
Network Security

COMP90007

Internet Technologies

What is Network Security?

- Network security is a combo of 4 related areas:
 - ❑ **Secrecy** (Keeping information hidden from a general audience)
 - ❑ **Authentication** (Ensuring the user you are giving content to has valid credentials)
 - ❑ **Non-repudiation** (Prove a content was created by a named user)
 - ❑ **Integrity control** (Ensure that a content has not been tampered with)
- All of these are **equally valid** and has been around for all systems for some time, but have different and sometimes more challenging implications in a networked environment
- Aspects of security can be found at all layers of a protocol stack, **there is no way to secure a network by building security into one layer only**
- Most security implementations are **based on common cryptographic principles** and appear on almost all layers

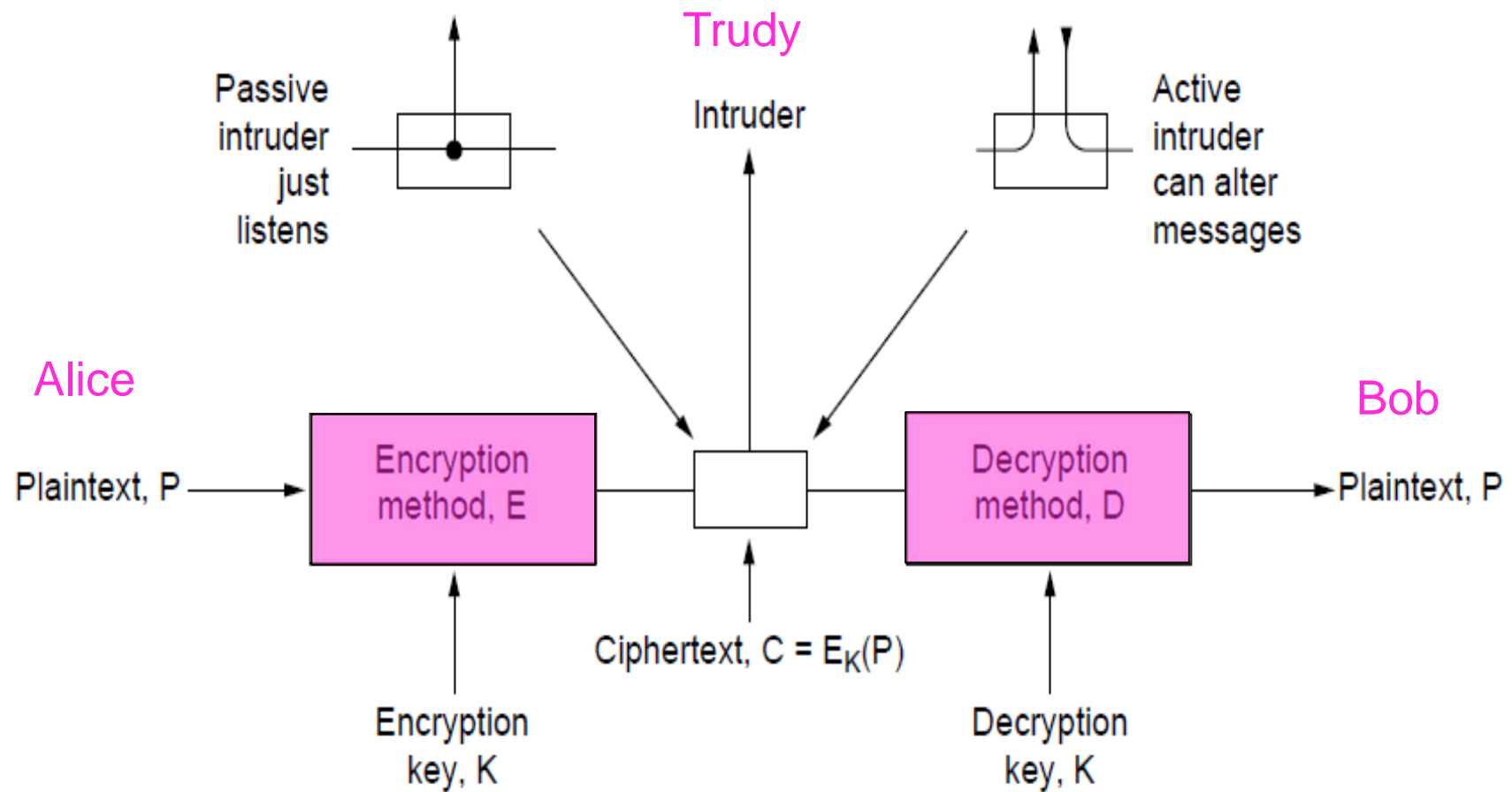
Some Well-Known Characters..

Adversary	Goal
Student	To have fun snooping on people's email
Cracker	To test out someone's security system; steal data
Sales rep	To claim to represent all of Europe, not just Andorra
Businessman	To discover a competitor's strategic marketing plan
Ex-employee	To get revenge for being fired
Accountant	To embezzle money from a company
Stockbroker	To deny a promise made to a customer by email
Con man	To steal credit card numbers for sale
Spy	To learn an enemy's military or industrial secrets
Terrorist	To steal germ warfare secrets

Cryptography

- A key area/set of algorithms for creating secrets, authenticating users, making sure messages are not tampered with, and edits are not denied by the original author....

Encryption Model



Key Cryptography Concepts

- Three foundations:
 - Plaintext
 - Keys
 - Ciphertext
- **Plaintext** messages to be encrypted can be transformed (encrypted/decrypted) by a function that is parameterized by a **key**, the output of the transformation process is **ciphertext**
- **Kerckhoff's** principle: Cryptographic Algorithms and related functions (E, D) are public; only the keys (K) are secret

A Simple Example

- Key/Method for Encryption: this function is a very simple one, transform every character to the next one in the alphabet for a given plaintext (and “z” becomes “a” to circle around the end)
- Input plaintext
 - “where”
- Output ciphertext
 - “xifsf”
- Decryption is the simple method to go back in the alphabet to reverse the effect of encryption

The Notation

- C = ciphertext, P = plaintext, E = encryption, D = decryption, K = key
- $C = E_K(P)$
- $P = D_K(C)$
- $D_K(E_K(P)) = P$
- In fact what we want in simple crypto-based network security is efficient methods where

$$D_{K1}(E_{K2}(P)) = P \text{ if and only if } K1=K2.$$

Keys Plays an Important Role

- A key is a **string that allows the selection** of one of many potential encryptions
- The **key can be changed** as often as required
- **Algorithms are more likely to be at the hands of attackers** anyhow, not changed as frequently
- **Cipher is a term** commonly used as the term for algorithm here
- The size of the overall key space is determined by the number of bits in the key string
- The **longer the key, the more effort is required to break a given encryption**

A common function used in ciphers: XOR

- An XOR is an “exclusive or” function used regularly.
- A XOR B means A or B, but not both
- XOR is commonly used in cryptography

A	B	A XOR B
F	F	F
F	T	T
T	F	T
T	T	F

Truth values	Binary Equivalents
T	1
F	0

Some Key Types of Ciphers

- Substitution cipher
 - Each letter of group of letters is replaced systematically by other letters or groups of letters (our example)
- Transposition cipher
 - All letters are re-ordered without disguising them
- One-time pad
 - Uses a random bit string as the key: convert the plaintext into a bit string, then XOR the two strings bit by bit
 - Harder to break
 - How to share the random key and its size are factors

Example revisited: Substitution cipher example

- Substitution ciphers replace each group of letters in the message with another group of letters based on a key with an intention to disguise the message.

plaintext:	a b c d e f g h i j k l m n o p q r s t u v w x y z
ciphertext:	Q W E R T Y U I O P A S D F G H J K L Z X C V B N M

- If “were” was the ciphertext received then it becomes

“bcdc”

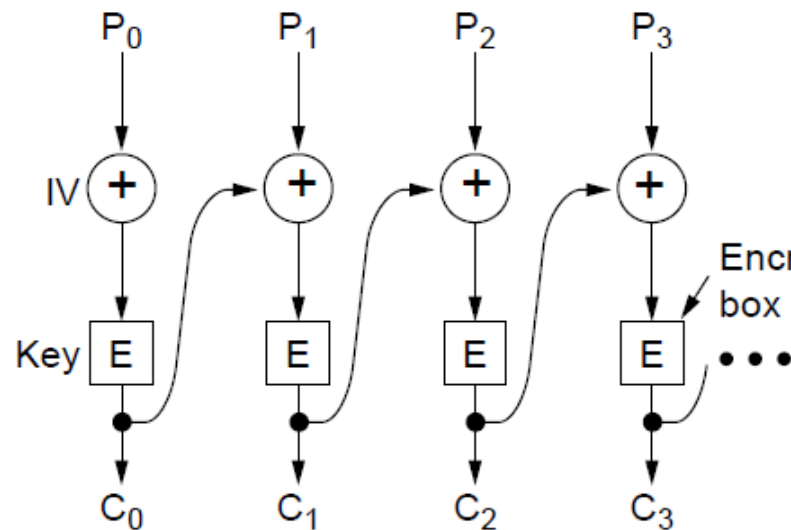
when decrypted

Modern Key-based Algorithms

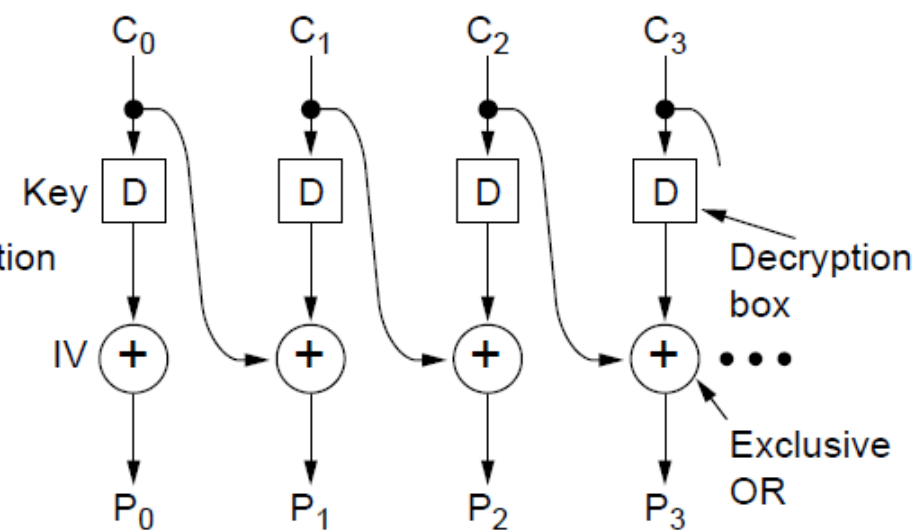
- **Two main categories**
- **Symmetric key algorithms** use the same key for both encryption and decryption
- Symmetric key algorithms can use permutation, substitution and a combination of both to encrypt and decrypt
- **2 Symmetric Key Algorithms**
 - Data Encryption Standard (DES)
 - Uses 64 bit blocks and 56 bit keys
 - 2^{56} key space
 - Triple DES has a 3×2^{56} key space
 - Advanced Encryption Standard (AES) in use since 2000s
 - Uses 128 bit blocks and 128 bit keys
 - 2^{128} key space
 - Still substitution and permutation based with multiple rounds

Cipher Block Chaining Mode

- **Same text leads to same ciphertext unless something else is done, thus:**
- In block chaining mode, each plaintext block is XOR'ed with the previous ciphertext block before being encrypted
- (a) encryption. (b) decryption



CBC mode encryption



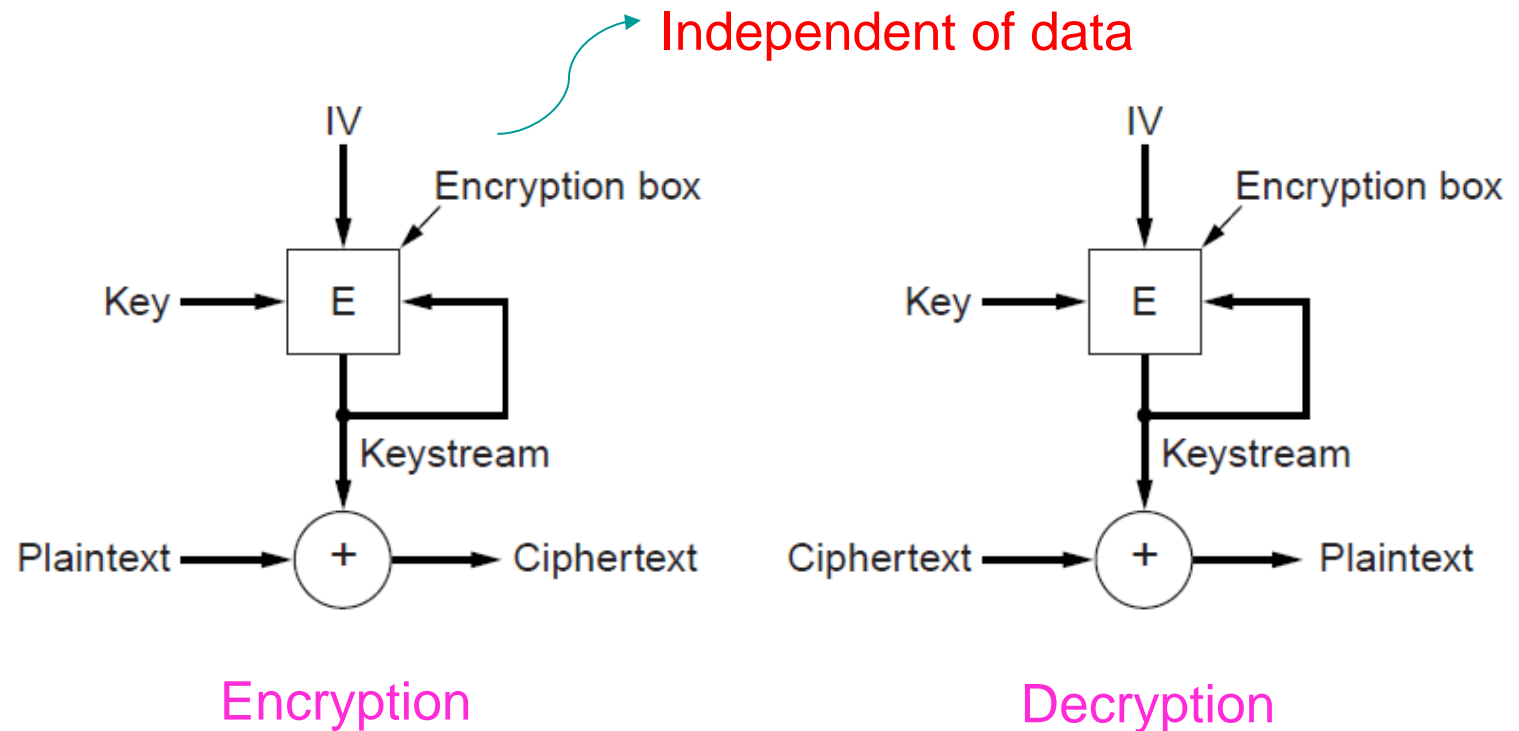
CBC mode decryption

Cipher Feedback Mode

- In cipher feedback mode, **byte-by-byte encryption** is used rather than block-by-block encryption
- Good for things like encrypting someones key strokes on a keyboard **where a lot of data is not immediately available**

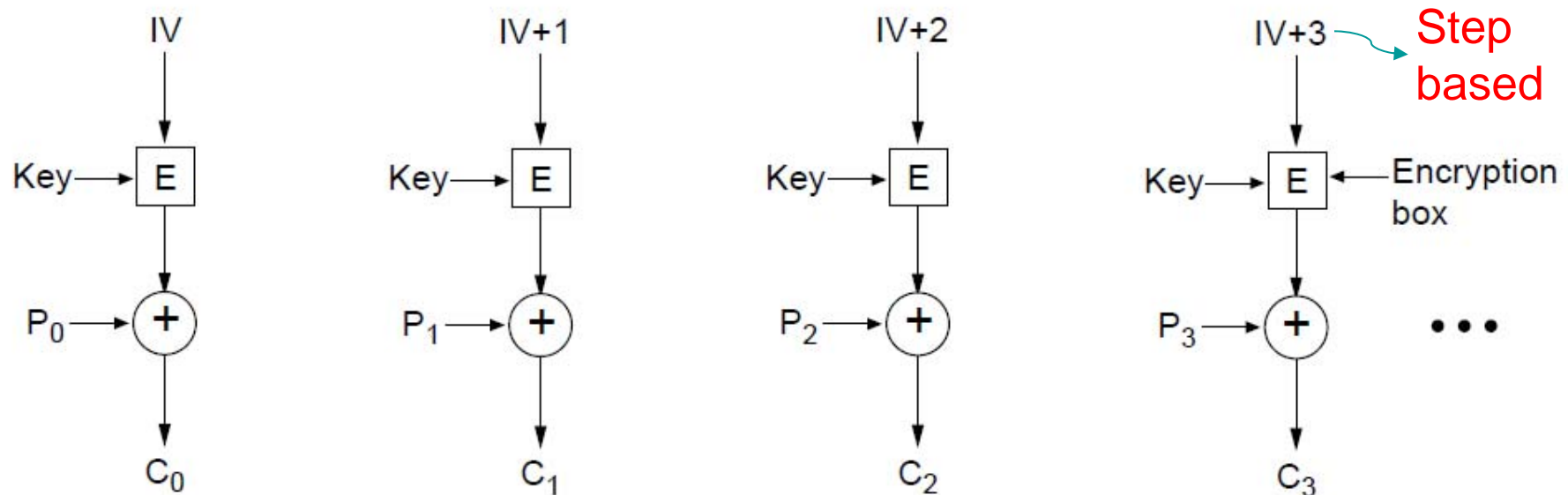
Stream Cipher Mode

- What if **data transmission errors occur**? In stream cipher mode, recursive sequential block encryption is used as a **one-time pad**, and XOR'ed with plaintext to generate ciphertext



Counter Mode

- But **how about random access to data after encryption?**
- In counter mode, plaintext is not directly encrypted, but an initialisation parameter plus an arbitrary constant is encrypted, and the resulting ciphertext is XOR'ed with plaintext



Many Symmetric Key Algorithms Exist

Cipher	Author	Key length	Comments
Blowfish	Bruce Schneier	1–448 bits	Old and slow
DES	IBM	56 bits	Too weak to use now
IDEA	Massey and Xuejia	128 bits	Good, but patented
RC4	Ronald Rivest	1–2048 bits	Caution: some keys are weak
RC5	Ronald Rivest	128–256 bits	Good, but patented
Rijndael	Daemen and Rijmen	128–256 bits	Best choice
Serpent	Anderson, Biham, Knudsen	128–256 bits	Very strong
Triple DES	IBM	168 bits	Second best choice
Twofish	Bruce Schneier	128–256 bits	Very strong; widely used