Introduction to Cryptography

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About the Speaker

- Network & System Administrator with 20 years of experience.
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Summary

- Vocabulary
- History
- Steganography
- Legal Aspects
- General Principles
- Hashing

- Symmetric Encryption
- Asymmetric Encryption
- Digital Signature
- TLS
- PGP, GPG and email encryption

Vocabulary and Definitions

- **encrypt**: converting plain text to an unreadable format.
- **decrypt**: converting a encoded text to plain text.
- **cryptology**: science of studying cryptology.
- **cryptanalysis**: researching weaknesses in cryptographic systems.

Few Historical Milestones

- Cryptography has been used since the Antiquity (Caesar’s cypher, …).
- It has been a decisive element during World War II.
- It has been revolutionzied during the 20th century with new algorithms and computing.

The Enigma Machine

Enigma Machine

Imperial War Museum

Londres

(source Wikimedia Commons)

Cryptography in Recent Years

- 2009 - Bitcoin and cryptocurrencies
- 2011 - Diginotar Incident
- 2012 - HeartBleed, Freak, Poodle, Beast
- 2013 - Wannacry and other ransomwares
- 2013 - Edward Snowden’s Revelations
- 2015 - San Bernardino Attack
- 2016 - Let’s Encrypt
- 2018 - TLS 1.3

Steganography

- Steganography is a way to hide a message under another one, less important.
- In itself, it doesn’t protect the content. Once it is revealed, the content is in plaintext.


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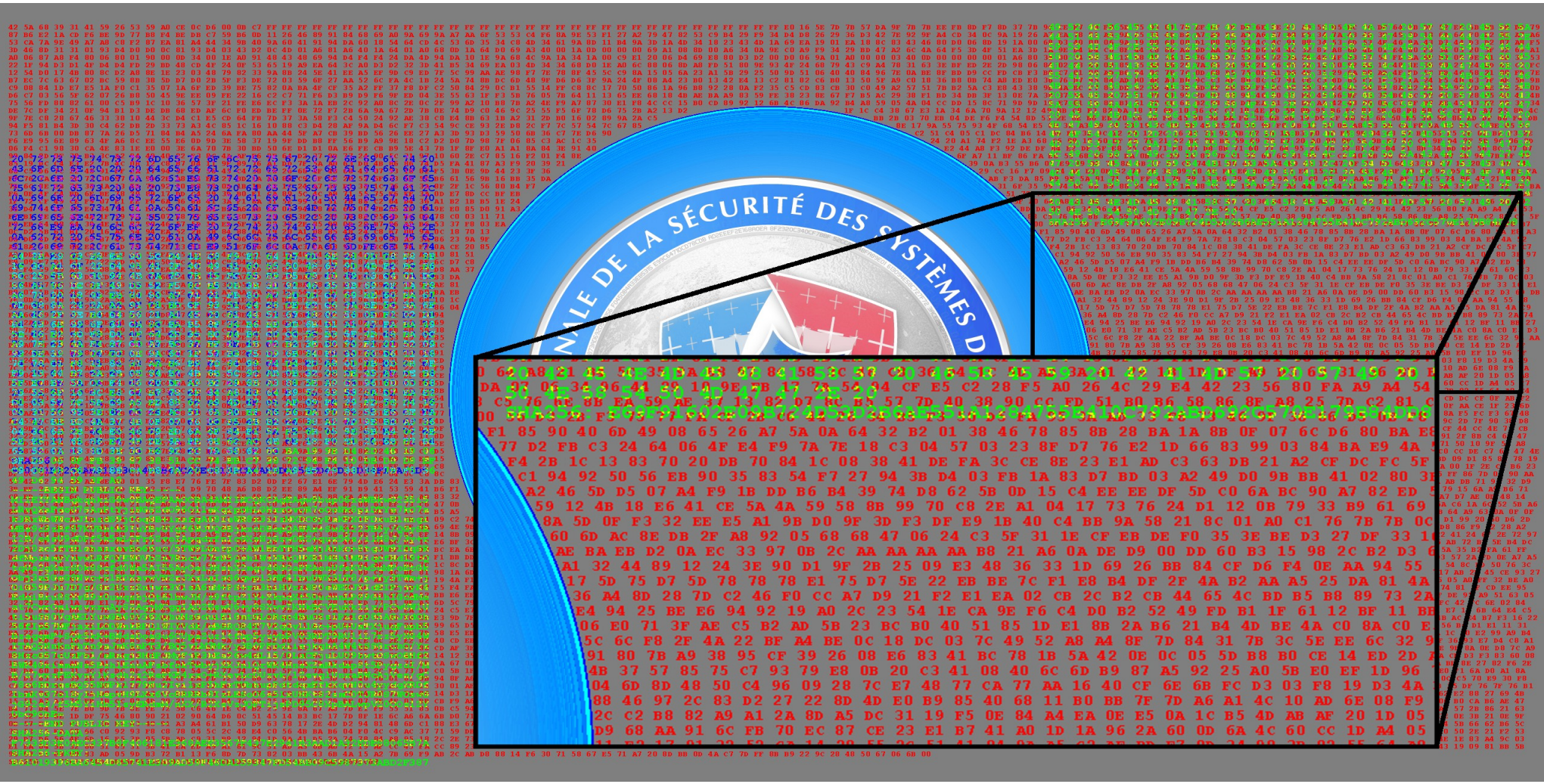
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Legal Aspects

- Using cryptographic tools is limited or illegal in certain countries.
- At the international level, import and export of cryptography is regulated by the Wassenaar Arrangement.

General Principles

- Any system is as secured as its weakest link.
- Encryption benefits only from regular usage.
- Only keys should be kept secret,
  not algorithms (*Kerckhoffs' Principle*).
- **Do not build your own cryptosystem**,
  use only proven, reliable tools and libraries.

Cryptography Benefits

Depending now how your are using cryptography, you can obtain the following benefits:

- **Encryption** will provide you:
  - confidentiality,
  - integrity,
  - authentification.
- A **digital signature** will provide you integrity and authentification.

Cryptography Limits

- Mathematical and technical improvements will require to keep your solution current.
- Systems and applications must be maintained up-to-date; security best practices must be enforced.
- Keys can be copied or stolen.
- The *National Security Agency*.

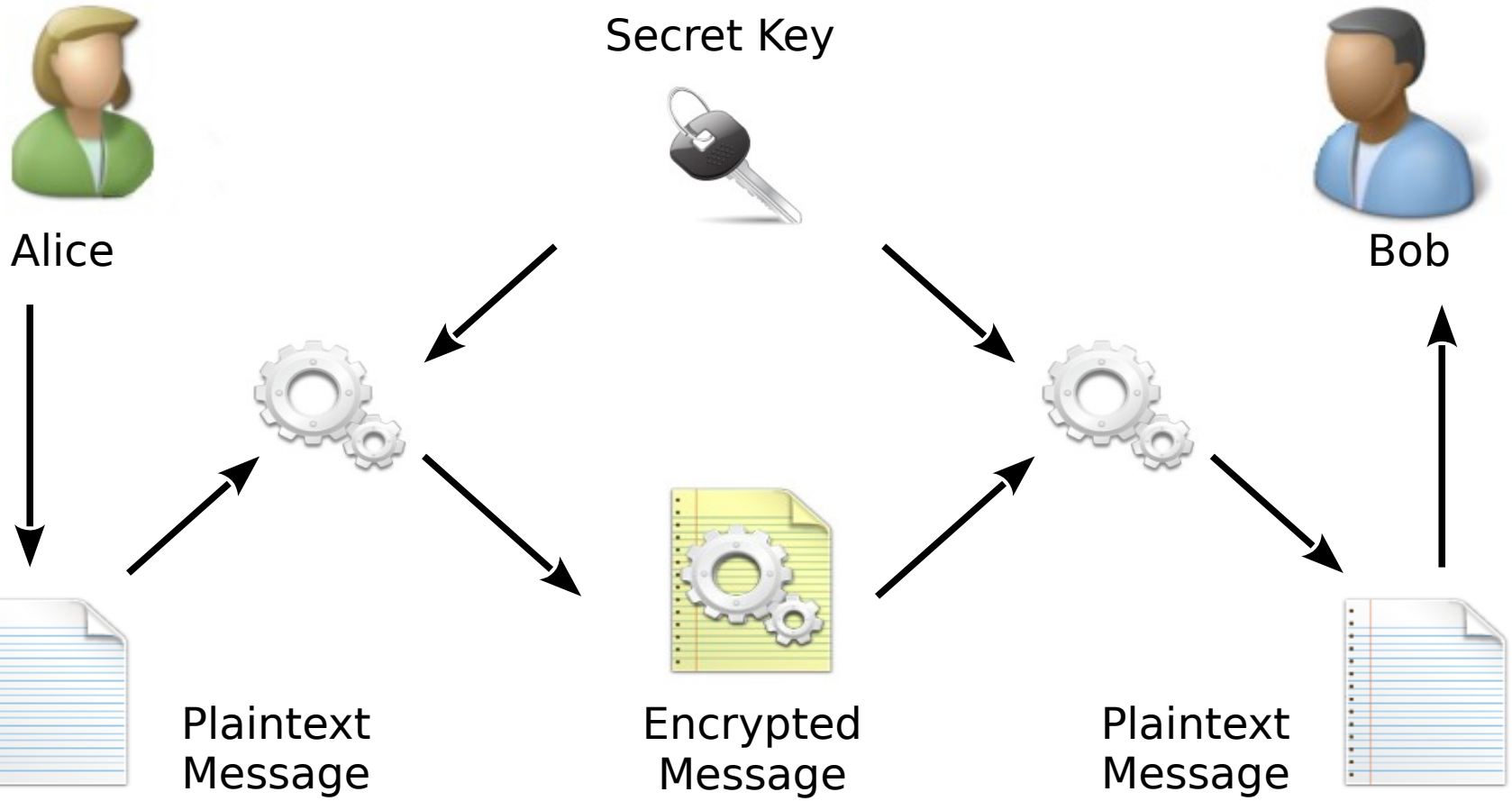
Hashing

- A cryptographic hash is a one way function that convert a message into a fixed size string.
- Hashes are used to check messages integrity.
- *MD5, SHA-1, SHA-2 (SHA-256), SHA-3*

Symmetric Encryption

- Also called "secret-key encryption".
- An encryption key is defined between the two parties.
- The same key is used to encrypt and to decrypt messages.

Using Symmetric Encryption



Symmetric Encryption Algorithms

- **DES**: *Data Encryption Standard*
- **AES**: *Advanced Encryption Standard* (*Rijndael*)
- **Salsa20/Chacha**
- **Vernam Cipher** *(One Time Pad)*

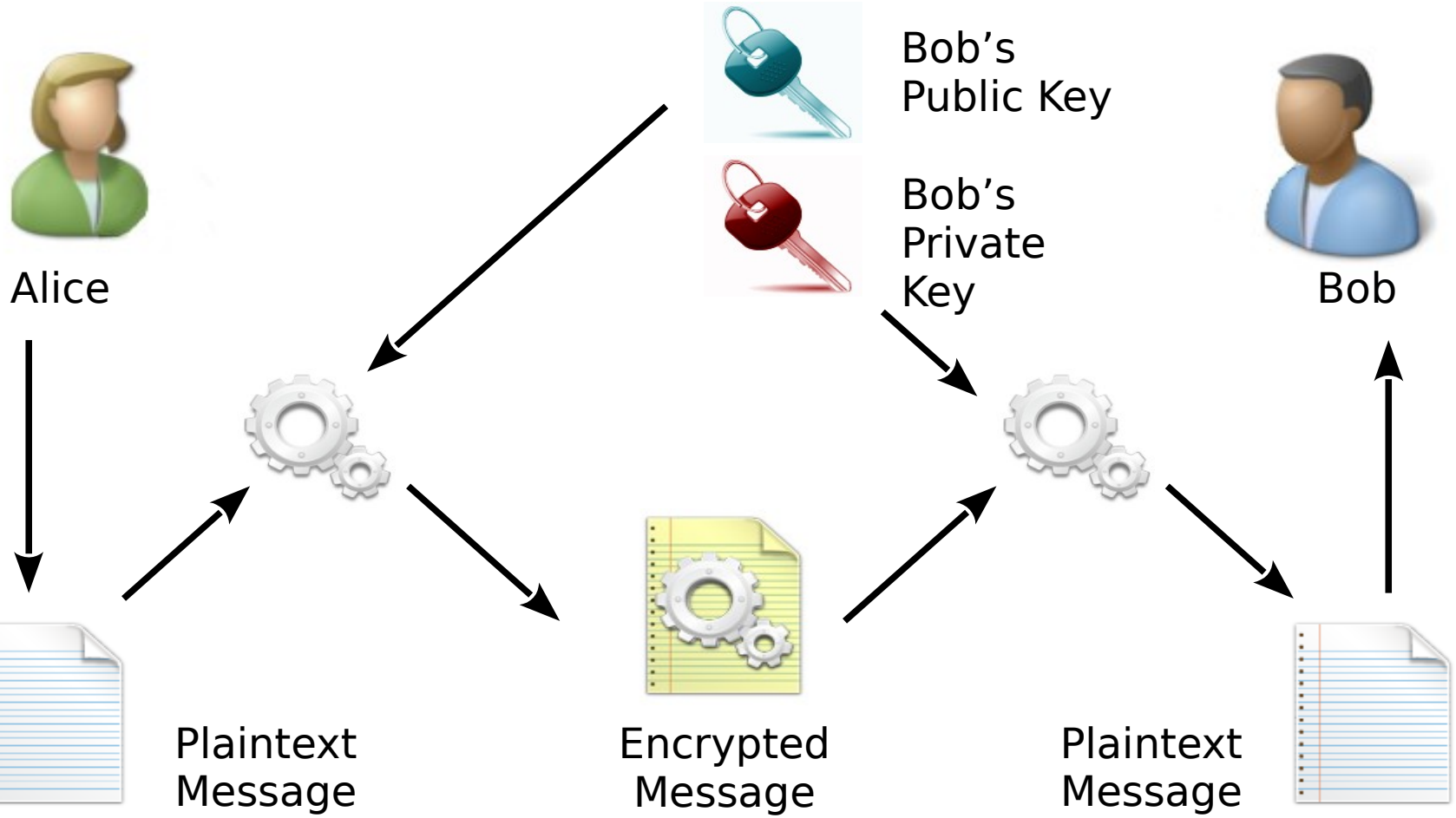
Symmetric Encryption Limits

- You must be able to share the key privately.
- When the number of participants increase, key management becomes an issue.
- For 10 people you will need:
  10x(10-1)/2 = 45 keys

Asymmetric Encryption

- Also called "public-key encryption"
- Each participant generate a private key, and a public key. That public key can be communicated to anyone.
- To send an encrypted message, you must use the public key of the recipient.

Using Asymmetric Encryption



Asymmetric Encryption Algorithms

- **RSA**: *Rivest, Shamir, Adleman*
- **Elliptic Curves**
- **ElGamal**

Asymmetric Encryption Limits

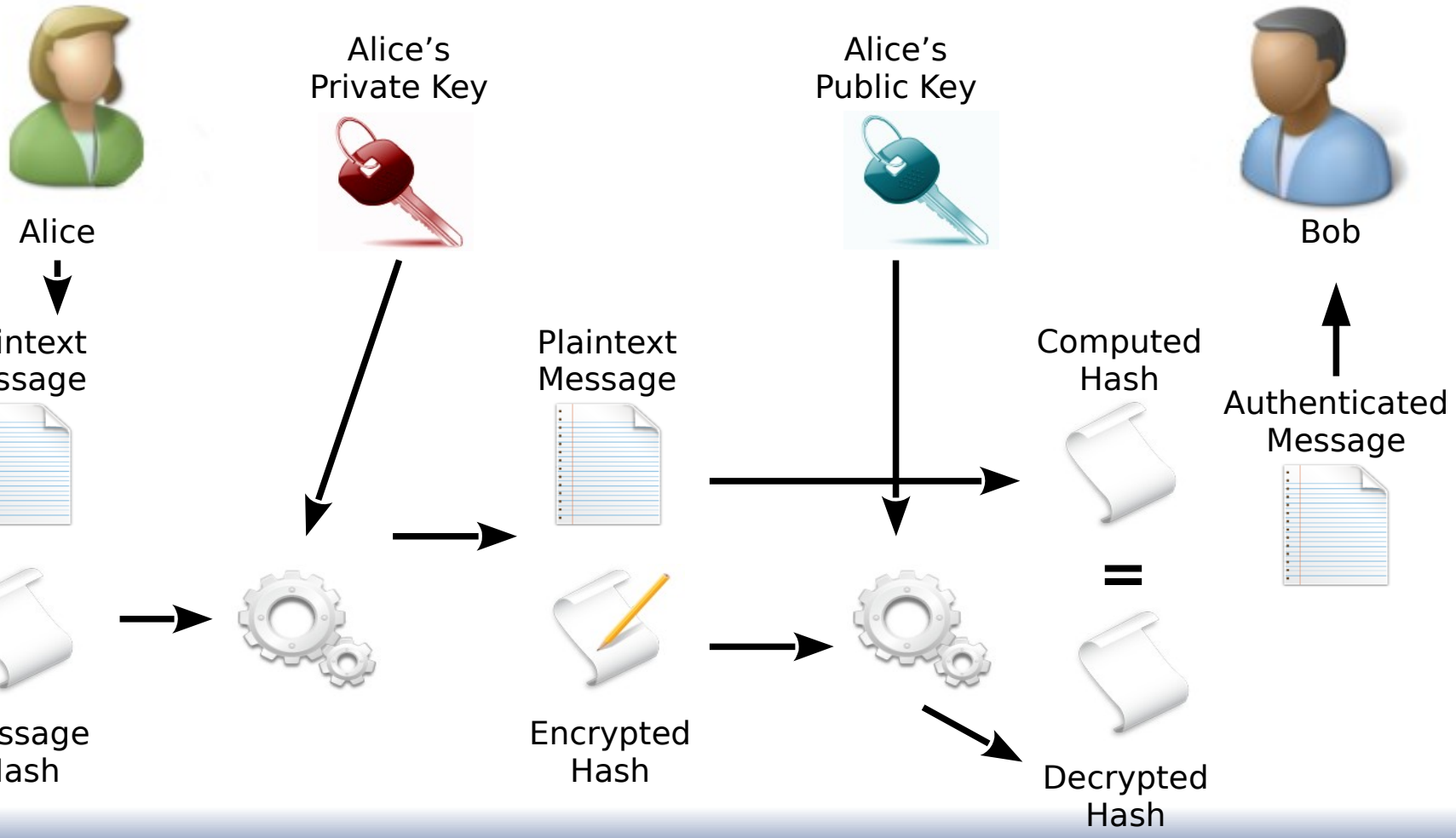
- Asymmetric encryption computation is much slower than symmetric encryption.
- You need to have a reliable and trustable way to distribute keys.

Digital Signature

- A digital signature can prove who wrote the message and that it has not been modified.

  The message itself is still readable by anyone.
- A digital signature will hash the message and then will rely on the same type of keys than for asymmetric encryption.

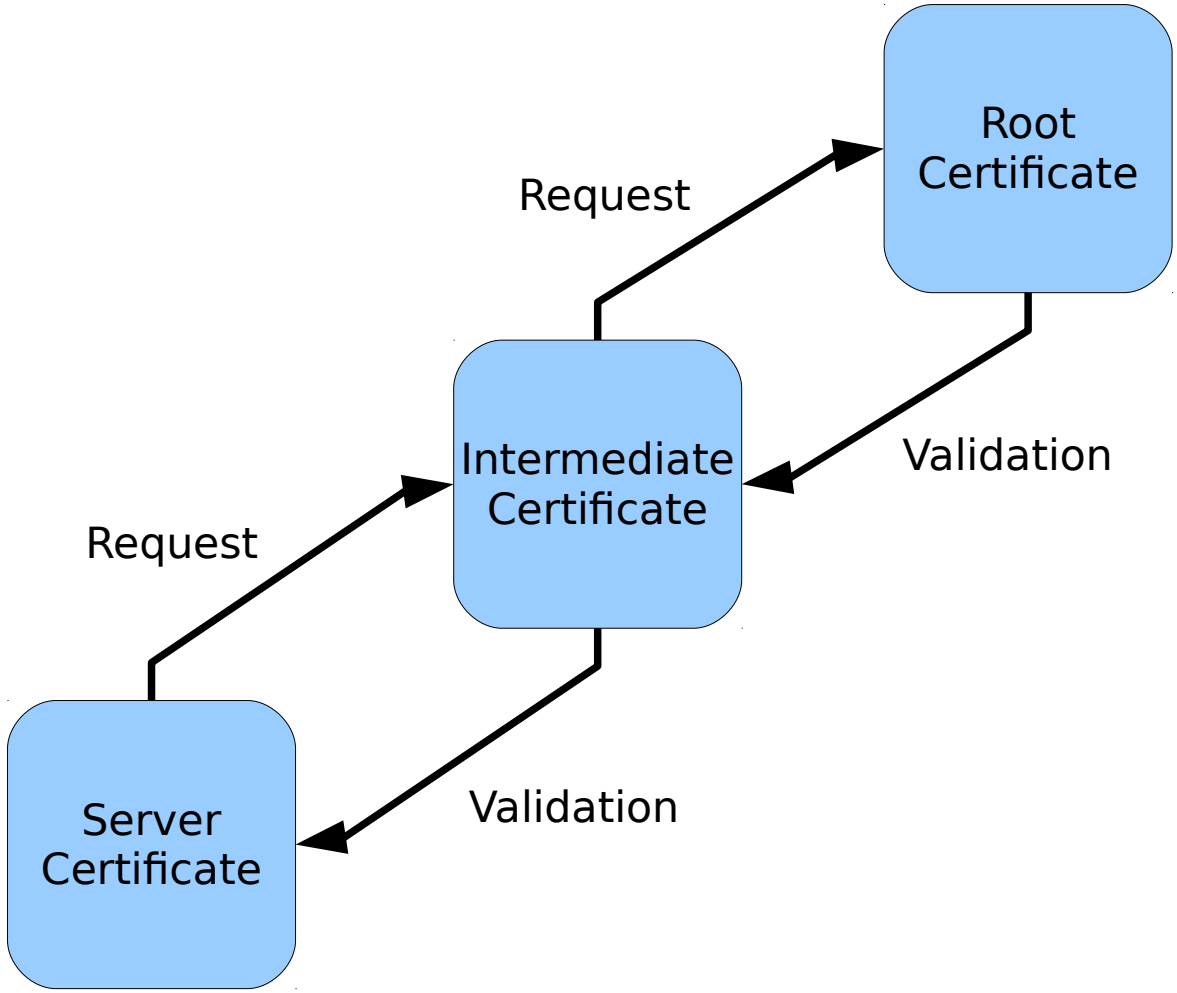
Using Digital Signature



TLS Certificates

X.509 Certificate

- Issuer
- Serial Number
- Validity (After)
- Validity (Before)
- Subject
- Subject Public Key
- Issuer's Signature



TLS Session Example

Client

Known Authorities

Client Hello (cipher suites)

Server Hello (certificate)

Key Exchange (pre-master secret)

Client Finish

Key Exchange (pre-master secret)

Server Finish

Server

X.509 Certificate

Pretty Good Privacy (PGP)

- Written by Philip Zimmermann in 1991.
- It was the first popular cryptographic software.
- PGP usage and popularity created more interest for cryptography.
- First versions were available for free; PGP is now a commercial software.

GNU Privacy Guard (GPG)

- GPG is the free software equivalent of PGP.
- It is using free, not patented algorithms.
- GPG is available on many systems and comply with the OpenPGP standard (*RFC 4880*).

Using GPG

- GPG is a command line application, with a high number of options.
- Various graphical interfaces are available for day to day use:
  - *KGPG* for KDE,
  - *Seahorse* for Gnome,
  - *WinGPG* and *Gpg4Win* for MS Windows,
  - *MacGPG2* for Apple Mac OS X.

Protecting E-mail

- Your e-mail client must be able to use GPG to verify, encrypt or decrypt messages
- Some e-mail clients have native OpenGPG support, other would require an extension.
- Email encryption will usually protect the message itself, but not the meta-data (headers).

Key Distribution

- Attending *key signing parties*
- Using key servers
- Using PKI (Public Key Infrastructure)

Questions
&
Discussion

Graphical Assets

- Aero Icons / gnome-look.org

  `http://www.gnome-look.org/content/show.php/Aero?content=35437`

- Nobile Font

  `https://fonts.google.com/specimen/Nobile`