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UNIVERSITY INSTITUTEOF ENGINEERING

Bachelor of Engineering (Computer Science & Engineering)

Operating System (20CST/ITT-313)

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System Protection and Security

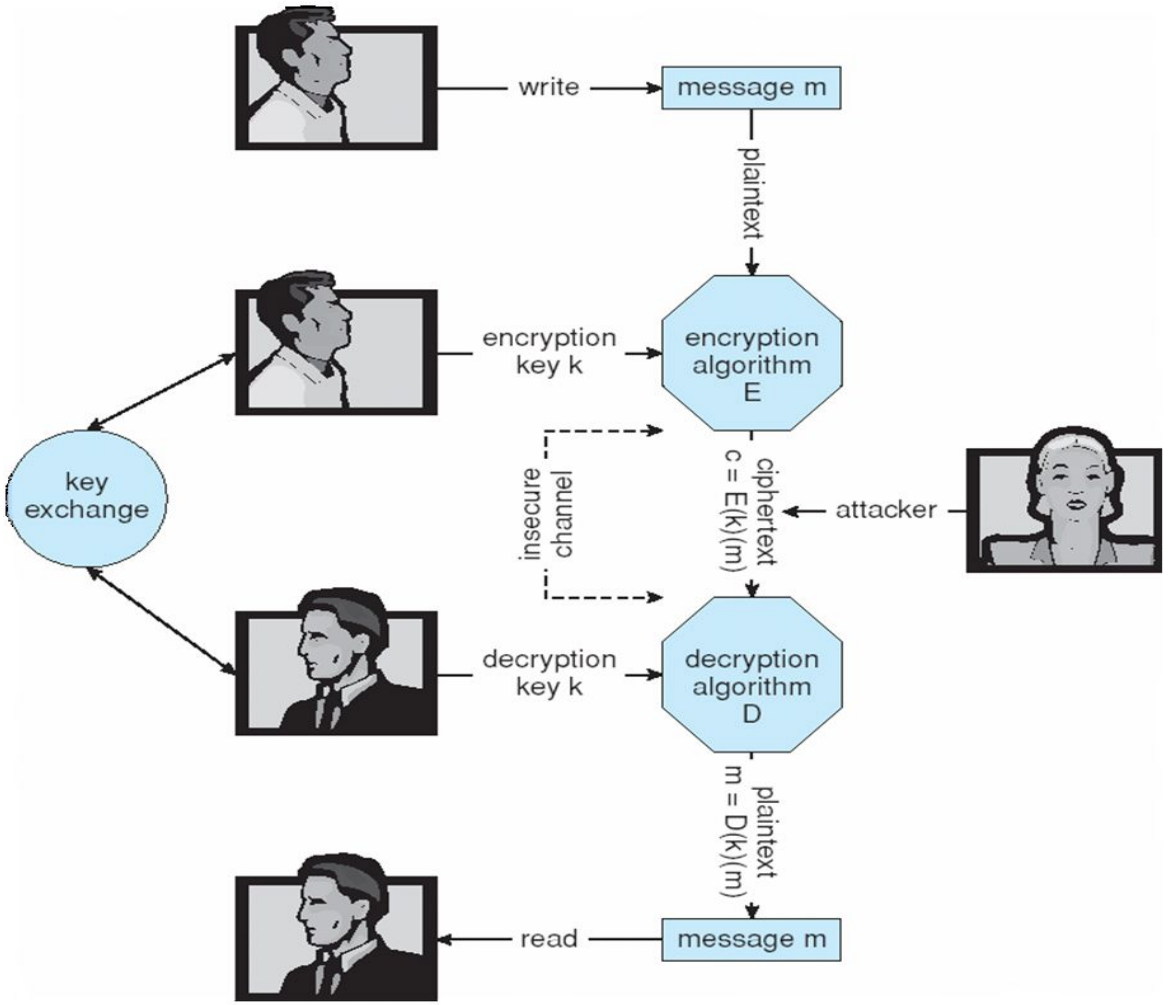
Cryptography as a Security Tool

- Broadest security tool available
  - Internal to a given computer, source and destination of messages can be known and protected
    - OS creates, manages, protects process IDs, communication ports
  - Source and destination of messages on network cannot be trusted without cryptography
    - Local network – IP address?
      - Consider unauthorized host added
    - WAN / Internet – how to establish authenticity
      - Not via IP address

Cryptography

- Means to constrain potential senders (*sources*) and / or receivers (*destinations*) of *messages*
  - Based on secrets (**keys**)
  - Enables
    - Confirmation of source
    - Receipt only by certain destination
    - Trust relationship between sender and receiver

Secure Communication over Insecure Medium



Encryption

- Encryption algorithm consists of
  - Set *K* of keys
  - Set *M* of Messages
  - Set *C* of ciphertexts (encrypted messages)
  - A function $E : K \rightarrow (M \rightarrow C)$. That is, for each $k \in K$, $E(k)$ is a function for generating ciphertexts from messages
    - Both *E* and $E(k)$ for any *k* should be efficiently computable functions
  - A function $D : K \rightarrow (C \rightarrow M)$. That is, for each $k \in K$, $D(k)$ is a function for generating messages from ciphertexts
    - Both *D* and $D(k)$ for any *k* should be efficiently computable functions
- An encryption algorithm must provide this essential property: Given a ciphertext $c \in C$, a computer can compute m such that $E(k)(m) = c$ only if it possesses $D(k)$
  - Thus, a computer holding $D(k)$ can decrypt ciphertexts to the plaintexts used to produce them, but a computer not holding $D(k)$ cannot decrypt ciphertexts
  - Since ciphertexts are generally exposed (for example, sent on the network), it is important that it be infeasible to derive $D(k)$ from the ciphertexts

Symmetric Encryption

- Same key used to encrypt and decrypt
  - $E(k)$ can be derived from $D(k)$, and vice versa
- DES is most commonly used symmetric block-encryption algorithm (created by US Govt)
  - Encrypts a block of data at a time
- Triple-DES considered more secure
- Advanced Encryption Standard (**AES**),
- RC4 is most common symmetric stream cipher, but known to have vulnerabilities
  - Encrypts/decrypts a stream of bytes (i.e., wireless transmission)
  - Key is a input to psuedo-random-bit generator
    - Generates an infinite **keystream**

Asymmetric Encryption

- Public-key encryption based on each user having two keys:
  - public key – public key used to encrypt data
  - private key – key known only to individual user used to decrypt data

- Must be an encryption scheme that can be made public without making it easy to figure out the decryption scheme
  - Most common is RSA block cipher
  - No efficient algorithm is known for finding the prime factors of a number which is product of two large prime numbers.

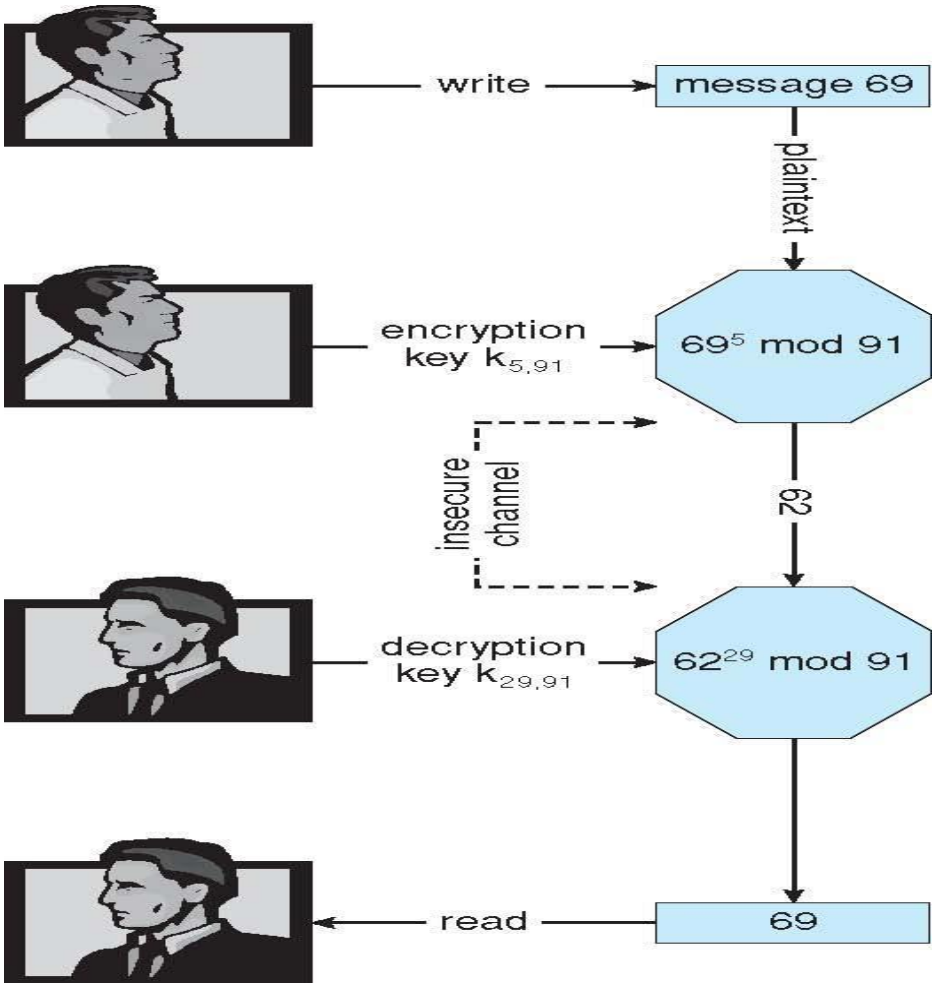
Asymmetric Encryption (Cont.)

- Formally, it is computationally infeasible to derive $D(k_d, N)$ from $E(k_e, N)$, and so $E(k_e, N)$ need not be kept secret and can be widely disseminated
  - $E(k_e, N)$ (or just k_e) is the **public key**
  - $D(k_d, N)$ (or just k_d) is the **private key**
  - N is the product of two large, randomly chosen prime numbers p and q (for example, p and q are 512 bits each)
  - Encryption algorithm is $E(k_e, N)(m) = m^{ke} \bmod N$, where k_e satisfies $k_e k_d \bmod (p-1)(q-1) = 1$
  - The decryption algorithm is then $D(k_d, N)(c) = c^{kd} \bmod N$

Asymmetric Encryption Example

- For example. make p = 7and q = 13
- We then calculate N = 7∗13 = 91 and $(p-1)(q-1)$ = 72
- We next select k_e relatively prime to 72 and< 72, yielding 5
- Finally, we calculate k_d such that $k_e k_d$ mod 72 = 1, yielding 29
- We now have our keys
  - Public key, k_e, N = 5, 91
  - Private key, k_d , N = 29, 91
- Encrypting the message 69 with the public key results in the cyphertext 62
- Cyphertext can be decoded with the private key
  - Public key can be distributed in cleartext to anyone who wants to communicate with holder of public key

Encryption and Decryption using RSA Asymmetric Cryptography



Cryptography (Cont.)

- Note symmetric cryptography based on transformations, asymmetric based on mathematical functions
  - Asymmetric much more compute intensive
  - Typically not used for bulk data encryption

Video Links

https://www.edureka.co/blog/what-is-cryptography/

https://book.cyberyozh.com/comprehensive-encryption-of-operating-system-or-hard-disk-drive/

References

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