

Understanding Digital Certificates on z/OS

Vanguard Las Vegas, NV
Session AST3
June 26th 2012

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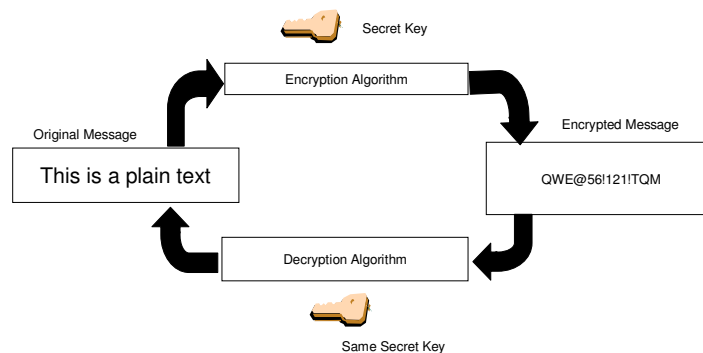
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Agenda

- Symmetric vs. Asymmetric Encryption
- What are digital certificates
- Certificate types and contents
- Overview of certificate utilities available on z/OS
- Certificate formats
- Summary

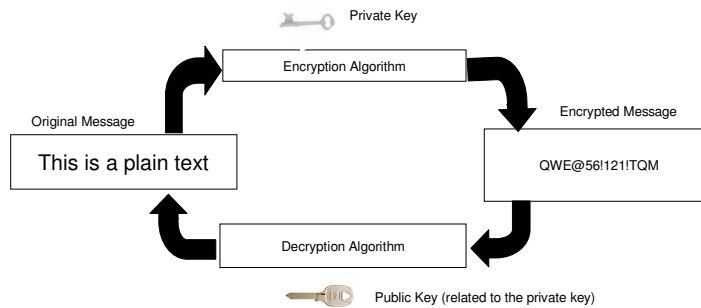
Symmetric Encryption

- Same key used for both encryption and decryption
- Provide data confidentiality
- Fast, used for bulk encryption/decryption
- Securely sharing and exchanging the key between both parties is a major issue
- Common algorithms: DES, Triple DES, AES



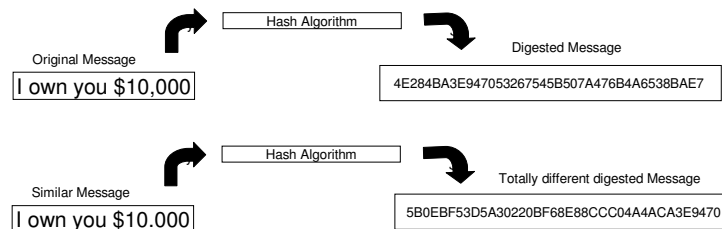
Asymmetric Encryption

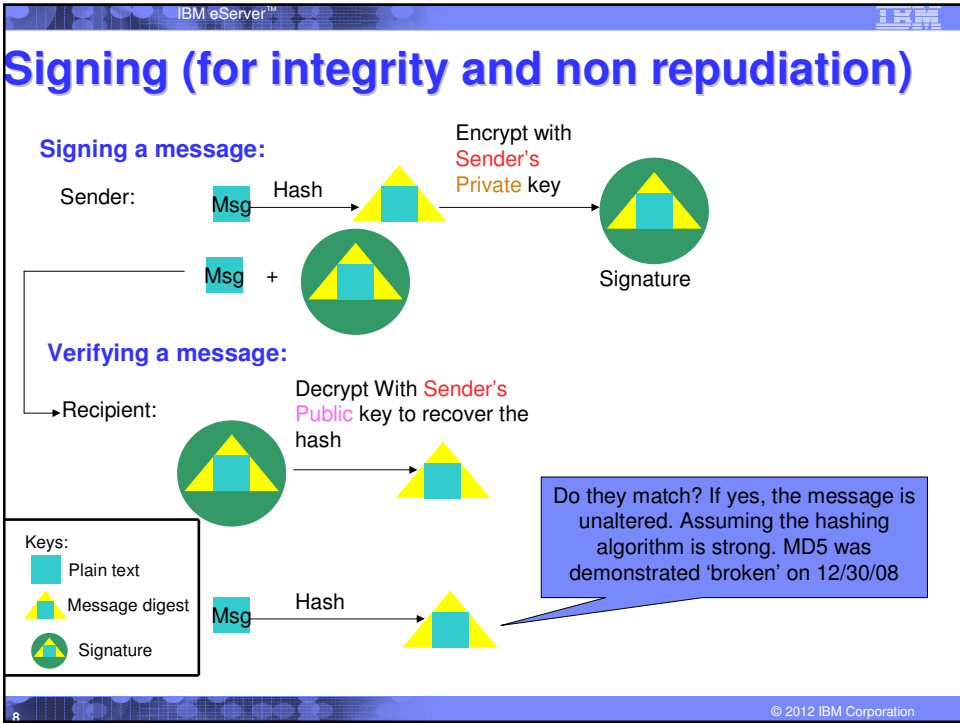
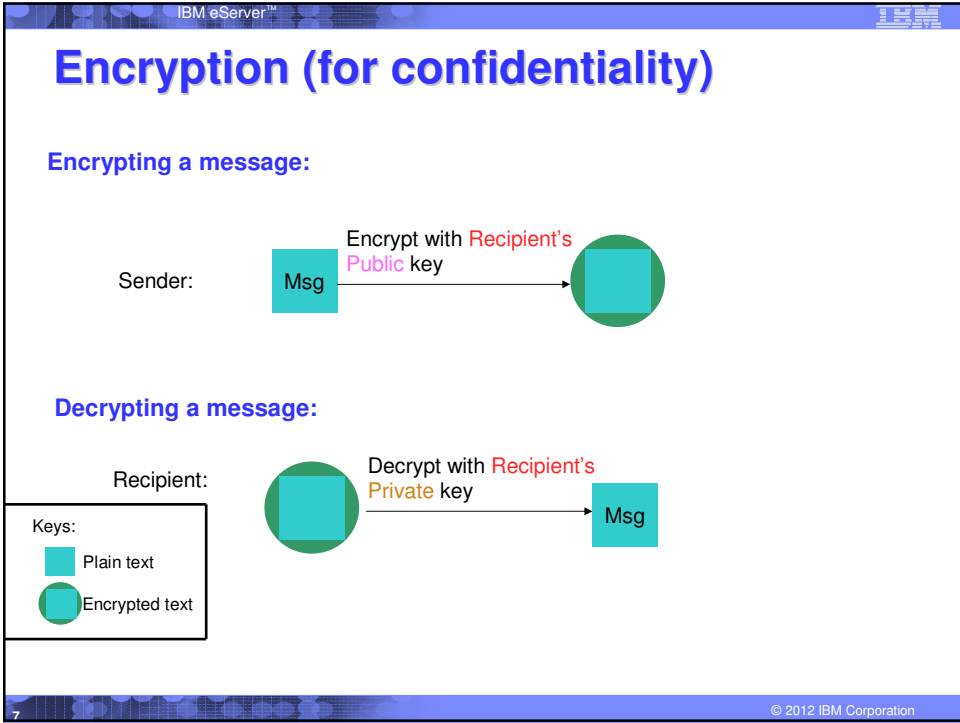
- 2 different keys - Public/private key pairs
- A public key and a related private key are numerically associated with each other.
- Provide data confidentiality, integrity and non repudiation
- Data encrypted/signed using one of the keys may only be decrypted/verified using the other key.
- Very expensive computationally
- Public key is freely distributed to others, private key is securely kept by the owner
- Common algorithms: RSA, DSA, ECC



Message Digest (Hash)

- A fixed-length value generated from variable-length data
- Unique:
 - the same input data always generates the same digest value
 - tiny change in data causes wide variation in digest value
 - Theoretically impossible to find two different data values that result in the same digest value
- One-way: can't reverse a digest value back into the original data
- NOT based on a key
- Play a part in data integrity and origin authentication
- Common algorithms: SHA1, SHA256





What is a Digital Certificate (1 of 2)

- **Generally digital certificates provide identity to a person or a server**
 - Person - like an ID card
 - Server – like a business license
- **To establish an identity or credential to be used in electronic transactions**
- **It binds the public key to the identity to be used by applications that are based on public key protocols. (e.g. SSL/TLS)**
- **Issued by a trusted third party called Certificate Authority (CA) that can ensure validity**

What is a Digital Certificate(2 of 2)

- **Packaging of the information is commonly known as the x.509 digital certificate. X.509 defines the format and contents of a digital certificate.**
 - IETF RFC 5280
- **Digital certificates been in existence for over 20 years**
- **Have evolved over time to not only bind basic identity information to the public key but also how public key can be used, additional identity data, revocation etc.**

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What's inside a Certificate?

Version 1, 2, 3

This is the hash/encrypt algorithm used in the signature, eg. sha256RSA – Beware of MD5!!!

The certificate binds a public key to a subject

CA signs the above cert info by encrypting the hash with its **private** key

The private key is NOT in the certificate. It is kept in a key store

You can NOT change ANY of the certificate information!

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Extensions of a x.509 digital Certificate(1 of 2)

- Adds additional definitions to a certificate and its identity information
- 15+ currently defined
- Top 6 extensions of interest
 - Authority Key Identifier
 - Subject Key Identifier
 - Key Usage
 - Subject Alternate Name
 - BasicConstraints
 - CRL Distribution Point

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Extensions of a x.509 digital Certificate(2 of 2)

- **Authority Key Identifier – Unique identifier of the signer**
- **Subject Key Identifier – Unique identifier of the subject**
- **Key Usage – defines how the public key can used**
 - Digital Signature
 - Key Encipherment
 - Key Agreement
 - Data Encipherment
 - Certificate Signing
 - CRL signing
- **Subject Alternate Name – additional identity information**
 - Domain name
 - E-mail
 - URI
 - IP address
- **Basic Constraints – Certificate Authority Certificate or not**
- **CRL Distribution – Locating of Revoked certificate information**

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Example of a x.509 digital Certificate

The image displays two screenshots of the IBM eServer Certificate management console. The left screenshot shows the 'General' tab of a certificate window. The 'Show:' dropdown is set to '<All>'. The certificate details are as follows:

Field	Value
Version	V3
Serial number	25 f5 d1 2d 5e 6f 0b d4 ea f2 ...
Signature algorithm	sha1RSA
Issuer	VeriSign Class 3 Secure Server...
Valid from	Wednesday, July 14, 2010 8:...
Valid to	Sunday, July 14, 2013 7:59:5...
Subject	www.amazon.com, Amazon.c...
Public key	RSA (1024 Bits)

Below the table, the certificate's Distinguished Name (DN) is shown: CN = www.amazon.com, O = Amazon.com Inc., L = Seattle, S = Washington, C = US.

The right screenshot shows the 'Details' tab of the same certificate window. The 'Show:' dropdown is set to '<All>'. The certificate details are as follows:

Field	Value
Basic Constraints	Subject Type=End Entity, Pat...
Key Usage	Digital Signature, Key Encipher...
CRL Distribution Points	[1]CRL Distribution Point: Distr...
Certificate Policies	[1]Certificate Policy:Policy Ide...
Enhanced Key Usage	Server Authentication (1.3.6...
Authority Key Identifier	KeyID=a5 ef 0b 11 ce c0 41 0...
Authority Information Access	[1]Authority Info Access: Acc...
1.3.6.1.5.5.7.1.12	30 60 a1 5e a0 5c 30 5a 30 58...

Below the table, the certificate's Key Usage is shown: Digital Signature, Key Encipherment (a0).

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Relationship between Certificate and Certificate Store

- Certificate must be placed in a certificate store before it can be used by an application to perform identification or validation
- The application needs to retrieve the certificate and/or its corresponding private key from the store
- On z/OS, many components like Communication Server, HTTP Server call System SSL APIs to access the store
- Certificate store = key ring = key file



Types of digital certificates – who issues it

- **Self signed**
 - Self-issued
 - Issuer and subject names identical
 - Signed by itself using associated private key
- **Signed Certificate**
 - Signed/issued by a trusted Certificate Authority Certificate using its private key.
 - By signing the certificate, the CA certifies the validity of the information. Can be a well-known commercial organization or local/internal organization.

Types of digital certificates – what is the usage

- **Secure Socket Layer (SSL) certificate**
 - Install on a server that needs to be authenticated, to ensure secure transactions between server and client
- **Code Signing certificate**
 - Sign software to assure to the user that it comes from the publisher it claims
- **Personal certificate**
 - Identify an individual, enable secure email – to prove that the email really comes from the sender and /or encrypt the email so that only the receiver can read it
- **More (name it whatever you want)...**
 - wireless certificate, smart card certificate...
- **Certificate Authority (CA) certificate**
 - Used to sign other certificates
 - Root CA: the top
 - Intermediate CA: signed by root CA or other intermediate CA

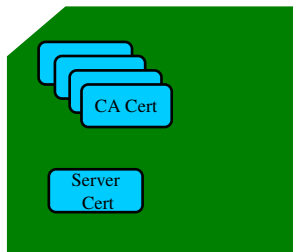
Types of digital certificates – what is the usage

- **Site certificate (in RACF)**
 - The usage assigned to a certificate when it is connected to a RACF key ring indicates its intended purpose
 - There may be a few certificate validation applications which treat a certificate that is connected to a key ring with usage site as a valid certificate authority certificate to bypass the normal certificate verification tests during SSL handshake, for example, an expired certificate can be considered trusted
 - Having a SITE certificate in RACF does not benefit you if the validation application does not make use of it

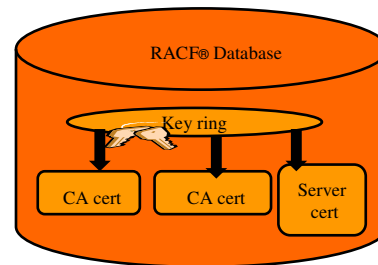
Certificate Stores on z/OS

- gskkyman manages certificates stored in a key database file
- RACDCERT manages certificates stored in a RACF key ring.

GSKKYMAN



RACDCERT



Certificate Store Protection

- gskkyman key database files
 - Protected by the file system's permission bits and password
 - Upon creation, permission bits are 700 giving the issuer of gskkyman read and write to the file only.
 - Applications using these files need at least read to the file
- RACF Key Rings
 - RACF key rings are protected by resource profiles.
 - Users rings need read access to IRR.DIGTCERT.LISTRING or <ring owner>.<ring name>.LST to be able to read the contents of their key ring
 - IRR.DIGTCERT.LISTRING – Global control
 - <ring owner>.<ring name>.LST – Granular control

Certificate Utilities

- **gskkyman** is a Unix based utility shipped as part of the System SSL product in the z/OS Cryptographic Services Element
- **RACDCERT** is a TSO command shipped as part of RACF
- Provide basic certificate functions
 - ▶ Create/delete certificate store (HFS key database file / SAF key ring)
 - ▶ Create certificate requests (to be signed by trusted Certificate Authority)
 - ▶ Import/Export certificates (with and without private keys)
 - ▶ Create self-signed certificates
- Do not have all the functions of a real Certificate Authority

Certificate Authority on z/OS

- **PKI Services** provides full certificate life cycle management
 - ▶ Request, create, renew, revoke certificate
 - ▶ Provide certificate status through Certificate Revocation List(CRL) and Online Certificate Status Protocol (OCSP)
 - ▶ Generation and administration of certificates via customizable web pages
 - ▶ Support Simple Certificate Enrollment Protocol (SCEP) for routers to request certificates automatically
 - ▶ Automatic notification or renewal of expiring certificates

Defining a Certificate

- **How will the certificate be used?**
- **What certificate store is to be used?**
- **Who will be the certificate authority?**
- **What is the size of the public/private keys?**
- **What subject name to use?**
- **Need additional identity information and extensions?**

Defining a Certificate Request to be signed by a CA

- A **certificate signing request** (also **CSR**) is a message sent from the certificate requestor to a certificate authority to obtain a signed digital certificate
- Contains identifying information and public key for the requestor
- Corresponding private key is not included in the CSR, but is used to digitally sign the request to ensure the request is actually coming from the requestor
- CSR may be accompanied by other credentials or proofs of identity required by the certificate authority, and the certificate authority may contact the requestor for further information.
- If the request is successful, the certificate authority will send back an identity certificate that has been digitally signed with the private key of the certificate authority.

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If you use gskkyman...

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Create a key database

Database Menu

- 1 - Create new key database**
- 2 - Open key database
- 3 - Change database password
- 4 - Change database record length
- 5 - Delete database
- 6 - Create key parameter file
- 7 - Display certificate file (Binary or Base64 ASN.1 DER)

0 - Exit Program

Enter your option number: **1**

Enter key database name (press ENTER to return to menu: **/tmp/my.kdb**)

Enter database password (press ENTER to return to menu: **password**)

Re-enter database password: **password**

Enter password expiration in days (press ENTER for no expiration): **<enter>**

Enter database record length (press ENTER to use 2500): **<enter>**

This will add a number of well-known trusted CA certificates to the key database.

Name of key database

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Importing a signing Certificate Authority Certificate

Key Management Menu

Database: /tmp/my.kdb

- 1 - Manage keys and certificates
- 2 - Manage certificates
- 3 - Manage certificate requests
- 4 - Create new certificate request
- 5 - Receive requested certificate or a renewal certificate
- 6 - Create a self-signed certificate
- 7 - Import a certificate
- 8 - Import a certificate and a private key
- 9 - Show the default key
- 10 - Store database password
- 11 - Show database record length

- 0 - Exit program

Enter option number (press ENTER to return to previous menu): 7

Importing a signing Certificate Authority Certificate Continued

File contains the CA
certificate

Enter import file name (press ENTER to return to menu): **cacert.b64**

Enter label (press ENTER to return to menu): **CA Certificate**

Certificate imported.

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Creating a new certificate request

Key Management Menu

Database: /tmp/my.kdb

- 1 - Manage keys and certificates
- 2 - Manage certificates
- 3 - Manage certificate requests
- 4 - Create new certificate request
- 5 - Receive requested certificate or a renewal certificate
- 6 - Create a self-signed certificate
- 7 - Import a certificate
- 8 - Import a certificate and a private key
- 9 - Show the default key
- 10 - Store database password
- 11 - Show database record length

0 - Exit program

Enter option number (press ENTER to return to previous menu): 4

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Fill in the information about the requestor (1 of 2)

Certificate Key Algorithm

- 1 - Certificate with an RSA key
- 2 - Certificate with a DSA key
- 3 - Certificate with an ECC key

Select certificate key algorithm (press ENTER to return to menu): 1

RSA Key Size

- 1 - 1024-bit key
- 2 - 2048-bit key
- 3 - 4096-bit key

Select RSA key size (press ENTER to return to menu): 2

Signature Digest Type

- 1 - SHA-1
- 2 - SHA-224
- 3 - SHA-256
- 4 - SHA-384
- 5 - SHA-512

Select digest type (press ENTER to return to menu): 2

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Fill in the information about the requestor(2 of 2)

File to contain certificate request

Enter request file name (press ENTER to return to menu): **certreq.arm**
Enter label (press ENTER to return to menu): **Server Certificate**
Enter subject name for certificate
Common name (required): **Server Certificate**
Organizational unit (optional): **Production**
Organization (required): **IBM**
City/Locality (optional): **Endicott**
State/Province (optional): **New York**
Country/Region (2 characters - required): **US**

Enter 1 to specify subject alternate names or 0 to continue: **1**

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Receiving a signed certificate request

Key Management Menu

Database: /tmp/my.kdb

- 1 - Manage keys and certificates
- 2 - Manage certificates
- 3 - Manage certificate requests
- 4 - Create new certificate request
- 5 - Receive requested certificate or a renewal certificate
- 6 - Create a self-signed certificate
- 7 - Import a certificate
- 8 - Import a certificate and a private key
- 9 - Show the default key
- 10 - Store database password
- 11 - Show database record length

0 - Exit program

File contains cert returned from CA

Enter option number (press ENTER to return to previous menu): **5**
Enter certificate file name (press ENTER to return to menu): **svrcert.arm**

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Marking a certificate as the default

Key and Certificate Menu

Label: Server Certificate

- 1 - Show certificate information
- 2 - Show key information
- 3 - Set key as default
- 4 - Set certificate trust status
- 5 - Copy certificate and key to another database
- 6 - Export certificate to a file
- 7 - Export certificate and key to a file
- 8 - Delete certificate and key
- 9 - Change label
- 10 - Create a signed certificate and key
- 11 - Create a certificate renewal request

- 0 - Exit program

Enter option number (press ENTER to return to previous menu): 3

If you use RACDCERT...
(ISPF Panel or Command)

RACDCERT Panel on Key Ring

```
RACF - Digital Certificate Key Ring Services
OPTION ==> _

For user: _____

Enter one of the following at the OPTION line:

1 Create a new key ring
2 Delete an existing key ring
3 List existing key ring(s)
4 Connect a digital certificate to a key ring
5 Remove a digital certificate from a key ring
```

RACDCERT Panel on Certificate

```
RACF - Digital Certificate Services
OPTION ==>

Select one of the following:

1. Generate a certificate and a public/private key pair.
2. Create a certificate request.
3. Write a certificate to a data set.
4. Add, Alter, Delete, or List certificates or
   check whether a digital certificate has been added to
   the RACF database and associated with a user ID.
5. Renew, Rekey, or Rollover a certificate.
```

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Create a key ring

Name of key ring

```
RACDCERT ID(FTPserver) ADDRING(MyRACFKeyRing)
```

Adding Certificate Authority(CA) Certificate to a key ring

Dataset contains the CA certificate

```
RACDCERT CERTAUTH ADD('user1.cacert') TRUST
WITHLABEL('CA Certificate')
```

```
RACDCERT ID(FTPServer) CONNECT (CERTAUTH LABEL('CA
Certificate') RING(MyRACFKeyRing) USAGE(CERTAUTH))
```

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Creating a new certificate request

```
RACDCERT ID(FTPServer) GENCERT SUBJECTSDN(CN('Server
Certificate')OU('Production')O('IBM')L('Endicott')SP('New
York')C('US'))
SIZE(1024) WITHLABEL('Server Certificate')
ALTNAME(DOMAIN('mycompany.com'))
```

```
RACDCERT ID(FTPServer) GENREQ(LABEL('Server Certificate'))
DSN('user1.certreq')
```

Dataset to contain certificate request

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Adding Certificate signed by CA to a key ring

```
RACDCERT ID(FTPServer) ADD('user1.svrcert')
WITHLABEL('Server Certificate')
```

Dataset contains cert
returned from CA

```
RACDCERT ID(FTPServer) CONNECT(ID(SUIMGTF)
LABEL('Server Certificate') RING(MyRACFKeyRing)
USAGE(PERSONAL) DEFAULT)
```

Listing a RACF Key Ring

```
RACDCERT ID(FTPServer) LISTING(MyRACFKeyRing)
```

Ring:

```
>MyRACFKeyRing<
```

Certificate Label Name	Cert Owner	USAGE	DEFAULT
CA Certificate	CERTAUTH	CERTAUTH	NO
Server Certificate	ID(FTPServer)	PERSONAL	YES

Note: RACF key rings allow for a certificate's private key to be stored into ICSF's (Integrated Cryptographic Service Facility) PKDS (Public Key Dataset) for added security.

Certificate Formats

- **X.509 certificates can exist in many different forms**
 - Single certificate
 - PKCS #7 certificate package
 - Contains 1 or more certificates
 - PKCS #12 certificate package
 - A password encrypted package containing 1 or more certificates and the private key associated with the end-entity certificate.
 - **Only package type that contains a private key**
- **Can be in binary or Base64 encoded format**

Base64 encoding

- **Converting binary data to displayable text for easy cut and paste.**

-----BEGIN CERTIFICATE-----

```
MIICPTCCAagAwIBAgIIR49S4QANLvEwDQYJKoZIhvcNAQEFBQAwNzELMAkGA1UE
BhMCVVMxDTALBgNVBAoTBFRlc3QxGTAXBgNVBAMMEFRlc3Rfc2VsZ19zaWduZWQw
HhcNMDEwMTE3MjMwNjQxMjMwNjQxMjMwNjQxMjMwNjQxMjMwNjQxMjMwNjQx
MAsGA1UEChMEVGVzdDEZMBcGA1UEAwwQVGZzdF9zZWxmX3NpZ25lZDZCbnzANBgkq
kig9w0BAQEFAAOBjQAwGyKCyYEA9tK0v5gLaceozMfMeVd891fCjBVoR+dpzhwK
R2B/QcQYBGLfQs4YM/wGSh6YrmVyg00VxocriySbcxRuBayw3pE4/3JI2myINmLp
bFIdPCnqk/qvFK+1N+nrEnBK9y1s7NmxDIuQQFFsX/o/DpoxwxzWxf+JbWDwirQR
NyLiTGMCAwEAAaNSMFAwHQYDVR0OBBYEFwDFLjOUCRa62BV53jVyHewuOWEMB8G
A1UdIwQYMBaAFAwDFLjOUCRa62BV53jVyHewuOWEMA4GA1UdDwEB/wQEAwIE8DAN
BgkqhkiG9w0BAQUFAAOBgQAC5sW1f3EdE0k9zc8wKNt1sczWkQBrVy4Rdr17ERqN
D2OfkBJQuXiNwN18pF6WPWFYg80MNwhP4oJSVePnzE1h4Wzi2w1/zI8rINSW7px3
w161z+8jEI84q/N0q0toPTAtEb6fIzwjKtctt3oF+IjunvE5QoRsXRJbbTMD/EG
jw==
```

-----END CERTIFICATE-----

Exporting Certificates through gskkyman

Key and Certificate Menu

Label: Server Certificate

- 1 - Show certificate information
- 2 - Show key information
- 3 - Set key as default
- 4 - Set certificate trust status
- 5 - Copy certificate and key to another database
- 6 - Export certificate to a file
- 7 - Export certificate and key to a file
- 8 - Delete certificate and key
- 9 - Change label
- 10 - Create a signed certificate and key
- 11 - Create a certificate renewal request

- 0 - Exit program

Enter option number (press ENTER to return to previous menu):

Exporting Certificates through gskkyman

Option 6 – Public Certificate Information

Export File Format

- 1 - Binary ASN.1 DER
- 2 - Base64 ASN.1 DER
- 3 - Binary PKCS #7
- 4 - Base64 PKCS #7

Option 7 – Public Certificate Information and Private Key

Export File Format

- 1 - Binary PKCS #12 Version 1 (Few very old applications still use V1)
- 2 - Base64 PKCS #12 Version 1
- 3 - Binary PKCS #12 Version 3
- 4 - Base64 PKCS #12 Version 3

Exporting Certificates through RACDCERT(1 of 2)

- **RACDCERT ID(userid) EXPORT**
(LABEL('label-name'))
DSN(output-data-set-name)
FORMAT(CERTDER | CERTB64 | PKCS7DER | PKCS7B64 |
PKCS12DER | PKCS12B64)
PASSWORD('pkcs12-password')

- **Example - Export Server Certificate with its private key**
 - RACDCERT ID(FTPServer) EXPORT
LABEL('Server Certificate') DSN('USER1.SERVER.CERT')
FORMAT(PKCS12DER) PASSWORD('passwd')

Exporting Certificates through RACDCERT(2 of 2)

- **Precaution needed for CERTAUTH certificate when you plan to preserve the certificate and the private key by exporting them in a pkcs12 package**
 - If the original CERTAUTH certificate got deleted and you re-add this package, the field that used for recording serial numbers that it has issued is not reserved
 - For example, if this CA certificate has issued 100 certificates, the next certificate to be issued should have serial number 101; but after re-adding it, the certificate to be issued will have serial number 1, which is already used – all the certificates issued by the same CA should have a unique serial number!

- **Before deleting CERTAUTH certificate, find out the last certificate's serial number it issued**

- **After re-adding, use r_datalib to bump up the serial number field to the appropriate number**

Summary

- **Digital certificates provide electronic identity and public key information to be utilized through public key protocols (ie. SSL/TLS)**
- **Utilizing trusted CAs is key to ensure validity of the digital certificate**
- **Protect the private key!!!**
- **Larger the public/private key pair size, greater security, but more computation intense**

Summary

- **When transferring certificates, use a format acceptable to the receiving side.**
- **When transferring certificates, be sensitive to binary and text modes to ensure proper transfer**

References

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- **RACF web site:**
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- **PKI Services web site:**
<http://www.ibm.com/servers/eserver/zseries/zos/pki>
- **IBM Redbooks**
z/OS V1 R8 RACF Implementation (SG24-7248)
- **Security Server Manuals:**
RACF Command Language Reference (SC22-7687)
RACF Security Administrator's Guide (SC28-1915)
- **Cryptographic Server Manual**
Cryptographic Services System Secure Sockets Layer Programming (SC24-5901)
- **RFCs**
RFC2459 - Internet X.509 Public Key Infrastructure Certificate and CRL Profile
RFC5280 - Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile

Questions ?

Questions
or Time for Coffee ?
See you later in
ATS4 (PKI Services)

