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Security

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Need for secure communication

- As old as communication through a third party
- Especially in
  - Warfare
  - Diplomacy
  - ...

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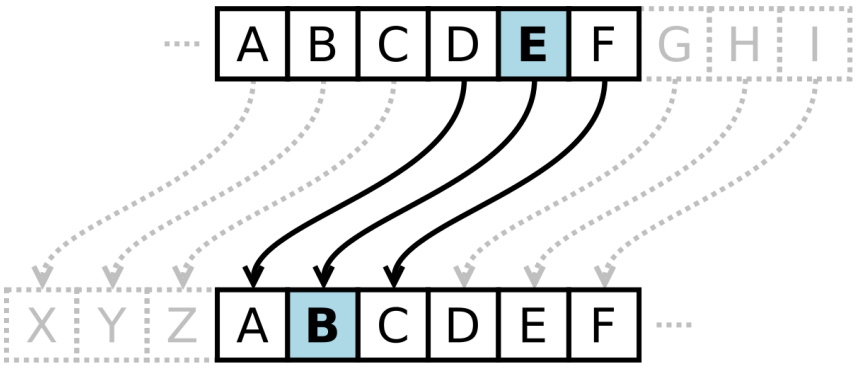
Classic historical ciphers

Caesar cipher (monoalphabetic)



Vigenere cipher (polyalphabetic)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
B	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
C	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B
D	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
E	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D
F	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E
G	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F
H	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G
I	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H
J	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I
K	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J
L	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K
M	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L
N	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M
O	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N
P	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Q	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
R	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
T	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
U	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
V	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
W	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
X	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Y	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Z	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y

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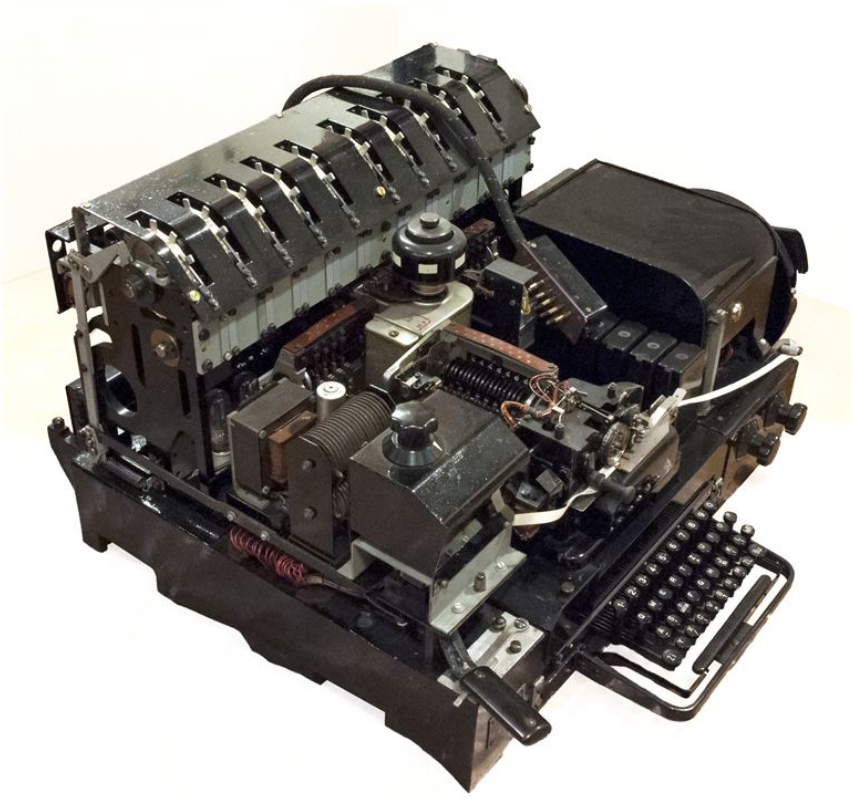
WW cryptosystems

Enigma

Geheimschreiber (T52)



Foundation of modern cryptography

If a lot of smart people for a long time have failed to solve a specific problem, it is unlikely that a solution will appear soon

(hopefully)

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Modern cryptography

- Encryption method is well-known
- Secret guarded by a *n-bit key*
  - Encryption and decryption in O(n) time
  - Key guessing in O(2^n) time
- Key management is crucial
- CIA triad represent desirable properties
  - Confidentiality
  - Integrity
  - Availability

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Problem: Public key exchange

Alice and Bob wants to communicate. They agree publically on *p* and *g.* After that, they do as follows:

Alice	**Bob**
Create secret key S_A	Create secret key S_B
Compute $T_A=g^{S_A}$ *mod* p	Compute $T_B=g^{S_B}$ *mod* p
Send T_A to Bob	Send T_B to Alice
Compute $K_1=T_B^{S_A}$ *mod* p	Compute $K_2=T_A^{S_B}$ *mod p*

How Alice and Bob now use
K_1 and K_2 to communicate securely?

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Solution

- $K_1 == K_2$
  - $T_B^{S_A} = (g^{S_B})^{S_A} = g^{S_B S_A} = g^{S_A S_B} = (g^{S_A})^{S_B} = T_A^{S_B}$ *mod* p

- Alice and Bob can communicate securely using symmetric key cryptography

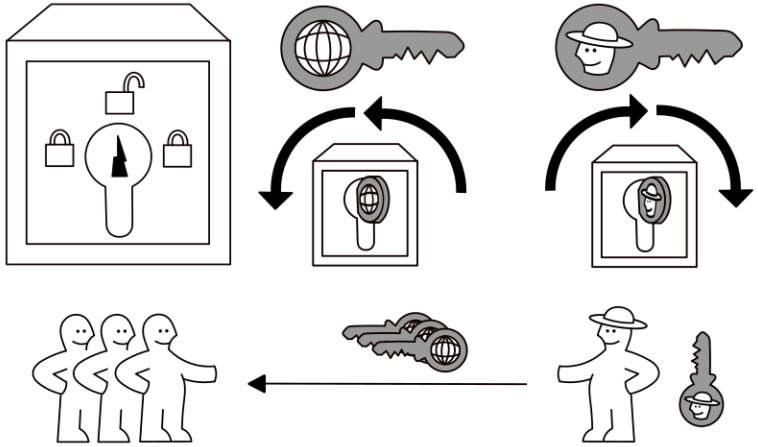
- Method called *Diffie-Hellman key exchange*

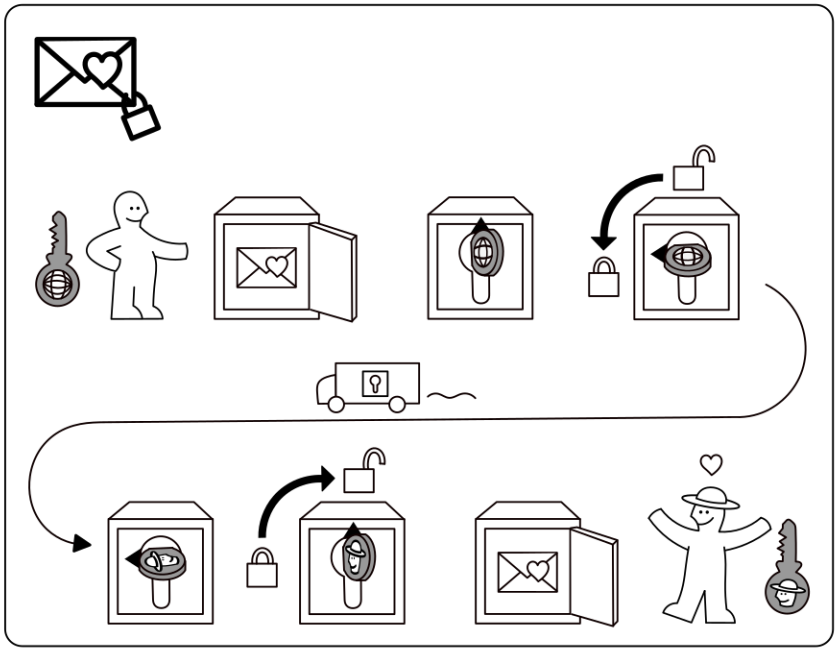
Can Diffie-Hellman be extended to let 3 different users communicate securely?

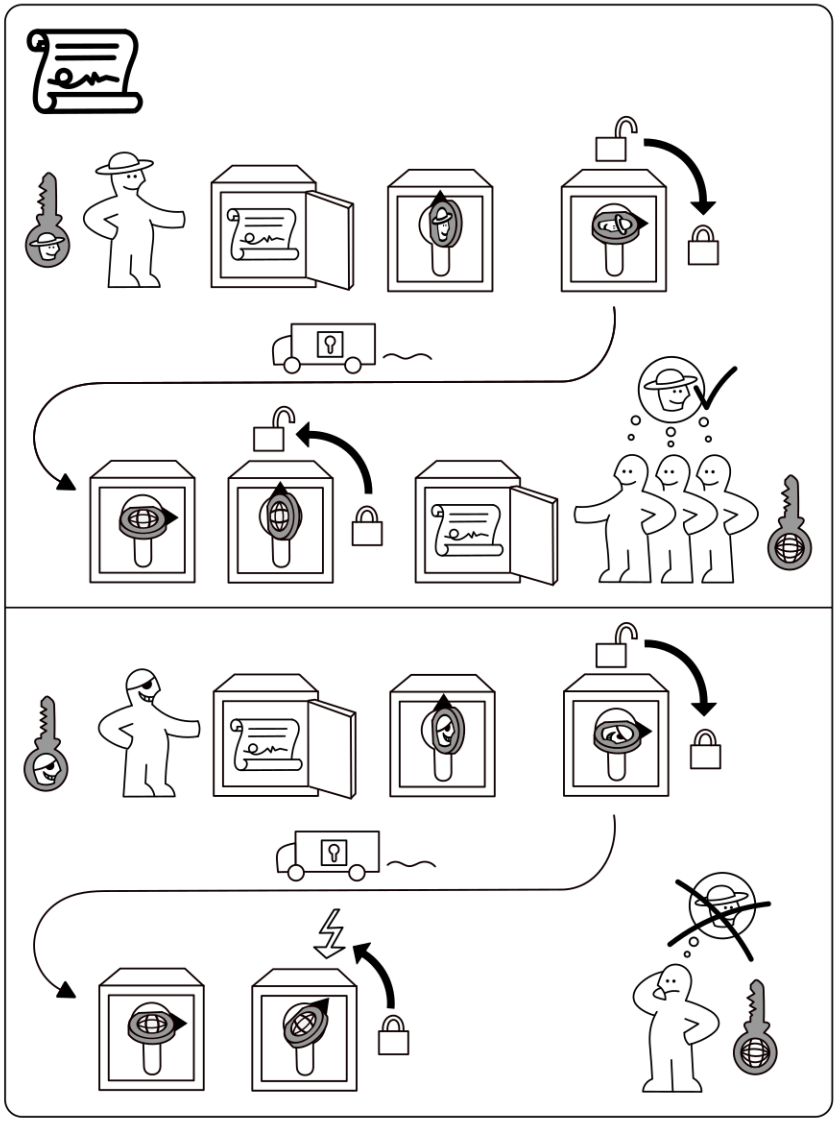
PUBLIK KEY KRYPTO

idea-instructions.com/public-key/
v1.1, CC by-nc-sa 4.0

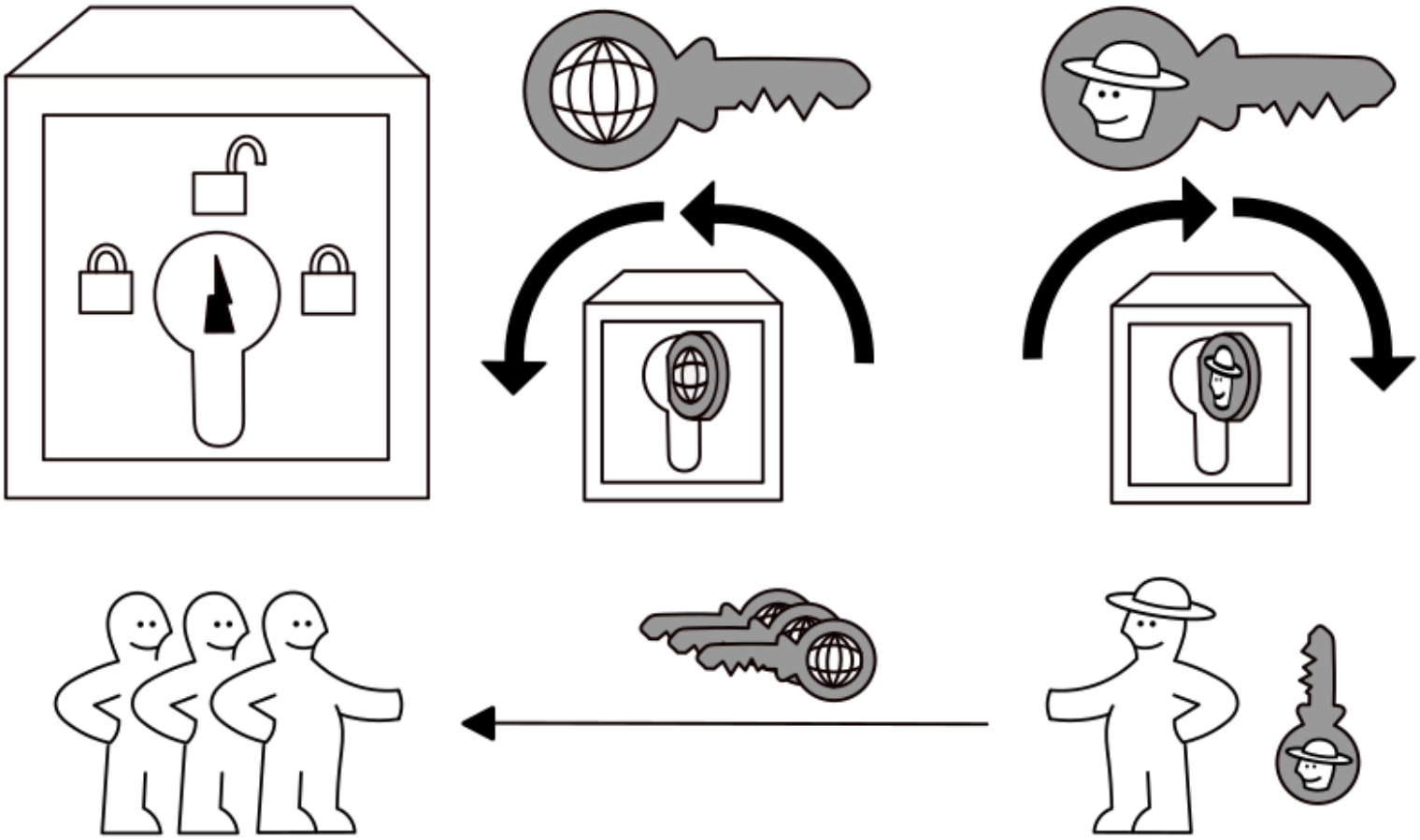
IDEA

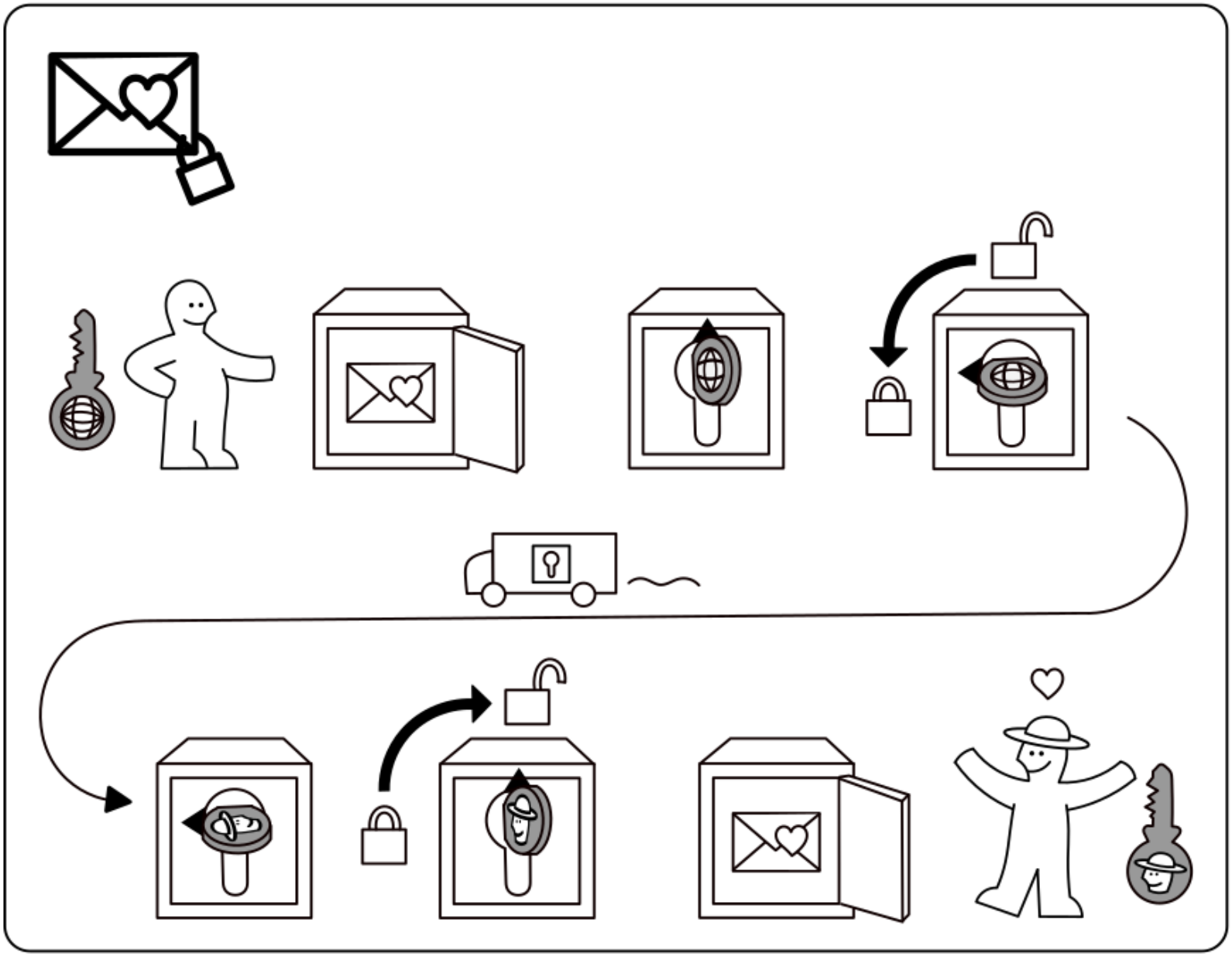


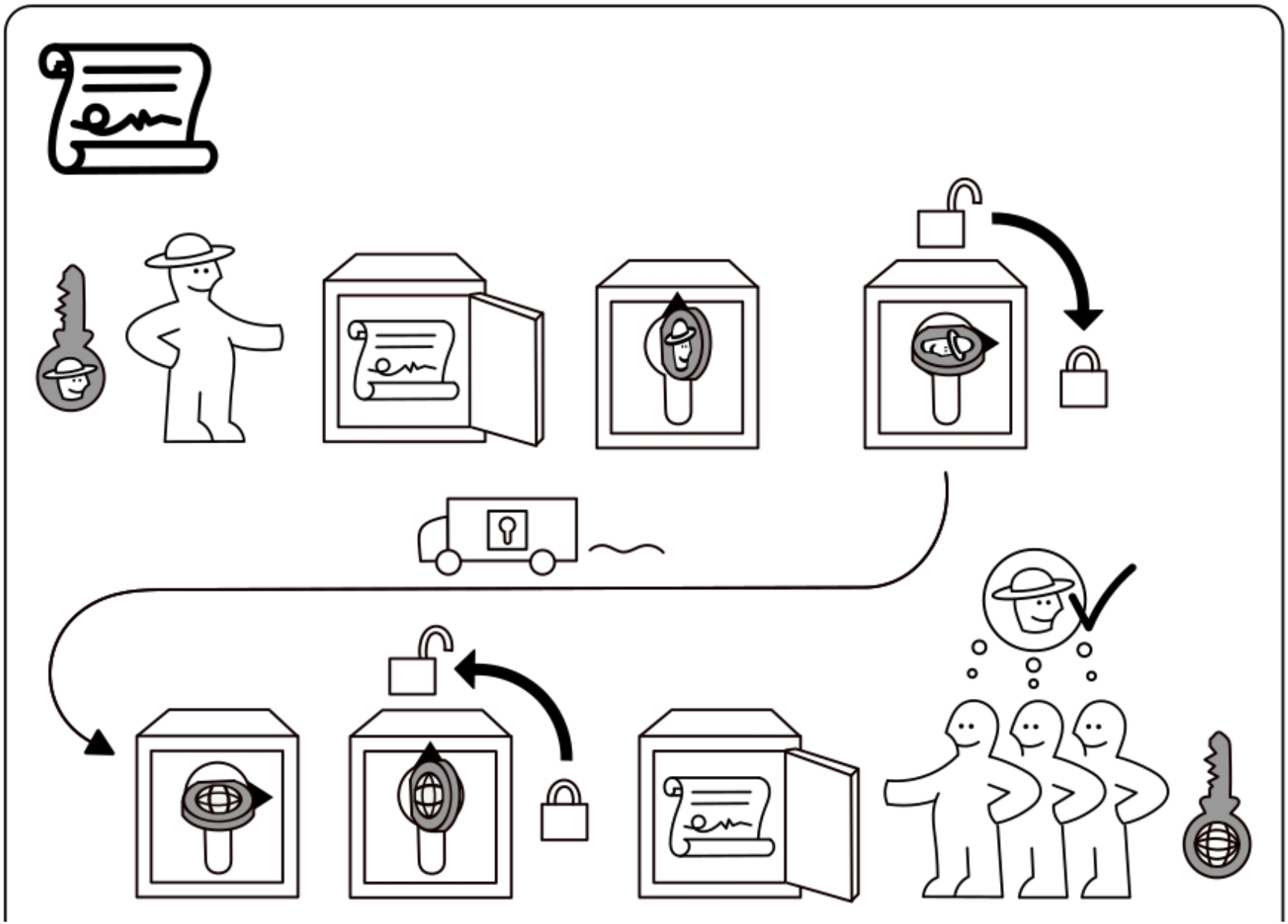


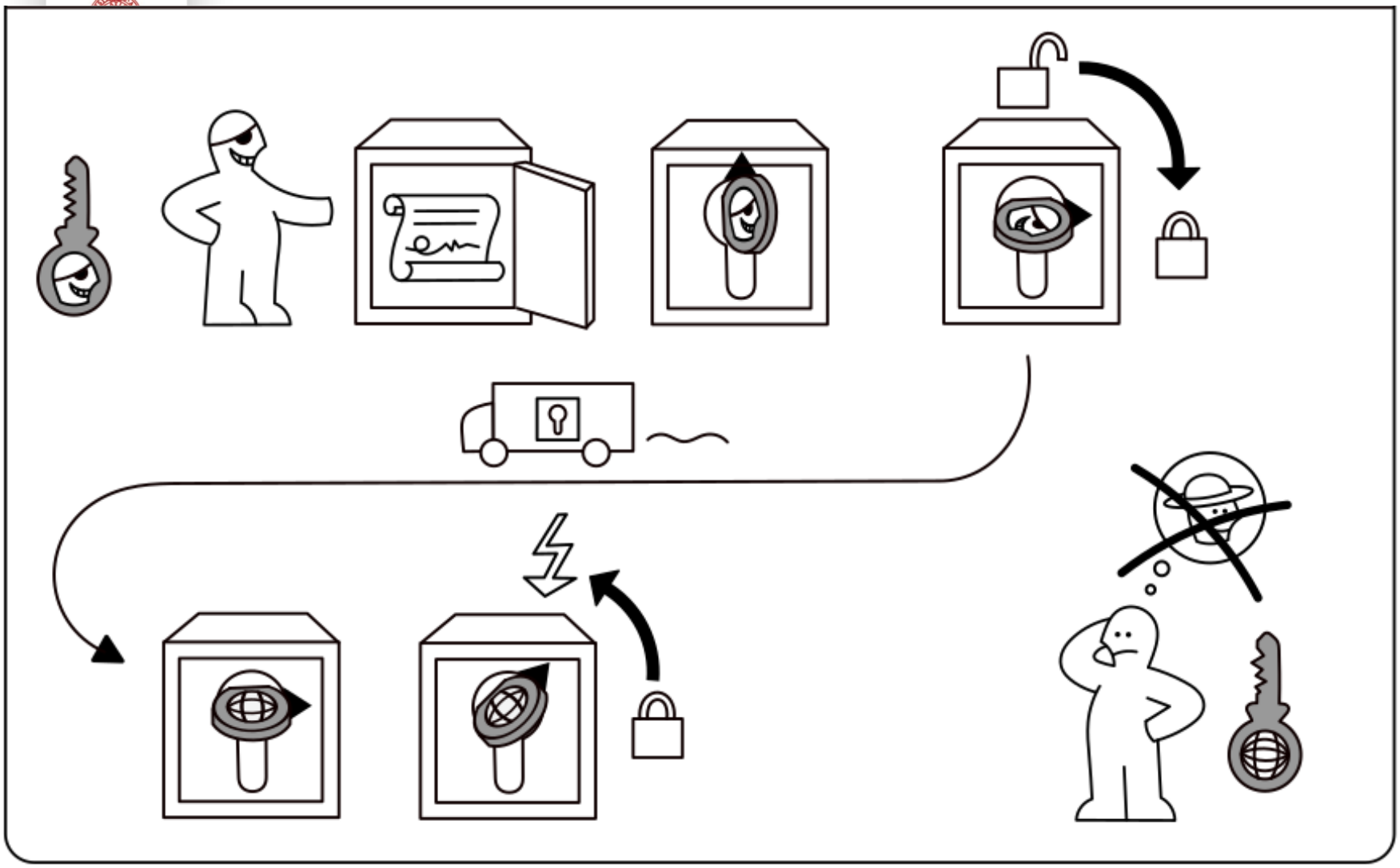


PUBLIK KEY KRYPTO









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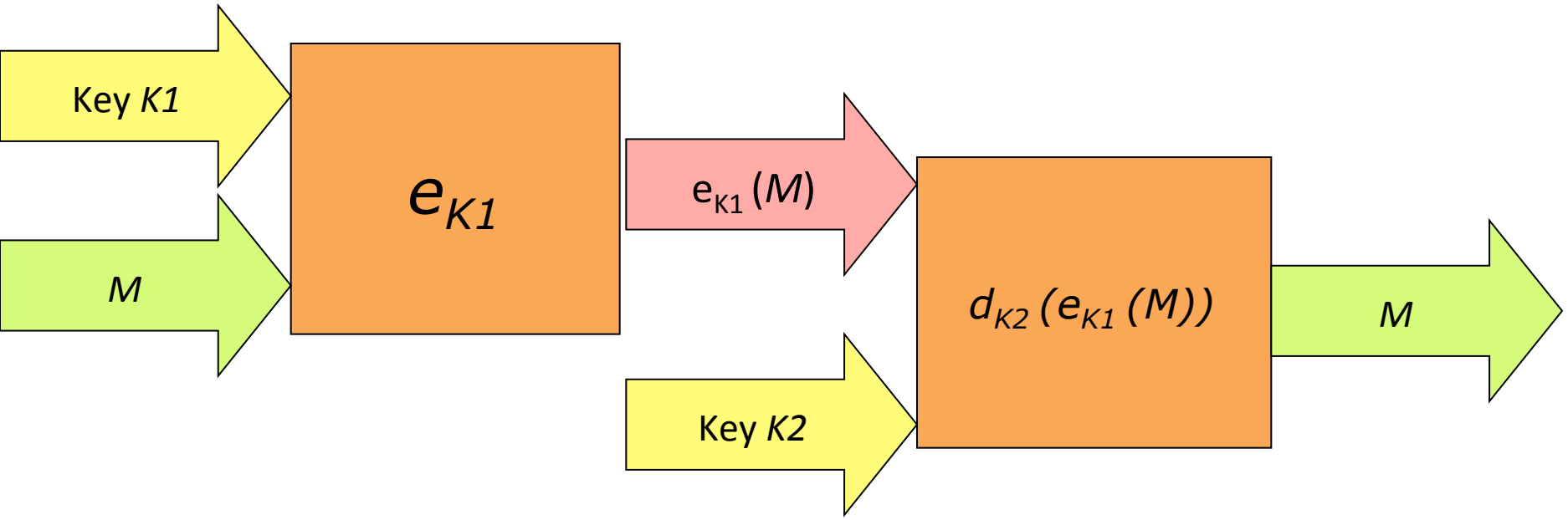
Asymmetric (public-key) encryption



What are pros and cons of this scheme?

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Public-key encryption (contd.)

- Key pairs
  - Private key *S*
  - Public key *P*

- $d_S(e_P(M)) = M$ (Encryption)
- $d_P(e_S(M)) = M$ (Signing)
- $d_{P_B}(d_{S_A}(e_{P_A}(e_{S_B}(M)))) = M$ (Both)

Where to find and how to trust public keys?

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Certification Authority (CA)

- Issues **digital certificates**
  - Digitally signed with the private key of the CA
  - Authorize a public key

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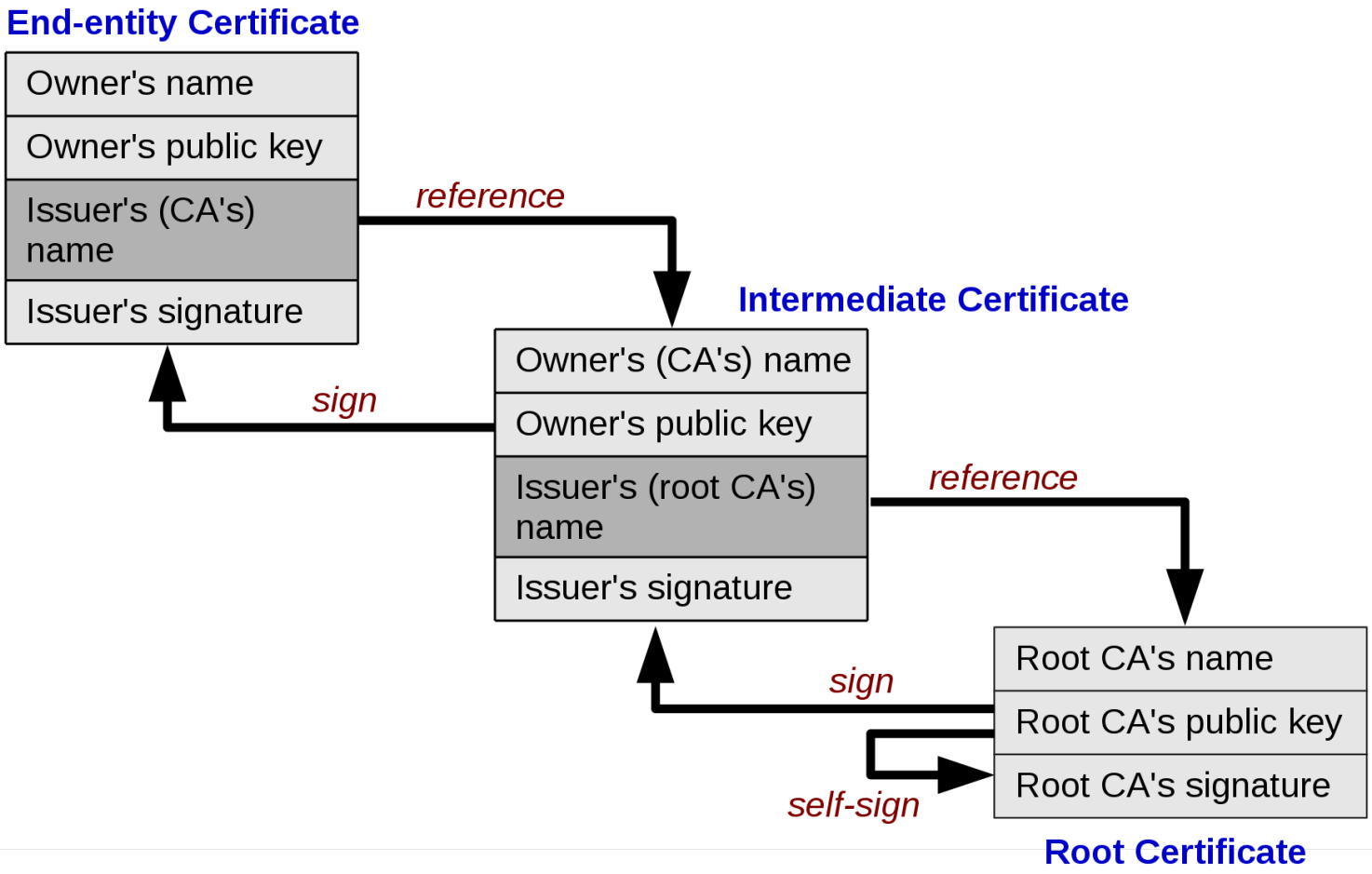
Chain of trust



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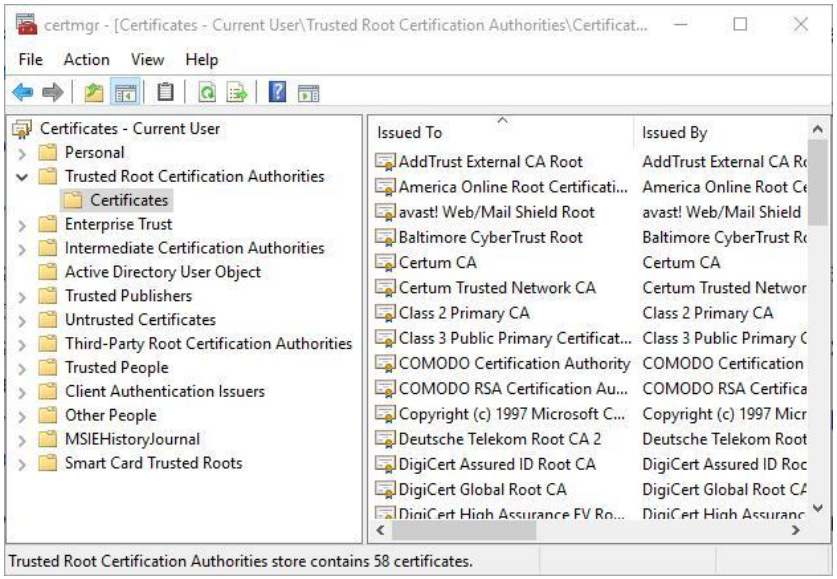
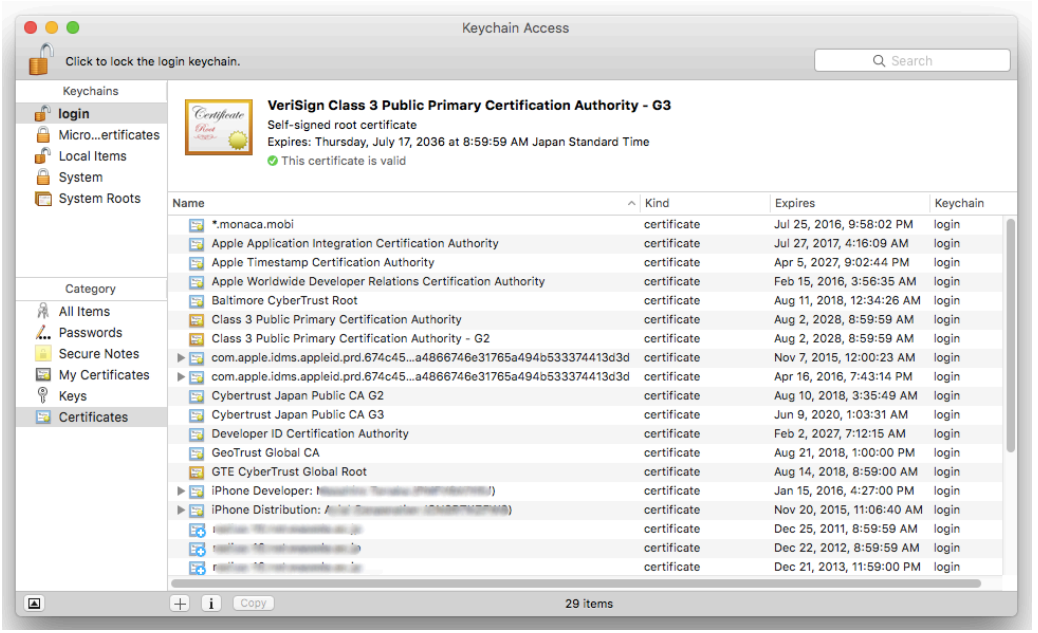
How to trust the root CA?





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Self-issued certificates

- Some sites present *self-issued* certificates
  - A little lite designing your own drivers license

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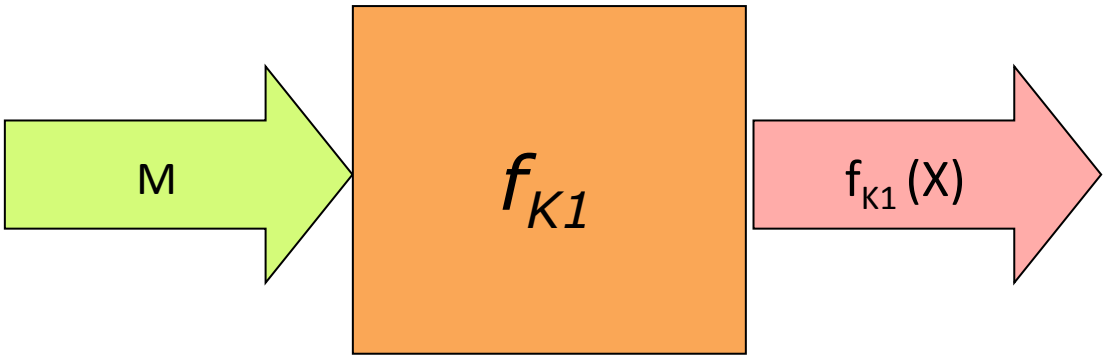
Cryptographic hashing



When is this useful?

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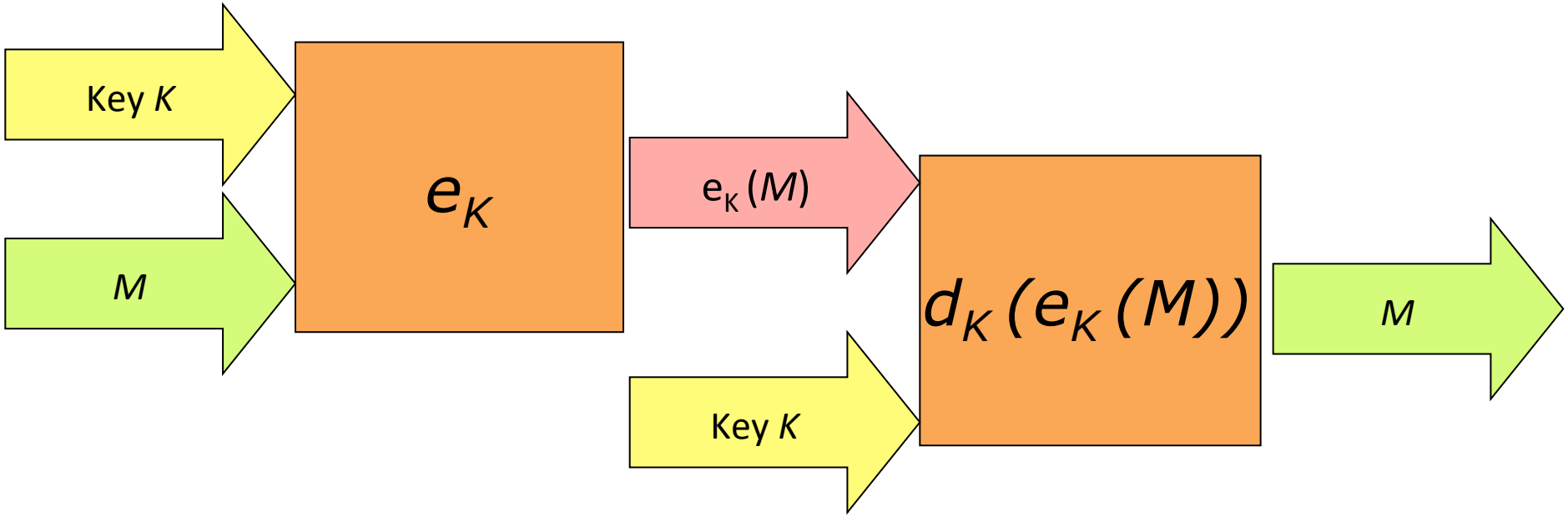
Symmetric encryption



What are pros and cons of this scheme?

Usage of modern cryptography

- Symmetric cryptography in encrypted sessions
  - public-key cryptography not fast enough
- Asymmetric cryptography in certain situations
  - To establish a symmetric key
  - Digital signatures and verification
- Cryptographic hashing for verification of authentic data

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Attacks on cryptosystems

- Known plaintext
- Known ciphertext
- Chosen plaintext
- Man-in-middle
- Denial-of-service
- Side-channel
- Brute-force
- Replay
- ...

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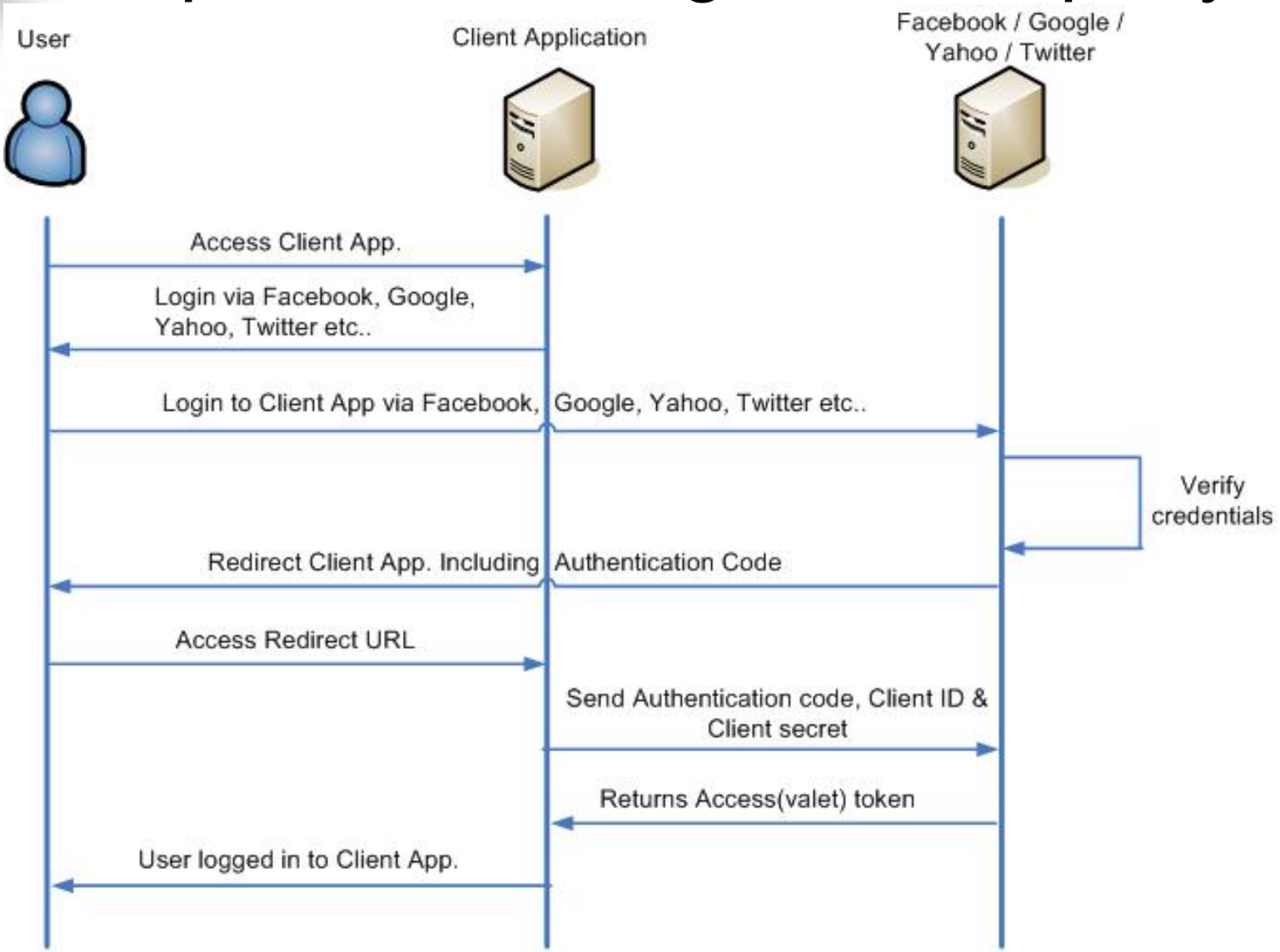
OpenAuth through trusted party



Authentication

- Two-factor authentication
  - Something you know
  - Something you have
  - Something you are
- Challenges
  - One-time codes

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Security in the Internet stack

- Application layer — DNSSEC
- Transport layer — SSL/TLS
- Network layer — IPsec
- Link layer — WEP/WPA
  MAC filtering, ...

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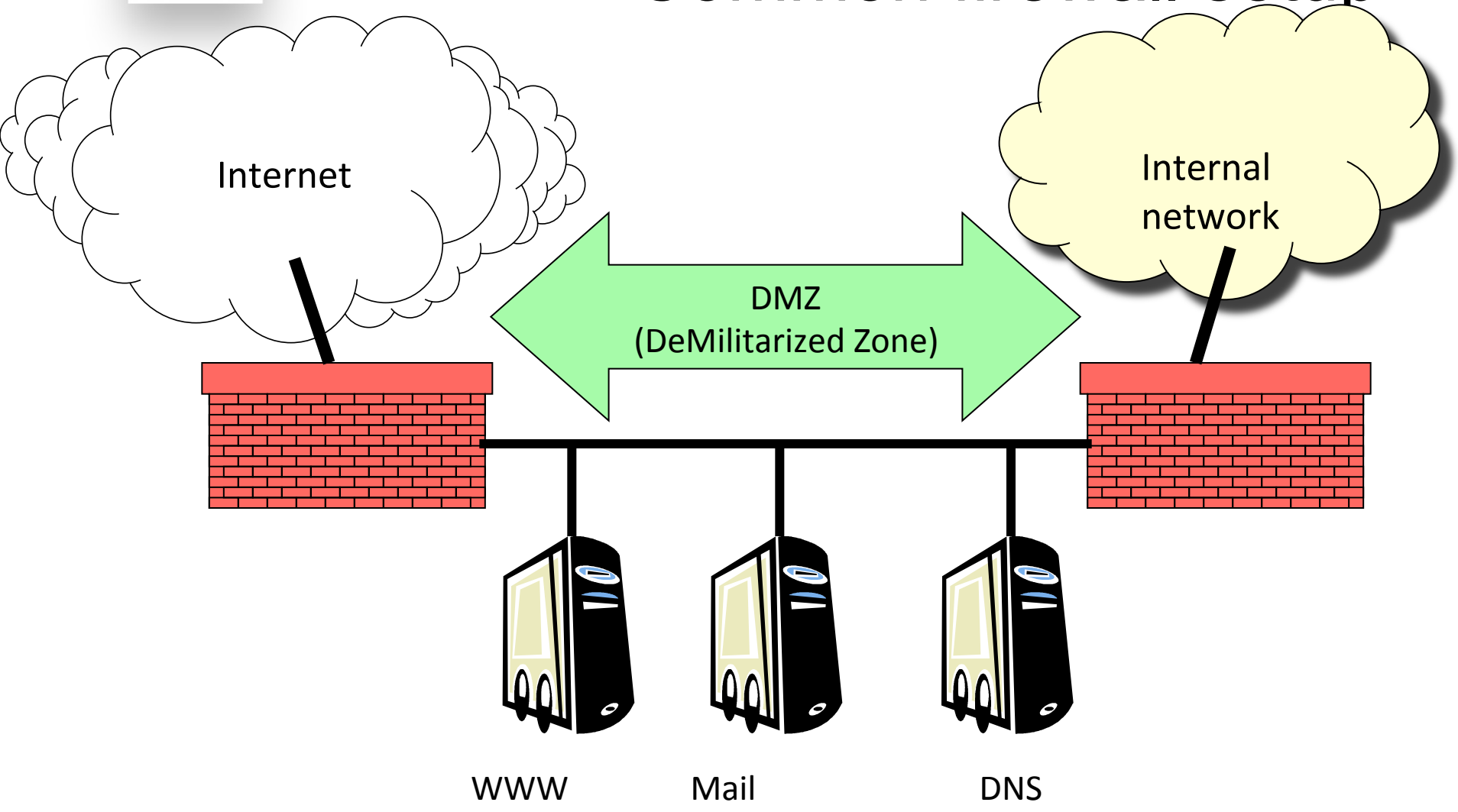
Common firewall setup



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NAT boxes and security

- Primary goal
  - Avoid over-consumption of global IP addresses
- Side effects
  - Computers with local IP unreachable from outside
  - “Holes” can be opened for servers
  - Servers can be placed in a DMZ
- Often include simple packet filters