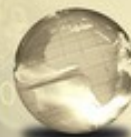# Cryptography and Network Security
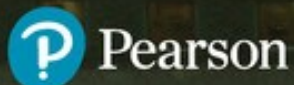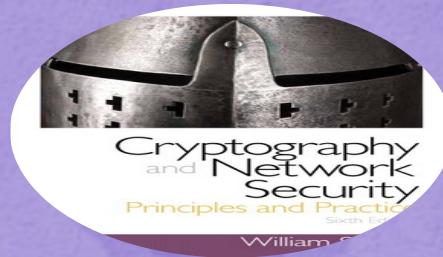
Principles and Practice

SEVENTH EDITION

William Stallings

Chapter 12

Message Authentication Codes

Message Authentication Requirements

Problems occours When Two parties are Communicating :

- Disclosure
  - Release of message contents to any person or process not possessing the appropriate cryptographic key
- Traffic analysis
  - Discovery of the pattern of traffic between parties
- Masquerade
  - Insertion of messages into the network from a fraudulent source
- Content modification
  - Changes to the contents of a message, including insertion, deletion, transposition, and modification

- Sequence modification
  - Any modification to a sequence of messages between parties, including insertion, deletion, and reordering
- Timing modification
  - Delay or replay of messages
- Source repudiation
  - Denial of transmission of message by source
- Destination repudiation
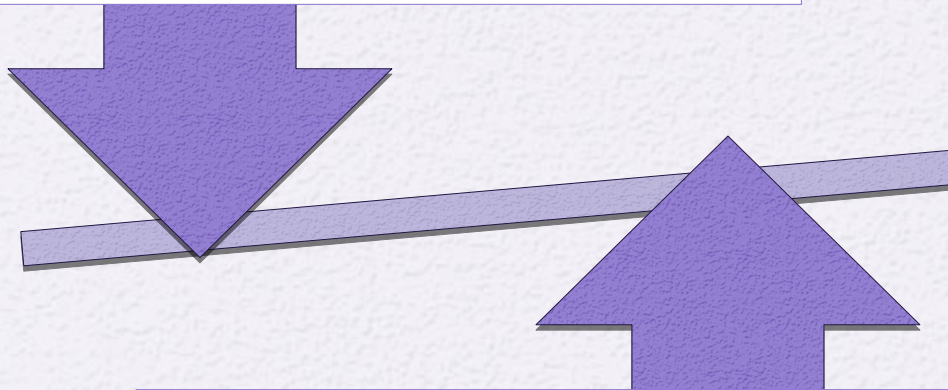 - Denial of receipt of message by destination

Message Authentication Functions

Mac ko hash calculate karnay k liye 2

Input Chaay
① Message
② Secret key

- Two levels of

Lower level
- There must be some sort of function that produces an authenticator

Higher-level
- Uses the lower-level function as a primitive in an authentication protocol that enables a receiver to verify the authenticity of a message
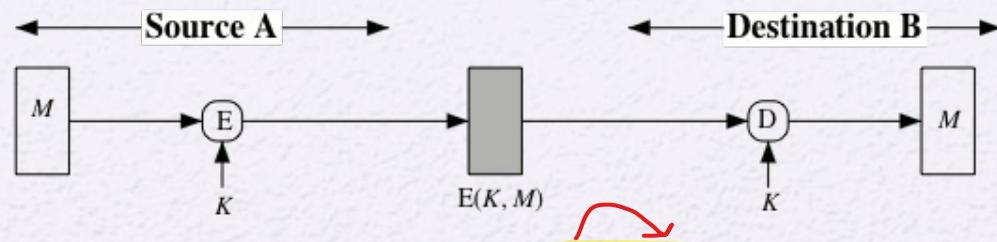
- Hash function
  - A function that maps a message of any length into a fixed-length hash value which serves as the authenticator
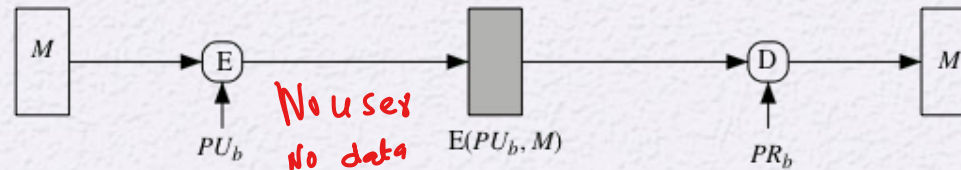
- Message encryption
  - The ciphertext of the entire message serves as its authenticator

- Message authentication code (MAC)
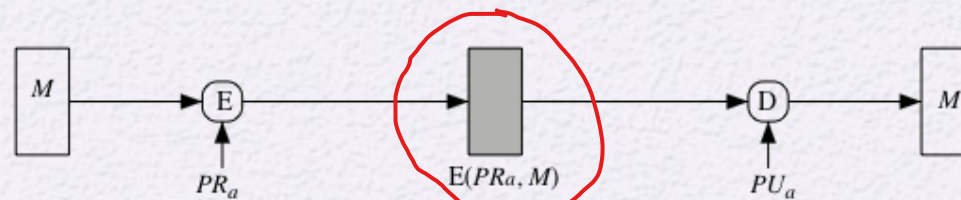 - A function of the message and a secret key that produces a fixed-length value that serves as the authenticator
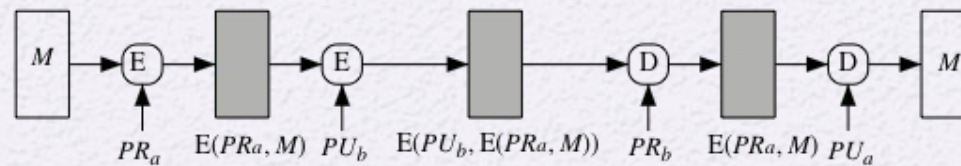
(a) Symmetric encryption: confidentiality and authentication

(b) Public-key encryption: confidentiality

(c) Public-key encryption: authentication and signature

(d) Public-key encryption: confidentiality, authentication, and signature

Figure 12.1 Basic Uses of Message Encryption
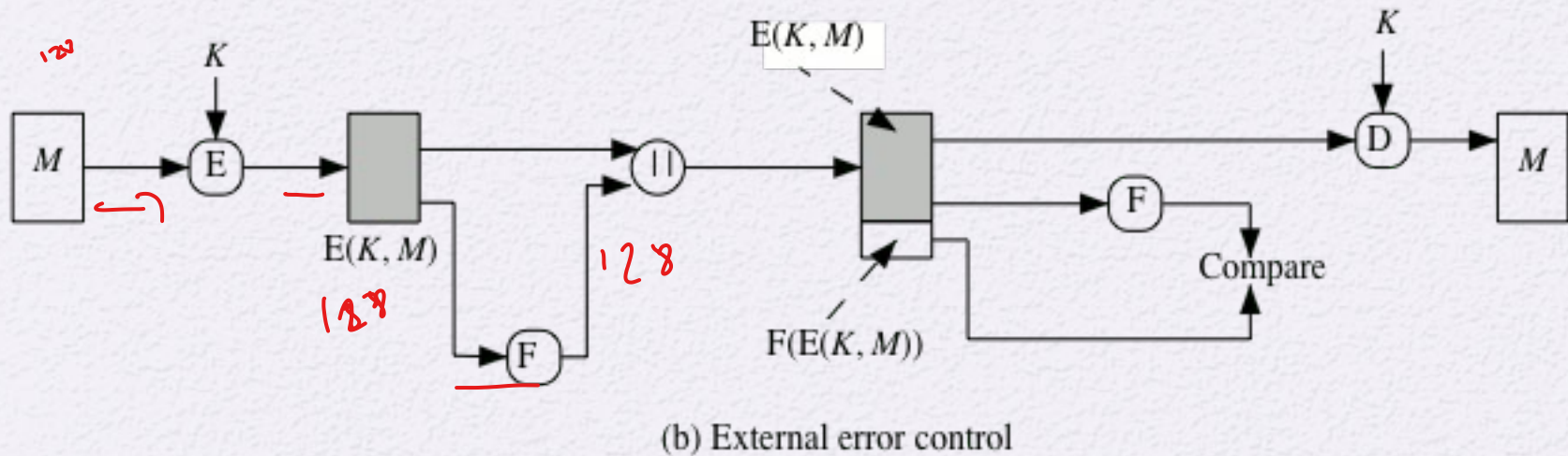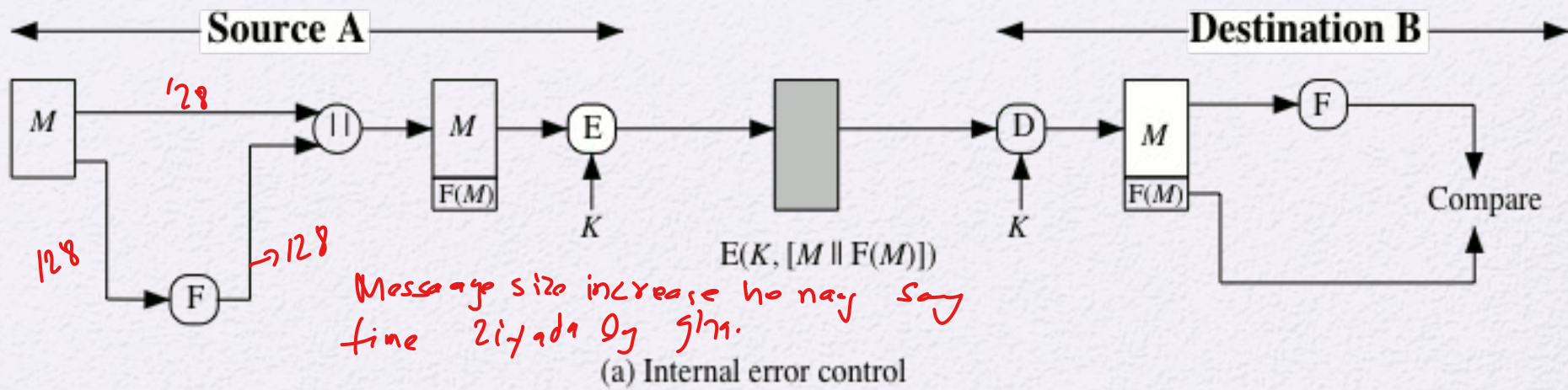
Figure 12.2 Internal and External Error Control

Public-Key Encryption

Message ki Authentication Ki baat ho Rhi Hai.

- The straightforward use of public-key encryption provides confidentiality but not authentication

- To provide both confidentiality and authentication, A can encrypt *M* first using its private key which provides the digital signature, and then using B's public key, which provides confidentiality

- Disadvantage is that the public-key algorithm must be exercised four times rather than two in each communication

(a) Message authentication

(b) Message authentication and confidentiality; authentication tied to plaintext

(c) Message authentication and confidentiality; authentication tied to ciphertext
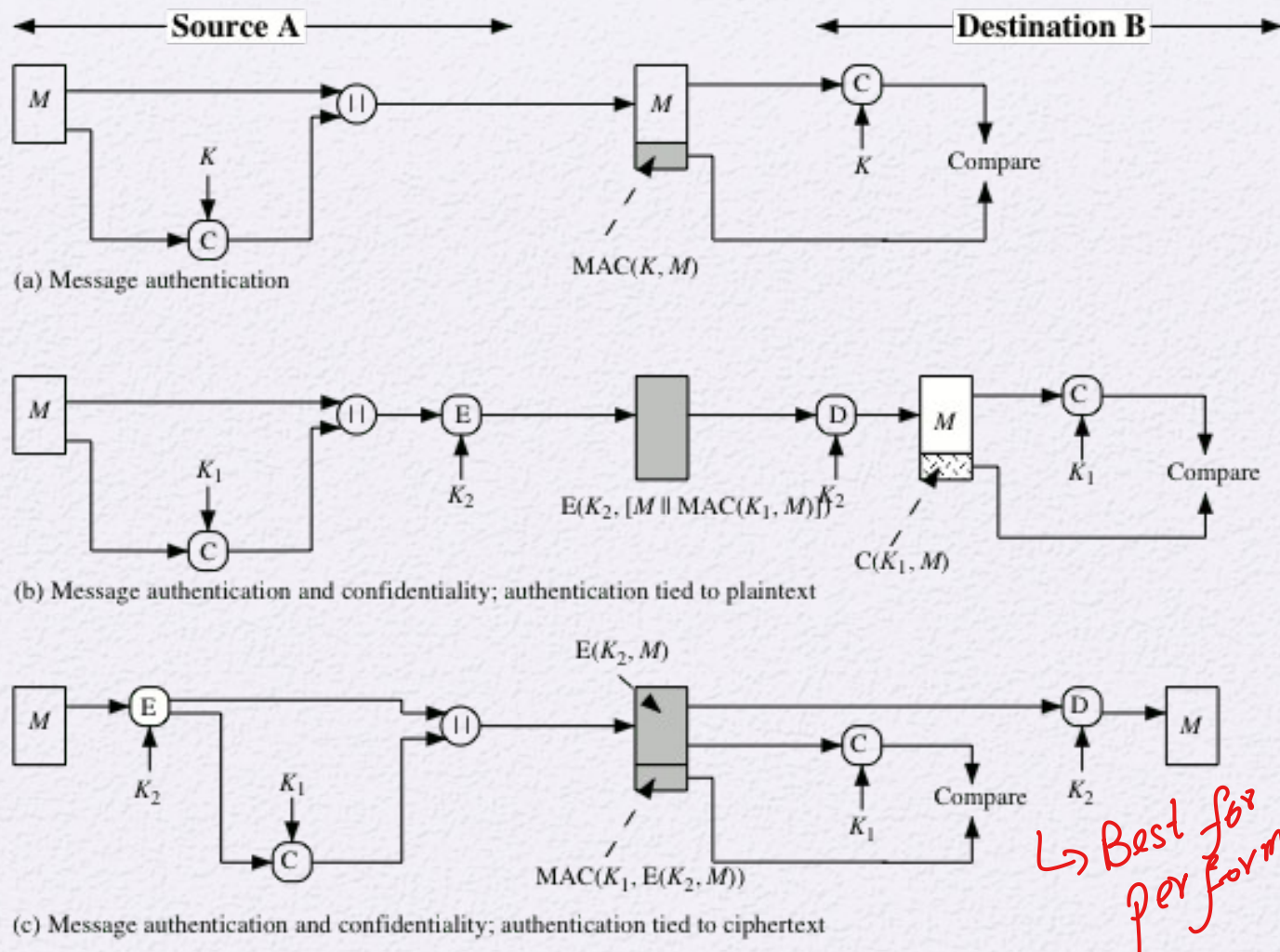
↳ Best for performance.

Figure 12.4 Basic Uses of Message Authentication Code (MAC)

Requirements for MACs

Taking into account the types of attacks, the MAC needs to satisfy the following:

The first requirement deals with message replacement attacks, in which an opponent is able to construct a new message to match a given MAC, even though the opponent does not know and does not learn the key

[handwritten annotations: M' ← C "known Attack"; M → C → tag, k →; "Collision Find Karty Plai"]
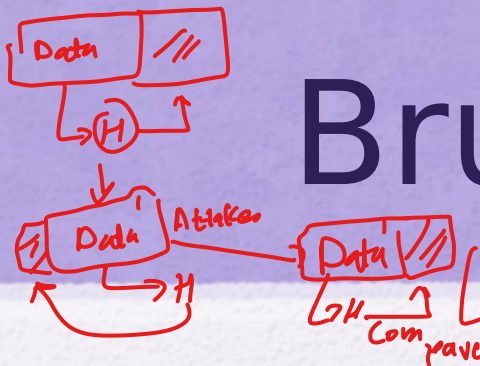
The second requirement deals with the need to thwart a brute-force attack based on chosen plaintext

The final requirement dictates that the authentication algorithm should not be weaker with respect to certain parts or bits of the message than others

[handwritten annotation: Probable Message Attack:]

Brute-Force Attack

- Requires known message-tag pairs
  - A brute-force method of finding a collision is to pick a random bit string y and check if H(y) = H(x)

Two lines of attack:

- Attack the key space
  - If an attacker can determine the MAC key then it is possible to generate a valid MAC value for any input x
- Attack the MAC value
  - Objective is to generate a valid tag for a given message or to find a message that matches a given tag
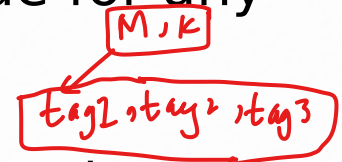
Cryptanalysis

- Cryptanalytic attacks seek to exploit some property of the algorithm to perform some attack other than an exhaustive search

- An ideal MAC algorithm will require a cryptanalytic effort greater than or equal to the brute-force effort

- There is much more variety in the structure of MACs than in hash functions, so it is difficult to generalize about the cryptanalysis of MACs

Modes of operation   Cipher block chain   N × 64

1 block   2 block   N-1 block

Time = 1	Time = 2	Time = N − 1	Time = N
D_1 (64 bits)	D_2	D_{N-1}	D_N

IV = 0

⊕   I output 1 block2   ⊕   ⊕   ⊕

| DES Encrypt | DES Encrypt | • • • • | DES Encrypt | DES Encrypt |
| K (56 bits) | K | | K | K |

| O_1 (64 bits) | O_2 | | O_{N-1} | O_N |

output

not consider

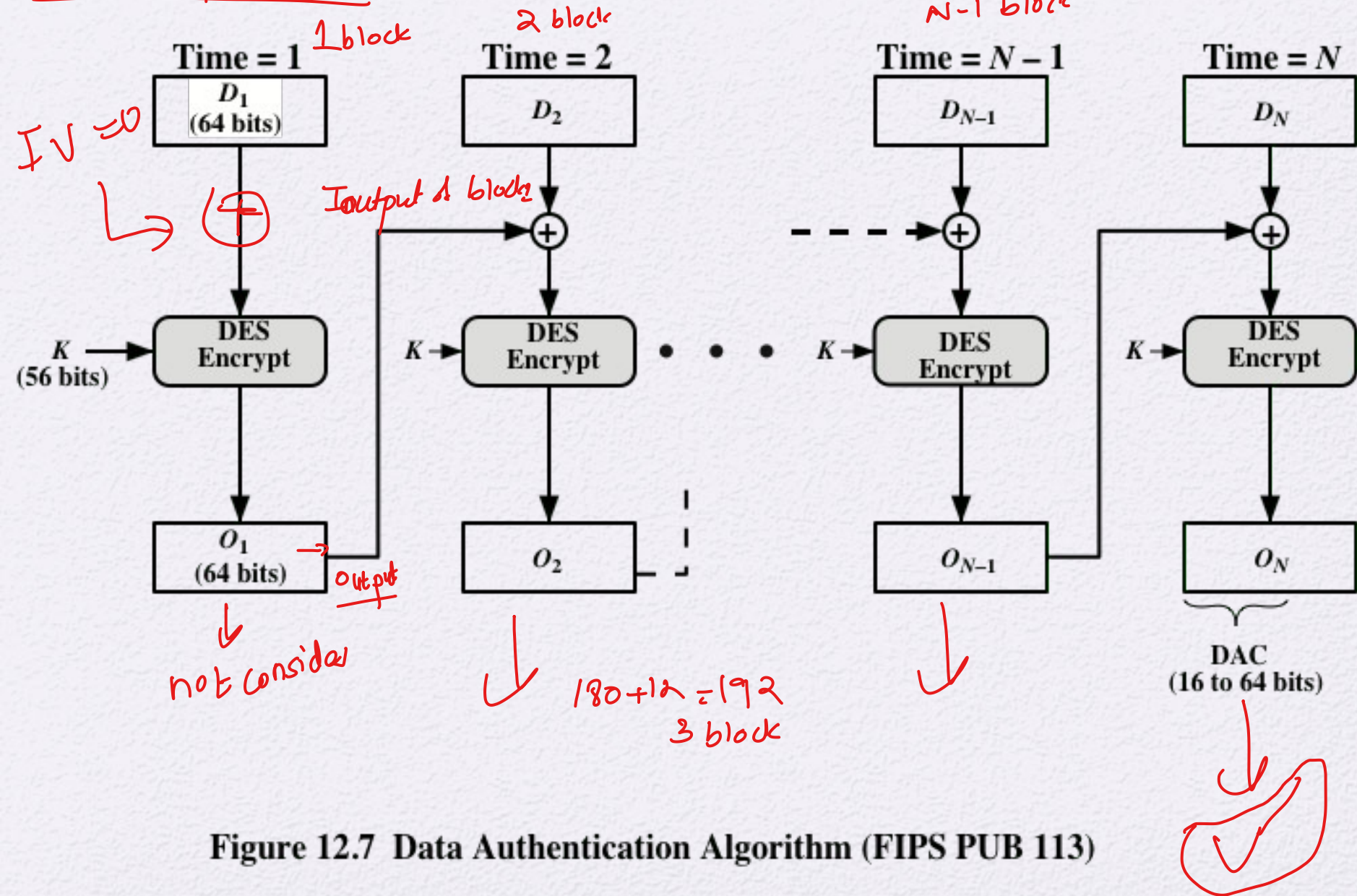180+12 = 192
3 block

DAC
(16 to 64 bits)

Figure 12.7 Data Authentication Algorithm (FIPS PUB 113)

Authenticated Encryption (AE)

- A term used to describe encryption systems that simultaneously protect confidentiality and authenticity of communications

- Approaches:
  - Hashing followed by encryption
  - Authentication followed by encryption
  - Encryption followed by authentication
  - Independently encrypt and authenticate

- Both decryption and verification are straightforward for each approach

- There are security vulnerabilities with all of these approaches

Summary

- Message authentication requirements

- Message authentication functions
  - Message encryption
  - Message authentication code

- Requirements for message authentication codes

- Security of MACs
  - Brute-force attacks
  - Cryptanalysis

- MACS based on block ciphers: DAA and CMAC

- Authentication encryption