North Alabama ISSA Chapter Meeting

Artifact-Driven Malware Analysis: A Digital Forensics Approach

21 April 2026

Agenda

- Introduction
- History
- Digital Artifact Types
  - ✓ Processes
  - ✓ Registry
- Artifact Collection
- Demonstration
- Questions

Introduction

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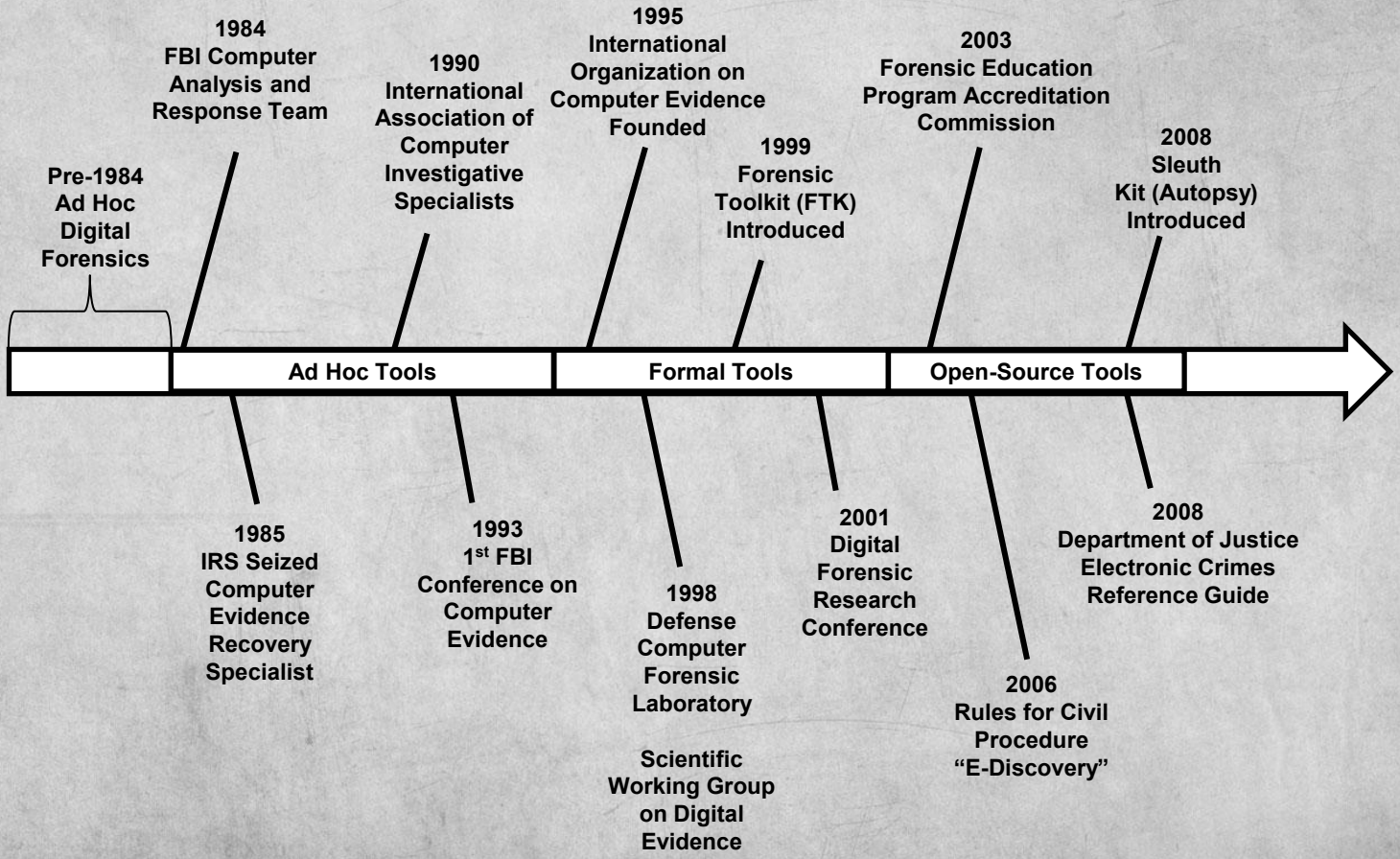
- West Point, 1998, B.S. Electrical Engineering
- U.S. Army, Infantry Officer, 1998 – 2004
- UAH, 2006, M.S. Electrical Engineering
- Auburn University, 2022, M.S. Computer Science and Software Engineering
- Experience
  - ✓ Defensive Cyber Operations
  - ✓ Digital Forensics
  - ✓ Risk Assessment
  - ✓ Cyber Training & Exercises
  - ✓ Advanced Networking
  - ✓ Vulnerability Mitigation
  - ✓ Blockchain

Digital Forensics History

Digital Forensics History



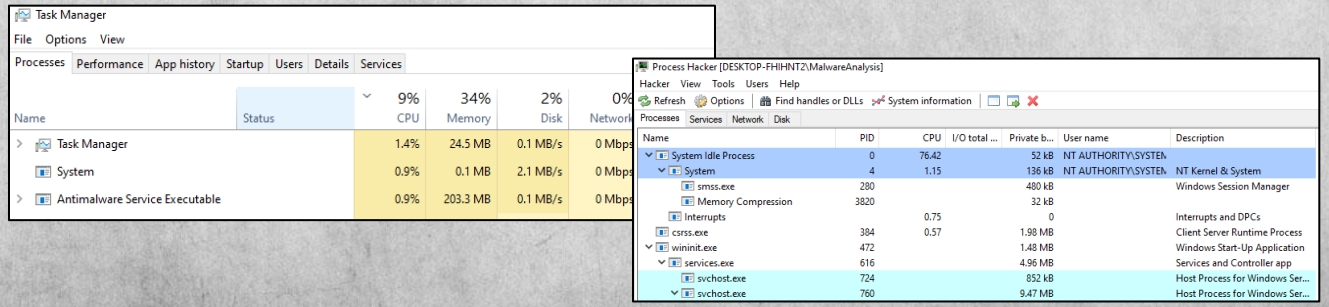
Digital Forensics in Malware Analysis

- Digital forensics underpins malware reverse engineering, enabling analysts to identify, analyze, and interpret malicious activity in controlled environments
- Dynamic analysis executes malware in isolation to reveal behavior & functionality:
  - ✓ Controlled execution and behavioral observation
  - ✓ Process and system activity monitoring
  - ✓ OS-level interaction and code behavior analysis
- Comprehensive monitoring uncovers malware impact and intent, including:
  - ✓ Process activity
  - ✓ Network communications
  - ✓ Registry modifications and persistence mechanisms
  - ✓ File system changes and artifacts
- Understanding normal OS behavior is critical for identifying anomalies and reconstructing malicious activity

Process Definitions

Processes

- A process is an instance of a program currently being executed that contains all program code, data, and system resources needed to run
- Each process has its own memory space, file handles, and system resources and is managed by the operating system, which allocates resources, schedules execution, and provides inter-process communication
- Each process running in memory provide information on system activities and are critical to detecting malware infections
- When spawned, processes provide a wealth of information about their operation including process names and offsets, process IDs, parent process IDs, number of threads and handles, and process start and exit times



Process Definitions

- There are several process related definitions we need to understand before analyzing malware:
  - ✓ Process ID (PID)
    - Unique numerical identifier assigned to each running process by the OS
  - ✓ Parent Process
    - Process that spawns or creates another process
  - ✓ Child Process
    - Process created by a parent process
  - ✓ Process Tree
    - Hierarchical representation of processes showing parent-child relationships

Windows Core Process Summary

Process Name	Parent Process	File Path	Singleton	Account	Start Time
SYSTEM	None	None	Yes	Local System	Boot
smss.exe	SYSTEM	C:\Windows\System32\smss.exe	No	Local System	Boot
wininit.exe	None	C:\Windows\System32\wininit.exe	Yes	Local System	Boot
taskhost.exe	services.exe	C:\Windows\System32\taskhost.exe	No	Many	Varies
lsass.exe	wininit.exe	C:\Windows\System32\lsass.exe	Yes	Local System	Boot
winlogon.exe	None	C:\Windows\System32\winlogon.exe	No	Local System	Varies
iexplore.exe	explorer.exe	C:\Program Files\Internet Explorer\iexplore.exe	No	Local Users	Varies
explorer.exe	userinit.exe	C:\Windows\explorer.exe	No	Local Users	Varies
lsm.exe	wininit.exe	C:\Windows\System32\lsm.exe	Yes	Local System	Boot
svchost.exe	services.exe	C:\Windows\System32\svchost.exe	No	Local System Network Service Local Service	Boot
services.exe	wininit.exe	C:\Windows\System32\services.exe	Yes	Local System	Boot
csrss.exe	None	C:\Windows\System32\csrss.exe	No	Local System	Boot

Malware Process Attacks

Process Attack Definitions

- Process Injection
  - ✓ Malware injects its code into legitimate processes to conceal its presence and bypass security measures
  - ✓ An example is where malware injects into running processes like explorer.exe or svchost.exe
- Process Hollowing
  - ✓ Malware creates a new process in a suspended state and replaces its legitimate code with its malicious payload
  - ✓ Upon process startup the malware runs while appearing as a legitimate process
- Process Privilege Escalation
  - ✓ Malware elevates privileges to manipulate processes and attempts to exploits vulnerabilities, weak configurations, or misconfigured access control

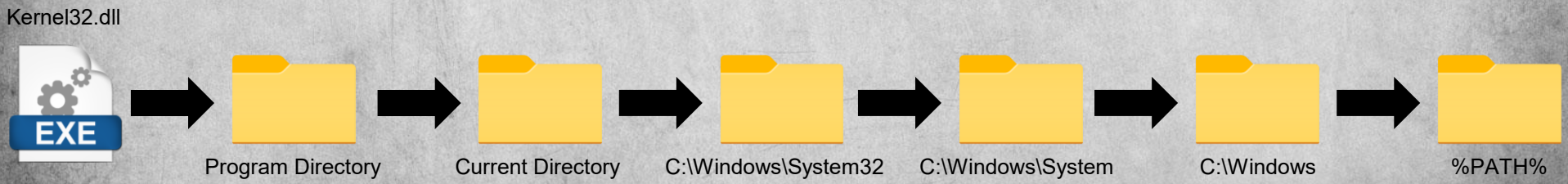
Process Attack Definitions

- Process Termination
  - ✓ Malware terminates critical processes to disrupt system operation and disable security features
- Process Hooking
  - ✓ Malware hooks into system APIs or process functions to intercept and modify their behavior
  - ✓ Successful process hooking results in data manipulation, network traffic interception, and privilege escalation
- Anti-Analysis Techniques
  - ✓ Malware evades analysis and detection by active circumvention of analysis tools, virtual environments, and sandboxes

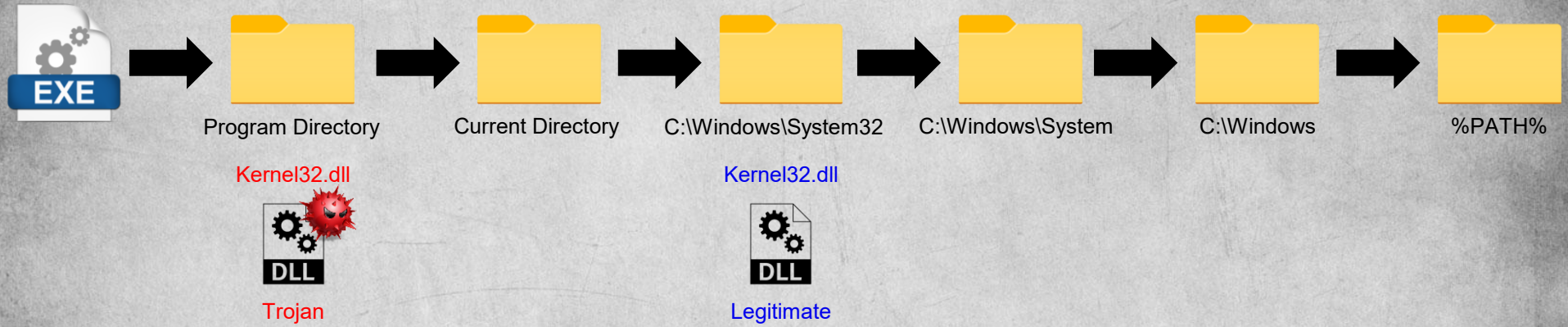
DLL Search Order

DLL Search Order

- Windows executables will work only if supporting DLL's are available
- When an application requires a DLL to fulfill a function or utilize a specific feature, it follows a predefined search order to locate the required DLL file
- If the application finds a DLL with the same name in multiple directories during the search process, it uses the DLL that is found in the directory with the highest priority according to the search order

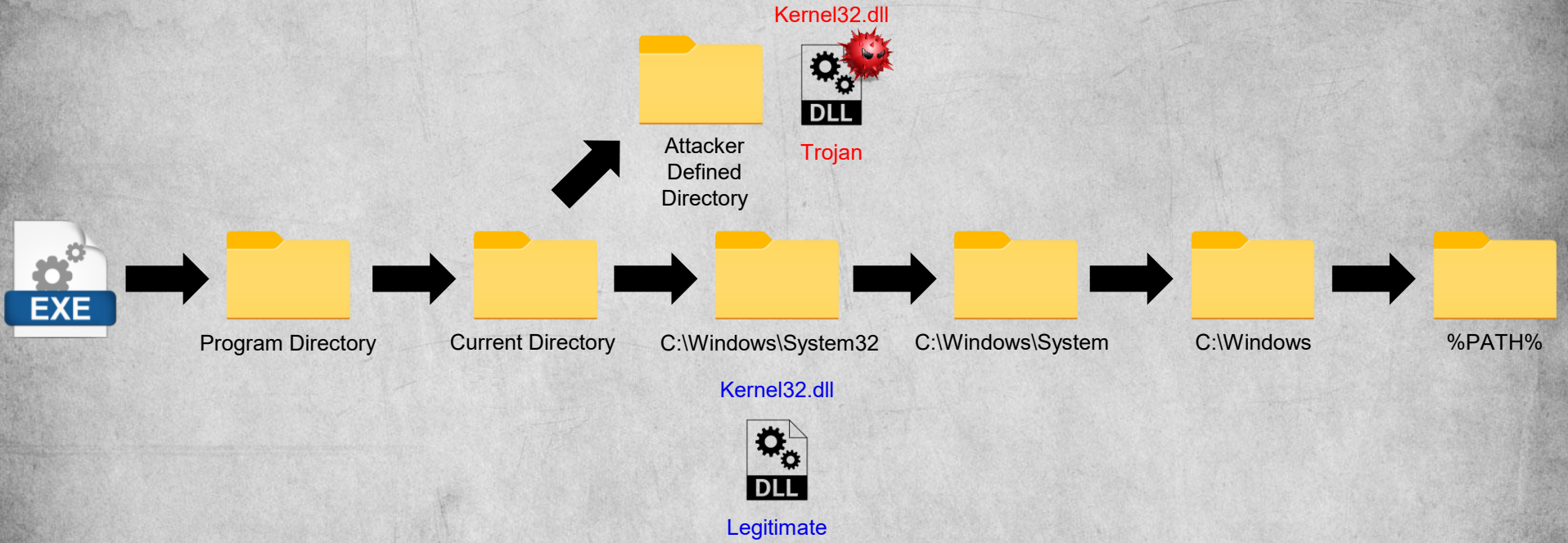


Insecure DLL Loading



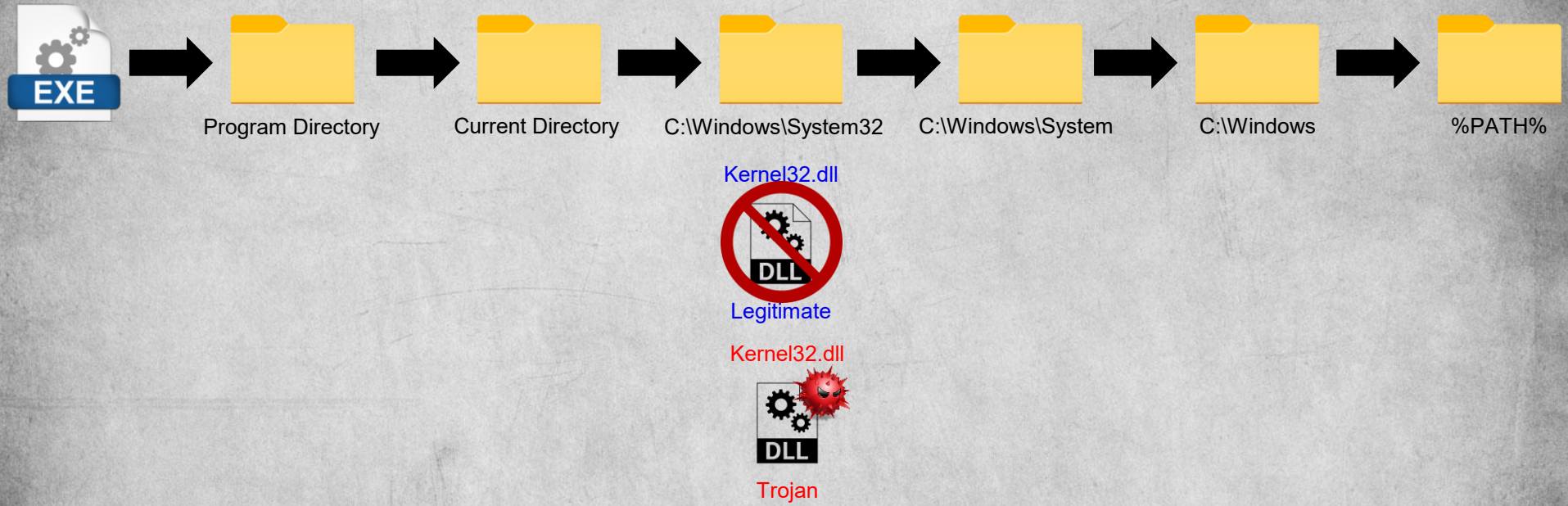
- Assume an executable needs Kernel32.dll to execute its functionality correctly
- In this scenario, the malware author plants a malicious DLL with the same name as a legitimate DLL and places it in a directory that the operating system searches before the legitimate DLL location

DLL Search Path Manipulation



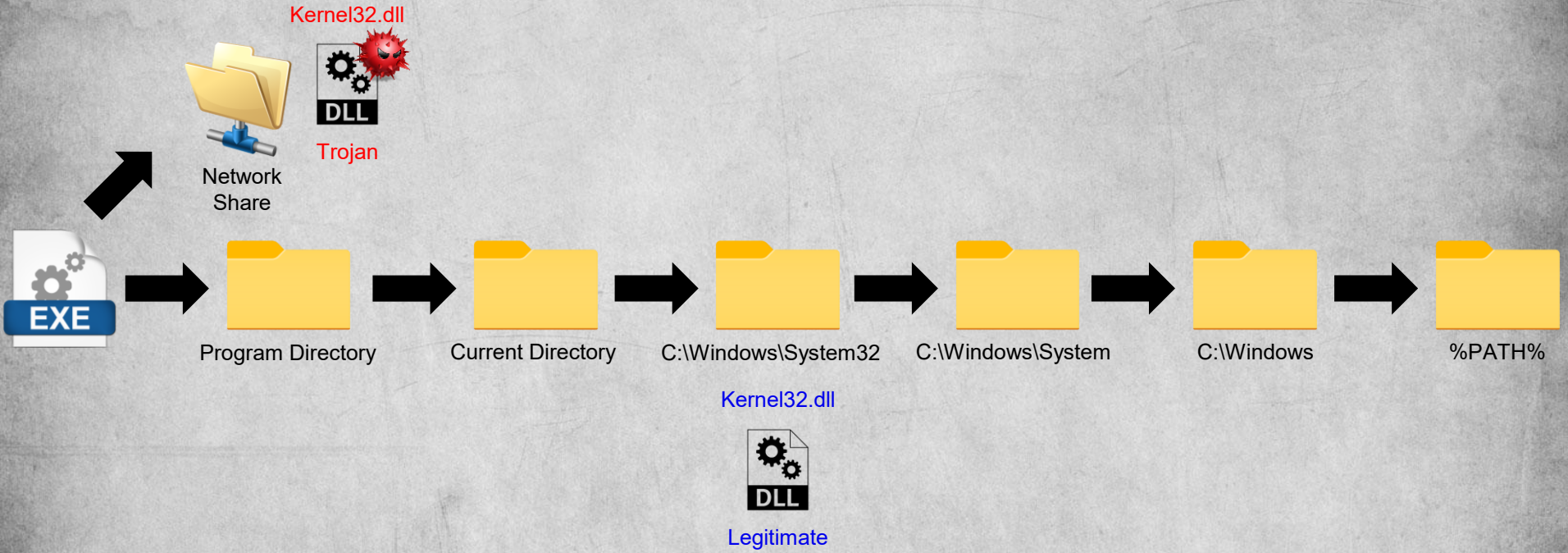
- In this scenario, the malware author manipulates the search path by altering environment variables which forces an application to load a malicious DLL from a directory under the attacker's control

Weak File Permissions



- In this scenario, the malware author finds weak file permissions and replaces a legitimate DLL with a malicious DLL in a directory that the application searches during DLL loading

DLL Side Loading



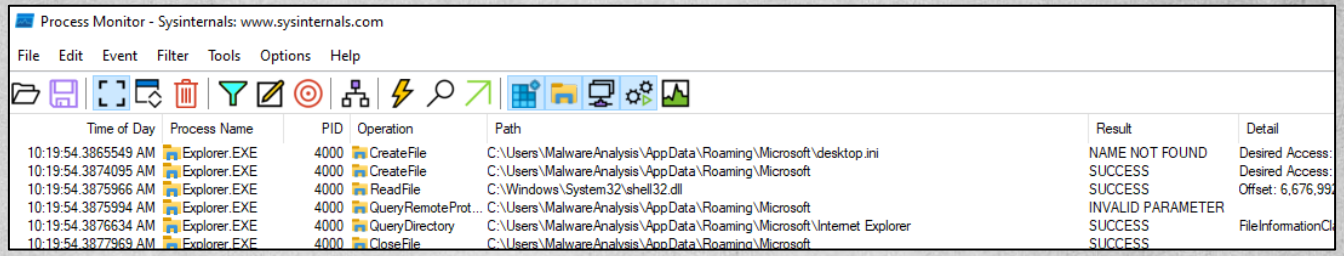
- In this scenario, the malware author uses external locations such as network shares or removable storage to make applications load external DLL's

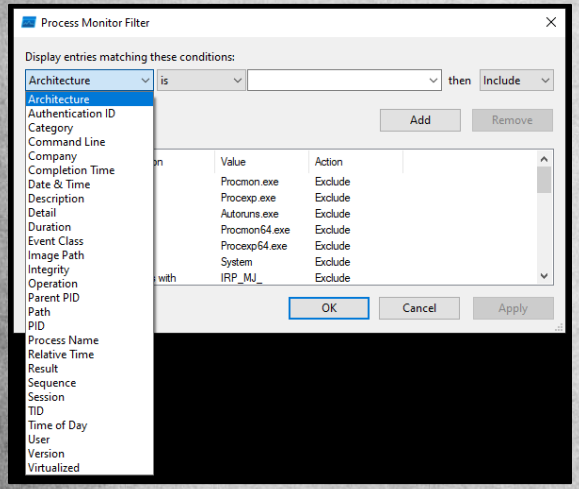
Process Artifacts

Process Monitor

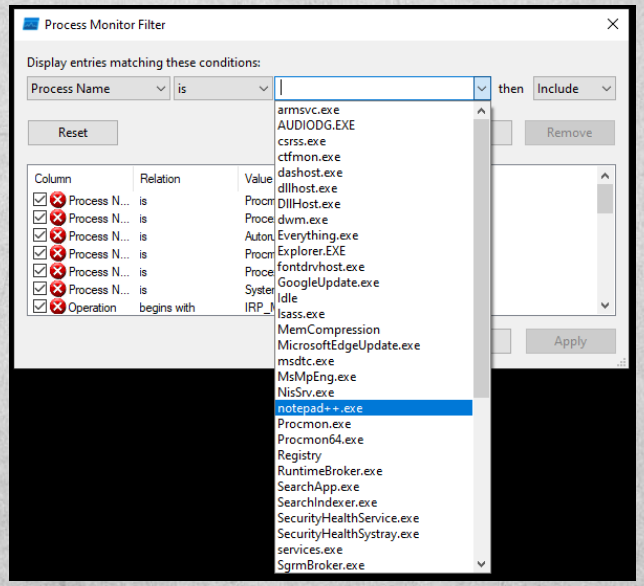
- Defined by Microsoft as “an advanced monitoring tool for Windows that shows real-time file system, registry, process, and thread activity”
- Combines functionality of two legacy Sysinternals utilities, Filemon and Regmon, and extends them by including:
  - ✓ Rich and non-destructive filtering
  - ✓ Comprehensive event properties including:
    - Session IDs
    - Usernames
    - Processes
    - Full thread stacks
    - Simultaneous logging to a file

Process Monitor Walkthrough

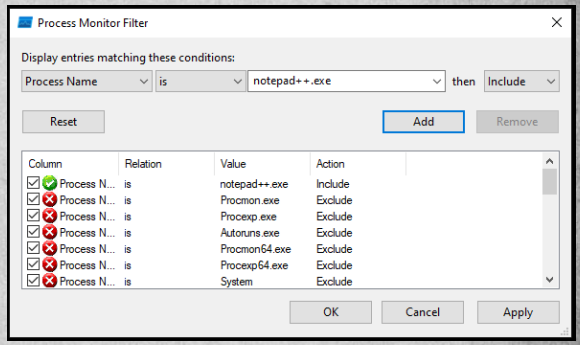




Select a Filter Type



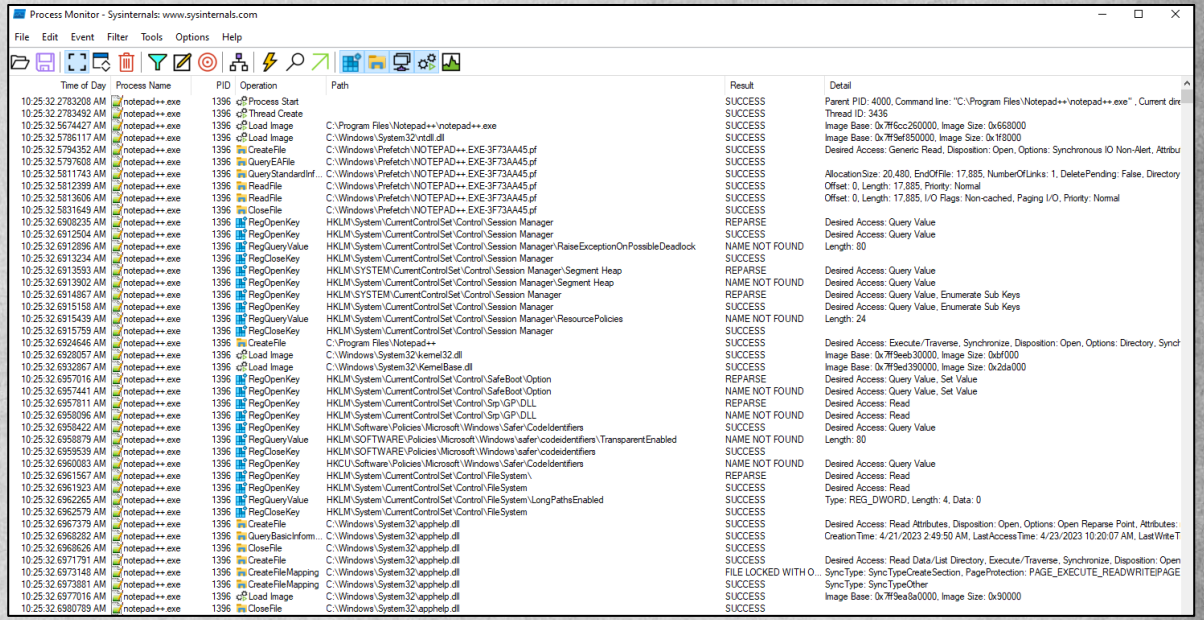
Select Filter Criteria



Add the Filter

Process Monitor Filtering

- Once filtered, we will be able to see every activity that occurred during the startup and execution of the process
- Note the different operations
  - ✓ Process Start
  - ✓ Thread Create
  - ✓ Load Image
  - ✓ RegOpenKey
  - ✓ RegQueryValue
  - ✓ RegCloseKey
  - ✓ File Creation
  - ✓ QueryBasicInformation



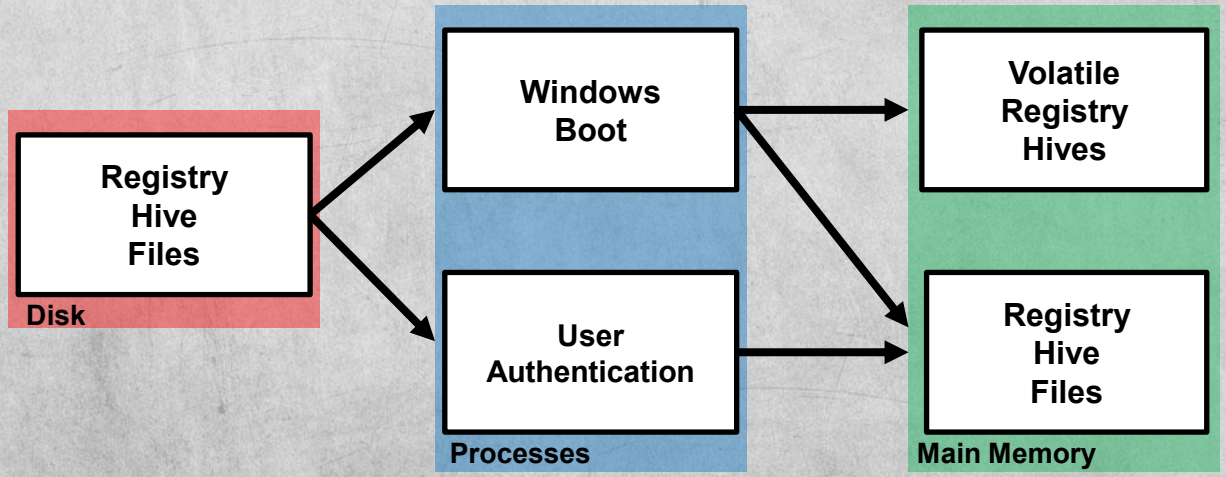
Registry Artifacts

Registry Monitoring

- The Windows operating system uses a centralized hierarchal database to store and manage configuration settings, preferences, and system-related information
- Windows does this for several reasons:
  - ✓ Efficient Access and Retrieval
  - ✓ Centralized Configuration
  - ✓ System Integration
  - ✓ User-specific Settings
  - ✓ Security and Access Control
  - ✓ Dynamic Configuration Changes
  - ✓ Compatibility and Legacy Support
- Malware abuses the Windows Registry and it is critical to understand how to collect and analyze artifacts produced by the Registry

Windows Registry Operation

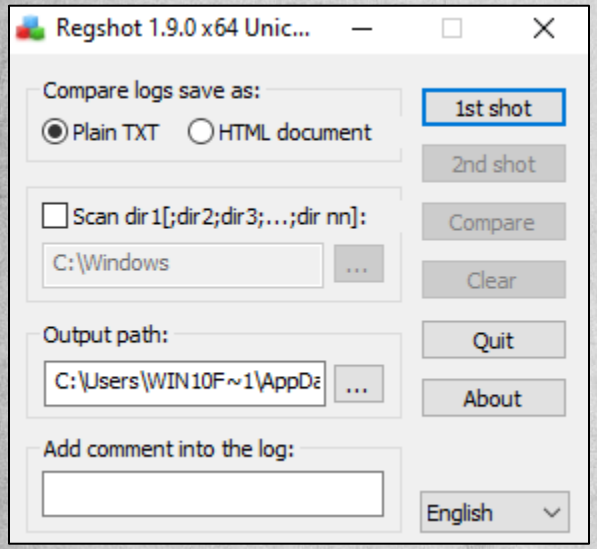
- A complete copy of the registry can only be found in main memory since it requires registry entries and active processes that create it
- From a forensics standpoint, this is significant because gathering a complete registry requires live memory capture



RegShot

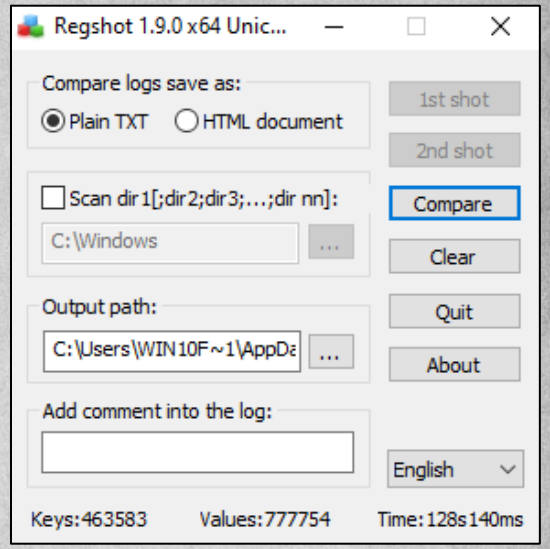
- Open-source utility for Windows that detects changes to Windows Registry before and after malware events
- An initial snapshot of the registry is compared against the registry after a malware event occurs and provides information about added, modified, or deleted registry keys, values, files, and folders
- RegShot provides a high-level final report for inclusion in malware analysis cases

Regshot



Run Before Malware Execution

After Execution Provide Sufficient Time Before Taking A Second Snapshot



Compare the Results

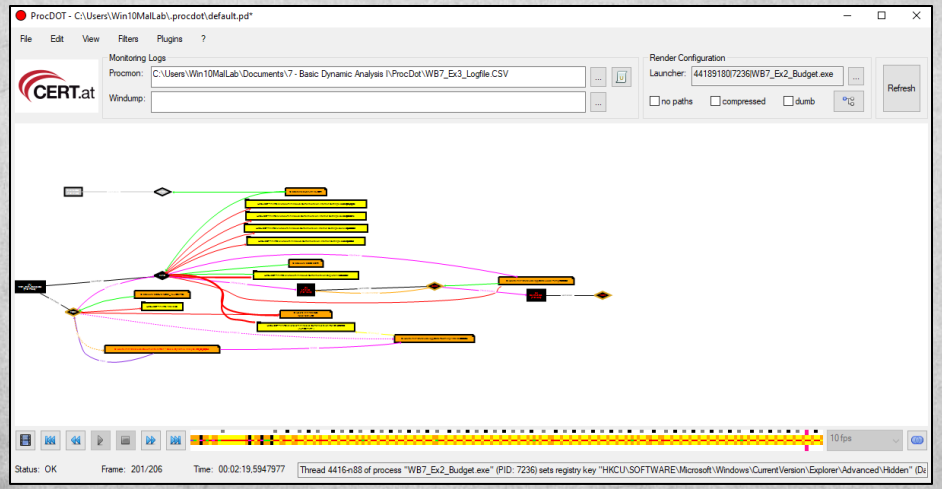
Timeline Analysis

ProcDot

- Created as an internal project at the Austrian CERT to support malware analysis workflows
- Designed and maintained by Christian Wojner, a malware analyst and reverse engineer at CERT.at.
- As the tool grew in complexity and features, it transitioned from a CERT.at project to a private project managed by Wojner, with its own dedicated site at procdot.com
- First public releases were made available through CERT.at's software section, later moved to procdot.com for downloads, documentation, and community support
- Still actively maintained, distributed as donationware, and widely used in malware research and education

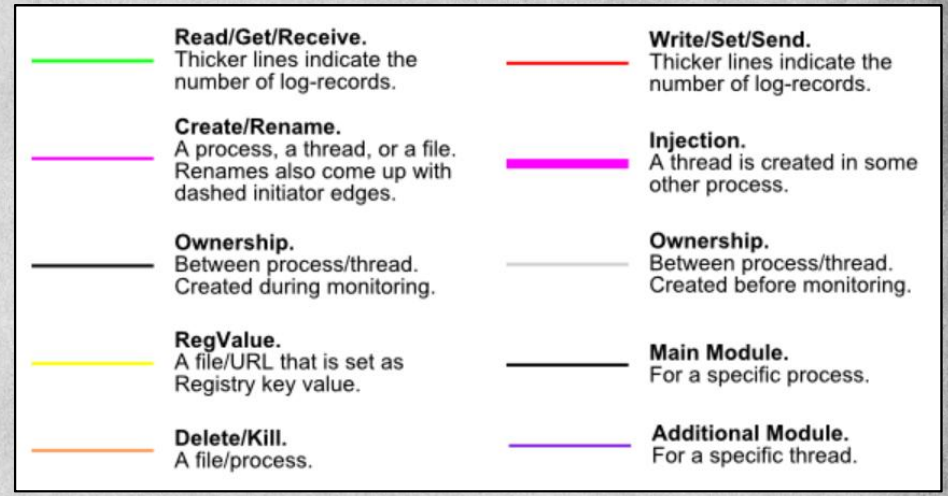
ProcDot Timelines

- Once ProcDot collects processes, network interfaces, and other artifacts, it then uses GraphViz to display events and the time in which they were generated



ProcDot Events

- As events are added to the ProcDot graph, they are colorized to represent different activities
- This helps to show file reads and writes and identify process ownership



Event Step

- Once a timeline is created, ProcDot generates a playable video that shows each event and highlights new events
- This can be helpful when looking for initial infections and follow-on system impacts

Demonstration

Questions?