Public Key Infrastructure (PKI)

Introduction

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Hack42, Arnhem

Who am I?

- Worked in Information Security for 12 years
- *Member* of Hack42 (https://www.hack42.nl/)

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2. Asymmetric Cryptography
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Background

What is PKI?

PKI is a (supporting) technical solution used to secure digital communication

Real-life Examples

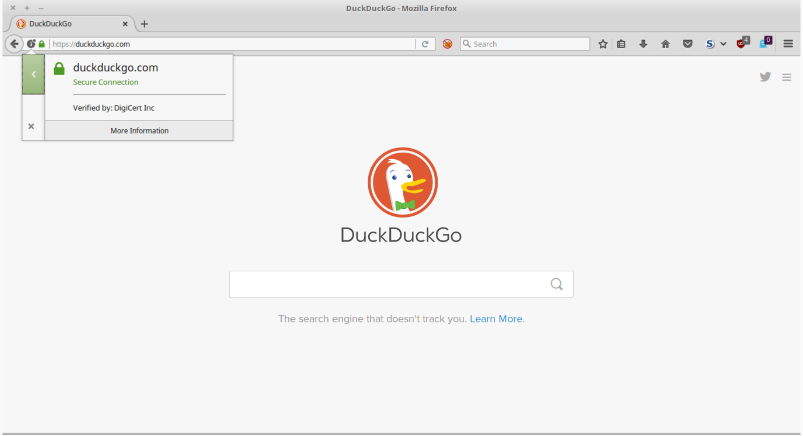
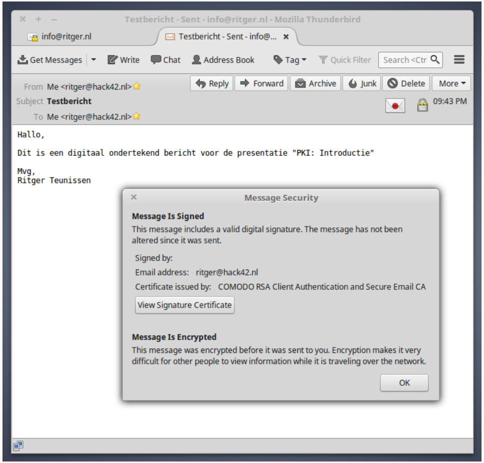

DuckDuckGo - Mozilla Firefox
DuckDuckGo
https://duckduckgo.com
Search
duckduckgo.com
Secure Connection
Verified by: DigiCert Inc
More Information
DuckDuckGo
The search engine that doesn't track you. Learn More.

Figure 1: Duck Duck Go

Real-life Examples



From Me <ritger@hack42.nl>
Subject **Testbericht**
To Me <ritger@hack42.nl>

```
Hallo,

Dit is een digitaal ondertekend bericht voor de presentatie "PKI: Introductie"

Mvg,
Ritger Teunissen
```

Message Is Signed

This message includes a valid digital signature. The message has not been altered since it was sent.

Signed by:
Email address: ritger@hack42.nl
Certificate issued by: COMODO RSA Client Authentication and Secure Email CA

Message Is Encrypted

This message was encrypted before it was sent to you. Encryption makes it very difficult for other people to view information while it is traveling over the network.

Figure 2: E-mail

Communication

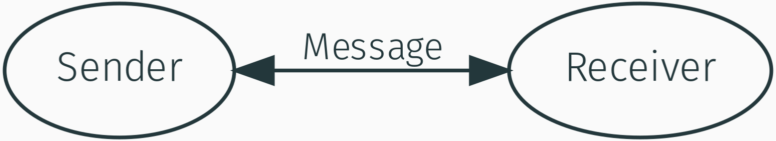


Figure 3: Communication

Securing Digital Communication

When can digital communication be considered secure?

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Authenticity
Do we know who the sender is?

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Do we know who the sender is?

Non-repudiation
Did the message really come from the sender and hasn't the message been changed?

Confidentiality
Can the message only be read by the sender and receiver?

Asymmetric Cryptography

Cryptography

When you use cryptography to solve a problem, you have TWO *problems*

Asymmetric Cryptography

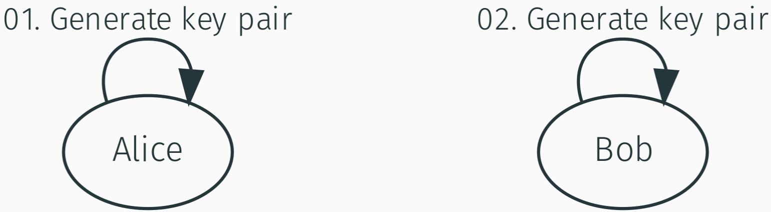


Figure 4: Key Generation

Asymmetric Cryptography

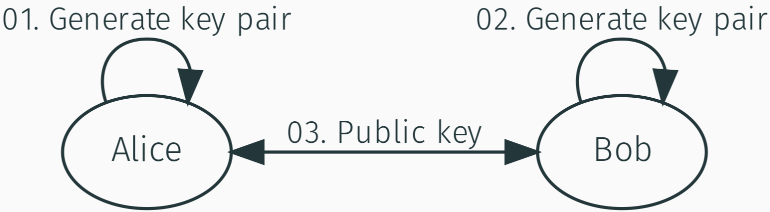


Figure 4: Key Generation

Key Pair
A key pair has both a public and private key

Non-repudiation

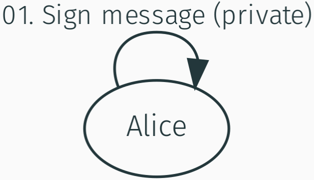
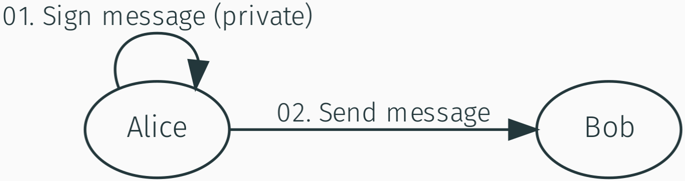


Figure 5: Digital Signature

Non-repudiation



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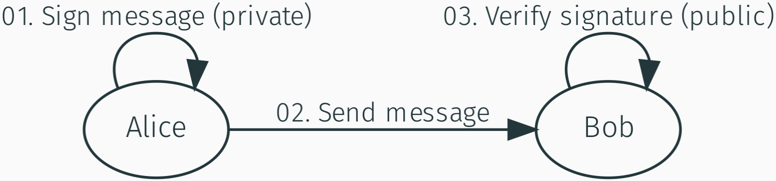

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Non-repudiation

Example
Digitally signing a document or e-mail message

Confidentiality

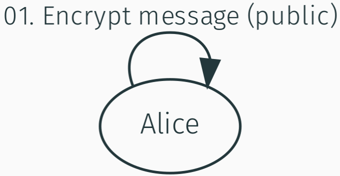
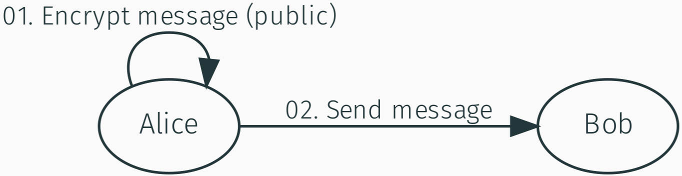


Figure 6: Encryption

Confidentiality



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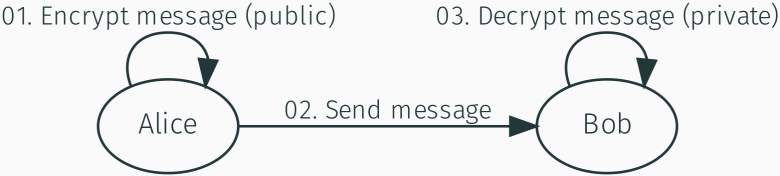

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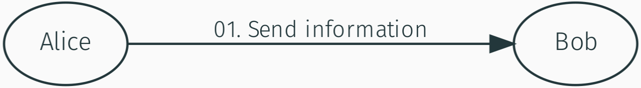
Encrypting a document or e-mail message

Authenticity

How to prove authenticity?
Prove possession of the private key for a public key



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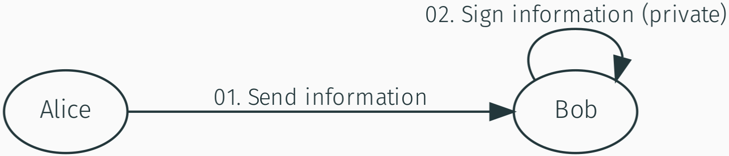

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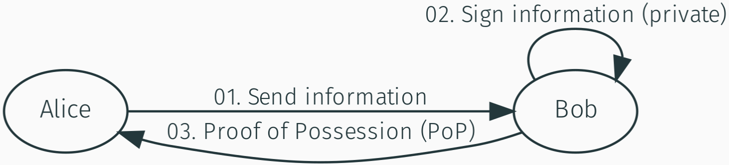

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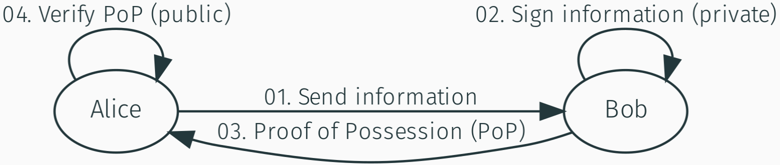

Figure 7: Authenticity

Authenticity

Why is authenticity separate from non-repudiation?

Authenticity

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Answer
Prevent unintended signature creation

Summary

What do you need to know?

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Digital Signature
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Encryption
Encryption using the public key, decryption using the private key

Public Key Infrastructure

Key Distribution

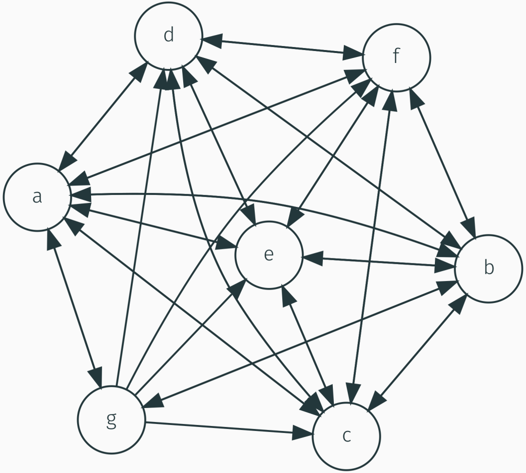

Figure 8: Key Distribution

Delegated Trust

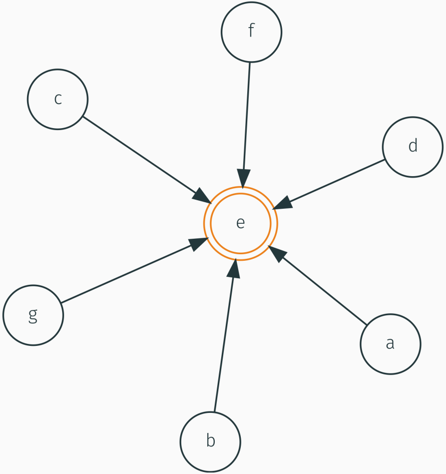

Figure 9: Delegated Trust

Certificate Authority (1)

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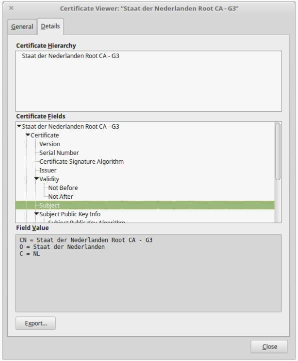
What is a Certificate Authority?

- Certifies the link between an identity and a public key
- Certifies a key for specific use cases
- Can revoke trust in a public key

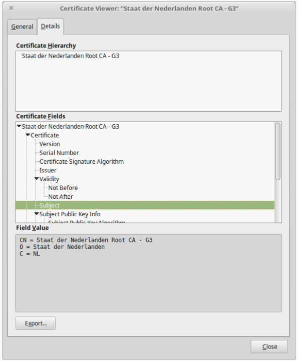
X.509 Certificates


Certificate Viewer: "Staat der Nederlanden Root CA - G3"
General
Details
Certificate Hierarchy
Staat der Nederlanden Root CA - G3
Certificate Fields
Staat der Nederlanden Root CA - G3
Certificate
Version
Serial Number
Certificate Signature Algorithm
Issuer
Validity
Not Before
Not After
Subject
Subject Public Key Info
Subject Public Key Algorithm
Field Value
Export...
Close

```
CN = Staat der Nederlanden Root CA - G3
O = Staat der Nederlanden
C = NL
```

Figure 10: X.509 Certificate

X.509 Certificates



Certificate Hierarchy

Staat der Nederlanden Root CA - G3

Certificate Fields

```
▼Staat der Nederlanden Root CA - G3
  ▼Certificate
     Version
     Serial Number
     Certificate Signature Algorithm
     Issuer
    ▼Validity
       Not Before
       Not After
     Subject
    ▼Subject Public Key Info
       Subject Public Key Algorithm
```

Field Value

```
CN = Staat der Nederlanden Root CA - G3
O = Staat der Nederlanden
C = NL
```

Figure 10: X.509 Certificate

- Certificate = identity + public key
- Limits key usage
- Limited validity (best-before date)
- Certificate Revocation List
- Digitally signed by issuer (CA)

Certificate Authority (2)

- Generates its own key pair (public and private key)

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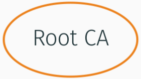
- Issues X.509 certificates for end entities
- Makes X.509 certificate non-reputable through a digital signature

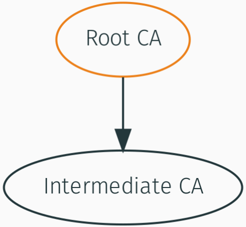
Setup



Root CA

Figure 11: PKI Architecture

Setup



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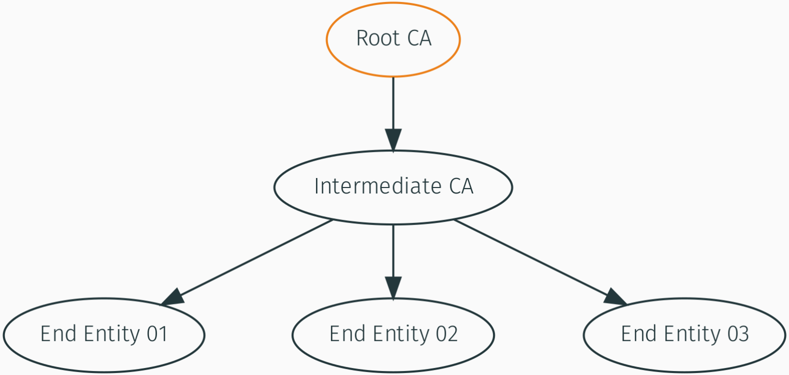

Figure 11: PKI Architecture

CA Trust

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End-entity & Intermediate CA
Trusted when the digital signature created by the CA is valid and the certificate has not been revoked

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Root CA
Trusted through the use of an Access Control List

Largest Use Case

Prove authenticity of devices

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Web Server
Is issued an end entity certificate by a CA, which allows clients to trust the web server by its address (FQDN)

Public & Private Trust

- Private CAs issue X.509 certificates for a closed (usually corporate) environment

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- Private CAs issue X.509 certificates for a closed (usually corporate) environment
- Publicly trusted CAs issue X.509 certificates which are automatically trusted

CA/B Forum

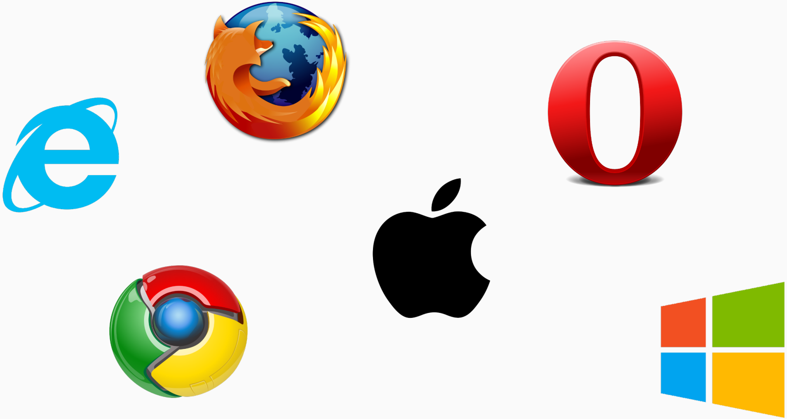

Figure 12: CA/B Forum

Problem?

What could possibly go wrong?

DigiNotar

DigiNotar
A VASCO COMPANY
DigiNotar
nternet Trust Services

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Certificate Authority
In PKI, the Certificate Authority manages trust. Everything start (or stops) with the CA

Conclusion

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- Trust is delegated to a Certificate Authority (CA)
- Certificate Authorities certify the combination of identity + key (including the CA public key itself)
- Global trust is managed by a small group of (very powerful) companies (CA/B Forum)

Questions?

Certificate Life Cycle

Certificate Life Cycle

01. Registration

Figure 13: Certificate Life Cycle

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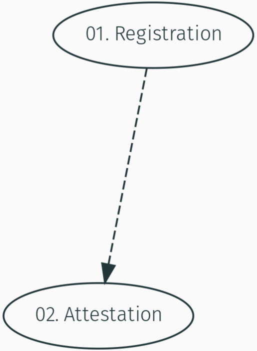

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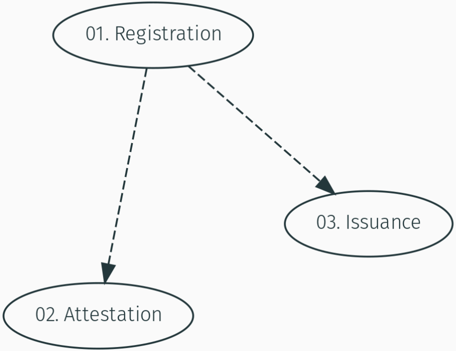

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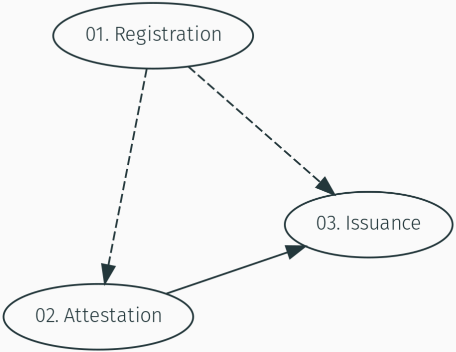

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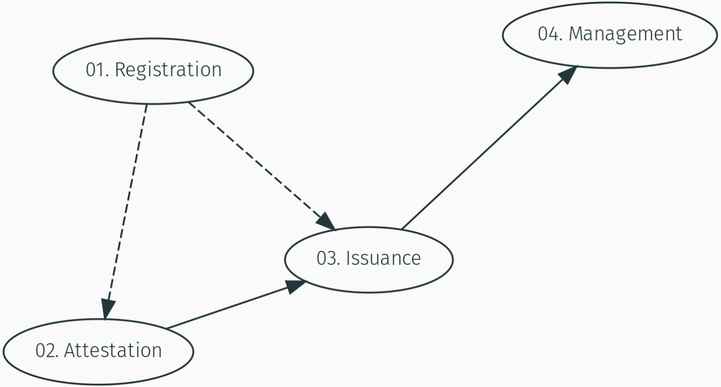

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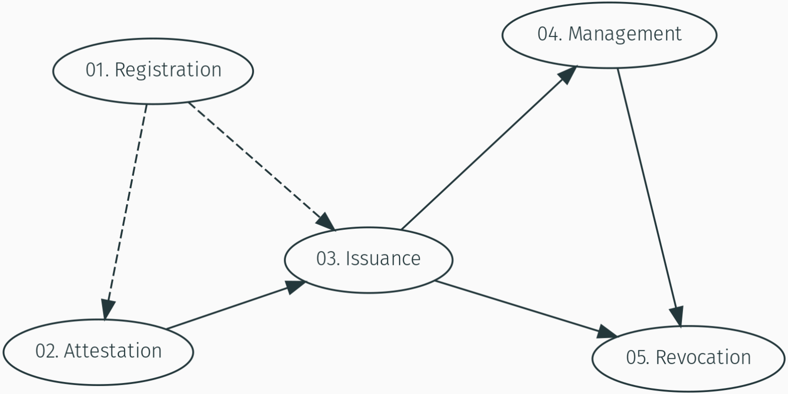

Figure 13: Certificate Life Cycle

Certificate Life Cycle

Registration
Create a new certificate request

Attestation
Attestation (validation) of the certificate request

Issuance
Issuance of an X.509 certificate

Management
Management of issued X.509 certificates

Revocation
Revocation of issued X.509 certificates

Challenges

- Often forgotten or neglected

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- ”Bob” manages certificates using Excel

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- Often forgotten or neglected
- ”Bob” manages certificates using Excel
- Manual work, does not scale and is expensive

Solution?

- Automation!

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- Certificate Management System (CMS)

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- Automation!
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- Provisioning Agents

Questions?