

# Lecture 05 – Malware

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# Malware definition and goals

- What is malware?
  - Set of instructions that run on your computer and do something an attacker wants it to do.
- Muddled Taxonomy, but difference primarily
  - How they get on your machine
  - What do they do

Encounter rate trends for the locations with the most computers reporting malicious and unwanted software encounters in 1H16, by number of computers reporting Country/Region

Country/Region	3Q15	4Q15	1Q16	2Q16
United States	10.8%	12.5%	11.9%	12.0%
China	14.9%	18.9%	19.1%	21.1%
Brazil	29.2%	34.4%	29.9%	29.4%
Russia	22.8%	28.7%	27.2%	24.9%
India	36.5%	44.2%	35.4%	32.6%
Turkey	32.6%	40.3%	34.8%	31.4%
France	18.8%	19.4%	17.0%	15.3%
Mexico	23.9%	28.5%	24.4%	23.8%
United Kingdom	11.9%	13.9%	13.7%	11.5%
Germany	12.2%	13.8%	13.0%	13.0%
Worldwide	17.8%	20.8%	18.3%	21.2%

# The Problem of Malware

- How does it manage to run?
  - Buffer overflow in network-accessible vulnerable service
  - Vulnerable client (e.g. browser) connects to remote system that sends over an attack (a *driveby*)
  - *Social engineering*: trick user into running/installing
  - “Autorun” functionality (esp. from plugging in USB device)
  - Slipped into a system component (at manufacture; compromise of software provider; substituted via MITM)
  - Attacker with local access downloads/runs it directly
    - Might include using a “local root” exploit for privileged access

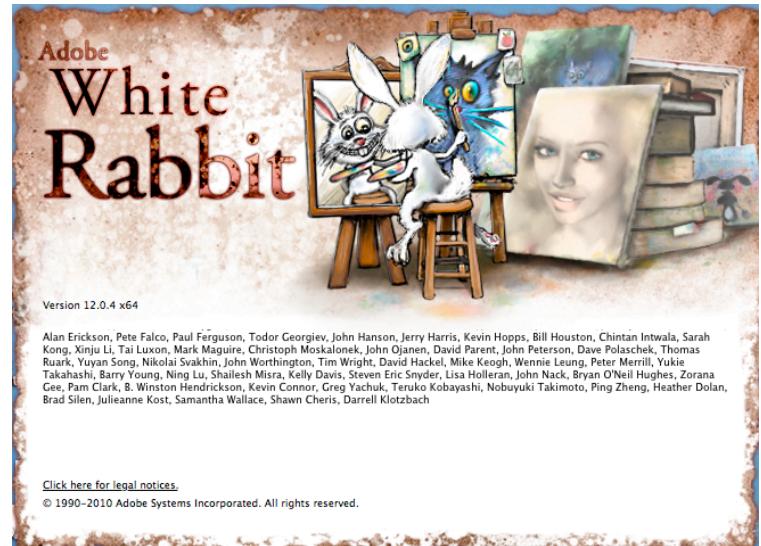
# Insider Attacks

- An **insider attack** is a security breach that is caused or facilitated by someone who is a part of the very organization that controls or builds the asset that should be protected.
- In the case of malware, an insider attack refers to a security hole that is created in a software system by one of its programmers.

# Backdoors

- A **backdoor**, which is also sometimes called a **trapdoor**, is a hidden feature or command in a program that allows a user to perform actions he or she would not normally be allowed to do.
- When used in a normal way, this program performs completely as expected and advertised.
- But if the hidden feature is activated, the program does something unexpected, often in violation of security policies, such as performing a privilege escalation.
- Benign example: **Easter Eggs** in DVDs and software

# Easter Eggs



# Logic Bombs

- A **logic bomb** is a program that performs a malicious action as a result of a certain logic condition.
- The classic example of a logic bomb is a programmer coding up the software for the payroll system who puts in code that makes the program crash should it ever process two consecutive payrolls without paying him.
- Another classic example combines a logic bomb with a backdoor, where a programmer puts in a logic bomb that will crash the program on a certain date.



# The Omega Engineering Logic Bomb

FEBRUARY 23, 1998 VOLUME 15, NUMBER 8

# NetworkWorld

THE NEWSWEEKLY OF ENTERPRISE NETWORK COMPUTING

Going with  
Gigabit Ethernet

GMAC's Niraj Patel has learned firsthand about the high-speed net technology. Page 9.

- An example of a logic bomb that was actually triggered and caused damage is one that programmer Tim Lloyd was convicted of using on his former employer, Omega Engineering Corporation.
- On July 31, 1996, a logic bomb was triggered on the server for Omega Engineering's manufacturing operations, which ultimately cost the company millions of dollars in damages and led to it laying off many of its employees.

## A view into a network attack

Net administrator charged in \$10M "logic bomb" case.

By Ellen Messmer  
Bridgeport, Conn.

In one of the costliest reported acts of computer sabotage, an engineering company next month will prosecute its former network administrator for electronically destroying computer files that the company claims cost it about \$10 million in sales.

Omega Engineering, Inc. is set to go to trial against Timothy Lloyd, the chief network program designer, who the company said planted a LAN-based logic bomb that went off after his job was terminated. The logic bomb wiped

out all the files on the company's Novell, Inc. network-based servers.

What detonated the Omega bomb was not immediately clear.

Security experts said a logic bomb usually is a software program that, once activated by a specific date for example, eats through files or reformats hard drives. The bomber's intent is to hopelessly damage and erase data.

"[Logic bombs] can be as simple as a script that runs a bunch of delete commands," said Chris Byrnes, vice president for servers and systems management strategy



*See Bomb, page 16*

# The Omega Bomb Code

- The Logic Behind the Omega Engineering Time Bomb included the following strings:
- 7/30/96
  - Event that triggered the bomb
- F:
  - Focused attention to volume F, which had critical files
- F:\LOGIN\LOGIN 12345
  - Login a fictitious user, 12345 (the back door)
- CD \PUBLIC
  - Moves to the public folder of programs
- FIX.EXE /Y F:\\*.\*
  - Run a program, called FIX, which actually deletes everything
- PURGE F:\ALL
  - Prevent recovery of the deleted files

# Defenses against Insider Attacks

- Avoid single points of failure.
- Use code walk-throughs.
- Use archiving and reporting tools.
- Limit authority and permissions.
- Physically secure critical systems.
- Monitor employee behavior.
- Control software installations.

# LOGIC BOMB SET OFF SOUTH KOREA CYBERATTACK



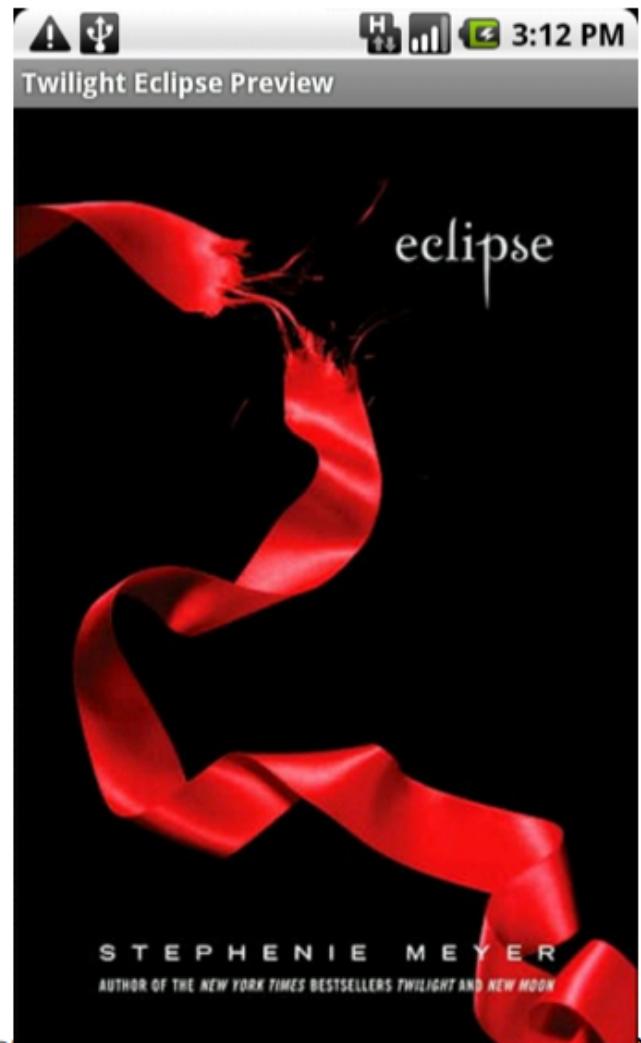
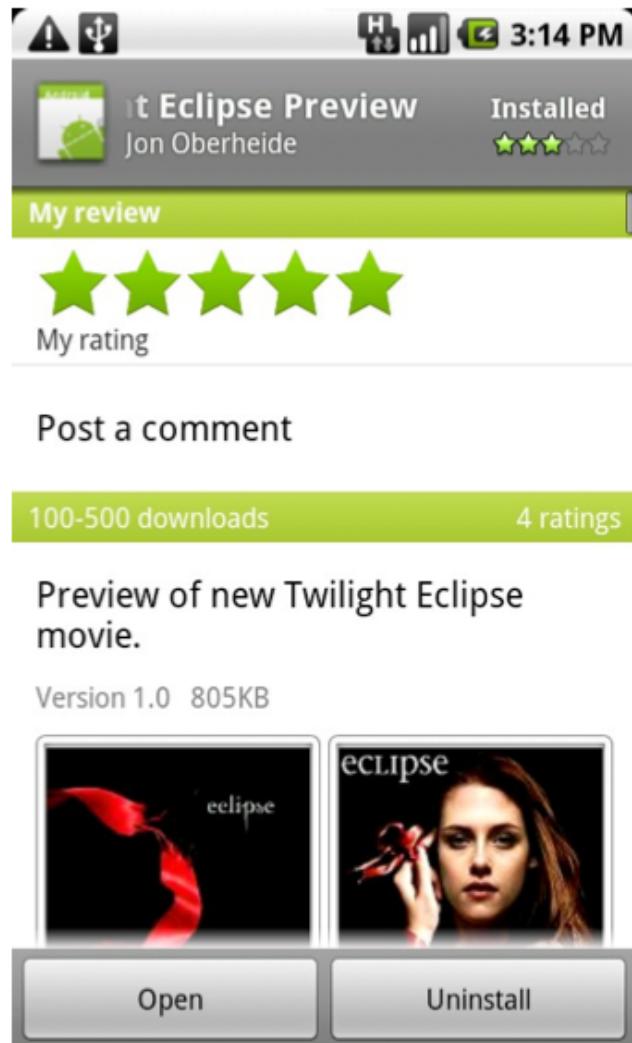
A disconnected computer monitor is seen at a newsroom of Korean Broadcasting System (KBS) at its headquarter in Seoul, South Korea, Wednesday, March 20, 2013. Computers networks at two major South Korean banks and three top TV broadcasters went into shutdown mode en masse Wednesday, paralyzing bank machines across the country. *Photo: AP/Kim Ju-sung, Yonhap*

# Trojan horse

- Software that appears to perform a desirable function but is actually designed to perform undisclosed malicious functions
  - Spyware: installed by legitimate looking programs, then provides remote access to the computer, such as logging keys or sending back documents
  - Adware: shows popup ads
  - Ransomware: encrypts data and requires payment to decrypt



# Android Example



# Example (cont.)

Comments

Andy 6/16/2010 ★★★★☆

Defective

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Jaime 6/16/2010 ★★★★☆

Loads but you can't see any other photos

[Read all comments](#)

- Still, 200+ downloads in under 24 hours
- With a legit-looking app/game, you could collect quite an install base for Rootstrap

# Repackaging

Android Market

Apps | Music | Books | Movies | My Library | Search

## Apps by Rovio Mobile Ltd

Visit Website for [Rovio Mobile Ltd](#)

 Angry Chicken ROVIO MOBILE LTD ★ First time ever, available for FREE! Get your copy while you can! ★★★★★ <a href="#">INSTALL</a>	 Very Hungry Cat ROVIO MOBILE LTD New game from the authors of Glass Tower series! Meow! The Cat is very hungry... ★★★★★ <a href="#">INSTALL</a>	 Crazy Penguin Catapult ROVIO MOBILE LTD The penguins are back and they mean business! Those polar bears are going to... ★★★★★ <a href="#">INSTALL</a>
 Bloons TD 4 ROVIO MOBILE LTD Brand new Apocolypse mode now available! How long can you survive? There's no... ★★★★★ <a href="#">INSTALL</a>	 Jetpack Joyride ROVIO MOBILE LTD Join Barry as he breaks in to a secret laboratory to commence the experiment... ★★★★★ <a href="#">INSTALL</a>	 Madden NFL 12 ROVIO MOBILE LTD Real teams. Real players. Real NFL. MADDEN NFL 12. True to the Game. GOON F... ★★★★★ <a href="#">INSTALL</a>
 Catch The Candy ROVIO MOBILE LTD Help a hungry little fuzzy creature as he uses his extendible grapping tongue... ★★★★★ <a href="#">INSTALL</a>	 Touch Grind ROVIO MOBILE LTD "one of the best games available for the platform" - Olymeda Winner of Most... ★★★★★ <a href="#">INSTALL</a>	 Batman Arkham City Lockdown ROVIO MOBILE LTD The inmates have escaped and Batman has his hands full defeating an army of h... ★★★★★ <a href="#">INSTALL</a>
 Chuzzle ROVIO MOBILE LTD It's a non-stop explosion of adorable action! Spin, zing and nudge chuzzles... ★★★★★ <a href="#">INSTALL</a>	 Rope N Fly ROVIO MOBILE LTD #1 top free app in US, France, Germany, UK, Australia, and more! #10 top the... ★★★★★ <a href="#">INSTALL</a>	 Cartoon Wars 2 Heroes ROVIO MOBILE LTD The most complete defense and real-time strategy game of the Cartoon Wars seri... ★★★★★ <a href="#">INSTALL</a>

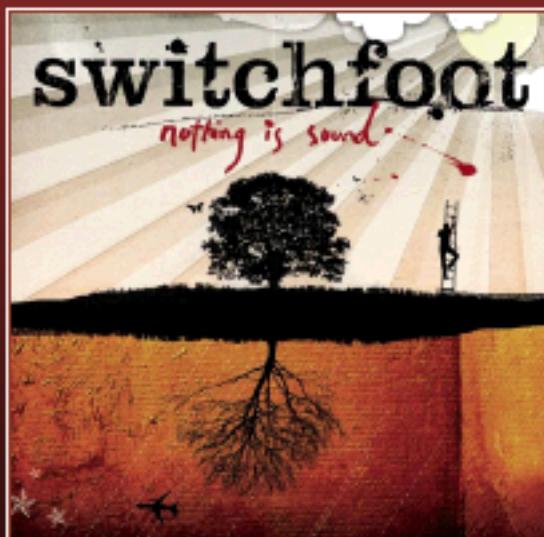


# Switchfoot

Nothing Is Sound



MUSIC



Lonely Nation	03:45
Stars	04:20
Happy Is A Yuppie Word	04:51
The Shadow Proves The Sunshine	05:04
Easier Than Love	04:29
The Blues	05:17
The Setting Sun	04:24
Politicians	03:28
Golden	03:36
The Fatal Wound	02:44
We Are One Tonight	04:42

Lonely Nation 00:00

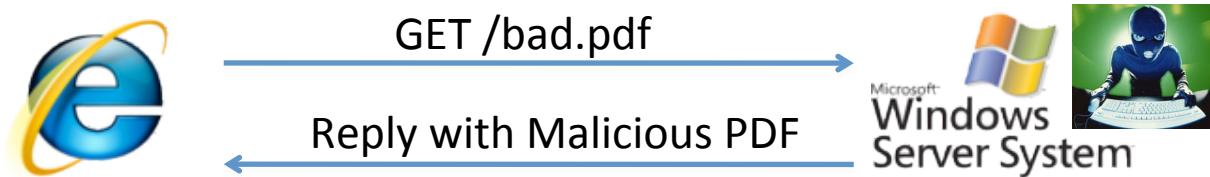
## CONSUMER ALERT

Please disregard this message if you have already updated the XCP software on this computer.

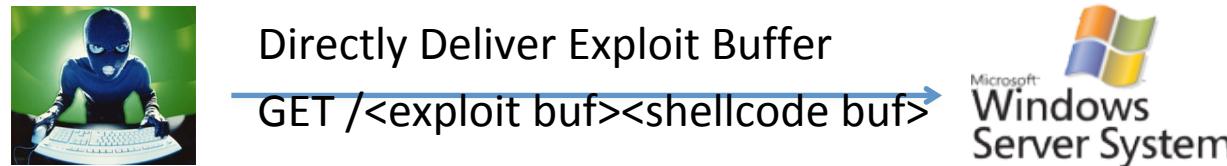
This CD contains XCP content protection technology. Installing XCP software on your computer may make it vulnerable to certain computer viruses. Click here for a security update to eliminate this vulnerability and for more information about XCP software.

# Code Injection Exploits

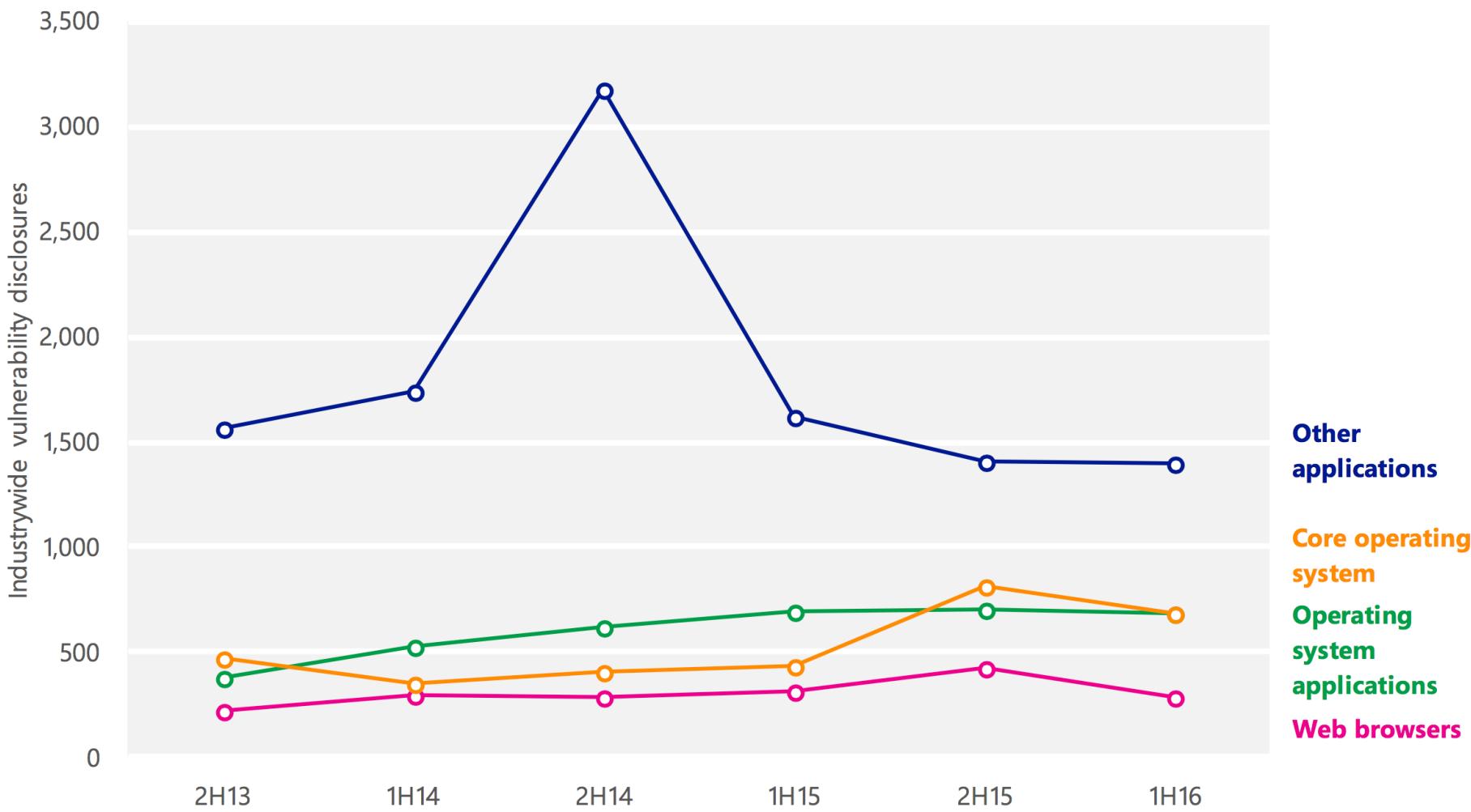
- Client software exploit (e.g. PDF, Flash, MSWord, etc.)



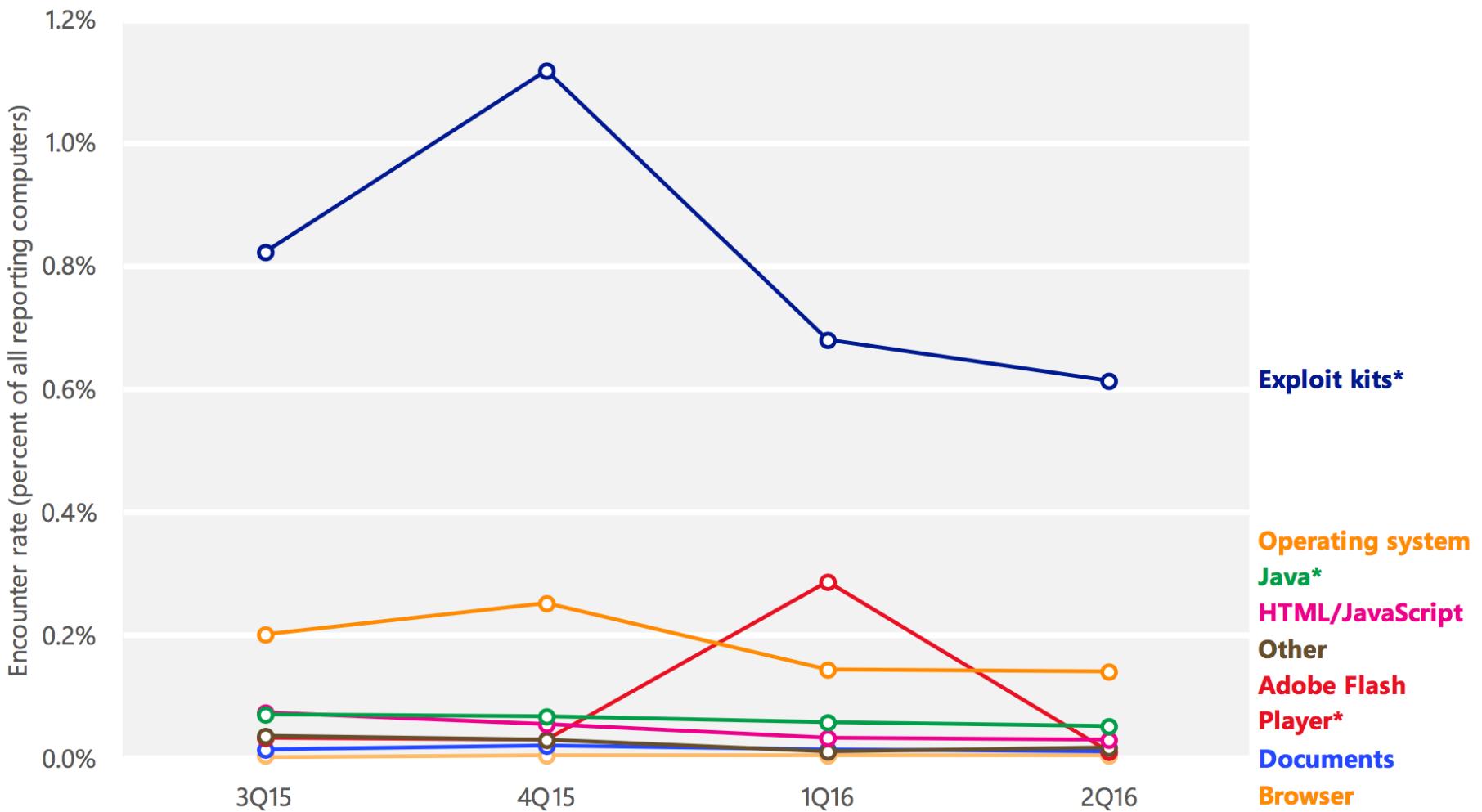
- Network-based exploit (HTTP, File, RPC servers, etc.)



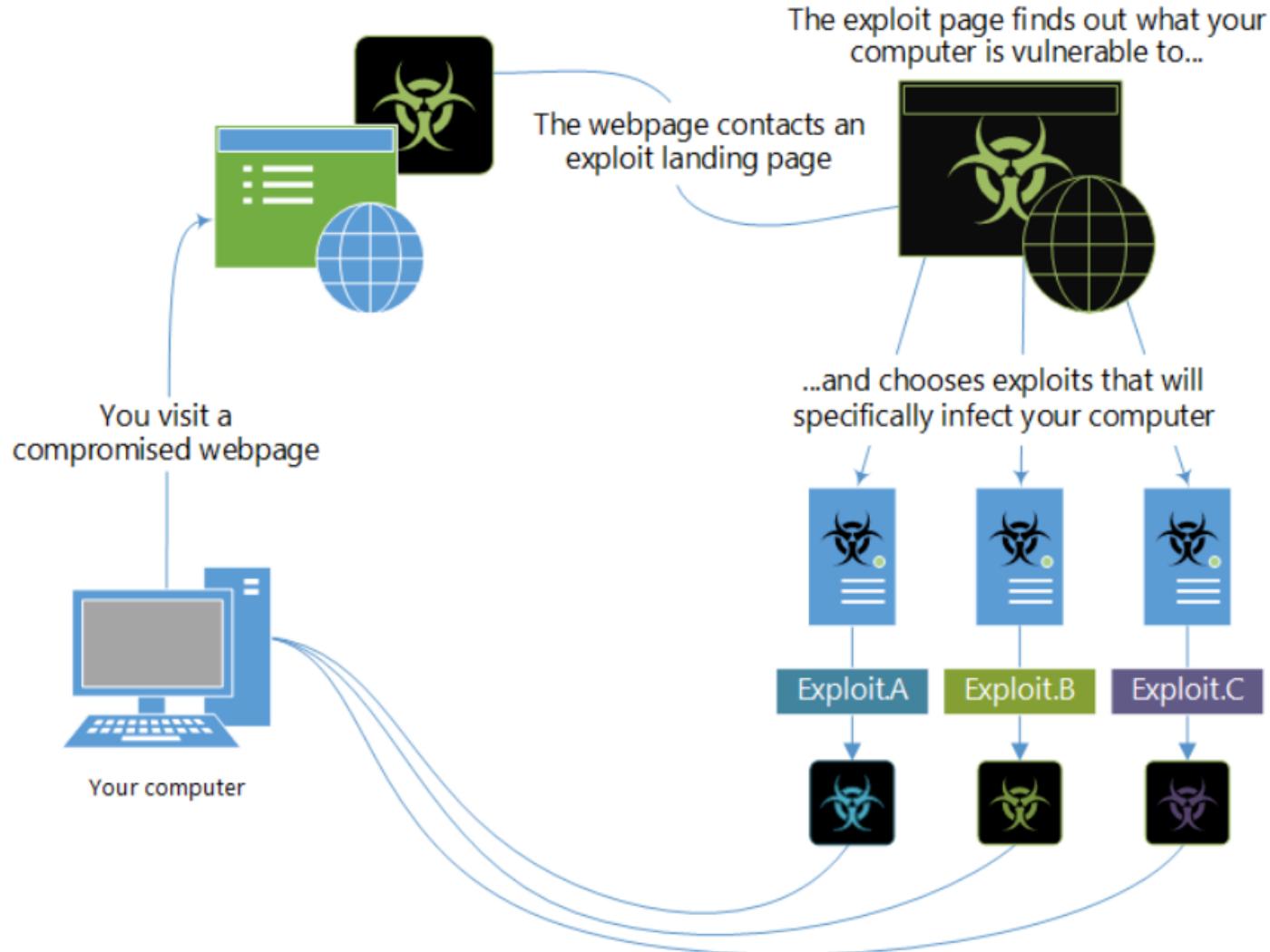
# Industry-wide operating system, browser, and application vulnerabilities, 2H13–1H16



# Encounter rates for different types of exploit attempts, 3Q15–2Q16



# How a typical exploit kit works



# Malware That Automatically Propagates

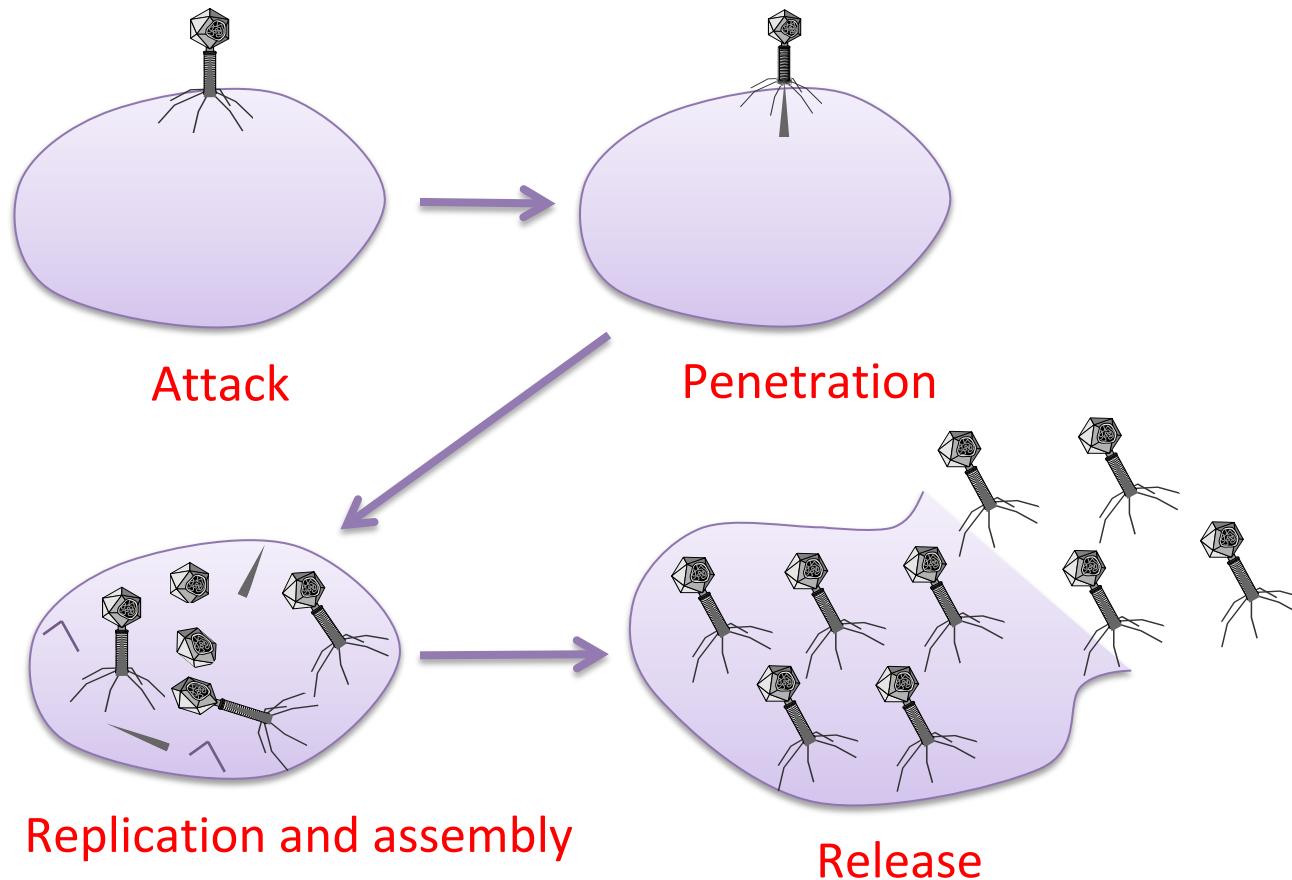
- Virus = code that propagates (**replicates**) across systems by arranging to have itself *eventually executed*, creating anew additional instance
  - Generally infects by altering stored code
  - Typically with the help of a user
- Worm = code that self-propagates/replicates across systems by arranging to have itself *immediately executed* (creating new addl. instance)
  - Generally infects by altering running code
  - No user intervention required
- (Note: line between these isn't always so crisp; plus some malware incorporates both styles)

# Computer Viruses

- A **computer virus** is computer code that can replicate itself by modifying other files or programs to insert code that is capable of further replication.
- This self-replication property is what distinguishes computer viruses from other kinds of malware, such as logic bombs.
- Another distinguishing property of a virus is that replication requires some type of **user assistance**, such as clicking on an email attachment or sharing a USB drive.

# Biological Analogy

- Computer viruses share some properties with Biological viruses



# Brain

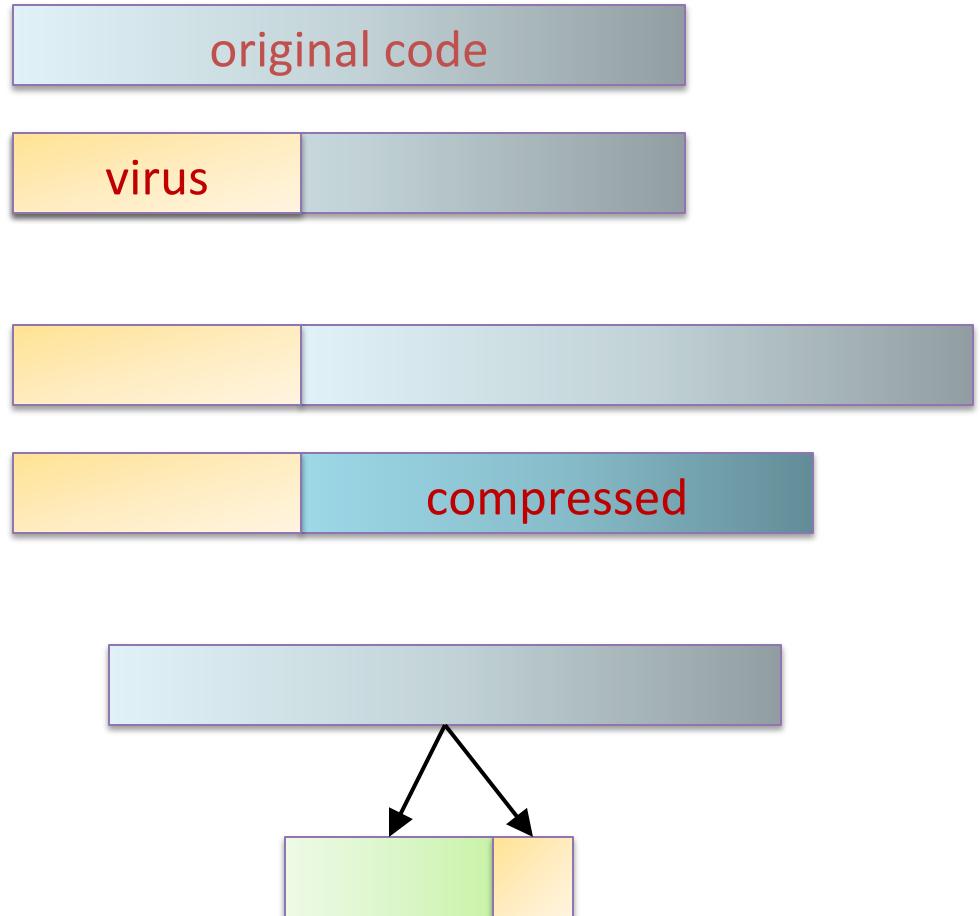
PC Tools Deluxe M.22														Disk View/Edit Service							
Path=4:																					
Absolute sector 0000000, System BOOT																					
Displacement														Hex codes							
0000(0000)	FA	E9	4A	01	34	12	00	07	14	08	01	08	00	00	00	00	20				
0016(0010)	20	20	20	20	20	20	57	65	6C	63	6F	6D	65	20	74	6F					
0032(0020)	20	74	68	65	20	44	75	6E	67	65	6F	6E	20	20	20	20	20				
0048(0030)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20				
0054(0040)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20				
0060(0050)	20	28	63	29	20	31	39	38	35	20	42	61	73	69	74	20					
0096(0060)	26	20	41	6D	6A	61	64	20	28	78	76	74	29	20	4C	74					
0112(0070)	64	2E	28	28	28	28	28	28	20	20	28	28	28	28	28	28	28				
0128(0080)	28	42	52	41	49	4E	20	43	4F	4D	50	55	54	45	52	20					
0144(0090)	53	45	52	56	49	43	45	53	2E	2E	37	33	30	20	4E	49					
0160(00A0)	5A	41	4D	20	42	4C	4F	43	4B	20	41	4C	4C	41	4D	41					
0176(00B0)	20	49	51	42	41	4C	20	54	4F	57	4E	20	20	20	20	20					
0192(00C0)	20	20	20	20	20	20	20	20	20	20	4C	41	48	4F	52						
0208(00D0)	45	2D	58	41	48	49	53	54	41	4E	2E	2E	58	48	4F	4E	LAHOR				
0224(00E0)	45	28	3A	34	33	38	37	39	31	2C	34	34	33	32	34	38	E :PAKISTAN..PHON				
0240(00F0)	2C	32	38	38	35	33	38	2E	20	20	20	20	20	20	20	20	E :430791,443248 ,280530.				
Home=beg of file/disk End=end of file/disk														ESC=Exit PgDn=forward PgUp=back F2=chg sector num F3=edit F4=get name							

# Virus Phases

- **Dormant phase.** During this phase, the virus just exists—the virus is laying low and avoiding detection.
- **Propagation phase.** During this phase, the virus is replicating itself, infecting new files on new systems.
- **Triggering phase.** In this phase, some logical condition causes the virus to move from a dormant or propagation phase to perform its intended action.
- **Action phase.** In this phase, the virus performs the malicious action that it was designed to perform, called **payload**.
  - This action could include something seemingly innocent, like displaying a silly picture on a computer's screen, or something quite malicious, such as deleting all essential files on the hard drive.

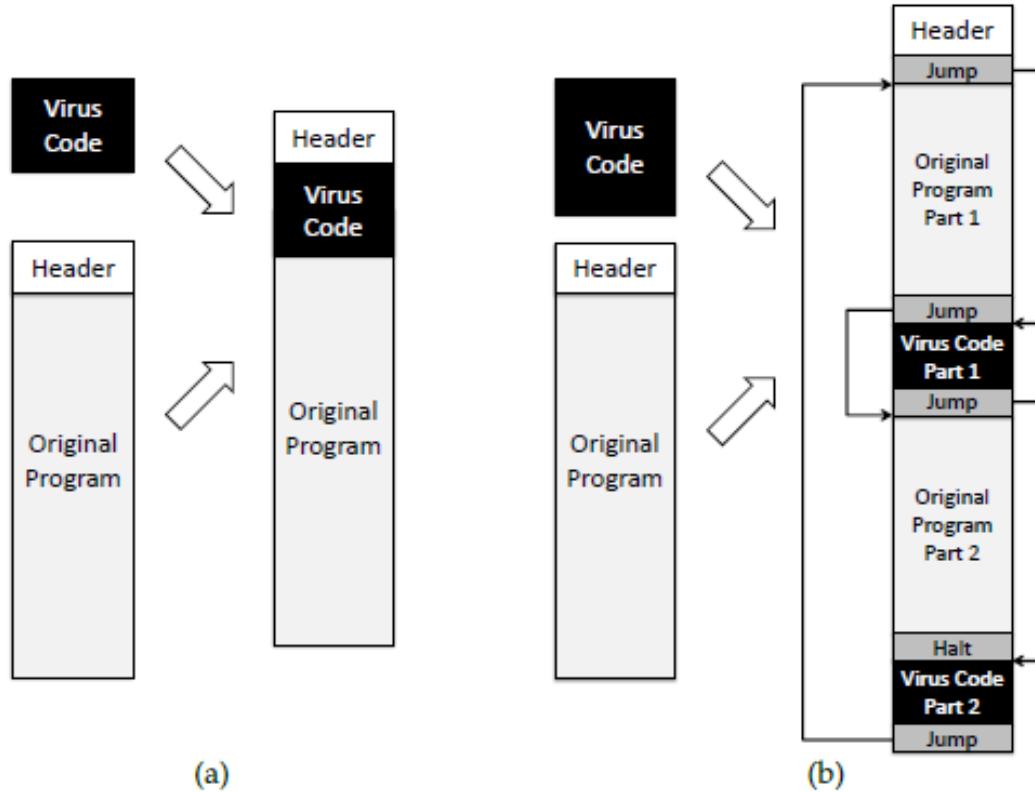
# Infection Types

- Overwriting
  - Destroys original code
- Pre-pending
  - Keeps original code, possibly compressed
- Infection of libraries
  - Allows virus to be memory resident
  - E.g., kernel32.dll
- Macro viruses
  - Infects MS Office documents
  - Often installs in main document template



# Degrees of Complication

- Viruses have various degrees of complication in how they can insert themselves in computer code.



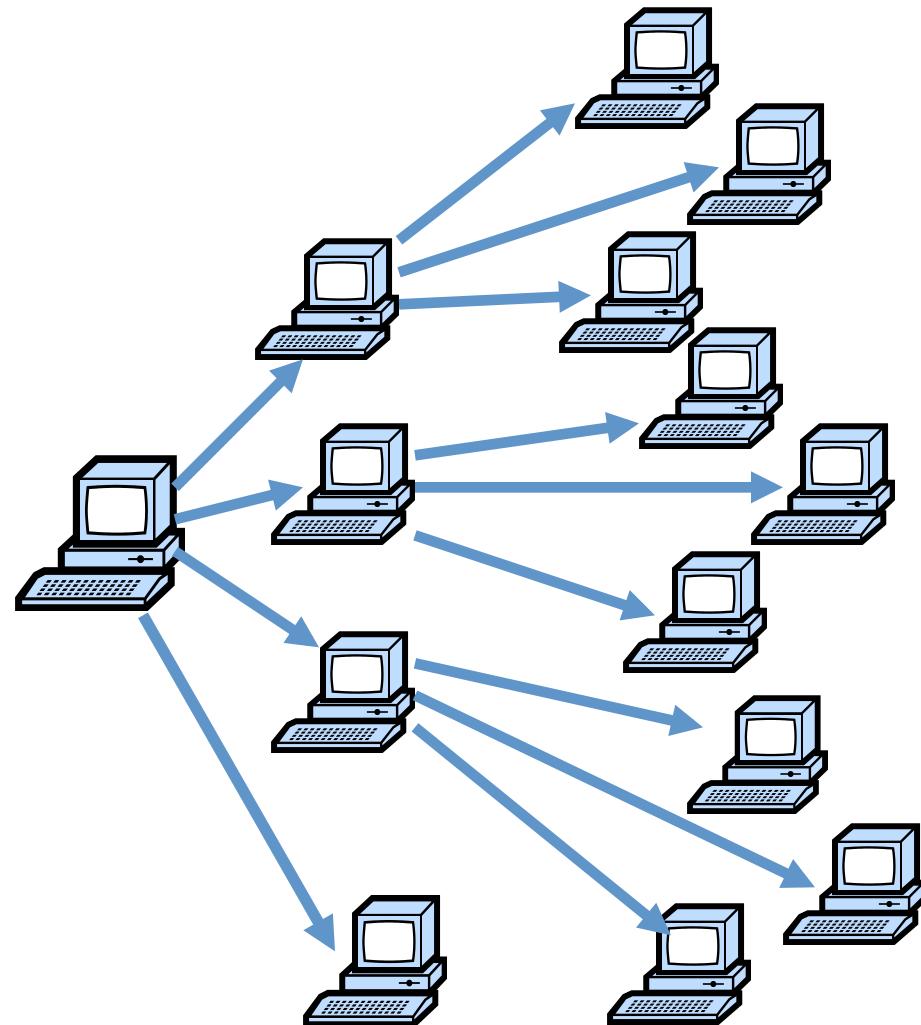
# Worm (preview)

- Worm = code that self-propagates/replicates across systems by arranging to have itself immediately executed
  - Generally infects machines by altering running code
  - No user intervention required

# Rapid Propagation

Worms can potentially spread quickly because they parallelize the process of propagating/replicating.

Same holds for viruses, but they often spread more slowly since they require some sort of user action to trigger each propagation.



# The Arrival of Internet Worms

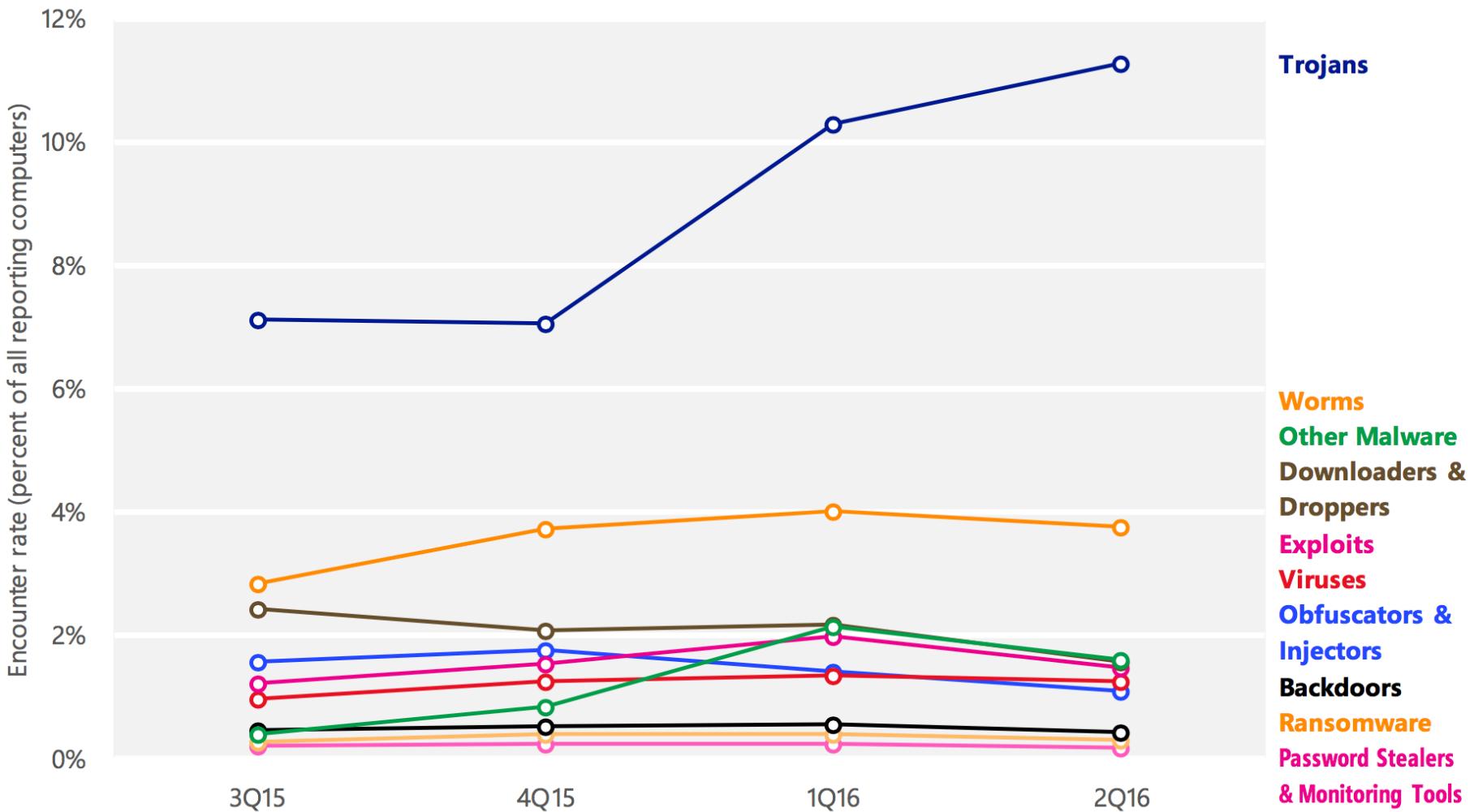
- Worms date to Nov 2, 1988 - the *Morris Worm*
- **Way** ahead of its time
- Employed a whole suite of tricks to infect systems ...
  - *Multiple* buffer overflows (“gets” function in finger server)
  - Guessable passwords
  - “Debug” configuration option in sendmail that provided shell access
  - Common user accounts across multiple machines
- ... and of tricks to find victims
  - Scan local subnet
  - Machines listed in system’s network config, e.g., /etc/hosts.equiv, /.rhosts
  - Look through user files for mention of remote hosts, e.g., .forward, .rhosts



# What Can Malware Do?

- Pretty much *anything*
  - Payload generally decoupled from how manages to run
  - Only subject to permissions under which it runs
- Examples:
  - Brag or exhort or extort (pop up a message/display)
  - Trash files (just to be nasty)
  - Damage hardware (Stuxnet?)
  - Launch external activity (spam, *click fraud*, DoS)
  - Steal information (*exfiltrate*)
  - Keylogging; screen / audio / camera capture
    - *Robbins v. Lower Merion School District*
  - Encrypt files (*ransomware*)
- Possibly delayed until condition occurs
  - “time bomb” / “logic bomb”

# Encounter rates for significant malicious software categories, 3Q15–2Q16

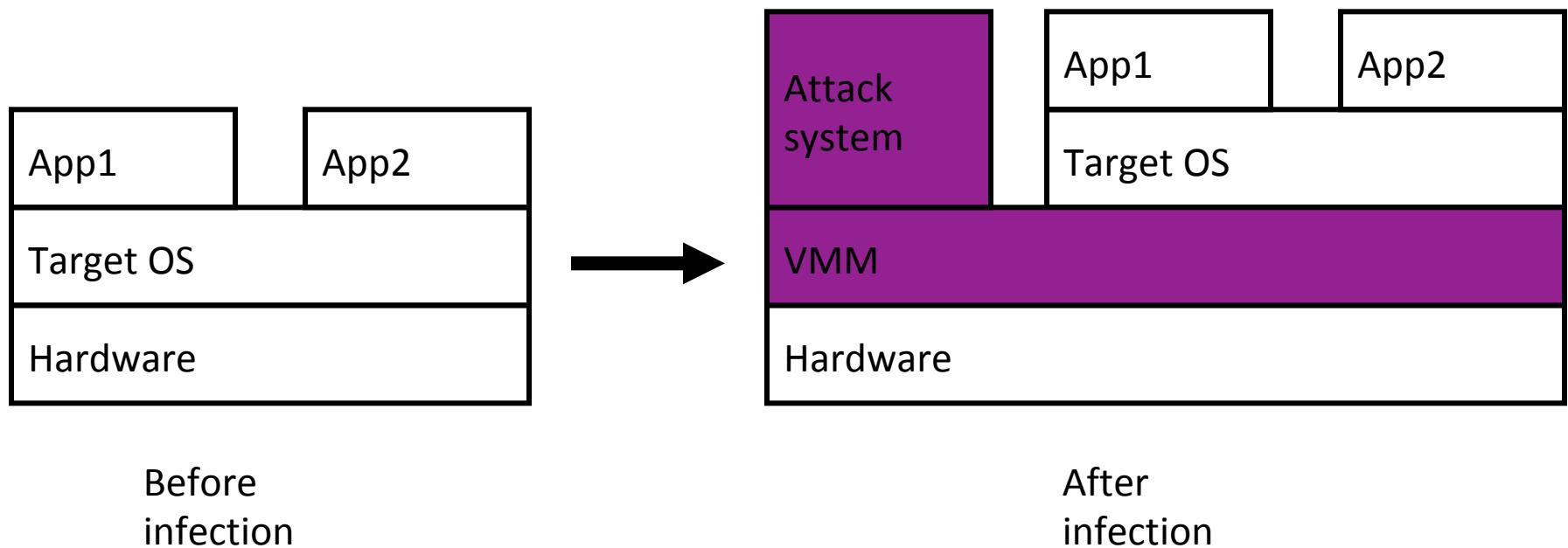


# Rootkits

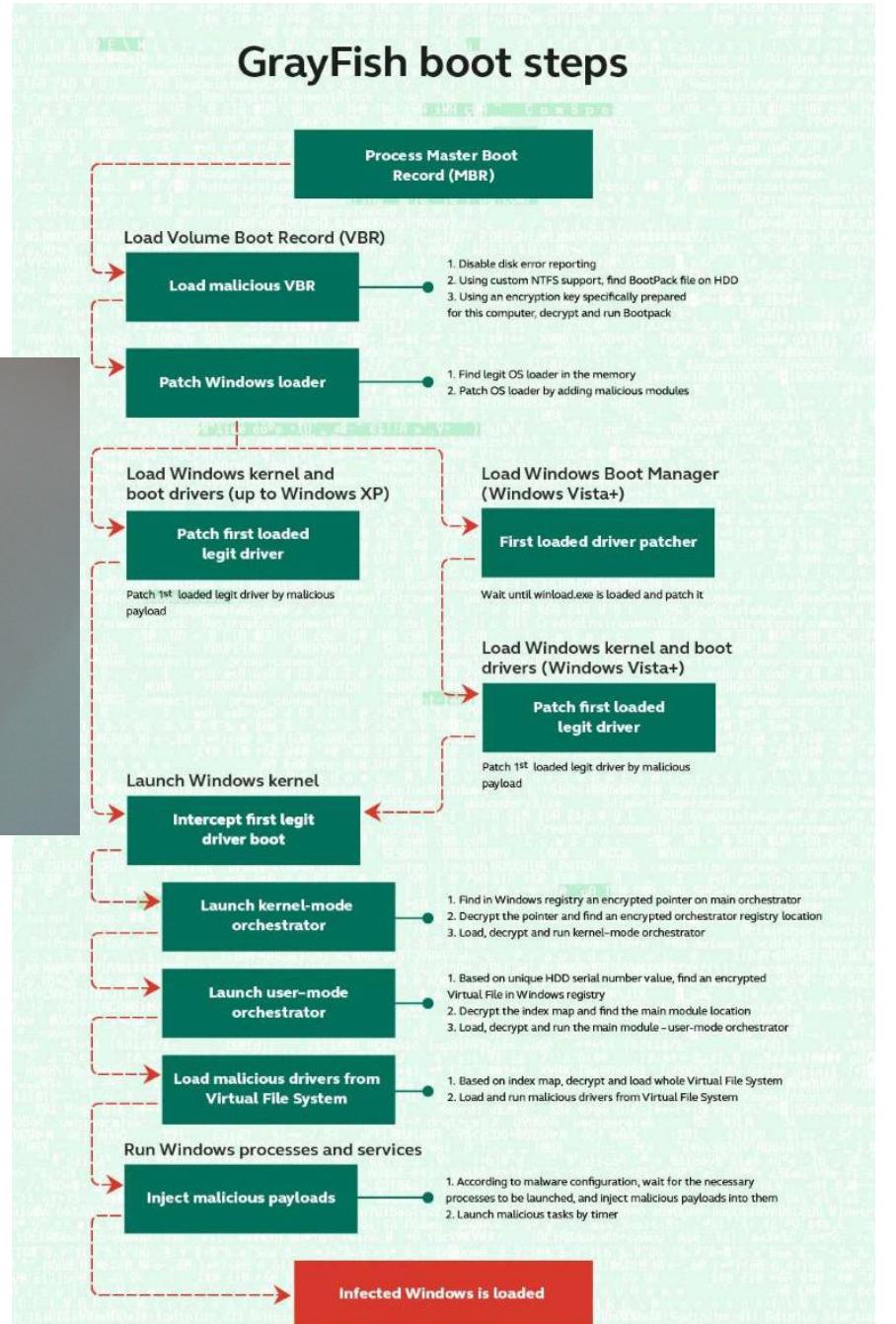
- A rootkit modifies the operating system to hide its existence
  - E.g., modifies file system exploration utilities
  - Hard to detect using software that relies on the OS itself
- Operation:
  - Intercept system calls for listing files, processes, etc.
  - Filter out malware's files and processes
  - Example: Magic prefix -- \$sys\$filename
  - Diagram:

Applications --> System Call ---> (Rootkit) --> Kernel  
<-- Results --- If call is from rootkit application (e.g. \$sys\$rootkit.exe), don't filter!
- RootkitRevealer
  - By Bryce Cogswell and Mark Russinovich (Sysinternals)
  - Two scans of file system
  - High-level scan using the Windows API
  - Raw scan using disk access methods
  - Discrepancy reveals presence of rootkit
  - Could be defeated by rootkit that intercepts and modifies results of raw scan operations

# Virtual-machine based rootkits (VMBRs)



# GrayFish boot steps



# Adware

The image displays two separate Internet Explorer windows side-by-side, both showing examples of adware or unwanted software distribution.

**Top Window:** The address bar shows <http://www.casinodelrio.com/>. A large yellow pop-up window is overlaid on the page. The pop-up has a red border with the word "FREE!" in large letters. It contains the following text:  
You've been chosen to receive a  
**FREE<sup>®</sup> Gateway Desktop Computer!**  
Intel Pentium 4 Processor 2.66 GHz  
256MB DDR-SDRAM, 80GB HD, 48x CD-RW  
19-inch Color CRT Monitor (18-inch viewable)  
[Click Here to Claim Your FREE<sup>®</sup> Desktop Computer!](#)  
by ExclusiveRewards  
The background page features a banner for "CASINO ON-NET" and a "SideFind" search toolbar.

**Bottom Window:** The address bar shows <http://www.poker-on-net.com/index.htm?SR=9160BB>. A Microsoft Internet Explorer dialog box is displayed, asking the user to click OK to download free software while browsing the site. The dialog box contains the text: "Click OK to download our free software while browsing the site". Below the dialog, the poker-on-net website is visible, featuring a "POKER ON-NET" logo, a "Download" button, and sections for "Current Events" and "GAMES".

# Ransomware

Cryptolocker 2.0

Your personal files are encrypted



Your files will be lost  
without payment on:

## Info

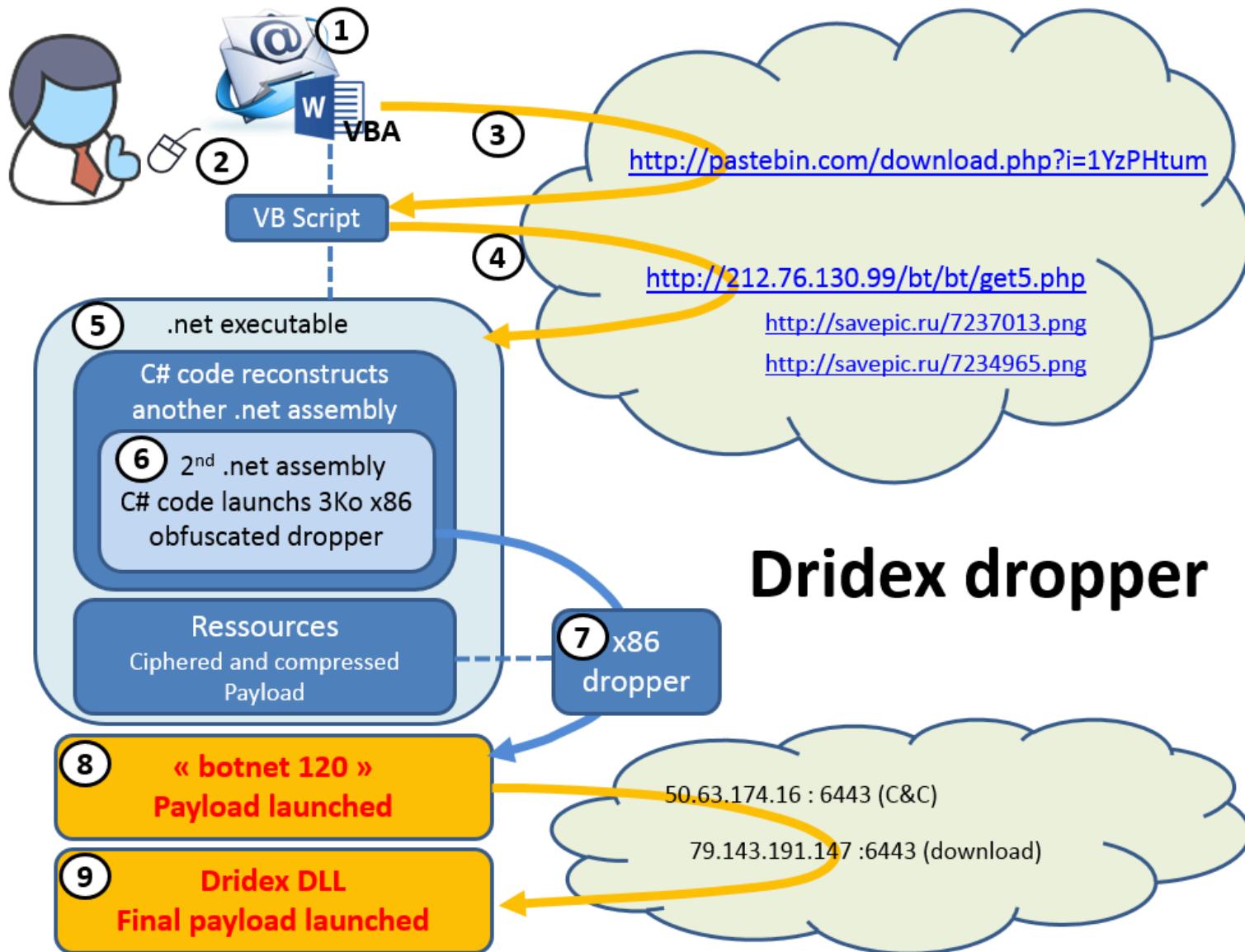
Your **important files were encrypted** on this computer: photos, videos, documents , etc. You can verify this by click on see files and try to open them.

Encryption was produced using **unique** public key RSA-4096 generated for this computer. To decrypt files, you need to obtain **private** key.

The single copy of the private key, which will allow you to decrypt the files, is located on a secret server on the Internet; **the server will destroy the key within 72 hours after encryption completed**. After that, nobody and never will be able to restore files.]

To retrieve the private key, you need to pay 0.5 bitcoins.

# Droppers



# Key logging and Password Stealing

blink182, asdfasdf, startrek, passwOrd, nintendo, arthur  
cocacola, ilovegod, football, emmanuel, danielle, bill  
http://77.81.229.38/p/gate.php, YUIPWDFILE0YUIPKDFILE0Y  
CryptAcquireCertificatePrivateKey, MsicGetComponentPathA  
";q=0, Content-Length: %lu, Content-Encoding: binary, U  
Software\Far\Plugins\FTP\Hosts, Software\Far2\Plugins\FT  
Software\Far\SavedDialogHistory\FTPHost, Software\Far2\  
Manager\SavedDialogHistory\FTPHost, wcx\_ftp.ini, \GHISL  
Software\Ghisler\Total Commander, \Ipswitch, \Ipswitch\H  
ome\QCToolbar, Software\GlobalSCAPE\CuteFTP 6 Professi  
Software\GlobalSCAPE\CuteFTP 7 Professional\QCToolbar,  
Software\GlobalSCAPE\CuteFTP 8 Professional\QCToolbar,  
Lite, \CuteFTP, Software\FlashFXP\3, Software\FlashFXP,  
\Sites.dat, \Quick.dat, \History.dat, \FlashFXP\3, \Fla  
filezilla.xml, Software\Filezilla Client, Install\_Dir,  
Server\_Port, ServerType, Last\_Server\_Host, Last\_Server  
Type, FTP Navigator, FTP Commander, \BulletProof\_Softwa  
Software\BulletProof\_FTP\_Client\Main, Software\BPFPT\_Bu  
Favorites.dat, History.dat, addrbk.dat, quick.dat, \Tur  
CredentialCheck, Software\Sota\FFFTP\Options, HostAdrs,  
Software\FTPware\COREFTP\Sites, profiles.xml, Software\Ex  
plorer\Profiles, PasswordType, InitialPath, FtpSite.x  
Software\VanDyke\SecureFX, UltraFXP, \sites.xml, \VTPR  
bitkinex.ds, Software\ExpanDrive\Sessions, \ExpanDrive,  
\_Password, Software\NCH Software\ClassicFTP\FTPAccounts  
Software\Fling\Accounts, Software\FTPClient\Sites, Soft  
SharedSettings.ccs, \SharedSettings.sqlite, \SharedSet  
sites.ini, \LeapWare\LeapFTP, SOFTWARE\LeapWare, Remote  
NDSites.ini, \NetDrive, RootDirectory, Software\South\_R  
Software\Opera Software, Last\_Directory\3, Last\_Install  
wiseftp.ini, FTPVoyager.ftp, FTPVoyager.qc, \RhinoSoft.  
prefs.js, signons.txt, signons2.txt, signons3.txt, SELE  
SeaMonkey, \Mozilla\SeaMonkey\, \Flock\Browser\, \Mozil  
Favorites.dat, sites.db, servers.xml, \FTPGetter, ESTdb  
Passwords, http://www.facebook.com/, Microsoft\_WinInet  
%\WebUrl, SiteServer %\Remote\_Directory, SiteServer %  
DeluxeFTP, sites.xml, Login\_Data, () CONSTRAINT, \Googl  
Bromium, \Nichrome, \RockMelt, K-Meleon, \K-Meleon, \E  
site.dat, LastPassword, LastAddress, LastUser, LastPort  
FTP++\Link\shell\open\command, Connections.txt, sites.i  
full\_address:si, .TERMSRV/, sites.xml, SOFTWARE\Robo-FT  
InitialDirectory, ServerType, Software\LinasFTP\Site Ma  
NppFTP.xml, \Notepad++, Software\CoffeeCup Software, FT  
destination\_port, FTP destination\_catalog, FTP profiles  
ServerList.xml, NexusFile, ftpsite.ini, FastStone Brows  
Computing\WinZip\FTP, Software\Nico\_Mak\_Computing\WinZi  
NovaFTP.db, \INSoftware\NovaFTP, .oeaccount, <POP3\_Pass  
\Microsoft\Windows\_Live\_Mail, Software\Microsoft\Window  
Software\RimArts\B2\Settings, DataDirBak, Mailbox.ini,  
\Poconail, Software\Incredimail, Technology, PopServer,  
account.cfg, account.cfn, \BatMail, \The Bat!, Software\KIT\The Bat!, Working\_Directory, ProgramDir, SMTP\_Email\_Address, SMTP  
Server, SMTP\_User\_Name, NNTP\_Email\_Address, NNTP\_User\_Name, NNTP\_Server, IMAP\_Server, HTTP\_User, HTTP\_Server\_URL, IMAP\_User,  
HTTPMail\_Server, SMTP\_User, POP3\_Port, SMTP\_Port, IMAP\_Port, IMAP\_Password2, NNTP\_Password2, SMTP\_Password2, POP3\_Password, IMAP  
Password, NNTP\_Password, HTTP\_Password, SMTP\_Password, Identities, Software\Microsoft\Office\Outlook\OMI\_Account  
Manager\Accounts, \Accounts, identification, identitymgr, inetcomm\_server\_passwords, outlook\_account\_manager\_passwords,  
identities, Thunderbird, \Thunderbird, FastTrack, Client\_Hash, STATUS-IMPORT-OK, YCreateToolhelp32Snapshot, CoTaskMemFree,  
yInternetCrackUrlA, {InternetCreateUrlA, 6inet\_addr, \*gethostbyname, 'connect, &closesocket, Gsetsockopt, !WSASStartup,  
aUnloadUserProfile



# Bridging the how and what of malware: Botnets

- Collection of compromised machines (bots) under (unified) control of an attacker (botmaster)
- Method of compromise decoupled from method of control
  - Launch a worm / virus / drive-by infection / etc.
- Upon infection, new bot “*phones home*” to rendezvous w/ botnet *command-and-control (C&C)*
- Lots of ways to architect C&C:
  - Star topology; hierarchical; peer-to-peer
  - Encrypted/stealthy communication
- Botmaster uses C&C to push out commands and updates

# Example of C&C Messages

1. Activation (report from bot to botmaster)
2. Email address harvests
3. Spamming instructions
4. Delivery reports
5. DDoS instructions
6. *FastFlux* instructions (rapidly changing DNS)
7. HTTP proxy instructions
8. Sniffed passwords report
9. IFRAME injection/report

From the “Storm”  
botnet circa 2008