MAINFRAME CRYPTO

Unscrambling the Complexity of Crypto!

Intro to Crypto

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THE EXCHANGE

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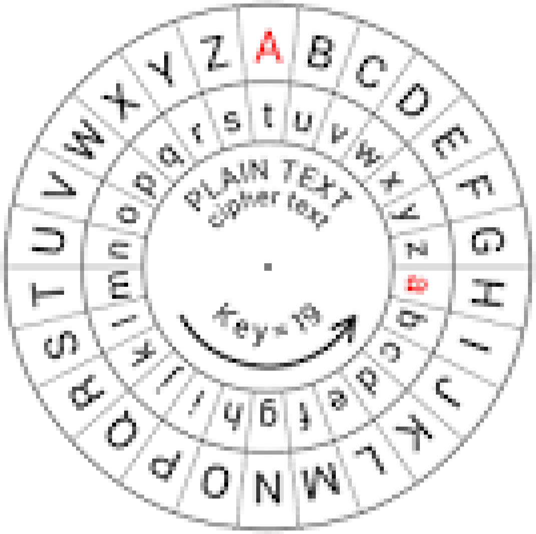
Agenda – Intro To Crypto

- Some background
- Crypto Functions
  - Symmetric algorithms
  - Asymmetric algorithms
  - Hashes
  - PIN Support

Historical Ciphers

Scytale



Caesar Cipher, Key = 3

MAINFRAME

PDLQIUDPH

	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

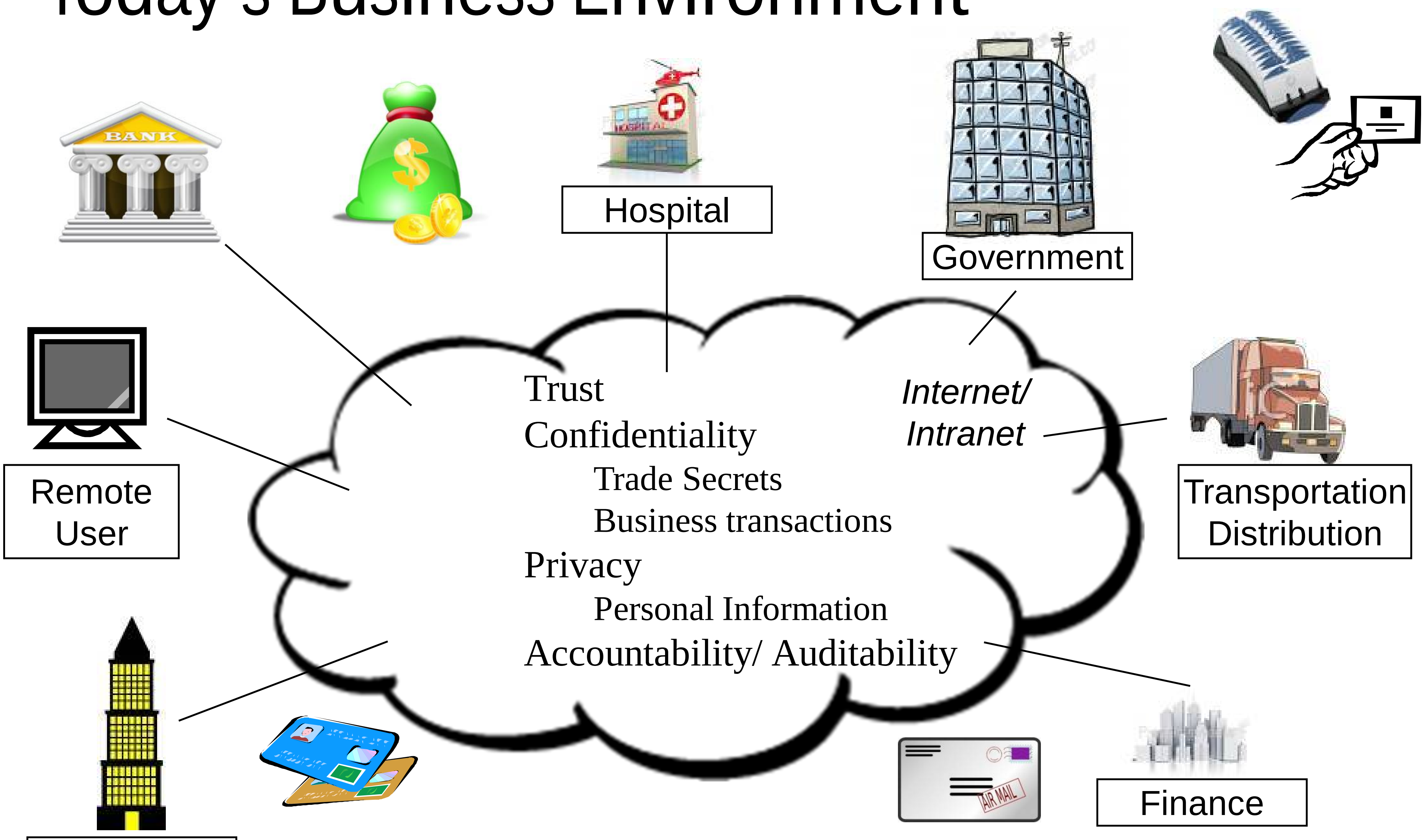
Vigenere Square, Key = BOYD

MAINFRAME

BOYDBOYDB

NOGQGFYPF

Today’s Business Environment



Endless Possibilities, but they require confidence

What is Cryptography?

Cryptography (or cryptology; from Greek κρυπτός, *kryptos*, "hidden, secret"; and γράφω, *gráphō*, "I write", or -λογία, *-logia*, respectively)[1] is the practice and study of hiding information. In modern times cryptography is considered a branch of both mathematics and computer science and is affiliated closely with information theory, computer security and engineering.

From Wikipedia

Cryptographic Functions

Data Confidentiality

- Symmetric – DES/TDES, AES
- Asymmetric – RSA, Diffie-Hellman, ECC

Data Integrity

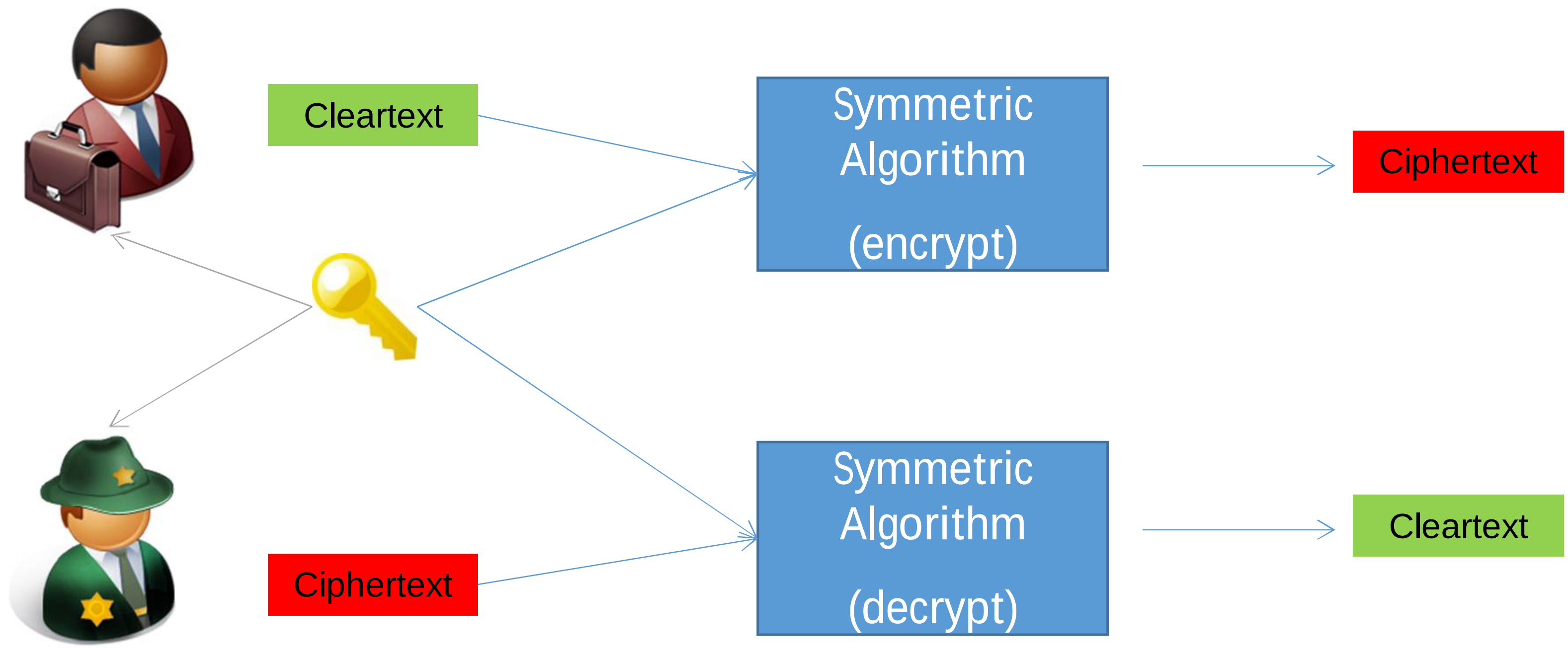
- Modification Detection
- Message Authentication
- Non-repudiation

Financial Functions

Key Security & Integrity

Confidentiality – Symmetric Algorithms

- Symmetric - One key shared by both parties

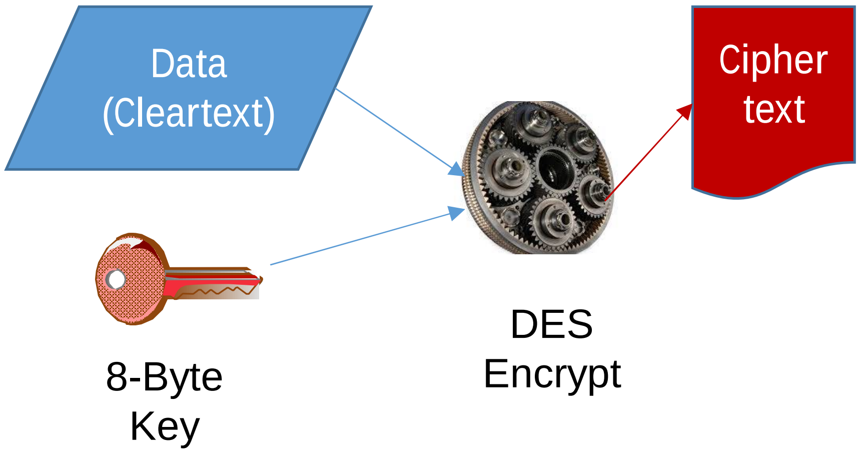


Symmetric Algorithms

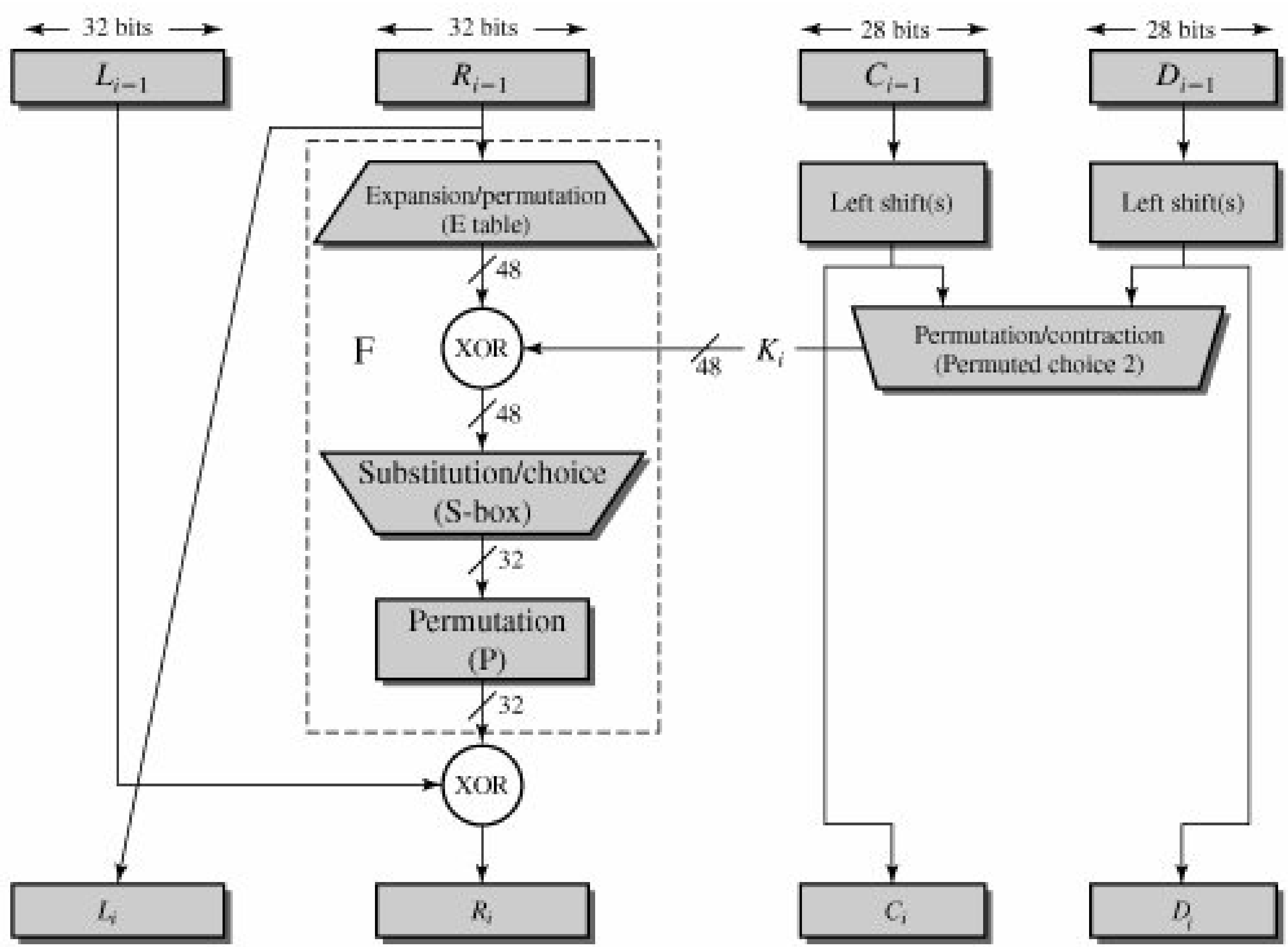
- Symmetric
  - DES/TDES*
  - AES*
  - Blowfish / Twofish
  - Serpent
  - IDEA
  - RC2 / RC4
  - Skipjack
  - ....

*Supported on IBM Hardware

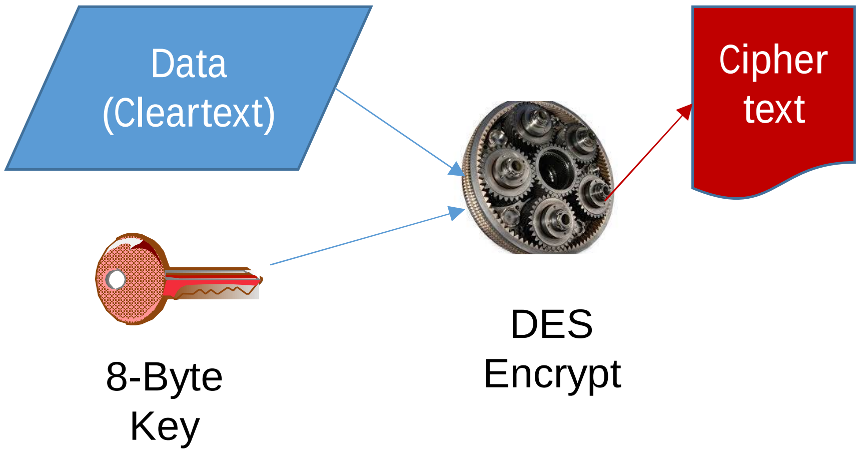
DES Algorithm - Encrypt

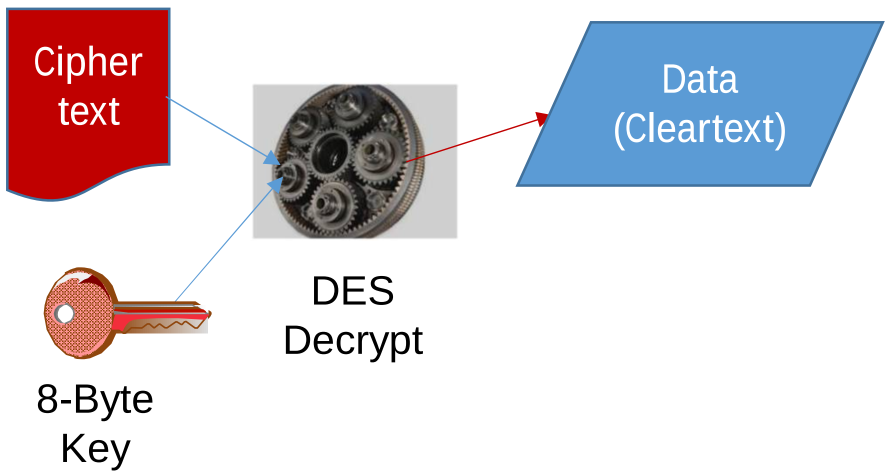


Single Round of DES Encrypt

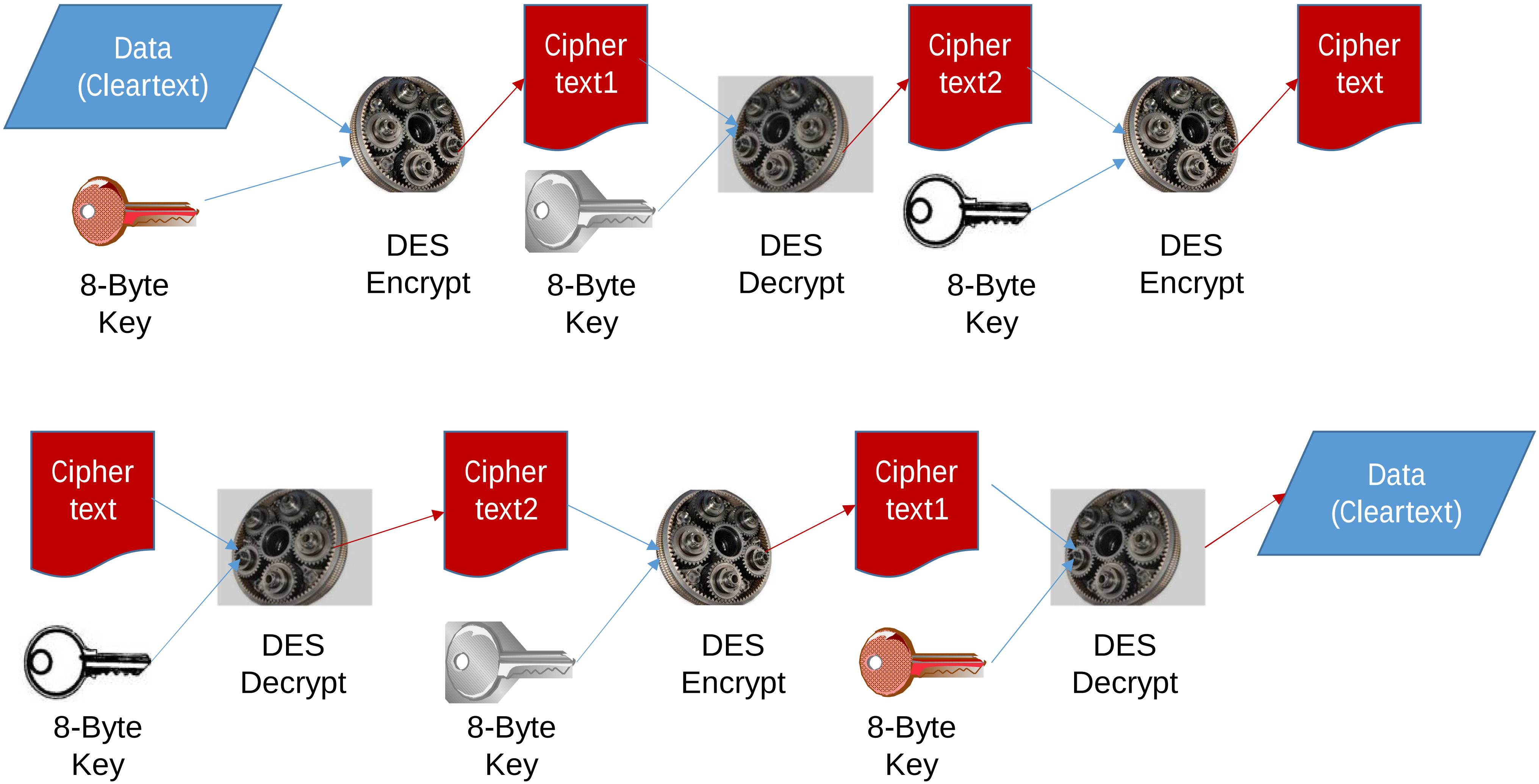


DES Algorithm - Decrypt

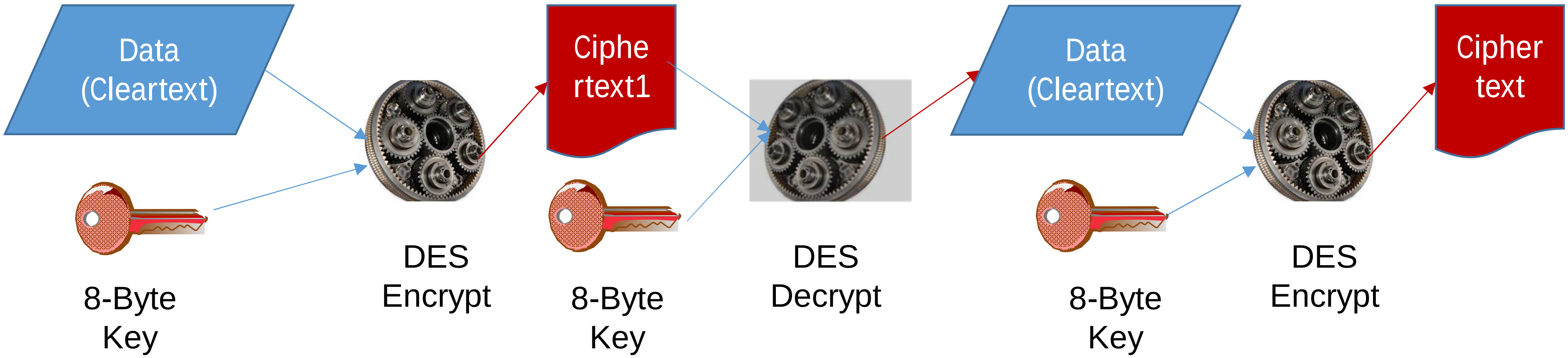




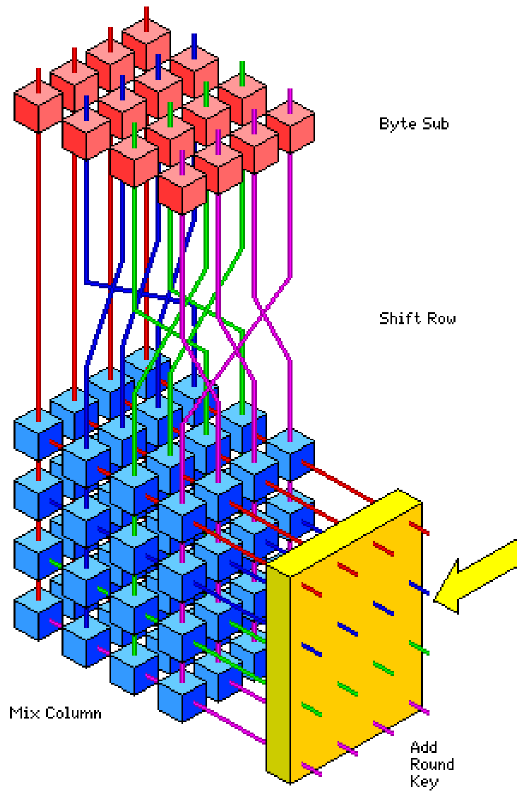
TDES Algorithm



TDES Algorithm



Data Confidentiality - AES

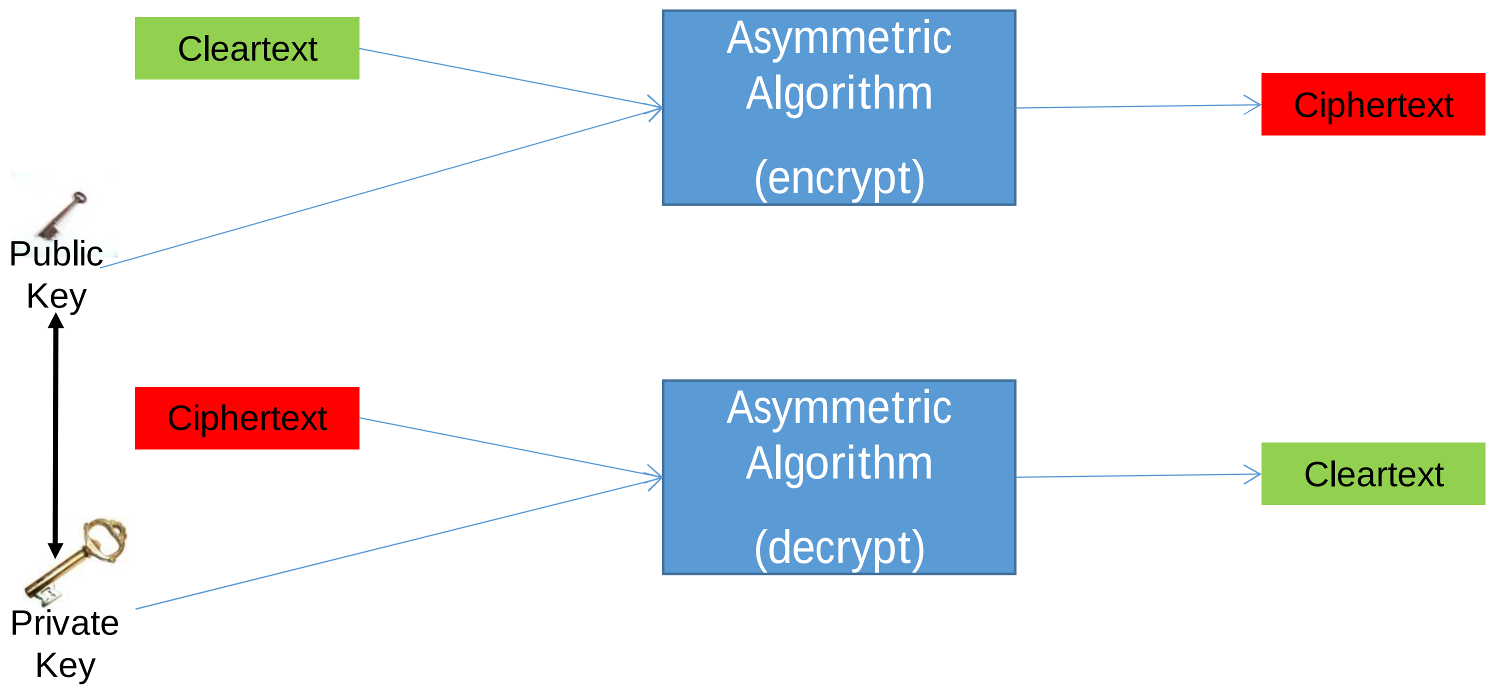


- Rijndael Algorithm
  - Block Cipher (16-byte blocks)
  - 128-, 192-, 256-bit key length
    - 128 bit key=> 3.4x10**38 (340 Undecillion)
    - 192 bit key=> 6.2x10**57 (6.2 Octodecillion)
    - 256 bit key=> 1.1x10**77 (almost a Googol)
  - Multiple round
  - Four steps per round (Byte substitution, shift row, mix column, add round key)

Image from http://www.esat.kuleuven.ac.be/~rijmen/rijndael

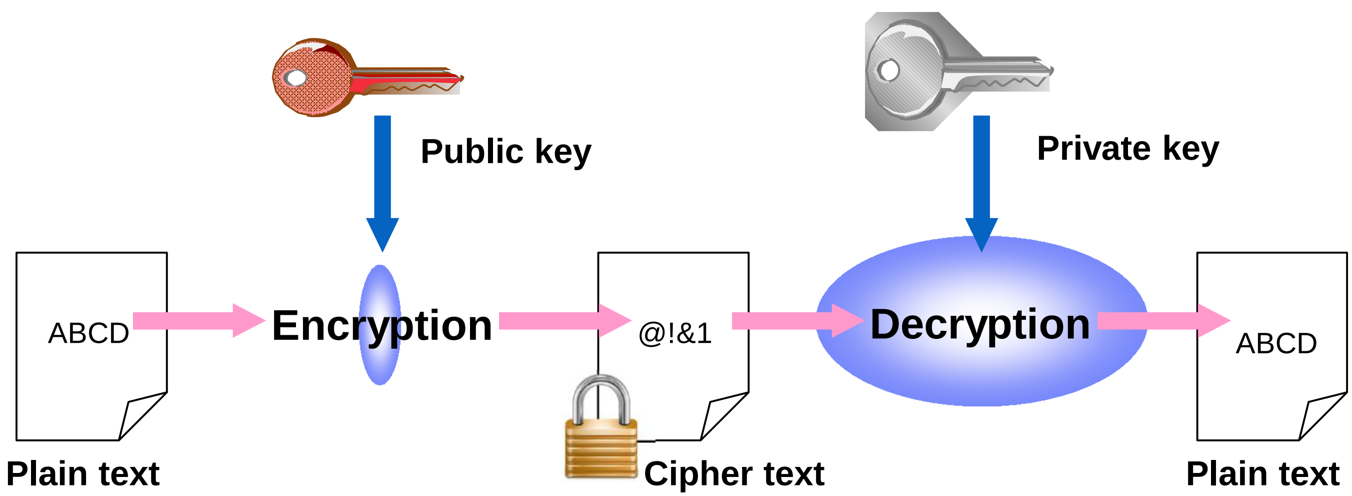
Secrecy Algorithms - Asymmetric

- Asymmetric – two different, but mathematically related keys (public and private)



Asymmetric Algorithms

- Public Key Architecture - PKA
  - RSA - factorization
  - Diffie-Hellman - logarithmic
  - Elliptic Curve – point multiplication



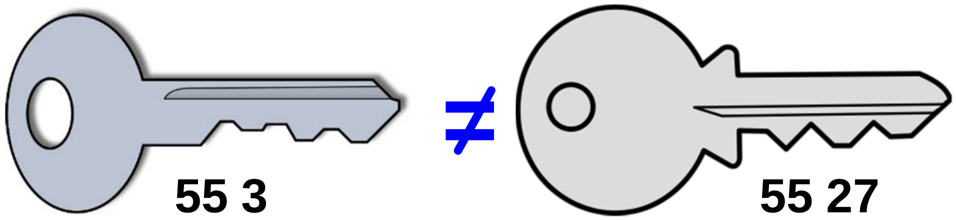
Generating RSA Keys

- RSA Keys consists of two parts, a modulus (N) and an exponent (E for the public key; D for the private key)
  - Public Key => N E
  - Private Key => N D
- The modulus is calculated by multiplying two prime numbers (P & Q) together
  - P = 5 Q = 11 (prime numbers and should be very large)
  - N = P x Q => 5 x 11 = 55
- Next, select an odd number, E, that will be the exponent for the public key
  - Good values include 3 or 65537 (64K+1) or 5, 17 or 257 with HCR77C0

  Public Key=> N E => **55 3**
- Finally, calculate the exponent for the private key, D, where

  1 = (D * E) MOD ((P-1)(Q-1)) **=> 1 = (D * 3) MOD ((5-1)(11-1))**
  - In our example, solve for 1 = (D * 3) MOD 40 => D = 27!

  Private Key => N D => **55 27**



Encipher the Message ‘MFC’

Public Key (N E) => 55 3

Private Key (N D) => 55 27

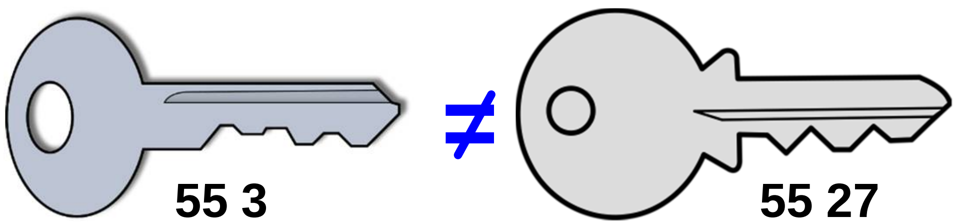
Convert characters to numeric (a=1, b=2, c=3, etc.)

‘M’ = 13; ‘F’ = 6; ‘C’ = 3;

ciphertext = (cleartextE) Mod N**

- For ‘M’ (13**3) MOD 55 => 2197 MOD 55 = 52
- For ‘F’ (6**3) MOD 55 => 216 MOD 55 = 51
- For ‘C’ (3**3) MOD 55 => 9 MOD 55 = 27

Ciphertext is 52 51 27



Decipher the message 52 51 27

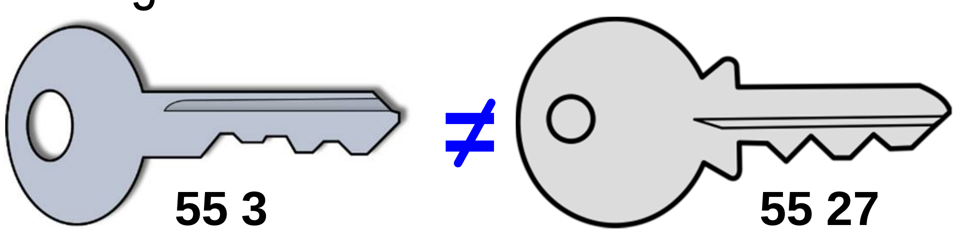
Public Key (N E) => 55 3

Private Key (N D) => 55 27

Cleartext = (ciphertextD) MOD N**

- For 52 52**27 MOD 55 = 13
  (52**27 = 2.1482769967144679013436706816572e+46)
- For 51 51**27 MOD 55 = 6
  (51**27 = 1.2717295264013893903823981998699e+46)
- For 27 27**27 mod 55 = 3
  (27**27 = 4.4342648824303776994824963061915e+38)

- My decrypted message is 13 6 3 => “M” “F” “C”



ECC Algorithm

Effective Key Size (bits)		
Symmetric	RSA	ECC
80	1024	163
112	2048	224
128	3072	256
192	7680	384
256	15360	512
From NIST SP 800-57 Part 1 (Table 2) at www.nist.gov		

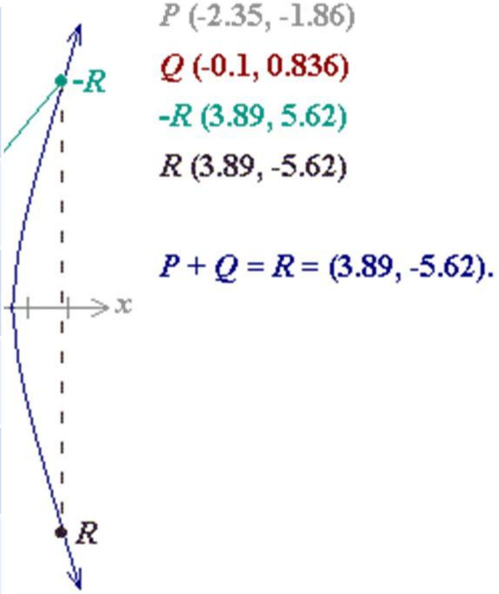
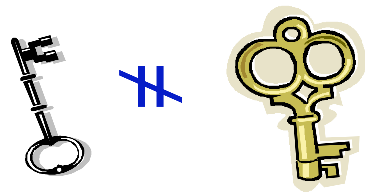


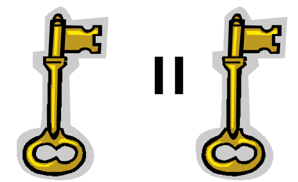
Image from crypto.stackexchange.com

Why Asymmetric and Symmetric Keys?

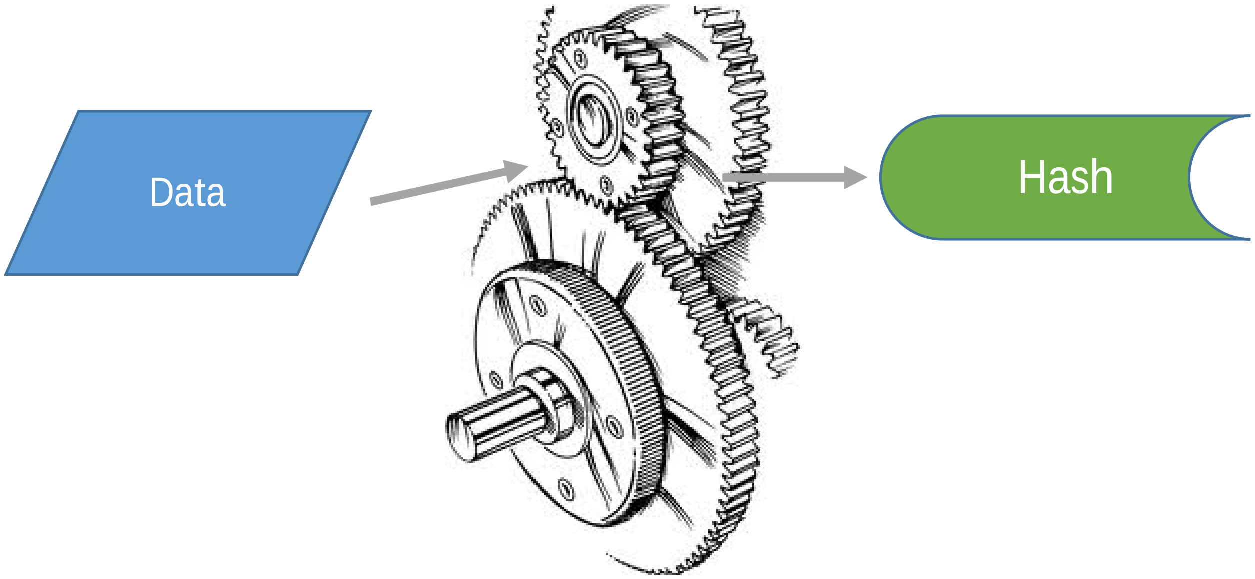
- Asymmetric
  - plus - its strength, can be used to establish a secret between two parties
  - minus – expensive in terms of performance



- Symmetric
  - plus - less resource intensive
  - minus - requires key to be shared securely



Hashing



Hash Algorithm

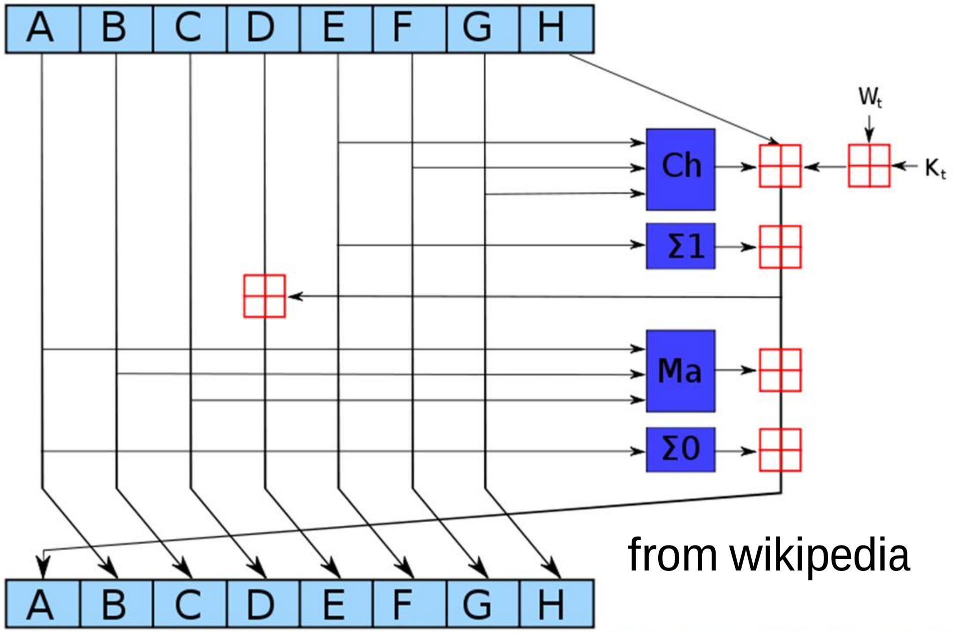
- Characteristics of a good hash algorithm
  - One-way – can't recover the data from the hash
  - Hard to find collisions
  - The result does not reveal information about the input

Hashing

- One iteration in a SHA-2 family compression function. The blue components perform the following operations:

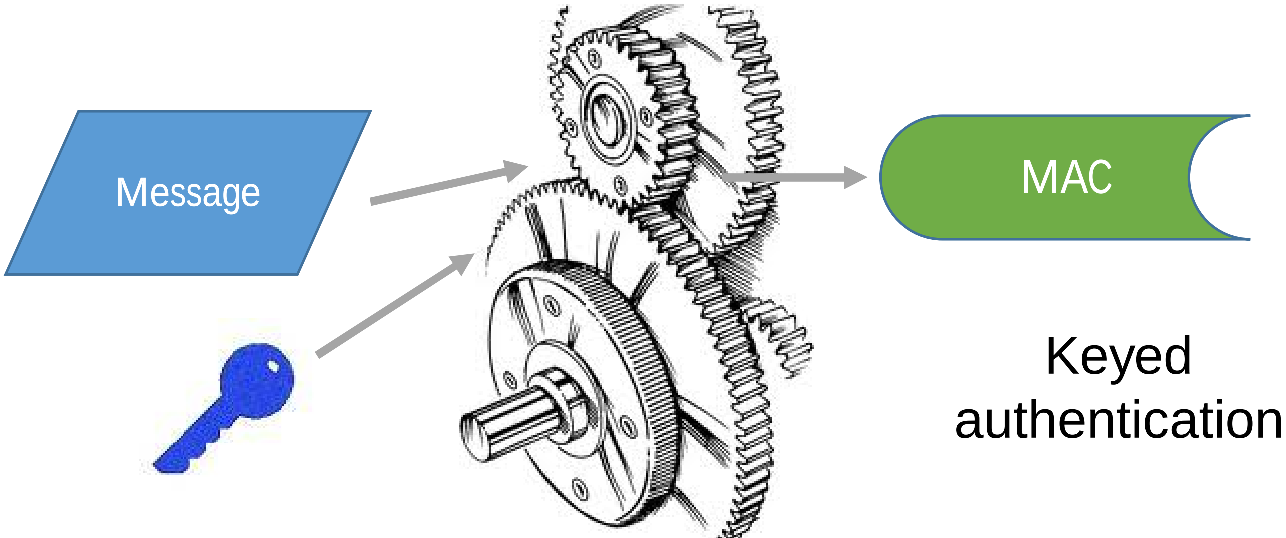
$$\mathrm{Ch}(E,F,G) = (E \land F) \oplus (\neg E \land G)$$
$$\mathrm{Ma}(A,B,C) = (A \land B) \oplus (A \land C) \oplus (B \land C)$$
$$\Sigma_0(A) = (A \ggg 2) \oplus (A \ggg 13) \oplus (A \ggg 22)$$
$$\Sigma_1(E) = (E \ggg 6) \oplus (E \ggg 11) \oplus (E \ggg 25)$$

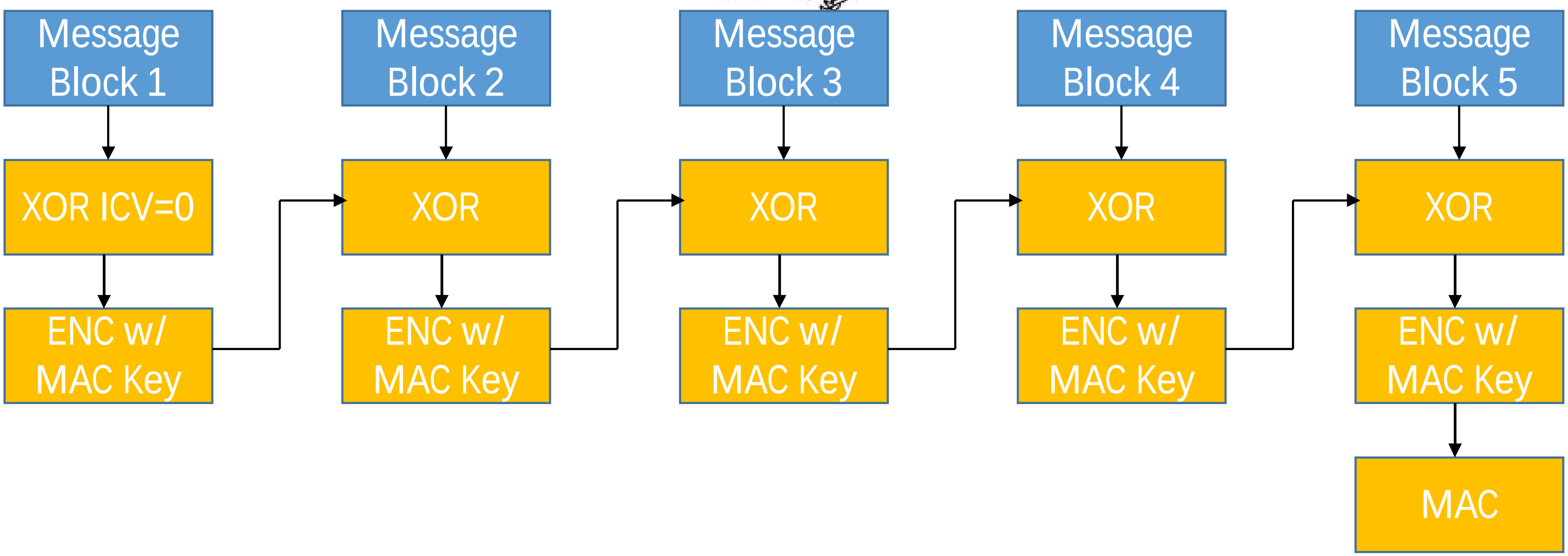
- The bitwise rotation uses different constants for SHA-512. The given numbers are for SHA-256. The red ⊞ is modulo 2^{32} addition.



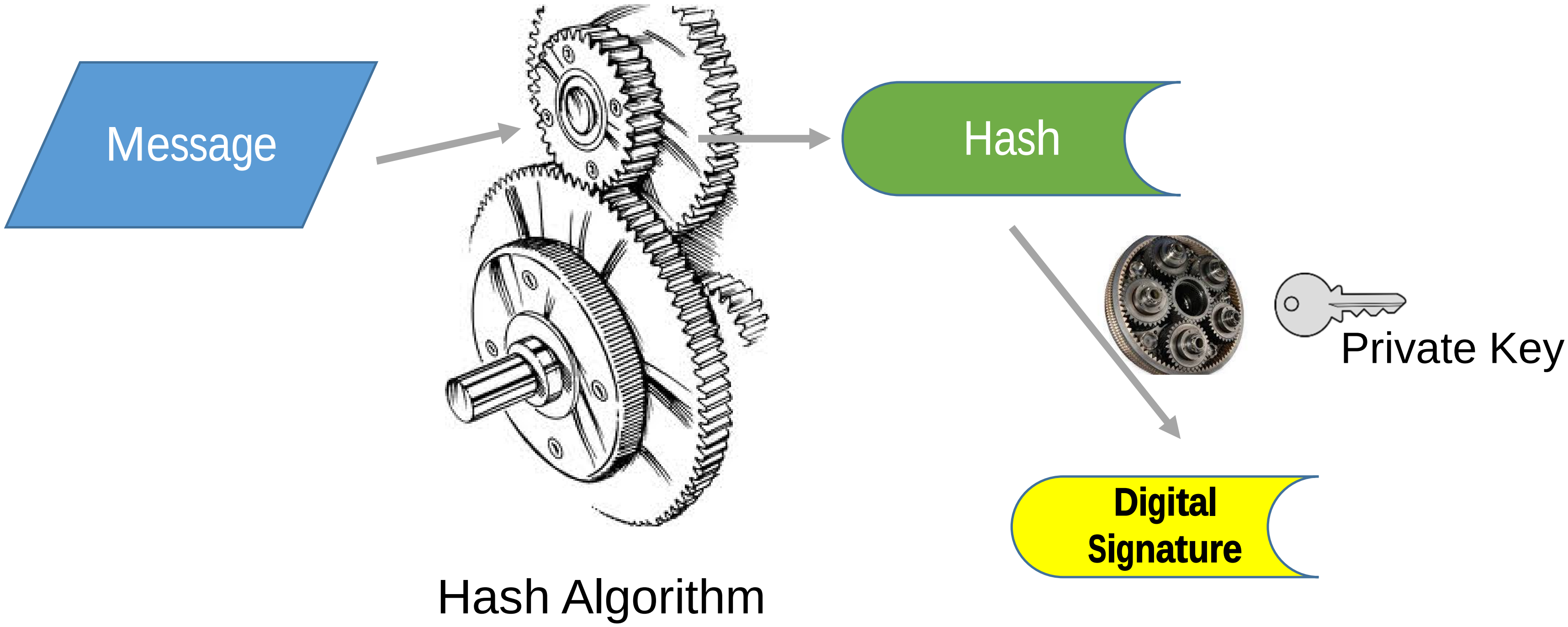
from wikipedia

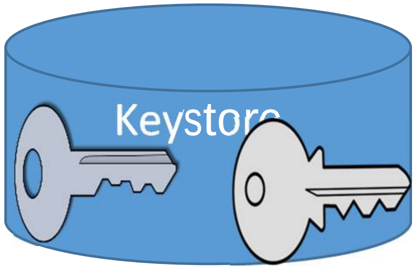
Hashing – Message Authentication Code



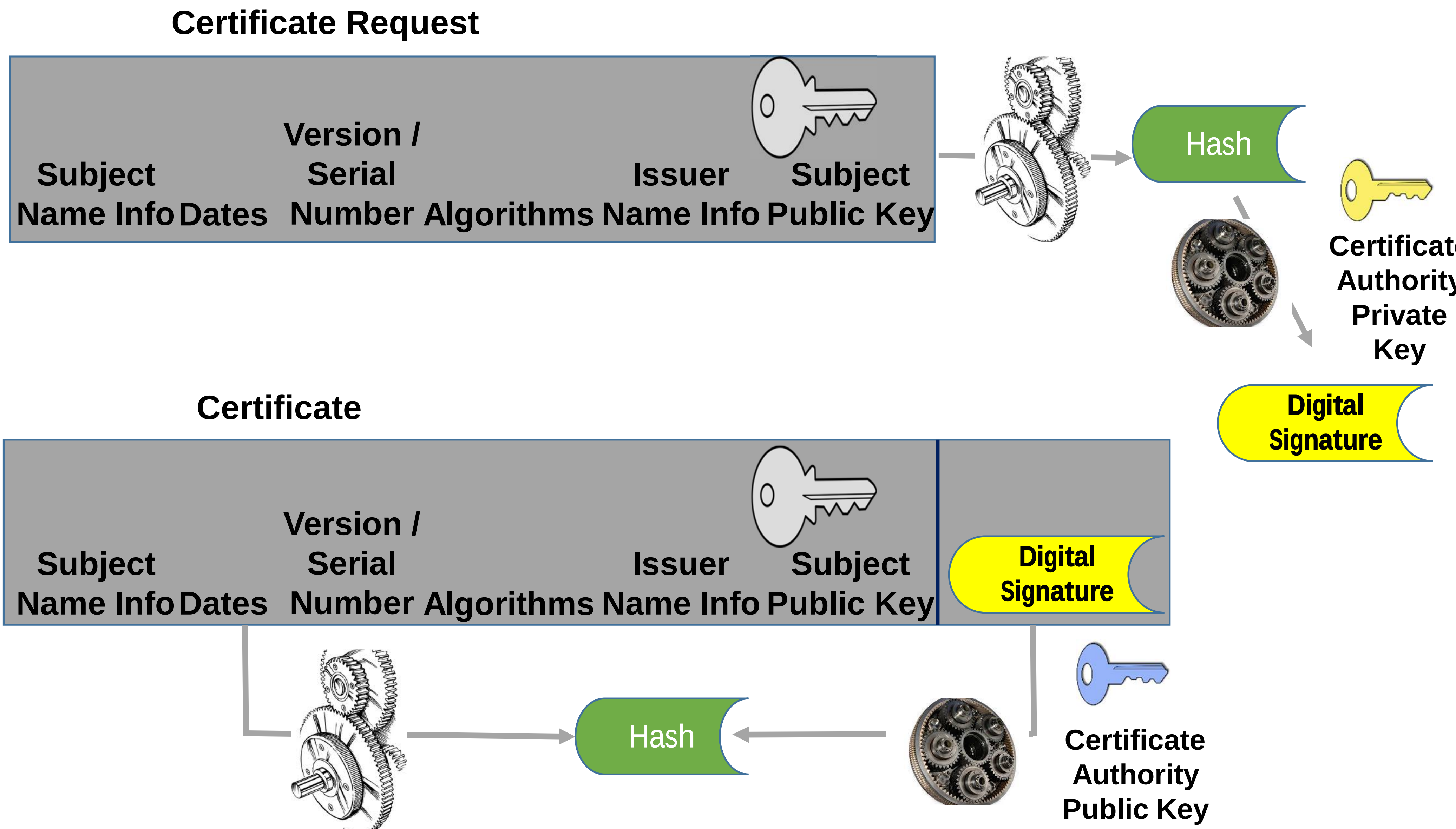


Digital Signatures





Certificates



Financial Authentication - PINs

Routing Number:
12345678

Account Number: **9876543210**

Sequence Number: **1**

PIN Block:

4567898765432101

8A092F6E7D637B25

0925

Offset:
1234

2159

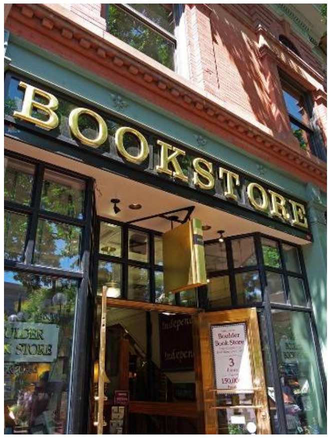
Decimalization Table			
0 -> 0	1 -> 1	2 -> 2	3 -> 3
4 -> 4	5 -> 5	6 -> 6	7 -> 7
8 -> 8	9 -> 9	A -> 0	B -> 1
C -> 2	D -> 3	E -> 4	F -> 5

Pin Block Formats

ECI-2, ECI-3, ISO-0, ISO-1, ISO-2, ISO-3,

VISA-2, VISA-3, VISA-4, 3621, 3624, 4704-EPP

References



- Cryptography Books
  - Bruce Schneier, "Applied Cryptography, Second Edition: Protocols, Algorithms, and Source Code in 'C'", Addison Weley Longman, Inc. 1997
  - Simon Singh, "The Code Book", Anchor Books, 1999
  - Niels Ferguson, Bruce Schneier, "Practical Cryptography", Wiley Publishing, Inc. 2003
- Free Stuff
  - www.schneier.com – Bruce Schneier website, with monthly newsletter Cryptogram

Standards Doc

- RSA
  - PKCS #1 RSA Cryptography Specifications Version 2.2 (https://tools.ietf.org/html/rfc8017)
- ECC
  - https://en.wikipedia.org/wiki/Elliptic-curve_cryptography
  - Also see 'Recommendation for Pair-Wise Key-Establishment Schemes Using Discrete Logarithm Cryptography https://csrc.nist.gov/publications/detail/sp/800-56a/rev-3/final
- AES
  - FIPS 197 Announcing the AES (https://doi.org/10.6028/NIST.FIPS.197)
- DES
  - FIPS 46-3 Data Encryption Standard - Withdrawn (http://csrc.nist.gov/publications/fips/fips46-3/fips46-3.pdf)
- TDES
  - SP 800-67 Recommendation for the Triple Data Encryption Algorithm (TDEA) Block Cipher (https://csrc.nist.gov/publications/detail/sp/800-67/rev-2/final)

Questions ...