Malware

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http://betanews.com/wp-content/uploads/2013/06/stop-malware-600x521.jpg

Malware: Malicious code that runs on the victim’s system

How does malware run?

- Attacks a user- or network-facing vulnerable service
  - e.g., using techniques from prior lectures
- Backdoor: Added by a malicious developer
- Social engineering: Trick user into running/clicking
- Trojan horse: Offer a good service, add in the bad
- Attacker with physical access installs & runs it

What does malware do?

- Potentially nearly anything (subject to permissions)
- Brag: “APRIL 1st HA HA HA HA YOU HAVE A VIRUS!”
- Destroy: files, hardware
- Crash the machine, e.g., by over-consuming resource
  - Fork bombing or “rabbits”: while(1) { fork();
- Steal information (“exfiltrate”)
- Launch external attacks: spam, click fraud, DoS
- Ransomware: e.g., by encrypting files
- Rootkits: Hide from user or software-based detection
  - Often by modifying the kernel
- Man-in-the-middle attacks to sit between UI and reality

Viruses vs. worms

- Virus: Run when user initiates something
  - Run program, open attachment, boot machine
  - Typically infects by altering *stored* code
  - Self-propagating: Create new instance elsewhere

- Worm: Runs while another program is running
  - No user intervention required
  - Typically infects by altering *running* code
  - Self-propagating: infect running code elsewhere

The line between these is thin and blurry; some are both

Technical challenges

- Viruses: Detection
  - Antivirus software wants to detect
  - Virus writers want to avoid detection as long as possible
  - ***Evade*** human response

- Worms: Spreading
  - The goal is to hit as many machines and as quickly as possible
  - ***Outpace*** human response

Viruses

Viruses

- They are **opportunistic**: they will *eventually* be run due to user action

- Two *orthogonal* aspects define a virus:
  1. How does it **propagate**?
  2. What else does it do (what is the "**payload**")?

- General infection strategy:
  - Alter some existing code to include the virus
  - Share it, expect users to (unwittingly, possibly automatically) re-share

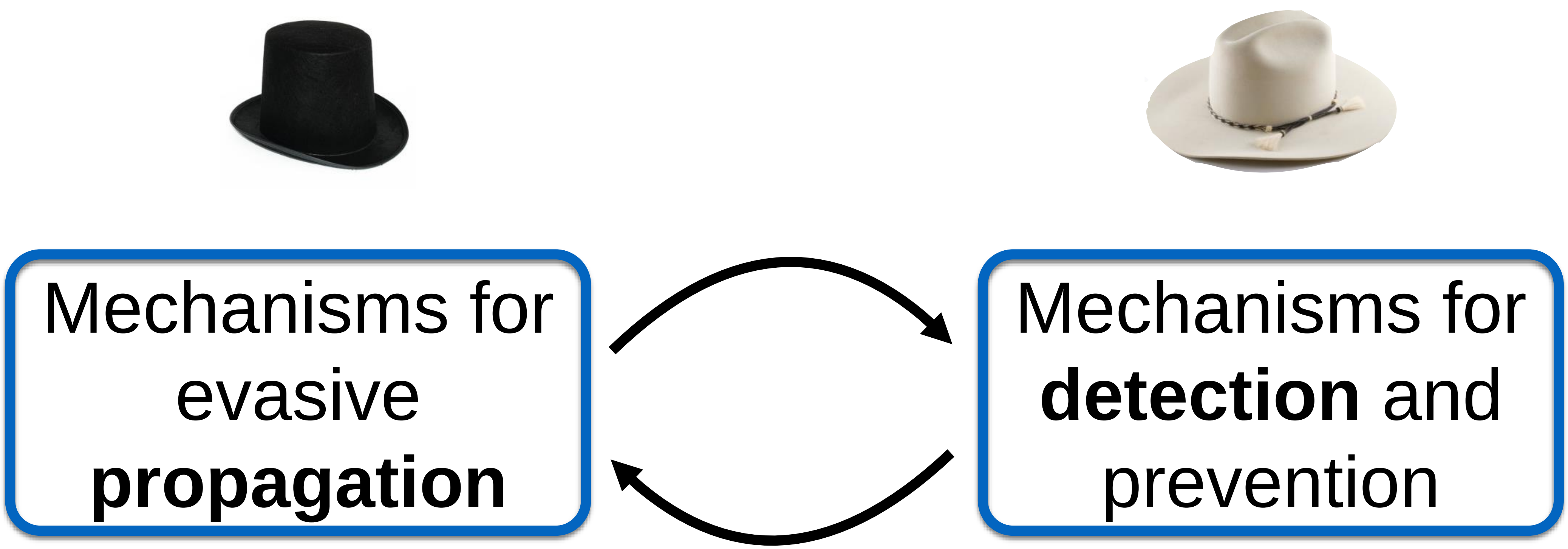
- Viruses have been around since at least the 70s

Classified by what they infect

- Document viruses
  - Implemented within a formatted document (Word, PDF, etc.)
  - Enabled by macros, javascript
  - (Why you shouldn’t open random attachments)
- Boot sector viruses
  - Boot sector: small disk partition at fixed location; loaded by firmware at boot
  - What’s *supposed* to happen: this code loads the OS
  - Similar: AutoRun on music/video disks
  - (Why you shouldn’t plug random USB drives into your computer)
- Etc.

Viruses have resulted in a technological arms race

The key is ***evasion***

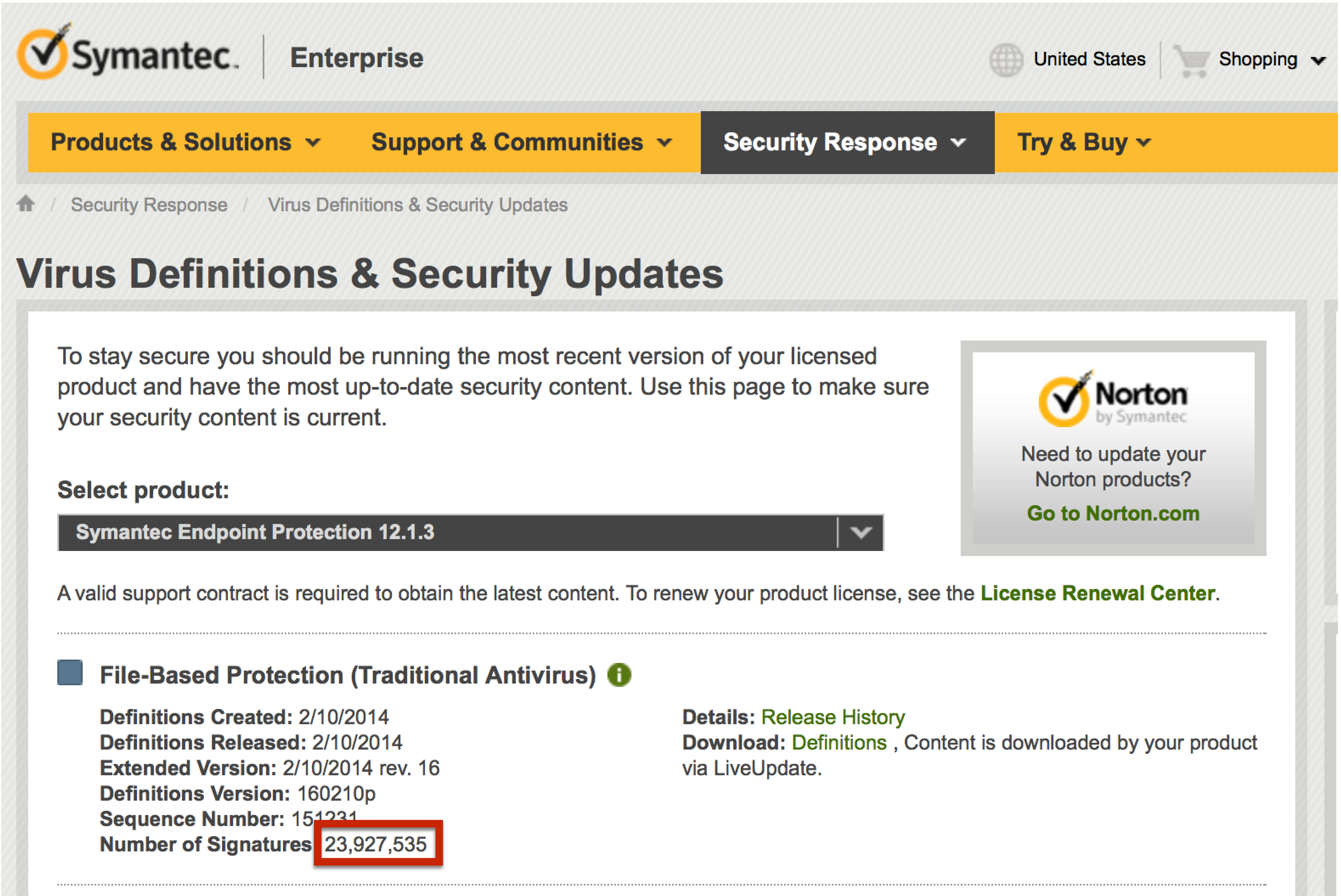


How viruses propagate

- **Opportunity to run:** attach to something likely
  - autorun.exe on storage devices
  - Email attachments
- **Opportunity to infect:**
  - See a USB drive: overwrite autorun.exe
  - User is sending an email: alter the attachment
  - Proactively create emails ("I Love You")

Detecting viruses: Signatures

- Identify bytes corresponding to known virus
- Install recognizer to check all files
  - In practice, requires fast scanning
- Drives multi-million$ antivirus market
  - Marketing via # signatures recognized
  - Is this a useful metric?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A valid support contract is required to obtain the latest content. To renew your product license, see the License Renewal Center.
File-Based Protection (Traditional Antivirus)
Definitions Created: 2/10/2014
Definitions Released: 2/10/2014
Extended Version: 2/10/2014 rev. 16
Definitions Version: 160210p
Sequence Number: 151231
Number of Signatures 23,927,535
Details: Release History
Download: Definitions , Content is downloaded by your product via LiveUpdate.

Um.. thanks?

FEATURE

Antivirus vendors go beyond signature-based antivirus

Robert Westervelt, News Director

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Security experts and executives at security vendors are in agreement that signature-based antivirus isn't able to keep up with the explosion of malware. For example, in 2009, Symantec says it wrote about 15,000 antivirus signatures a day; that number has increased to 25,000 antivirus signatures every day.

"Signatures have been dying for quite a while," says Mikko H. Hypponen, chief research officer of Finnish-based antivirus vendor, F-Secure. "The sheer number of malware samples we see every day completely overwhelms our ability to keep up with them."

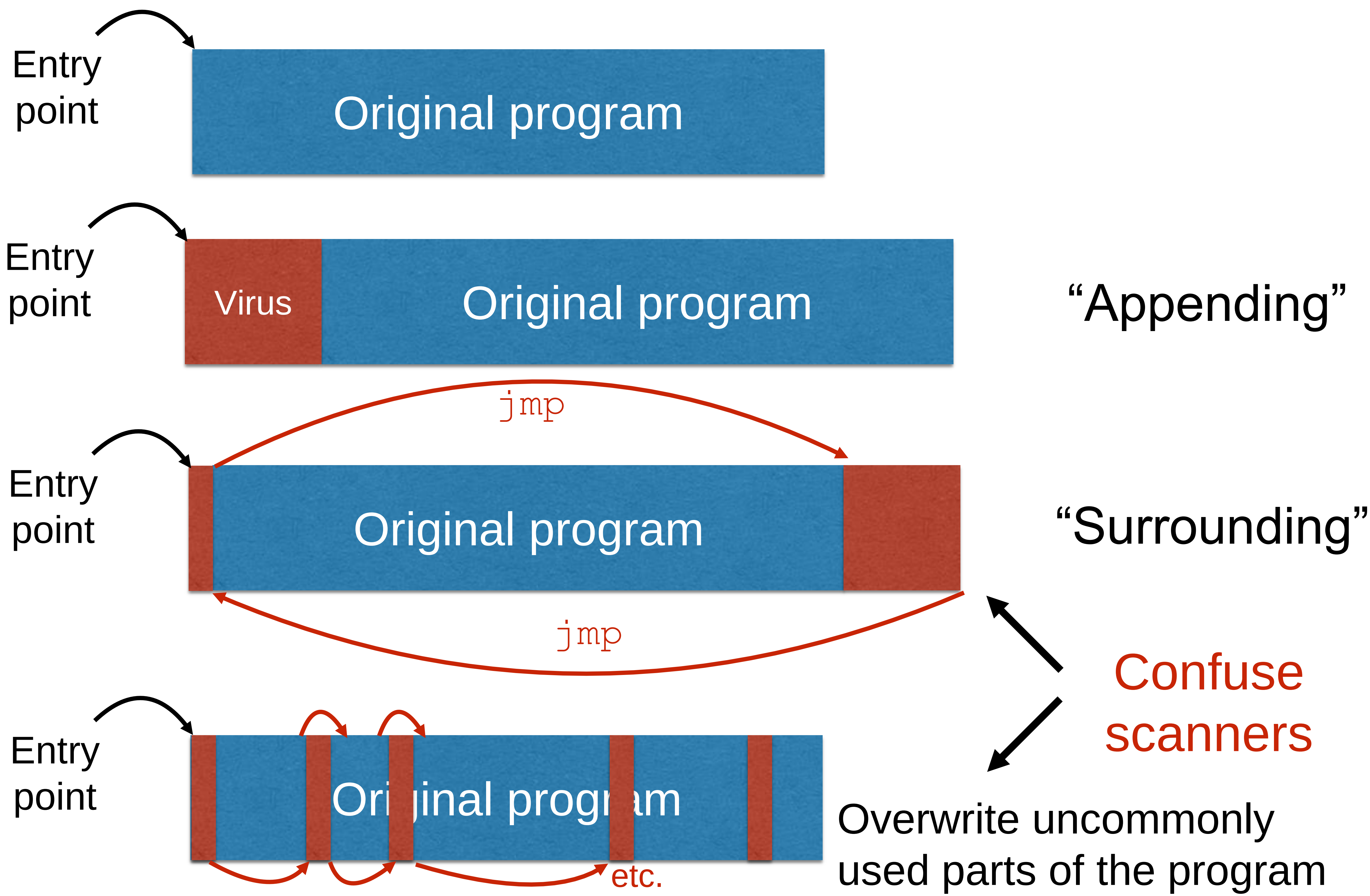
Security vendors have responded by updating their products with additional capabilities, such as file reputation and heuristics-based engines. They're also making upgrades to keep up with the latest technology trends, such as virtualization and cloud computing.

You are a virus writer

- Your goal is for your virus to spread far and wide
- How do you avoid detection by antivirus software that uses signatures?

1. Make signature **harder to find**

How viruses infect other programs



You are a virus writer

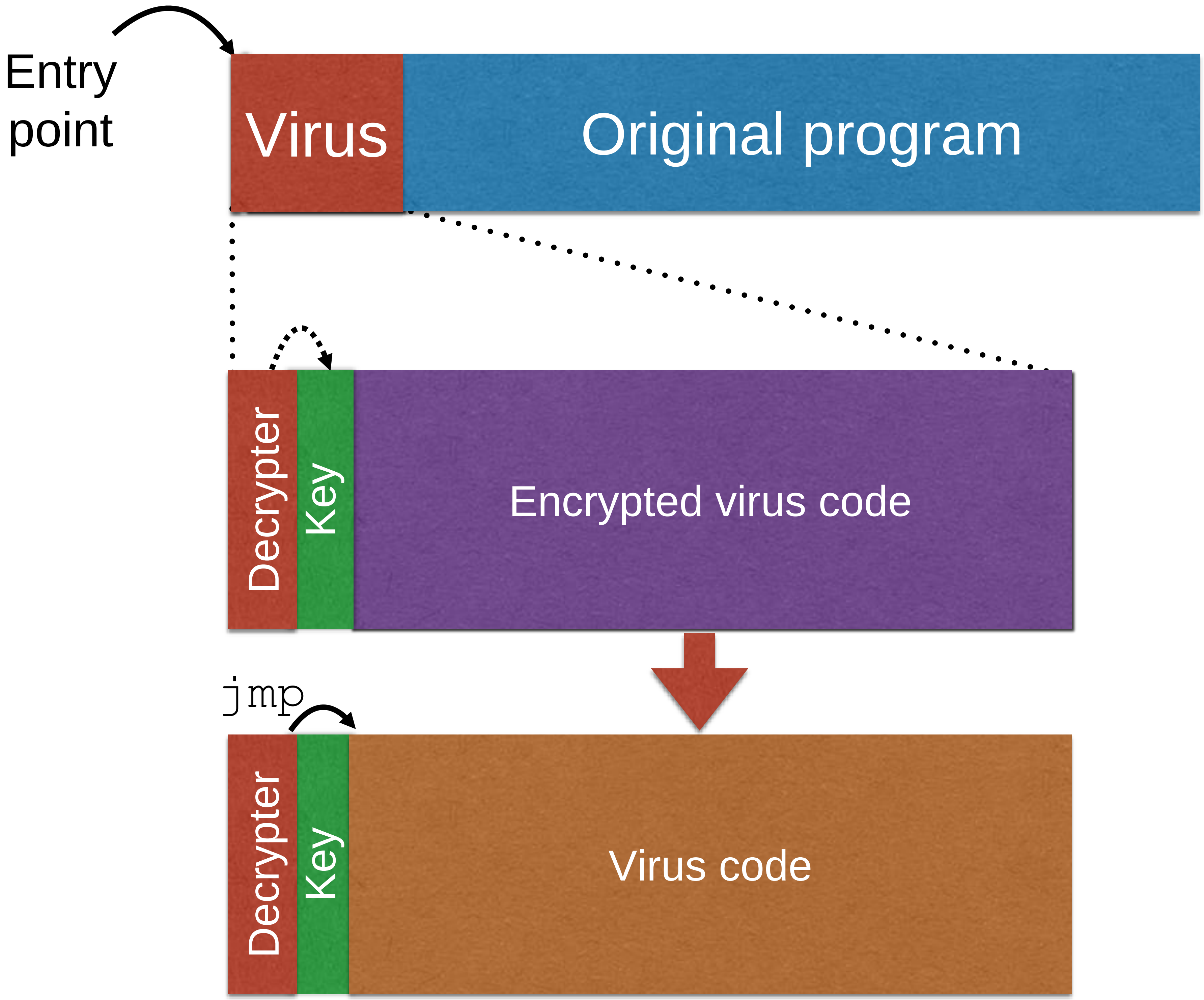
- Your goal is for your virus to spread far and wide
- How do you avoid detection by antivirus software that uses signatures?

1. Make signature harder to find
2. **Change code** to prevent defining a signature

Mechanize **code changes:**
Goal: every time you inject your code, it looks different

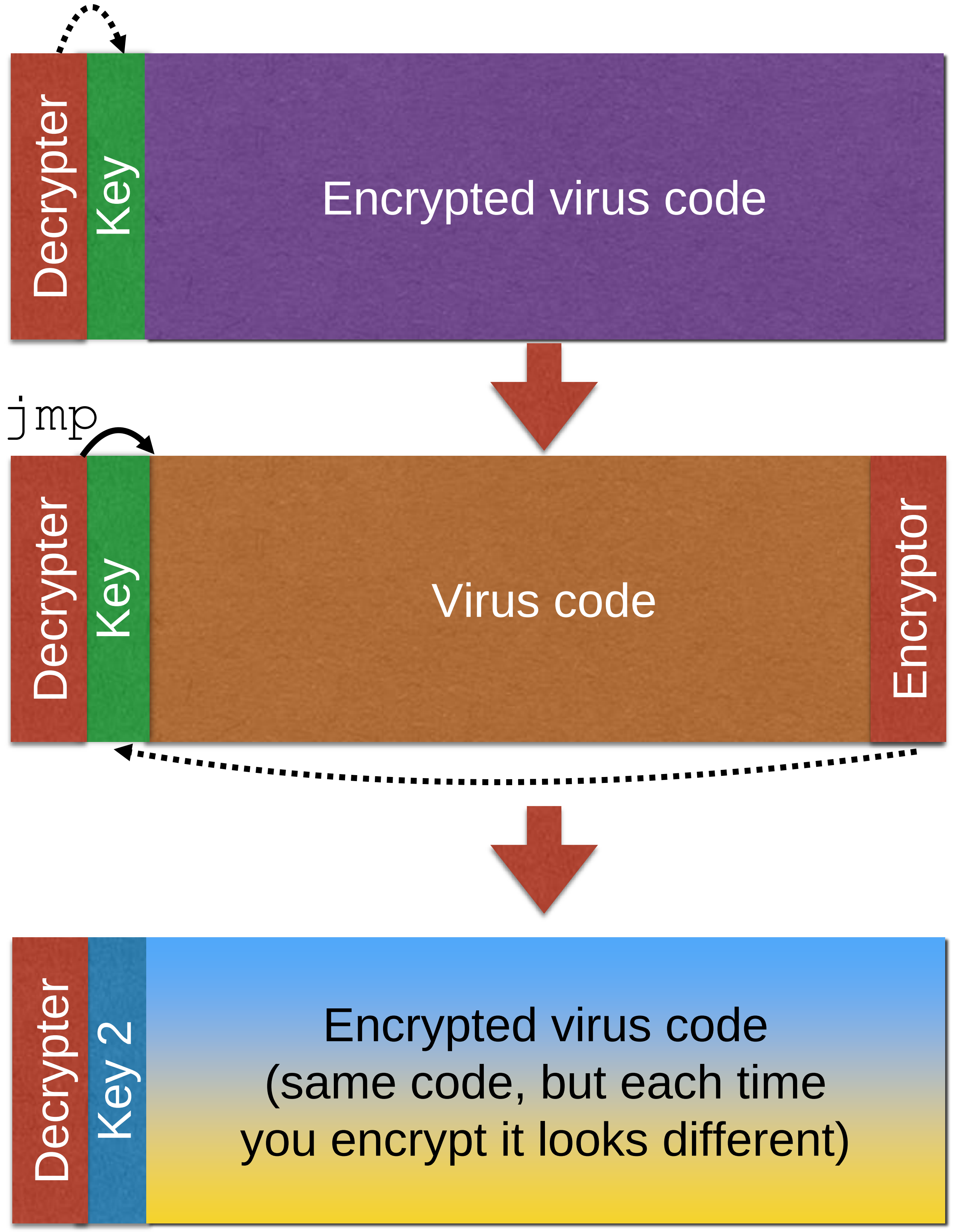
Polymorphic and metamorphic viruses

Polymorphic using encryption



Take over the entry point

Making it automatic



When used properly, encryption will yield a different, random output upon each invocation

Polymorphic viruses: Arms race

Now you are the antivirus writer: how do you detect?

- Idea #1: Narrow signature to catch the decrypter
  - Often very small: can result in many false positives
  - Attacker can spread this small code around and `jmp`
- Idea #2: Execute or statically analyze the suspect code to see if it decrypts.
  - How do you distinguish from common “packers” which do something similar (decompression)?
  - How long do you execute the code??

Now you are the *virus* writer again: how do you *evade*?

Polymorphic countermeasures

- Change the decrypter
  - Oligomorphic viruses: assemble decrypter from several interchangeable alternative pieces
  - True polymorphic viruses: can generate an endless number of decrypters
    - Different encryption methods
    - Random generation of confounds
    - Downside: inefficient

Metamorphic viruses

- Every time the virus propagates, generate a *semantically different* version of the code
  - Higher-level semantics remain the same
  - But the way it does it differs
    - Different machine code instructions
    - Different algorithms to achieve the same thing
    - Different use of registers
    - Different constants….

- How would you do this?
  - Include a code rewriter with your virus
  - Add a bunch of complex code to throw others off (then just never run it)

```
5A               pop   edx
BF04000000       mov   edi,0004h
8BF5             mov   esi,ebp
B80C000000       mov   eax,000Ch
81C288000000     add   edx,0088h
8B1A             mov   ebx,[edx]
899C8618110000   mov   [esi+eax*4+00001118],ebx

58               pop   eax
BB04000000       mov   ebx,0004h
8BD5             mov   edx,ebp
BF0C000000       mov   edi,000Ch
81C088000000     add   eax,0088h
8B30             mov   esi,[eax]
89B4BA18110000   mov   [edx+edi*4+00001118],esi
```

Figure 4: Win95/Regswap using different registers in new generations

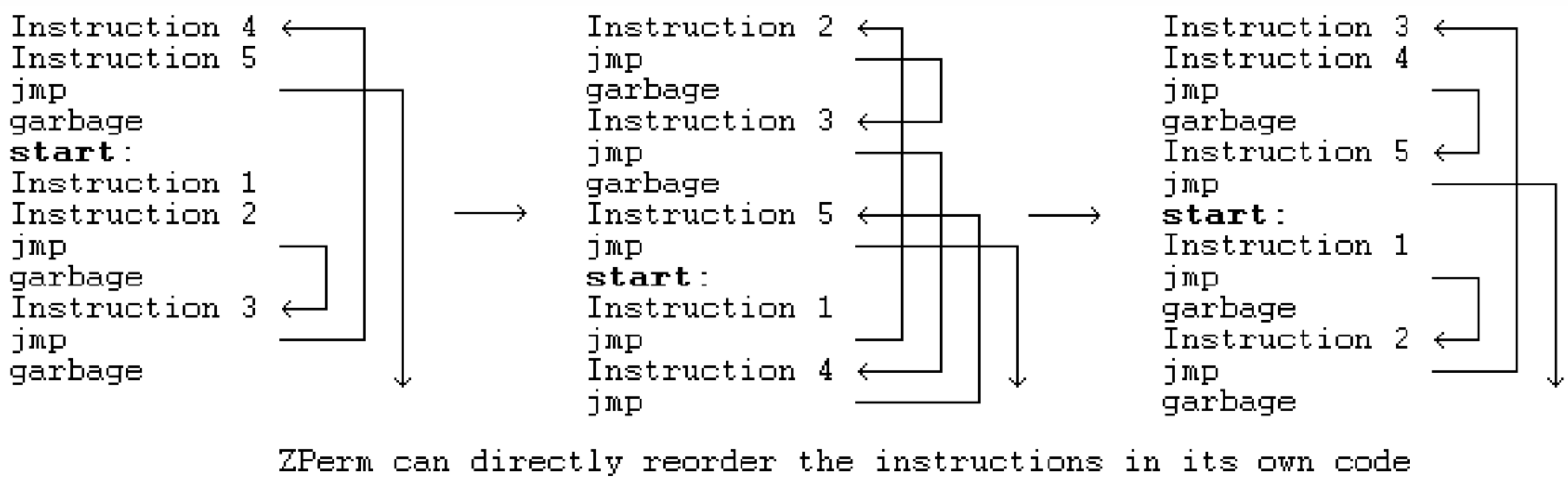
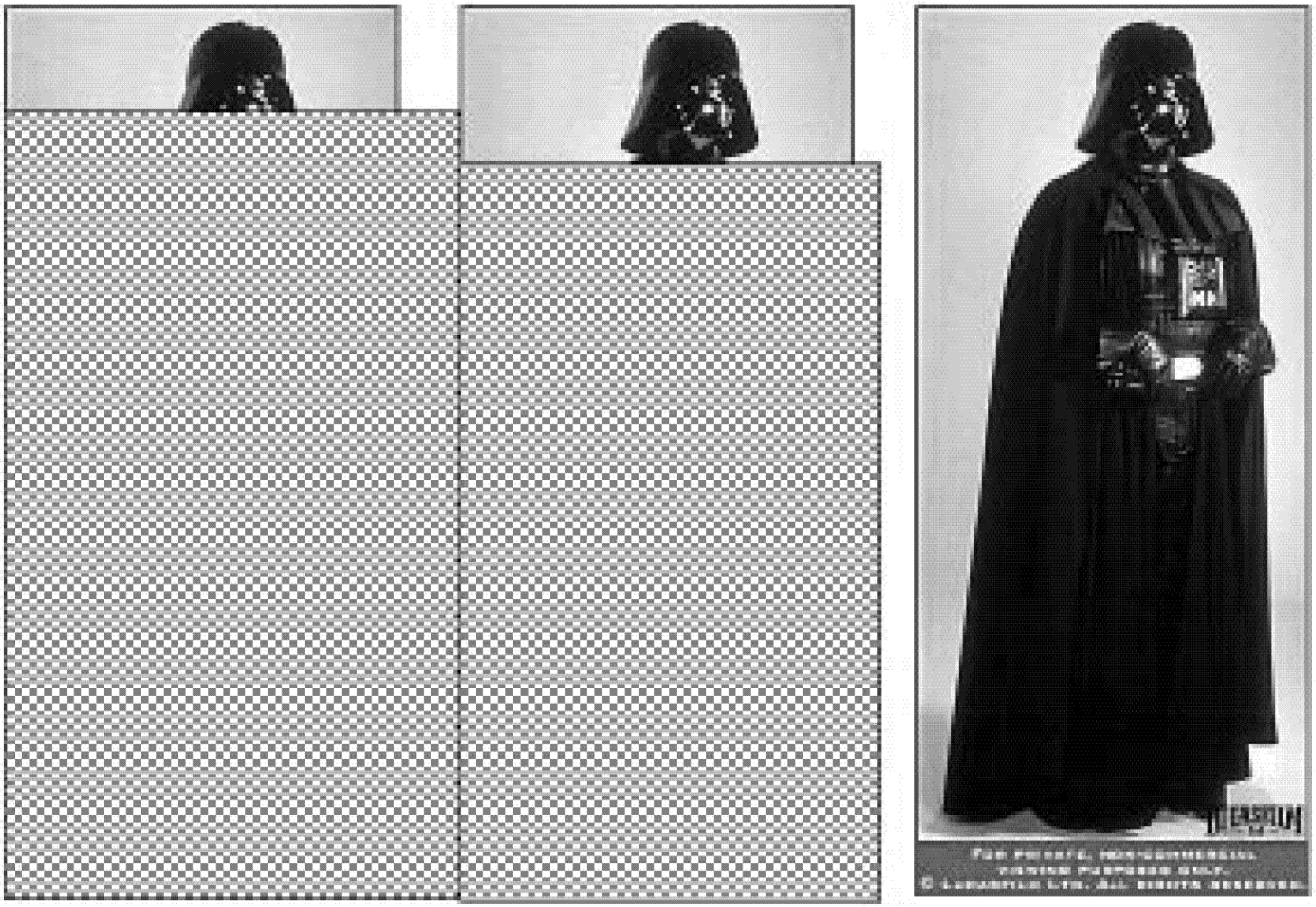


Figure 7. Zperm.A inserts JMP instruction into its code

```
a. An early generation:

C7060F000055   mov       dword ptr [esi],5500000Fh
C746048BEC5151 mov       dword ptr [esi+0004],5151EC8Bh

b. And one of its later generations:

BF0F000055     mov       edi,5500000Fh
893E           mov       [esi],edi
5F             pop       edi
52             push      edx
B640           mov       dh,40
BA8BEC5151     mov       edx,5151EC8Bh
53             push      ebx
8BDA           mov       ebx,edx
895E04         mov       [esi+0004],ebx

c. And yet another generation with recalculated ("encrypted") "con-
stant" data.

BB0F000055     mov       ebx,5500000Fh
891E           mov       [esi],ebx
5B             pop       ebx
51             push      ecx
B9CB00C05F     mov       ecx,5FC000CBh
81C1C0EB91F1   add       ecx,F191EBC0h ; ecx=5151EC8Bh
894E04         mov       [esi+0004],ecx
```

Figure 6: Example of code metamorphosis of Win32/Evol

Polymorphic



When can AV software successfully scan?

Figure 8: A partial or complete snapshot of polymorphic virus during execution cycle

Metamorphic

When can AV software successfully scan?

Figure 10: T-1000 of Terminator 2

Detecting metamorphic viruses?

Scanning isn’t enough

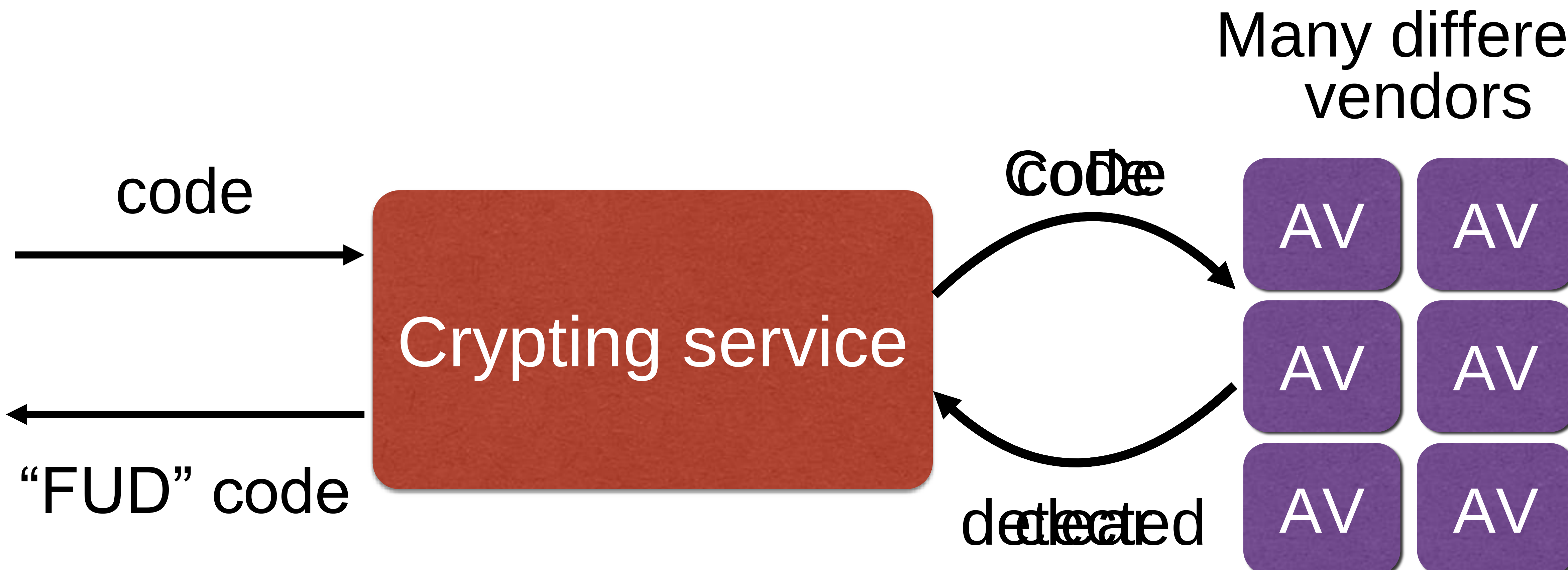
- Need to analyze execution behavior
- Two broad stages in practice (both take place in a safe environment, like gdb or a virtual machine)
  1. AV company analyzes new virus to find behavioral signature
  2. AV system at end host analyzes suspect code to see if it matches the signature

Detecting metamorphic viruses

- Countermeasures
  - Change slowly (hard to observe pattern)
  - Detect if you are in a safe execution environment (e.g., gdb) and act differently
- Counter-countermeasures
  - **Detect detection** and skip those parts
- Counter-counter-counter…. Arms race

Attackers have the upper hand:
AV systems hand out signature *oracles*

Crypting services



Iteratively obfuscate the code (encrypt + jmp + …)

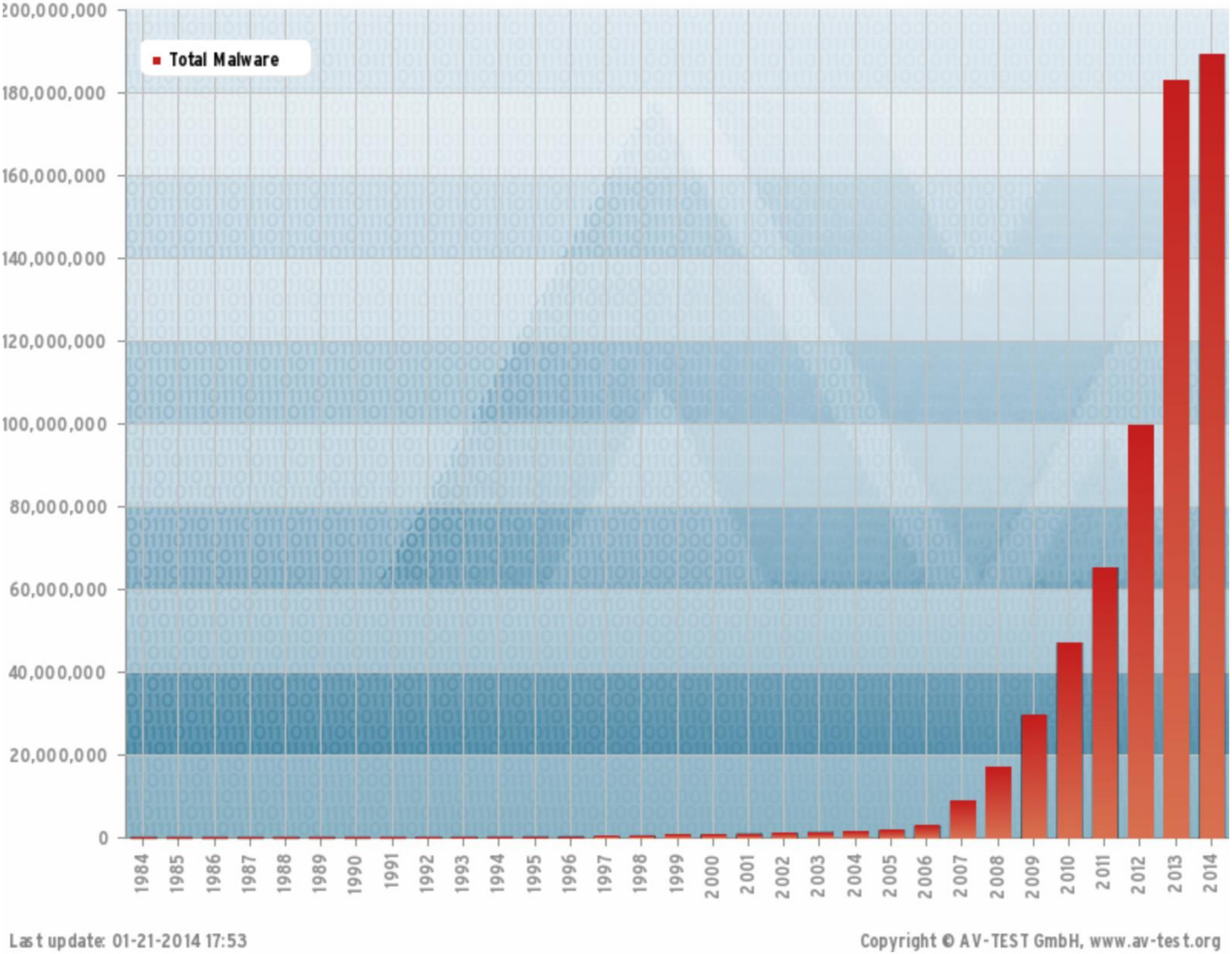
Until the obfuscated code is “fully undetectable”

So how much malware is out there?

- Polymorphic and metamorphic viruses can make it easy to *miscount* viruses

- Take numbers with a grain of salt
  - Large numbers are in the AV vendors' best interest

- Previously, most malware was showy
  - Now primary goal is frequently to not get noticed


Total Malware
200,000,000
180,000,000
160,000,000
140,000,000
120,000,000
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How do we clean up an infection?

- Depends what the virus did, but..

- May require restoring / repairing files
  - A service that antivirus companies sell

- What if the virus ran as root?
  - May need to rebuild the entire system

- So what, just recompile it?
  - What if the malware left a backdoor in your compiler?
    - Compile the malware back into the compiler
  - May need to use original media and data backups

Malware summary

- Technological arms race between those who wish to detect and those who wish to evade detection
- Started off innocuously
- Became professional, commoditized
  - Economics, cyber warfare, corporate espionage
- Advanced detection: based on behavior, anomalies
  - Must react to attacker responses