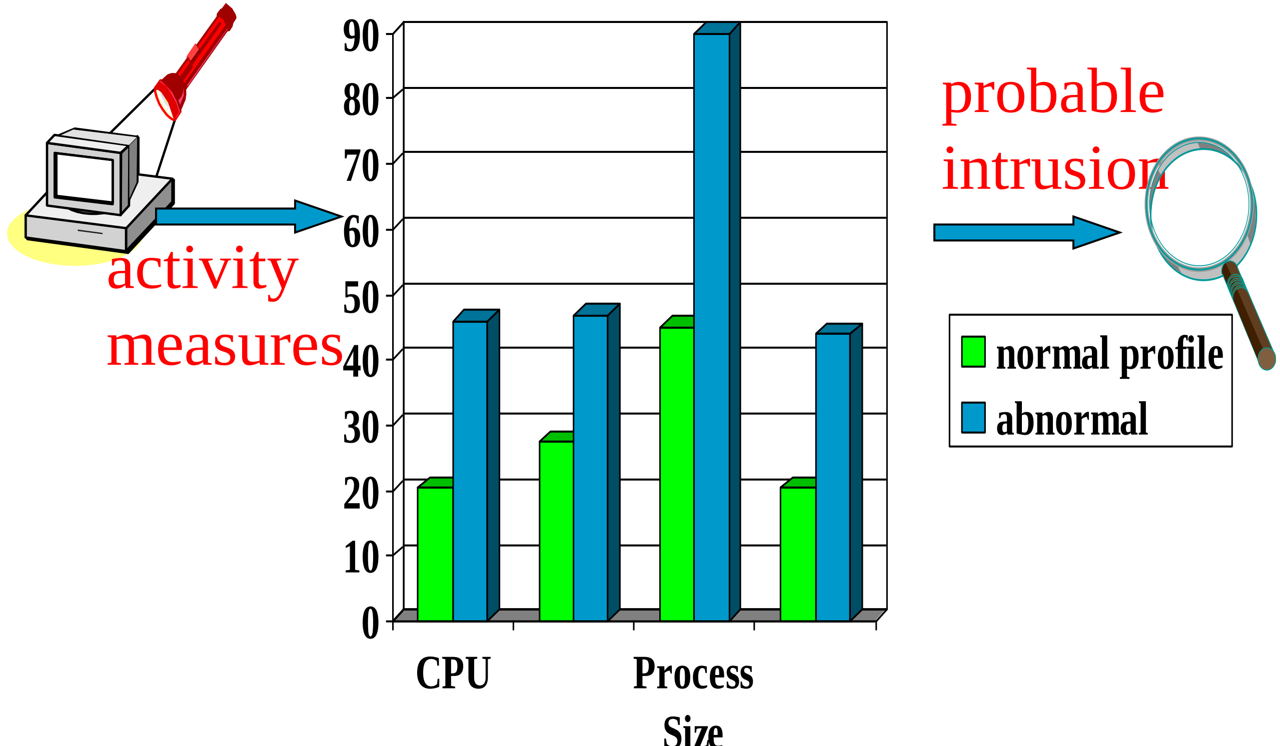


Example: ***if*** (src_ip == dst_ip) ***then*** "land attack"

*This causes some TCP implementation to keep sending ack packet to itself.

Can't detect new attacks

Anomaly Detection



Problem: Relatively high false positive rate

- Anomalies can just be new normal activities.
- Anomalies caused by other element faults
  - E.g., router failure or misconfiguration, P2P misconfiguration

Problems with Current IDSs

- Inaccuracy for exploit based signatures
- Cannot recognize unknown anomalies/intrusions
- Cannot provide quality info for forensics or situational-aware analysis
  - Hard to differentiate malicious events with unintentional anomalies
    - Anomalies can be caused by network element faults, e.g., router misconfiguration, link failures, etc., or application (such as P2P) misconfiguration
  - Cannot tell the situational-aware info: attack scope/target/strategy, attacker (botnet) size, etc.

Key Metrics of IDS/IPS

- Algorithm
  - Alarm: A;
  - Intrusion: I
  - Detection (true alarm) rate: $P(A|I)$
    - False negative rate $P(\neg A|I)$
  - False alarm (aka, false positive) rate: $P(A|\neg I)$
    - True negative rate $P(\neg A|\neg I)$

- See [Slides on "The Base Rate Fallacy and its Implications for the Difficulty of Intrusion Detection"]

Coming Attractions …

- Discretionary Access Control