Malware (2)

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Propagation mechanisms

(malware classification)

1. Infection
2. Exploitation
3. **Social engineering**

Social engineering

Definition: “tricking” users to **assist** in the **compromise** of their own systems or personal information

Examples:

- a user views and responds to a **spam** e-mail
- a user permits the **installation** and execution of a **Trojan horse** program

Spam and phishing

Spam emails can carry malware:

- attached document, which, **if opened**, may exploit a software vulnerability to install malware

Phishing attacks

- **a fake website** that attempts to capture user's credentials
- **forms** with personal details to allow user impersonation

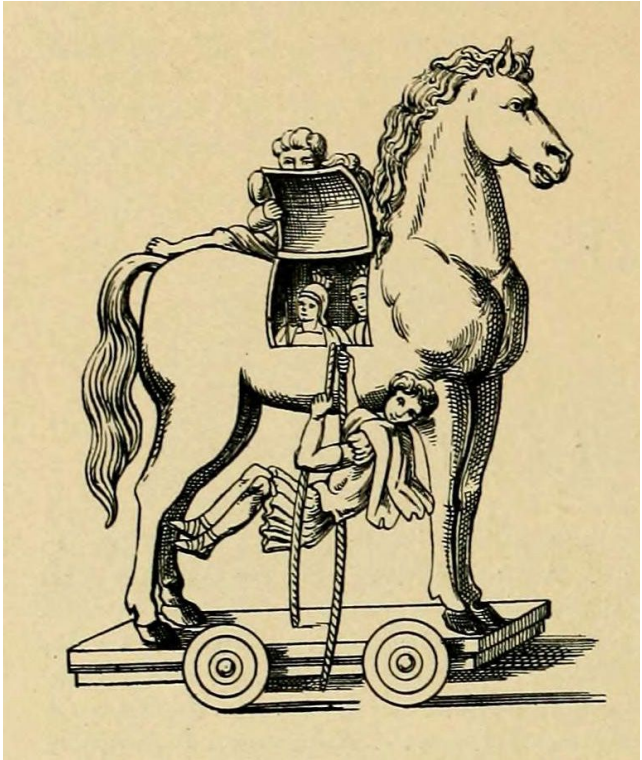
Phishing over HTTPS: fake websites have valid HTTPS certificates, thanks to free CAs such as Let's Encrypt

Phishing over social networks: spam email phenomenon is reducing thanks to filters, but social media offer a **new vehicle** for social engineering attacks

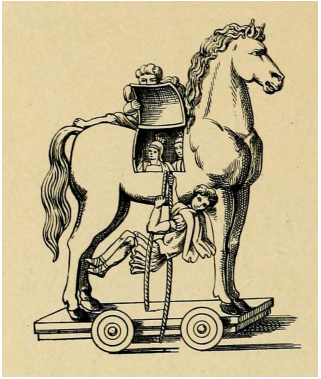
Trojan horses

Trojan horse: a useful, or apparently useful, program containing hidden code that, when invoked, performs some **unwanted or harmful function**

- **Example**: incorporate malicious code into a game and making it available via a known app store



Categories of Trojans



1. Continuing to perform the original function and **additionally** performing a separate malicious activity
2. Continuing to perform the original function but **modifying** it so to perform malicious activity or to **disguise** other malicious activity. For example:
   a. a **Trojan horse version of a login program** collecting passwords
   b. a **Trojan horse version of `ls`** not displaying malicious processes
3. Performing a malicious function that completely **replaces** the original one

Note: some Trojans exploit vulnerabilities to install but, unlike worms, they **do not replicate**

Payload action

(malware classification)

1. **corruption of system / data**
2. theft of a service
3. theft of information
4. stealthing

Corruption of system / data

Chernobyl virus (1998): destructive Windows virus infecting executables. On trigger date, **zeroed the hard drive**

Klez mass-mailing worm (2001): a destructive worm infecting Windows-95 to XP systems. It spreaded by e-mailing and stopped anti-virus programs. On the 13th of several months each year, it caused files to **become empty**

Ransomware (1989): encrypts data and asks for a ransom. First ransomwares used weak crypto. Modern ransomwares use state-of-the-art crypto

- **Example**: WannaCry

Real-world damage: Stuxnet, Flame, recent attack on Ukrainian power system (2015)

Payload action

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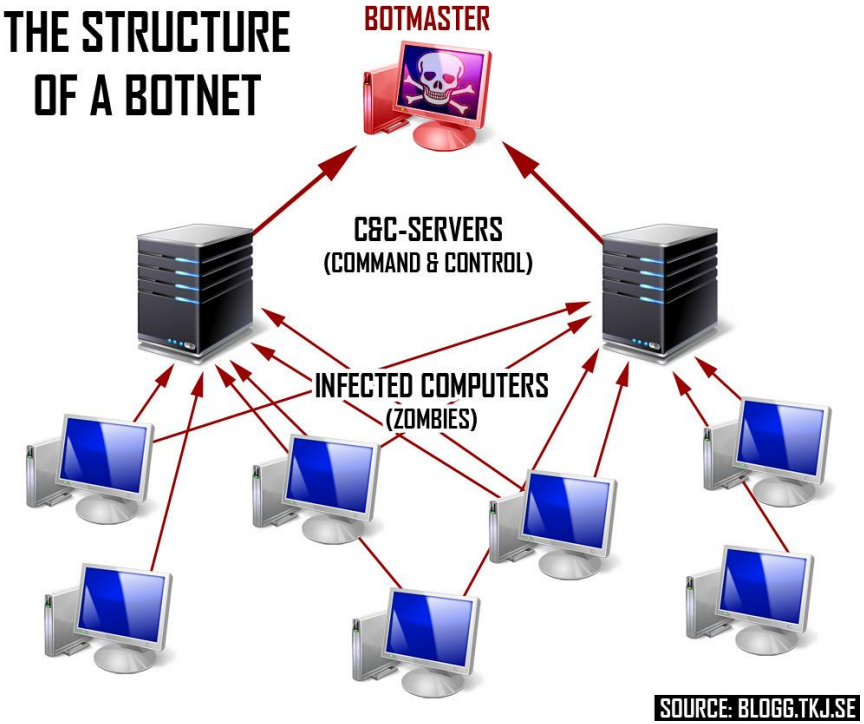
Botnets

Bot (zombie): device whose computational and network resources have been subverted for **use by the attacker**

***Botnet*:** a collection of bots that can act in a coordinate manner

- thousands of computers, servers, embedded devices (**IoT**), ...



Botnet activities

Distributed DoS (DDos): **flooding** the target

Spamming: massive amount of **bulk emails**

Sniffing traffic (infected hosts): retrieving **sensitive** information

Keylogging (infected hosts): useful when traffic is encrypted

Spreading malware: botnet as the start base for **viruses** or **worms**

Automated tasks: get **financial** advantage (e.g. clicking on ads)

Manipulating polls and on-line games: votes and activities from thousand of different IPs will appear as from distinct users

Botnet Command & Control (C&C)

C&C control servers are contacted by zombies in the botnet

Fixed address: easy to take over by law enforcement agencies

Pool of addresses generated automatically: if server is down bot contacts the next address

⇒ Much harder to **detect**

C&C servers:

- issue **commands** to bots
- send **updates**
- **gather** sensitive information collected by bots

Note: A number of C&C have been taken over and shut down in the recent years

Payload action

(malware classification)

1. corruption of system / data
2. theft of a service
3. **theft of information**
4. stealthing

Information theft

Keylogger: captures keystrokes extracting credentials

- Graphical applets used by banks

Spyware: allows for monitoring wide range of activity

- Can **actively modify** exchanged data compromising or redirect users to fake websites

Phishing: exploits social engineering to leverage user's trust by masquerading as communications from a trusted source

Spear-phishing: targets a specific victim, so to make message content more realistic

- **Examples**: espionage, bogus wire-transfer authorizations, ...

Payload action

(malware classification)

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Backdoors

Backdoor (or ***trapdoor***): a **secret entry point** into a program that allows someone to gain access without going through the usual security access procedures

- Used to maintain and test programs

Trigger: special sequence of input, a certain user ID, an unlikely sequence of events ...

Malware Backdoors are installed on compromised systems and used as an entry point by attackers

- Usually a **network service** listening on a non-standard port
- or, connecting “back” to some external host

Rootkits

Rootkit: a set of programs installed on a system to maintain **covert access** to that system with **administrator** privileges, while hiding evidence of its presence

- **Persistent**: easier to detect as it needs to be stored, or
- **Memory based**: harder to detect but does not survive reboots

User mode: Intercepts APIs and modifies results. Example: hide rootkit file in `ls`

Kernel mode: privileged mode, hides processes, modifies kernel memory

Virtual machine based: runs the OS in a lightweight virtual machine

External mode: direct access to hardware (BIOS, Intel SMM, ...)

Kernel mode rootkits

Change syscalls:

1. **Modify the system call table**: The attacker modifies entries so to point to the rootkit's functions
2. **Modify system call table targets**: The attacker overwrites selected legitimate system call routines
3. **Redirect the system call table**: The attacker redirects references to a new table in kernel memory

The idea is to exploit a "layer-below" for of attack:

- Any "anti-virus" program would now be subject to the **same "low- level" modifications** that the rootkit uses to hide its presence

⇒ Detecting the rootkit becomes much harder!

Countermeasures

Countermeasures

Prevention:

- **Appropriate access control** (possibly MAC) so to limit virus propagation
- Keep systems **up-to-date**: reduce vulnerabilities limiting worm propagation
- Improve **user awareness** so to limit social engineering attacks

Mitigation, when prevention fails:

- **Detection**: malware should be promptly detected and located
- **Identification**: once detected, identify the specific malware
- **Removal**: once identified, remove all traces of malware

Note: when identification or removal are not possible it is necessary to restore a **backup** or **reinstall** system

Malware detection

Where?

- on the infected host (anti-virus)
- on the perimeter (firewall or IDS)

Host-based detection

1st generation: searches for a "signature", i.e., **fixed byte pattern**
⇒ only **known malware**!
Looks for changes in **length** in known programs

2nd generation: searches for **suspicious fragments** of code, e.g., a decryption loop and key.
Uses crypto hash function to check program **integrity**

3rd generation: memory-resident, inspecting malware behaviour. Looks for suspicious sequences of actions.
⇒ **dynamic analysis**, can detect unknown malware

4th generation: varieties of techniques used together: static and dynamic analysis, access control to limit propagation, ...

Sandbox analysis

Run malware in an ***emulated sandbox*** so to study its behaviour and develop adequate mitigation strategies

Problem 1: How **long** should the analysis run?

- modern malware extensively **sleep** to evade sandbox analysis

Problem 2: Is it possible to make sandbox **indistinguishable** from real setting?

- modern malware tries to detect if it is running in a sandbox and, in such a case, it **deactivates**

Example: network connections are *emulated* to prevent that malware easily notices isolation.
Read how this killed WannaCry!

Host-based dynamic analysis

Monitor suspicious behaviour:

- **Attempts** to open, view, delete, and/or modify files
- Attempts to format disk drives and other **unrecoverable** disk operations
- **Modifications** to the logic of executable files or macros
- Modification of **critical** system settings, such as start-up settings
- **Scripting** of e-mail and instant messaging clients to send executable content
- Initiation of **network** communications

Perimeter scanning

Ingress monitors: signature-based and anomaly-based analysis of incoming malware traffic

Honeypots can be used to capture/analyze incoming malware traffic (e.g. detecting **botnets**)

Egress monitors: catch malware attacks from inside, such as:

- Worm **scanning**
- Mass emails

Catch **data exfiltration** of sensitive information

Problem: encrypted messages **cannot be inspected**: *TLS forward proxies* decrypt and re-encrypt traffic so to make it possible to inspect it