CSE331 Computer Security Fundamentals

8/31/2017

Threat Landscape and Basic Security Principles

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Threats, Vulnerabilities, and Attacks

A *threat* is a potential cause of an incident, malicious or otherwise, that could harm an asset

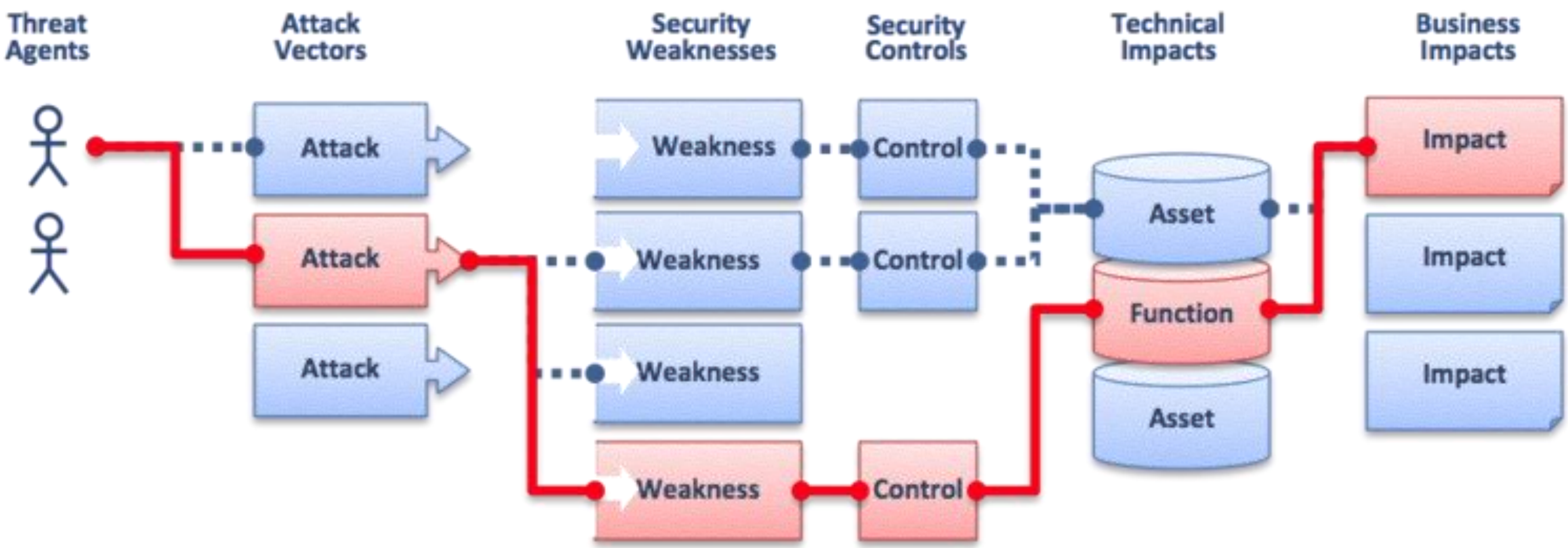
- Different kinds: loss of services, compromise of information or functions, technical failure, …
- Different origins: deliberate, accidental, environmental, …

A *vulnerability* is a weakness that makes a threat possible

An *attack* is an action that exploits a vulnerability or enacts a threat

- Active vs. passive
- Insider vs. outsider

Threats, Vulnerabilities, and Attacks



© Neil Smithline - http://www.owasp.org/index.php/File:2010-T10-ArchitectureDiagram.png

Threat Classification and Risk Assessment

Classification example: Microsoft's STRIDE

- Spoofing: TCP/IP, identity, HTTP headers, email address, poisoning, …
- Tampering: network traffic, code, HTTP cookies/URLs/parameters, …
- Repudiation: deniability, audit log scrubbing/modification, …
- Information disclosure: unauthorized data access, data leakage, …
- Denial of Service: crashing, flooding, resource stagnation, …
- Elevation of privilege: gain admin access, jailbreaking, …

Risk assessment example: Microsoft's DREAD

- Damage: how bad would an attack be?
- Reproducibility: how easy is it to reproduce the attack?
- Exploitability: how much work is it to launch the attack?
- Affected users: how many people will be impacted?
- Discoverability: how easy is it to discover the threat?

Threat Model

Set of assumptions about possible attacks that a system tries to protect against

- Understanding potential threats is crucial for taking appropriate measures

Various threat modeling approaches: attacker-centric, software-centric, asset-centric, …

Example: data flow approach

- *View the system as an adversary:* identify entry/exit points, assets, trust levels, usage patterns, …
- *Characterize the system:* identify usage scenarios, roles, objectives, components, dependencies, security alerts, implementation assumptions, …
- *Identify threats:* what can the attacker do? How? What is the associated risk? How can the respective vulnerabilities be resolved?

Policies and Mechanisms

Threat model ➔ security policy ➔ security mechanisms

Security policy: a definition of what it means for a system/organization/entity to be secure

- Access control, information flow, availability, …
- Computer, information, network, application, password, …

Enforced through security mechanisms

- Prevention
- Detection
- Recovery
- Awareness

Threat Actors

’90s: script kiddies

’00s: criminals

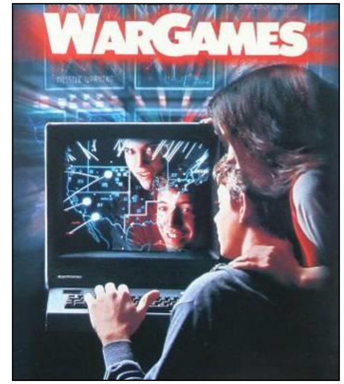
’10s: nations *(OK, much earlier, but now we talk about it)*

Different motives

- $$$$$$$$$$$$
- Honest but curious individuals
- Political or social ends
- Bribed or angry insiders
- Espionage
- Military *

Different resources: $$$$$$$$$, skills, infrastructure, …

Know your enemy!



Then: fun

Now: profit

* *“Cyberwar,” “cyberterrorism,” “cyberweapons:” exaggerated terms that (should?) express fear of lethal outcomes. Instead, so far we’ve seen mostly sabotage, espionage, and subversion*

Vulnerability

"A property of a system or its environment which, in conjunction with an internal or external threat, can lead to a security failure, which is a breach of the system's security policy." [Anderson]

Various classifications

- *SDL:* design, implementation, operation, maintenance
- *Abstraction level:* low vs high level, OSI network layers, hardware/firmware/OS/middleware/application, system vs. process, …
- *Type of error/condition/bug:* memory errors, range and type errors, input validation, race conditions, synchronization/timing errors, access-control problems, environmental/system problems (e.g. authorization or crypto failures), protocol errors, logic flaws, …
- *Disclosure process:* zero-day vs. known, private vs. public, "responsible" vs. full disclosure, …

Multiple vulns. are often combined for a single purpose

Vulnerability (Another Definition)

"The intersection of a system susceptibility or flaw, access to the flaw, and the capability to exploit the flaw." [AFRL ATSPI]

System Susceptibility: focus on what's critical

Reduce access points to only those that are absolutely necessary

Access to the flaw: move it out of band

Make critical access points and associated security elements less accessible to the adversary

Capability to exploit the flaw: prevent, detect, react

Appropriate response upon detection of an attack

Related term: ***attack surface***

The different points through which an attacker can interact with the system/environment

Increases with complexity (more logic, features, dependencies, …)

Intrusions

* Welcome to CityPower Grid Rerouting *
Authorised Users only!
New users MUST notify Sys/Ops.
login:
rcr ebx, 1
bsr ecx, ecx
shrd ebx, edi, CL
80/tcp open http
[mobile]
nmap -v -sS -O 10.2.2.2
Starting nmap V. 2.54BETA25
Insufficient responses for TCP sequencing (3), OS detection may be less
accurate
Interesting ports on 10.2.2.2:
(The 1539 ports scanned but not shown below are in state: closed)
Port State Service
22/tcp open ssh
No exact OS matches for host
Nmap run completed -- 1 IP address (1 host up) scanned
sshnuke 10.2.2.2 -rootpw="Z1ON0101"
Connecting to 10.2.2.2:ssh ... successful.
Attempting to exploit SSHv1 CRC32 ... successful.
Reseting root password to "Z1ON0101".
System open: Access Level <9>
ssh 10.2.2.2 -l root
root@10.2.2.2's password:
RIF CONTROL
ACCESS GRANTED

Intrusions

“Any set of actions that attempt to compromise the integrity, confidentiality or availability of information resources” [Heady et al.]

“An attack that exploits a vulnerability which results to a compromise of the security policy of the system” [Lindqvist and Jonsson]

Most intrusions…

- Are carried out remotely
- Exploit software vulnerabilities
- Result in arbitrary code execution or unauthorized data access on the compromised host

Attack Source

Local

Unprivileged access ➔ privilege escalation

Physical access ➔ I/O ports (launch exploits), memory (cold boot attacks), storage (just remove it), shoulder surfing (steal credentials), dumpster diving (steal information), bugging (e.g., keylogger, internal components, external antennas/cameras/sensors), …

Remote

Internet

Local network (Ethernet, WiFi, 3/4G, bluetooth, …)

Infected media (disks, CD-ROMs, USB sticks, …)

Phone (social engineering)

Intrusion Method

Social engineering (phishing, spam, scareware, …)

Viruses (~~disks~~, ~~CD-ROMs~~, USB sticks, downloads, …)

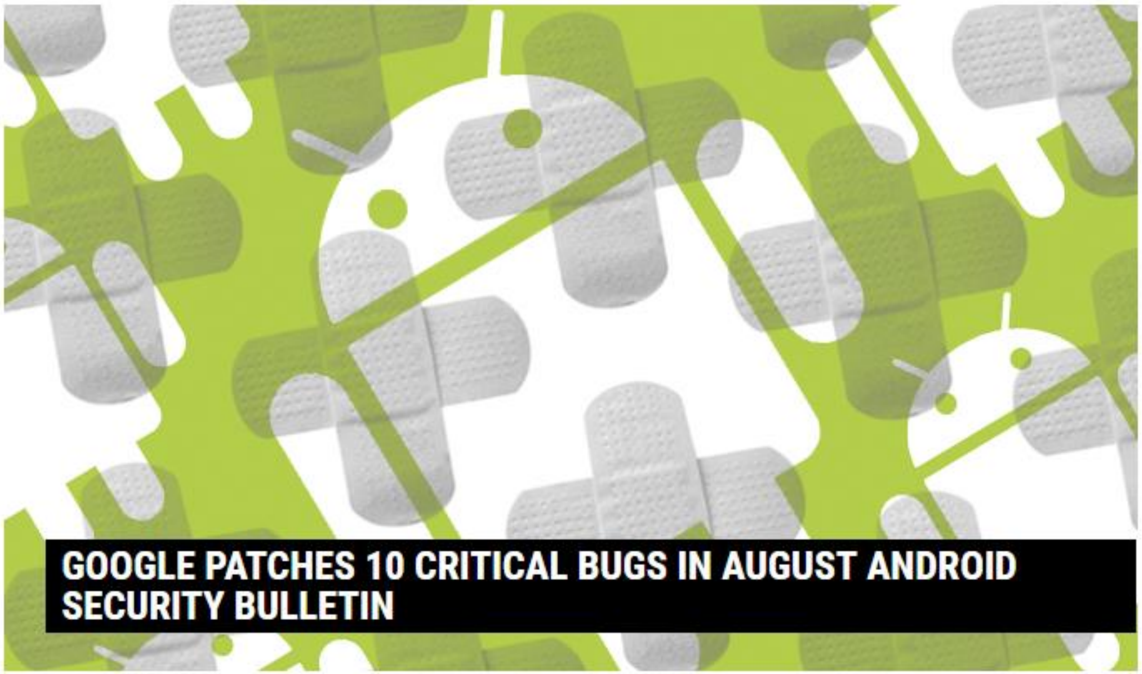
Network traffic interception (access credentials, keys, …)

Password guessing/leakage (brute force, root:12345678, …)

Physical access (reboot, keylogger, screwdriver, …)

Software vulnerability exploitation

Just This Month's News…



by Tom Spring

August 8, 2017 , 8:12 am

Google patched 10 critical remote code execution bugs in its August Android Security Bulletin issued Monday. It warned the most severe RCE vulnerabilities could enable a remote attacker, using a specially crafted file, to execute arbitrary code within the

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Microsoft Patches Critica ×

AO Kaspersky Lab [RU] | https://threatpost.com/microsoft-patches-critical-windows-search-vulnerability/127303/

Welcome > Blog Home > Hacks > Microsoft Patches Critical Windows Search Vulnerability

by Tom Spring August 8, 2017 , 5:21 pm

Microsoft patched more than two dozen remote code execution vulnerabilities today, many of them rated critical. One was a RCE bug that allowed an attacker to take complete control of a server or workstation via Windows Search.

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JUNIPER ISSUES SECURITY ALERT TIED TO ROUTERS AND SWITCHES

by Tom Spring

August 10, 2017 , 1:56 pm

Juniper Networks warned customers Thursday of a high-risk vulnerability in the GD graphics library that could allow a remote attacker to take control of systems running certain versions of the Junos OS.

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NEPTUNE EXPLOIT KIT DROPPING CRYPTOCURRENCY MINERS THROUGH MALVERTISEMENTS

by Chris Brook

August 22, 2017 , 5:51 pm

Despite a marked decrease in activity, exploit kits haven't completely disappeared just yet. The Neptune, or Terror Exploit Kit, is alive and well; during the last month, researchers have observed the kit as part of a campaign to abuse a legitimate popup ad service to drop cryptocurrency miners.

Researchers with FireEye said Tuesday the kit has been redirecting victims with popups from fake hiking ads to exploit kit landing pages and in turn to HTML and Adobe Flash exploits. Researchers elected not to disclose the name of the popup ad service, but stressed that it's within Alexa's top 100.

The landing pages run a handful of exploits, including three targeting Internet Explorer (CVE-

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APT28 USING ETERNALBLUE TO ATTACK HOTELS IN EUROPE, MIDDLE EAST

by Tom Spring

August 12, 2017 , 8:00 am

Russian-speaking cyberespionage group APT28, also known as Sofacy, is believed to be behind a series of attacks last month against travelers staying in hotels in Europe and the Middle East. APT28 notably used the NSA hacking tool EternalBlue as part of its scheme to steal credentials from business travelers, according to a report released Friday by security firm FireEye.

One of the goals of the attack is to trick guests to download a malicious document masquerading as a hotel reservation form that, if opened and macros are enabled, installs a dropper file that ultimately downloads malware called Gamefish. Gamefish establishes a foothold in targeted systems as a way to install the open source tool called Responder, according to FireEye.

“Once inside the network of a hospitality company, APT28 sought out machines that controlled both guest and internal Wi-Fi networks,” wrote authors of the report Lindsay Smith and Benjamin Read,

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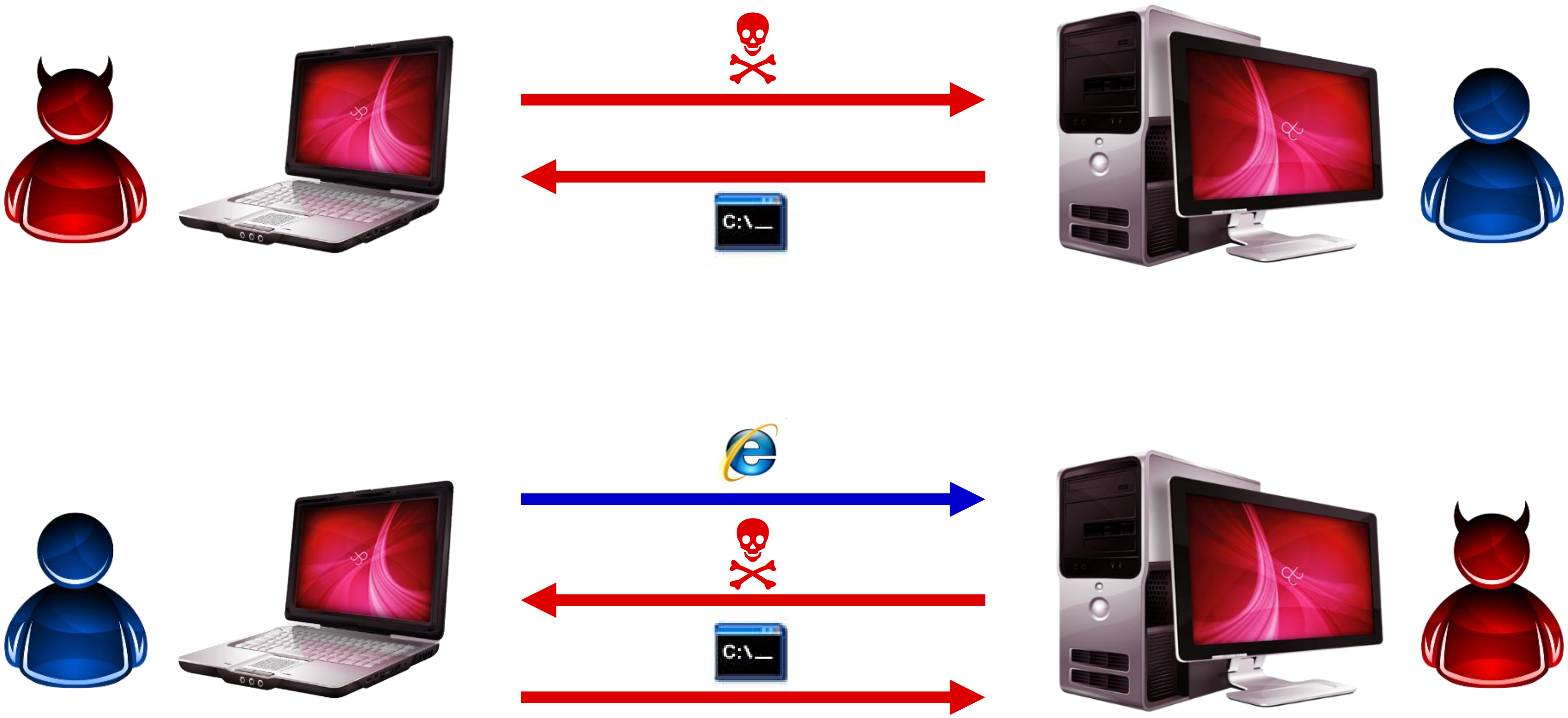
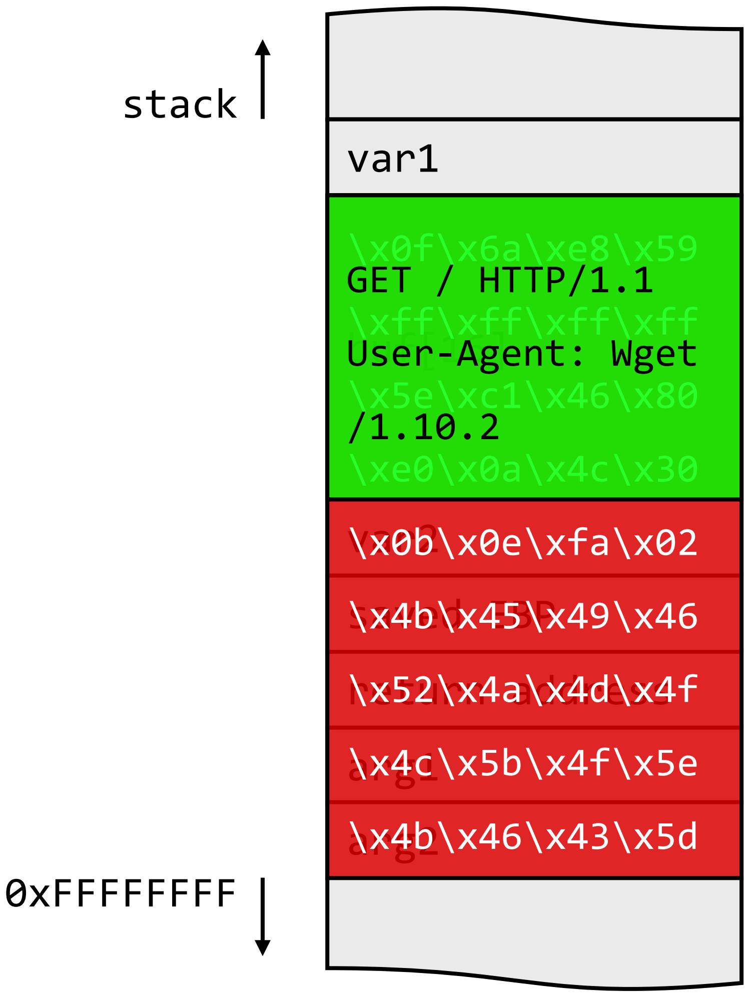
Remote Exploitation: Server-side vs. Client-side



(Very Simple) Buffer Overflow Exploitation



Code injection

Shellcode

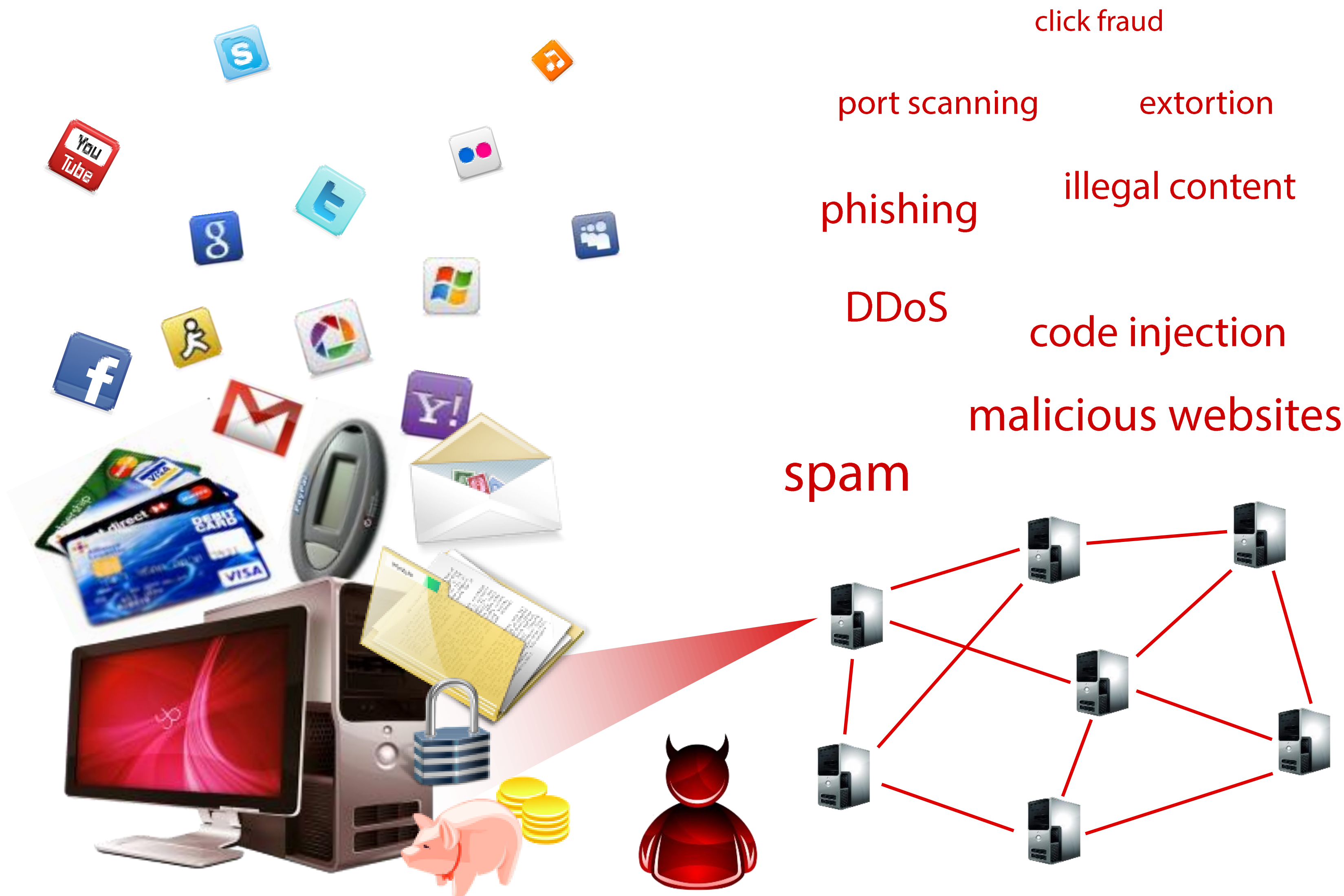
spawn shell

listen for connections

add user account

download and execute malware

Malware and Botnets



Basic Phases of a Typical Targeted Attack

Reconnaissance and information gathering

Exploitation

Privilege Escalation

Persistent access

Internal reconnaissance

Lateral movement

Data exfiltration/damage/other goal

Many more threats…

Password Attacks

Information Leakage

Spoofing

Repudiation

Privilege escalation

Information gathering

Session hijacking

Social engineering

Denial of Service

Tampering

Information disclosure

Sniffing

Spoofing

…subject of future lectures

Basic Security Principles

In the 1970s, J. H. Saltzer and M. D. Schroeder had been working on Multics

Identified a set of design principles intended to help designers of time-sharing OSs protect information

- Some of the earliest thinking on building secure systems

The Protection of Information in Computer Systems

JEROME H. SALTZER, SENIOR MEMBER, IEEE, AND MICHAEL D. SCHROEDER, MEMBER, IEEE

Invited Paper

Abstract—This tutorial paper explores the mechanics of protecting computer-stored information from unauthorized use or modification. It concentrates on those architectural structures—whether hardware or software—that are necessary to support information protection. The paper develops in three main sections. Section I describes desired functions, design principles, and examples of elementary protection and authentication mechanisms. Any reader familiar with computers should find the first section to be reasonably accessible. Section II requires some familiarity with descriptor-based computer architecture.

Authorize	To grant a principal access to certain information.
Capability	In a computer system, an unforgeable ticket, which when presented can be taken as incontestable proof that the presenter is authorized to have access to the object named in the ticket.
Certify	To check the accuracy, correctness, and

Economy of Mechanism

Economy of Mechanism

Security mechanisms should be as simple as possible

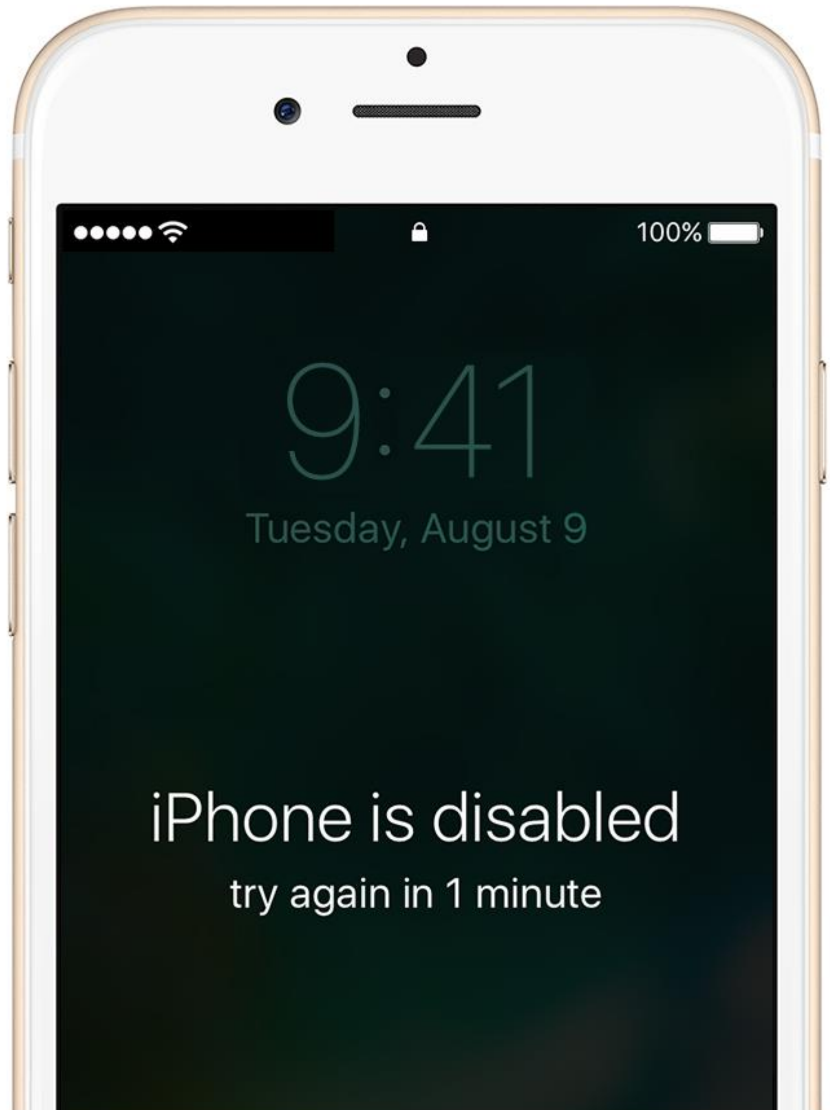
Simper design and implementation ➔ fewer possibilities for flaws

- Facilitates understanding by developers and users
- Facilitates careful review and verification
- Minimizes interfaces and interdependencies

Trusted computing base (TCB)

- Those portions of the system that are critical to its security
- Vulnerabilities in the TCB may jeopardize the security of the entire system
- The TCB should be as small as possible

Fail-safe Defaults



Fail-safe Defaults

Default action should be to deny access, unless privileges have been explicitly granted

- E.g., default user group has minimal access rights

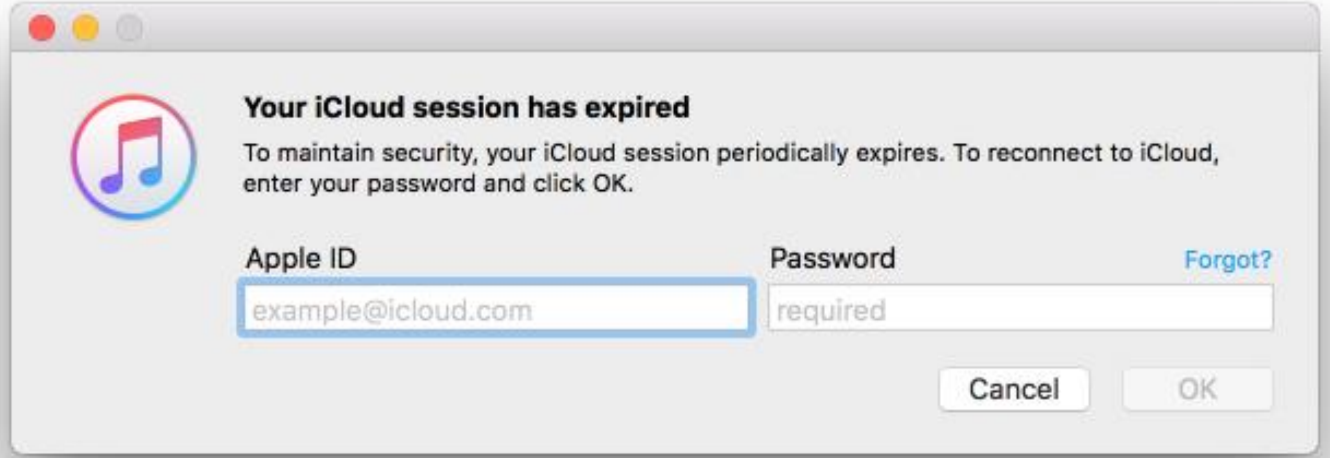
Oversights regarding handling corner cases are a common cause of vulnerabilities

- Deny by default ➔ denial of service
  Will be reported by legitimate users and corrected quickly
- Allow by default ➔ potential for unauthorized access
  Will not be detected and turn into a vulnerability

Main challenge: usability vs. security

- Logging in as root, disabling Windows' UAC, jailbreaking, …
- Striking the right balance is not always easy

Complete Mediation



Complete Mediation

Every access should be checked to ensure it is allowed

E.g., each transaction on an ATM requires re-entering the PIN

The mediation mechanism should be part of the TCB

E.g., the OS kernel mediates access to memory, files, devices

Main challenge: performance vs. security

Checking file permissions before opening vs. on every access: permissions may change after opening

Caching DNS responses vs. always asking the authority: an attacker may be able to poison the cache

More frequent checks ➔ higher overhead

Open Design


Education works
best when all the parts
are working.
TEACHERS
STUDENTS
PARENTS

Open Design

The security of a mechanism should not rely on the secrecy of its design or implementation

Open design encourages scrutiny by multiple parties

- Earlier discovery of potential design or implementation errors

Security through obscurity is fragile

- Secrets may leak (e.g., insiders, neglect, theft)
- Reverse engineering

Especially true in cryptography

- Kerkhoff's principle: *a cryptosystem should be secure even if everything about the system, except the key, is public knowledge*
- Secret keys/passwords are not algorithms: easily *replaceable*

Separation of Privilege

Separation of Privilege

It is more secure to grant permission based on multiple conditions instead of a single one

- E.g., transfers of $50K or more must be signed off by two officers

Two-factor authentication

- Attackers have to achieve more than simply stealing a password

Related implication: *system compartmentalization*

- Limit the damage caused by a compromise of any individual component
- Separation: Monolithic OS kernel vs. microkernel, single process vs. multiple cooperating processes, …
- Confinement: virtualization, containers, sandboxing, …

Least Privilege

Least Privilege

The system should grant the bare minimum set of privileges necessary to complete a given task

- Fewer privileges ➔ smaller damage upon compromise

Granularity matters

- All or nothing (e.g., root or non-root) vs. fine-grained permissions (e.g., capabilities, seccomp, access control lists)
- Poor design: running as root just for a single activity ➔ full system access when compromised
- Permissions may be needed only temporarily: start as root (e.g., for binding to a port <1024) and drop privileges right after
- Another example: Android app permissions (used to be all-or-nothing, now can be modified individually)
- Main challenge: identify the minimal set of privileges

Least Common Mechanism

Least Common Mechanism

Mechanisms allowing resources to be shared by multiple processes or users should be minimized

More shared state ➔ more possibilities for inadvertent information flows

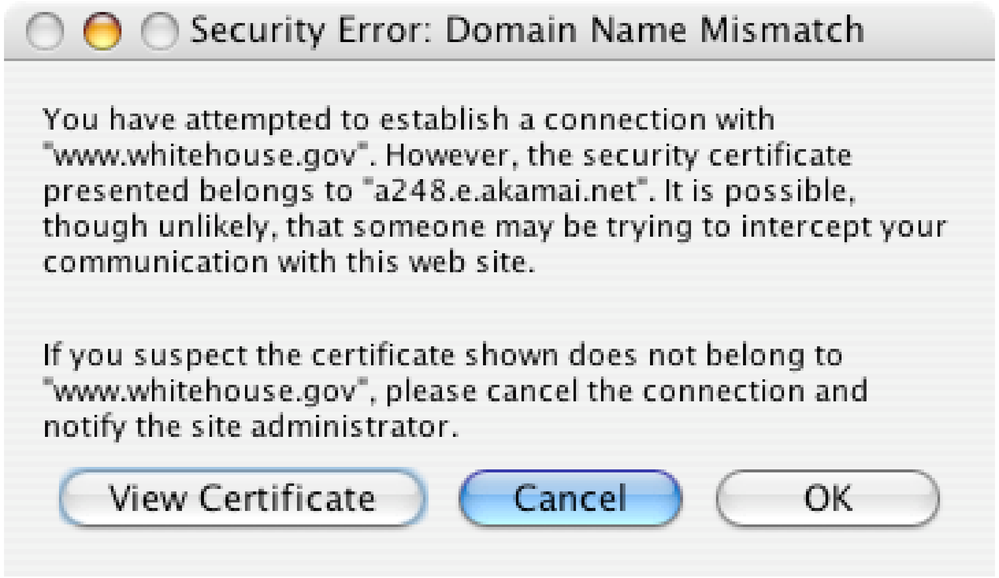
- Shared system surfaces are attractive targets for attackers
- Confinement and compartmentalization can help

Main challenge: less state requires more careful (and potentially more complex) design

- Structured programming: avoid global state, avoid a single DB table for everything, …

Additional challenge: side channels

Psychological Acceptability



Psychological Acceptability

© Johnathan Nightingale - http://blog.johnath.com/2007/10/11/todo-break-internet/

Psychological Acceptability

User interfaces should be intuitive and adhere to ordinary users' expectations

If users (including administrators) can't understand the system, they won't use it correctly

- Increased complexity leads to misconfigurations and mistakes: e.g., TLS certificates, PGP, Tor onion services, …
- Too much interruption leads to annoyance: ignore flood of IDS alerts, turn off AV, …
- Too much burden leads to workarounds: use a VPN to bypass firewall rules, write password on post-it note due to complex password requirements, …

Work Factor

Work Factor

The cost of bypassing a security mechanism should be compared with the resources an attacker must spend

Know your enemy: different threat models require different security mechanisms

- Online vs. offline password cracking, script kiddie vs. NSA, …

Quite challenging in practice due to advances in technology and state of the art

- Encryption key sizes that were considered safe are not anymore
- Code reuse replaced code injection

Elusive goal: "raise the bar for successful exploitation"

- The work factor is often hard to quantify

Compromise Recording

Compromise Recording

Detection and logging is equally important

Defense in depth

If prevention mechanisms fail, detection mechanisms can be an additional layer of defense

Intrusion detection

Monitor networks or hosts for malicious activities or policy violations

Situational awareness

Have a clear understanding of what is happening on the network and in the IT environment

Audit logs facilitate incident response and forensics