Information Security

CS3002

Lecture 20

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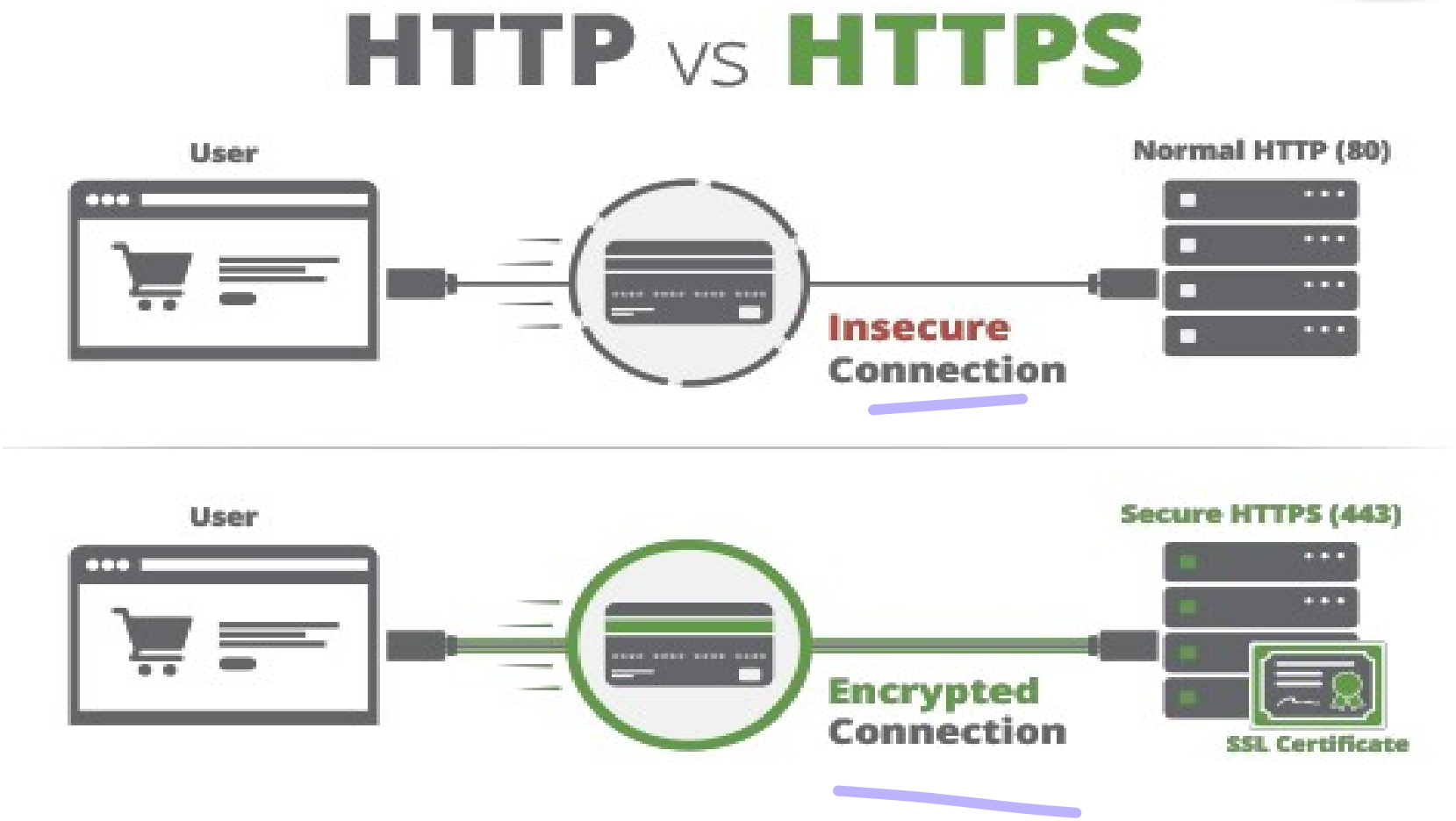
Secure Socket Layer (SSL)

SSL what is it?

- Security at layer 4 (Transport layer)
- **S**ecure **S**ockets **L**ayer (SSL)
- Secure transport channel (session level):
  - peer authentication (server, server + client)
  - message confidentiality
  - message authentication and integrity
  - protection against replay attacks
- Easily applicable to all protocols based on TCP:
  - HTTP, SMTP, FTP, TELNET, ...
  - e.g. the famous secure HTTP (https://....) = 443/TCP

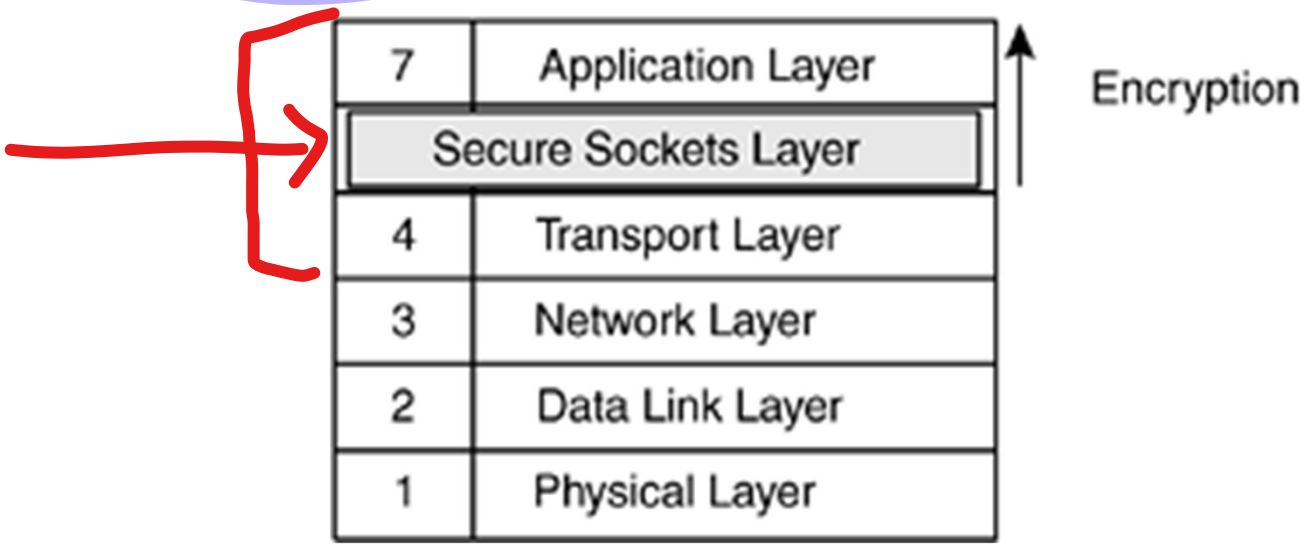
SSL/TLS


https:/


HTTP vs HTTPS
User
Normal HTTP (80)
Insecure
Connection
User
Secure HTTPS (443)
Encrypted
Connection
SSL Certificate

SSL/TLS

- Philosophy of SSL: Easier to deploy something if no changes in OS required
- Application's API (Socket) is interface to SSL: Hence secure socket layer
- API to SSL is the superset of API to TCP
- SSL/TLS operate above TCP. OS doesn't change applications do!



SSL Certificate

An SSL certificate is a data file hosted in a website's origin server.

SSL certificates include:

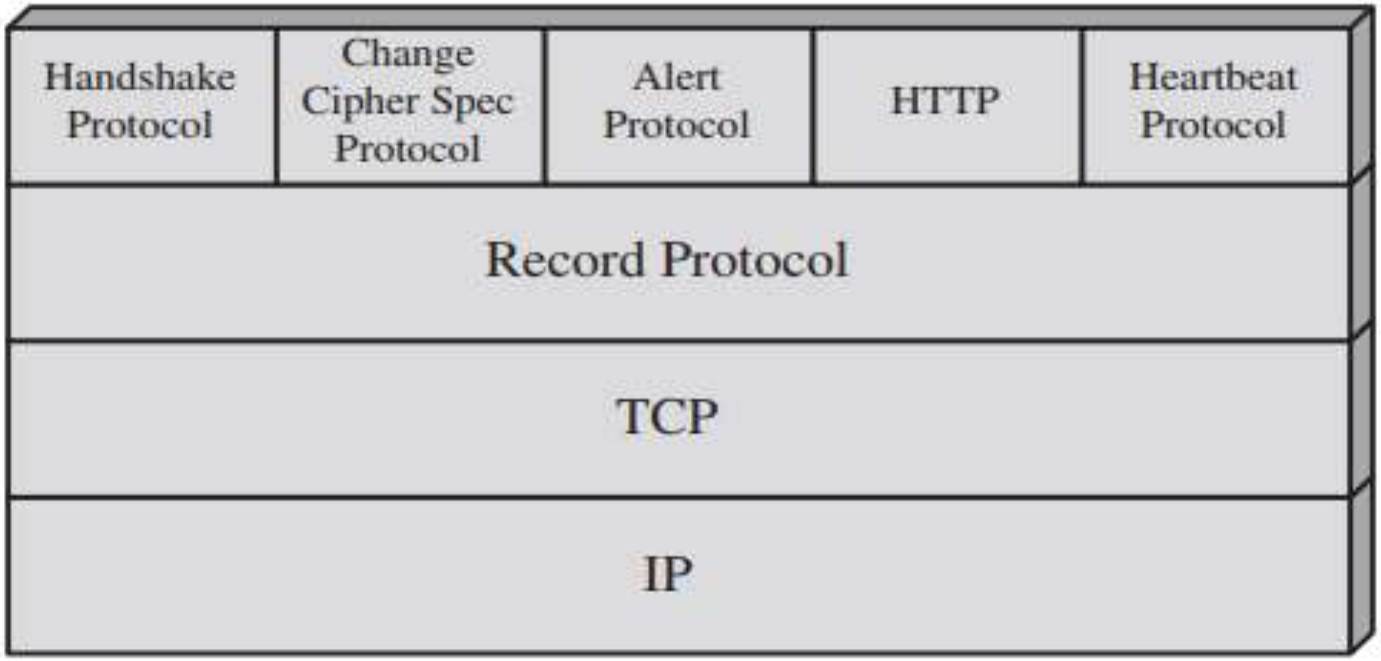
- The domain name that the certificate was issued for
- Which person, organization, or device it was issued to
- Which certificate authority issued it
- The certificate authority's **digital signature**
- Associated subdomains
- Issue date of the certificate
- Expiration date of the certificate
- The public key
  (the private key is kept secret)

SSL/TLS


https:/


Hello, let's set up a secure SSL session
Hello, here is my certificate
Also checks that:
• Certificate is valid
• Signed by someone user trusts
1
2
Customer
Server
3
Here is a one time, encryption key for our session
(encrypted using Server's public key)
4
Server decrypts session key using its private key and establishes a secure session
01010010110
01010010110

SSL V3 Architecture



- Handshake: enables the SSL or TLS client and server to establish the secret keys with which they communicate
- Change cipher spec: indicates the usage of secret key for data communication
- Alert: signal problems with SSL connection, give current status
- Record protocol: permits the encapsulation of higher level protocols
- Heartbeat protocol: it assures the sender that the recipient is alive

SSL Handshake

1 • Agree on a set of algorithms for confidentiality, integrity and authentication

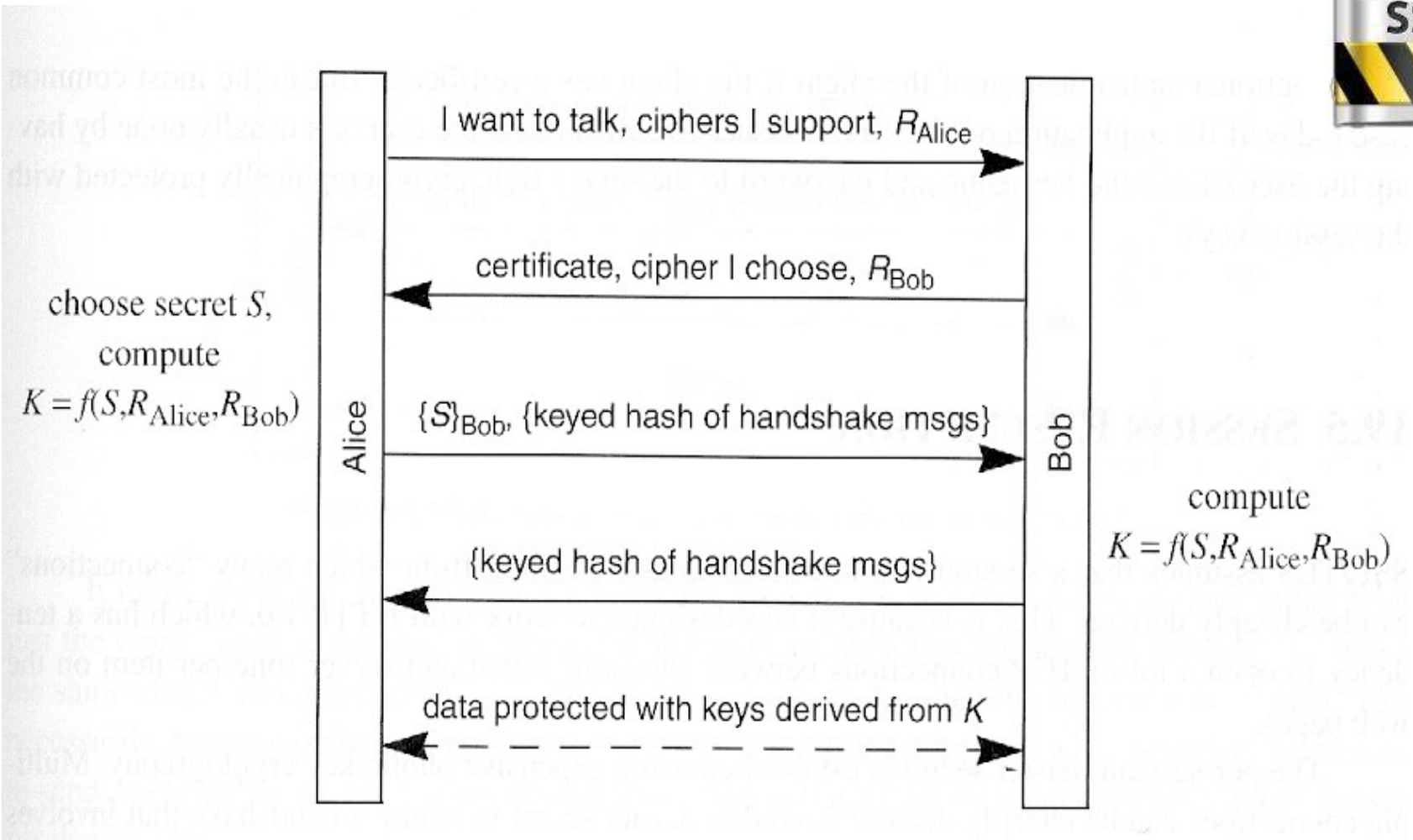
2 • Exchange random numbers between the client and the server to be used for the subsequent generation of the keys

3 • Establish a symmetric key by means of public key operations, e.g. RSA

4 • Negotiate the session-id

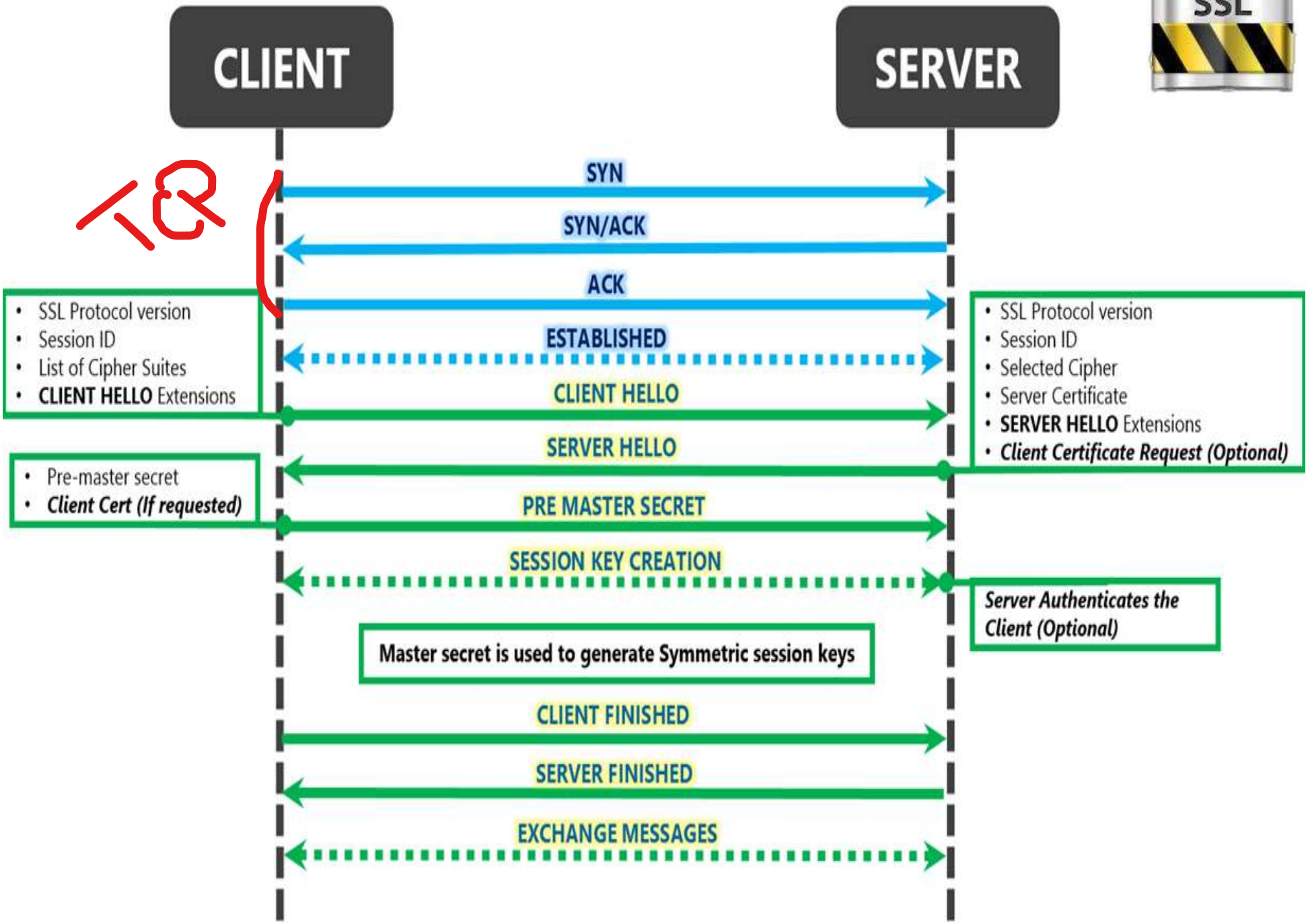
5 • Exchange the necessary certificates

SSL Handshake Simplified



- Secrets are: Pre-master key S, Master Key K
- Server authentication
- Client authentication by password (optional)

SSL Handshake in Detail



Key Terms

1 • HELLO Extensions: request extended functionality by sending data in the extensions field.

Enhance the handshake process by requesting additional functionality.

- E.g: max_fragment_length, status request
- The server may not oblige
- Client may abort the handshake

A secret value generated by the client or obtained from key exchange methods e.g diffie

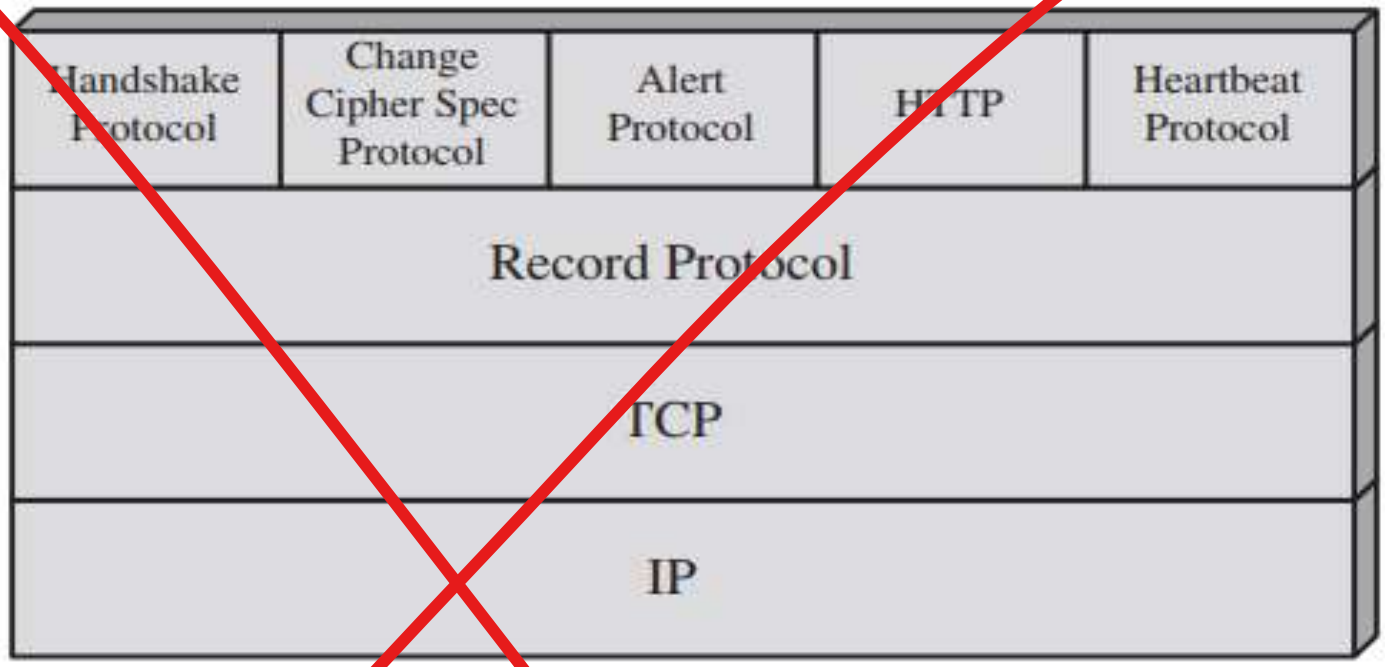
2 • Pre-shared Secret (key): generated by client OR directly obtained from the key exchange. E.g: (DH: g^{ab} mod p)

3 • Master keys: generated from the pre-shared secret + random.client + random.server by applying a PRF

- Master key = PRF (pre-shared secret, random.client, random.server)
- PRF = Pseudo Random Function

Combine the following:
Pre-shared secret.
Random values exchanged between the client and server.
Use PRF to make master key

SSL V3 Architecture



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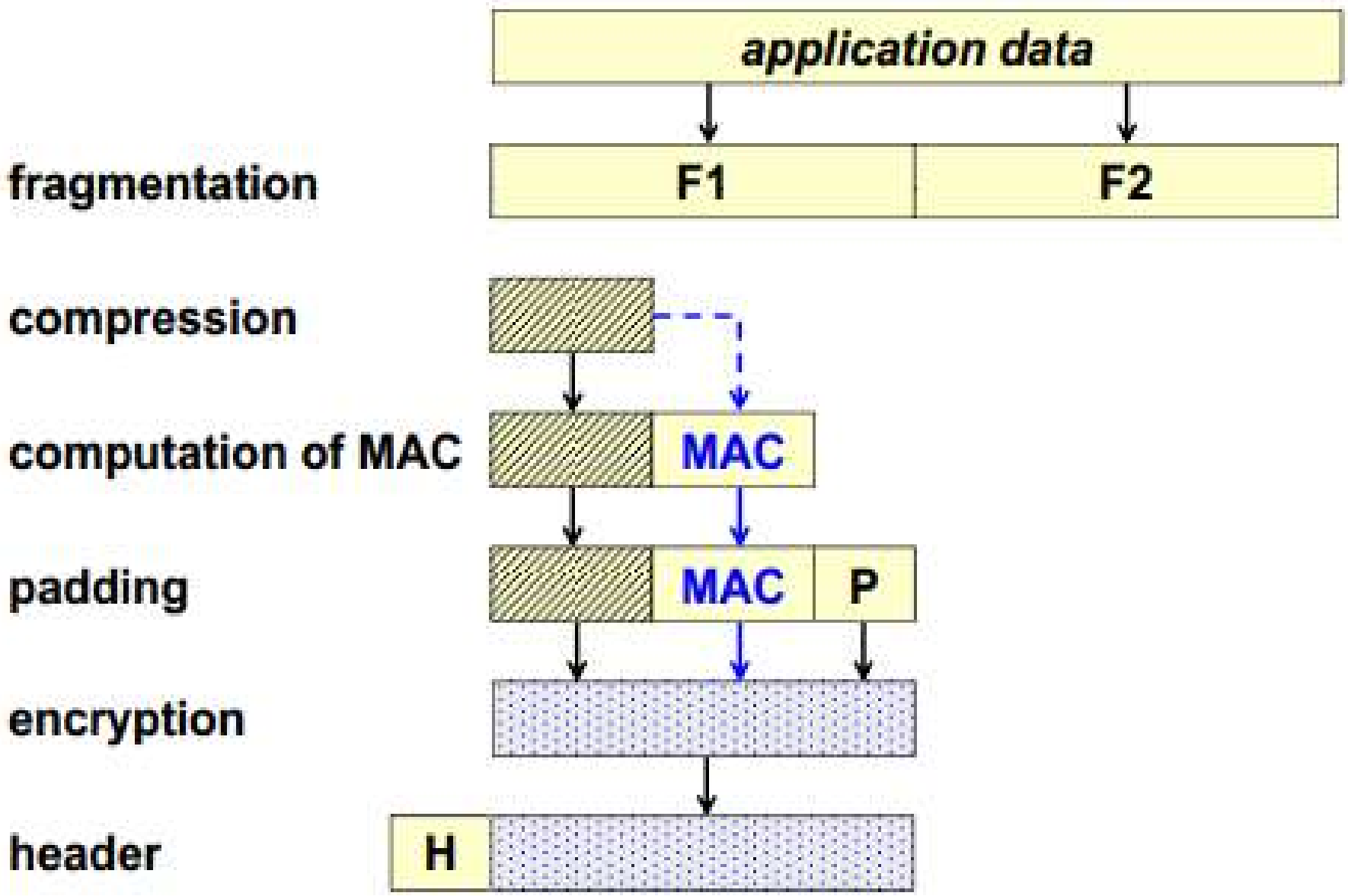
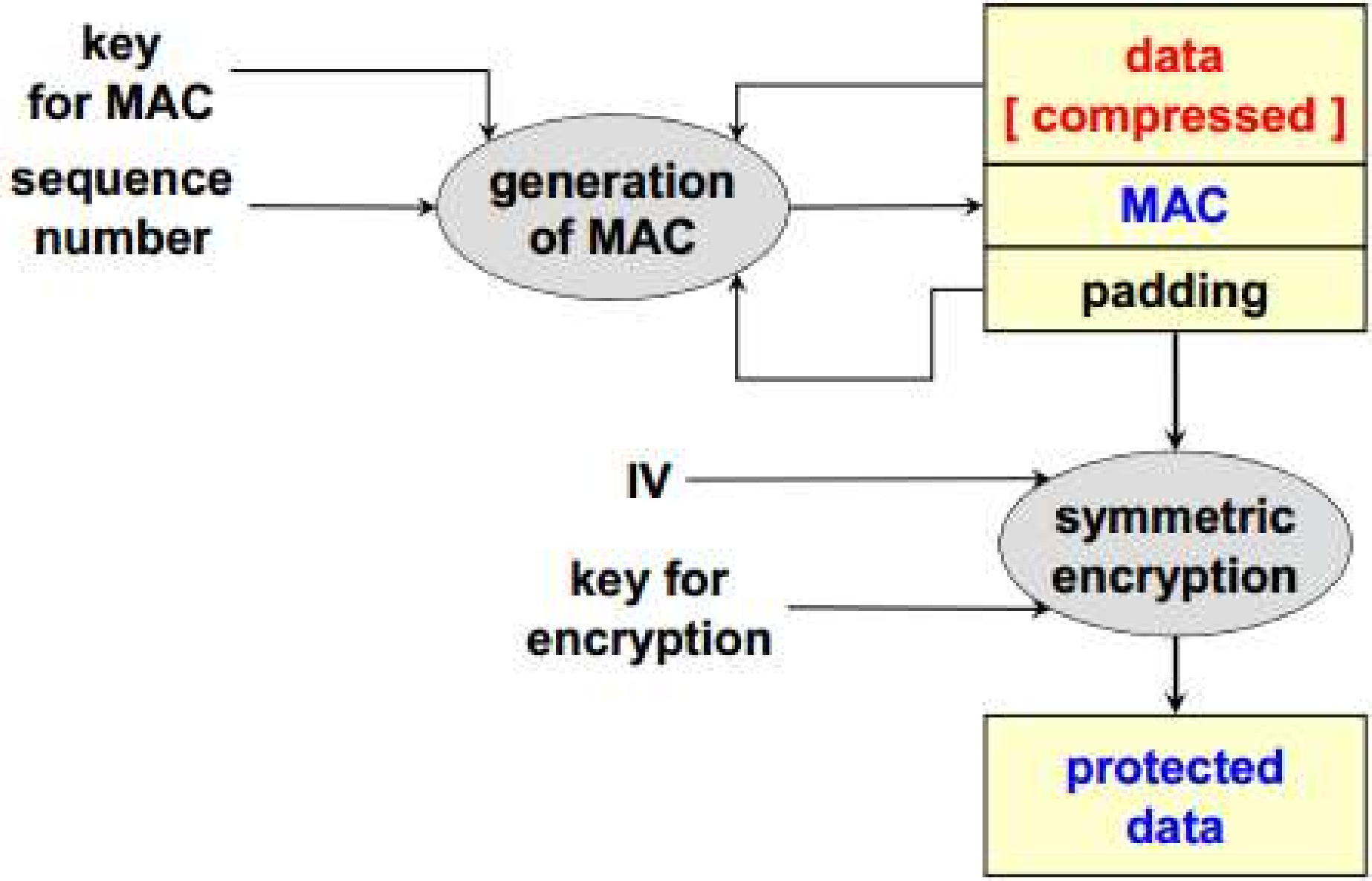
SSL3/TLS Record Protocol



SSL MAC Computation

- MAC = message_digest (key, seq_number | type | version | length | fragment)
- message_digest
  - depends on the chosen algorithm
- key
  - sender-write-key or receiver-read-key
- seq_number
  - 32-bit integer
- Type
  - Type of record
    - change cipher spec (20)
    - alert (21)
    - Handshake (22)
    - Application data (23)
- length
  - length of the fragment/plaintext

Data Protection in SSL



SSL-3 New Features with Respect to SSL-2

- data compression:
  - optional
  - Done before encryption
- data encryption is optional: in order to have only authentication and integrity
- possibility to re-negotiate the SSL connection:
  - periodical change of keys
  - change of the algorithms