UNIVERSITY INSTITUTEOF ENGINEERING

Bachelor of Engineering (Computer Science & Engineering)

Operating System (20CST/ITT-313)

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Introduction to Operating System

DISCOVER . LEARN . EMPOWER

System Protection and Security

Authentication

- Constraining set of potential senders of a message
  - Complementary and sometimes redundant to encryption
  - Also can prove message unmodified

- Algorithm components
  - A set K of keys
  - A set M of messages
  - A set A of authenticators
  - A function $S : K \to (M \to A)$
    - That is, for each $k \in K$, $S(k)$ is a function for generating authenticators from messages
    - Both S and $S(k)$ for any k should be efficiently computable functions
  - A function $V : K \to (M \times A \to \{\text{true, false}\})$. That is, for each $k \in K$, $V(k)$ is a function for verifying authenticators on messages
    - Both V and $V(k)$ for any k should be efficiently computable functions

Authentication

- For a message m, a computer can generate an authenticator $a \in A$ such that $V(k)(m, a)$ = `true` only if it possesses $S(k)$
- Thus, computer holding $S(k)$ can generate authenticators on messages so that any other computer possessing $V(k)$ can verify them
- Computer not holding $S(k)$ cannot generate authenticators on messages that can be verified using $V(k)$
- Since authenticators are generally exposed (for example, they are sent on the network with the messages themselves), it must not be feasible to derive $S(k)$ from the authenticators

Authentication – Hash Functions

- Basis of authentication
- Creates small, fixed-size block of data (**message digest**, **hash value**) from *m*
- Hash Function *H* must be collision resistant on *m*
  - Must be infeasible to find an $m' \neq m$ such that $H(m) = H(m')$
- If $H(m) = H(m')$, then $m = m'$
  - The message has not been modified
- Common message-digest functions include **MD5**, which produces a 128-bit hash, and **SHA-1**, which outputs a 160-bit hash

Authentication - MAC

- Symmetric encryption used in **message-authentication code** (**MAC**) authentication algorithm
- Simple example:
  - MAC defines $S(k)(m) = f(k, H(m))$
    - Where f is a function that is one-way on its first argument
      - k cannot be derived from $f(k, H(m))$
    - Because of the collision resistance in the hash function, reasonably assured no other message could create the same MAC
    - A suitable verification algorithm is $V(k)(m, a) \equiv (f(k,m) = a)$
    - Note that k is needed to compute both $S(k)$ and $V(k)$, so anyone able to compute one can compute the other

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Authentication – Digital Signature

- Based on asymmetric keys and digital signature algorithm
- Authenticators produced are **digital signatures**
- In a digital-signature algorithm, computationally infeasible to derive $S(k_s)$ from $V(k_v)$
  - V is a one-way function
  - Thus, k_v is the public key and k_s is the private key
- Consider the RSA digital-signature algorithm
  - Similar to the RSA encryption algorithm, but the key use is reversed
  - Digital signature of message $S(k_s)(m) = H(m)^{ks} \bmod N$
  - The key k_s again is a pair d, N, where N is the product of two large, randomly chosen prime numbers p and q
  - Verification algorithm is $V(k_v)(m, a) \equiv (a^{kv} \bmod N = H(m))$
    - Where k_v satisfies $k_v k_s \bmod (p - 1)(q - 1) = 1$

Authentication Contin….

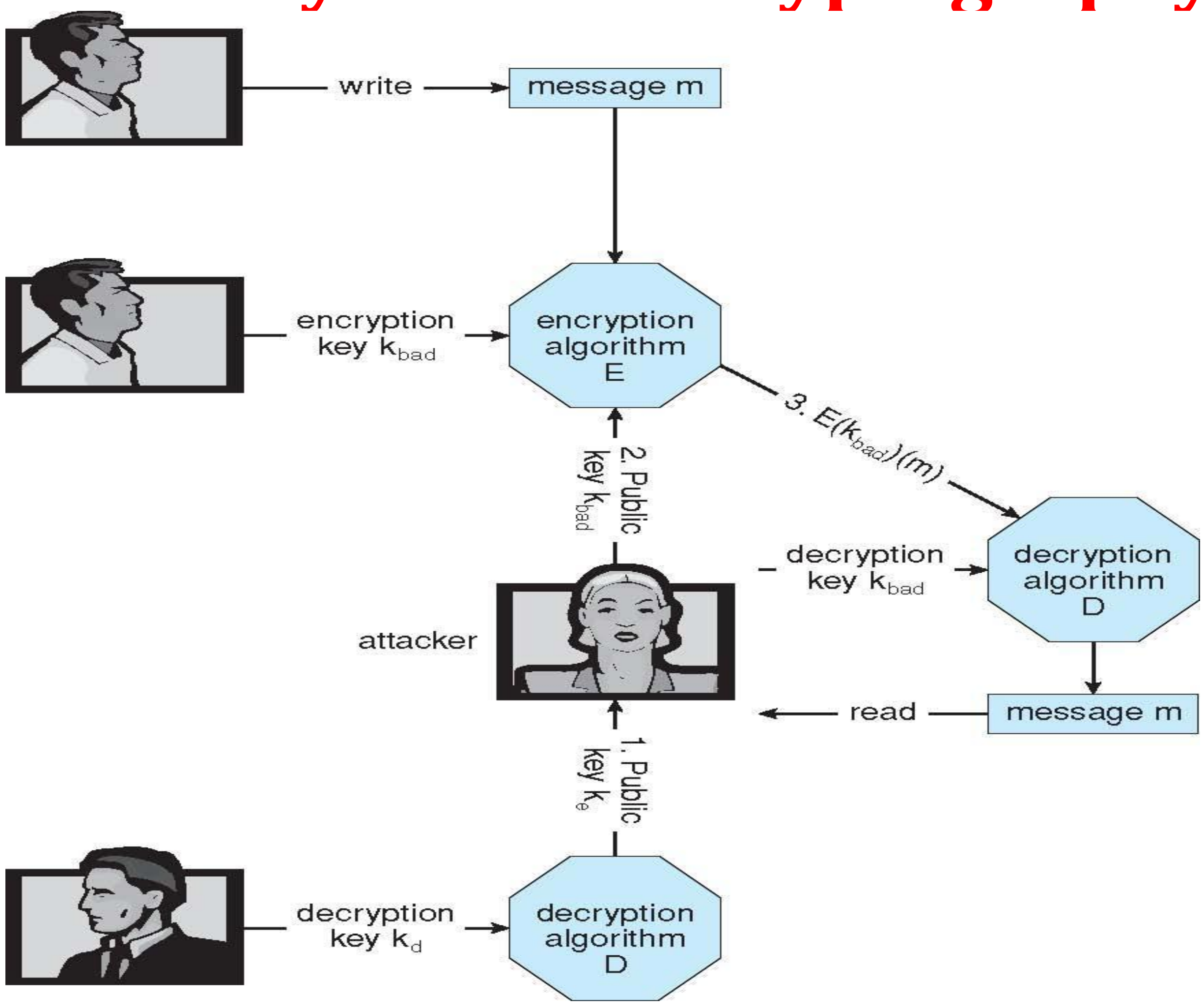
- Why authentication if a subset of encryption?
  - Fewer computations (except for RSA digital signatures)
  - Authenticator usually shorter than message
  - Sometimes want authentication but not confidentiality
    - Signed patches et al
  - Can be basis for **non-repudiation**

Key Distribution

- Delivery of symmetric key is huge challenge
  - Sometimes done **out-of-band**

- Asymmetric keys can proliferate – stored on **key ring**
  - Even asymmetric key distribution needs care – man-in-the-middle attack

Man-in-the-middle Attack on Asymmetric Cryptography



Digital Certificates

- Proof of who or what owns a public key
- Public key digitally signed a trusted party
- Trusted party receives proof of identification from entity and certifies that public key belongs to entity
- Certificate authority are trusted party – their public keys included with web browser distributions
  - They vouch for other authorities via digitally signing their keys, and so on

User Authentication

- Crucial to identify user correctly, as protection systems depend on user ID
- User identity most often established through *passwords*, can be considered a special case of either keys or capabilities
- Passwords must be kept secret
  - Frequent change of passwords
  - History to avoid repeats
  - Use of “non-guessable” passwords
  - Log all invalid access attempts (but not the passwords themselves)
  - Unauthorized transfer
- Passwords may also either be encrypted or allowed to be used only once
  - Does encrypting passwords solve the exposure problem?
    - Might solve **sniffing**
    - Consider **shoulder surfing**
    - Consider Trojan horse keystroke logger
    - How are passwords stored at authenticating site?

Passwords

- Encrypt to avoid having to keep secret
  - But keep secret anyway (i.e. Unix uses superuser-only readably file `/etc/shadow`)
  - Use algorithm easy to compute but difficult to invert
  - Only encrypted password stored, never decrypted
  - Add “salt” to avoid the same password being encrypted to the same value
- One-time passwords
  - Use a function based on a seed to compute a password, both user and computer
  - Hardware device / calculator / key fob to generate the password
    - Changes very frequently
- Biometrics
  - Some physical attribute (fingerprint, hand scan)

- Multi-factor authentication
  - Need two or more factors for authentication
    - i.e. USB “dongle”, biometric measure, and password

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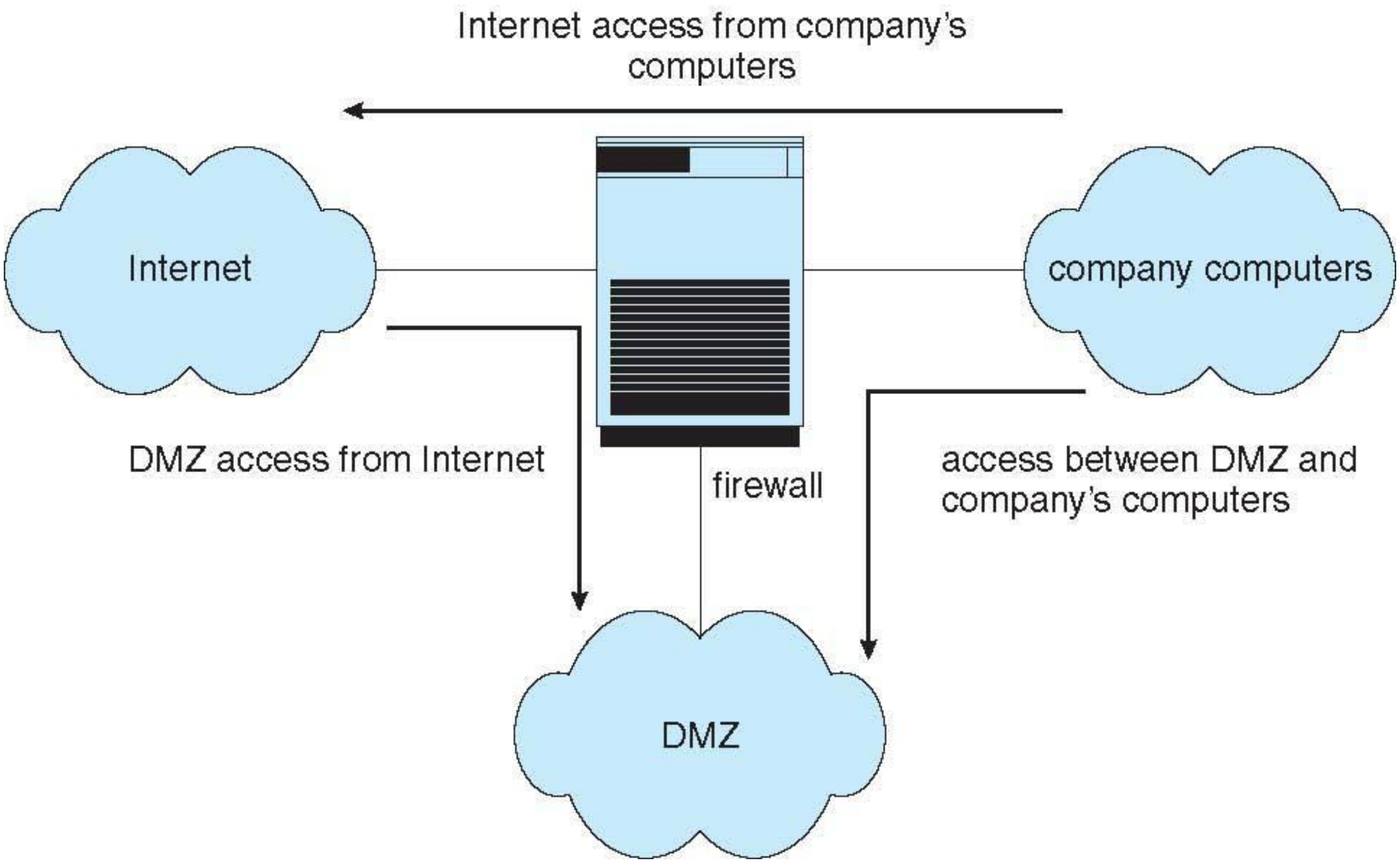
Implementing Security Defenses

- **Defense in depth** is most common security theory – multiple layers of security
- Security policy describes what is being secured
- Vulnerability assessment compares real state of system / network compared to security policy
- Intrusion detection endeavors to detect attempted or successful intrusions
  - **Signature-based** detection spots known bad patterns
  - **Anomaly detection** spots differences from normal behavior
    - Can detect **zero-day** attacks
  - **False-positives** and **false-negatives** a problem
- Virus protection
- Auditing, accounting, and logging of all or specific system or network activities

Firewalling to Protect Systems and Networks

- A network firewall is placed between trusted and untrusted hosts
  - The firewall limits network access between these two security domains
- Can be tunneled or spoofed
  - Tunneling allows disallowed protocol to travel within allowed protocol (i.e., telnet inside of HTTP)
  - Firewall rules typically based on host name or IP address which can be spoofed
- **Personal firewall** is software layer on given host
  - Can monitor / limit traffic to and from the host
- **Application proxy firewall** understands application protocol and can control them (i.e., SMTP)
- **System-call firewall** monitors all important system calls and apply rules to them (i.e., this program can execute that system call)

Network Security Through Domain Separation Via Firewall



Computer Security Classifications

- U.S. Department of Defense outlines four divisions of computer security: **A**, **B**, **C**, and **D**
- **D** – Minimal security
- **C** – Provides discretionary protection through auditing
  - Divided into **C1** and **C2**
    - **C1** identifies cooperating users with the same level of protection
    - **C2** allows user-level access control
- **B** – All the properties of **C**, however each object may have unique sensitivity labels
  - Divided into **B1**, **B2**, and **B3**
- **A** – Uses formal design and verification techniques to ensure security

Video Links

https://www.youtube.com/watch?v=3yLf2dNqDzw

https://www.youtube.com/watch?v=w4J1RZyUv_I

References

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