z/TPF V1.1

TPF Users Group Fall 2008

z/TPF Public Key Infrastructure Support

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Venue: Communications Subcommittee

AIM Enterprise Platform Software
IBM z/Transaction Processing Facility Enterprise Edition 1.1.0

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Agenda

- **Brief review of symmetric key cryptography and current z/TPF secure key management support**
- **Public key cryptography education and use cases**
- **OpenSSL and public key cryptography**
- **z/TPF PKI support preview**

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Symmetric Key Cryptography

- **The same key that encrypts the data is also used to decrypt the data**
- **Algorithms include variations of**
  - Data Encryption Standard (DES)
  - Advanced Encryption Standard (AES)
- **Can be used to encrypt small or large amounts of data**

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Current z/TPF Secure Key Management Support

- **Ability to create, manage, and use symmetric keys in a secure manner**
- **Supports DES, Triple-DES, AES-128, AES-256**
- **Uses hardware acceleration to perform cryptographic operations**
  - Scales to tens or hundreds of thousands of secure key operations per second on a single z/TPF image

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Public Key Cryptography

- **Also known as asymmetric key cryptography**
- **Public key pair**
  - Public key
    - Can be openly distributed
  - Private key
    - Must be kept secret/protected
- **Any data encrypted with a public key can only be decrypted using the corresponding private key**
- **Any data encrypted with a private key can only be decrypted using the corresponding public key**
- **Commonly used algorithm is Rivest, Shamir, and Adleman (RSA)**

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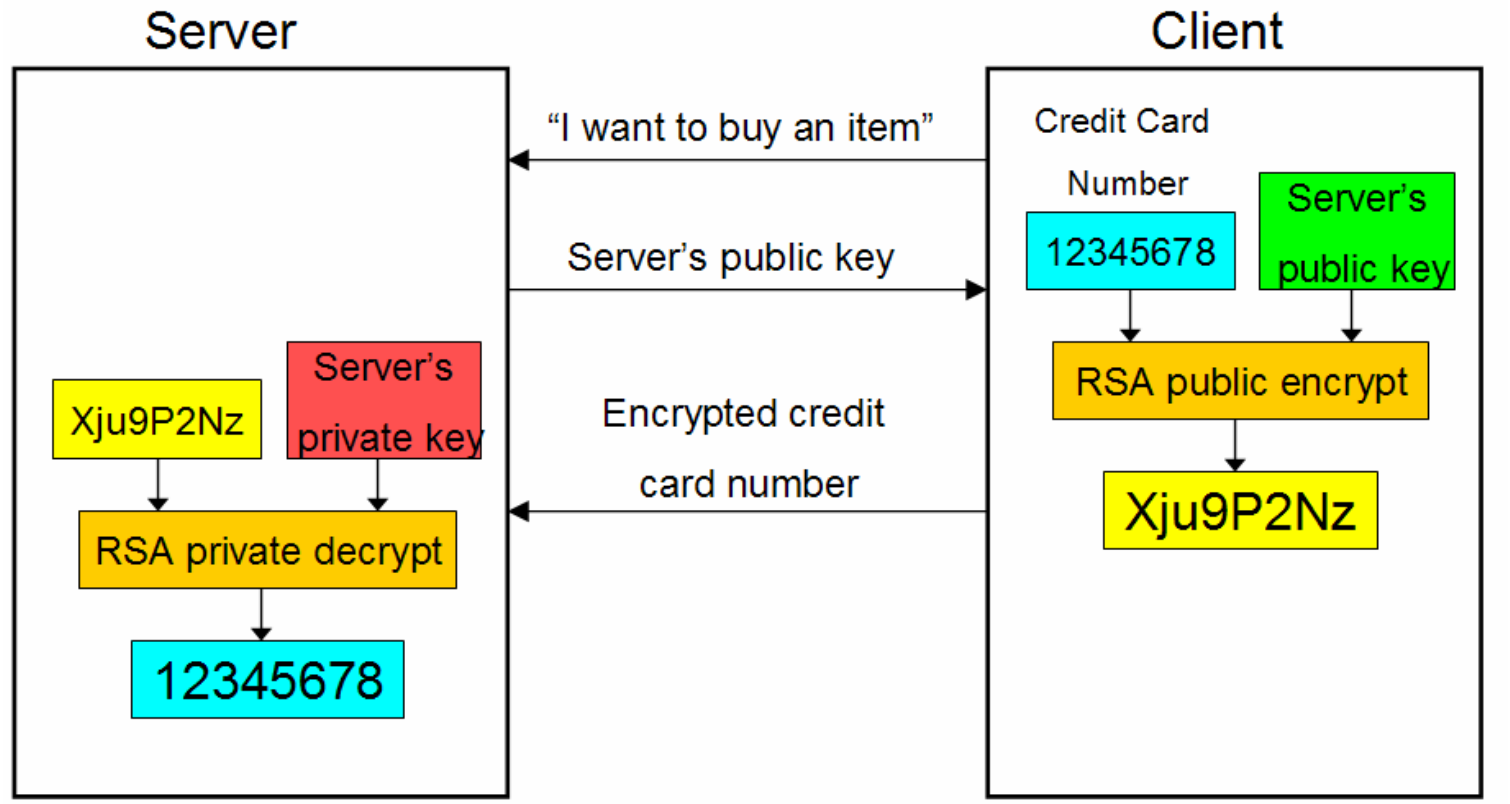
Simple Public Key Cryptography Example



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Simple Public Key Cryptography Example Steps

1. **Client wants to purchase an item from the server**
2. **Server sends its public key to the client**
3. **Client encrypts its credit card number using the server's public key**
4. **Client sends the encrypted credit card number to the server**
5. **Server decrypts the client's credit card number using the server's private key**

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Limitations of Public Key Cryptography

- **Can only encrypt small amounts of data**
  - For example, a 1024-bit RSA public key can only encrypt up to 128 bytes of data
- **Is much more computationally expensive compared to symmetric key cryptography**
  - True even when using hardware cryptography. For example on an IBM System z10 using a fixed data size:
    - One Crypto Express2 accelerator can perform up to 3000 private key decrypt operations per second (RSA 1024-bit)
    - One Central Processor Assist for Cryptographic Functions (CPACF) coprocessor can perform over 600,000 symmetric key operations per second (AES-256)

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Best Practice for Encrypting Large Amounts of Data

- **To encrypt large amounts of data efficiently:**
  1. Client creates a symmetric key (KEY1)
  2. Client encrypts KEY1 using the server's public key and sends the encrypted KEY1 to the server
  3. Server decrypts KEY1 using its private key
  4. Client and server exchange data encrypted with KEY1
- **Secure Sockets Layer (SSL) works this way**
- **Another variation is for an enterprise key manager (EKM) to create the symmetric key and distribute it to both the client and server nodes using public key cryptography**
- **Public key cryptography solves the problem of symmetric key distribution/exchange over unsecure (public) networks**

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Digital Signatures

- **Another important use case for public key cryptography is digital signatures**
- **Ability for the receiver of a message (data) to verify that the message was sent by the who the sender claims to be and that the message has not been altered after the sender built and signed the message (non-repudiation)**
- **The signed data can be in clear, encrypted, or a combination of both**

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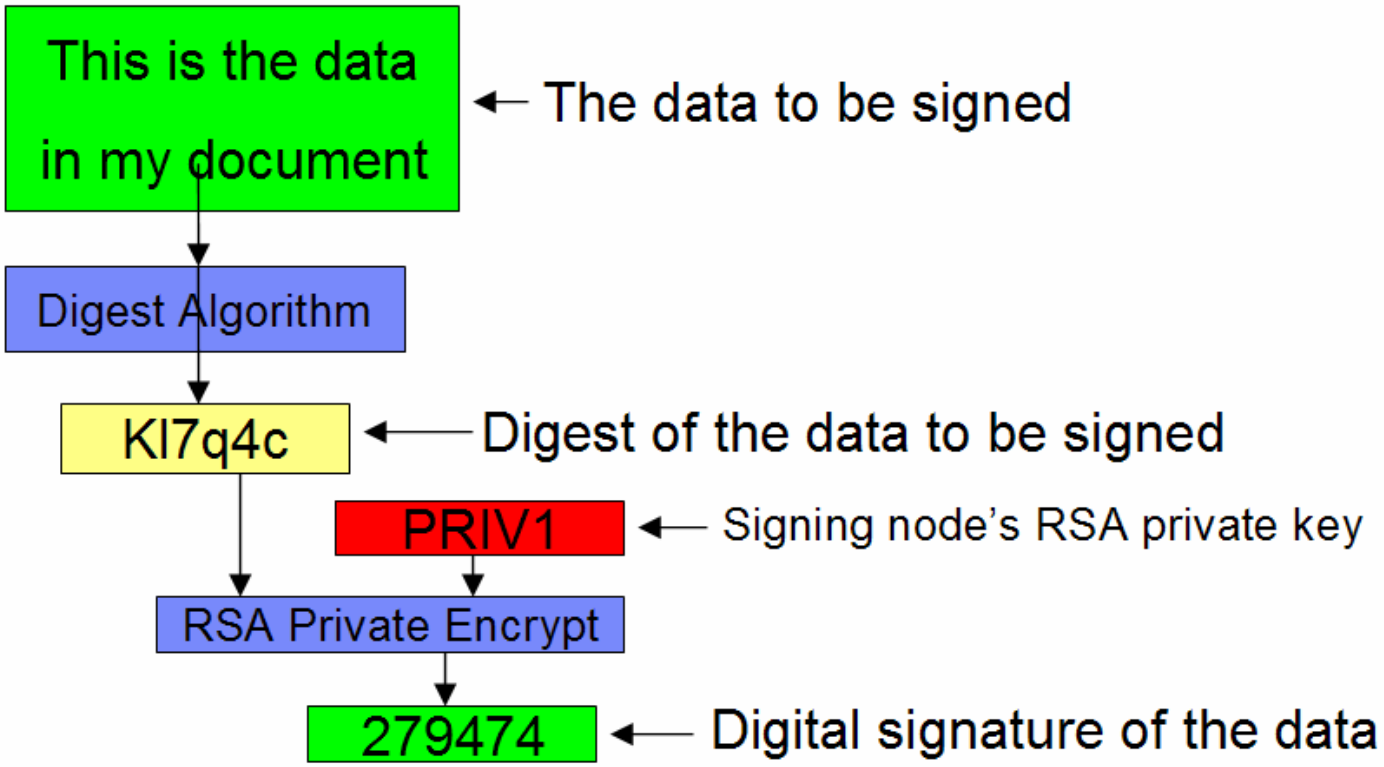
Creating a Digital Signature



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Steps for Creating a Digital Signature

1. **Create a digest of the data to be signed**
   - Produces a fixed-length digest value
     - 20 bytes for SHA-1, 32 bytes for SHA-256
2. **Encrypt the digest using your RSA private key and the result is a digital signature of the data**
3. **Attach/append the digital signature to the data**
4. **Send the data and its digital signature to the remote partner**

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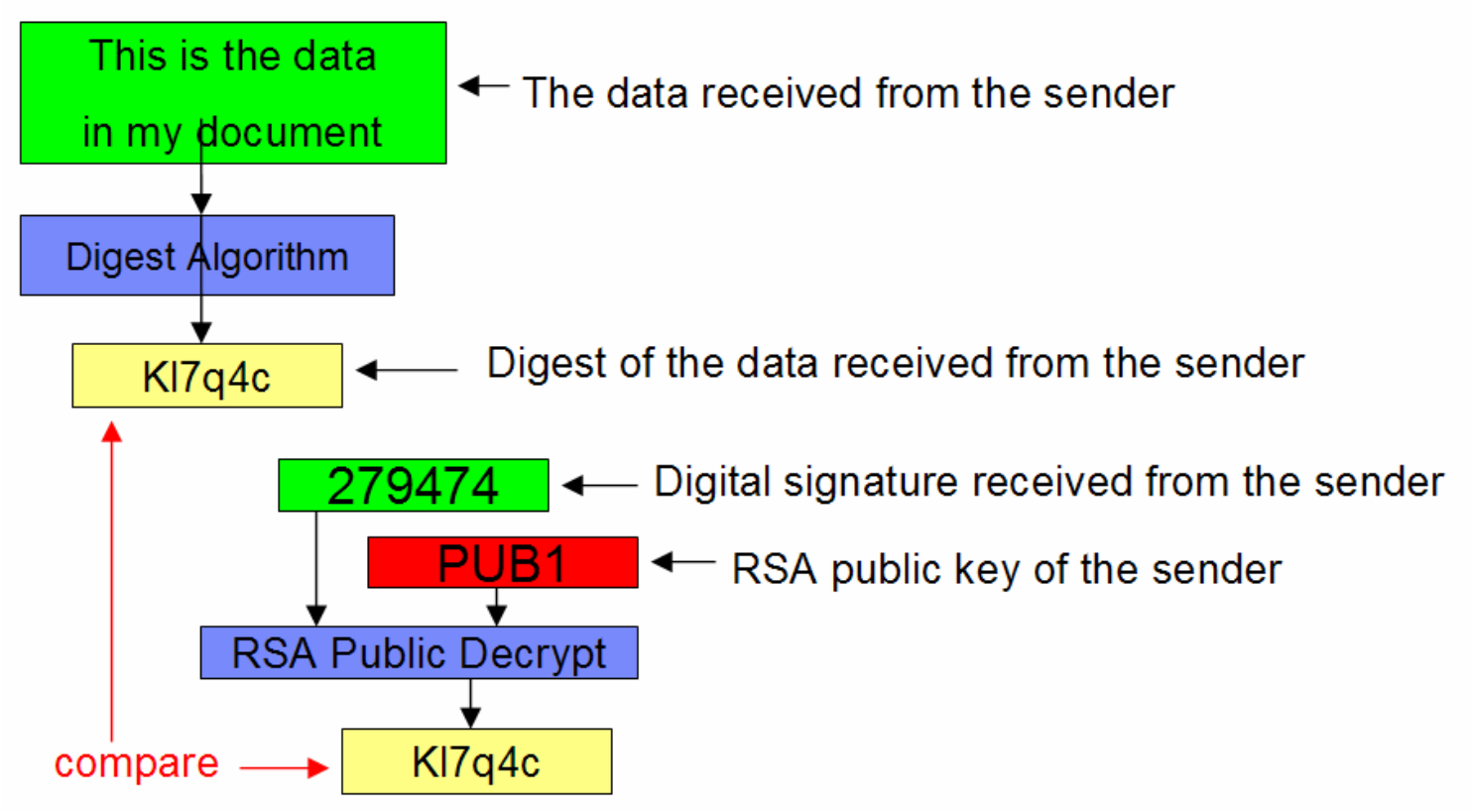
Verifying a Digital Signature



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Steps for Verifying a Digital Signature

1. **Create a digest of the data received from the sender**
2. **Take the digital signature received from the sender and decrypt it using the sender's RSA public key.**
3. **Compare the output of steps 1 and 2. If the values match, the digital signature is valid, meaning the sender did indeed send this data and the data has not been altered after it was signed by the sender**

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Considerations for Distributing Public Keys

- **It is not safe to just send your RSA public key by itself over unsecure networks to remote partners**
  - "Man in the middle" attacks can replace the real public key with the attacker's public key causing the receiver to encrypt sensitive data that the attacker will be able to decrypt/access
- **The answer to public key distribution is by using digital certificates**
  - Send your digital certificate to remote partners
    - Digital certificate contains your public key

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Digital Certificates

- **Uniquely identify a person, node, or application**
- **Are created/signed by a trusted authority called a certificate authority (CA)**
- **Have expiration date**
- **Analogous to passports issued by governments to its citizens**

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X509 version 3 Digital Certificate Contents

- **Data Section**
  - Serial number
  - Subject information (who the certificate identifies)
  - Public key of the subject
  - Issuer information (what CA created this certificate)
  - Validity period (start and end dates that the certificate can be used)
  - Optional certificate extensions to provide more information about the subject
- **Signature Section**
  - Digital signature of the information in the data section
  - Signed using the CA's private key

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Public Key Infrastructure (PKI)

- **Enables users of an unsecure (public) network to securely and privately exchange data**
- **Uses public key cryptography**
- **Public keys are shared/distributed using digital certificates that are created/signed by a trusted authority called a certificate authority (CA)**

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OpenSSL Programming Model

- **Server application issues APIs specifying the file names (in the file system) that contain:**
  - The server's private key
  - The server's digital certificate
- **If client authentication is being used, the client application must also issue APIs specifying the file names that contain:**
  - The client's private key
  - The client's digital certificate

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Private Key Files in OpenSSL

- **Having the private key in the clear in the file system or flowing across the network is a security risk**
- **When the private key file is created, you can optionally encrypt the contents (the private key) with a user specified password**
  - Applications must issue an OpenSSL API specifying the password that is needed to decrypt the information in the private key file

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Current SSL Setup Procedures for z/TPF

1. **Create an RSA key pair on another platform**
   - This also creates the RSA private key file
2. **Create a certificate request on another platform using the RSA public key from step 1 as input**
3. **Send the certificate request to a CA that will create and sign the certificate**
4. **Send (FTP) the certificate file and private key file to the z/TPF file system**

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OpenSSL Private Key Security Risks

- **SSL protocol relies/requires that the value of private key not be known by anyone other than the systems code on the node to which this private key is assigned**
- **Private key file is in the clear when sent across the network to z/TPF or in the file system**
  - Encrypting the private key file contents with a password alleviates this… somewhat
    - Operator that created the private key file knows the password
    - Application programmers also know the password as it must be coded in the applications that use this private key file
- **When the application issues the API telling the system the name of the private key file, the private key is brought into memory**
  - Private key value is in the clear in the application program's memory space
- **If the private key is compromised, anyone who finds out the private key value can access any data flowing over SSL**

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z/TPF PKI Support Basics

- **Allows you to create, manage, and use RSA key pairs in a secure manner**
  - Extends z/TPF secure key management support
- **Supports 1024-bit and 2048-bit RSA key pairs**
- **Key pair is referenced by name**
- **Private key value is secured – not visible to operators, applications, coverage, and so on**
- **Public key value is available to anyone**

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Creating an RSA Key Pair

- **Use the ZPUBK GENERATE command**
  - Specify the name of the key pair (for example, KEYPAIR1) which is how subsequent operator commands and APIs will reference/use this key pair
  - Specify the key length (1024-bit or 2048-bit)
  - RSA key pair is created and added to the PKI keystore
- **Issue additional operator commands to backup the keystore and activate the key pair making it available for use**

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Creating a Certificate

1. **z/TPF operator creates an RSA key pair called KEYPAIR1**
2. **Create a file (called myinfo.cfg in this example) containing the subject information needed to create a certificate request**
3. **Issue the ZPUBK REQCERT command. Input includes:**
   - Key pair name (KEYPAIR1) that says which public key to use
   - Name of the file (myinfo.cfg) containing the subject information
   - Name of the file (mycert.fil) into which to build the certificate request (PKCS #10 format)
4. **Send (FTP) the certificate request to the CA who will create the digital certificate**
5. **From the CA, send (FTP) the certificate to your z/TPF system**

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Self-Signed Certificates

- **A self-signed certificate is where the subject and issuer of the certificate are the same**
- **In production typically the only nodes that have/create self-signed certificates are CAs**
- **It is often convenient to have self-signed certificates for test systems**
- **To create a self-signed certificate on z/TPF**
  - Specify the SSIGNED option on the ZPUBK REQCERT command
  - Creates a certificate (self-signed) rather than a certificate request

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Solving OpenSSL Private Key Concerns

- **OpenSSL programming model cannot be changed**
  - Would break lots of middleware built on top of OpenSSL
- **SSL applications will be able to use an RSA key pair generated by z/TPF**
- **Application program still uses standard OpenSSL APIs to indicate the name of the file that contains the private key**
  - If the file name path starts with a special prefix (/tpfpubk), this tells z/TPF that the name that follows is really the name of the RSA key pair to use and not to try and open/use a file in the file system

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Solving OpenSSL Private Key Concerns (continued)

- **z/TPF operator creates an RSA key pair called KEYPAIR1**
- **To use this RSA key pair, an SSL application on z/TPF issues the *SSL_CTX_use_PrivateKey_file* API with the private key file name set to:**
  - /tpfpubk/keypair1.pem
- **The private key value is not copied into the application program's memory space**
  - Only the key pair name (KEYPAIR1) is saved in the SSL structure in the application's memory space

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Middleware using OpenSSL that Accesses Private Key File

- **Middleware using OpenSSL typically has its own configuration file that includes:**
  - The file name of the RSA private key
  - The file name of certificate
- **Some middleware opens/reads the private key file to determine whether the private key is encrypted and if so, prompts the operator for the password**
- **Some middleware also compares the public key information in the private key file to the public key in the certificate to make sure they match**

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Solving the Middleware Access Problems

- **When you create an RSA key pair on z/TPF**
  - A dummy private key file is created in the /tpfpubk directory
  - This file includes:
    - An unencrypted private key (no password needed)
      - This is NOT the real private key value!
      - Part of fake private key value includes the key pair name
    - The real public key value
- **Allows middleware to continue to work without any changes to the middleware**
  - Middleware does not have access to the real private key value

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Data Encryption Outside the Scope of SSL

- **If you create a symmetric key on z/TPF and one z/TPF complex is the only one that needs to use that key**
  - Key distribution is not an issue
  - Example – z/TPF application encrypts data before writing it out to the z/TPF database and that application reads the data (and decrypts) it later on
- **If you want exchange data with another platform and the data is encrypted at the application level using a symmetric key**
  - A key distribution mechanism is needed

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Solving the Symmetric Key Distribution Problem

- **z/TPF will support RSA key wrapping to securely import symmetric keys**
- **Remote key manager that creates the symmetric key (KEY1) will wrap (encrypt) KEY1 using z/TPF's public key**
- **The remote key manager sends the encrypted KEY1 value to z/TPF**
  - How this is done is not architected (not standardized)
- **API on z/TPF will unwrap (decrypt) the KEY1 value (using z/TPF's private key) and add KEY1 to the symmetric key keystore**
  - The KEY1 value is never in the clear during the key exchange

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How Does the Remote Key Manager get Public Key Values

- **Remote key manager needs z/TPF's public key to be able to securely send a wrapped symmetric key to z/TPF**
- **Can extract the public key on z/TPF**
  - Use the ZPUBK EXTRACT command
  - Creates a public key file containing the public key
  - Can send (secure FTP) the public key file to the remote key manager
- **The other (and more commonly used) option is to send z/TPF's certificate to the remote key manager**
  - Certificate contains z/TPF's public key

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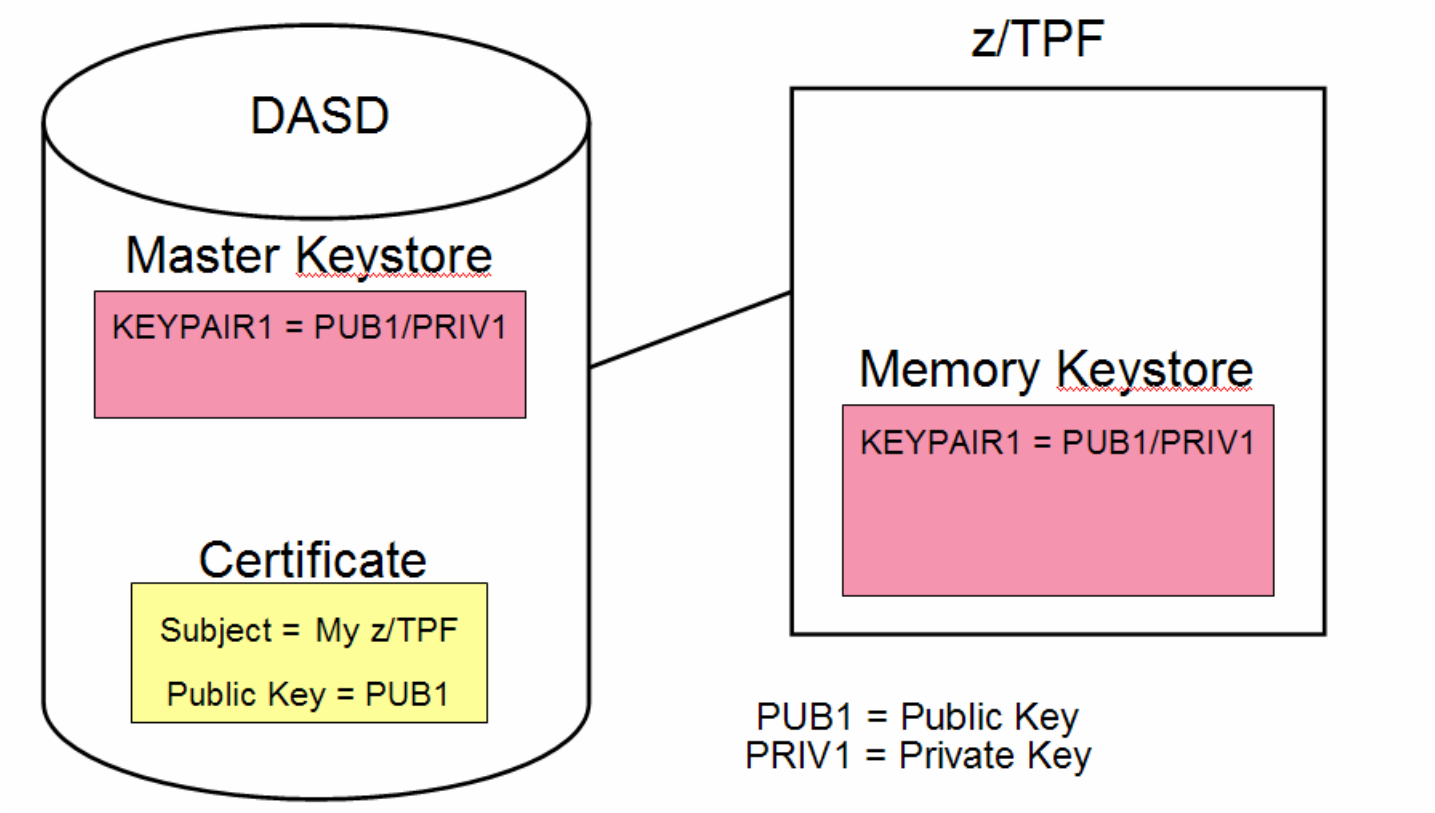
Secure Key Import Example – Step 1
Create RSA Public Key Pair (KEYPAIR1) and Certificate



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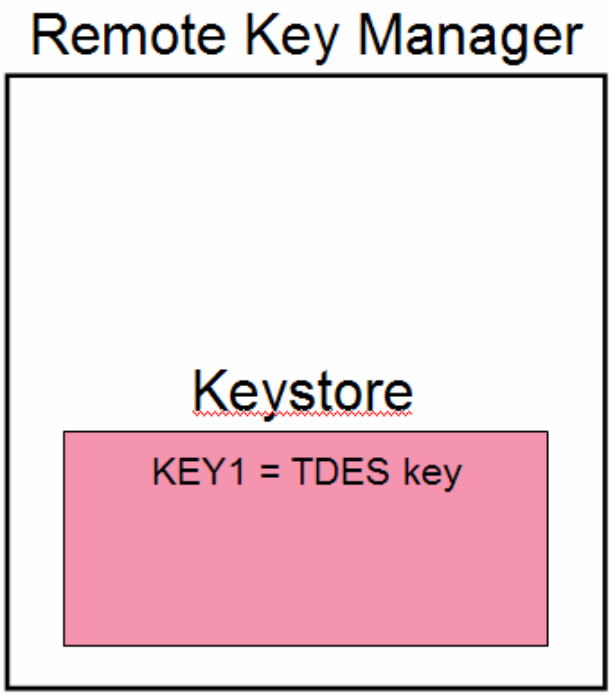
Secure Key Import Example – Step 2
Key Manager Creates Symmetric Key (KEY1) Using TDES



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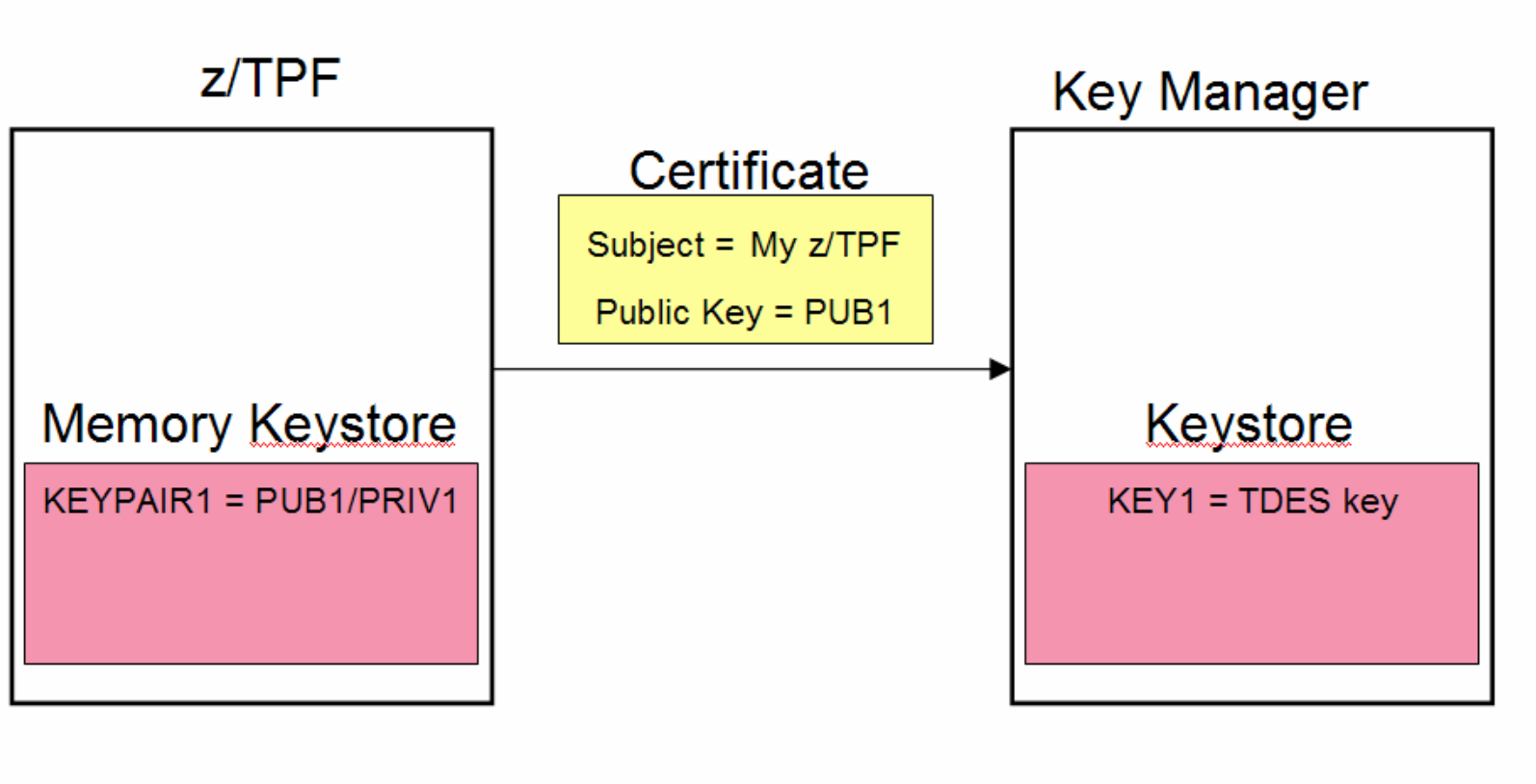
Secure Key Import Example – Step 3
Send z/TPF's Public Key (Certificate) to Key Manager



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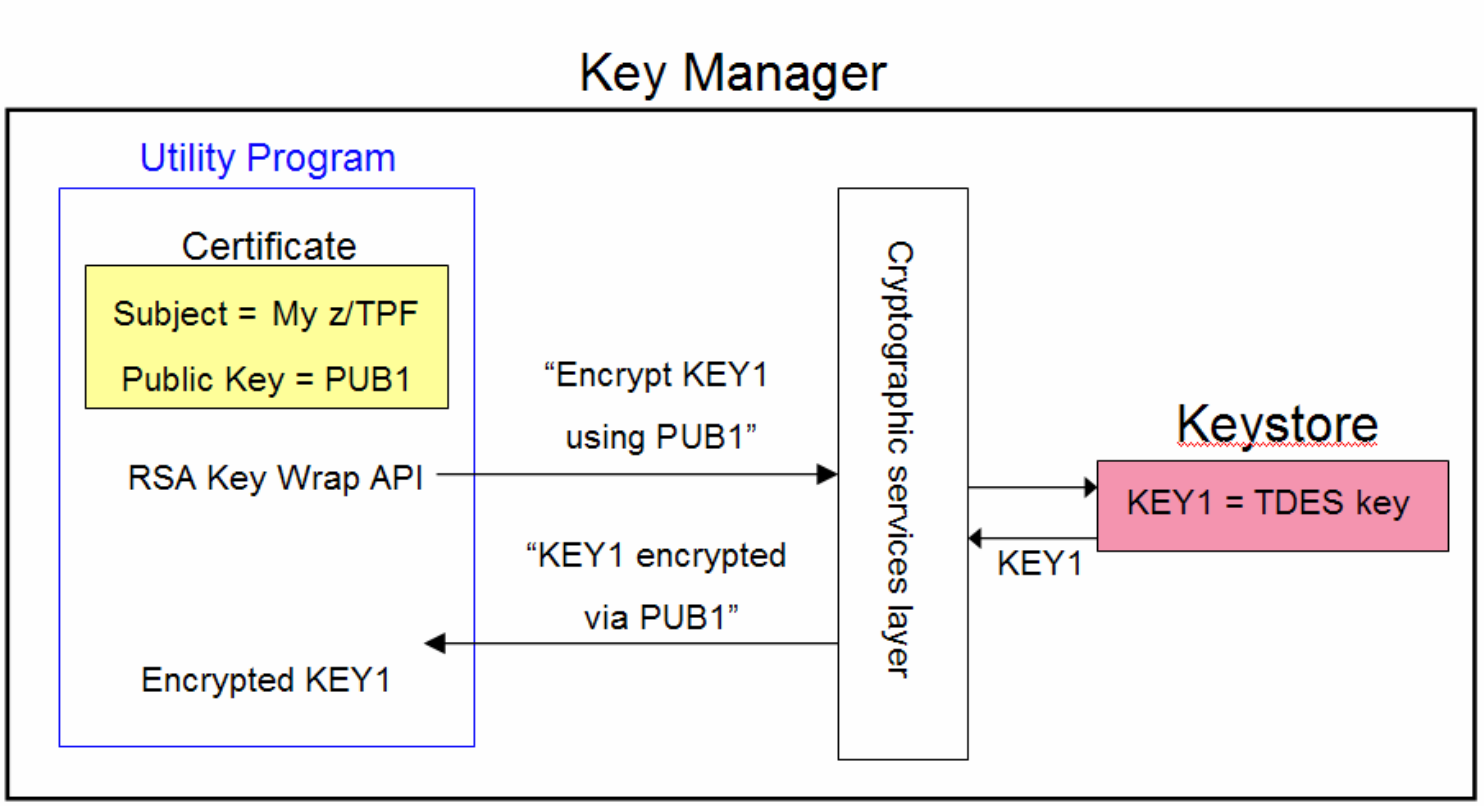
Secure Key Import Example – Step 4
Wrap Symmetric Key (KEY1) Using z/TPF's Public Key



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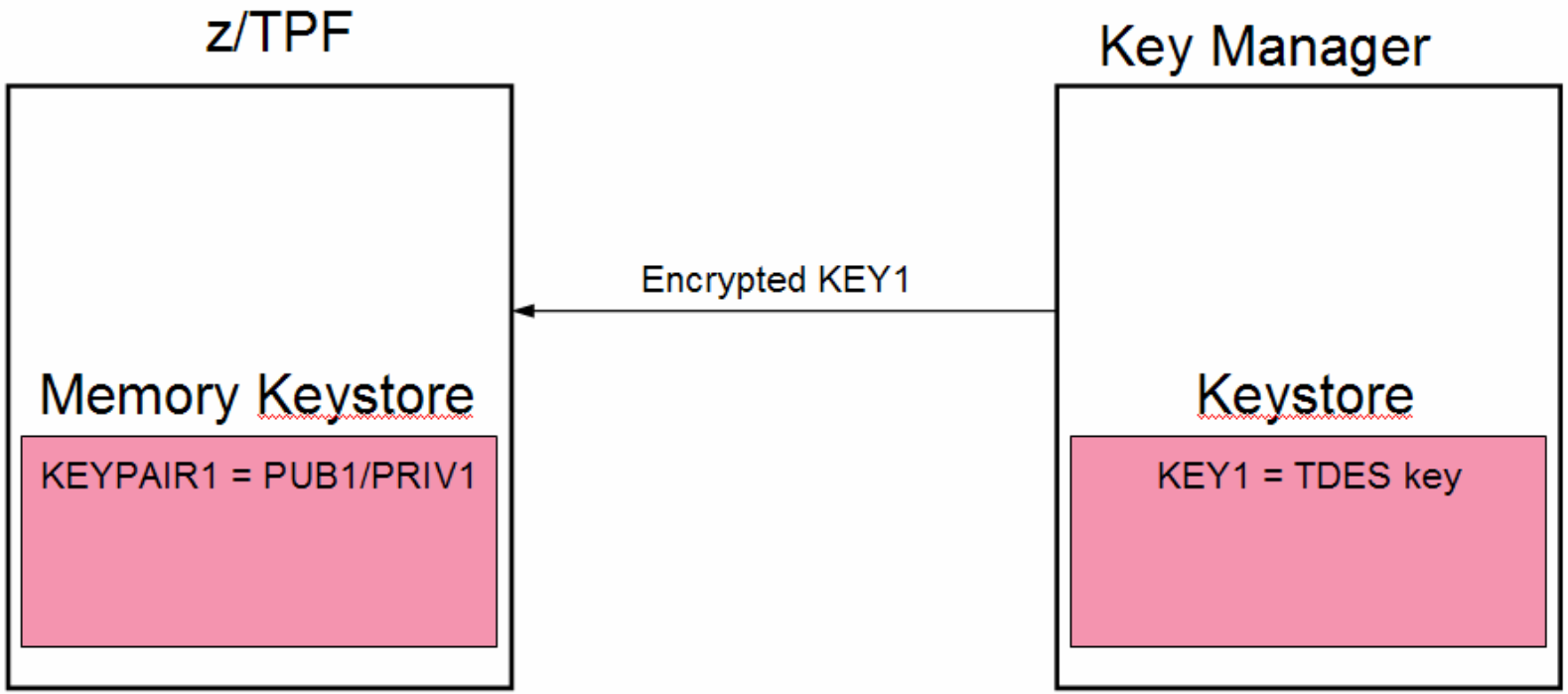
Secure Key Import Example – Step 5
Send Wrapped Symmetric Key to z/TPF



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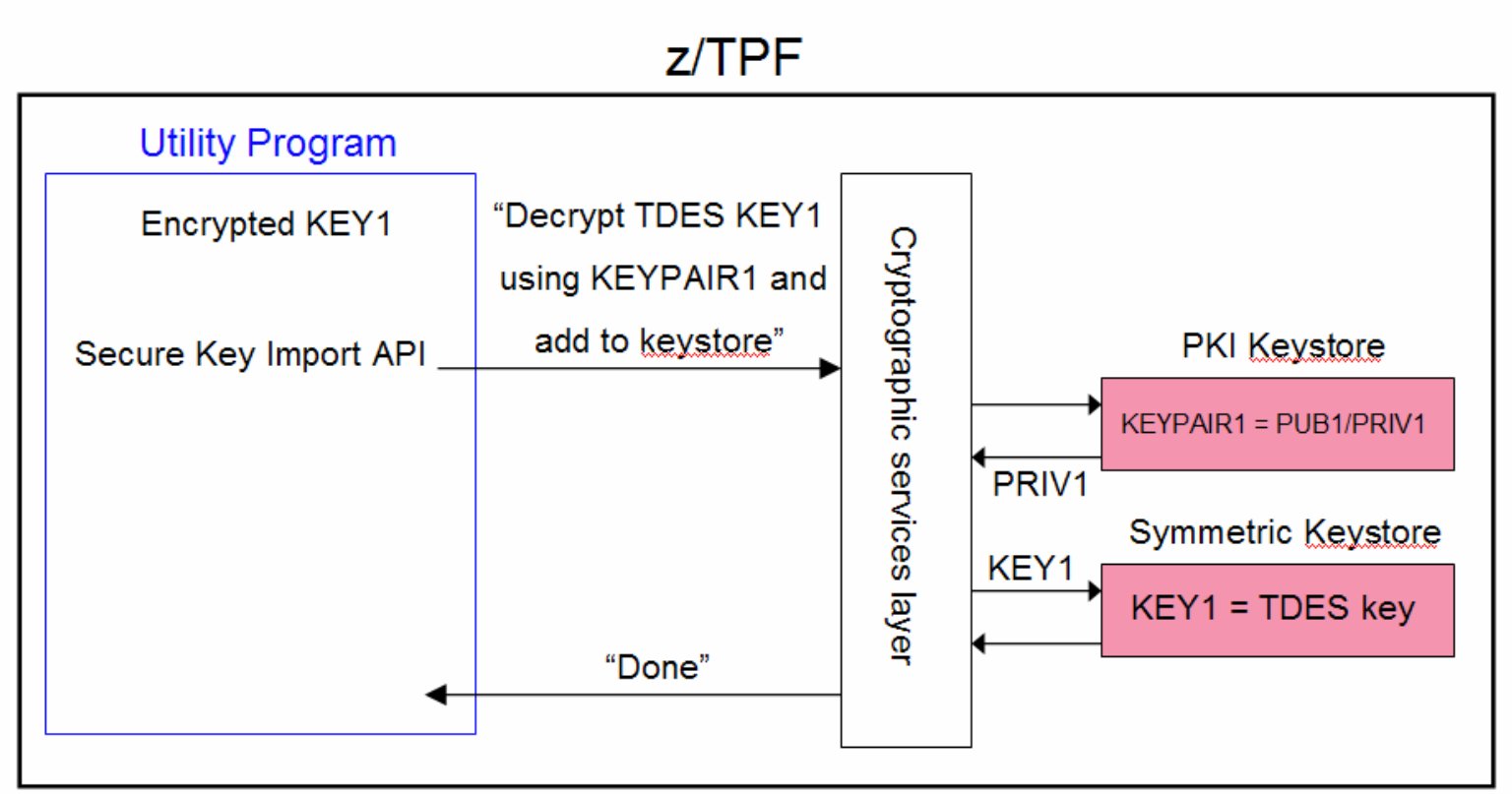
Secure Key Import Example – Step 6
Unwrap Symmetric Key (KEY1) Using z/TPF's Private Key and Add KEY1 to the z/TPF Keystore



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Initial z/TPF PKI Support Summary (statement of direction)

- Create and manage RSA public key pairs in a secure manner on z/TPF
  - Create, activate, deactivate, display, delete RSA public key pairs
  - Backup and restore the PKI keystore
- Use the RSA keys generated on z/TPF to create digital certificate requests as well as self-signed digital certificates
- Enable z/TPF SSL applications and middleware to use private keys generated by z/TPF
- Ability to extract a public key from the z/TPF keystore that can be distributed to remote partners such as key managers
- Ability to import a symmetric key in a secure manner using public key cryptography

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z/TPF PKI Support Phase 2 (statement of direction)

- **New operator command to display contents of a digital certificate in human-readable format**
- **Allow applications and middleware to use RSA directly:**
  - APIs to encrypt/decrypt user data using RSA public key cryptography
  - APIs to create and verify RSA digital signatures

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Questions?

- **Answers:**
  1. It depends
  2. No
  3. Yes
  4. We are exploring that
  5. Soon
  6. I'll be retired by then
  7. Go ask your mother

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