Public Key Infrastructure

Chapter 7

Computer Security, The foundations

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Public Key Infrastructure

- Encryption Revisit
  - Sample Scenario
  - Missing Link
- What is PKI?
- Digital Certificate
- Who do you trust?
- (Legal) Issues of Digital Certificate
- Public Key Infrastructure
- Conclusion

Encryption Revisit

- ★ Hash/Digest
  - ○ Fastest
  - ○ Integrity

- ★ Symmetric Encryption
  - ○ Fast
  - ○ Confidentiality
  - ○ Integrity ?
  - ~~○ Scalability~~
  - ~~○ Authentication~~
  - ~~○ Non-Repudiation~~

- ★ Asymmetric Encryption
  - ○ Slow
    (100 - 1000 times slower than that of Symmetric Encryption)
  - ○ Confidentiality
  - ○ Integrity
  - ○ Scalability
  - ○ Authentication?
  - ○ Non-Repudiation

Combination of methodologies (protocols) can solve most issues, except **AUTHENTICATION.**

Scalability of Symmetric Encryption (Revisit)

★ Assuming that a professor wants to share a piece of information with 100 students, how many (symmetric) key do we need in order to prove the integrity of the information? (ie. proof that the document is created by a professor.)

★ Hint.
With one key, anyone (with the key) can write a message.

Asymmetric Encryption

- Now, we only have to keep the private key. Our public key can freely be distributed. (eg. posted on our personal page.)
- A key pair can be used for
  - Confidentiality - Encrypted with public key, only a person with the private key can read.
  - Integrity - Decrypted with public key, only a person with the private key can create.
  - Scalability - A key pair is enough for a person.

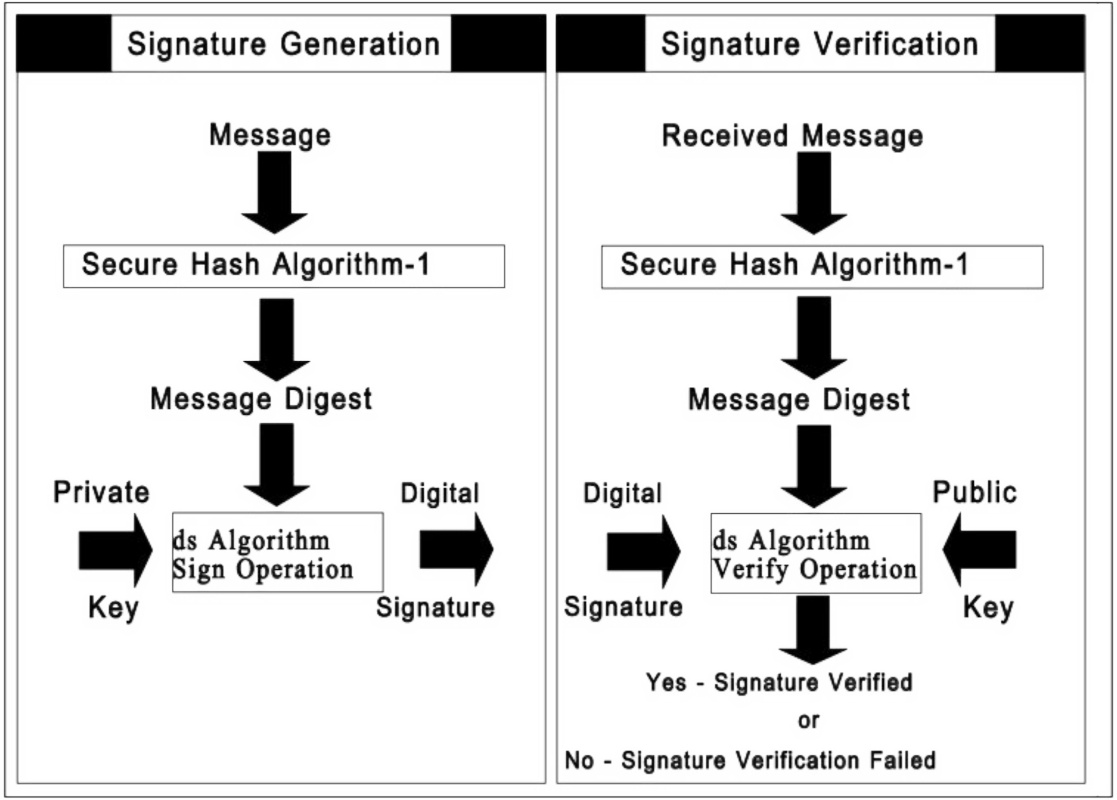
Missing Link (Asymmetric Encryption)

★ Unless we can bind a private key to a person, we cannot solve **Authentication**.

★ Receiving a public key in a sealed envelope with a person name on it, can you prove that it belongs to this person?

Security Protocol: Digital Signature (Revisit)

- ★ A receiver can verify the originality of the a (plain) text.
- ★ Combine the speed of message digest with the scalability of public key.



Digital Certificate

- A Digital Certificate is a binding between an entity’s
- Public Key and one or more Attributes relating its Identity.
- Digital Certificate is a trusted document issued and signed by a (known/trusted third) party with digital signature.

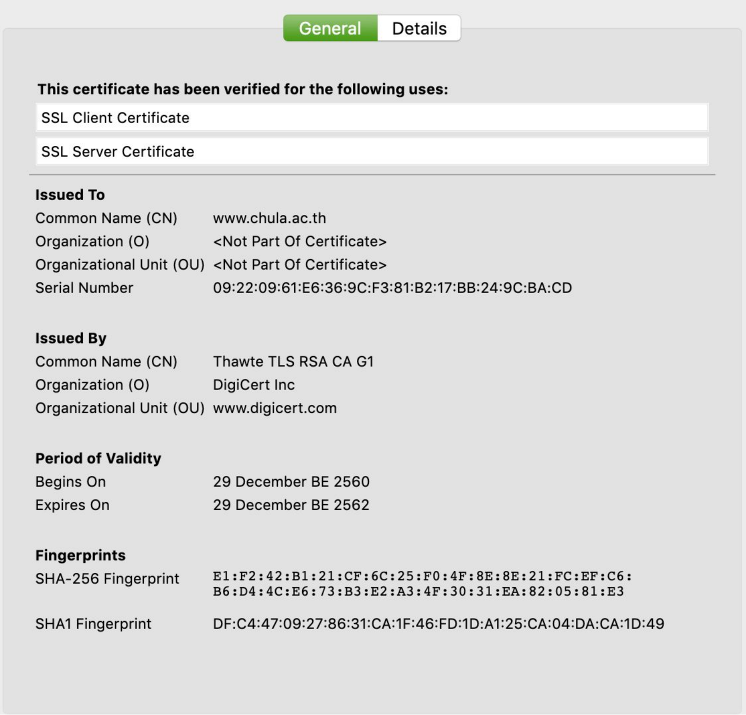
Web of Trust

Do you trust a document signed by a trusted party?

- ★ Assuming that you have a public key of a trusted person/organization, a document (certificate) signed by the associated private key can/should be trustworthy.

Digital Certificate

- ★ Digicert Inc has verified Thawte TLS RSA is real.
- ★ Thawte TLS RSA has verified www.chula.ac.th is real.
- ★ If we have a public of Digicert Inc in hands, we should be able to verified that www.chula.ac.th is valid.



This certificate has been verified for the following uses:

SSL Client Certificate

SSL Server Certificate

Issued To

Common Name (CN)	www.chula.ac.th
Organization (O)	<Not Part Of Certificate>
Organizational Unit (OU)	<Not Part Of Certificate>
Serial Number	09:22:09:61:E6:36:9C:F3:81:B2:17:BB:24:9C:BA:CD

Issued By

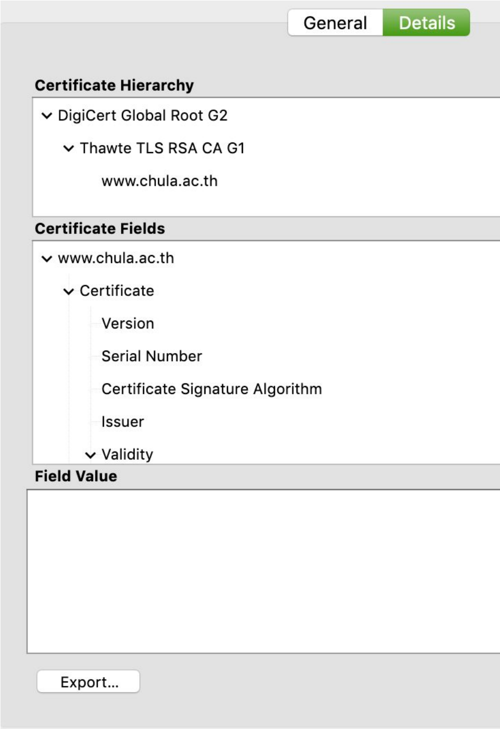
Common Name (CN)	Thawte TLS RSA CA G1
Organization (O)	DigiCert Inc
Organizational Unit (OU)	www.digicert.com

Period of Validity

Begins On	29 December BE 2560
Expires On	29 December BE 2562

Fingerprints

SHA-256 Fingerprint	E1:F2:42:B1:21:CF:6C:25:F0:4F:8E:8E:21:FC:EF:C6: B6:D4:4C:E6:73:B3:E2:A3:4F:30:31:EA:82:05:81:E3
SHA1 Fingerprint	DF:C4:47:09:27:86:31:CA:1F:46:FD:1D:A1:25:CA:04:DA:CA:1D:49



Certificate Hierarchy

- DigiCert Global Root G2
  - Thawte TLS RSA CA G1
    - www.chula.ac.th

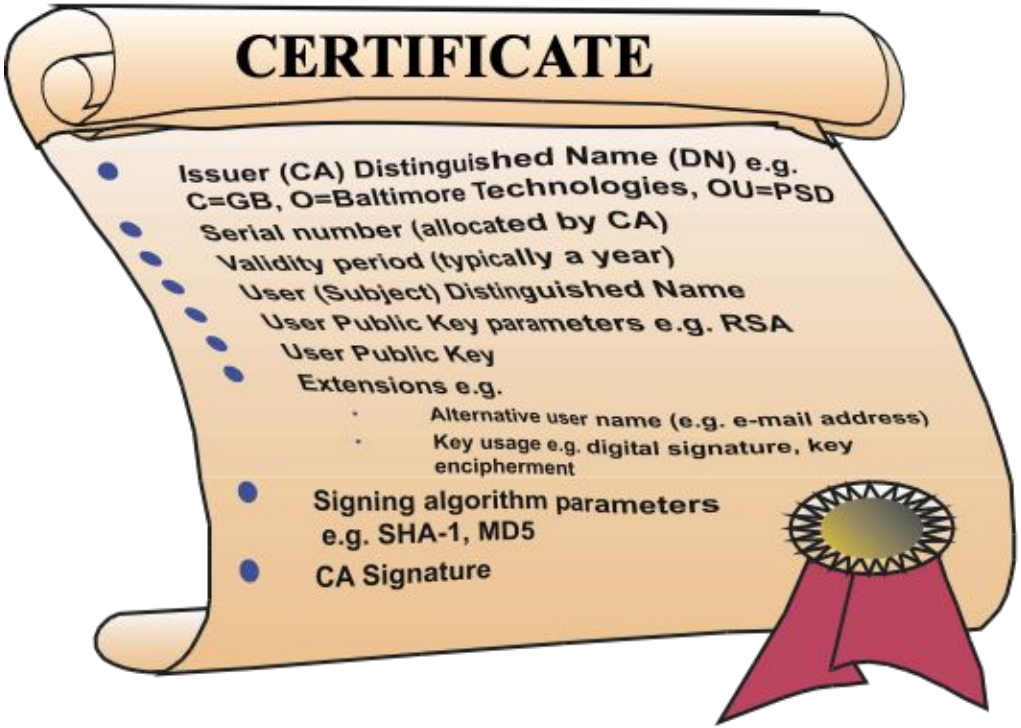
Certificate Fields

- www.chula.ac.th
  - Certificate
    - Version
    - Serial Number
    - Certificate Signature Algorithm
    - Issuer
    - Validity

Field Value

Anatomy of Certificate

- ★ Issuer
- ★ Subject
- ★ Subject Public Key
- ★ Issuer Digital Signature



CERTIFICATE

- Issuer (CA) Distinguished Name (DN) e.g. C=GB, O=Baltimore Technologies, OU=PSD
- Serial number (allocated by CA)
- Validity period (typically a year)
- User (Subject) Distinguished Name
- User Public Key parameters e.g. RSA
- User Public Key
- Extensions e.g.
    - Alternative user name (e.g. e-mail address)
    - Key usage e.g. digital signature, key encipherment
- Signing algorithm parameters e.g. SHA-1, MD5
- CA Signature

Picture is taken from https://www.slideshare.net/natemiller67/pki-overview

Fact

Self-Signed Certificate

★ Technically, a person may create and sign his/her own certificate (self-signed).
★ You may personally hand the public key/certificate to another person. (ie. import a certificate to the browser.)
★ Do you trust this person?

(Legal) Issues of Digital Certificate

- ★ How are Digital Certificates Issued?
- ★ Who is issuing them?
- ★ Why should I Trust the Certificate Issuer?
- ★ How can I check if a Certificate is valid?
- ★ How can I revoke a Certificate?
- ★ Who is revoking Certificates?

Public Key Infrastructure (to the rescue)

What is Public Key Infrastructure?

- Set of (physical) roles, policies, and procedures for enforcing:
  - The registration of public key
  - The management of public key (create, store, distribute, validate, revoke)
  - The validation of public key
- Based on digital certificates
- Bind public keys to identities (persons, organizations)

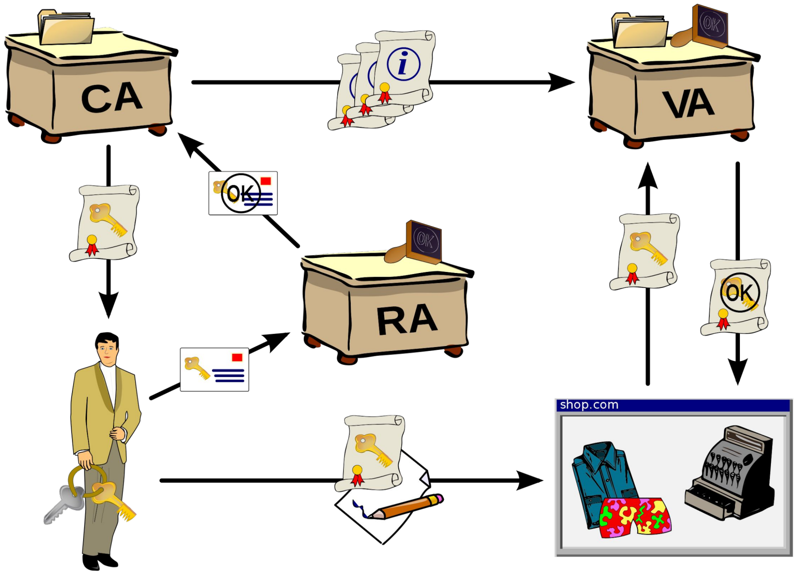
PKI Standards

- There exist several PKI standards (X509, SPKI, etc). We only focus on
  - X509 PKI
  - X509 Digital Certificates
- Standards defined by IETF, PKIX WG:
  - http://www.ietf.org/

PKI Parties

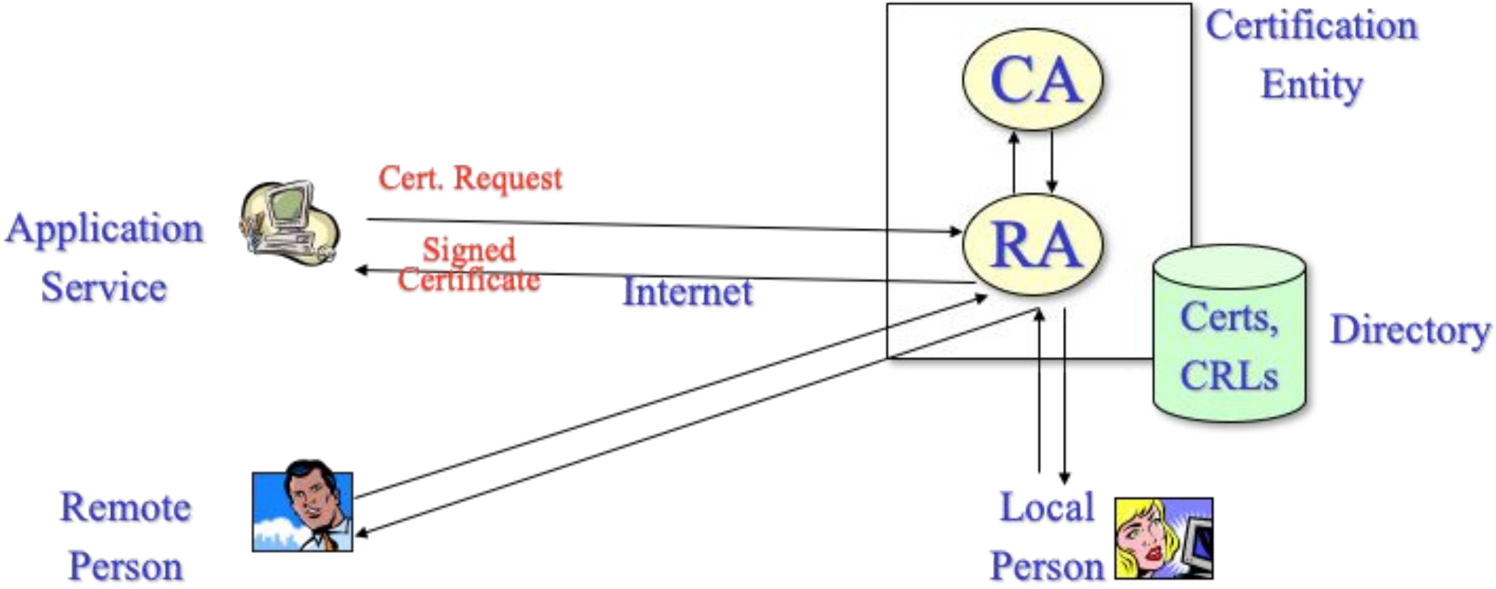
- ★ Certificate Authority (CA)
- ★ Verification Authority (VA)
- ★ Certificate management system
- ★ Central directory
- ★ Certificate policy

- ★ Optional - Registration Authority (RA)
- ★ PKI-Enabled Applications



Taken from https://upload.wikimedia.org/wikipedia/commons/thumb/3/34/Public-Key-Infrastructure.svg/2560px-Public-Key-Infrastructure.svg.png

X509 PKI - Simple Model



Picture is taken from https://www.slideshare.net/natemiller67/pki-overview

Roles

- CA
  - Key Generation
  - Digital Certificate Generation
  - Issuance and Distribution
  - Revocation
  - Key Backup and Recovery System
  - Cross Certification
- RA
  - Face-to-Face Registration
  - Remote Registration
  - Automatic Registration
  - Revocation

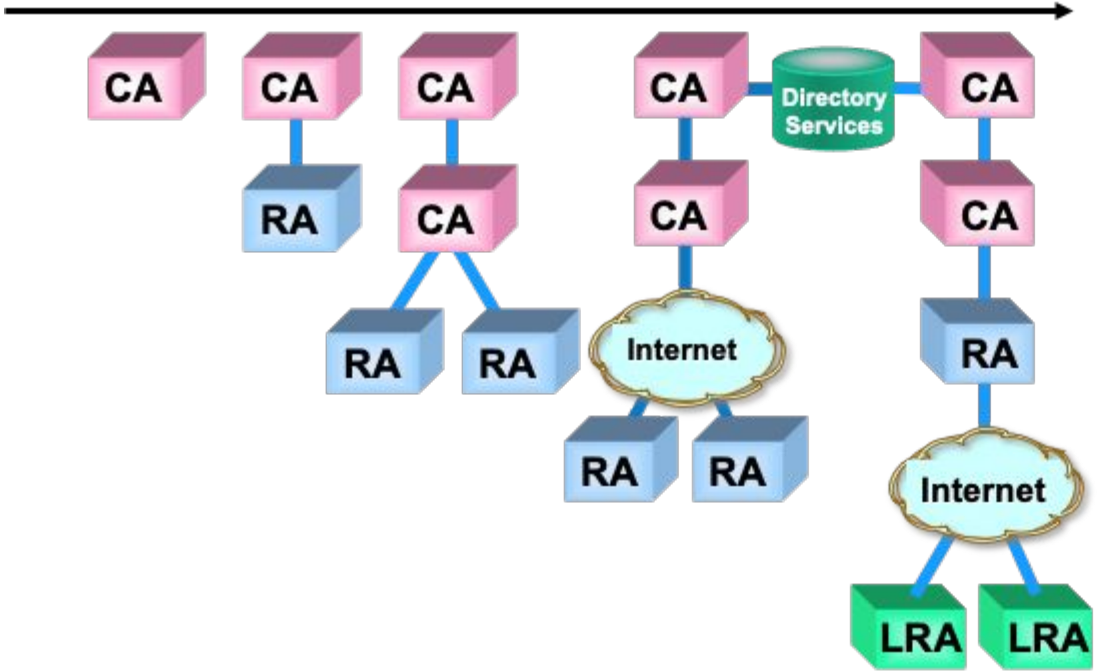
Roles (ctd.)

- Certificate Distribution System
    - Digital Certificates
    - Certificate Revocation Lists (CRLs)
    - LDAP or Special Purpose Databases
    -

Why should I trust CA?

- ★ Why should I Trust a CA?
  - ○ Certificate Hierarchies, Cross-Certification
- ★ How can I determine the liability of a CA?
  - ○ Certificate Policies (CP)
  - ○ Certificate Policy Statement (CPS)

CA in real life



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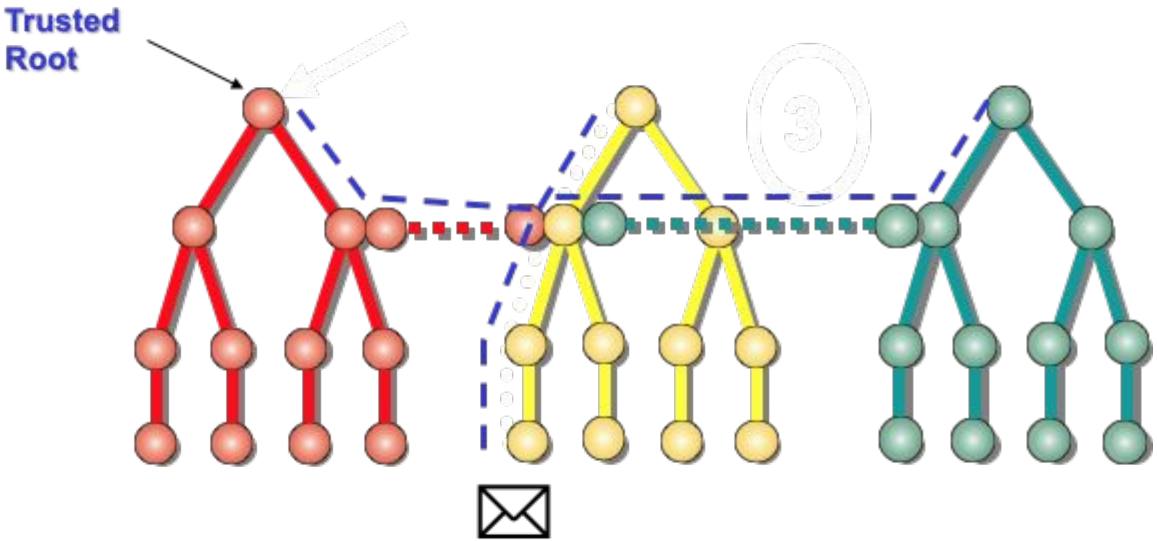
Cross-Certification and Path Discovery



Conclusion

- PKI is a physical infrastructure for managing Digital Certificate.
- The main function is to validate the identity of public key owner.
- We do not cover the policy and the legal part here.

Food for Thought: Root Certificate

- ★ If a bad guy can manage to install a root certificate to your computer, how bad can it be?
- ★ Historically, a chinese company was able to ask every browsers to install its root certificate. Since they abused this certificate, several harmful things happened. What were the harmful things?

End of Chapter 7