SOPHOS

Viruses and virus detection

Paul Jarvis

Virus Engine Team Leader

30 October 2002

The Virus lab teams

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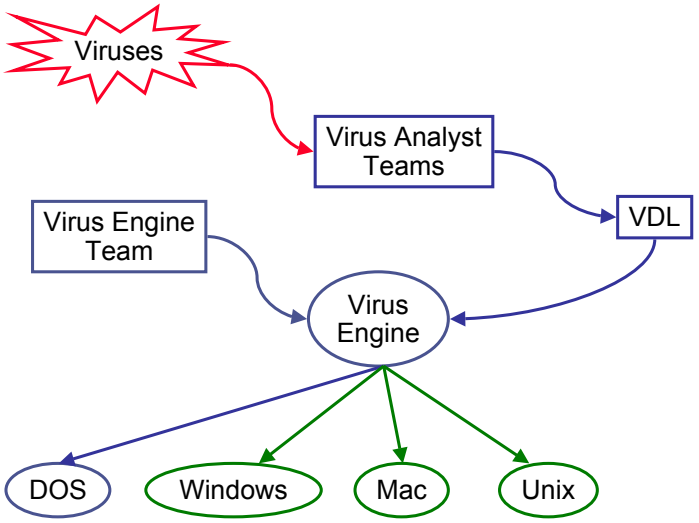

Viruses and virus detection

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- Introduction to viruses
- The changing threat
- Virus writers
- Virus types
- Executable file infection
- Virus hiding techniques
- Finding viruses

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Viruses and virus detection

Introduction to viruses

Malicious software attacks

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- Trojans
- Viruses
- Worms

Trojans

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- Executable code
- Do not self-replicate
- Unexpected result
- Usually malicious payload

Viruses

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- Self replication
- Require a host
- Executable path
- Side effects
- Disguise

Worms

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- “Self-contained” viruses
- Usually use the Internet

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Viruses and virus detection

The changing threat

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Viruses - a short history

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- 1982 - First self-replicating code (Xerox)
- 1984 - First paper on viruses (Fred Cohen)
- 1986 - First large-scale virus infection (Brain)
- 1987 - First anti-virus software
- 1992 - First virus construction kits
- 1998 - First Access, PowerPoint and Java viruses, CIH
- 1999 - First viruses mass spread by Email, Melissa
- 2001 - First ITW Unix viruses

Virus numbers

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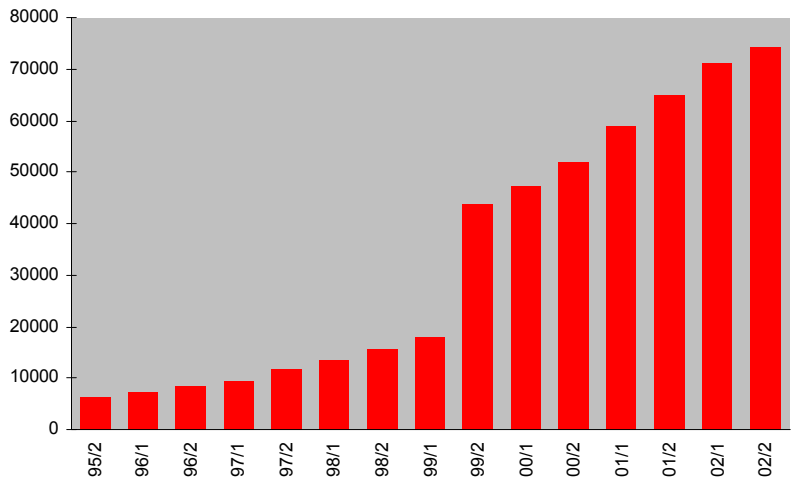

New viruses

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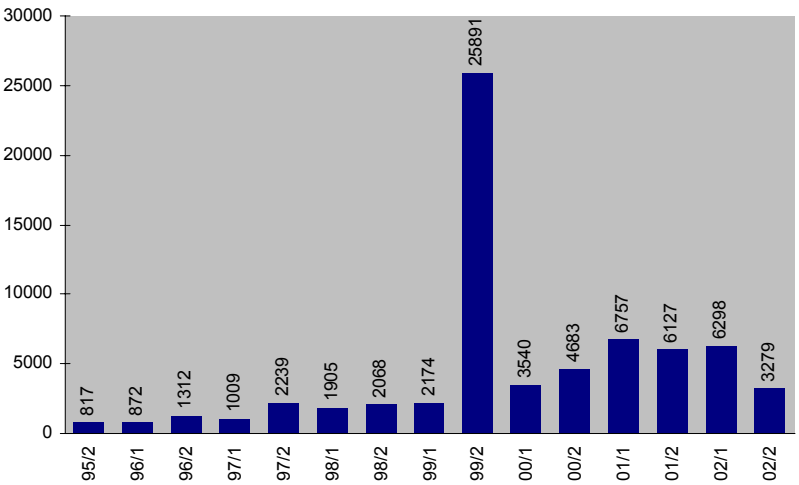

Overview of the Top 10 Reports

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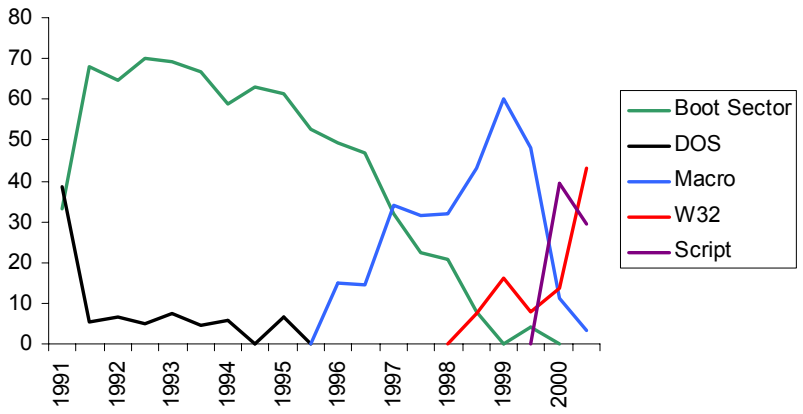

Viruses known to Sophos

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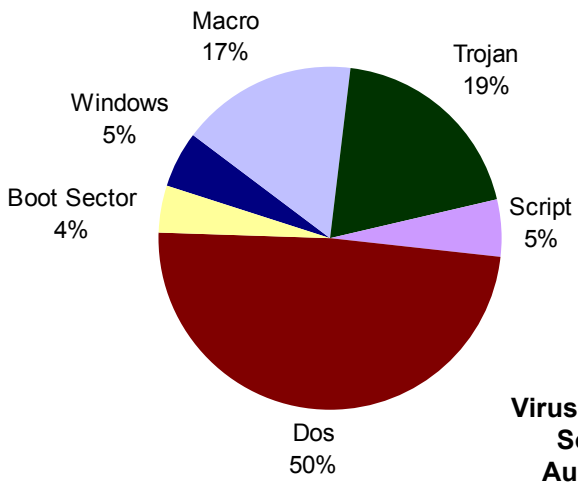

Viruses known to Sophos in August 2002

Viruses reported to Sophos

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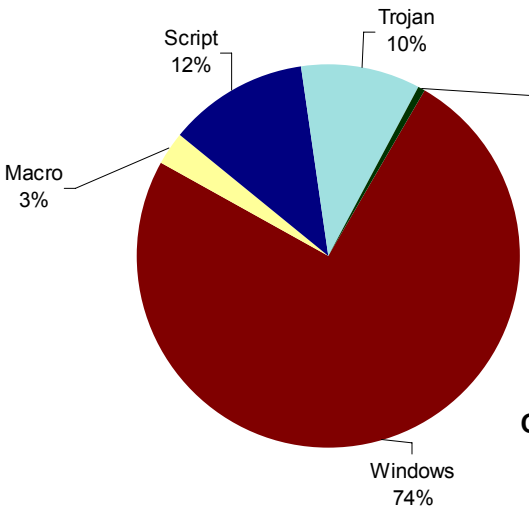

Customer reports to Sophos August 2002

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Viruses and virus detection

Virus writers

Who writes viruses?

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No “standard” virus writer, no “standard” motivation

- School children
- Undergraduates
- Post-graduates
- IT Professionals

Virus writers...

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- Are organised
- Publish books and magazines
- Exchange information
- Operate web sites
- Are (generally) male

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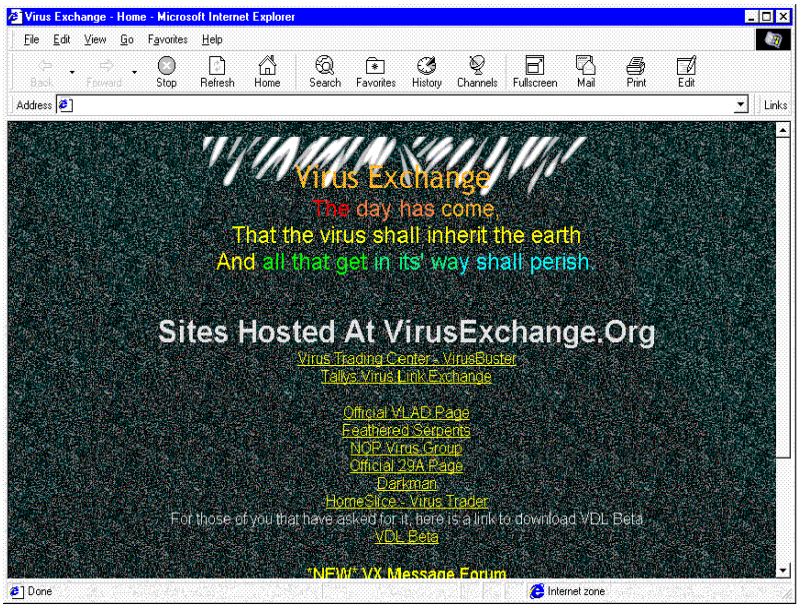

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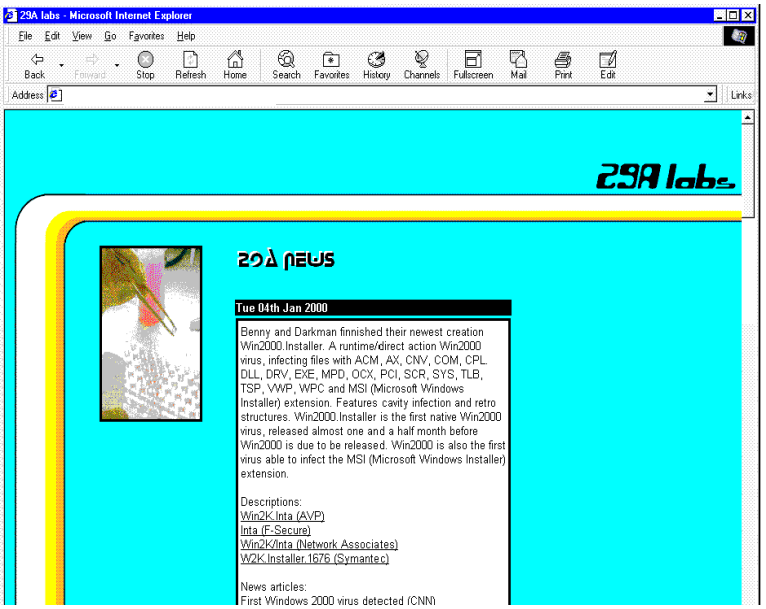

Virus construction tools

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- VCS (?, 1990)
- VCL (Nowhere Man [Nuke], 1992)
- PS-MPC (Phalcon/Skism, 1992)
- G2 (Phalcon/Skism, 1993)
- CVEX (Golden Cicada, 1995)
- Various WM toolkits (1997+)

Polymorphic toolkits

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- Mutation Engine (Dark Avenger, 1992)
- TPE (Masud Kafir, 1993)
- DSME (Taiwan, 1993)
- SMEG (England, 1995)
- WinLamer (Taiwan, 1995)
- RDA (?, 1995?)

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Viruses and virus detection

Virus types

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Virus types

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- Hoaxes
- Boot sector viruses
- Macro viruses
- Script viruses
- Executable viruses

Hoaxes

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- Always from a trusted source e.g. Microsoft, IBM
- Will do terrible things, e.g. delete all files without even opening the email
- Usually includes a request to forward on to everyone you know
- Examples:
  - Good Times
  - Irina
  - Penpal greetings
  - JOIN THE CREW

Boot sector viruses

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- Independent of installed operating system
- Cannot handle modern filing systems
- Generally spread by exchanging floppy disks
- Very effective spreading initially
- Currently no significant threat
- Can cause the operating system not to initialise

Macro viruses

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- Fast spread
- Mass infections
- Easy to write
- Easy to modify
- Cross-platform

Script viruses

SOPHOS

- Easy to write
- Easy to modify
- Existing tools
- No programming knowledge required

Executable viruses

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- Available for DOS, Win9x, NT/2000, Unix, Mac
- Are specific to operating system
- More complex to write
- Can use the operating system facilities (e.g. filestore access)

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Viruses and virus detection

Executable file infection

Overview

SOPHOS

- Only covering executable file infections
  (Other viral types are generally much more simple)
- Executable viruses require more knowledge to write and are thus usually more complex
- These often include code to hinder detection
- Recent additions include code to prevent disinfection

Com files

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- The most basic executable format on DOS
- Are small - maximum 64K
- Contain just the raw program
- Are copied into memory and run
- Very simple to infect

Infecting com files

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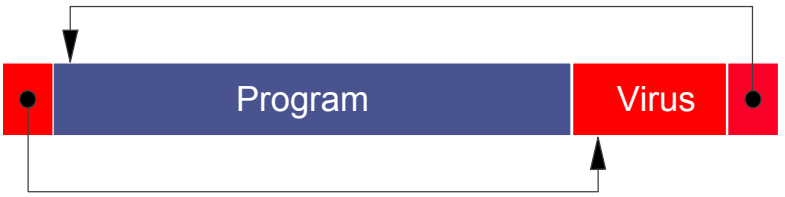

Com files

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- Increase in file size
- Care required to not multiply infect a file
- Require ‘stealth’ to hide
- Not straight forward to disinfect

Exe (16 bit files)

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- Have a defined structure
- Can be large
- Can use overlays
- Simple to infect

MZ File format

SOPHOS

MZ header
Image size
Entry point
Relocation table(s)
Code

```
4D 5A 9A 00 29 00 00  00-20 00 C5 00 FF FF A7 05  MZ..)... ....
80 00  00 00 10 00 CF 04-1E 00 00 00 01  00 00 00  ................
00 00  00 00 00 00 00  00-00 00 00 00 00  00 00 00  ................
00 00  00 00 00 00 00  00-00 00 00 00 00  00 00 00  ................
00 00  00 00 00 00 00  00-00 00 00 00 00  00 00 00  ................
00 00  00 00 00 00 00  00-00 00 00 00 00  00 00 00  ................
00 00  00 00 00 00 00  00-00 00 00 00 00  00 00 00  ................
00 00  00 00 00 00 00  00-00 00 00 00 00  00 00 00  ................
```

Exe (16 bit files)

SOPHOS

- Similar infection to com files
- Header requires correct updating
- Stealth to hide size change
- Slightly more difficult to disinfect

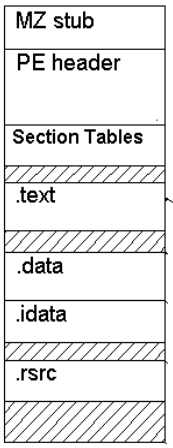
Exe (32 bit files)

SOPHOS

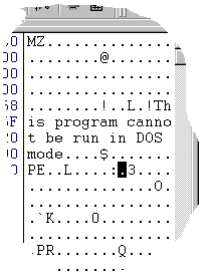
- Have a defined structure
- More complicated than 16 bit exe
- Can be very large
- Start with a 16 bit ‘stub’
- Slightly harder to infect

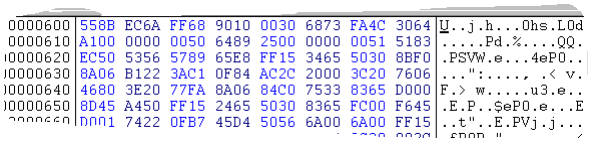
PE File format

SOPHOS



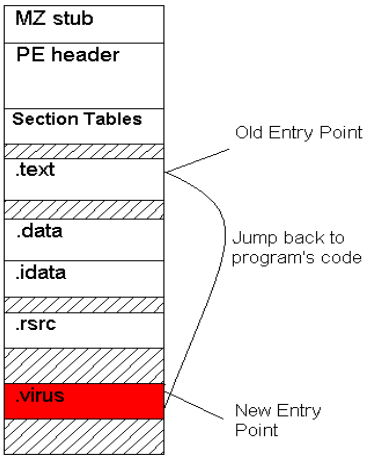
Entry Point





Simple Win32 virus

SOPHOS



Exe (32 bit files)

SOPHOS

- Header requires correct updating
- Stealth to hide size change, but ...
- File structure leaves gaps
- Cavity infection leaves no size change

Cavity infection

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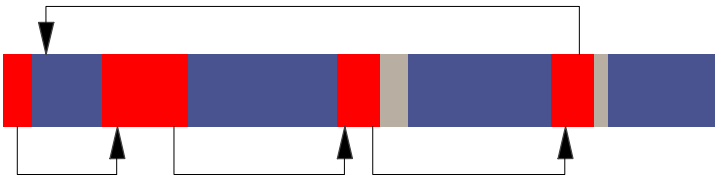
Uninfected program (grey = unused)



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Viruses and virus detection

Virus hiding techniques

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Hiding techniques

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- Originally hiding required to:
  - Ensure further infection before detection
  - To remain undetected until the payload activates - trigger date.
- Currently:
  - Mass emailers don't bother to hide
  - Back doors require to remain undetected

Hiding techniques

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- If active in memory then a virus can:
  - infect other files
  - ‘hack’ requests that would reveal it
- The virus can hide in files using:
  - Encryption
  - Polymorphism
  - Metamorphism

Normal system

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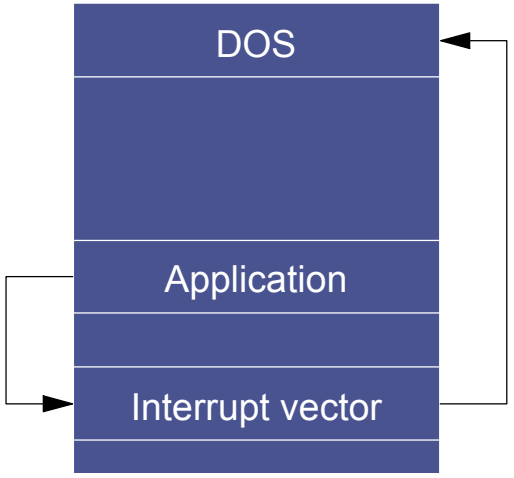

Device driver installed

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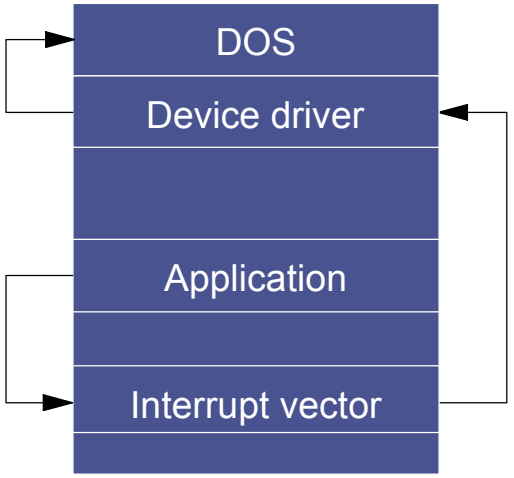

Virus installed

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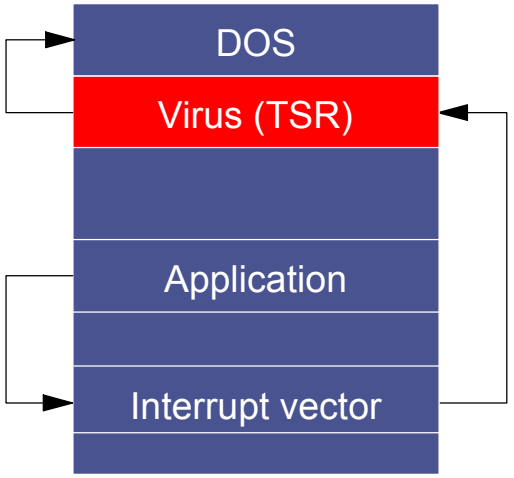

Encrypted virus

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Program 1	DEYu*&81|p[@#
Program 2	DE132{+as$5\%6
Program 3	DE!"334%'dfs6456

Polymorphic virus

SOPHOS

Program 1	DEYu*&81|p[@#
Program 2	4k132{+as$5\%6
Program 3	^x!"334%'dfs6456

Metamorphic viruses

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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") "constant" 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
```

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Viruses and virus detection

Finding viruses

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Finding viruses

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- With a simple executable virus this is quite straight forward:
  - Use the header to find the entry point
  - Read the code bytes at the entry point
  - Compare these bytes to the virus identities
- Win32 virus identity

Proprietary information removed

Detection of encrypted viruses

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- The decryption loop is constant
- We can simply search for the encryption loop itself, and/or the virus in it's encrypted form
- Encrypted virus are almost as easy to process as unencrypted ones
- Polymorphic viruses are more of a problem

Detection of polymorphic viruses

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- Originally detection was done using only our ‘Virus Definition Language’ (VDL) to follow the decryption loop
- The identities were very complex and have to be run on every executable file
- Care was required to avoid the identity being too slow

Identity for a polymorphic virus

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Proprietary information removed

The solution is … an emulator

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- The virus engine now includes an emulator to simulate a program running on a Windows PC
- At its heart is a simple loop:
  - Read code bytes
  - Decode code bytes
  - Execute the decoded instruction
  - Track any writes to memory
  - Move to the start of the next code bytes

What does it do?

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- When it is run on a polymorphic virus, the emulator will track the decryption of the virus body as it is written to memory
- In most cases, we only need to decrypt some of the virus body to recognise the virus
- This constant decrypted virus body can then be given to VDL. This makes detection of polymorphic virus much simpler

The benefits of the emulator

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- Creating identities is easier and quicker:
  - The analysts don't have to study the virus code in as much depth
- Scanning files is quicker:
  - The emulator is run on every executable file. Luckily most clean executables stop emulating after only a few instructions and so generally emulation is quick
  - The complicated polymorphic identities are no longer used so the overall scanning is faster

Emulator virus identity

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Proprietary information removed

Problems with emulation

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- The main problem is knowing when to stop
- The emulator needs to be run long enough to decrypt some of the virus body
- But it must not slow down the scanning of clean files
- One solution is to use VDL to control the emulator

Decryption of the virus body

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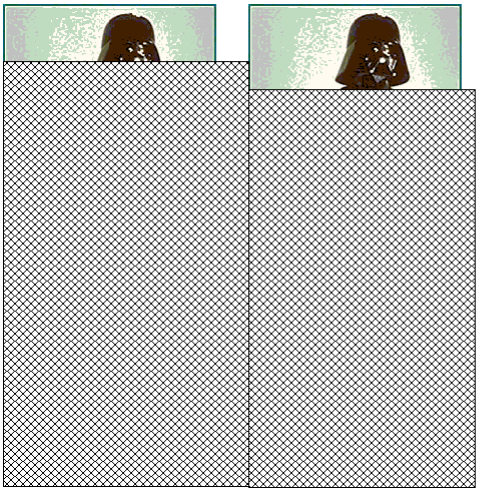

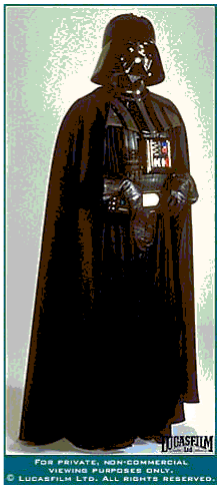

Tracking the virus body

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- The decryption of the virus body can happen in many ways
- The simplest is a forward growing continuous block
- Other methods are used just to make detection harder. For example:

Backwards

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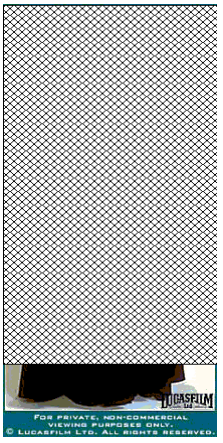

Nested

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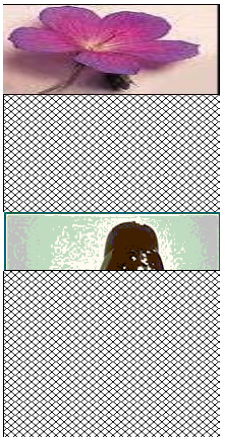

Multiple buffers

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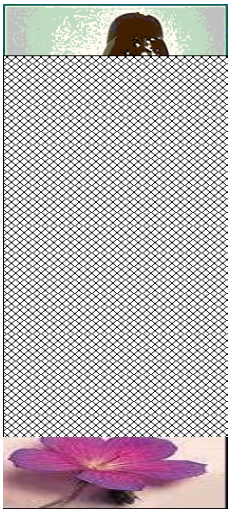

Random order

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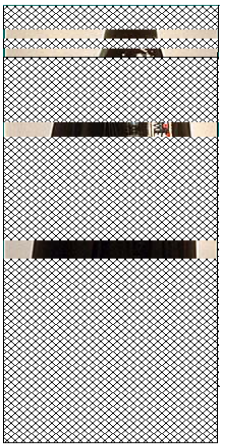

Anti-emulation tricks

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- Virus writers put tricks in their virus code to make emulators fail:
  - Calls to dll functions
  - Do nothing loops
  - Junk instructions
  - Using structured exception handling
  - Random virus code execution
  - Checking elapsed time
- An emulator has to keep changing as the virus writers come up with new tricks

New challenges

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- .Net Framework for Windows XP:
  - The executables for XP have an extended PE file format
  - There are no viruses at present
  - They have a new instruction set which is complied when the file is run (JIT compilation)
- Metamorphic Viruses:
  - No constant virus body anywhere
  - The actual virus code changes

W95/Zmist

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- "Undetectable Virus Technology"
- ZMist has a bit of everything:
  - Sometimes it has polymorphic decryptors
  - It is metamorphic
  - It merges itself with the original file's code
- How can we detect ZMist?
  - Look at the file structure. This will give false positives
  - Use the emulator to look for important instructions

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Viruses and virus detection

Paul Jarvis

Virus Engine Team Leader

Sophos plc

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