Host Vulnerabilities

UT LAW379M

SPRING 2021

LECTURE NOTES

What is “Malicious Code”?

“Software or firmware intended to perform an ***unauthorized*** process that will have ***adverse impacts*** on the confidentiality, integrity, or availability of a system. A virus, worm, Trojan horse, or other code-based entity that infects a host. Spyware and some forms of adware are also examples of malicious code.”

NIST Special Publication 800-53, Revision 5

Common Malware Classes

Malware can be classified by how it spreads or generically behaves

- Virus – typically has to be attached to another program (infection)
- Worm – typically spreads via network vulnerabilities
- Trojan Horse – typically appears benign but contains hostile operations

Malware can also be classified by its behavior

- Spyware – typically designed to steal information, observe behavior, etc.
- Adware – typically designed to “trap” a user into viewing certain ads
- Ransomware – typically locks data unless the user pays a ransom

Two Primary Components

Payload – The code that performs the (harmful) action

Attack Vector/Exploit/Delivery – The code that enables the payload

- May include a transmission component
- May include a stealth component
- May include a mechanism for bypassing security
- May be as simple as an email with an attachment

Malware History

Much of early computer security driven by military concerns

The biggest concern was an unauthorized user or program

Other concerns developed over time

The following slides are a very brief overview/highlight

1972 Government Report:

The technical issue of multilevel computer security is concerned with the concept of malicious threat. By this we recognize that the nature of shared use multilevel computer systems present to a malicious user a unique opportunity for attempting to subvert through programming the mechanism upon which security depends (i. e., the control of the computer vested in the operating system). This threat, coupled with the concentration of the application (data, control system, etc.) in one place (the computer system) makes computers a uniquely attractive target for malicious (hostile) action. Recognition of the implication of malicious threat is important to understanding the security limitations surrounding application of contemporary computer systems. The threat that a single user of a system operating as a hostile agent can simply modify an operating system to by-pass or suspend security controls, and the fact that the operating system controlling the computer application(s) is developed outside of USAF control, contribute strongly to the reluctance to certify (i. e., be convinced) that contemporary systems are secure or even can be secured.

https://apps.dtic.mil/sti/pdfs/AD0758206.pdf

1987: Fred Cohen's Viruses

"Computer Viruses: Theory and Experiments" Fred Cohen, 1987

Introduced the concept of a self-replicating, evil program

The program attaches to a "good" program infecting it

When the infected program is run, the virus runs

The virus does it's evil AND spreads itself to other programs

Concepts first proposed by Cohen in 1984

1988: Morris Worm

Robert Morris wrote a self-spreading piece of code (worm)

Spread using exploits in:

- send mail,
- Finger
- rsh/rexec

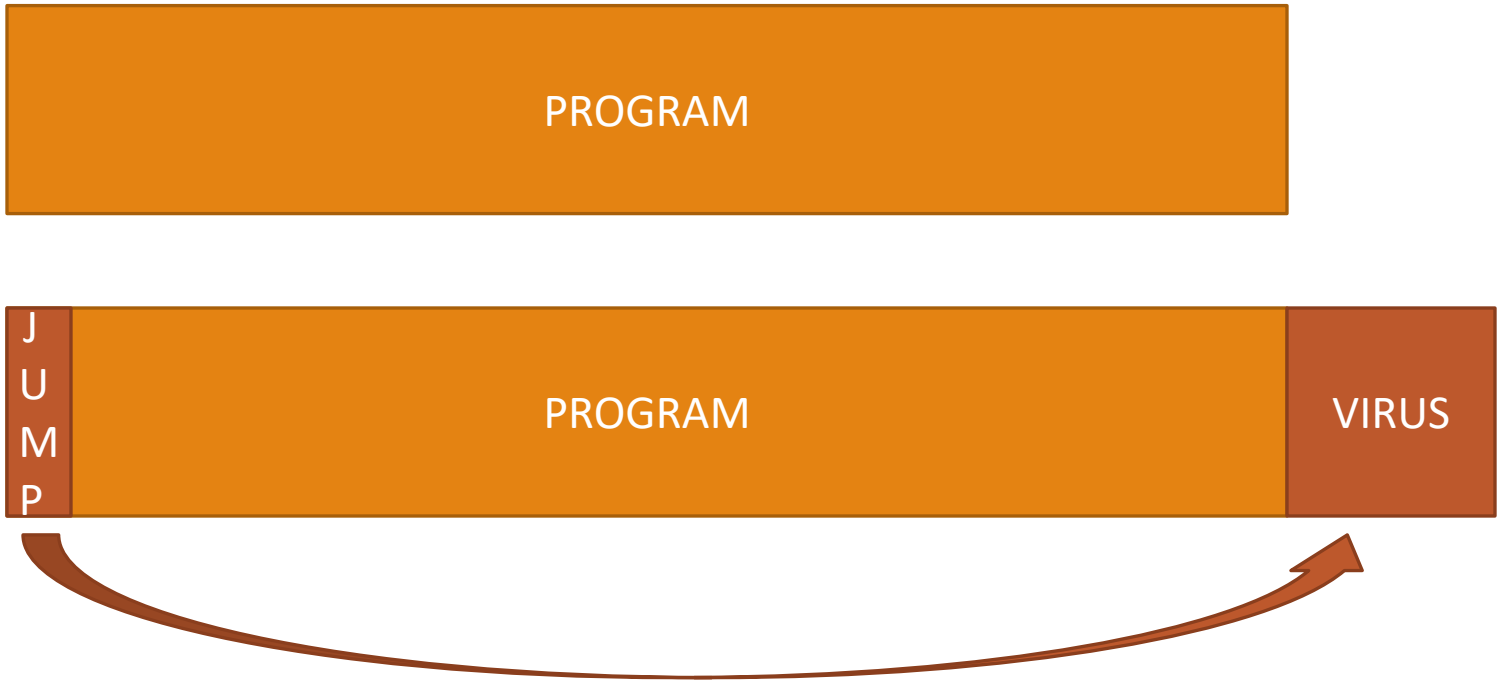
Also guessed weak passwords

Copied code to new machine, compiled, and executed

Accidentally re-infected machines until machines became unusable

DOS attack brought down the Internet

Early DOS Viruses



Impact of Early Viruses

Amazingly, most early malware ***DID MINIMAL DAMAGE***

Often just a delivery system with a weak payload

Many viruses spread for the sake of spreading

Even the Morris worm was disruptive by accident

There were exceptions, but also plenty of hype

1995: Concept Macro Virus

Microsoft Word and Excel have limited scripting (“Macros”)

Concept was the first virus written completely as a macro

It was a delivery system only with no payload

But was an important proof-of-concept

Users often open documents directly from email

2000: I Love You

Visual Basic Script virus

Appears as email attachment:

- LOVE-LETTER-FOR-YOU.txt.vbs
- The .vbs often hidden on Windows

When executed:

- Damaged many office files
- Sent email out to email address book ***automatically***

Spread worldwide in hours

2004: MyDoom

Fastest spreading mass mailer virus at the time
- Slows overall internet performance by about 10%
- Slows average web page load times by about 50% percent
- Responsible for approximately one in ten e-mail messages.

Appears as a delivery error, mail error, etc

Includes an attachment that, if clicked on, mails out copies

Also attempted to spread via P2P vile sharing Kazaa

Opened a back door for remote control

Attempted to launch a DDOS against the SCO Group's website

2005: Sony Rootkit

Sony CD's from the 2004-2005 era installed a "Rootkit"

- Rootkit, as name implies, usually installs with elevated access
- Using this elevated access, it can change the OS
- This bypasses usual security such as antivirus, etc
- Also usually very good at being undetectable

Installed at root with an EULA ***that did not mention the software***

In 2005, ***US-CERT ISSUED AN ADVISORY!!!***

Texas, ***under Greg Abbot***, was the first state to sue

Why is the Sony Rootkit So Bad?

In addition to violations of privacy, etc, caused:

- Slowing the system, consuming resources
- False alarms from antivirus

OPENED HOLES FOR ADDITIONAL MALWARE

- “Stinx-E trojan”

2013: Cryptolocker

Modern Ransomware

(1980's had a ransomware called CyberAIDS)

Locks up system and uses public key crypto

In addition to fiat currency, accepted BitCoin

2016: Mirai

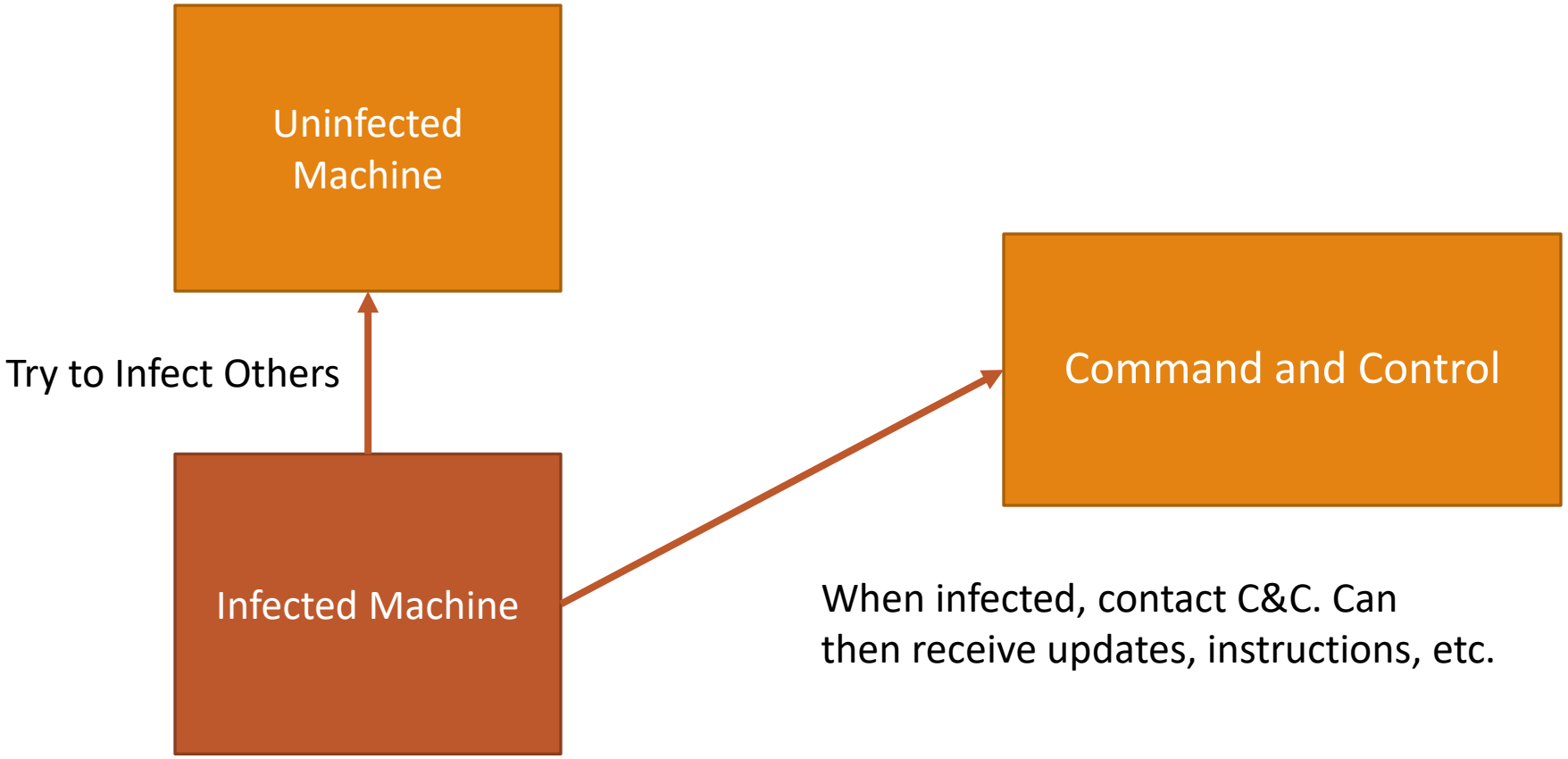
Worm that finds vulnerabilities in IoT devices

Takes over the device (“Zombie”)

Corrdinates all devices with a Command and Control

Launched a powerful DDOS against “krebs on security”

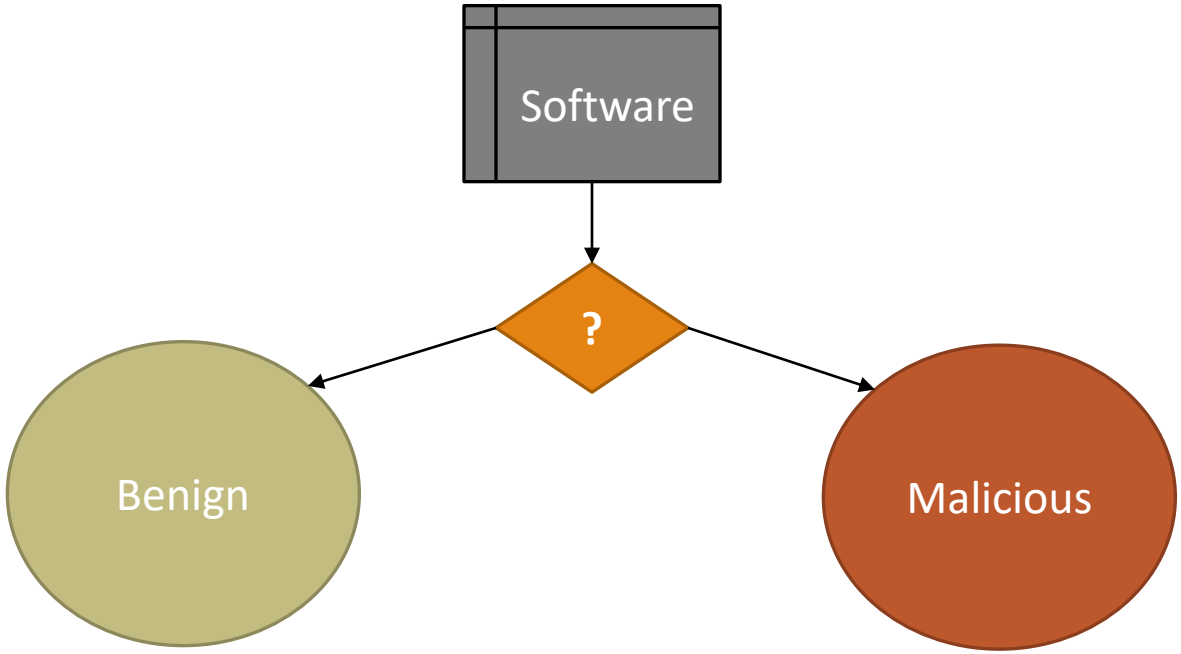
Command and Control Concept



Identify and neutralize	Identify and neutralize malware before the attack
Mitigate	Mitigate malicious activity during the attack
Recover or restore	Recover or restore damaged systems after the attack

Identifying Malware

Primarily a ***classification*** problem



Classification Approaches

Static Analysis

- Analyze the software to categorize it
- Compare against known patterns (signatures)
- Or ~~determine~~ ***guess*** how it will behave (heuristics)

Dynamic Analysis

- Analyze the software's ***execution***
- Identify behavior that violates a security policy
- Or, ~~determine~~ ***guess*** if behavior is dangerous
- Typically in a "safe" container (emulation or sandboxing)

Early “Anti Virus”

“Virus Bulletin” started in 1989

Still available at www.virusbulletin.com

Used to print ***BYTE SEQUENCES*** of known viruses

8 Tunes - CER: The virus probably originates in Germany and infects COM and EXE files. The length of the virus code is 1971 bytes. When triggered, it will play one out of eight different tunes. The virus attempts to deactivate two anti-virus programs: Bombsquad and Flushot+.

```
8 Tunes          33F6 B9DA 03F3 A550 BB23 0353 CB8E D0BC ; Offset variable
```

Virus Bulletin, January 1991

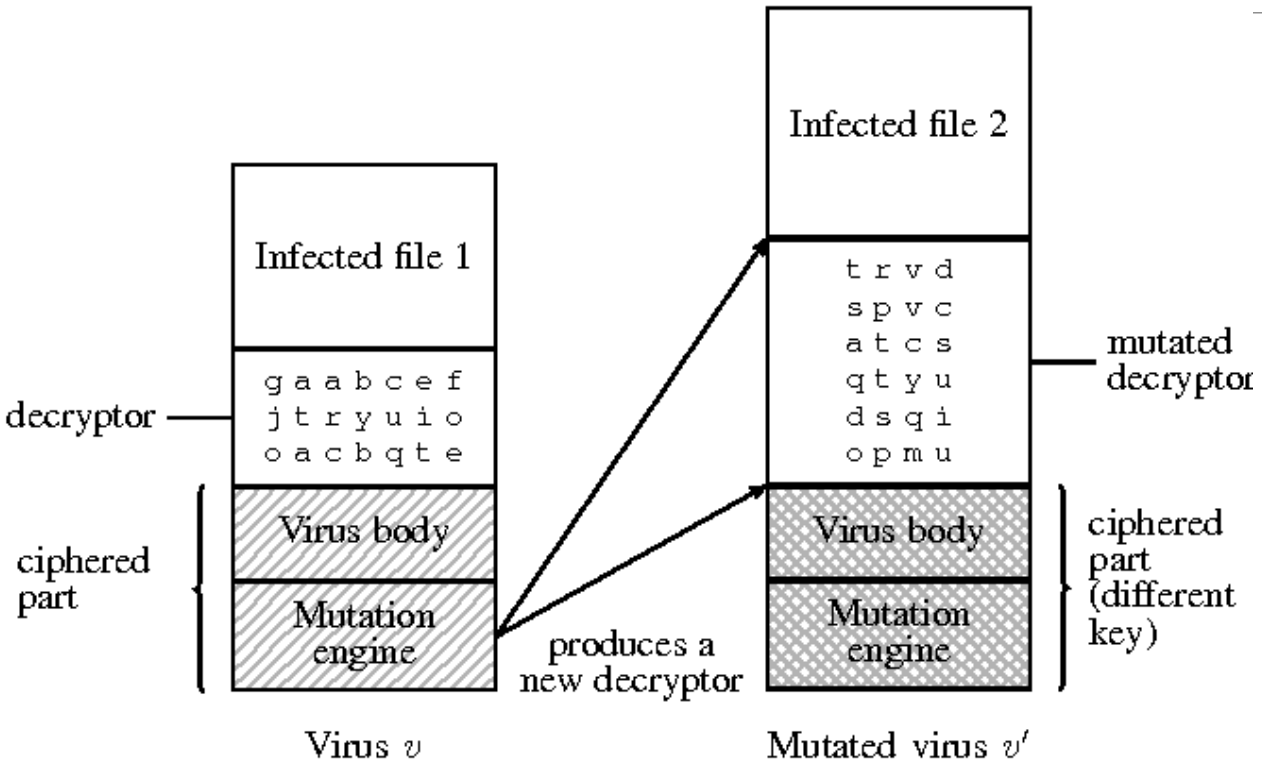
Virus Advancements

Antivirus scanners emerged with “libraries” of virus signatures

In response, viruses became “polymorphic”’

- Each infection encrypts virus under a different key
- Decryption engine decrypts virus for operations
- Encryption means that each infection has unique bytes

Polymorphic Virus Diagram



"Automated extraction of polymorphic virus signatures using abstract interpretation" by Chaumette and Tabary

Anti-virus Arms Race

Advanced Signatures

- Signature is not just a byte sequence
- Each “signature” is a mini-program of detection instructions

Partial Interpreter

- Virus usually takes control early
- Interpret the first bytes to see if its decrypting
- Decrypt and then scan

(Developed in the 1990’s)

Beyond Scanning

Behavior Blockers

- Tries to block bad behavior
- But what counts as “bad”?

Integrity Checkers

- Checksum files
- Detect unauthorized changes
- But what is authorized?

Heuristics

- Look for “telltale” signs
- Minimally effective; too many false positives

Emulation and Sandboxing

Emulation ***simulates*** execution

- Default arguments
- Stubbed I/O
- Simulate the “beginning” when viruses activate

Sandboxing runs the software in a virtual environment

- Default arguments
- Usually for a limited amount of time (e.g., 1 minute)
- Observe changes to the filesystem

Problems

- Non-contextual execution including arguments
- Malware that detects sandboxes

Malware Scanning

Antivirus scanning is representative of all malware scanning

Always “behind” the enemy

Signatures can only catch “known” malware

Guesses always have FP and FN

Dynamic execution can be detected/evaded

Enemy: Halting Problem

Decidability is a classic computer science problem

Halting Problem:

- Given: a program P and input I
- Can you write a program D that determines if P ***halts*** on input I
- (Halts, meaning e.g., not stuck in an infinite loop)
- Over the ***set of all possible programs***, the answer is ***NO***
- (Maybe able to determine for some, but not for all)

Alan Turing proved this in 1936!

Halting problem proven to extend to any non-trivial characteristic

In Other Words

There is no program that can detect all malware

Is this just theoretical?

- What if we can detect 99.9999999%?
- What if we can detect all the “important” threats?

Thoughts from 1995

In 1995, Gryaznov wrote, “Scanners of the year 2000”

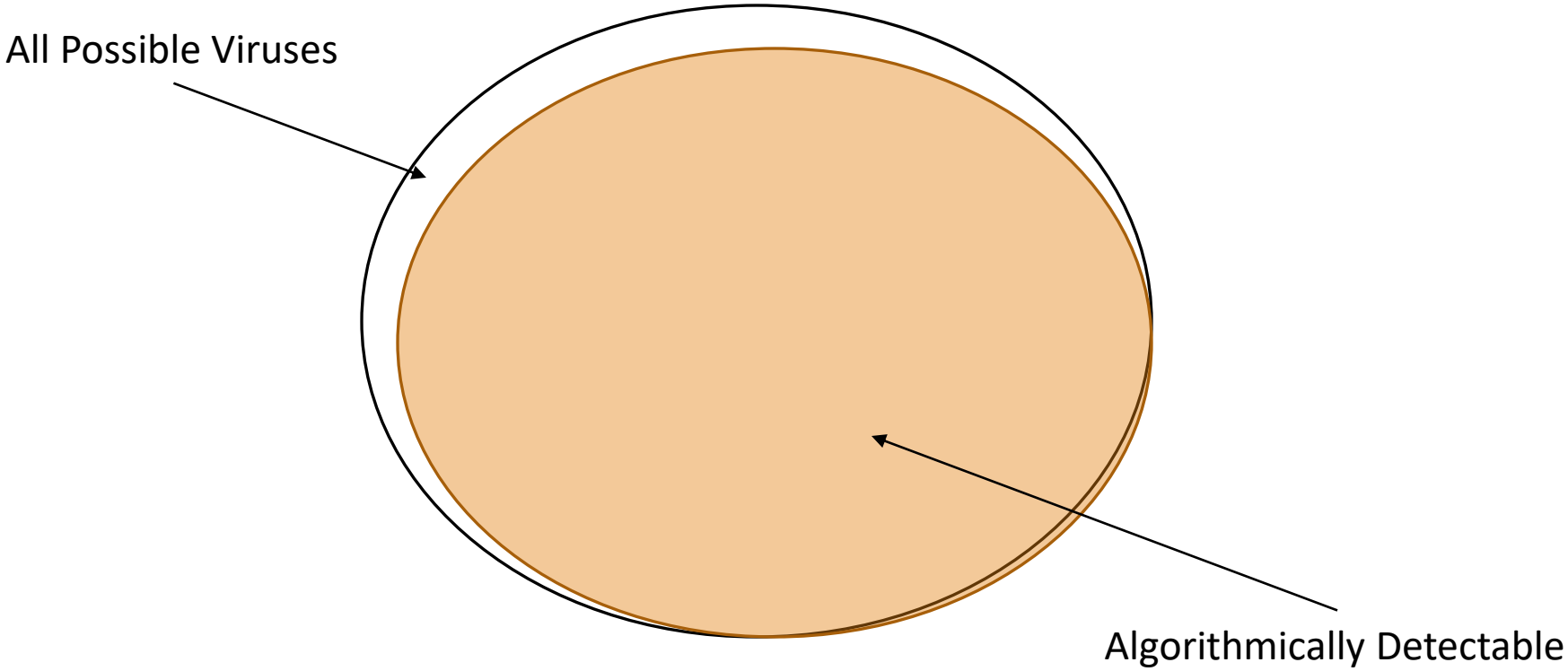
He discussed Heuristics

Specifically mentioned the halting problem, but said:

Fortunately, this does not rule out a possibility of 90 or even 99 per cent reliability. And with the remaining one per cent cases we hopefully shall be able to deal with using *our traditional virus signatures scanning technique.*

GRYAZNOV WAS WRONG.

Gryaznov's View



Why It Doesn’t Work

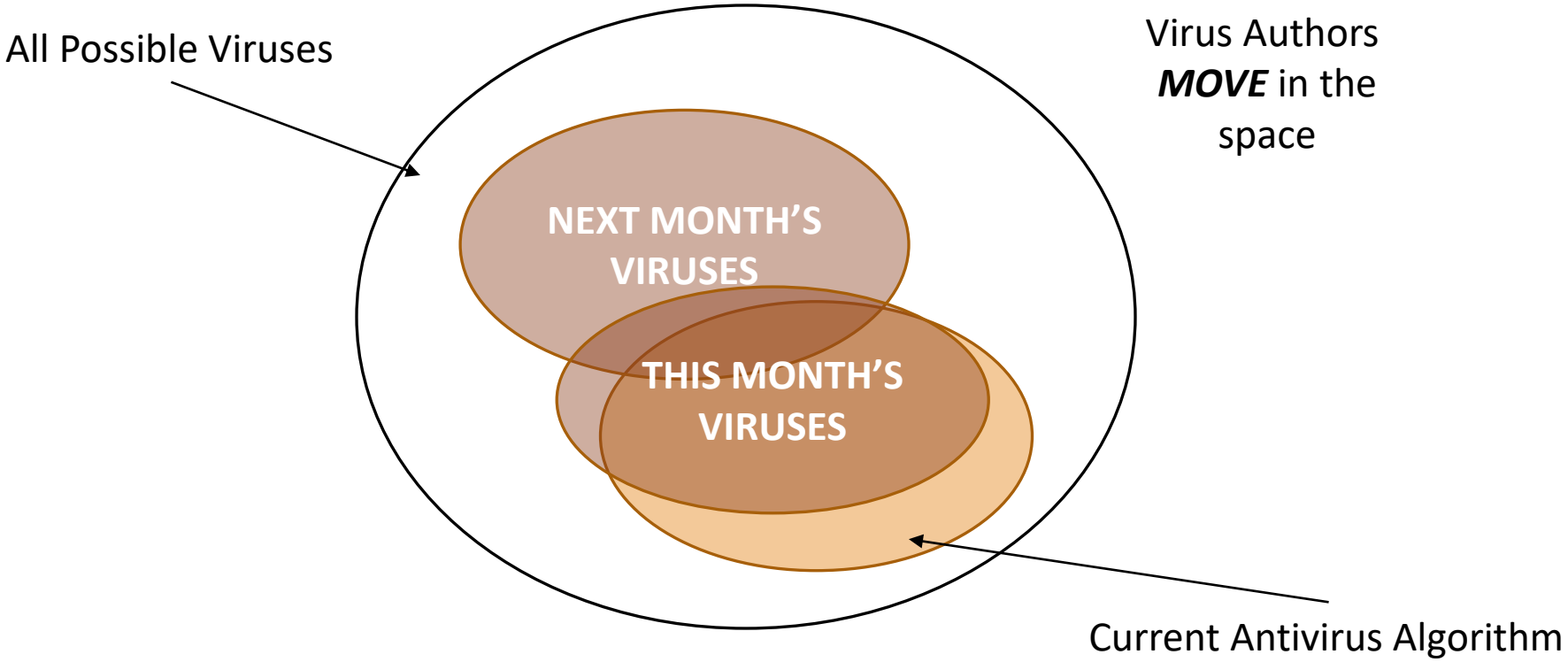
Gryaznov treats viruses as if they are created at random

Viruses are created by ***human beings***

If an antivirus writer creates an algorithm, the adversary adjusts

The adversary moves into the space not detected by the algorithm

Correct View



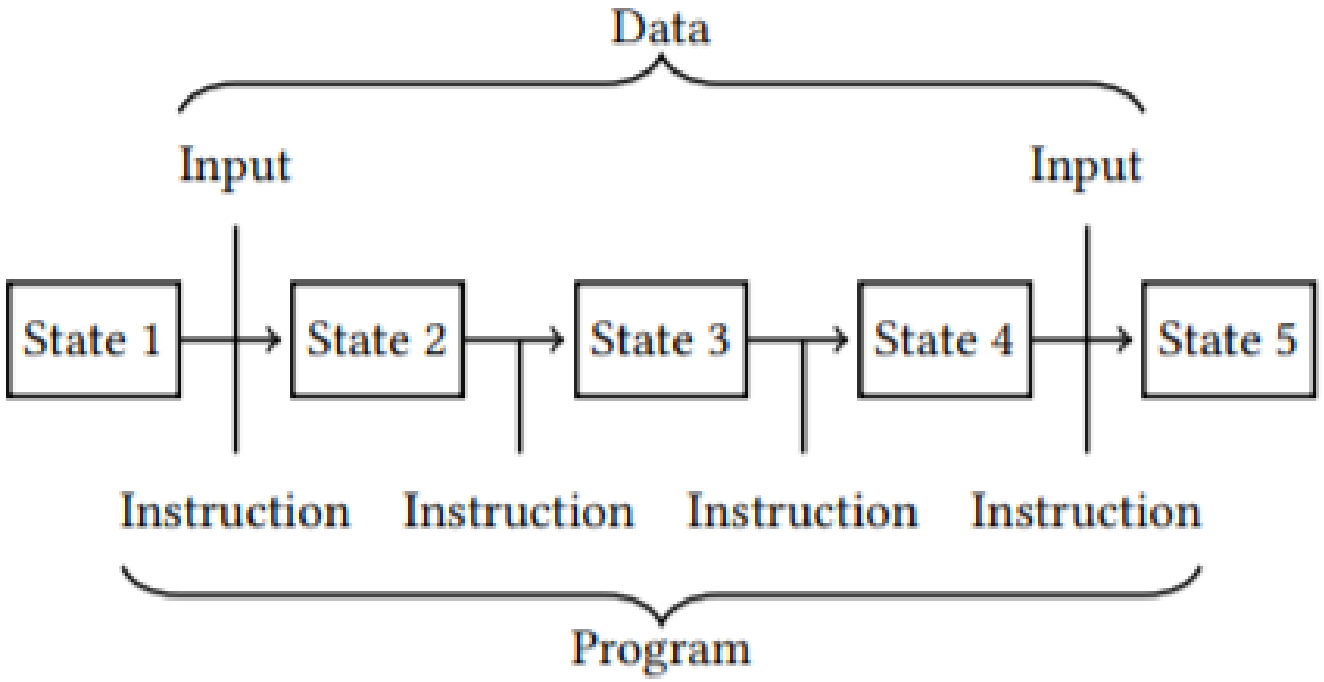
“Weird Machines”

“Weird machines, exploitability, and provable unexploitability”

Written by Thomas Dullien

Explains that users interacting with a program ***is a program***

What is a Program?



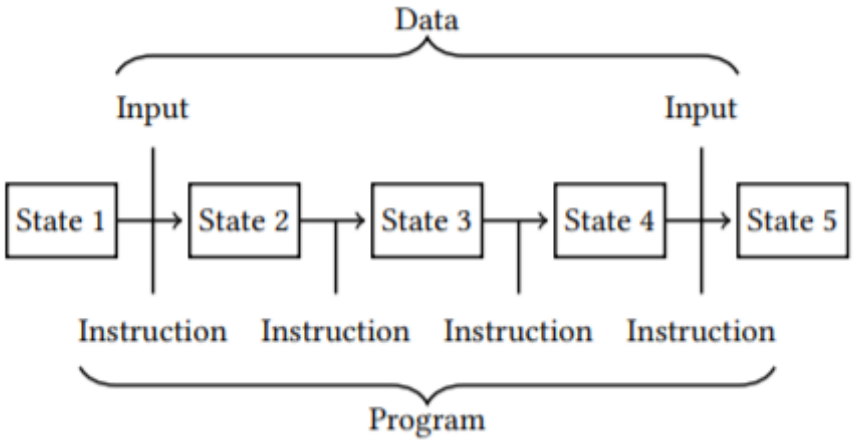
*From Dullien's Paper

State Machine View

View a “Program” as a state machine

Program starts in state S_0

Based on instruction, advances to state S_i

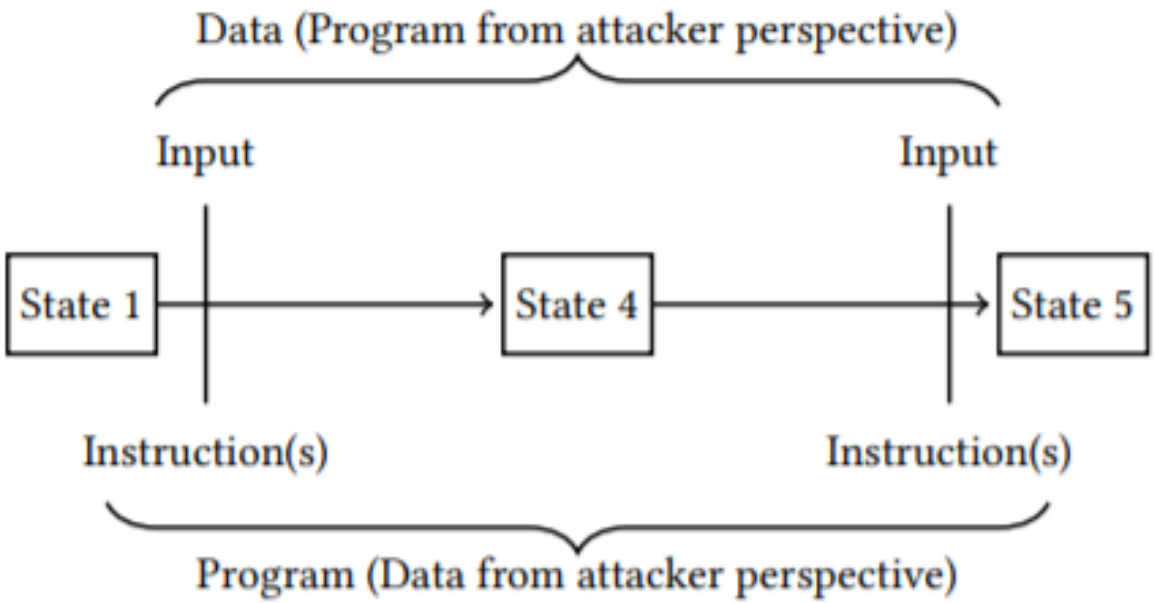


States and User Interactions

Program is in some State. Call it S_0

User interacts with the program

Program advances to state S_1



What is a “User”?

Do we literally mean a flesh-and-blood human?

Really, “user” is just whatever provides the input

This can, of course, just be another process

Thus, two processes interacting ***IS A PROGRAM***

Therefore, determining if “behavior” is good is undecidable

One More Big Problem

Decidability is a fundamental, ***unsolvable*** problem

Another big problem is ***Supply Chain***

1984: Thompson's Reflections

"Reflections on Trusting Trust" by Ken Thompson, 1984

Demonstrated creating an evil compiler

Would compile a login program with a backdoor

BUT! ***ALSO COMPILED <u>COMPILERS</u> WITH THIS LOGIC!***

"Clean" compiler source code compiled by an evil compiler ***is evil!***

Proved that a "source code review" can't catch all evil