Public-key Infrastructure

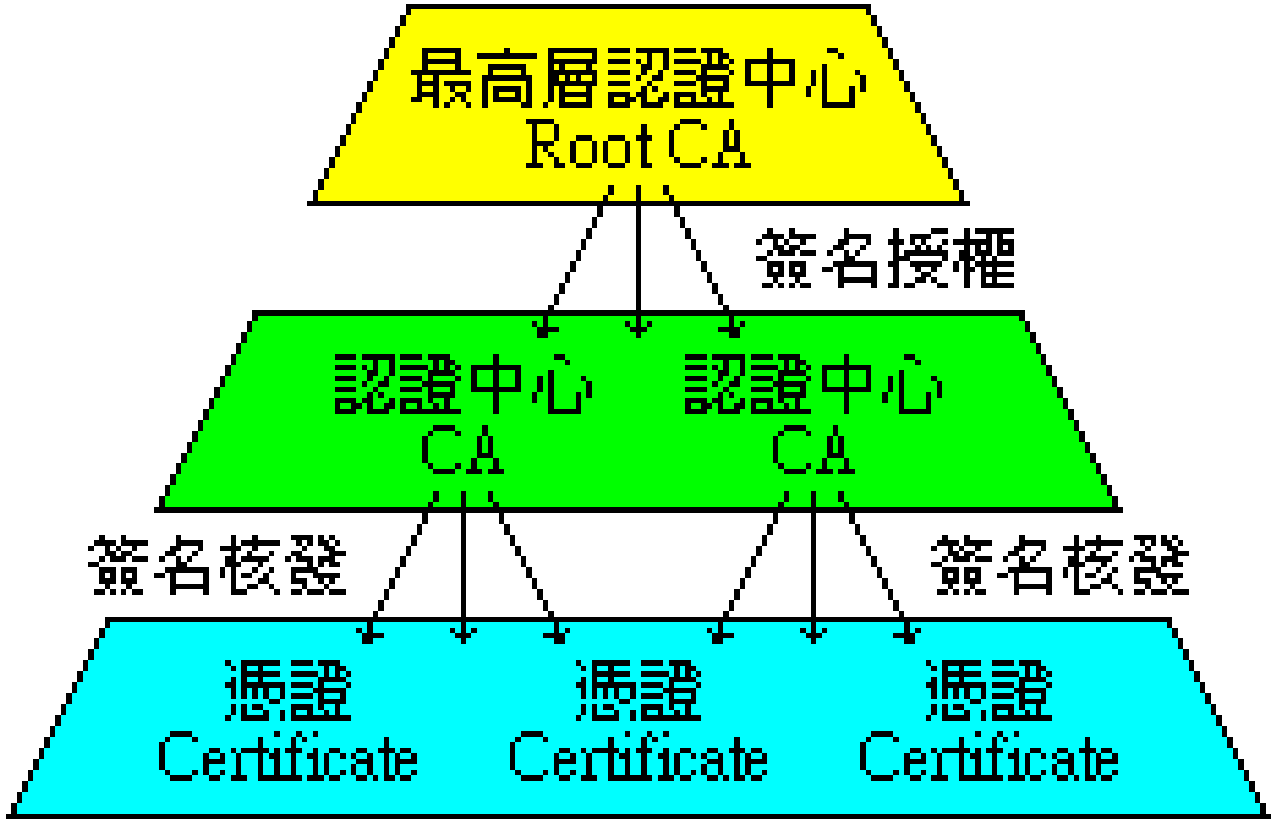
Public-key Infrastructure

- A set of hardware, software, people, policies, and procedures.
- To create, manage, distribute, use, store, and revoke digital certificates.

- Encryption, authentication, signature
- Bootstrapping secure communication protocols.

CA: Certificate Authority (1)

- In God We Trust



CA: Certificate Authority (2)

- Certificate
  - Contains data of the owner, such as Company Name, Server Name, Name, Email, Address,…
  - Public key of the owner.
  - Followed by some digital signatures.
    - Sign for the certificate.
  - In X.509
    - A certificate is signed by a CA.
    - To verify the correctness of the certificate, check the signature of CA.

CA: Certificate Authority (3)

- Certificate Authority (CA)
  - “憑證授權” in Windows CHT version.
  - In X.509, it is itself a certificate.
    - The data of CA.
    - To sign certificates for others.
  - Each CA contains a signature of Root CA.
  - To verify a valid certificate
    - Check the signature of Root CA in the certificate of CA.
    - Check the signature of CA in this certificate.
  - Reference: http://www.imacat.idv.tw/tech/sslcerts.html

What is a CA ? (1)

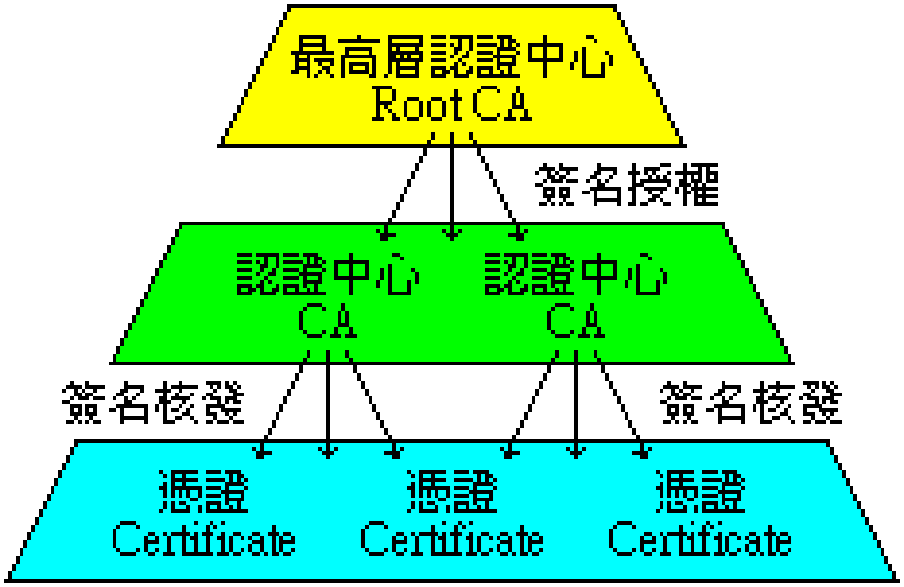
- *Certificate Authority* (認證中心)
- Trusted server which signs certificates
- One private key and relative public key
- Tree structure of X.509
  - *Root CA*

What is a CA ? (2)

- Root CA (**最高層認證中心**)
  - In Micro$oft:「根目錄授權憑證」
  - Root CA do not sign the certificates for users.
    - Authorize CA to sign the certificates for users, instead.
  - Root CA signs for itself.
    - It is in the sky.
  - To trust Root CA
    - Install the certificate of Root CA via secure channel.

What is a CA ? (3)

- Tree structure of CA

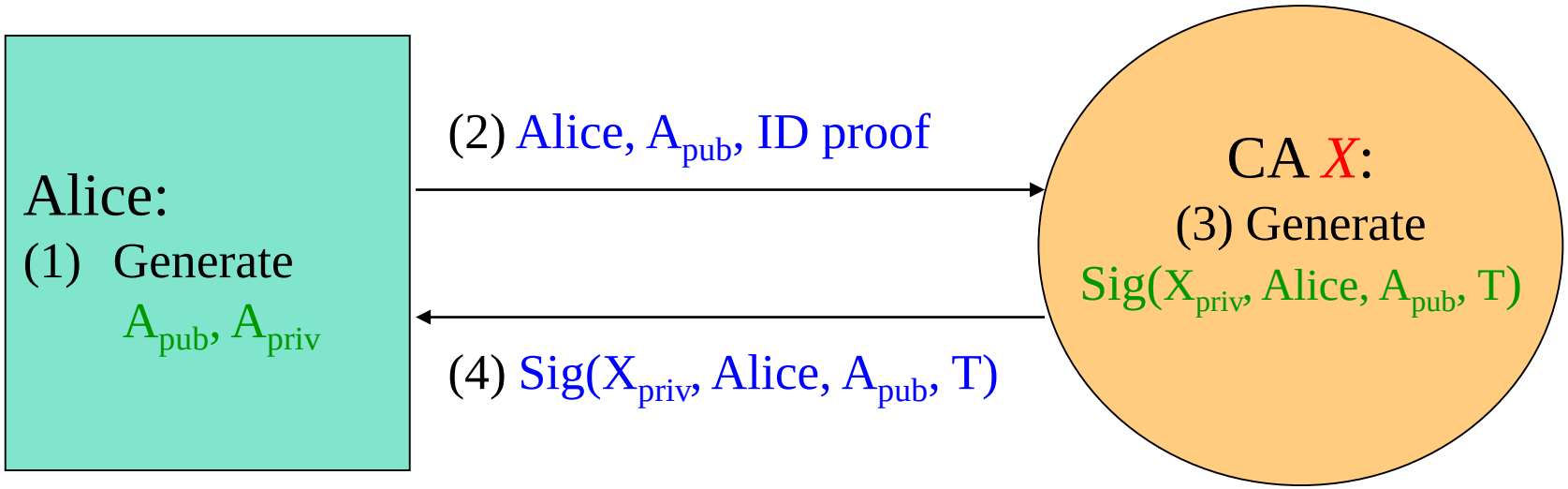


- Cost of certificate
  - HiTrust : NT *$30,000* / per year / per host
  - Myself : NT *$0*

Certificate (1)

- Digital Certificate, Public-key Certificate, Network Identity
- A certificate is issued by a CA *X*
- A certificate of a user A consists:
  - The name of the issuer CA *X*
  - His/her public key A_{pub}
  - The signature $Sig(X_{priv}, A, A_{pub})$ by the CA *X*
  - The expiration date
  - Applications
    - Encryption / Signature

Certificate (2)



$Cert_{A,X}$=[Alice, A_{pub}, Sig(X_{priv}, Alice, A_{pub}, T)]

Note: CA does not know A_{priv}

Certificate (3)

- Guarantee of CA and certificate
  - Guarantee the public key is of *someone*
  - *Someone* is not guaranteed to be *safe*
- Security of transmitting DATA
  - Transmit *session key* first
    - *Public-key cryptosystem*
  - Transmit DATA by session key
    - *Symmetric-key cryptosystem*

OpenSSL

OpenSSL

- http://www.openssl.org/
- In system
  - /usr/src/crypto/openssl
- In ports
  - security/openssl

ports/Mk/bsd.openssl.mk

```
# WITH_OPENSSL_BASE=yes - Use the version in the base system.
# WITH_OPENSSL_PORT=yes - Use the port, even if base is up to date
# WITH_OPENSSL_BETA=yes - Use a snapshot of recent openssl
# WITH_OPENSSL_STABLE=yes   - Use an older openssl version
 ……
#   if no preference was set, check for an installed base version
#   but give an installed port preference over it.
.if !defined(WITH_OPENSSL_BASE) && \
    !defined(WITH_OPENSSL_BETA) && \
    !defined(WITH_OPENSSL_PORT) && \
    !defined(WITH_OPENSSL_STABLE) && \
    !exists(${DESTDIR}/${LOCALBASE}/lib/libcrypto.so) && \
    exists(${DESTDIR}/usr/include/openssl/opensslv.h)
WITH_OPENSSL_BASE=yes
.endif
```

Example: Apache SSL settings

Example: Apache SSL settings – Flow

- Flow
  - Generate random seed
  - Generate RootCA
    - Generate private key of RootCA
    - Fill the Request of Certificate.
    - Sign the certificate itself.
  - Generate certificate of Web Server
    - Generate private key of Web Server
    - Fill the Request of certificate
    - Sign the certificate using RootCA
  - Modify apache configuration ➔ restart apache

Example: Apache SSL settings – Generate random seed

- openssl rand -out rnd-file num

  % openssl rand -out /etc/ssl/RootCA/private/.rnd 1024

- chmod go-rwx rnd-file

  % chmod go-rwx /etc/ssl/RootCA/private/.rnd

Example: Apache SSL settings – Generate private key of RootCA

- openssl genrsa -des3 -rand rnd-file -out rootca-key-file num

  % openssl genrsa -des3 -rand /etc/ssl/RootCA/private/.rnd \

  -out /etc/ssl/RootCA/private/rootca.key.pem 2048

  - Note: phrase are asked (something like password)

- chmod go-rwx rootca-key-file

  % chmod go-rwx /etc/ssl/RootCA/private/rootca.key.pem

Example: Apache SSL settings – Fill the Request of Certificate

- openssl req -new -key rootca-key-file -out rootca-req-file

```
% openssl req -new -key /etc/ssl/RootCA/private/rootca.key.pem \
    -out /etc/ssl/RootCA/private/rootca.req.pem
```

- chmod go-rwx rootca-req-file

```
% chmod go-rwx /etc/ssl/RootCA/private/rootca.req.pem
```

```
Enter pass phrase for rootca-key-file:

Country Name (2 letter code) [AU]:TW
State or Province Name (full name) [Some-State]:Taiwan
Locality Name (eg, city) []:HsinChu
Organization Name (eg, company) [Internet Widgits Pty Ltd]:NCTU
Organizational Unit Name (eg, section) []:CS
Common Name (eg, YOUR name) []:nasa.cs.nctu.edu.tw
Email Address []:liuyh@cs.nctu.edu.tw

A challenge password []: (No need，Enter please)
An optional company name []: (Enter please)
```

Example: Apache SSL settings – Sign the certificate itself

- openssl x509 -req -days num -sha1 -extfile path_of_openssl.cnf -extensions v3_ca -signkey rootca-key-file -in rootca-req-file -out rootca-crt-file

  % openssl x509 -req -days 5109 -sha1 -extfile /etc/ssl/openssl.cnf -extensions v3_ca -signkey /etc/ssl/RootCA/private/rootca.key.pem -in /etc/ssl/RootCA/private/rootca.req.pem -out /etc/ssl/RootCA/private/rootca.crt.pem

- rm -f rootca-req-file

  %rm -f /etc/ssl/RootCA/private/rootca.req.pem

- chmod go-rwx rootca-crt-file

  %chmod go-rwx /etc/ssl/RootCA/private/rootca.crt.pem

Example: Apache SSL settings – Generate private key of Web Server

- openssl genrsa -out host-key-file num

  %openssl genrsa -out /etc/ssl/nasa/private/nasa.key.pem 2048

- chmod go-rwx host-key-file

  %chmod go-rwx /etc/ssl/nasa/private/nasa.key.pem

Example: Apache SSL settings – Fill the Request of Certificate

- openssl req -new -key host-key-file -out host-req-file

  % openssl req -new -key /etc/ssl/nasa/private/nasa.key.pem -out /etc/ssl/nasa/private/nasa.req.pem

- chmod go-rwx host-req-file

  % chmod go-rwx /etc/ssl/nasa/private/nasa.req.pem

Example: Apache SSL settings – Sign the certificate using RootCA

- Tramsmit host-req-file to Root CA, and do following steps in RootCA
  - openssl x509 -req -days num -sha1 -extfile path_of_openssl.cnf -extensions v3_ca -CA rootca-crt-file -CAkey rootca-key-file -CAserial rootca-srl-file -CAcreateserial -in host-req-file -out host-crt-file

    % openssl x509 -req -days 365 -sha1 -extfile /etc/ssl/openssl.cnf

    -extensions v3_ca -CA /etc/ssl/RootCA/private/rootca.crt.pem
    -CAkey /etc/ssl/RootCA/private/rootca.key.pem
    -CAserial /etc/ssl/RootCA/private/rootca.srl -CAcreateserial
    -in /etc/ssl/nasa/private/nasa.req.pem
    -out /etc/ssl/nasa/private/nasa.crt.pem
  - rm -f host-req-file (in both RootCA and Web Server)

    % rm -f /etc/ssl/nasa/private/nasa.req.pem
  - Transmit host-crt-file back to Web Server

Example: Apache SSL settings – Certificate Authority (8)

- Include etc/apache22/extra/httpd-ssl.conf

```
##
## SSL Virtual Host Context
##
<VirtualHost _default_:443>
#   General setup for the virtual host
DocumentRoot /home/wwwadm/data
<Directory “/home/wwwadm/data">
    Options Indexes FollowSymLinks
    AllowOverride All
    Order allow,deny
    Allow from all
</Directory>
ServerName nasa.cs.nctu.edu.tw:443
ServerAdmin liuyh@nasa.cs.nctu.edu.tw
ErrorLog /var/log/httpd/nasa.cs-error.log
CustomLog /var/log/httpd/nasa.cs-access.log common

SSLEngine on
SSLCipherSuite ALL:!ADH:!EXPORT56:RC4+RSA:+HIGH:+MEDIUM:+LOW:!SSLv2:+EXP:+eNULL
SSLCertificateFile /etc/ssl/nasa/nasa.crt.pem
SSLCertificateKeyFile /etc/ssl/nasa/private/nasa.key.pem
```

Appendix: PGP

PGP

- Pretty Good Privacy
- Public key system
  - Encryption
  - Signature
- security/gnupg

- Will talk more in Network Administration

- Ref: http://security.nknu.edu.tw/textbook/chap15.pdf