Software Security

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What I want to share

- Secure software →

  Development process and security development lifecycle
  Threat modeling
  Security requirements
  Microsoft SDL

- Mycompany’s demo →

  Dynamic/static analyses
  Client-side and server-side penetration tests
  Network Sniffing
  Denial of service attacks
  & more…

- Wrap up →

  More attacks
  Cyber security resources

Secure software

- Flawed software → Ignoring security during the design phase
  Add security when functional requirements are satisfied

- Better approach → Incorporate security into all phases of the development process

Development process

Four common phases:

1. Requirements + security
2. Design + security
3. Implementation + security
4. Testing + security

Where is security?

Development process

Four common phases:

1. Requirements + security →
   - Security requirements
   - Abuse cases
2. Design + security →
   - Architectural risk analysis
   - Security-oriented design
3. Implementation + security →
   - Code review (manual + tools)
4. Testing + security →
   - Risk-based security tests
   - Penetration testing

Where is security?

Secure software vs. hardware

- Software →
  - Easily changeable
  - Can be weak at security

- Hardware →
  - Hard to change
  - Exploiting hardware is not easy
  - Intel SGX (encrypted computation)

Threat modeling

- A threat model is a structured representation of all the information that affects the security of an application, IoT, distributed system and so on

- The threat model is critically important

- This is part of architectural risk analysis

- STRIDE is a model of threats (Spoofing, Tampering, Repudiation, Information Disclosure, Denial of service, Elevation of privilege)

Example: Snooping user

As a malicious user who is connected to a network where others are also working:

1. Read others’ messages

2. Intercept, modify, and duplicate messages

3. Flood the network with invalid packets

…

Session hijacking, Privacy disclosure, Denial of service, Side-channel attack

Example: Co-located user

As a malicious user who has installed a malware on a user’s machine:

1. Read/write users’ files
2. Read/write users’ memory
3. Record user’s keystroke

…

Confidential information theft, Encrypting users’ data (Ransomware)

Threat-driven design

- Different threat models can provide different aspects of your software security
- E.g. In the snooping attack scenario encrypting user traffic is important (IPsec, SSL, WPA3, …)
- E.g. In the co-located user scenario providing users with additional means of authentication is necessary

Security requirements

- Software requirements: what the software should do?

- Security requirements →
  - Security goals or policies (secrecy of user’s bank balance)
  - Security mechanisms (passwords)

Kinds of requirements

- Policies
  - Confidentiality : sensitive information should not be leaked
  - Integrity : changing the content of a network packet
  - Availability : DoS to weaken availability
- Mechanisms
  - Authentication : password, biometrics, multi-factor auth..
  - Authorization : access controls, role-based or user-based permissions
  - Auditability : logging every event in the system - backups

Security principles

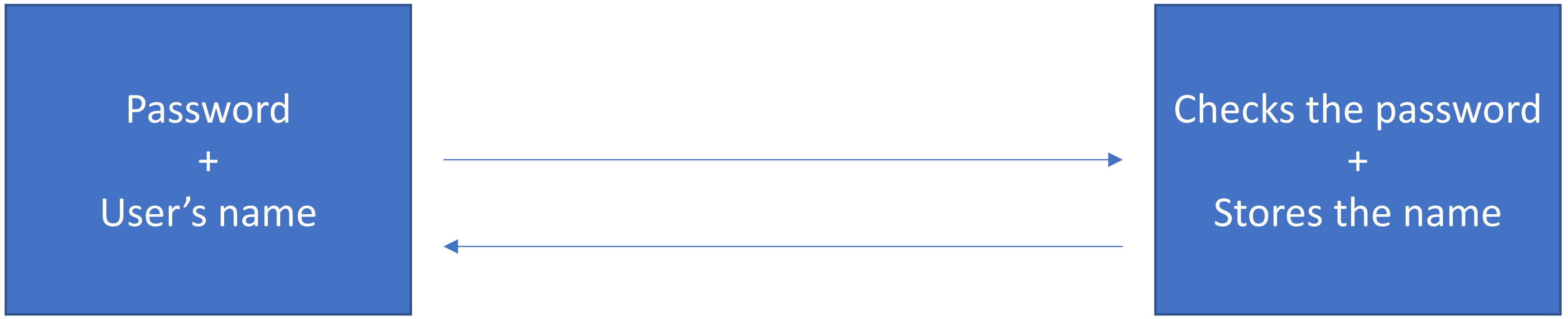
- Prevention
  - Eliminate software defects completely
  - Heartbleed bug would have been prevented by a type safe language
- Mitigation
  - Reduce the damage from unknown exploitation possibilities
  - Run each browser’s tab in a separate process
- Detection
  - Identify the attack and undo the damage
  - Monitoring and taking snapshots periodically

Microsoft SDL – Security Development Lifecycle

- The Microsoft SDL incorporate security and privacy considerations into all phases of the development process, supporting developers build highly secure software, address security compliance requirements, and reduce development costs.

https://www.microsoft.com/en-us/securityengineering/sdl

Mycompany – A very bad example!



Password
+
User's name

Checks the password
+
Stores the name

Client side – C++ application

Server side – PHP application

Security through obscurity

Mycompany - demos

- Static/Dynamic analyses 🟩🟥
- Traffic analysis 🟩🟥
- SQL injection 🟩🟥
- DoS 🟩

Terminology – DoS attacks

- A Denial-of-Service (DoS) or Distributed DoS attacks meant to shut down or slow down a machine or a network

- DoS attacks accomplish this by flooding the target with traffic, which is commonly useless. Sometimes the traffic triggers a crash in the remote program

- The attack is easy to perform for attackers

- ICMP and SYN flood

Terminology – SQL injection

- SQL injection makes it possible to execute malicious SQL statements

- An attacker can insert, update, or delete a record

- The problem is rooted in unchecked inputs

Mycompany – lessons learned

- Obfuscate the code / do not use hard-coded secrets
- Validate the inputs / use web-based firewalls
- Limit the number of request per machine + firewalls/IPS/IDS
- Encryption + TLS
- Not made-up approaches such as concatenation of weak random numbers

Hmmm..

More demo?

Pcap file analysis 🟩

- Pcap files are commonly data files generated by network packet capturing programs
- They normally contain the packet data of a network
- Many hands-On packet analysis courses exist….

Android analysis

- Reverse engineering Android applications
- Exploit Android vulnerabilities
- Discover hard-coded secrets
- …

Cryptography

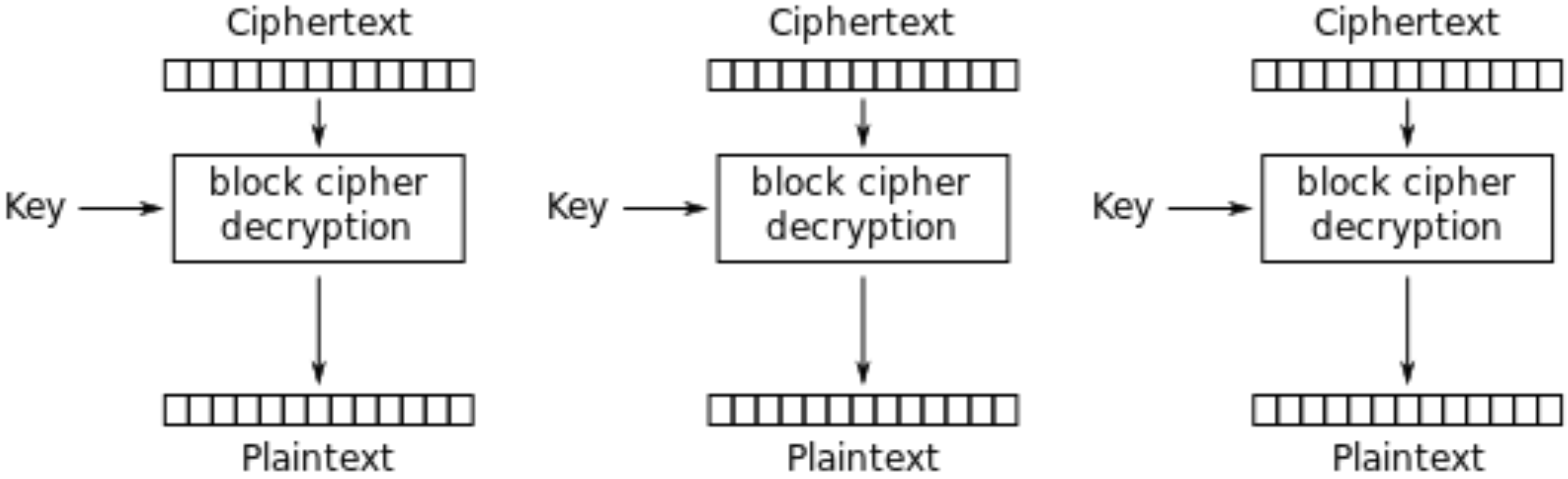
- Hashing algorithms (MD5, SHA-1 (160-bit) , SHA-2, ….)
- Symmetric encryption

  1. Employs a single cryptographic key to encrypt and decrypt data
  2. It is fast compared to its counterpart (asymmetric)
  3. **DES – 3DES – AES (all are block ciphers)**

Block ciphers…

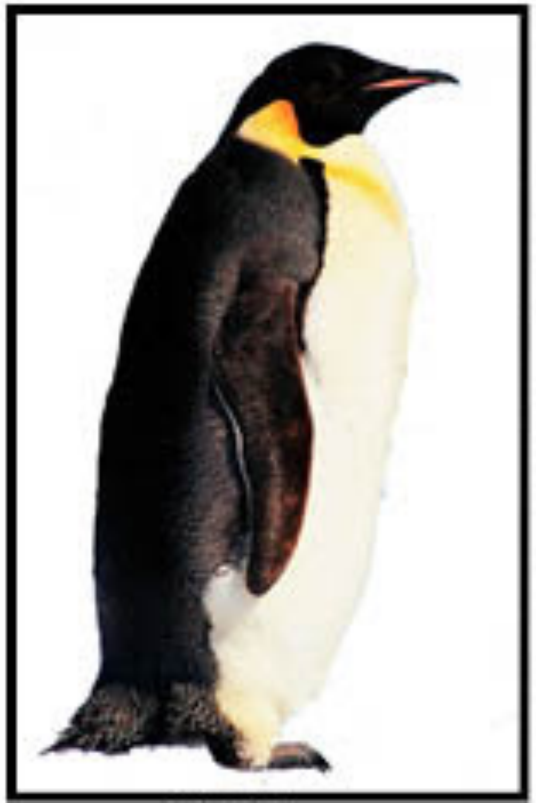
- … employs various modes of encryption (ECB, CBC, CTR, …)
- … necessitates the input to be an exact multiple of the block size
- **ECB** jeopardizes the security of your software system!
- **Duplicated plaintext** blocks give the same ciphertext block!

ECB

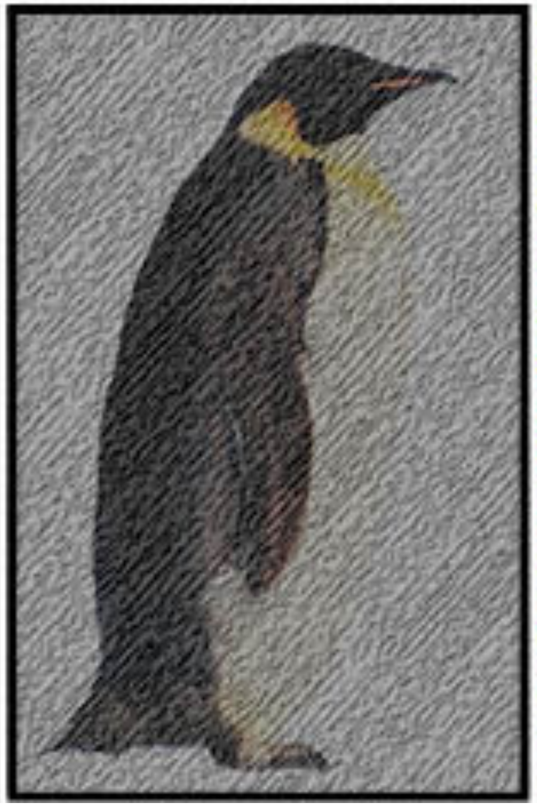


Electronic Codebook (ECB) mode decryption

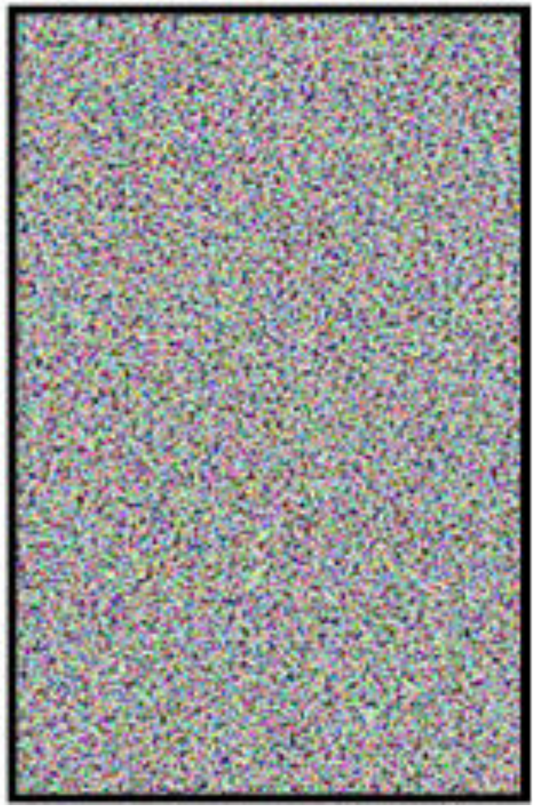
ECB



Unencrypted



ECB mode encrypted



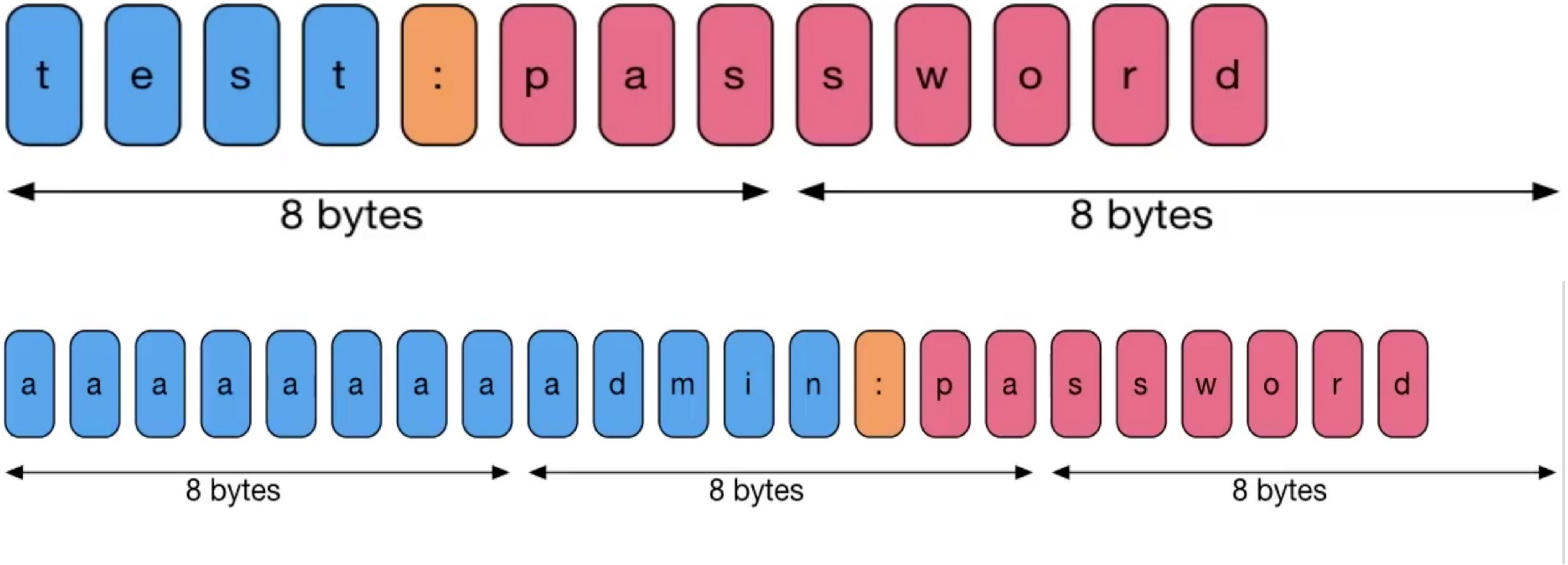
CBC mode encrypted

The broken system… 🟥

- The cookie contains a username and password encrypted by an algorithm and ECB mode
- Base64 is an encoding algorithm used in the cookie
- The problem is encryption provides confidentiality but not integrity
- Integrity checks for data tampering

The broken system…

If the username is **test** and password is **password**:



t e s t : p a s s w o r d

8 bytes 8 bytes

a a a a a a a a a d m i n : p a s s w o r d

8 bytes 8 bytes 8 bytes

DNS rebinding attack 🟥

- Cross-origin policy (SOP) in browsers restricts how a document or script loaded by one origin can interact with a resource from another origin
- However, SOP only checks the domain names!
- DNS rebinding effortlessly circumvents SOP!

DNS rebinding attack 🟥

- Ubuntu – the attacker – uses a DNS changer
- Kali Linux – the victim – only has a localhost on his machine
- The attacker wants to **read** the victim's "**oh.txt**" file, locating in the **victim's localhost**
- The victim **visits** the attacker's **malicious website**
- The malicious website **continuously checks** for an **update** in the victim's browser cache

What else?

- Reconnaissance
- Network scanning
- System hacking
- Malware threats
- Hacking mobile platforms

What else?

- Social engineering
- Session hijacking
- Evading IDS or firewalls
- Hacking web servers
- Cryptography

Certifications in cyber security

- Security+
- Certified Information Systems Security Professional (CISSP)
- Certified Ethical Hacker (CEH)
- Offensive Security Certified Professional (OSCP)
- Offensive Security Wireless Professional (OSWP)
- Offensive Security Experienced Penetration Tester (OSEP)
- Offensive Security Exploit Developer (OSED)
- eLearnSecurity Certified Professional Penetration Tester (eCPPT)
- www.pentesterlab.com

Now you should know

- What is a secure software?
- What is Microsoft SDL?
- How a vulnerability can be exploited?
- What security aspects must be taken into account when writing software?