Encryption

Todays topics

Hey, check out these slides...

- What is ***encryption***
- What is a ***cryptosystem***
- Types of encryption
  - Symmetric encryption
  - Asymmetric encryption
- Public and Private keys
- Key Exchanges

What is Encryption

Encryption is the process of *encoding* information with a purpose (typically for security security). This process converts the original representation of the information, known as *plaintext*, into an alternative form known as *ciphertext*.

This process, combined with its reverse *decryption*, and all of the data/algorithms necessary to encrypt and decrypt messages form a *cryptosystem*.

-Wikipedia

Encoding and Encrpytion

Figure 1: Scytale

What is Encryption (continued)

Some points:

- Encryption is reversible (with a key)
- Encryption is everywhere
- Encryption does NOT need a computer (but good encryption probably does...)

Cryptosystem

Five-tuple (sequence) of the following elements:

Element	description
E	the set of ***Encryption*** algorithms
D	the set of ***Decryption*** algorithms
M	the set of plaintext ***Messages***
K	the set of ***Keys***
C	the set of encrypted messages or ***Ciphertexts***

$\boldsymbol{E} = f(\ \boldsymbol{K},\boldsymbol{M}\ )$ -> $\boldsymbol{C}$

$\boldsymbol{D} = f(\ \boldsymbol{K},\boldsymbol{C}\ )$ -> $\boldsymbol{M}$

Scytale Cryptosystem

Element	description
$\boldsymbol{E}$	wrap around scytale & write *message*
$\boldsymbol{D}$	wrap around scytale & read *message*
$\boldsymbol{M}$	the *message*
$\boldsymbol{K}$	???
$\boldsymbol{C}$	strip or paper with letters

Caesar Cipher

AKA rotational cipher, shift cipher, probably more. Simple encryption via substitution.

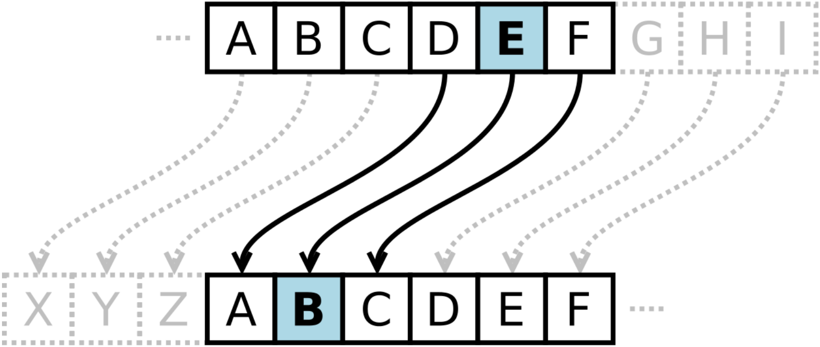


Figure 2: caesar cipher

Lets get Math-y

Element	description
M	***? ?? ????***
C	***F XJ EBOB***
E	$\boldsymbol{C}$[n]=($\boldsymbol{M}$[n] - 3) Mod 26
D	$\boldsymbol{M}$[n]=($\boldsymbol{C}$[n] + 3) Mod 26
K	What is the key?

```
M[n] = ABCDEFGHIJKLMNOPQRSTUVWXYZ
C[n] = XYZABCDEFGHIJKLMNOPQRSTUVW
```

Two types of Encryption

Symmetric

Same key for both encrypting and decrypting

Asymmetric

Different keys for encrypting and decrypting

Symmetric Encryption

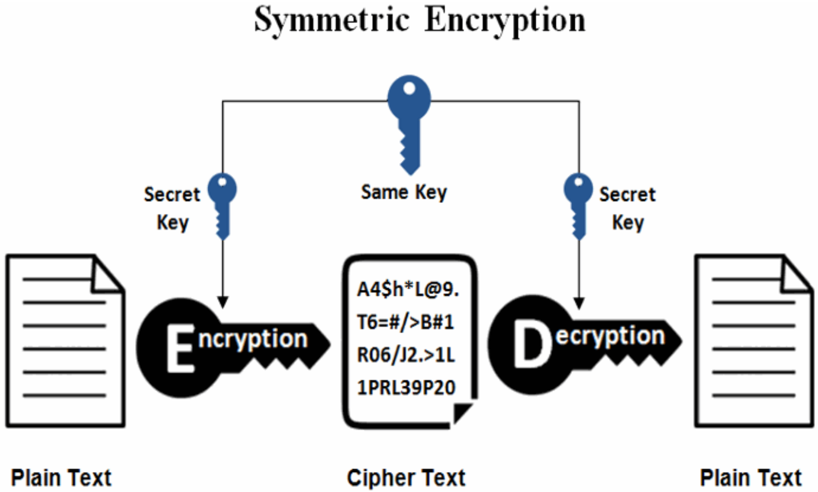


Figure 3: symmetric key encryption

Keys are identical for encryption and decryption.

Asymmetric Encryption

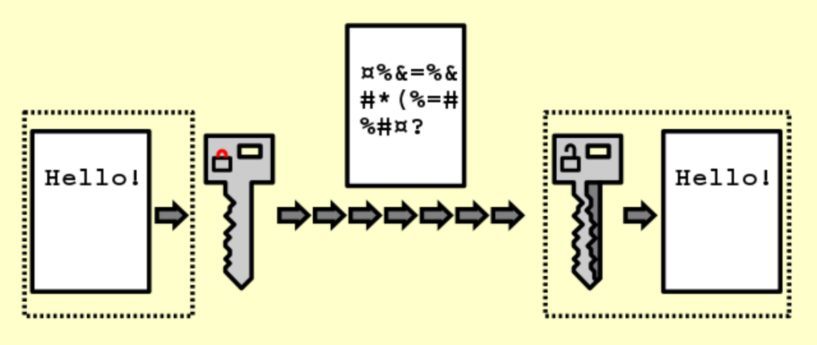


Figure 4: public key encryption

Keys are different but mathematically related.

Differences

Symmetric	Asymmetric
* One key * Fast * Used to encrypt various amounts of data * Key must be secured	* Multiple keys * Slow * Used to authenticate and initiate symmetric encryption * only private key needs securing
* Needs more keys to establish secure communications within a group	* Needs fewer keys to establish secure communication in a group

Apples and Oranges

Although the end goal is the same (end up with *encrypted* data in the form of a cipher text), asymmetric and symmetric encryption work very differently.

	Asymmetric (RSA 2048)	**Symmetric (AES 128)**
Encrypt spd	1.5 MB/s	100 MB/s
Decrypt spd	0.4 MB/s	100 MB/s

Public and Private Key pairs

- Public key is public information, can be shared with anyone.
- Assume **everyone** has your public key
- Private key must be kept private
- **Public** and **Private** key pairs share a unique mathematical relation:
  - Anything **encrypted** with the **public key** can only be *decrypted* with the *private key*
  - Anything **encrypted** with the **private key** can only be *decrypted* with the *public key*

Key Pairs continued

If we trust this relationship, and we trust that recorded knowledge of who has what keys:

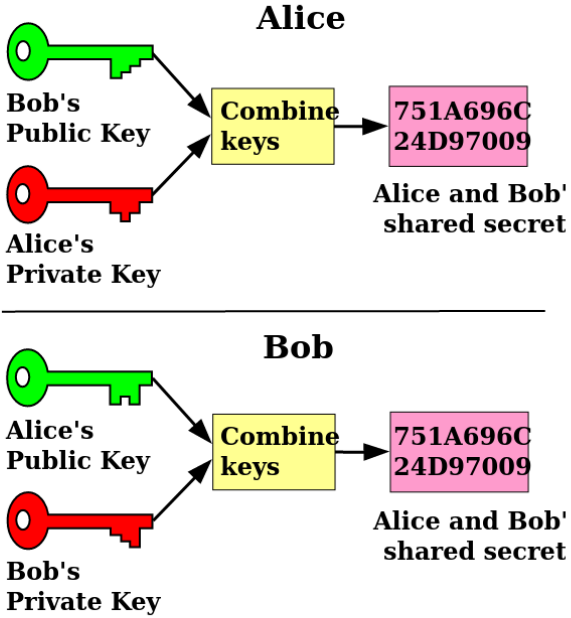
- We can check *Authenticity* by asking them to encrypt something with their private key
- We can recieve (one way) secure communications (ask someone else to first encrypt with your public key)
- If we send something encrypted with our private key who can read it???

Diffie-Hellman Key Exchange

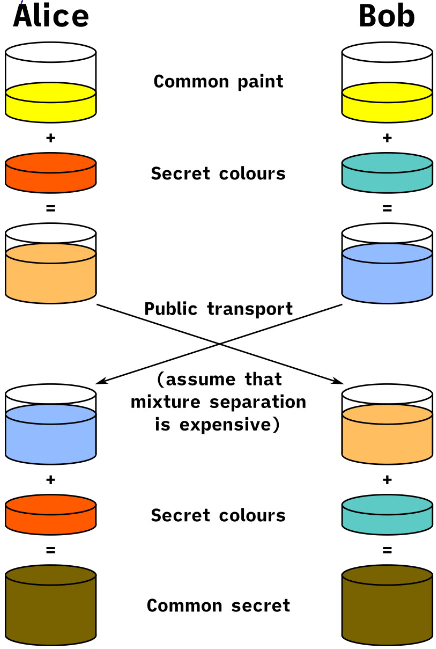
Solves the problem of securely exchanging cryptographic keys over a public channel.

- The internet is public and filled with many potential eavsdroppers (***Eve's***)
- 
- How to establish a *secure* communication channel across an insecure one?

Diffie-Hellmen



Diffie-Hellman w/colors



Diffie-Hellman usage

HTTPS://

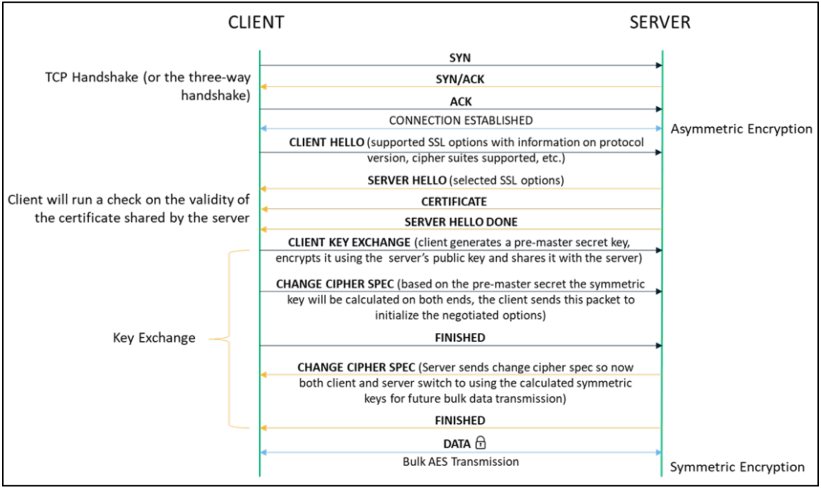


Figure 7: TCP Handshake