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CYB 630
Email Security

Lecture 10



- Understand email basics,
- Explain email security,
- Explain email security threats,
- Explain Pretty Good Privacy (PGP),
- Explain Secure/Multipurpose Internet Mail Extension (S/MIME).

- E-mail is a computer-based application for the exchange of messages between users.
- A worldwide e-mail network allows people to exchange e-mail messages very quickly.
- E-mail is the electronic equivalent of a letter, but with advantages in timeliness and flexibility.

Three major components:

- user agents
- mail servers
- simple mail transfer protocol (SMTP)

User Agent or mail reader

- composing, editing, and reading mail messages. Examples of user agents are (i)Outlook and (ii)Thunderbird
- Outgoing, and incoming messages stored on the server

Mail servers:

- mailbox contains incoming messages for the user
- message queue of outgoing (to be sent) mail messages

SMTP protocol between mail servers to send email messages

- Client: sending mail server
- Server: receiving mail server

Scenario: Alice sends message to Bob

1. Alice uses UA to compose a message “to” bob@some school.edu
2. Alice’s UA sends the message to her mail server; the message is placed in the message queue.
3. The client side of SMTP opens a TCP connection with Bob’s mail server.
4. SMTP client sends Alice’s message over the TCP connection.
5. Bob’s mail server places the message in Bob’s mailbox.
6. Bob invokes his user agent to read the message.

- Email is the most popular and well-regarded network services
- Email contents are not secure
 - may be inspected in transit
 - or by suitably privileged users on the destination system

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

Common email security threats

Delivering malware through spam

- Malware is one of the most dangerous, yet frequent threats is malware, which is frequently transmitted through emails.
- Victims are readily tricked into downloading malicious files by spam messages that pretend to be legitimate senders like clients, partners, or suppliers.
- Victims usually are unaware that they are downloading malware onto their systems.
- The process of infecting the entire IT infrastructure might take days or even months. The attackers can stealthily gain control of the victim's computer and then infiltrate the company IT network to distribute the malware to neighboring computers.

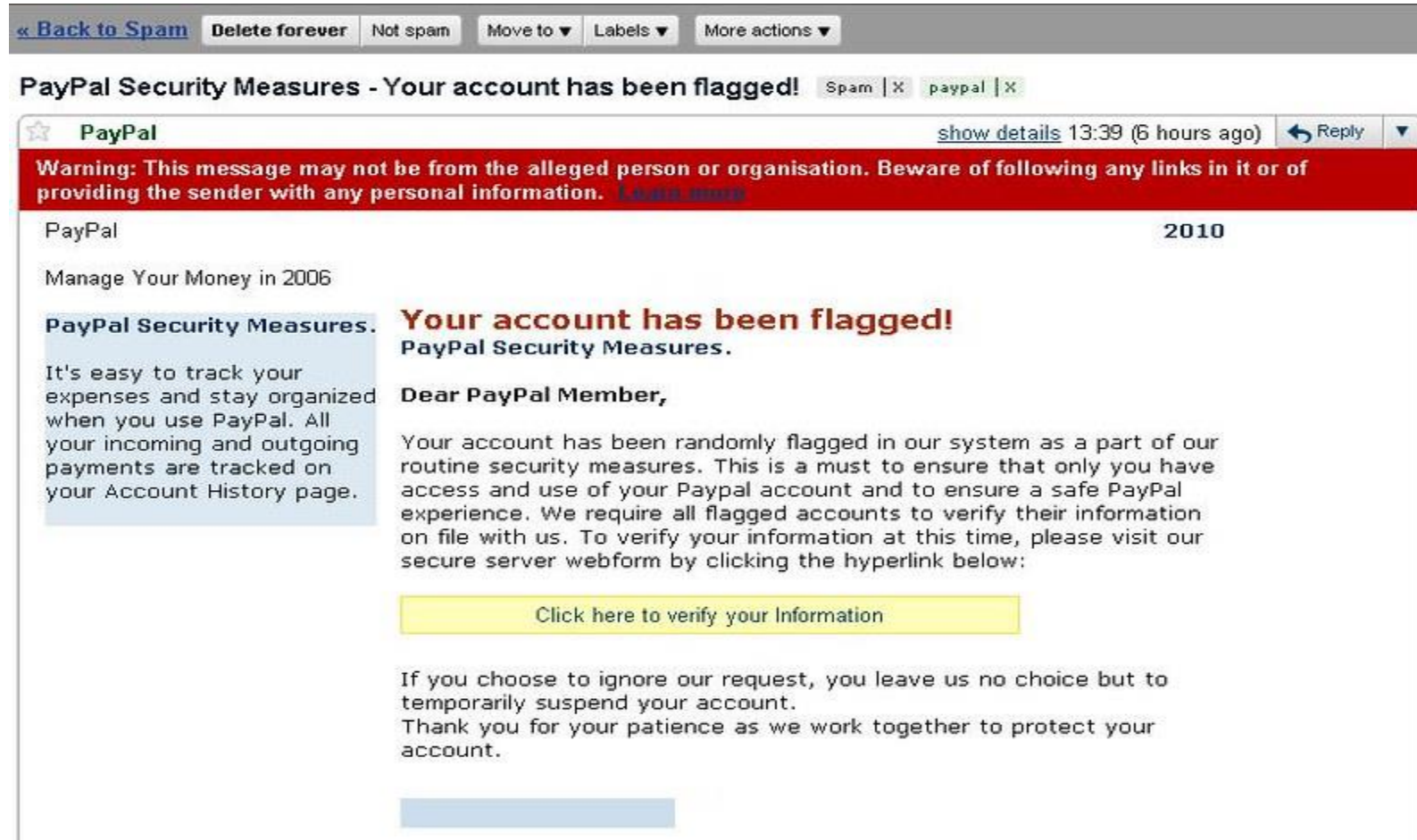
Common email security threats (cont.)

Credential Theft via Phishing Emails

- Phishing emails are quite like spam, with the exception that they are more personalized and frequently intended to trick victims into directly disclosing sensitive information.
- For example, attackers could somehow acquire a list of customer data from a financial institution, possibly leaked from a previous data breach.
- The list may contain the customers' names, email addresses, bank account numbers, and perhaps other personal information.
- The attackers may utilize this list to create spear-phishing emails that are extremely convincing in order to trick the victims into clicking a bogus link that asks them to enter their online banking login information.

Common email security threats (cont.)

Credential Theft via Phishing Emails



Common email security threats (cont.)

Malicious Bot and DDoS Attacks

- Attackers can employ compromised botnets to send a myriad number of emails to a targeted organization, resulting in the email server crashing from system overload, similar to what a traditional DDoS attack does to the victim's web server.
- B2B companies are more likely to be the target of DDoS attacks on their email servers because a significant portion of their sales is conducted via email.

Common email security threats (cont.)

Authentication Attacks on mail servers

- Attackers may choose to concentrate on the email inbox itself. In this scenario, attackers would try to access the email server by breaking authentication via brute force, credential stuffing, and other techniques.
- As a result, the attackers would then have access to any email messages and attachments kept on the system

- PGP stands for Pretty Good Privacy which is invented by Phil Zimmermann.
- PGP was designed to provide all four aspects of security, i.e., privacy, integrity, authentication, and non-repudiation in the sending of email.
- PGP uses a digital signature to provide integrity, authentication, and non-repudiation.
- PGP uses a combination of secret key encryption and public key encryption to provide privacy. Therefore, we can say that the digital signature uses one hash function, one secret key, and two private-public key pairs.
- PGP is an open-source and freely available software package for email security.

- PGP provides authentication through the use of a Digital Signature.
- It provides confidentiality through the use of symmetric block encryption.
- It provides compression by using the ZIP algorithm, and EMAIL compatibility using the radix-64 encoding scheme.
- Available as a plug-in for popular e-mail clients, can also be used as stand-alone software.
 - Microsoft Exchange
- - outlook

- **Based on well-known algorithms**
 - These algorithms have survived extensive public review and are considered extremely secure.
 - Integrated these algorithms into a general-purpose application
- It is cross-platform (can run on Windows, UNIX, Macintosh, etc.)
 - Open and free code.
- **Wide range of applicability** from corporations that wish to select and enforce standardized security to individuals
- **Independent** – meaning not developed or controlled by governmental or standards organizations
 - Based on mutual trust between clients

Digital signature	DSS/SHA or RSA/SHA	A hash code of a message is created using SHA-1. This message digest is encrypted using DSS or RSA with the sender's private key and included with the message.
Message encryption	CAST or IDEA or Three-key Triple DES with Diffie-Hellman or RSA	A message is encrypted using CAST-128 or IDEA or 3DES with a one-time session key generated by the sender. The session key is encrypted using Diffie-Hellman or RSA with the recipient's public key and included with the message.

Compression	ZIP	A message may be compressed, for storage or transmission, using ZIP.
Email compatibility	Radix 64 conversion	To provide transparency for email applications, an encrypted message may be converted to an ASCII string using radix 64 conversion.
Segmentation		To accommodate maximum message size limitations, PGP performs segmentation and reassembly.

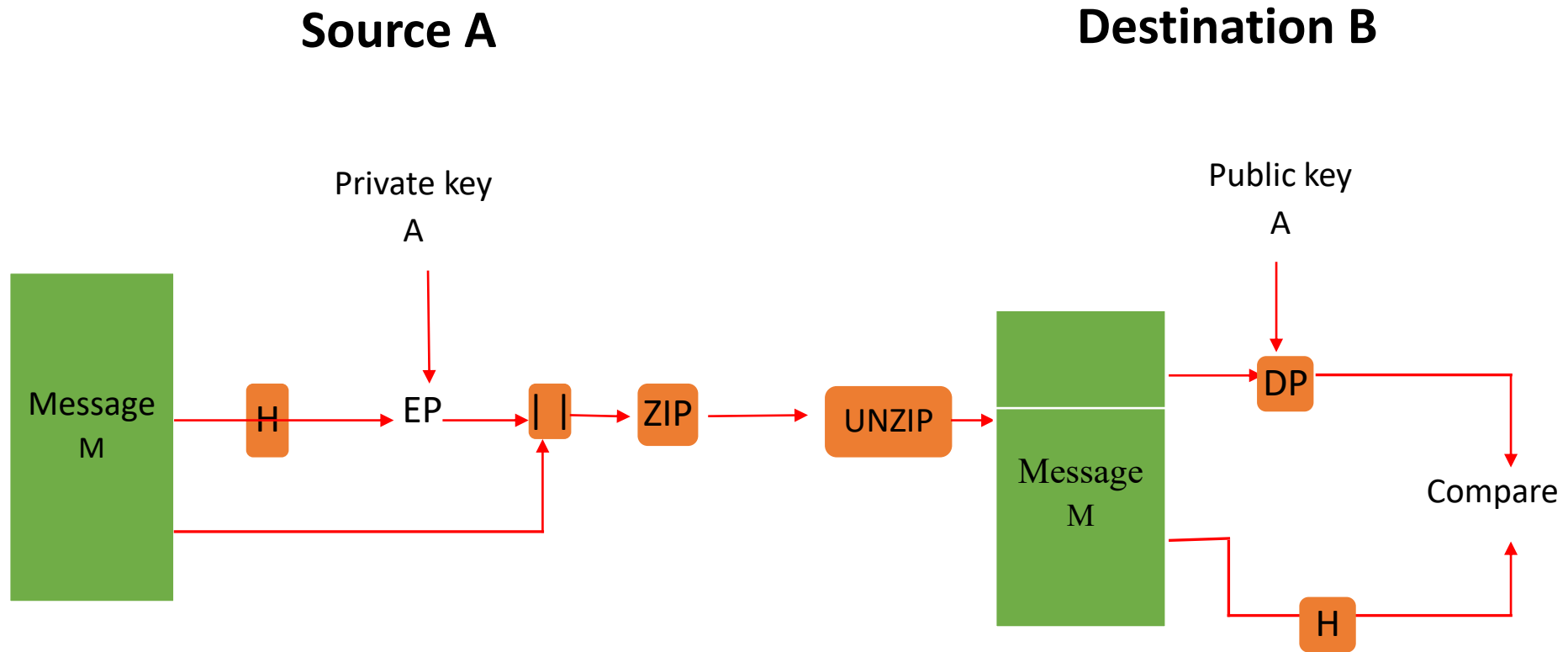
PGP can provide

Authentication/Digital Signature

Confidentiality/Encryption

Confidentiality & Authentication

- Sender creates a message
- Sender generates a hash code of the message
 - uses SHA-1 algorithm in order to generate 160-bit hash code
- Hash code encrypted with RSA (sender's private key)
 - the result is prepended to the message
- Receiver recovers the hash code
 - uses RSA with the sender's public key
- Receiver generates a new hash code of the message and compares the two codes.
 - If the two matches, the message is accepted as authentic.



PGP Signed Message

-----BEGIN PGP SIGNED MESSAGE-----

Hash: SHA1

This is simply the text of the message.

It has not been encrypted, simply signed

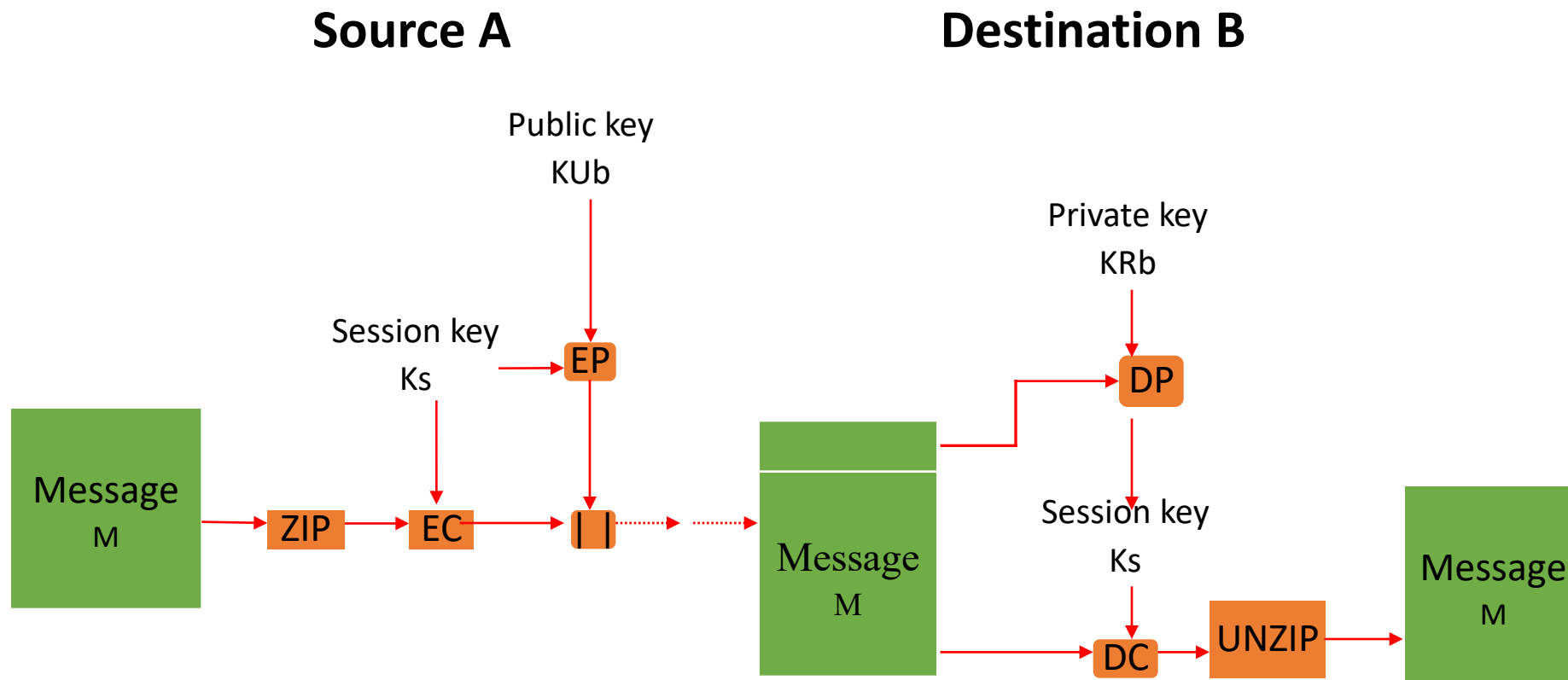
-----BEGIN PGP SIGNATURE-----

Version: PGPfreeware 6.5.3 for non-commercial use
<<http://www.pgp.com>>

iEYEARECAAYFAj5Ha6AACgkQ99/KQPj2cRNHsQCffKf64LwWQ
MfRliKUfs6QrokB7twAnR5gDobzGapPgyLKQ0gLklj1Wllp=gX
ad

-----END PGP SIGNATURE-----

- Sender generates a message and also a session key
The session key is a random 128-bit number to be used as a session key for this message only
- Sender encrypts the message
Uses CAST-128 (IDEA or 3DES) algorithm with the session key
- Sender encrypts the Session key with RSA and prepended to the message
- Receiver decrypts the session key
uses RSA with its private key
- Receiver decrypts the message with the Session key



Source A



- Saving space both for e-mail transmission and for file storage
- PGP uses ZIP to compress the message
- PGP compresses the message after applying the signature but before message encryption.
- Encryption is applied after compression to strengthen cryptographic security.

- E-mail facilities are often restricted to a maximum message length.
- Longer messages must be broken up into segments, which will be mailed separately.
- PGP automatically subdivides a message that is too large into segments that are small enough to send via e-mail.
- The receiver strips off all e-mail headers and reassembles the block.

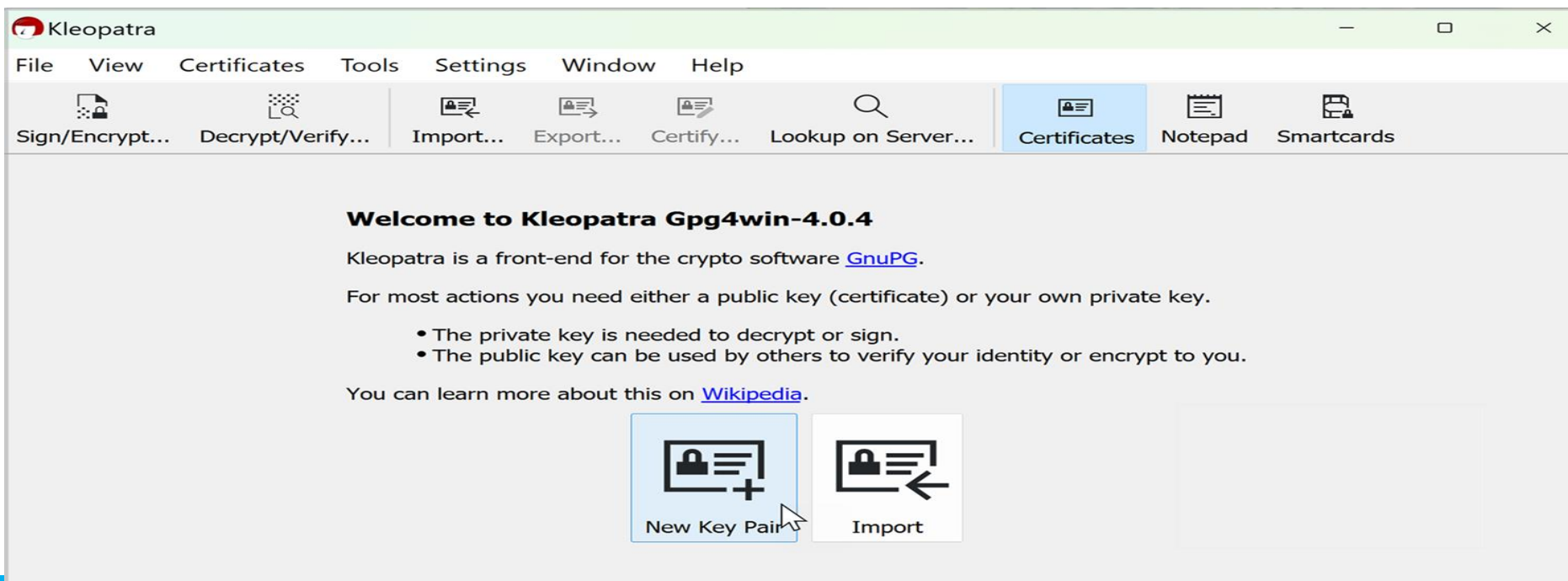
Chapter 08

PGP Encryption using Kleopatra (installation and demo)

Kleopatra Download: <https://www.gpg4win.org/download.html>

Online PGP Key Generator

<https://www.attogtech.com/pgp-key-generator/>



- Security enhancement to MIME email
 - Original Internet RFC822 email was text only
 - MIME provided support for varying content types and multi-part messages Image, video, audio
 - S/MIME added security enhancements
- Have S/MIME support in various modern mail agents: MS Outlook, Netscape, etc

SMTP Limitations - Can not transmit, or has a problem with:

- executable files, or other binary files (jpeg image)
- “national language” characters (non-ASCII)
- messages over a certain size
- lines longer than a certain length (72 to 254 characters)

- **Enveloped Data:** Encrypted content and encrypted session keys for recipients.
- **Signed Data:** Message Digest encrypted with the private key of “signer.”
- **Clear-Signed Data:** Signed but not encrypted.
- **Signed and Enveloped Data:** Various orderings for encrypting and signing.

- **Hash functions** : SHA-1 and MD5
- **Digital Signatures**: DSS and RSA
- **Secret-Key Encryption**: Triple-DES, RC2/40 (exportable)
- **Public-Private Key Encryption**: RSA with key sizes of 512 and 1024 bits.

Stallings, W. (2006). Cryptography and network security principles and practices 4th edition



Thank You