



Cryptography and Network Security

Chapter 6

Electronic Mail Security

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Outline

- Pretty Good Privacy
- S/MIME

Electronic Mail Security

- In virtually all distributed environments, electronic mail is the most heavily used network-based application.
- Users expect to be able to, and do, send e-mail to others who are connected directly or indirectly to the Internet, regardless of host operating system or communications suite
- With the explosively growing reliance on e-mail, there grows a demand for authentication and confidentiality services
- Two schemes in use: Pretty Good Privacy (PGP) and S/MIME

Electronic Mail Security

- Currently message contents are not secure
 - may be inspected either *in transit*
 - or by suitably privileged users on *destination system*
- PGP provides a *confidentiality* and *authentication* service that can be used for electronic mail and file storage applications

Email Security Enhancements

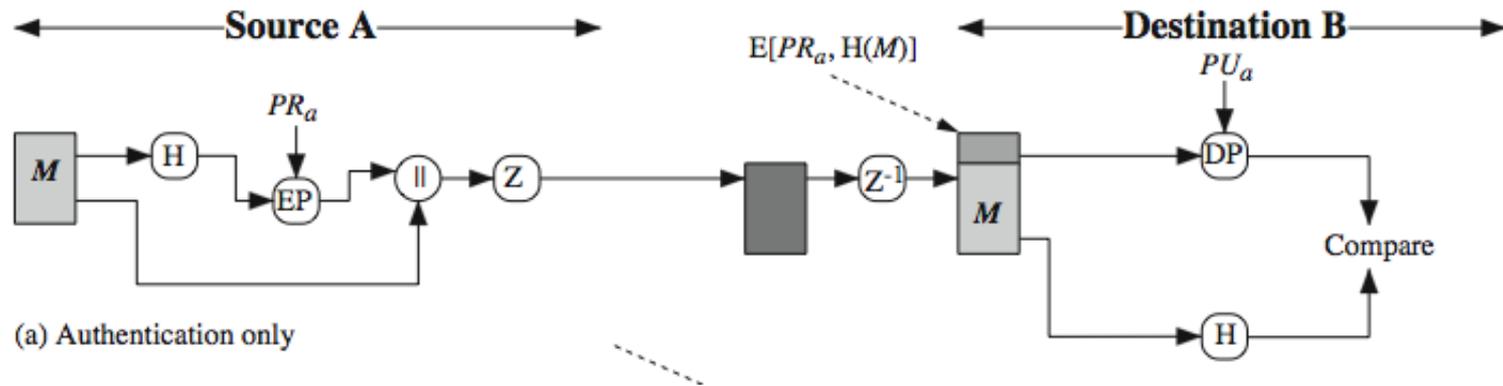
- **Confidentiality**
 - protection from disclosure
- **Authentication**
 - of sender of message
- **Message integrity**
 - protection from modification
- **Non-repudiation of origin**
 - protection from denial by sender

Pretty Good Privacy (PGP)

- widely used de facto secure email
- developed by Phil Zimmermann
- selected **best available crypto algorithm** to use
- integrated into a single program
- on Unix, PC, Macintosh and other systems
- originally free, now also have commercial versions available

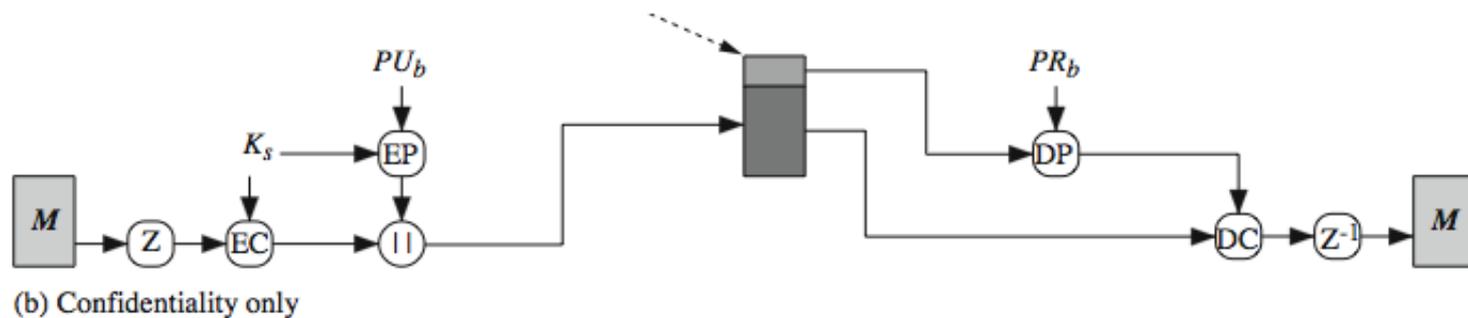
PGP Operation - Authentication

1. sender creates message
2. make SHA-1160-bit hash of message
3. attached RSA signed hash to message
4. receiver decrypts & recovers hash code
5. receiver verifies received message hash



PGP Operation - Confidentiality

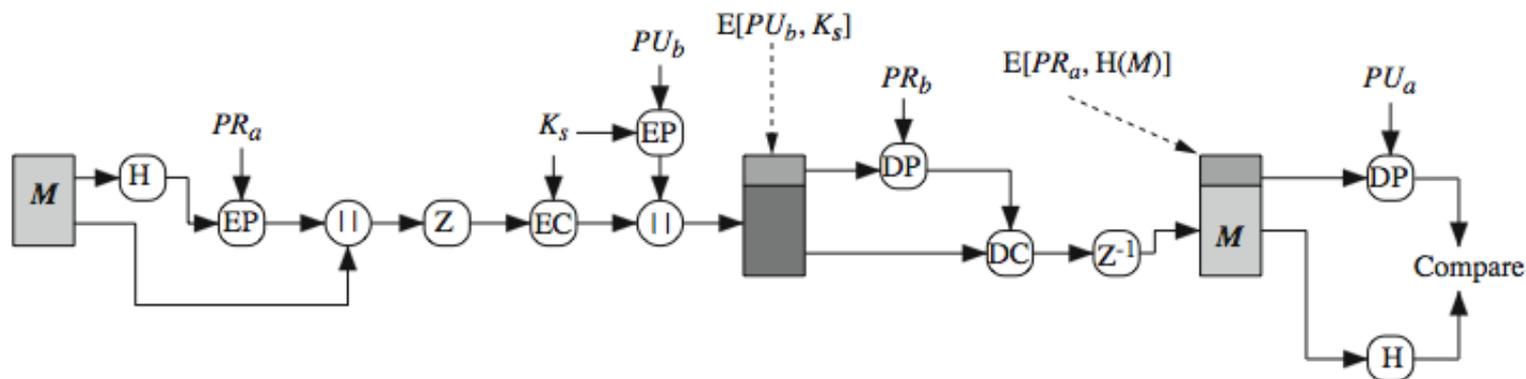
1. sender forms 128-bit random session key
2. encrypts message with session key
3. attaches session key encrypted with RSA
4. receiver decrypts & recovers session key
5. session key is used to decrypt message



PGP – Authentication & Confidentiality

Can use both services on same message

- create signature & attach to message
- encrypt both message & signature
- attach RSA/ElGamal encrypted session key



(c) Confidentiality and authentication

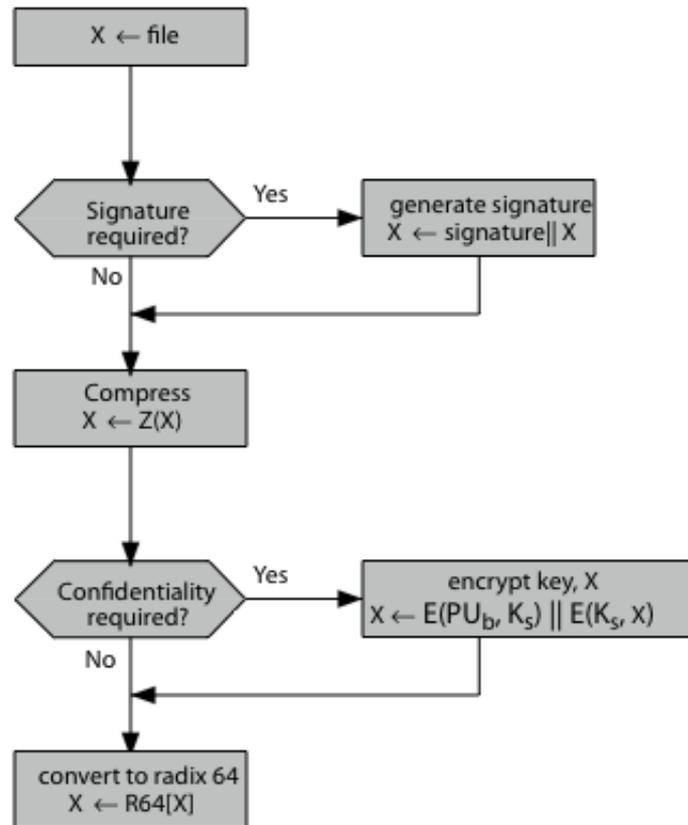
PGP Operation - Compression

- by default PGP compresses message **after** signing but **before** encrypting
 - so can store uncompressed message & signature for later verification
 - & because compression is non deterministic
- uses ZIP compression algorithm

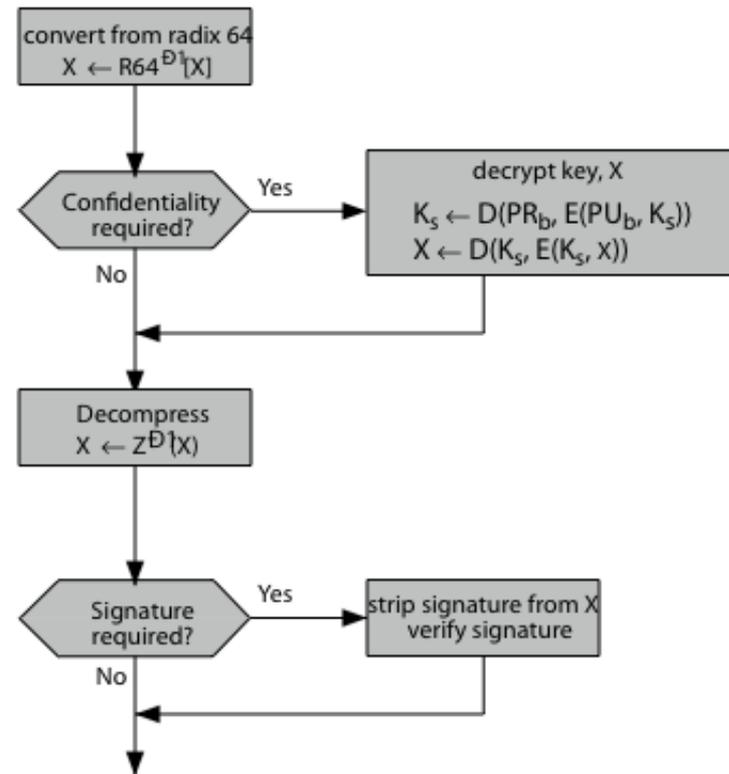
PGP Operation – Email Compatibility

- When PGP is used, at least part of the block to be transmitted is encrypted
- However email was designed only for text
- Hence PGP must encode raw binary data into printable ASCII characters
- Uses radix-64 algorithm
 - maps 3 bytes to 4 printable chars
 - also appends a CRC
- PGP also segments messages if too big

PGP Operation – Summary



(a) Generic Transmission Diagram (from A)



(b) Generic Reception Diagram (to B)

S/MIME

- **Secure/Multipurpose Internet Mail Extensions**
- **security enhancement to MIME email**
 - original Internet RFC822 email was text only
 - MIME provided support for varying content types and multi-part messages
 - with **encoding** of binary data **to** textual form
 - S/MIME added security enhancements
- **have S/MIME support in many mail agents**
 - eg MS Outlook, Mozilla, Mac Mail etc

S/MIME Functions

- **enveloped data**
 - encrypted content and associated keys
- **signed data**
 - encoded message + signed digest
- **clear-signed data**
 - cleartext message + encoded signed digest
- **signed & enveloped data**
 - nesting of signed & encrypted entities

S/MIME Cryptographic Algorithms

- **Digital signatures: DSS & RSA**
- **Hash functions: SHA-1 & MD5**
- **Session key encryption: ElGamal & RSA**
- **Message encryption: AES, Triple-DES, RC2/40 and others**
- **MAC: HMAC with SHA-1**
- **Have process to decide which algorithms to use**

S/MIME Messages

- S/MIME secures a MIME entity with a signature, encryption, or both
- Forming a MIME wrapped PKCS object
- Have a range of content-types:
 - enveloped data
 - signed data
 - clear-signed data
 - registration request
 - certificate only message

S/MIME Certificate Processing

- S/MIME uses X.509 v3 certificates
- managed using a hybrid of a strict X.509 CA hierarchy & PGP's web of trust
- each client has a *list of trusted CA's certificates*
- and own public/private key pairs & certificates
- certificates must be signed by trusted CA's

Certificate Authorities

- have several well-known CA's
- Verisign one of most widely used
- Verisign issues several types of Digital IDs
- increasing levels of checks & hence trust

Class	Identity Checks	Usage
1	name/email check	web browsing/email
2	+ enroll/addr check	email, subs, s/w validate
3	+ ID documents	e-banking/service access

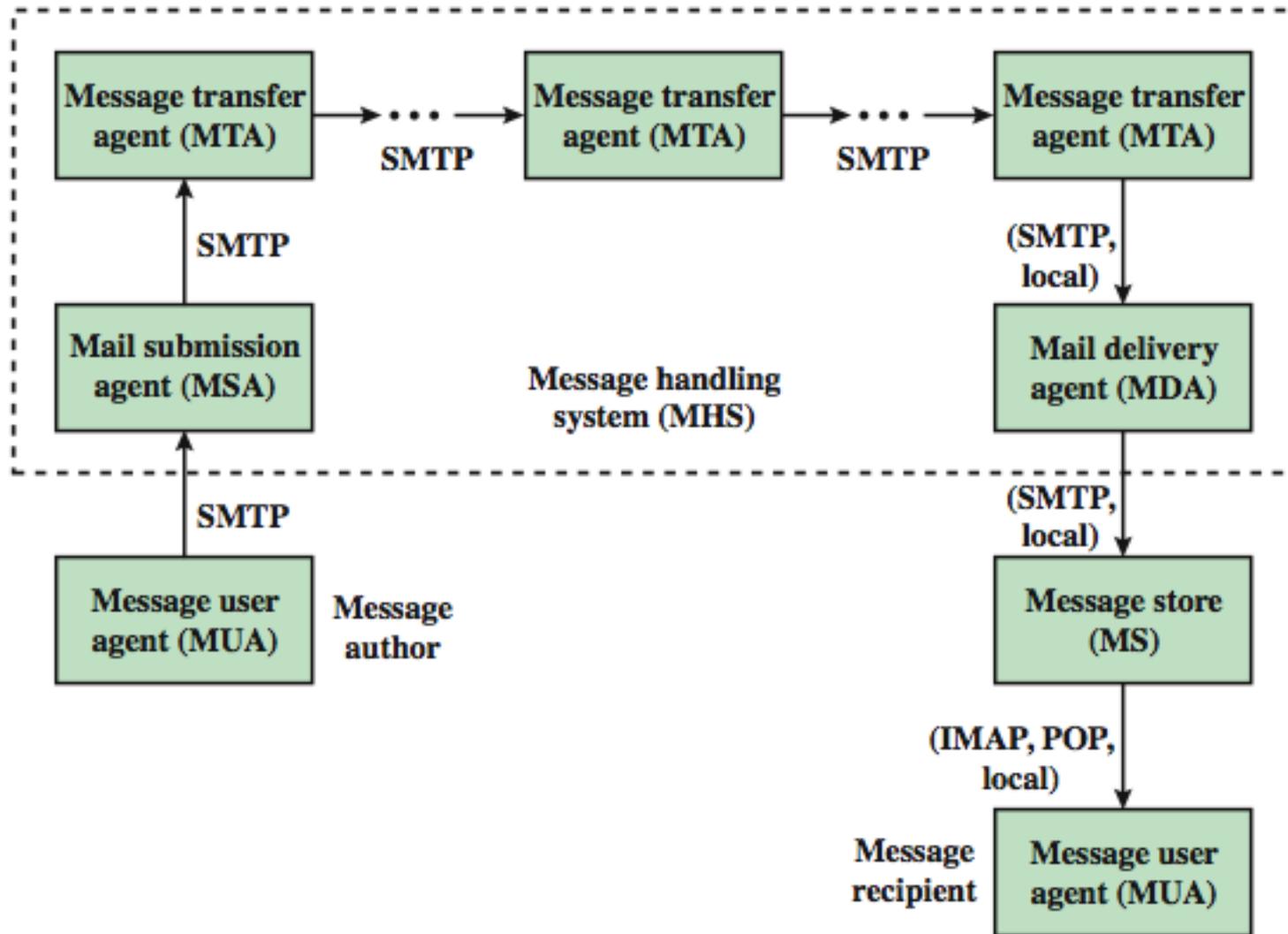
S/MIME Enhanced Security Services

- **3 proposed enhanced security services:**
 - signed receipts
 - security labels
 - secure mailing lists

Domain Keys Identified Mails

- a specification for cryptographically signing email messages
- so signing domain claims responsibility
- recipients / agents can verify signature
- proposed Internet Standard RFC 4871
- has been widely adopted

Internet Mail Architecture



Email Threats

- see RFC 4684- *Analysis of Threats Motivating DomainKeys Identified Mail*
- describes the problem space in terms of:
 - range: low end, spammers, fraudsters
 - capabilities in terms of where submitted, signed, volume, routing naming etc
 - outside located attackers

Summary

We have discussed:

- Pretty Good Privacy
- S/MIME

References

1. Cryptography and Network Security, Principles and Practice, William Stallings, Prentice Hall, Sixth Edition, 2013