Mitigating Ransomware Threat - a Backup Solution perspective

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Agenda

- Introduction
- Real-world Examples
- Solution
- Code Injection Prevention
- Key Aspects
- Additional Protection Mechanisms
- Future Directions
- Key Takeaways
Introduction
What is ransomware

- Malware that encrypts victim’s valuable data and asks for money in return for decryption key.
  - LockBit, Conti, WannaCry, Petya, Clop to name a few
- Uses phishing and code exploits to escalate privilege and propagate
- Some ransomware employ advanced techniques
  - Deletes VSS snapshots, system restore points
  - Injects code into running processes
- Having backup copy of data is a critical component to defending against ransomware
Typical Backup Solution

- Data protection solution

- Example workloads: File Server, Email server, DB server etc.

- One or more media servers and agents on workload servers

- Supported Target Storage: disk, cloud, dedupe (disk/cloud based), tape

- The ransomware resilience technology that we will be doing a deep-dive of today protects disk-based backup images accessed locally or over network from malware
Typical Backup Solution Architecture
Ransomware Defense - Pillars

Detect
- Anomaly detection
- Malware scan
- I/O pattern monitoring
- Access pattern monitoring
- Audit logging

Protect
- Immutable file system
- Immutable point-in-time image
- Immutable disaster recovery copies
- Compliance clock
  - To protect against system clock tampering

Recover
- Identify latest good backup image to restore from
- Rapid recovery
Defense against Ransomware – Backup Perspective

- Use of immutable storage (WORM)
- Hardening of backup infrastructure
- Use the 3-2-1 rule
  - 3 copies of data on 2 different storage media types and 1 copy kept offsite
- Whatever happens keep backup images safe
- This deep-dive is about protecting backup images from untrusted processes
Ransomware Resiliency - Protection Mechanisms

- Allow only trusted backup software processes to make changes to backup images
- Trusted processes need to be protected from code injection
- The protection must be in both kernel mode and user mode
- The communication of control information to the driver needs to be trusted/secure.
- Have a centralized trusted user mode component to handle all communication to the driver
  - In order to supply control information (like which file system location to protect) to the driver other components talk to this user mode component.
Shared Disk Scenario

- An environment can have a federation of backup servers
- One backup server can expose a disk storage so that others can write via SMB/CIFS
- Need to protect the folder containing backup images in this case
Self-Protection of the Lockdown Driver

- Must be able to protect backup images in absence of the user mode component
- Start in early boot phase
  - Least possible window where protection is unavailable
- Do not allow driver unload
  - Prevent malware from disabling protection mechanisms
- Do not allow deletion, rename of the driver
- Protection of configuration information
  - If stored in registry / file, those keys/files need to be protected
- Handling uninstallation
  - Allow genuine uninstall, block malware
Real-world Examples
Real-World Examples

- We have had exposure to real-world scenarios involving ransomware attacks and backup technology
- Seen this technology thwart ransomware attacks on the backup images while the entire environment got attacked
- Had cases where the entire environment could be successfully restored from backups when it seemed that all was lost
Solution
Solution - How

- File System Mini-Filter Driver to prevent unauthorized access
- A “Lockdown Service” (LDS) that operates in conjunction with the driver
  - User Mode Service
  - Implements logic to determine which processes / servers are authorized
Why File System Mini-Filter Driver?

- Typical solution to prevent unauthorized access is to employ ACLs (Access Control List)
- However, Ransomware running with administrative privileges can workaround ACLs
- File System Mini-filter can see all IOs on a volume
- Has the ability to prevent a particular IO operation
What is a FS Mini-Filter Driver?

- **CreateFile()**
- **ReadFile()**
- **WriteFile()**
- **MoveFile()**

**User Mode**

**Kernel Mode**

- Mini Filter 1
- Mini Filter 2
- Mini Filter 3

**File System Driver**

**File System (E.g. NTFS, ReFS)**
LDS – Simple Centralized Architecture

- Backup processes
- Control messages
- Lockdown service (LDS)
- Control message to driver
- Lockdown mini filter driver
- Prevent non-legitimate write/modification
- Disk-based backup storage
Lockdown Mechanics

- LDS may receive PID of process attempting to modify protected folder
- LDS should use a secure mechanism to validate the process
  - E.g., check the Authenticode Certificate of Process binary using Certificate APIs
  - WinVerifyTrust() API only verifies trust chain terminates in a trusted certificate
    - Use **custom checks** to validate other parameters such as Subject / Public Key of known Intermediate Provider
Lockdown Mechanics

Arbitrary Process

Lockdown Mini-filter Driver

Lockdown Service (LDS)

User Mode

Kernel Mode

LockdownMatch()

Kernel In-Memory Folder Store

Modify Storage Folder

<Path to folder 1>
<Path to folder 2>

IsTrustedProcess(<PID>)}
LDS Control plane architecture

- Control plane operations
  - Adding/removing backup storage folders for lockdown
  - Enable/disable lockdown
  - ...

- It is critical to identify the authenticity of the LDS clients
- Need an IPC mechanism that allows verifying the authenticity of the connecting client

- Usage of RPC allows LDS to
  - Query RPC client PID via RPC runtime APIs
  - Use client PID to validate various process parameters such as name / path etc.
  - Perform Authenticode Certificate Validation
LDS Control plane architecture

Backup Processes

IPC Call AddFolder ("<Path to folder1>")

Mini-filter Driver

AddFolder() Call to Driver

Create

Kernel In-Memory Folder Store

<Path to folder1> <Path to folder2>

Secure Config Store

<Path to folder1> <Path to folder2>

<Path to folder2>
Tusting the trusted

- Need to ensure that the driver can indeed trust the user-mode LDS
- Use mechanisms involving cryptographic hash of binaries and a secure handshake mechanism
  - Even the cryptographic hash needs to be secured in a configuration store
  - If the configuration store is maintained in the registry, use the Lockdown Driver itself to protect this store via kernel mode registry callback APIs
Network Storage Protection

- Necessary where network folders are used as storage destination
  - Also in multi-server deployments

- Challenges
  - Network path can be accessed in a variety of ways:
    - `\MachineName\Share\Folder`
    - `\MachineName\c$\<PathToFolder>`
    - `\FQDNName\Share\Folder`
    - `\IPvAddress<v4/v6>\Share\Folder`

- This can be solved using marker file etc.
Code Injection Prevention
Why

- We have made sure that only the trusted processes can modify backup storage
- What if the trusted processes are compromised?
- Code injection allows attacker to run in the context of trusted processes and evade any kind of checks
Code Injection Prevention Mechanism

- **Code Injection attack**
  - Open Process Handle
  - Allocate Memory in process context and write a stub of executable code
  - Create a remote thread to execute that stub and load a malicious Dll to do the actual damage

- **Use kernel-mode mechanisms like Windows object manager callbacks to monitor any attempts to gain write access to process memory**
  -Disallow and log attempts to gain such access
Code Injection Prevention – Special Considerations

- To those technically inclined, a few more points...
- Parent process needs to have complete access to child process / thread handles / memory space
  - Places restrictions on who can launch Backup processes / services
- Windows Privileged Processes also need to have access to every process
- Need to separate ‘Services’ from user launchable executables / tools
Key Aspects
Key Aspects

- Consider protection against indirect ways for file modification
  - Memory mapped, file handle duplication, open using file id
- Balance between usability and security
  - Require password / captcha for un-install?
- Supportability
  - Non-Killable LDS?
- Where to monitor
  - File system, volume level, disk level
- Provision to disable protection
  - For supportability, debugging
- Provision to exclude other specific application
  - E.g. AMSI client
Additional Protection Mechanisms
Additional Protection Mechanisms

- Immutable Devices
- Use of cloud storage
- Ransomware Resilient Storage System
  - Can be physical / virtual
Future Directions
Future Directions

- Many possibilities along each of the 3 pillars -- Detect, Protect, Recover
- Protection of configuration / Backup Catalogs in addition to storage
  - No recovery of backup server necessary
- Orchestrate recovery from ransomware attacks factoring cross-system and cross-application dependencies
  - E.g., Recovery path: Active Directory → Domain Controller → Exchange Server
- Research mechanisms for detect – use of AI / ML based approaches
  - Visibility into entire environment being a Backup Solution
Key Takeaways
Key Takeaways

- Ransomware attack is a major threat
- Backup is critical component of defense against ransomware
- Remember the three pillars
  - Detect, Protect, Recover
- Protecting from ransomware demands deep technical capabilities
  - Often requires kernel mode presence
Q&A
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