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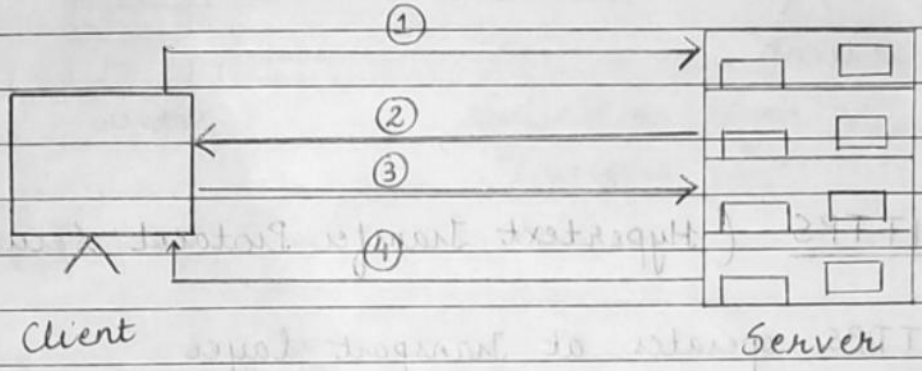
Unit - 4

Secure Socket Layer (SSL)

1. SSL was first developed by Netscape. Version 2 of SSL was released in 1995 and version 3 was released on 1999.
2. Internet Engineering Task Force (IETF) launched TLS (Transport Layer Security) in 2015.
3. Internet Protocol for secure exchange of information between browser and server.
4. Provides security at transport layer.
5. Provides safe and secure Internet connection.
6. Data safety is a primary goal.



(1) The client sends a request to the server to set up a secure SSL session.
(2) The server responds by sending the certificate to the client.
(3) The client then generates its session key and sends it to the server.
(4) Secure SSL session is established.

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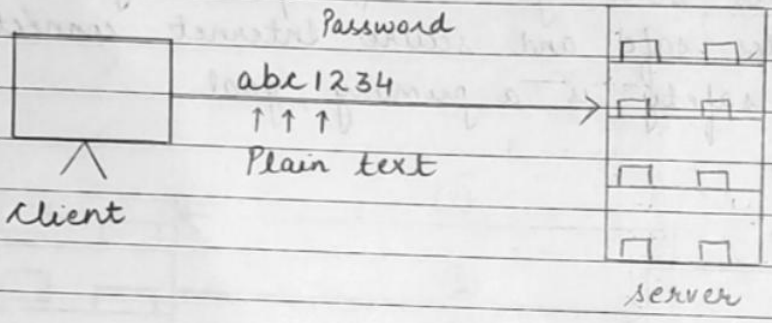
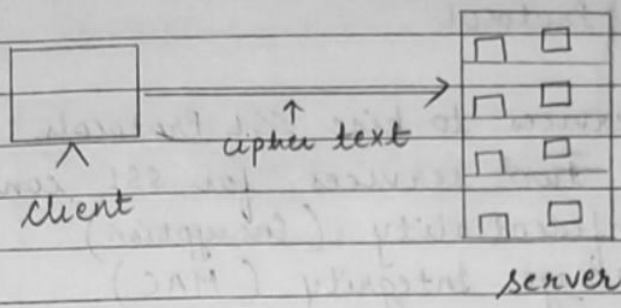
HTTP (Hypertext Transfer Protocol)

1. HTTP operates at Application layer inside TCP/IP
2. It lacks the security mechanism to encrypt the data.
3. Since there is no encryption of the data, it transfers data in the form of plain text.
4. It is good only for accessing the internet/ browser. It is an insecure method as no encryption methods / algorithms are used.



HTTPS (Hypertext Transfer Protocol Secure)

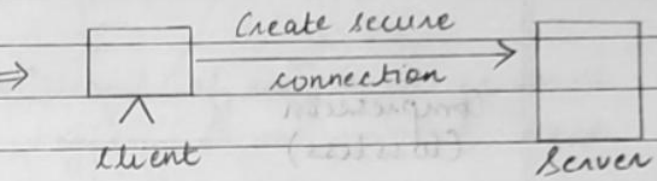
1. HTTPS operates at Transport layer.
2. HTTPS provides SSL to secure the communication between server and client.
3. It encrypts all the data and transfers data in the form of cipher text (encrypted text).
4. It is a combination of SSL protocol and HTTP.
5. Various web browsers and websites which need login credentials should use HTTPS protocol for sending the data.



Position of SSL in TCP/IP

Application layer
SSL
Transport layer
Internet layer
Network interface

TCP/IP



SSL is located between the application layer and the Transport layer.

Goals of SSL

C - Confidentiality
I - Integrity
A - Authentication / Availability

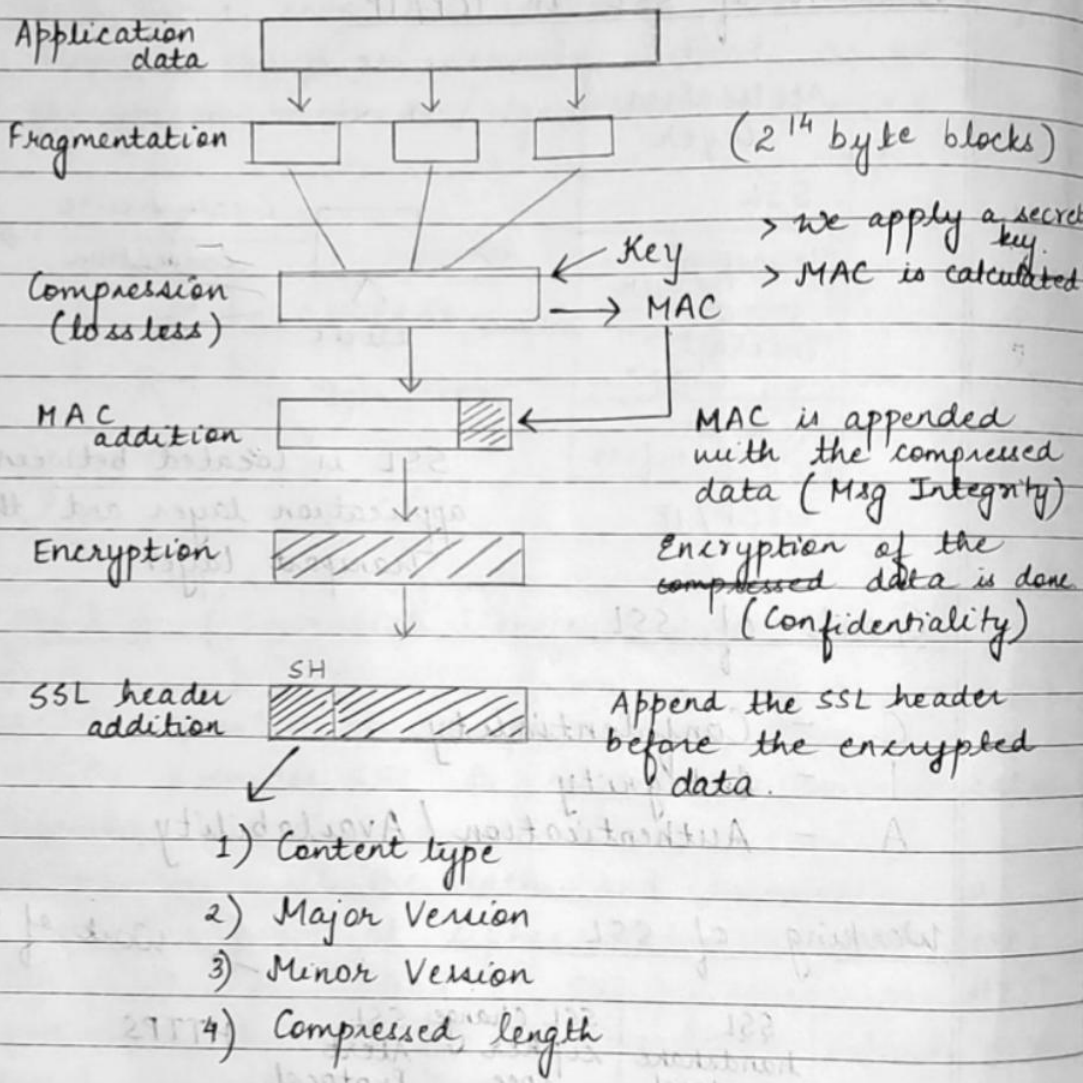
Working of SSL

→ Work of SSL

SSL handshake protocol	SSL Change cipher spec	SSL Alert Protocol	HTTPS
SSL Record Protocol			
TCP			
IP			

SSL Record Protocol

1. It offers services to hire SSL Protocols.
2. It provides two services for SSL connections.
   i) Confidentiality (Encryption)
   ii) Message Integrity (MAC)



* Backbone of SSL - Handshake protocol
Record protocol

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SSL header

Content type	Major Version	Minor Version	Compressed length
Compressed data			
MAC			

SSL V3

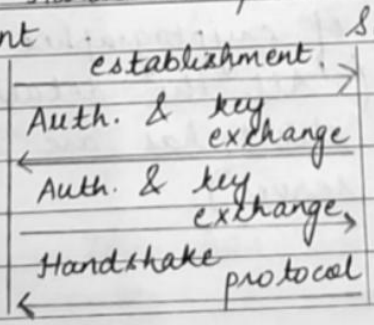
Major version - 3
Minor version - 0

Compressed length - The length of compressed fragment.
Content type - The higher layer protocol used to process the enclosed fragments.

SSL Handshake protocol

Most
1. Complex protocol.
2. Establishment of secure connection between 2 entities.
3. Authentication between client and server.
4. Negotiation of Encryption / MAC algorithm.
5. Exchange cryptographic keys.

Simple Handshake protocol



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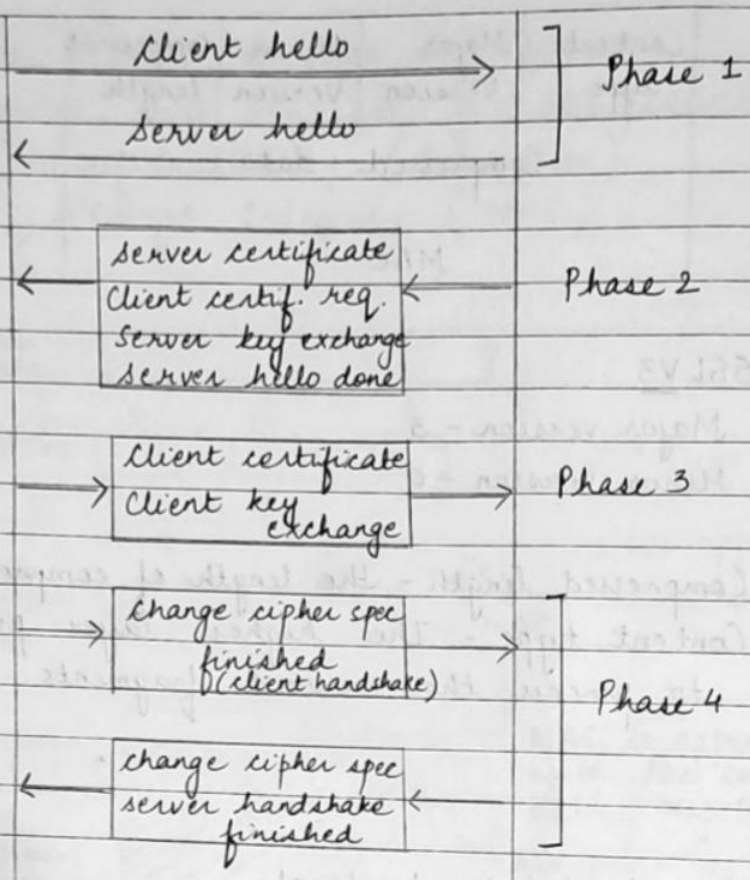
Complex Handshake Protocol



Phase 1 - 4 Parameters

1) SSL version (version 2 or 3)
2) Session id (The id which identifies the entire session)
3) Cipher suite (list of cryptographic algorithms)
4) Compression method (All the details that client has are sent to the server)

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Handshake protocol uses four phases to complete its cycle -

> Phase 1 - In Phase 1, both client and server send hello-packets to each other.

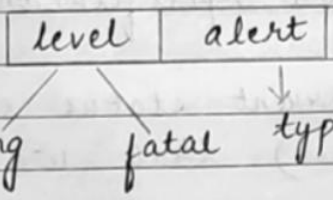
> Phase 2 - Server sends his certificate and server key exchange. It requests for the client certificate. The server ends phase-2 by sending the "server hello done".

> Phase 3 - In this phase, client replies to the server by sending his certificate and client-exchange-key.

> Phase 4 - In Phase-4, change cipher spec occurs and after this the handshake protocol ends, first from the client side and then from the server side.

SSL Alert Protocol

The primary job of the SSL Alert Protocol is to inform the other end (server or client) about the issues in the current session



Warning - This has no impact on the connection between sender and receiver. Only ~~the~~ a warning

would be received, the communication / program will continue.

Fatal - This immediately breaks the connection between sender and receiver. The communication will stop.

* Alert occurs when the two entities that are communicating face any kind of problem.
* An entity informs the other entity if it encounters any error.

Type of Alert	Alert Message	Description
(1)	close_notify	It notifies that the sender will no longer send any msgs
(2)	unexpected_message	incorrect message received
(3)	bad_record_mac	wrong MAC received
(4)	bad_certificate	when the received certificate is corrupt
(5)	certificate_expired	when a certificate has expired.

SSL change cipher specification protocol

1. It keeps the current status of the protocol (cipher protocols) that we are using right now.

2. It has only one message (1 Byte)

3. This protocol's purpose is to cause the pending state to be copied into the current state.

4. One message of 1 Byte consists of value 1. (1-1-1)

TLS (Transport layer security)

> TLS was proposed by IETF (Internet Engineering Task Force)
> TLS is defined in RFC 2246] SSL 3.0
> It is a protocol that provides authentication, privacy and data integrity between two communicating computer applications.
> It is designed to provide security at transport layer.
> TLS was derived from SSL.
> Encrypts the communication between web app and server.
> It's the most widely deployed security protocol in use today and is best suited for web browsers and other applications that require data to be securely exchanged over a network.
> TLS is a cryptographic protocol that provides end to end communication security over network.
> It is a widely used protocol for internet communication / data sharing and online transactions.

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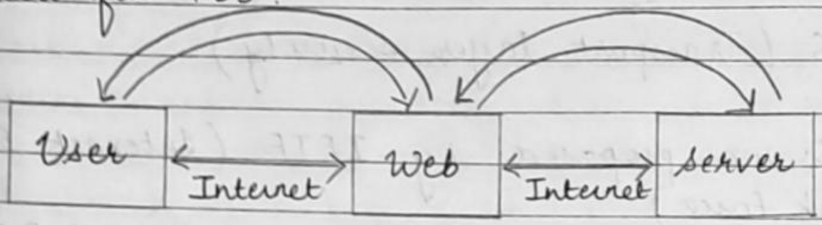
Goals of TLS

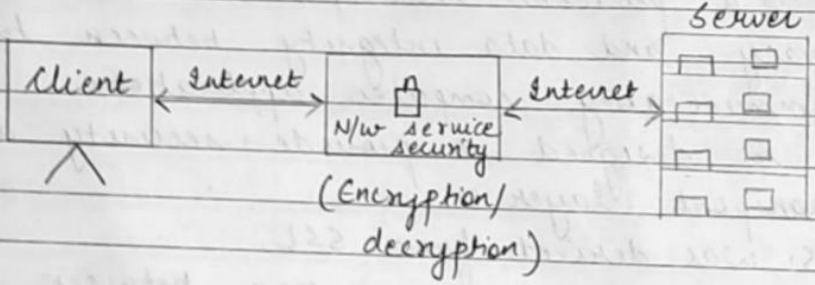
Record Protocol { C - Confidentiality
I - Integrity (HMAC)
Handshake { A - Authentication / availability

Need for TLS:

Simple internet communication

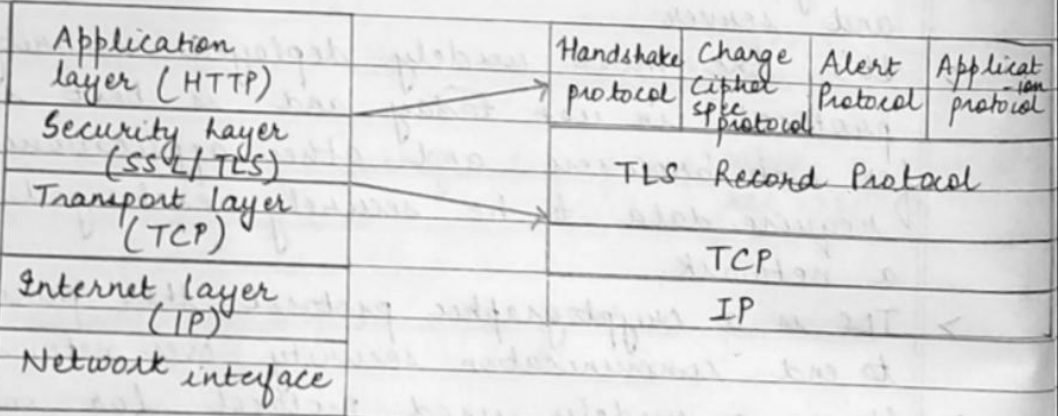


Online transaction



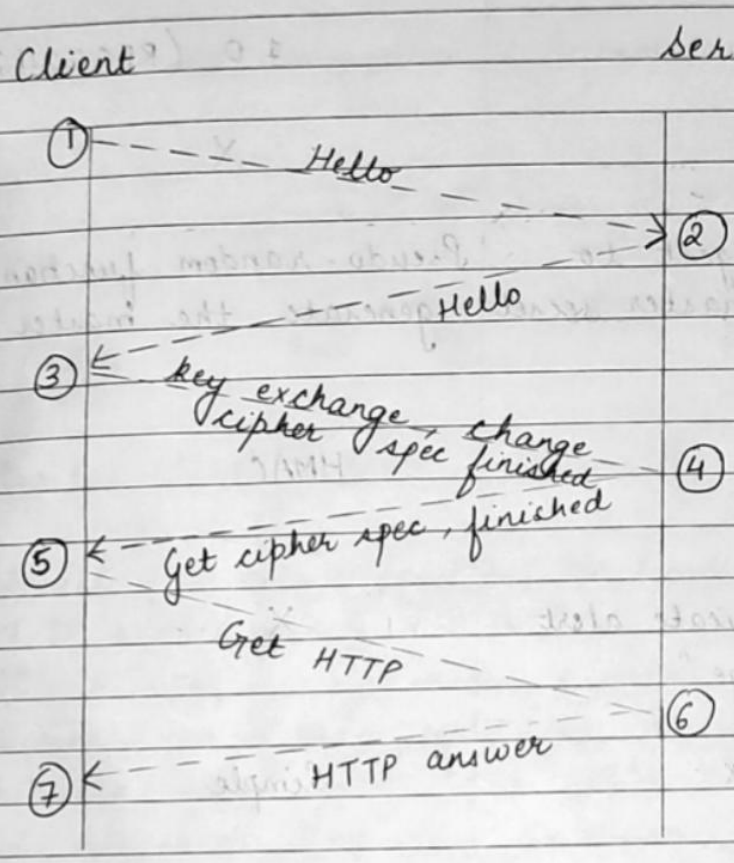
Higher level protocol

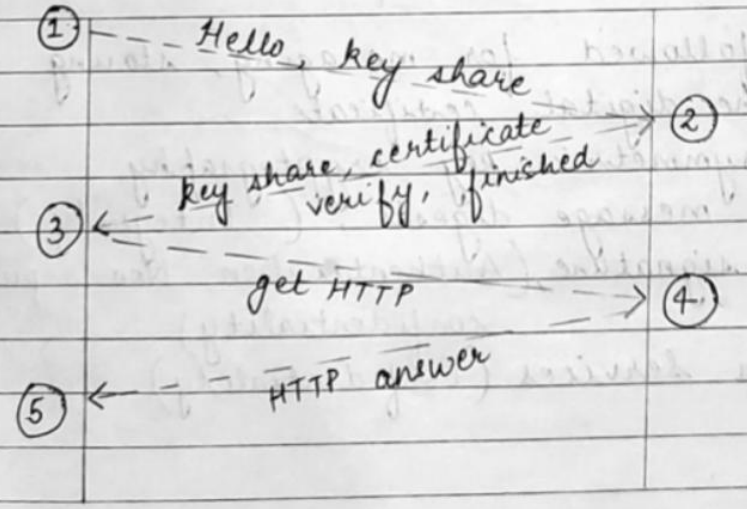
Lower layer protocol



* TLS Record Protocol works exactly the same as in SSL, the only difference being that here HMAC (Hash Message Authentication Code) is

used instead of MAC.





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Difference between SSL & TLS

	SSL	TLS
Version:	3.0	1.0 (RFC 2246)
Cipher suite	Fortezza	X
Cryptography Secret	Message digest to generate master secret	Pseudo-random function to generate the master secret.
Record Protocol	MAC	HMAC
Alert Protocol	"No certificate alert Message"	X
Certificate verification	Complex	Simple

PKI (Public Key Infrastructure)

> Standard followed for managing, storing and revoking the digital certificate.
> follows asymmetric key cryptography
> Includes message digests, (Integrity)
Digital signature, (Authentication, Non-repudiation, confidentiality)
Encryption services (Confidentiality)

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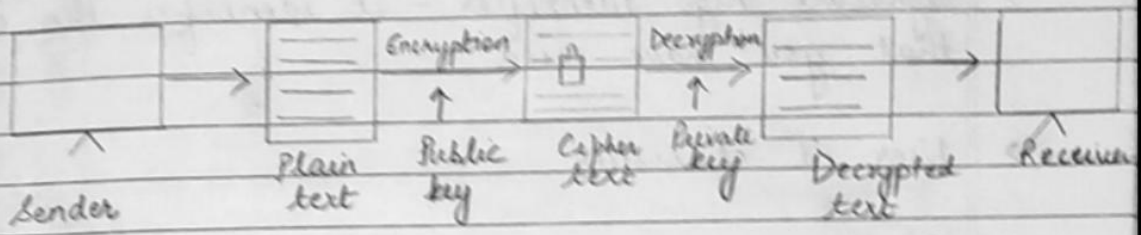
> To enable all the services, digital certificates are required

Public key encryption (Asymmetric key Cryptography)



Digital Certificate

1. Small file on computer / Electronic device.
2. File extension is (.cer)
3. It is issued by some trusted party / entity.
4. Digital certificate establishes a relationship between the user and public key.
5. It requires name of the user and his public key.

Sample Digital Certificate

Username : abc
Public key : <abc &#12>
Serial no : 12345
Other information : email-id
Valid from : 23-04-2022
Valid to : 23-04-2026
Issuer Name : Entrust, verisign

Fields of Digital Certificate

> Version : X.509 - It defines the standard of digital certificate.

> Signature Algo Identifier - It identifies the algo that you have used.

> User id of issuer

> CA digital Signature (Certification Authority) : used during digital certificate verification.

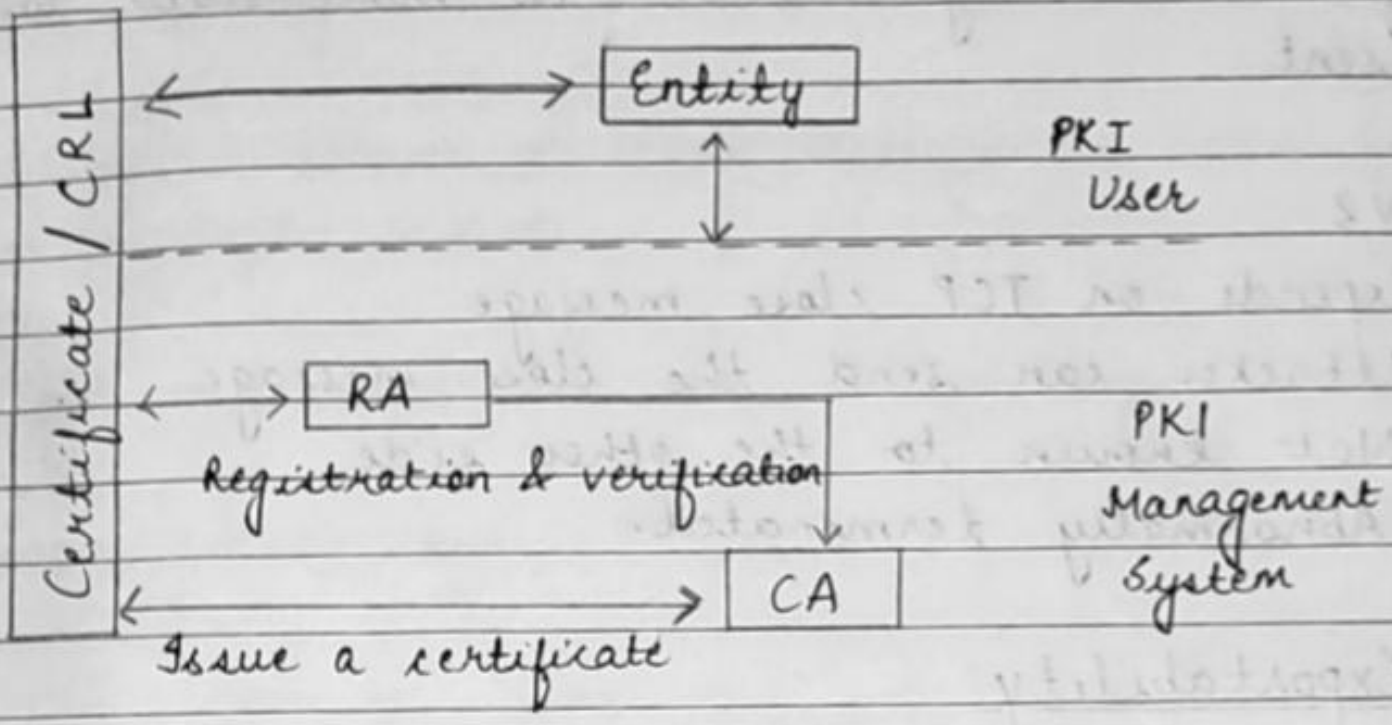
* What is Certification Authority (CA) ?

CA are trusted agency that can issue digital certificate.

Components of PKI

1. Certificate Management System
2. Digital Certificate
3. Validation Authority
4. Certification Authority
5. Registration Authority
6. End user

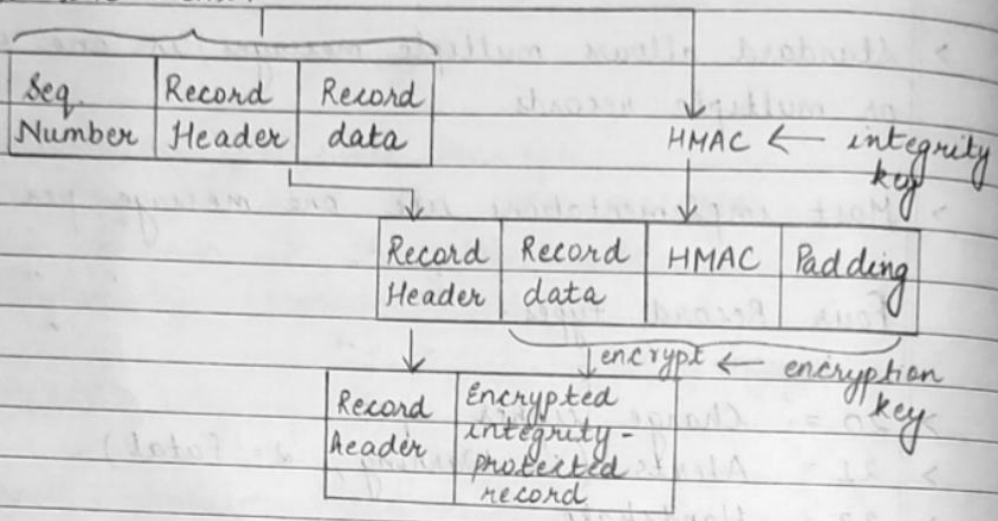
Architecture of PKI



CRL - Certificate Revocation list
It is a list of digital certificates that have been revoked by the issuing certificate authority (CA) before their scheduled expiration date and should no longer be trusted.

> Block cipher = 40B padding in SSLV3,
44B in TLS

> Final block of each record is used as IV for the next.



Secure Electronic Transaction (SET)

> open encryption and security specification designed to protect credit-card and debit-card transactions on the Internet.

Services of SET :

> Provides a secure communication channel
> Provides authentication by use of digital certificates.
> Ensures confidentiality (The information is available only to the parties involved in the transaction)

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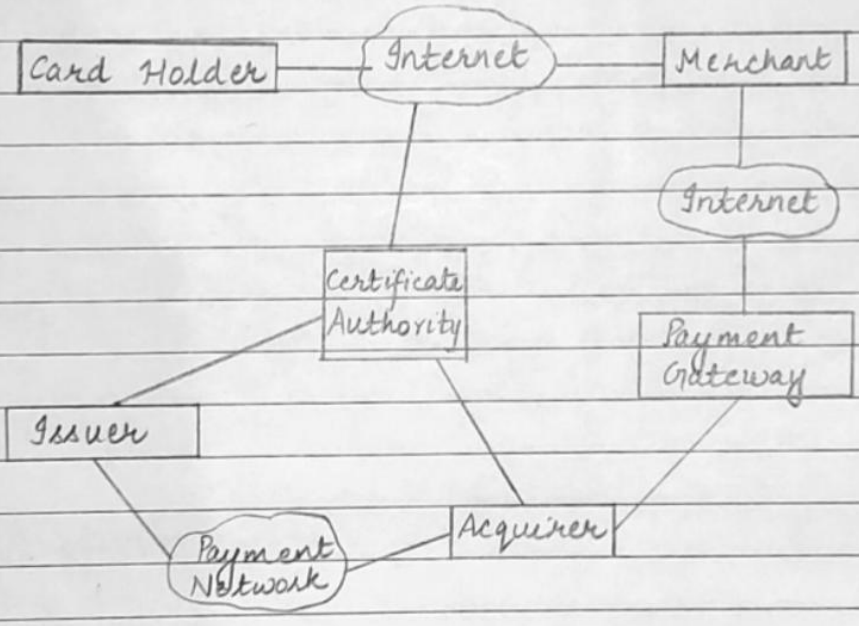
SET Participants:

i) Card holder (User)
ii) Merchant
iii) Issuer (Financial Institution - Bank which provides payment card)
iv) Acquirer (has relation with the merchant for processing of the payment card authorisation)

v) Payment Gateway - It is a third party organisation which exists between client and merchant. It processes the payment messages on behalf of the merchant)

vi) Certificate Authority - Provides and verifies the digital certificate.



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Requirements in SET :

i) Mutual authentication
ii) Payment / order information confidentiality
iii) No message modification
iv) Interoperability

⇒ SSL attacks fixed in V_3 -:

There are two types of attacks.

① Downgrade Attack (stripping attack)	In V_2	In V_3
	• No integrity checks, i.e., Active attacker can remove cipher suits	• Finished message, i.e., Digest of all the previous messages.

• Basically, it is a type of cyber attack in which hackers downgrade a web connection from the more secure HTTPS to less secure HTTP

② Truncation Attack	In V_2	In V_3
	• Depends on TCP Close message	• Finished message indicate, no more data to be sent.

Attacker can send the close msg., not known to other side & abnormally terminated

- Basically, In a truncation attack on attacker inserts into a message a TCP code indicating the message has finished, thus preventing the recipient picking up the rest of the message.

⇒ Exportability :- • Weak Crypto - Export Controls
Strong Crypto - Complex mechanism

In SSL V_2

- Limited to 40 bits
- Uses 128 bit key in which,
  - 40 bit - Secretly Encrypted with server's Public key
  - 88 bits - Non-secret bits
- Also uses Client Master key

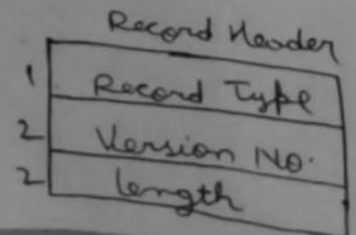
In SSL V_3

- Only 40 bits keys are allowed
- Servers can encrypt keys using 512 bit RSA keys (Normal RSA keys are 1024 bit)
- Ephemeral key is of 512 bits

⇒ Encoding :- • All Exchanges are in records up to $2^{14}B - 2^{16} - 1B$
- Standard allows multiple messages in one record or multiple records
- Most implementations use 1 msg / record

Four Record Types :

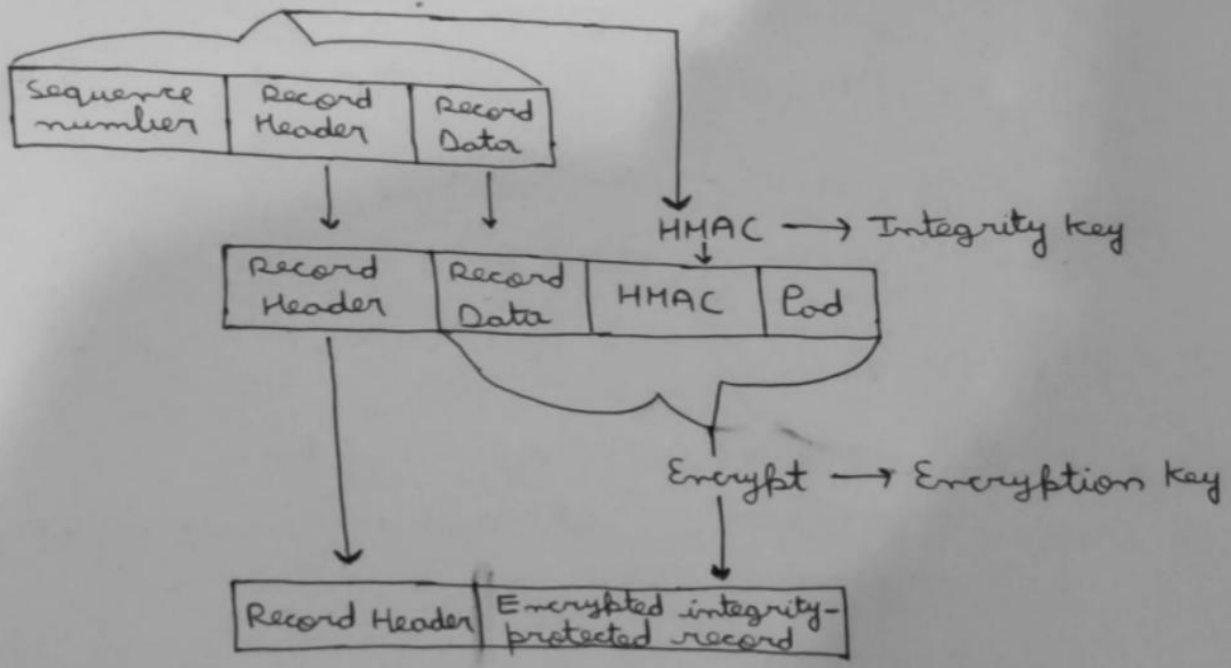
- 20 = Change Cipher Spec
- 21 = Alerts (1 = warning, 2 = Fatal)
- 22 = Handshake
- 23 = Fatal



- Each msg. starts with a 1B message-type and 3B message length

⇒ Encrypted Record Protocol -:

- Integrity is provided by H-MAC using the integrity key
- Data prefixed by 64 bit sequence
- Block Cipher ⇒ 40 B Padding in SSL V3, 44B in TLS
  Final Block of each record is used as IV for the next



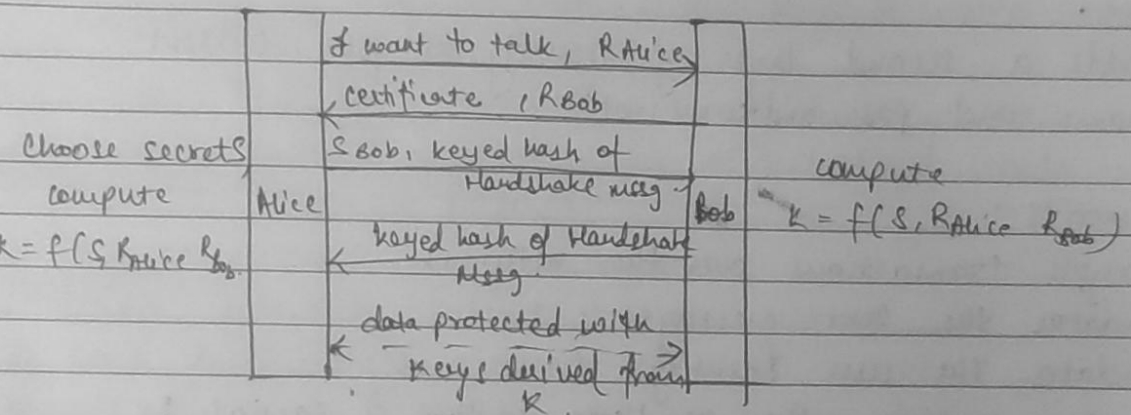
Network Security (Unit 4)

(*). Computing the keys:

→ The secret S sent in first exchange is the pre-master secret. Alice chooses a random number S and sends it, encrypted with Bob's public key.

→ She also sends a hash of master secret K and the handshake messages, both to prove she knows the keys.

→ The notation $f(K_{Alice\,Bob}, R)$ means that R is cryptographically transformed with Alice and Bob's shared secret $K_{Alice\,Bob}$.



S = Pre-master secret

K = f(S, R_A, R_B)

6 keys = g_i(K, R_A, R_B)

Rs : 32 bytes

(*). Client Authentication:

→ A process by which users securely access a server or remote computer by exchanging a Digital certificate.

→ The digital certificate is used to cryptographically bind a user's identity to a unique Digital certificate.

→ The Digital certificate can then be mapped to a user account and used to provide access control.

→ Just as an Organization needs to control which individual users have access to corporate n/ws and resources, they also need to be able to identify which machines & servers have access.
→ The digital certificates used for client and device authentication may look the same as any other digital certificate but they are likely to have different properties depending on use.
→ Client Authentication can be used to prevent unauthorized access.
→ It adds a second layer of security to your current username and password combination.

(*) · Benefits :
→ Encrypts transactions over the network.
→ Validates the sent messages.
→ Validates the user identity.
→ You can configure the certificate so that it cannot be exported to other devices, i.e., its unique to the device it is installed on.
→ Secures Integrity & confidentiality.
→ Prevents malicious attacks.