Queens College

Internet and Web Technology (CSCI 355)

Winter 2024

1/11 Lecture07: Internet Security Notes

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Internet Security

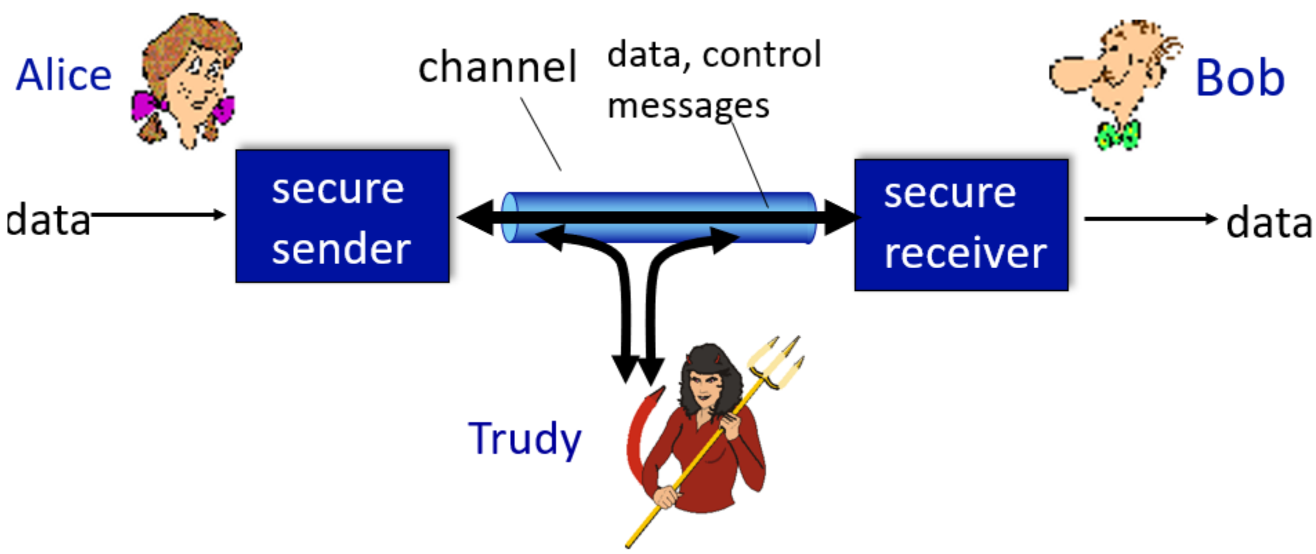
What is network security?

Goals: CIA

- **C**onfidentiality: Do not allow other (non-intended) actors to have access to our data.
  - Not so simple in the context of networking. Analogy: driving in the highway, everyone can see you and your car.
- **I**ntegrity: ensure data is not altered in any way.
- **A**uthentication/Availabilty: Sender, receiver confirm their identities and services must be accessible and available to users.

Goals addressed in different ways.

Scenarios:



Alice and Bob want to communicate but Trudy may intercept, delete, add messages.

Alice and Bob can represent:

- Actual people trying to communicate, exchange information.
- Web browser/server
- On-Line banking client/server
- DNS server

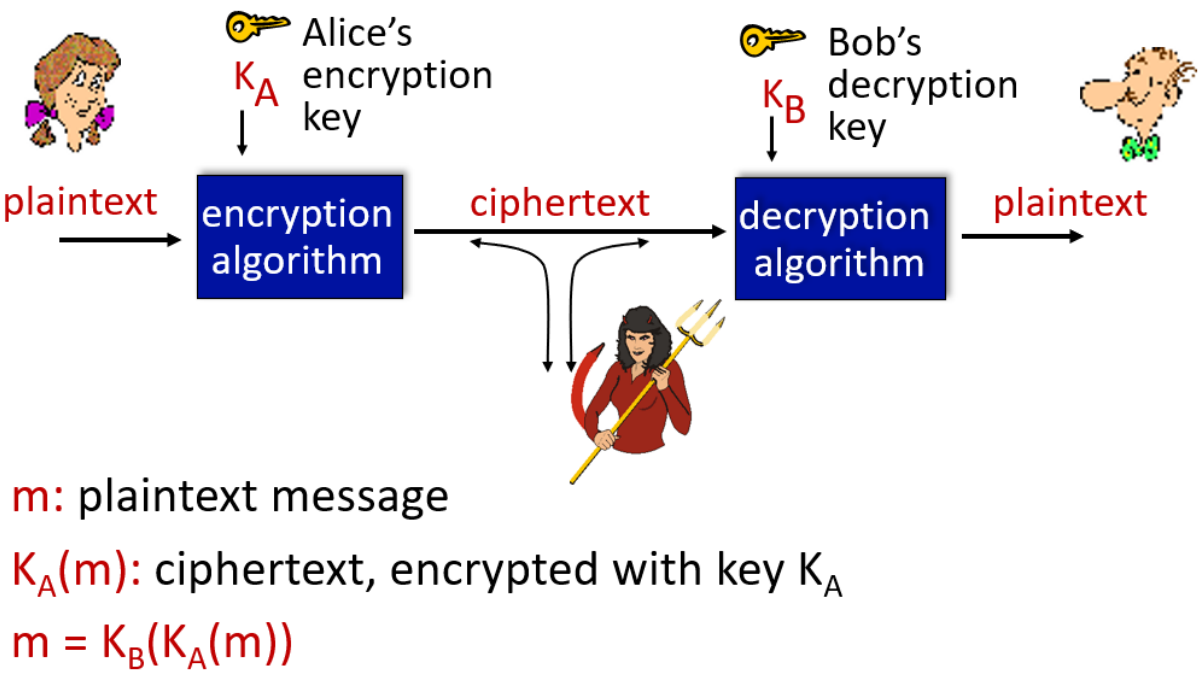
- BGP routers: Border Gateway Protocol (standard inter-AS protocol)

Trudy can perform:

- Eavesdrop: ex. using Wireshark to see what people are doing.
- Insert messages.
- Impersonate.
- Hijack
- DoS: Denial of Service, overwhelming a server with activity that it does not have time for anything else.
- DDoS: Distributed Denial of Service:
  - more volume, generate bad traffic
  - harder to track

Answer?: Cyptography

CRYPTOGRAPHY



- m = message
- K(A) = encryption key
- K(B) = decryption
- ciphertext = plaintext packet that has been encrypted.

Question: How much of the packet do you encrypt?

- Can be super secure that it can become useless.

Shift-Cipher: Simple, shifting letters by a set amount. Ex. bump A to become D, B to E, etc.

- Encryption shifts forward
- Decryption shifts backward

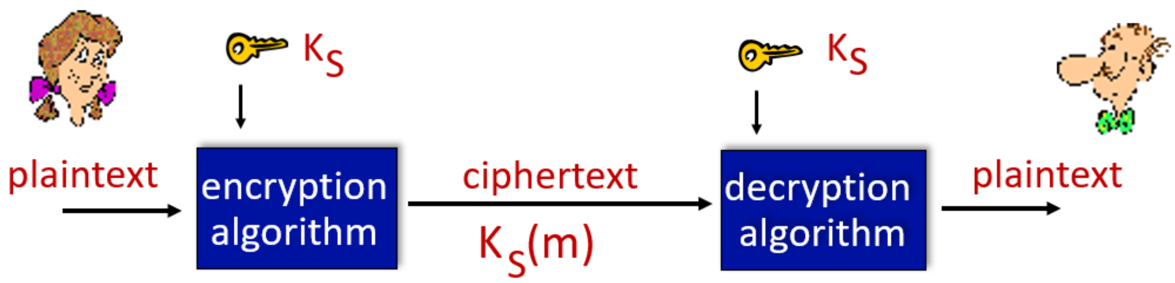
- 26 possible shifts if using english alphabet, can be more if others used.

Permutation-Cipher: "A" gets mapped to "E" but "B" gets mapped to "X". Leads to 26! possibilities.

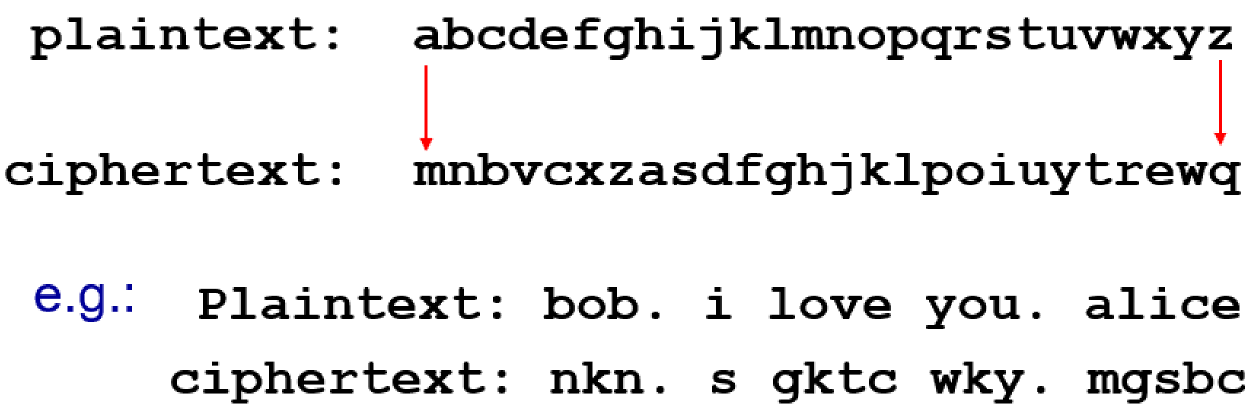
Breaking Encryption Schemes:

- Use brute force. Shift-cipher can be easily cracked.
- Statistical Analysis.
- Trudy has the plaintext corresponding to ciphertext.

Symmetric Key Cryptography



Bob and Alice share same (symmetric) key: K



Permutation-cipher that uses an encryption key that maps from a set of 26 letters to a set of 26 letter (26!).

To make more difficult: have several permutation ciphers and alternate between them but it needs to be known/shared, this is still risky.

DES: Data Encryption Standard

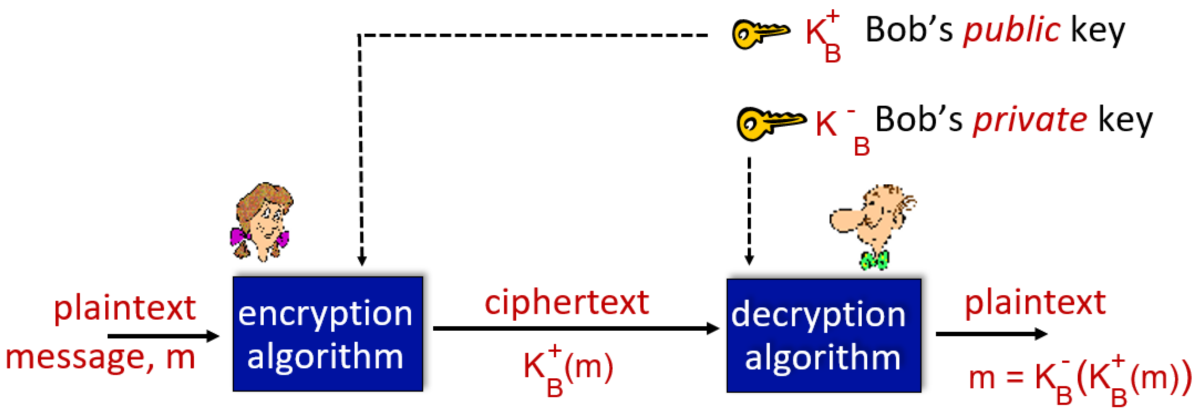
- Symmetric key.
- Chopped into chunks.
- Not that good in modern day since it can be decrypted by brute force.
- 1 sec to decrypt with modern technology.

AES: Advanced Encryption Standard

- Symmetric key.
- Harder than DES, 149 trillion years to decrypt using brute force.

Public Key Cryptography: Highlight

- How can something public be secret?
- RSA78
- public encryption key known to all, can be accessed.
- private decryption key known only to receiver.
- Not a symmetric key, just because you know how to encrypt doesn't mean you know to decrypt. Ex: A bank wants people to send it data, the bank publishes the encryption key but only the customer knows the decryption.



Alice wants to send an encrypted message to Bob: * Alice uses Bob's public key to encrypt. * But only Bob's private key can decrypt. * Bad actors do not know Bob's private key, not even Alice.

RSA: Encryption/Decryption algorithm developed by Rivest, Shamir, Adelson 0. given (n,e), public key, and (n,d), private key.

- n = product of two large prime numbers, p and q (ex: 1024 bits, ~10^300 range).
- e < n, e has no common factors with z
- z = (p-1)(q-1)
- d = (e*d) - 1 is exactly divisible by z ((e*d)mod z = 1)

1. to encrypt message m (<n) compute c = m^e mod n
   - Take message and convert to binary number
   - Take binary and convert to decimal
   - Take decimal and raise to e power.
2. to decrypt received bit patter c, compute m = c^d mod n

Magic: m = (m^e mod n)^d mod n

- the relationship between e and d is such that they cancel each other out and get back m.
- e and d are carefully chosen
- whole world knows e, but they don't know d.
- n ~ 10^700
- nature of e and d is such that they can be interchanged and result in the same thing. Ex: (A^B)^C = (A^C)^B
  - useful depending on what is trying to accomplished.

- Can be used as integrity.

The following property will be *very* useful later:

$$\underbrace{K_B^-(K_B^+(m))}_{\substack{\text{use public key}\\ \text{first, followed}\\ \text{by private key}}} = m = \underbrace{K_B^+(K_B^-(m))}_{\substack{\text{use private key}\\ \text{first, followed}\\ \text{by public key}}}$$

result is the same!

RSA example:

Bob chooses $p=5$, $q=7$. Then $n=35$, $z=24$.
$e=5$ (so e, z relatively prime).
$d=29$ (so $ed-1$ exactly divisible by z).

encrypting 8-bit messages.

	bit pattern	m	m^e	$c = m^e \bmod n$
encrypt:	00001100	12	24832	17

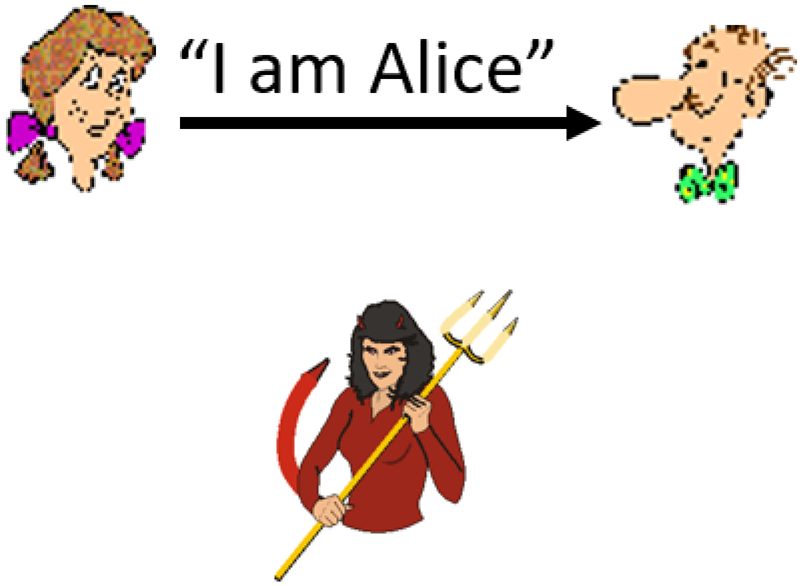
	c	c^d	$m = c^d \bmod n$
decrypt:	17	481968572106750915091411825223071697	12

Problem: SLOW to work with. Trick: Use some RSA to share the permutation cipher then use permutation cipher for the remainder of the sessions.

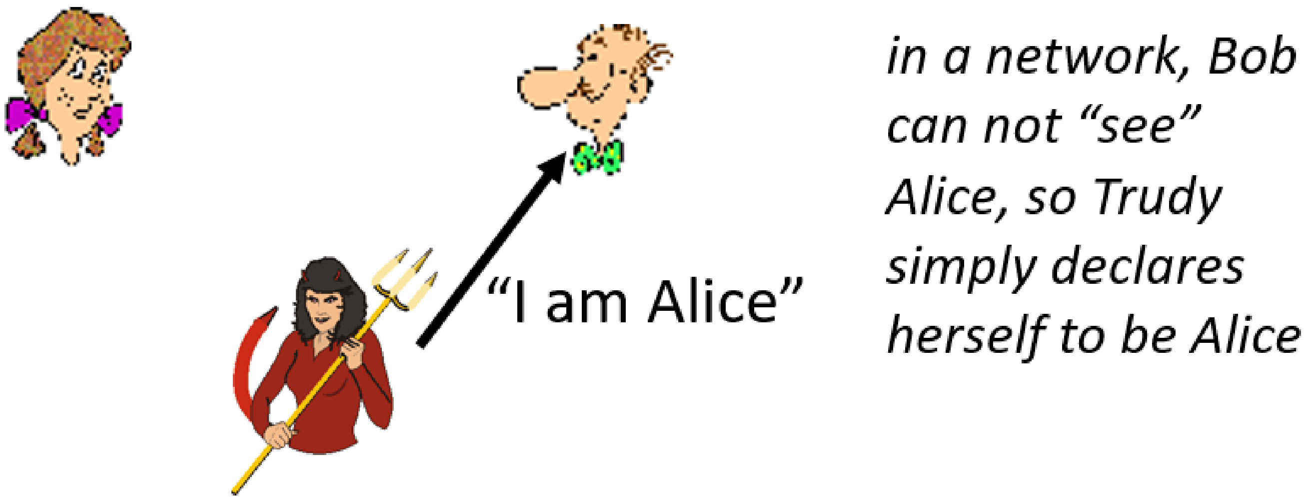
- Two-phased model

Authentication

How to use cryptography to achieve goals?

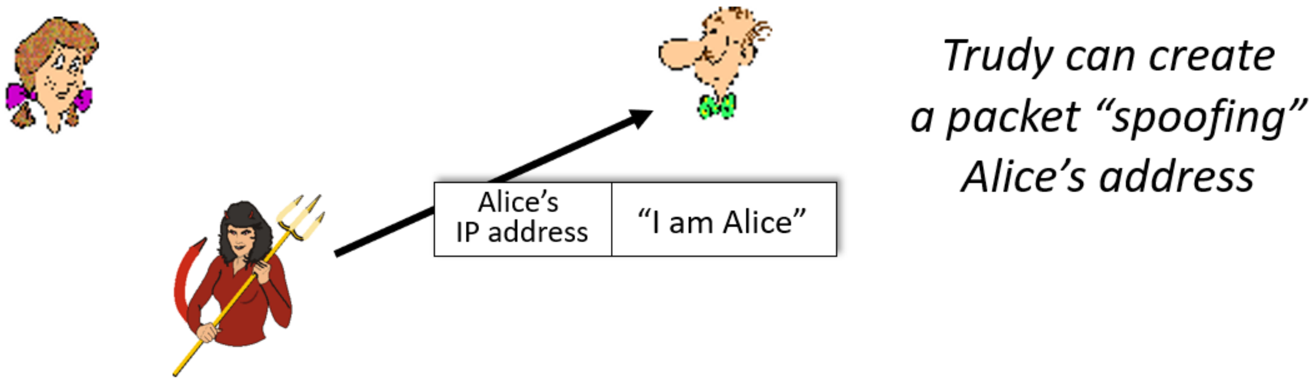


Failure Scenario 1:



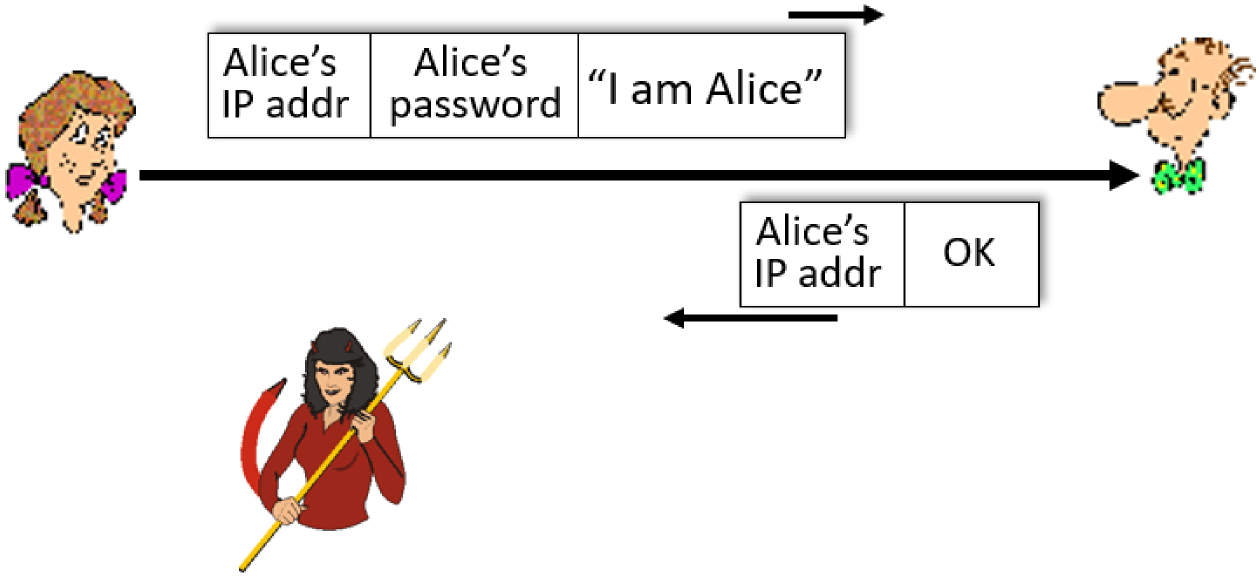
- AI can be used to replicate the "voice" tricking Bob to think it is Alice.

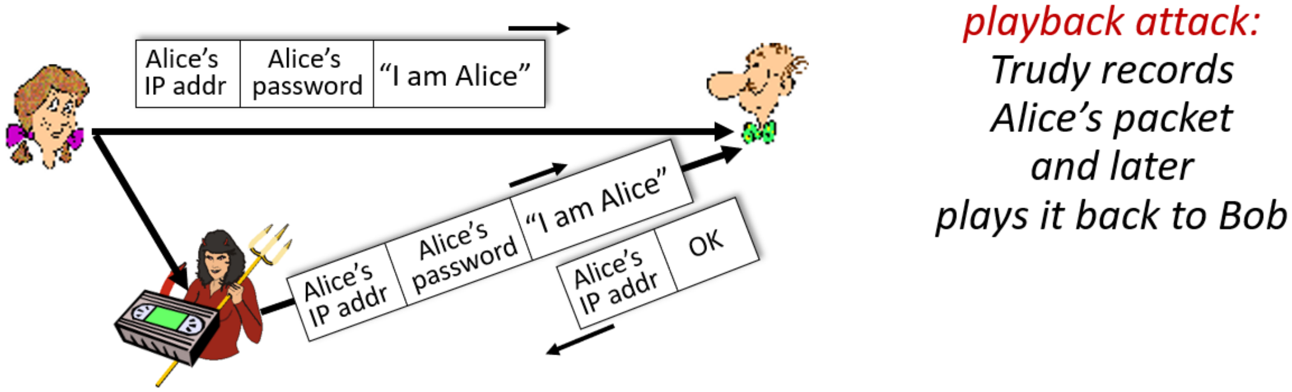
Failure Scenario 2:



- Alice sends from her own IP address.
- Trudy spoofs Alice's IP address, Bob recognized IP address and is tricked.

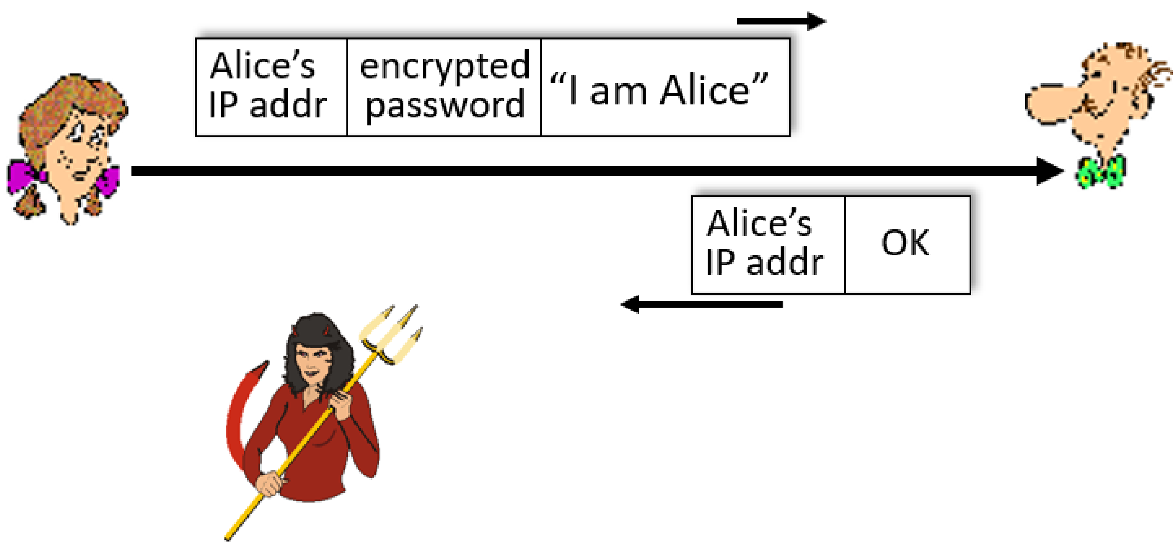
Failure Scenario 3:

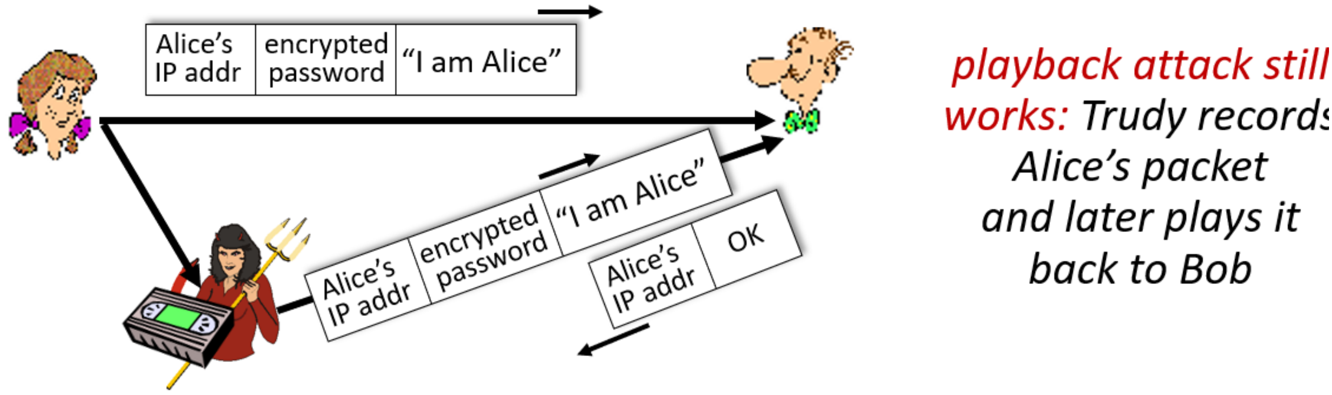




- Alice uses a password in the message that Bob recognizes.
- Trudy can read channel, sees weird characters that is the PW. She records and uses the same PW to trick Bob.

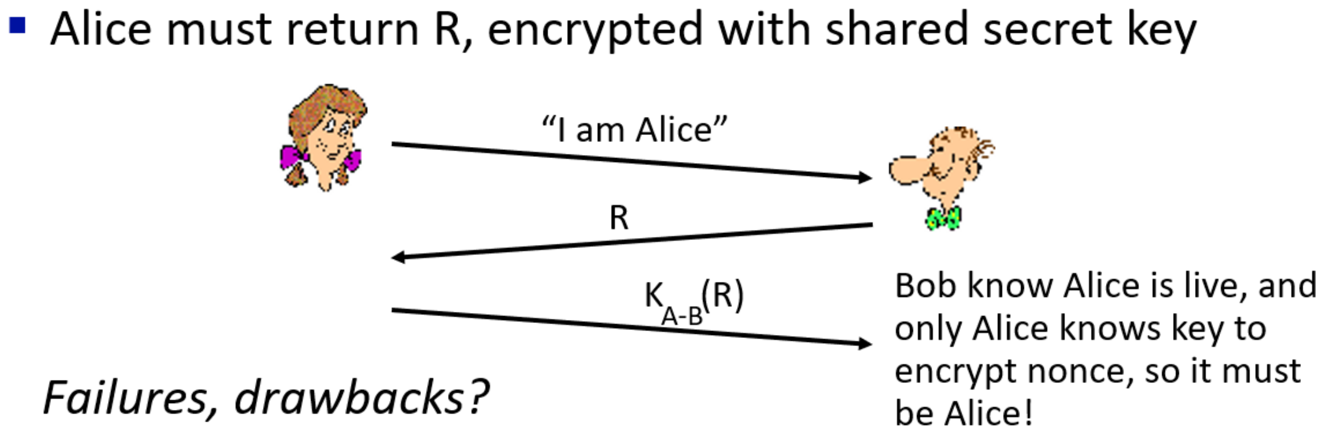
Failure Scenario 4:



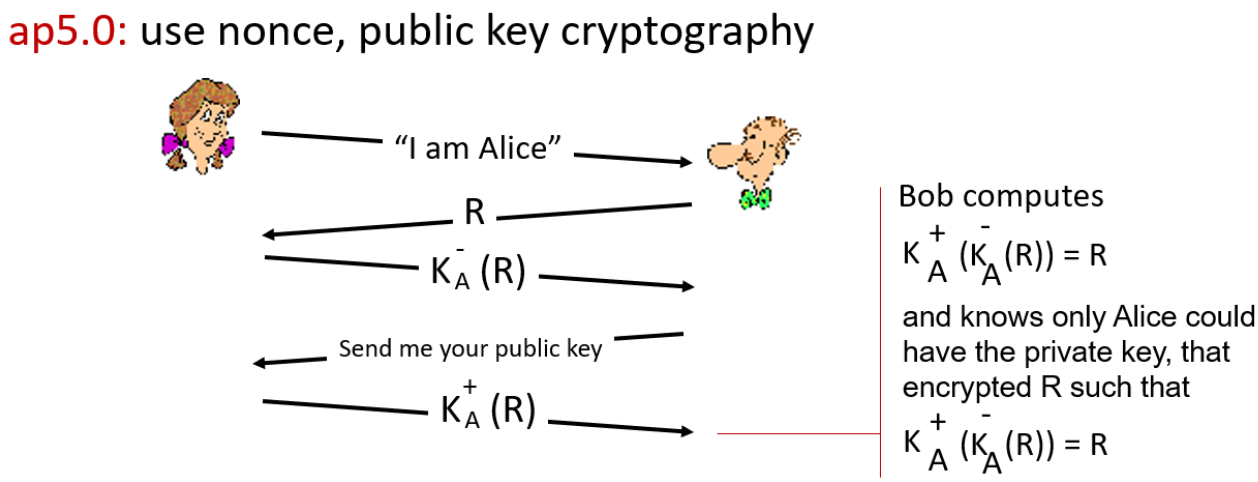


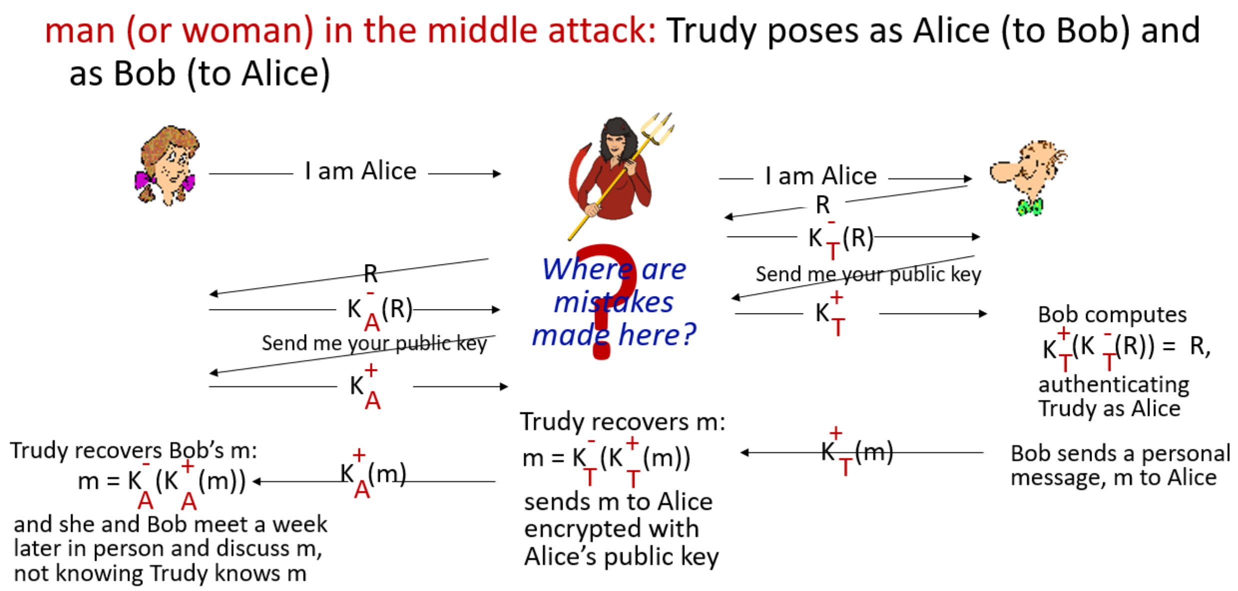
- Alice encrypts password.
- Bob see's something encrypted and understands its Alice.
- Problem: Trudy, since she is monitoring, uses the same encrypted password.

Failure Scenario 5:



- Bob sends a **naunce** message, used once in a lifetime.
- Alice sends the **naunce** back to Bob encrypted.
- Will not be the same each time.





- Trudy sits in between and wrecks havoc.

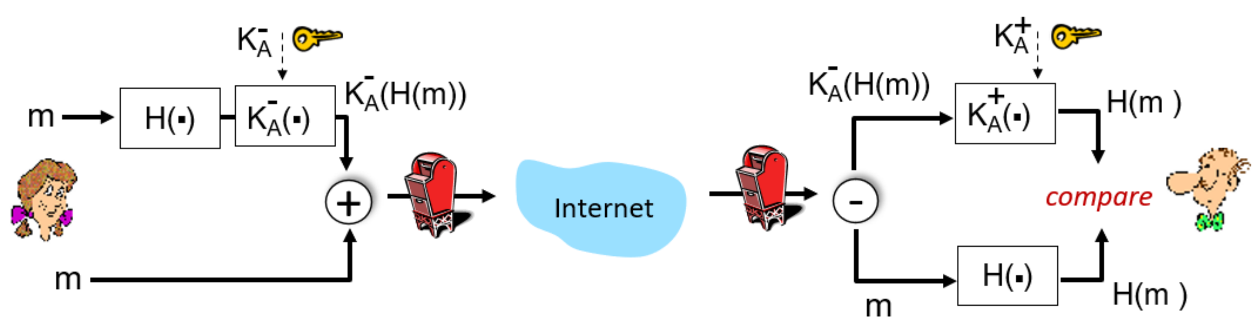
Digital Signatures

- Analogous to hand-written signatures, ex: pdf's.
- **Message Digest** (MD): ex MD5 available in databases, SQL.
  - Kind of a hash
  - SHA-1 also used
  - MD5 is large, must make sure there is enough space in DB to store MD5.
- **Internet CheckSums**:

Need for certified public keys

- ex. pizza shop asks for payment in advance.
- **Certificate Authority** (CA) needed to certify users. To record/validate identity for access to a public key.

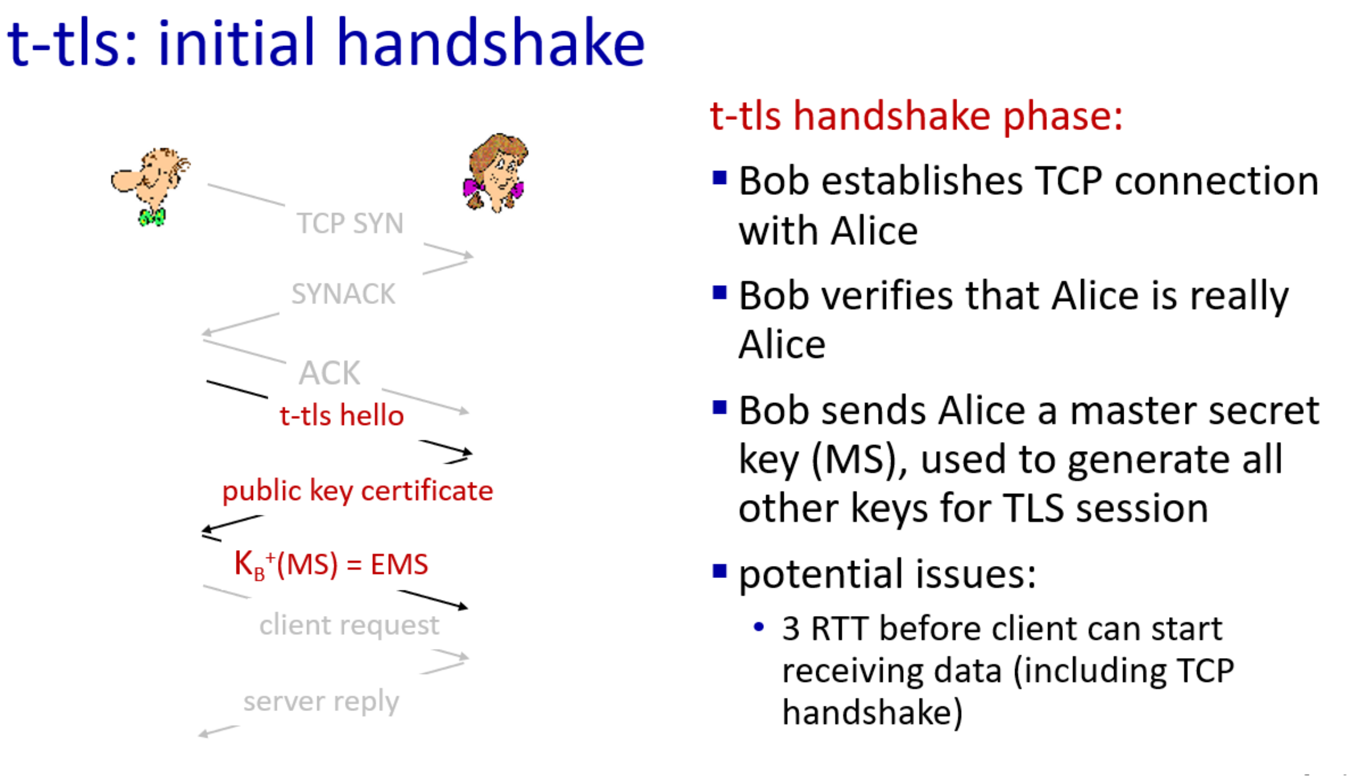
Secure Email: REMEMBER FOR EXAM!!



- Which side is the public key, private key in terms of confidentiality?
  - Sent with the public key. Only one who can decrypt it is the recipient.
- For message integrity and authentication, it's the other way around.
  - Use the private key to encrypt, anyone can decrypt it with the public key but only the individual can do it.

Transport-layer Security (TLS)

- A combination of message integrity, authentication and confidentiality.
- Together with HTTP makes HTTPS.
- Provides:
    - confidentiality - via symmetric encryption (NOT RSA, instead permutation ciphers types).
    - integrity - via cryptographic hashing (if someone were to change one pixel or character, you will find out about it since it will be different)
    - authentication - via public key cryptography.

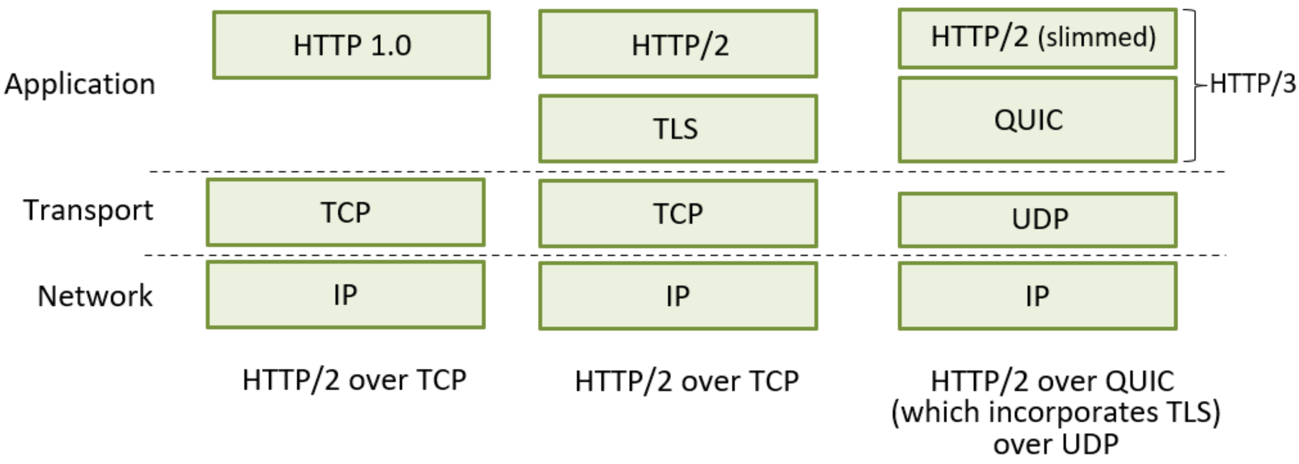


- top light-gray exchange is standard three-way handshake.
- Problem: 3 RTT (Round Trip Time). A lot of overhead.

T-TLS: Encrypting Data

- Possible issues:
    - Re-ordering: man-in middle intercepts TCP segments and reorders
    - Changing the sequence makes putting it back together a problem.
    - Connection closure: attacker forges TCP connection close segment. Must check if legitimate closure.

HTTP View of TLS:

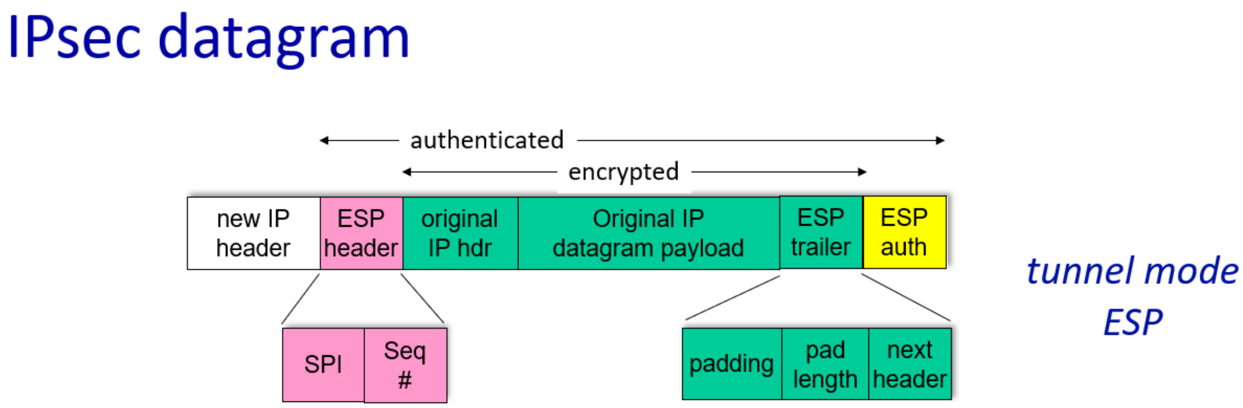


- HTTP 1.0 has no security
- HTTP/2 (HTTPS) is HTTP + TLS
- HTTP/3 uses QUIC, not using TLS works around it.

Some approaches attempt to wrap more of the cryptography earlier on in the exchange.

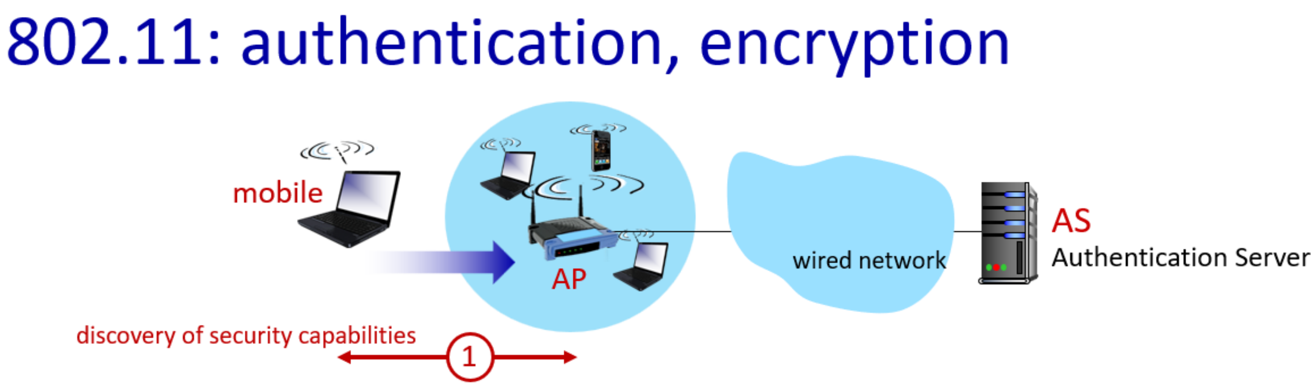
Where does this cryptography happen?

- Application Layer:
  - In computer email client applications
  - ZIP, using WinZip PW protection
  - VPN essentially
  - People don't want to bother with encryption.
- IP Layer/Network Layer:



  - Encrypted data sitting inside another data is sometimes done.

802.11: WIFI Authentication, Encryption



- Easier to listen to something as opposed to wired.
- Need to establish a wireless connection to an access point (AP).
- Can be unreliable.

FIREWALLS: IMPORTANT TOPIC

- Gets name from construction to slow down the spread of fire.
- In our context:
    - Keep things in: ex: company employee attempts to leak secrets to sell.
        - Company firewall looks at all communication going out.
    - Main thing, Keep things out:
        - Have a white-list of IP addresses that are allowed.
            - Doesn't necessarily prevent someone from impersonating someone else.
        - Have a black-list of bad actor IP addresses to deny entry.
        - Packet filter: if anyone sends anything to a webserver not on port 80, for example, that is a red flag.
            - Why are they sending other things? Suspicious.
        - Ex of a packet filter: **Access Control List** (ACL)

Access Control Lists

ACL: table of rules, applied top to bottom to incoming packets: (action, condition) pairs: looks like OpenFlow forwarding (Ch. 4)!

action	source address	dest address	protocol	source port	dest port	flag bit
allow	222.22/16	outside of 222.22/16	TCP	> 1023	80	any
allow	outside of 222.22/16	222.22/16	TCP	80	> 1023	ACK
allow	222.22/16	outside of 222.22/16	UDP	> 1023	53	---
allow	outside of 222.22/16	222.22/16	UDP	53	> 1023	----
deny	all	all	all	all	all	all

Intrusive Detection Systems

- Deep packet inspection

- looks at data itself for virus, malware
    - virus' can be in images since it's an executable file.