# Information Security CS 526

## Topic 15

Malware Defense

# Announcements

- Project 2 out on Tuesday (10/22)
- Two Yes/No questions are regraded
  - Check answers in Piazza for specific questions
  - Both answers are considered correct
  - If you lose points on them, submit your midterm
- Distribution of Accumulative Grades (HW1,2,QZ1,2+midterm)
  - > 90% 11; 85% to 90% 11
  - 80% to 85% 7; 70% to 80% 10
  - 60% to 70% 4; 55% to 60% 4
  - Under 55% 4

# Anti-Virus Software

- 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

# 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

- Uses patterns that looks for specific code behavior instead of specific strings

- 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

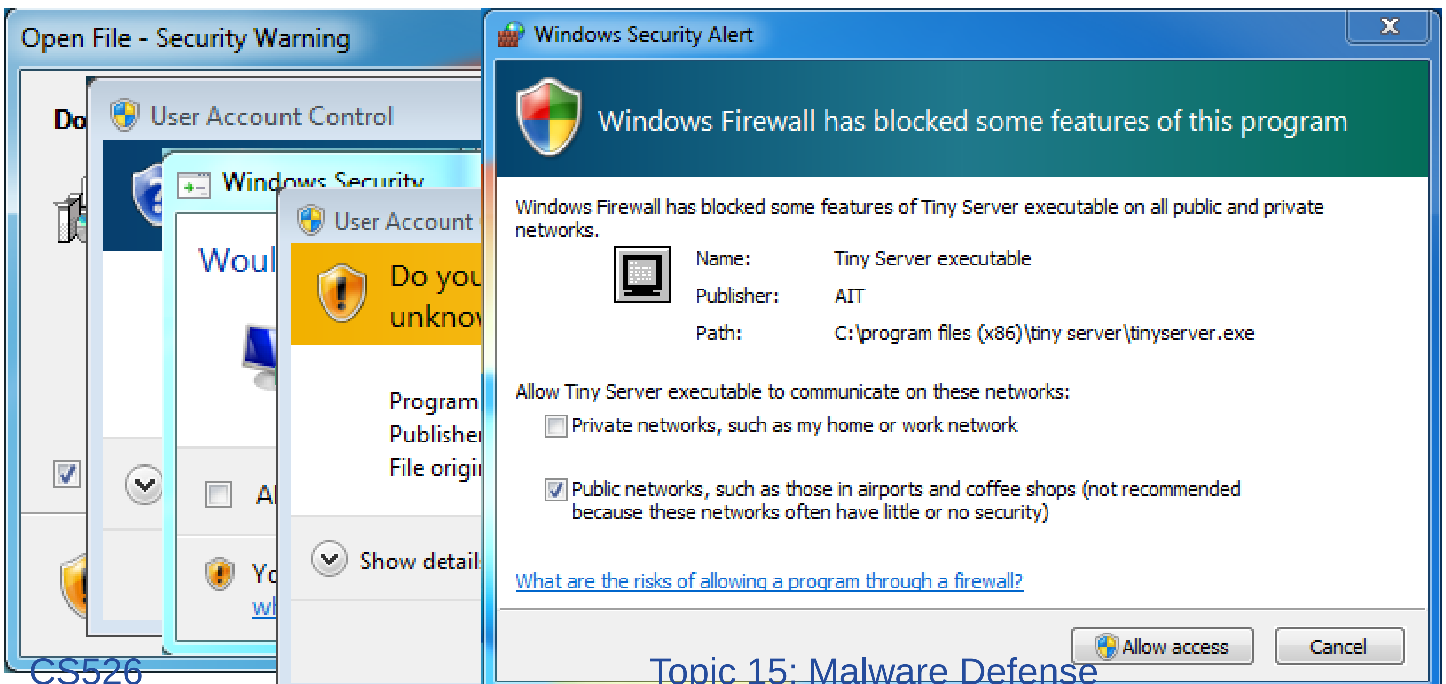
# CodeShield: Personalized Application Whitelisting

- 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 – 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<br>• Trusted Signatures = add to whitelist<br>• Trusted Installers = add to whitelist<br>• All else blocked | • Execute all software<br>• Executed = added to whitelist<br>• Written = added to whitelist<br>• 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 – 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

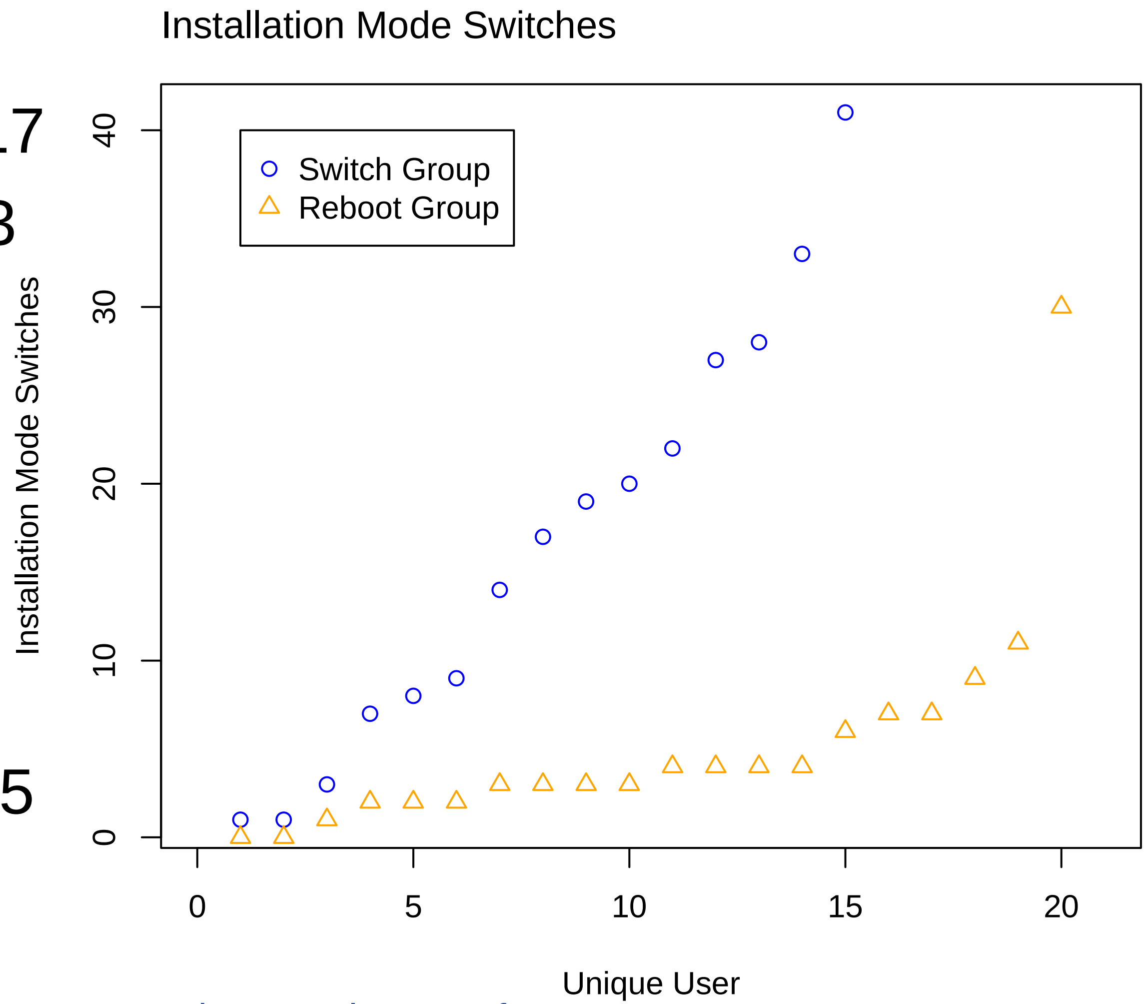
- Simple switch to installation mode
  - Advantage – it's easy
  - Disadvantage – user may enter installation mode often
- High overhead switch to installation mode (ex. reboot)
  - Advantage – it makes a user less likely to switch unless needed
  - Disadvantage – high overhead may lead to annoyance
- 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

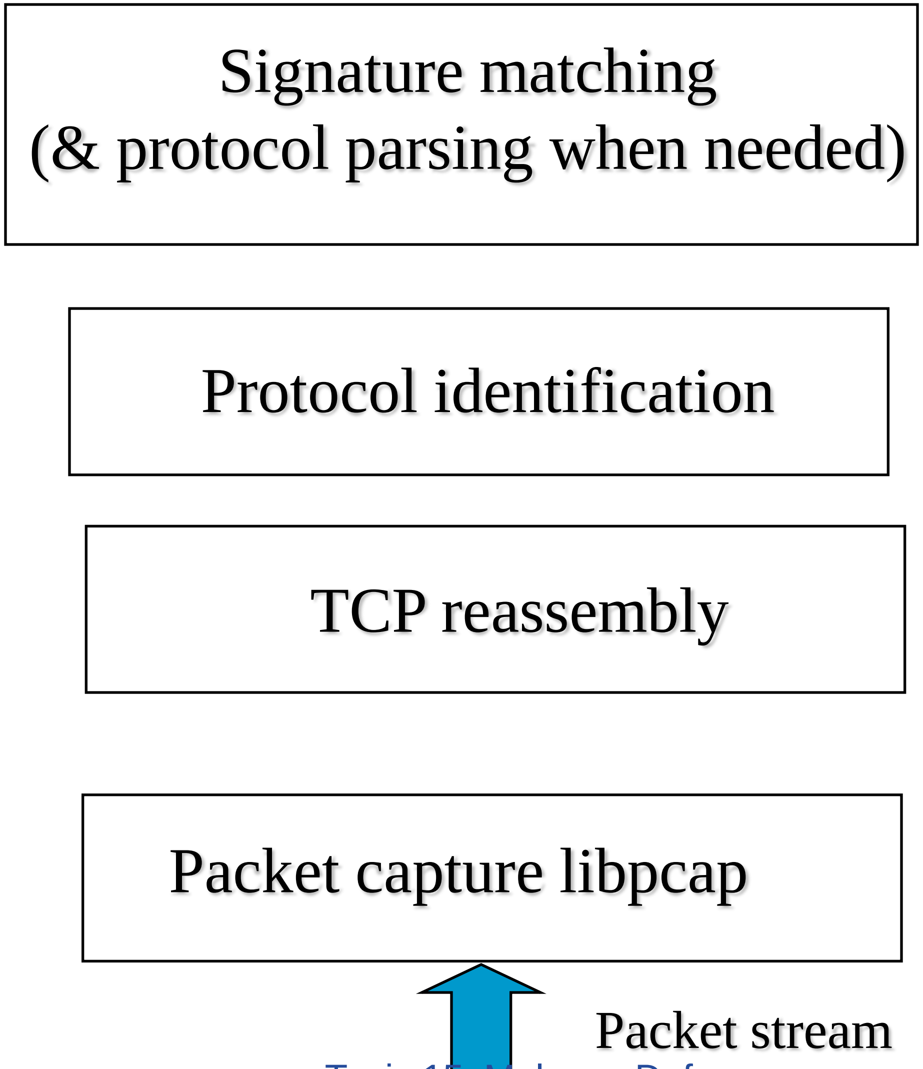
- Switch
  - Median - 17
  - Useful - 13
- Reboot
  - Median - 3.5
  - Useful - 3.5



# 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
  - Look into the data portions of the packets for malicious code
- May be easily defeated by encryption
  - Data portions and some header information can be encrypted
  - The decryption engine may still be there, especially for exploit

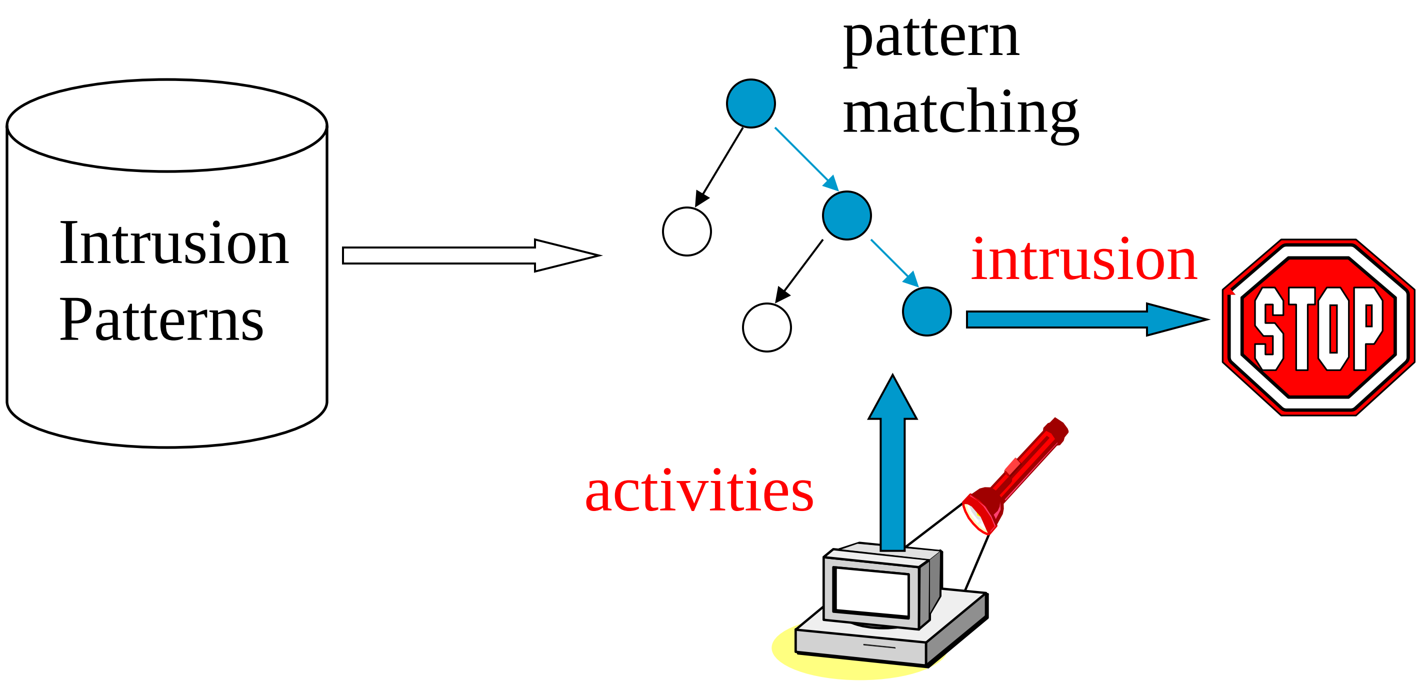
# Architecture of Network IDS



# Host-Based IDSs

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

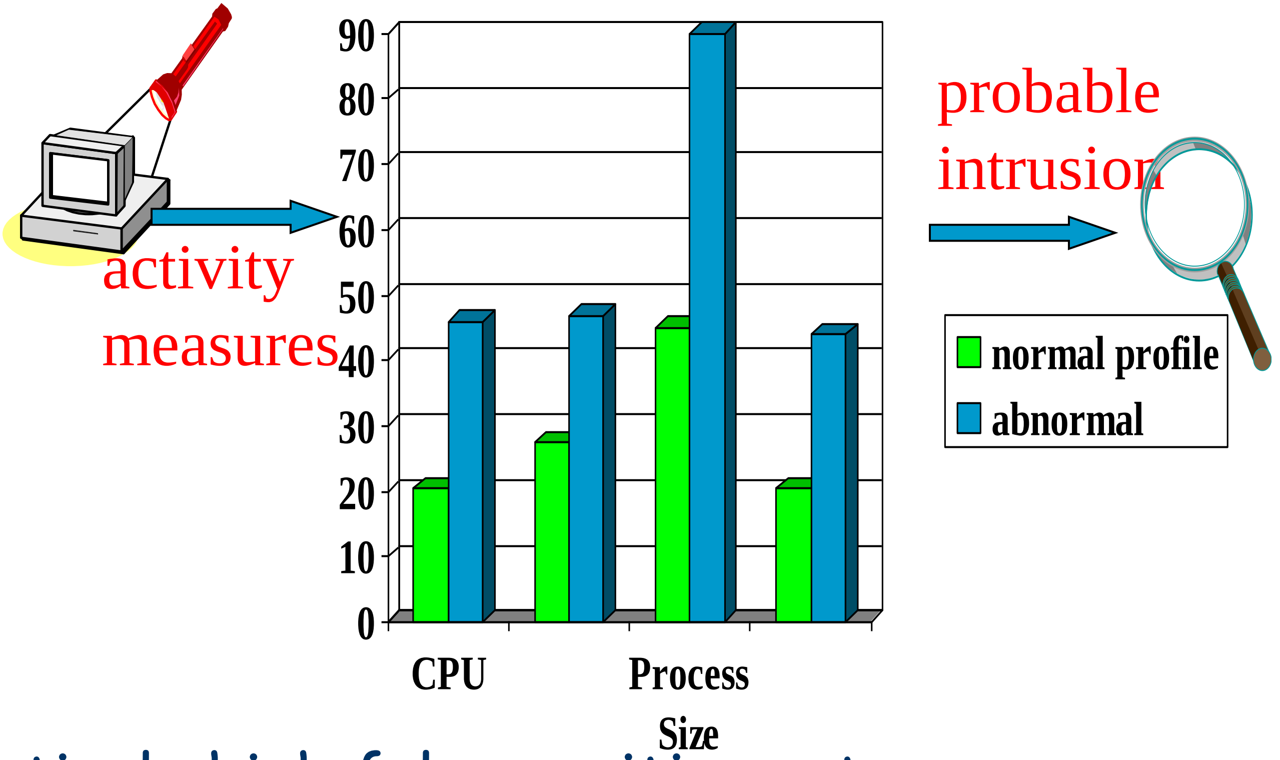
# Misuse Detection (aka Signature detection)




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

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(¬A|I)
  - False alarm (aka, false positive) rate: P(A|¬I)
    - True negative rate P(¬A|¬I)

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

# Coming Attractions …

- Writing Secure Software