INFS 766
Internet Security Protocols

Lecture 10
PKCS

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PKCS

- **Public-key cryptography standards (PKCS)**
- **Owned by RSA and motivated to promote RSA**
- **Created in early 1990's**
- **Numbered from PKCS1 to PKCS15**
- **Some along the way have**
  - **lost interest**
  - **folded into other PKCS**
  - **taken over by other standards bodies**
- **Continue to evolve**

PKCS 1

- RSA Cryptography Standard
  - Version 2.0 onwards (1998)
- RSA Encryption Standard
  - Version 1.5 (1993)

PKCS 1

- Specifies how to use the RSA algorithm securely for encryption and signature
- Why do we need this?
  - Padding for encryption
  - Different schemes for signature

PKCS 1

- Chosen ciphertext attack based on multiplicative property of RSA
  - Attacker wishes to decrypt c
  - Choose r, compute c’ = $c.r^e$ mod n
  - Get victim to decrypt c’ giving $c^d.r$ mod n
  - $c^d.r.r^{-1}$ mod n = c^d mod n
- Padding destroys multiplicative property

PKCS 1

- Version 1.5, 1993
  - Encryption padding was found defective in 1998 by Bleichenbacher
  - Possible to generate valid ciphertext without knowing corresponding plaintext with reasonable probability of success (chosen ciphertext)

PKCS 1

- Version 2.0, 1998
  - Uses Optimal asymmetric encryption protocol (OAEP) by Bellare-Rogoway 1994
    - provably secure in the random oracle model
    - Informally, if hash functions are truly random, then an adversary who can recover such a message must be able to break RSA
    - plaintext-awareness: to construct a valid OAEP encoded message, an adversary must know the original plaintext
  - PKCS 1 version 1.5 padding continues to be allowed for backward compatibility
  - Accommodation for multi-prime RSA
    - Speed up private key operations

PKCS 1

- Cryptographic primitives
- Cryptographic scheme
  - Encryption scheme
  - Signature scheme
    - Signature with appendix: supported
    - Signature with message recovery: not supported
- Encoding and decoding
  - Converting an integer message into an octet string for use in encryption or signature scheme and vice versa

PKCS 1

- Cryptographic primitives
  - Encrypt RSAEP((n,e),m)
  - Decrypt RSADP((n,d),c)
  - Sign RSASP1((n,d),m)
  - Verify RSAVP1((n,e),s)
- Basically exponentiation with differently named inputs

PKCS 1

- Encryption scheme
  - Combines encryption primitive with an encryption encoding method
  - message → encoded message → integer message representative → encrypted message
- Decryption scheme
  - Combines decryption primitive with a decryption decoding method
  - encrypted message → integer message representative → encoded message → message
- Original version 1.5 scheme and new version 2.0 scheme

PKCS 1

- ❖ Signature scheme
  - ➢ Combines signature primitive with a signature encoding method
  - ➢ message → encoded message → integer message representative → signature
- ❖ Decryption scheme
  - ➢ Combines verification primitive with a verification decoding method
  - ➢ signature → integer message representative → encoded message → message
- ❖ Original version 1.5 scheme
  - ➢ Signature with appendix

PKCS 1

- ❖ The future
- ❖ Probabilistic signature scheme (PSS)
  - ➢ Provably secure in random oracle model
  - ➢ Natural extension to message recovery

PKCS 5

- ❖ Password-Based Cryptography Standard
  - ➢ Version 1.5, 1993
  - ➢ Version 2.0, 1999
- ❖ Oriented towards protection of private keys
- ❖ Does not specify a standard for password format

PKCS 5

- ❖ Password-based key derivation function
  - ➢ Key = PBKDF(passwd, salt, iteration count)
- ❖ salt allows same password to give many keys
  - ➢ May actually have same password
  - ➢ Separate dictionary attack for every salt
- ❖ Iteration count controls complexity of dictionary attack

PKCS 5

- Version 1.5 PBKDF1
  - Key size limited to 160 bits
  - Only MD5 and SHA as underlying hash functions
  - Assumes key will be used for CBC
  - 8-byte salt
  - No security proof

PKCS 5

- Version 2.0 adds PBKDF2
  - Arbitrary length key
  - Any underlying hash function, most likely with HMAC
  - Salt not fixed at 8 bytes
  - Provable security in random oracle model

PKCS 5

- ❖ Encryption schemes
  - ➢ PBES1
    - PBKDF1 with DES or RC2 in CBC
  - ➢ PBES2
    - PBKDF2 with some underlying encryption scheme
- ❖ MAC scheme
  - ➢ PBMAC1
    - PBKDF2 with some underlying MAC scheme

PKCS 10

- ❖ Certification Request Syntax Standard
- ❖ Specifies format of unsigned certificate requested to be signed
- ❖ Does not specify format of returned signed certificate

PKCS 10

- Version 1.0, 1993
  - In widespread use
- Version 1.5, 1998
- Version 1.7, 2000
  - Minor changes such as references to PKCS 6 replaced by references to X.509v3

PKCS 10

- CertificationRequestInfo
  - version
  - subjectName
  - subjectPublicKeyInfo
  - attributes

PKCS 10

- **CertificationRequest**
  - **certificationRequestInfo**
  - **signatureAlgorithm**
  - **signature**
- **Signed with private key corresponding to public key in request**
  - **very RSA specific**
  - **IETF RFC 2511 defines a different format: certificate request message format**

PKCS 8

- **Private-Key Information Syntax Standard**
  - **Version 1.2, 1993**

PKCS 8

- ❖ PrivateKeyInfo
  - ➢ version
  - ➢ privateKeyAlgorithm
  - ➢ privateKey
  - ➢ attributes

PKCS 8

- ❖ encryptedPrivateKeyInfo
  - ➢ encryptionAlgorithm
  - ➢ encryptedData
    - privateKeyInfo BER-encoded and encrypted
- ❖ Usually encrypted using PKCS 5

PKCS 12

- ❖ Personal Information Exchange Syntax Standard
  - ➢ Version 1, 1999
- ❖ Builds on PKCS 8
- ❖ Further evolution PKCS 15

PKCS 12

- ❖ 6 types of information
  - ➢ PKCS 8 shrouded key
  - ➢ Private key
  - ➢ Certificates
    - X.509v3
    - SDSI
  - ➢ CRLs
    - X.509
  - ➢ Secret
    - Whatever
  - ➢ Recursive composition of these

PKCS 12

- ❖ Each of these can be
  - ➢ Plaintext
  - ➢ Enveloped
    - Encrypted using a secret key which is encrypted using a public key
  - ➢ Encrypted
    - Secret key encrypted
    - Usually password derived
      - – Use PKCS 5 and a password formatting standard which is part of PKCS 12

PKCS 12

- ❖ The entire stuff is then either
  - ➢ Signed
    - And accompanied with signing certificate
  - ➢ MAC’ed
    - PKCS 5 based and accompanied with salt and iteration count
- ❖ Notice: opposite of usual sequence
  - ➢ Encrypt and then authenticate, versus
  - ➢ Authenticate and then encrypt

PKCS
DISCONTINUED OR DISINTERESTED

- **PKCS 2**
  - **discontinued, incorporated into PKCS 1**
- **PKCS 3**
  - **Diffie-Hellman Key Agreement, 1993**
- **PKCS 4**
  - **discontinued, incorporated into PKCS 1**

PKCS
TAKEN OVER BY OTHERS

- **PKCS 6**
  - **Extended Certificate Syntax Standard**
  - **Taken over by X.509v3**
- **PKCS 7**
  - **Cryptographic Message Syntax Standard**
  - **Taken over by IETF PKIX CMS**

PKCS 9

- ❖ **PKCS 9**
  - ➢ **Selected Attribute Types**
  - ➢ **For use in PKCS 6, 7, 8, 10**

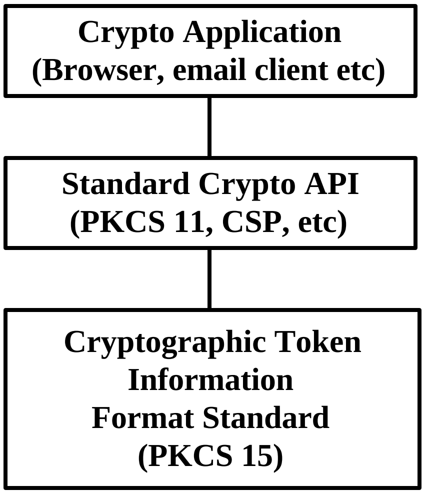
PKCS 11

- ❖ **PKCS 11**
  - ➢ **Cryptographic Token Interface Standard**
  - ➢ **API used by Netscape (pre 6.0)**
  - ➢ **Microsoft CSP (Cryptographic Service Provider) is a competitor**

PKCS
IN DEVELOPMENT

- **PKCS 13 (new, in development)**
  - **Elliptic Curve Cryptography Standard**
  - **There are IEEE standards, so not clear why**
- **PKCS 14 (new, in development)**
  - **Pseudorandom Number Generation Standard**
- **PKCS 15 (new, in development)**
  - **Cryptographic Token Information Format Standard**
  - **Crypto API neutral**

PKCS 11 vs PKCS 15


Crypto Application
(Browser, email client etc)

Standard Crypto API
(PKCS 11, CSP, etc)

Cryptographic Token
Information
Format Standard
(PKCS 15)