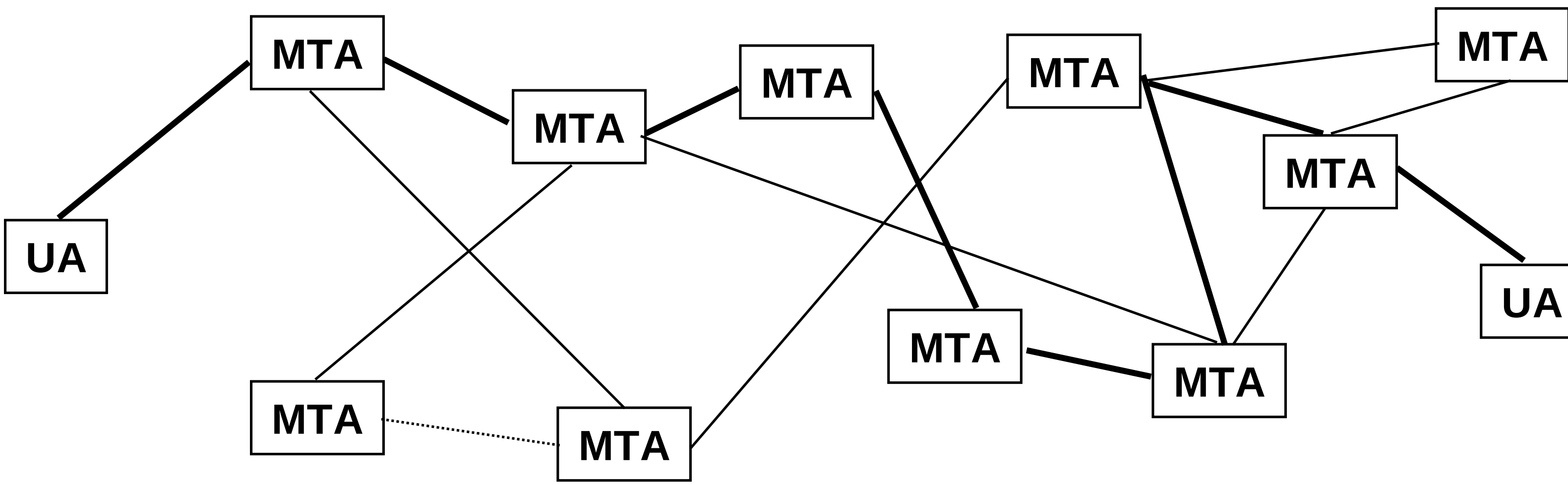
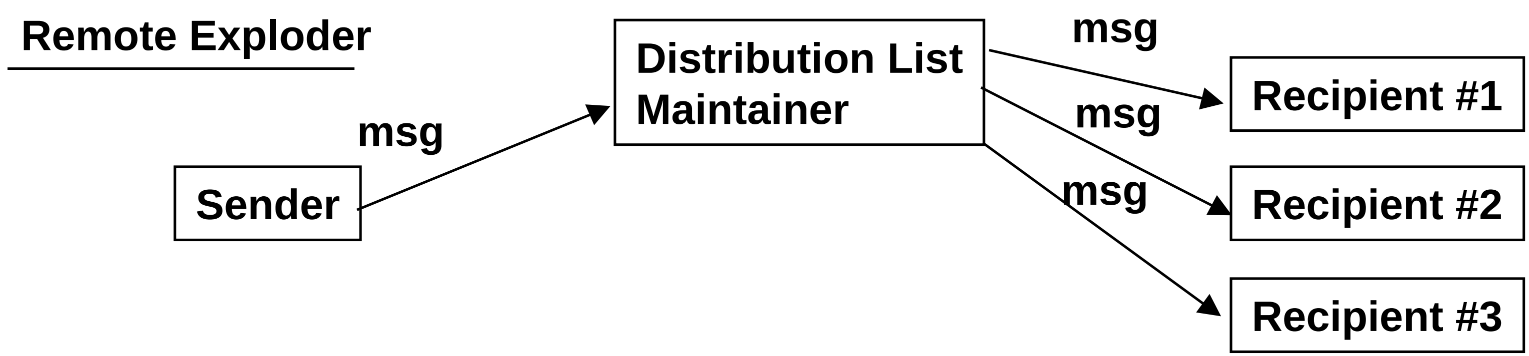
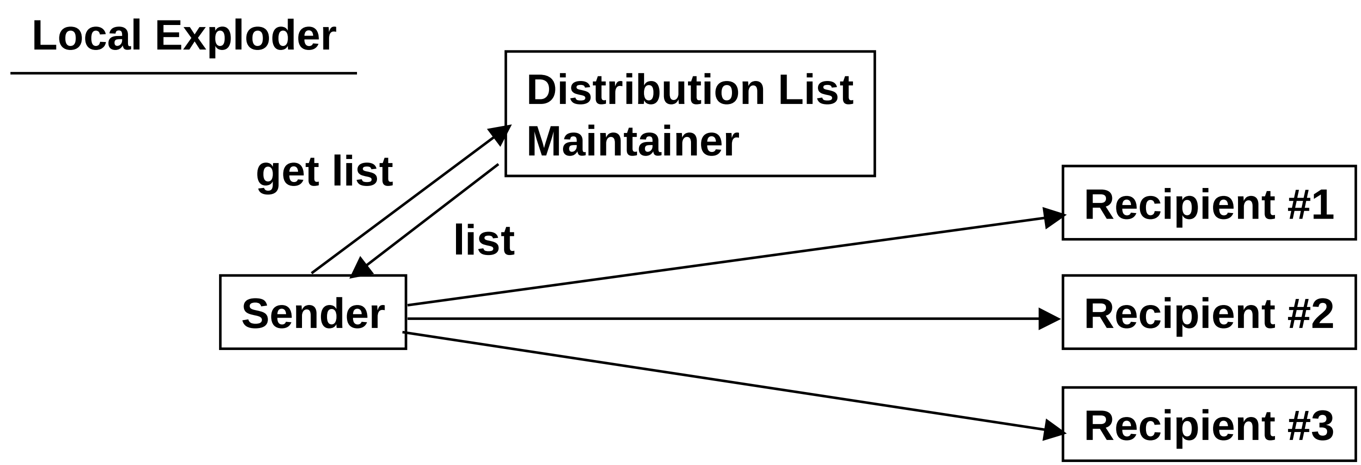
Store and Forward Processing



UA : User Agent
MTA : Message Transfer Agent

Distribution Lists





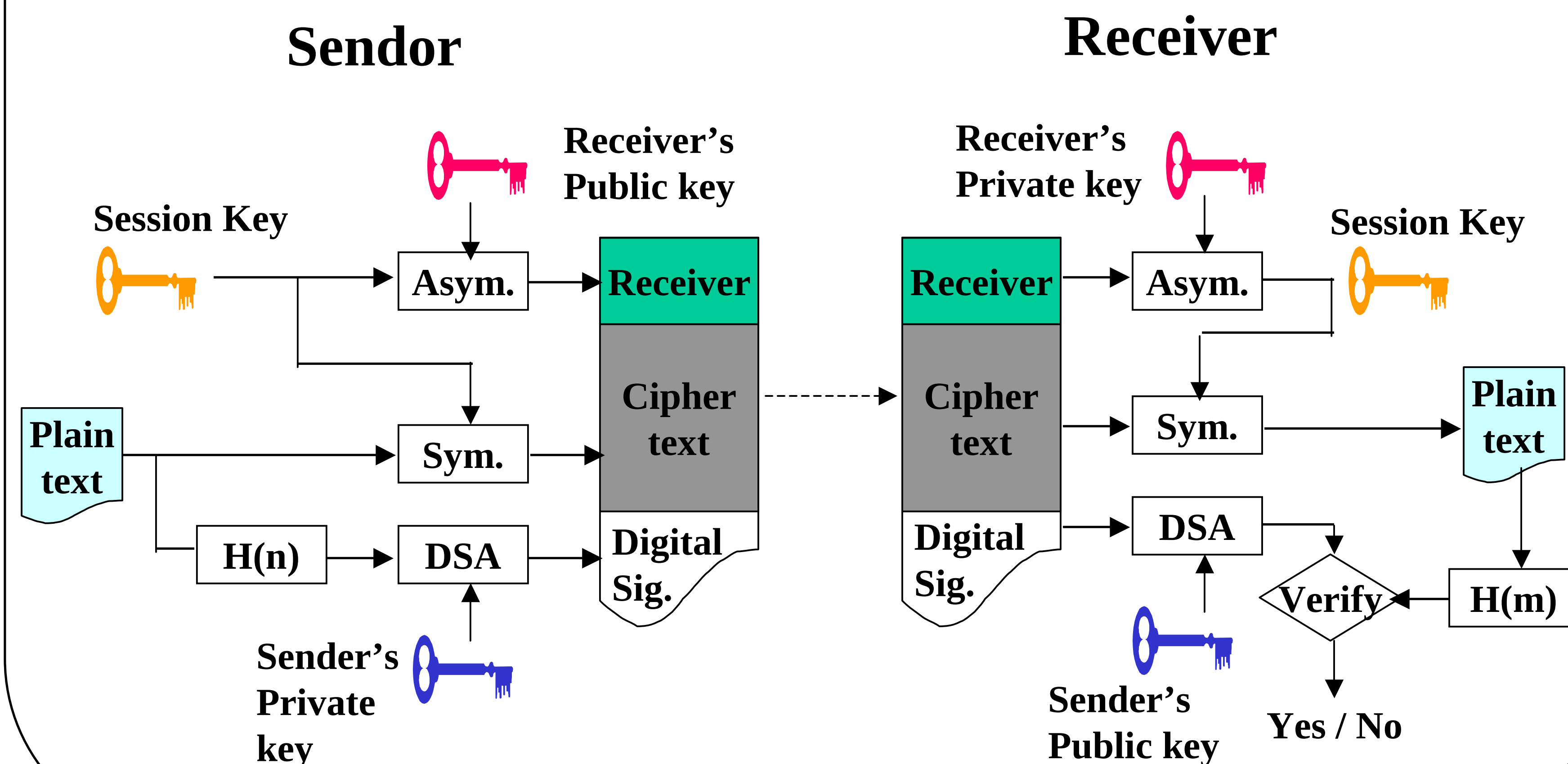
Real World

- Private e-mail to friends
- Private e-mail to business associates
- Private and authenticated e-mail to business partners
- Electronic Commerce
- etc.

Security Req't of E-mail

- Privacy
- Authentication
- Integrity
- Non-repudiation : third-party authentication
- Proof-of-submission : certified mail
- Proof-of-delivery
- Message flow confidentiality : C can't know the fact A and B communicates
- Anonymity : Not revealing sender's ID information
- Containment : security labeling
- Audit : logging specific day's mailing facts
- Accounting : extract statistics
- Self destruct : self destruct after receiving
- Message sequence integrity : sequential delivery of messages

Implementation Example



Non-repudiation

- (Definition in OSI)
  - security service that counters repudiation where repudiation is defined as “denial by one of the entities involved in a communication of having participated in all or part of the communication”
  - anti-repudiation is better choice
- (Definition in ABA)
  - Strong and substantial evidence of the identity of the signer of a message and of message integrity, sufficient to prevent a party from successfully denying the origin, submission of delivery of the message and the integrity of its contents.

Non-repudiation

- **Non-repudiation of Origin (NRO)**
  - **prevents or resolves disagreements as to whether a particular party originated a particular item.**
- **Non-repudiation of Receipt (NRR)**
  - **prevents or resolves disagreements whether a particular party received a particular data item, the time the delivery occurred.**

Implementing Non-repudiation

- Direct Method
  - Secret exchange protocol
  - Oblivious Transfer protocol
  - Fairness Problem
- Indirect Method
  - TTP(Ex : Post Office)
  - DA(Delivery Agent)
- TimeStamping

How NRO happens

- A recipient claims to have received
  - a message, but the party identified as sender claims not to have sent any message.
  - a message different from that which the sender claims to have sent.
  - a particular message originated on a specific date and time, but the party identified as sender claims not to have sent that particular message at that specific time and date.

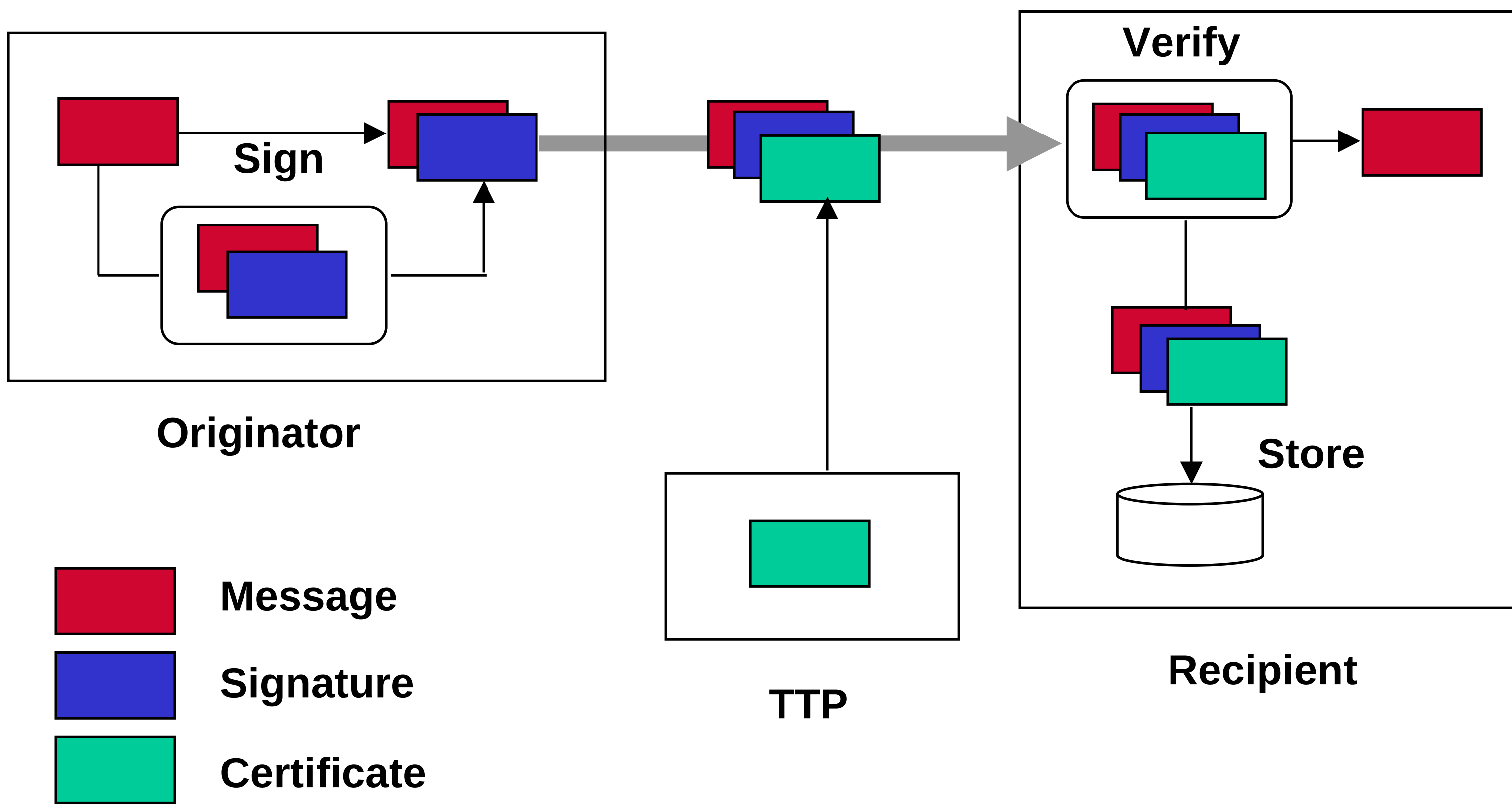
Measures against NRO

- Adequately associate, or link together, various pieces of information including at least
  - The identity of the originator and
  - The content of the message,

  optionally
  - The date and time at which origination occurred.
  - The identity of the intended recipients and
  - The identity of any TTP involved in generating evidence

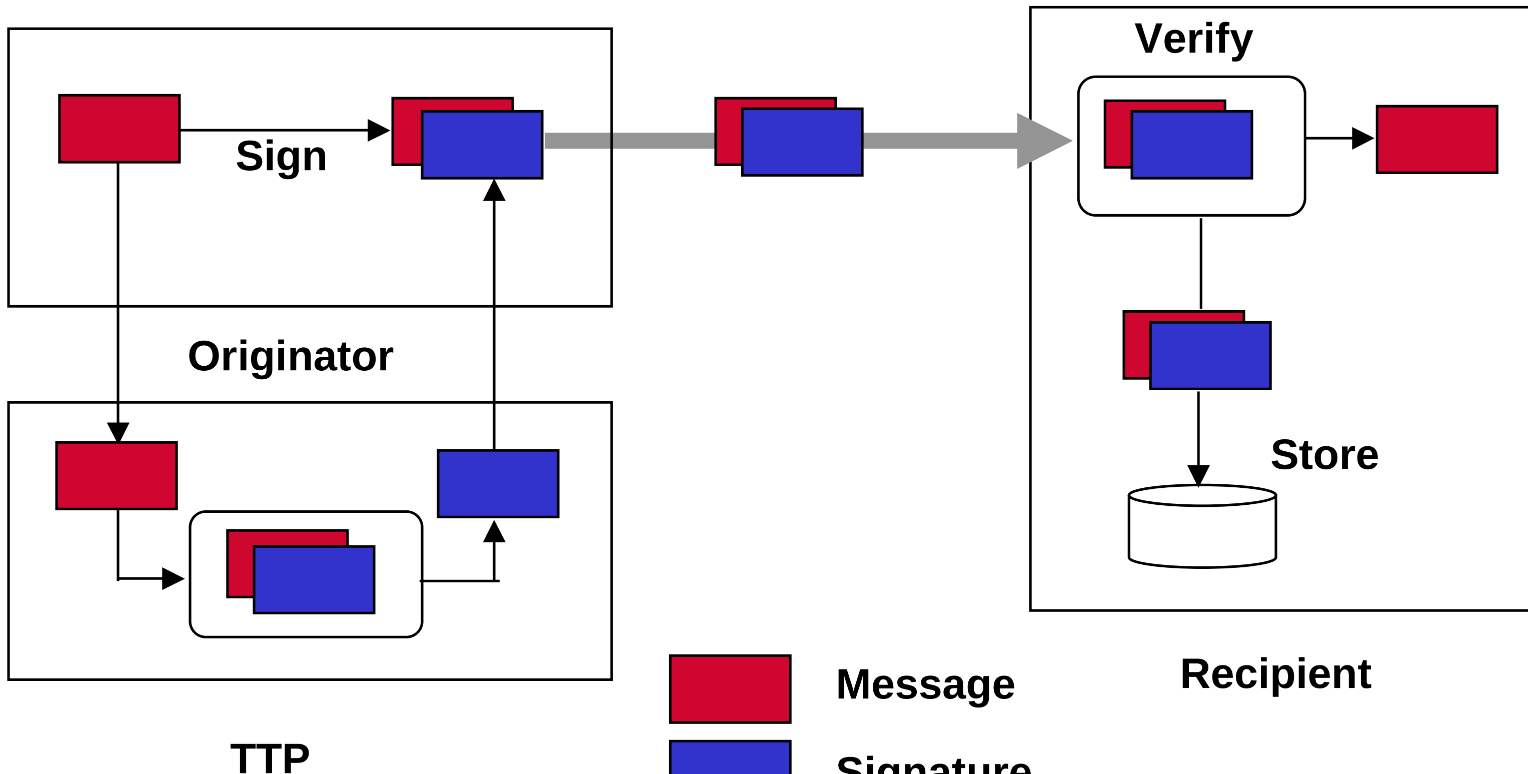
Way of NRO

(1) Originator's Digital Signature



Way of NRO(II)

(2) Digital Signature of TTP



Why NRR happens

- A sender claims to have sent
  - a message, but the party identified as recipient claims not to have sent any message.
  - a message different from that which the recipient claims to have received.
  - a particular message originated on a specific date and time, but the party identified as recipient claims not to have received that particular message at a time and on a date consistent with the claimed time and date of sending.

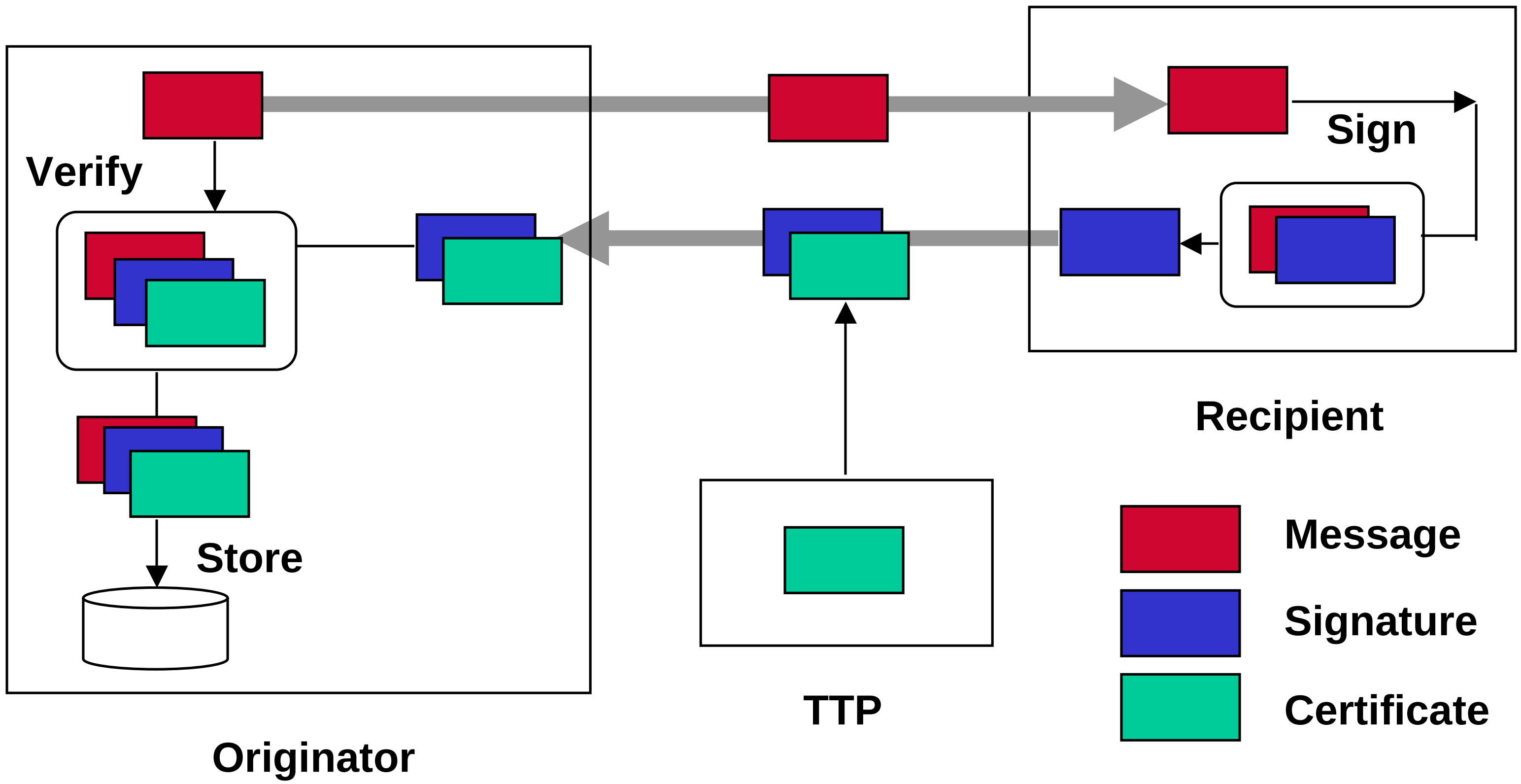
Measure against NRR

- Adequately associate, or link together, various pieces of information including at least
  - The identity of the recipient and
  - The content of the message,

  optionally
  - The date and time at which delivery of the message occurred.
  - The identity of the originator and
  - The identity of any TTP involved in generating evidence

Way of NRR

(1) Recipient's Signature



History of e-mail

- **Early 1980 :Secure/32, Charli Merritt, using PKC**
- **1986 : Mail Safe, RSADSI, DOS**
- **1990 :**
  - PEM(Privacy Enhanced Mail)
    - ✓ RIPEM (Riordan's Internet PEM)
    - ✓ TIS/PEM
  - PGP (Pretty Good Privacy)
  - S/MIME : Multimedia e-mail

Document of PEM

- RFC 1421, Part I: Message Encryption and Authentication Procedure
- RFC 1422, Part II: Certificate-based Key Management
- RFC 1423, Part III:Algorithms, Modes, and Identifiers
- RFC 1424, Part IV : Key Certification and Related Services

Design Environments of PEM

- Work with existing e-mail system in Internet
- Not restricted to particular host or OS
- Compatible with normal, non secure e-mail
- Performed on PC as well as on large system
- Compatible with a variety of key-management approach including manual distribution, centralized key distribution

Security Services of PEM

- Confidentiality
- Data origin authentication
- Message Integrity
- Non-repudiation of origin
- Key Management

Cryptographic Algorithm

- Data Encryption : DES in CBC
- Key Management : DES in ECB,CBC and RSA
- MIC : RSA+MD2, RSA+MD5
- Digital Signature : RSA+MD2, RSA+MD5

Style of message

- Ordinary, unsecured data
- MIC-Clear : integrity and authentication, but no confidentiality (integrity-protected unmodified data)
- MIC-Only : MIC-Clear + encoding(Integrity-protected encoded data)
- ENCRYPTED : MIC-Only + confidentiality(encoded encrypted integrity-protected data)

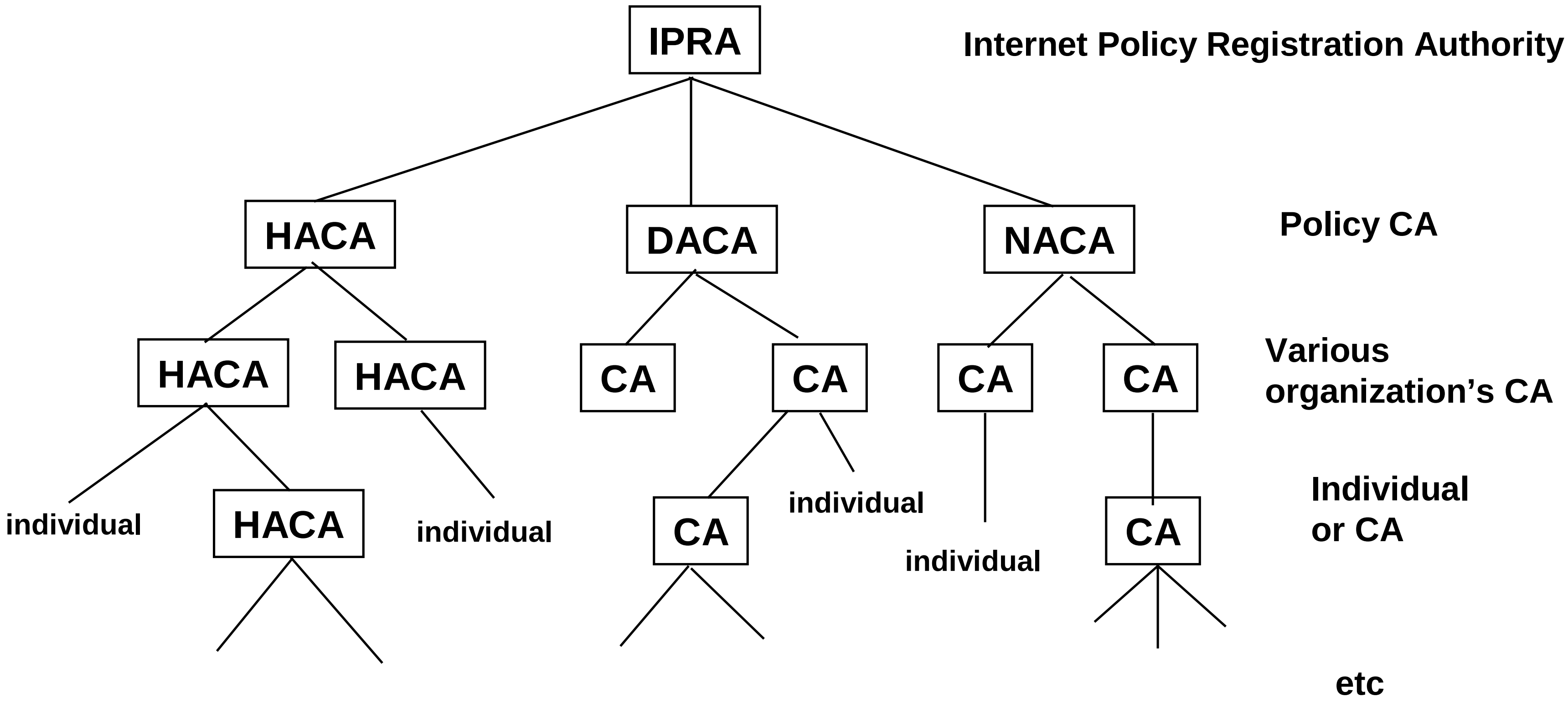
PEM Message

BEGIN-PRIVACY-ENHANCED-MESSAGE
Processing Type
Content Domain
Message text encryption algorithm
Issuing authority
Version/expiration
Origination certificate
Originator key information
Issuer certificate
MIC information
Issuing authority
Version/expiration
Encrypted DEK
User Text
END-PRIVACY-ENHANCED-MESSAGE

Processing steps of PEM Message

- Sending
  - Canonicalization
  - Message Integrity and originator authentication
  - Encryption(optional)
  - Transmission encoding(optional)
- Receiving
  - Decoding(optional)
  - Decrypting(optional)
  - Verifying message integrity and authenticity
  - Translation

Certification Hierarchy



HA : High Assurance, DA:Discretionary Assurance, NA:No Assurance

PGP

- Program for confidentiality and authentication service
- Select best available algorithm
  - Integrate algorithms into general-purpose
  - Made the package and its document, including source code, freely available via Internet
  - Low-cost commercial version by Viacrypt and Public-domain version

Background of PGP

- Available in various platforms
- Use algorithm survived extensively public review like RSA, DSS, DH, CAST-128, IDEA and 3DES, SHA-1
- Wide range of applicability from cooperation to individual
- Not developed by, nor controlled by, any government and standards organization

History of PGP(I)

- Designed by Phil Zimmerman
  - High security
  - public domain S/W
  - popular for personal use
- PGP Classic : Can't handle Internet Mail
  - PGP v.1.0 : '91.6
  - PGP v.2.0 : '92. 9
  - PGP v.2.3a : '93. 7 (last version of PGP didn't use RSAREF)
  - PGP v.2.4 : original ViaCrypt PGP
  - PGP v.2.5 : Interim release of PGP with RSAREF
  - PGP v.2.6 : Freeware version of PGP
  - PGP v.2.7 : Commercial version by ViaCrypt

History of PGP(II)

- 4 versions
  - PGP Classic : non commercial use
  - PGP 5.0 : Improve security but don't adapt RSA
  - PGP/MIME
    - ✓ MIME-based
    - ✓ Use special certificate
    - ✓ Handle Internet Mail
  - OpenPGP
  - Use DH, DSA, SHA-1
  - Interoperability with S/MIME

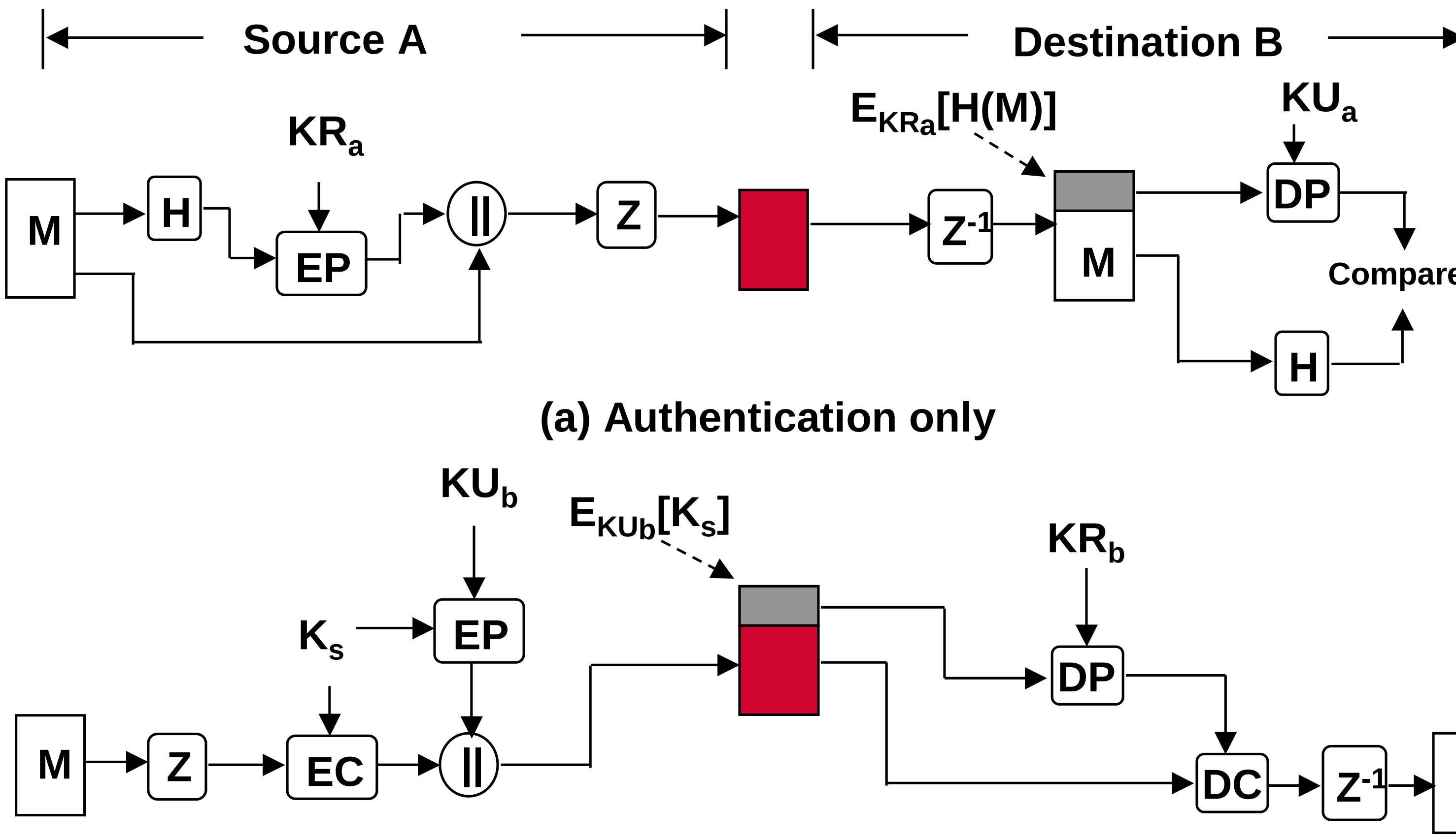
Features of PGP

Function	Algorithm
Digital Signature	DSS/SHA or RSA/SHA
Message Encryption	CAST-128 or IDEA or 3DES (64bCFB) w/ DH or RSA
Compression	ZIP **(Note) Signing before compression** **Encryption after compression**
E-mail compatibility	Radix 64
Segmentation	

Notation

- Ks : session key for conventional algorithm
- KR_a : Private key of user A for PKC
- KU_a : Public key of user A for PKC
- EP : PK encryption
- DP : PK decryption
- EC : conventional encryption
- DC : conventional decryption
- H : Hash function
- || : concatenation
- Z : compression
- R64 : conversion to radix 64 ASCII format

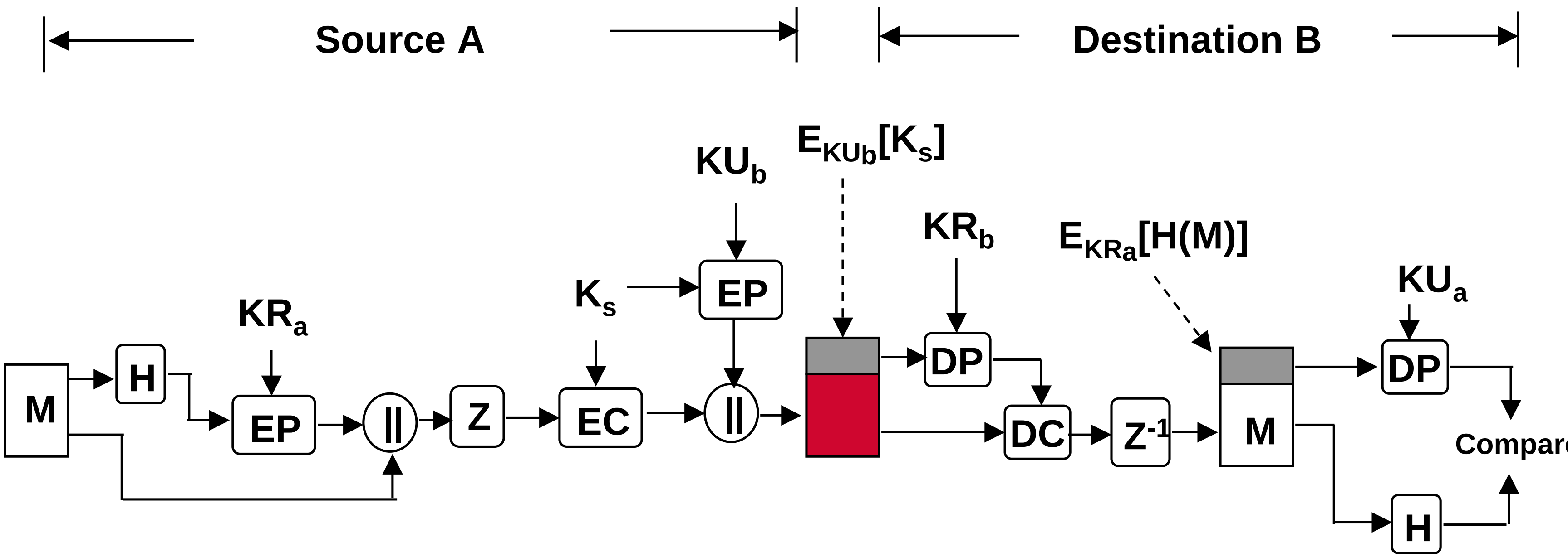
Security Service in PGP(I)



(a) Authentication only

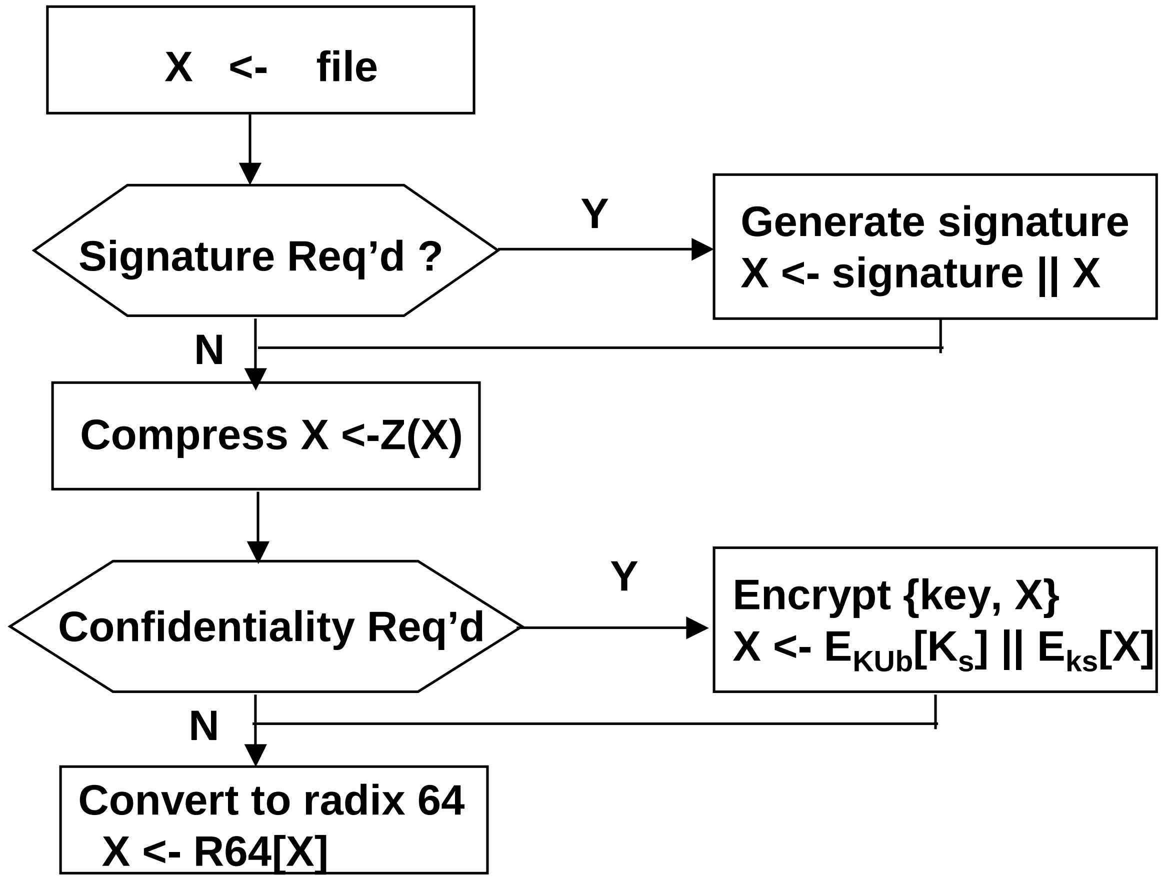
(b) Confidentiality only

Security Service in PGP(II)

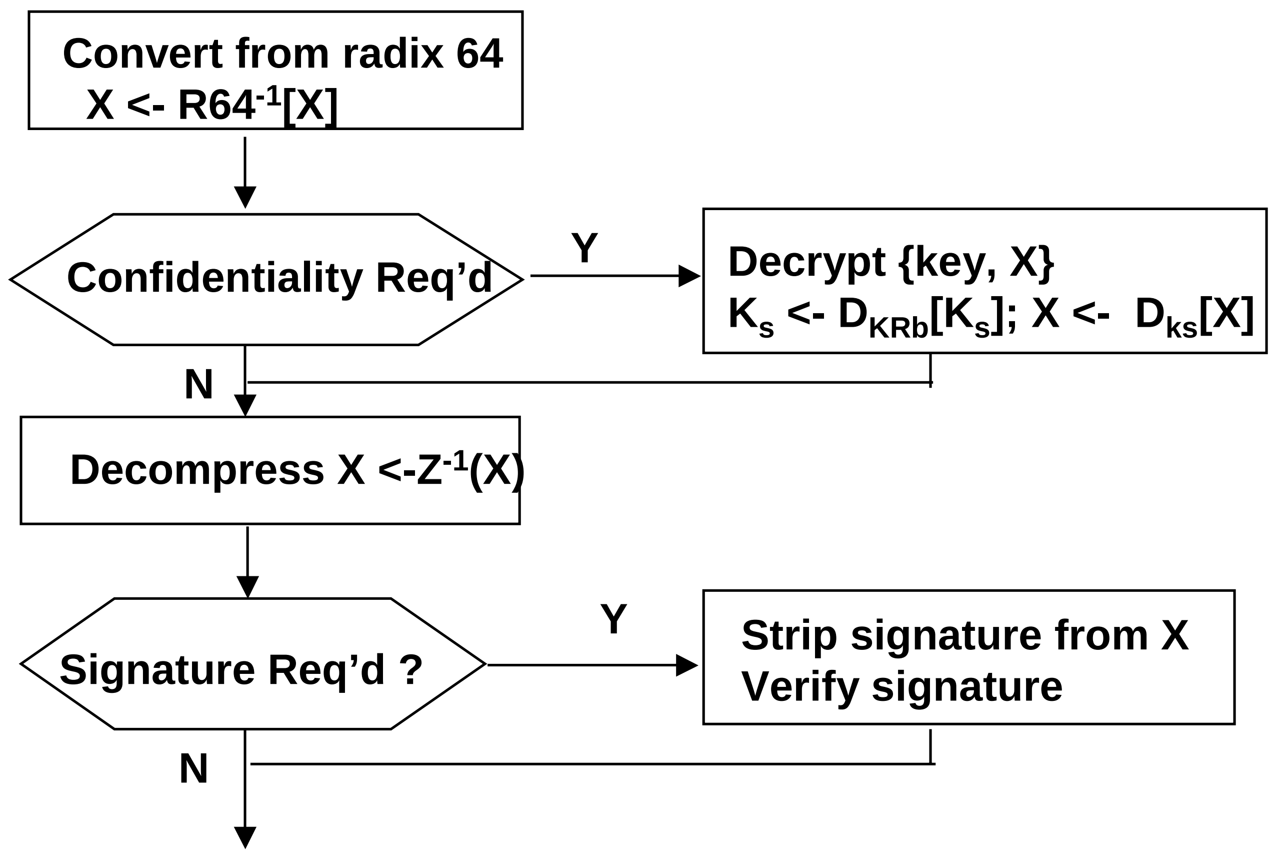


(c) Confidentiality and Authentication

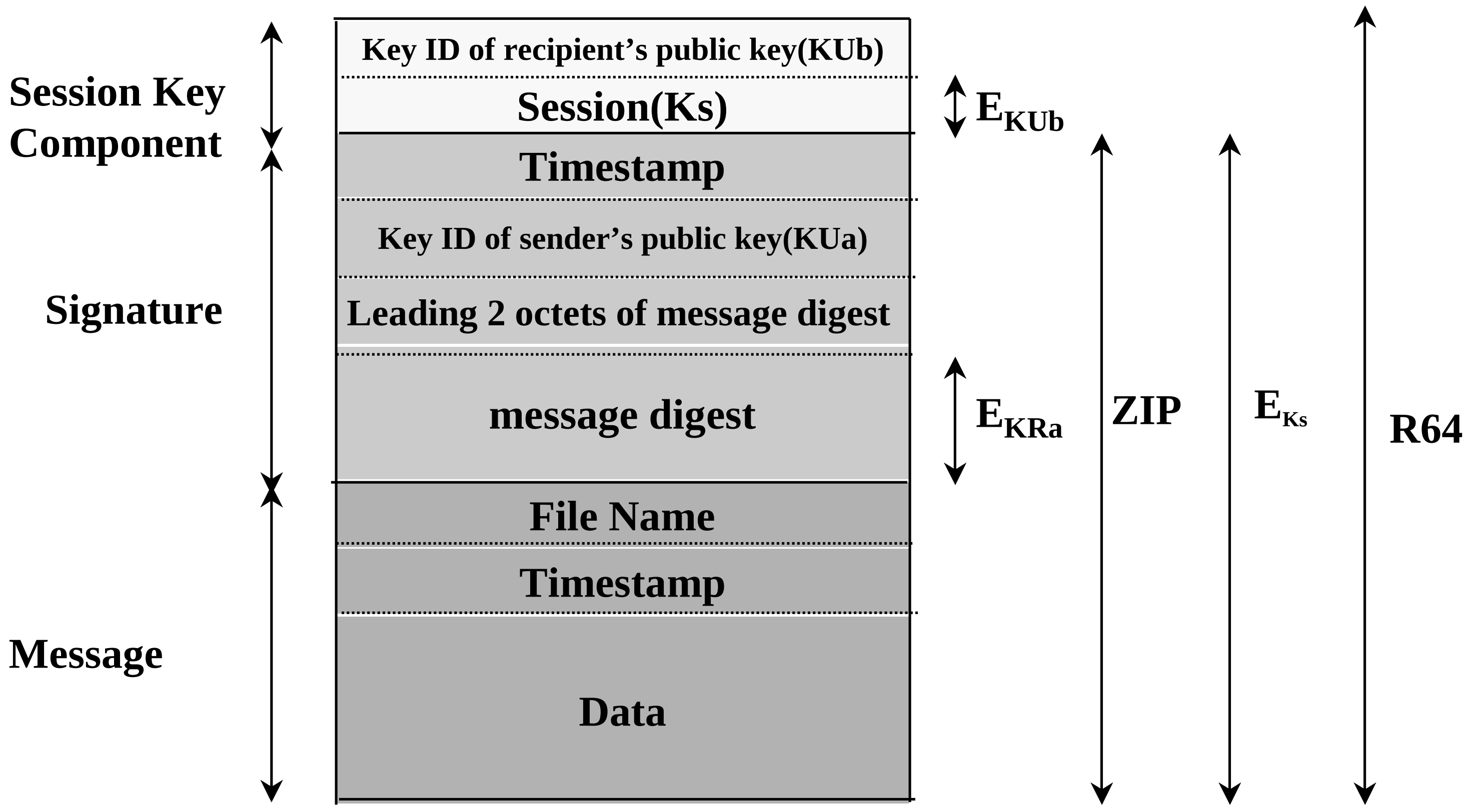
Steps of sending a message



Steps of receiving a message



Message format (A->B)



E_{KUb} : encryption with user b's public key
E_{KRa} : encryption with user b's private key
E_{Ks} : encryption with session key

ZIP : ZIP compression functions
R64 : Radix-94 conversion function

Key Management

- One-time session key : 128bit for CAST or IDEA, 168 bit for 3DES)
- Public Key
- Private Key
- Passphrase-based conventional key

Key Rings of PGP

Private Key ring : store his own public and private keys

Timestamp	KeyID	Public Key	Encrypted Private key	UserID
Ti	$KU_i \bmod 2^{64}$	KUi	$E_{H(Pi)}[KRi]$	User i

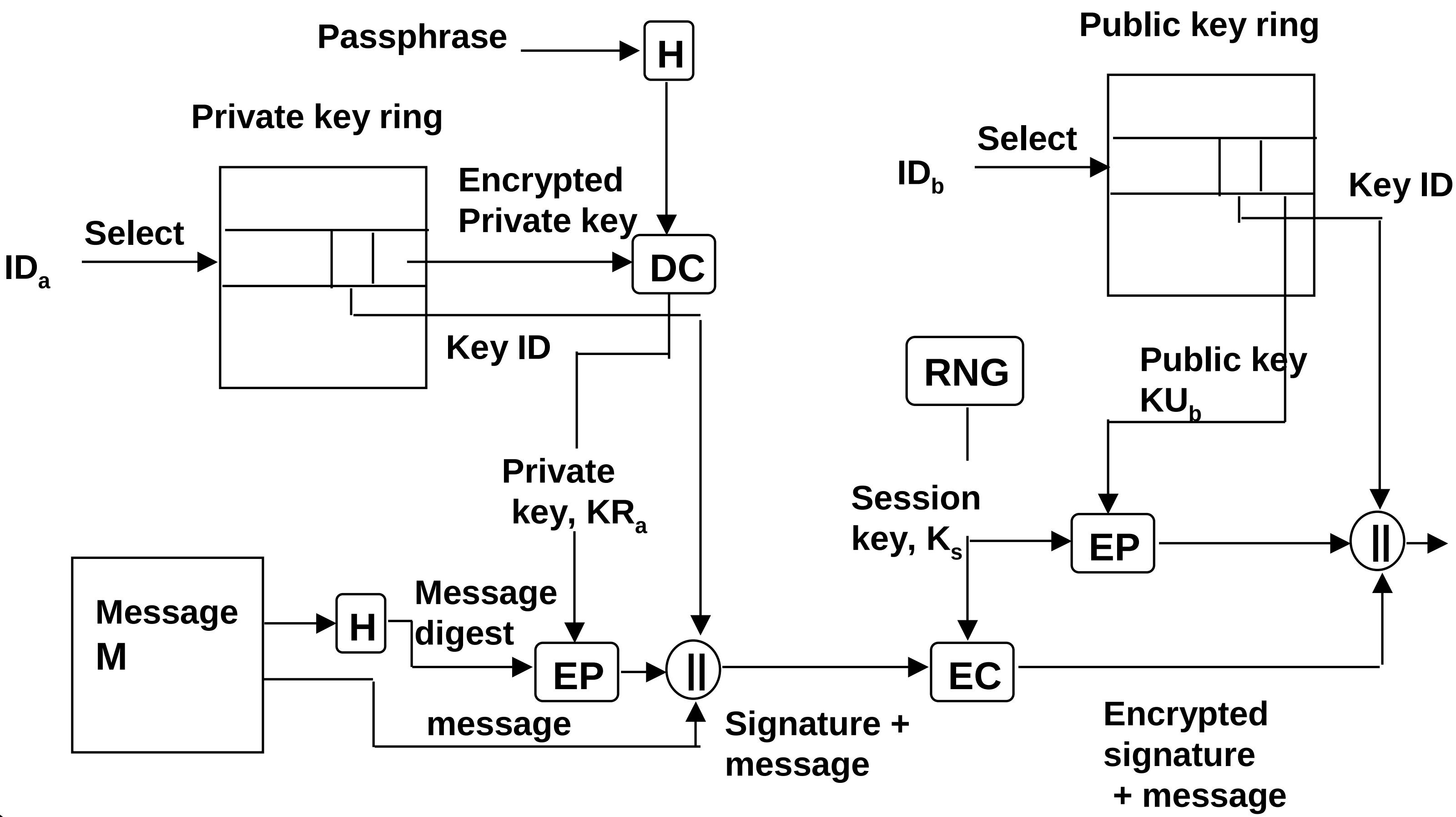
Public Key ring : store all known entities' public key

Time stamp	KeyID	Public Key	Owner Trust	UserID	Key Legitimacy	Signature(s)	Signature Trust(s)
Ti	$KU_i \bmod 2^{64}$	KUi	trust_flagi	User i	trust_flagi	ERj(H([KUi])) ERk(H([KUi]))	complete marginal

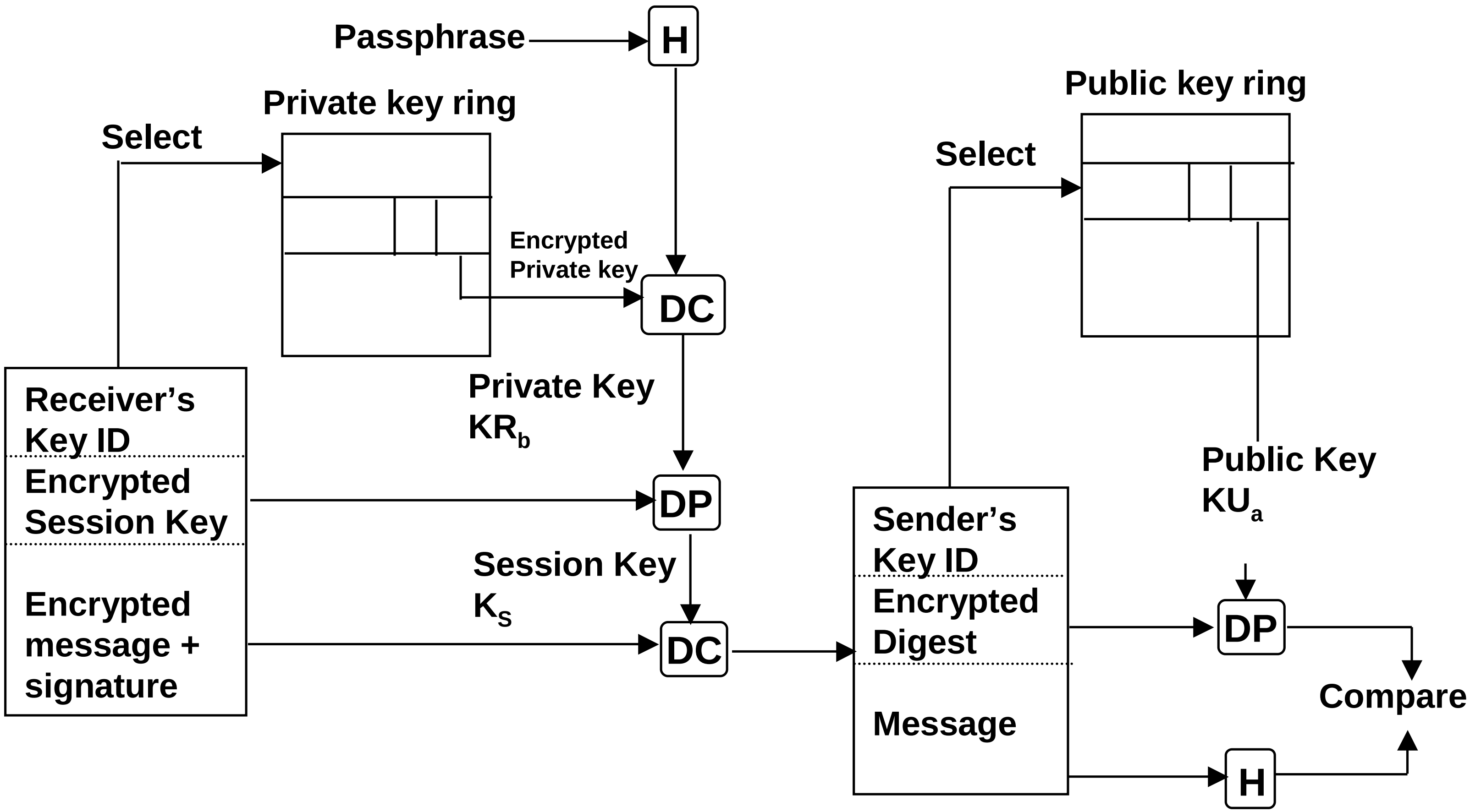
Use of private key

- ❑Using IDEA, store encrypted key
  - ✓User selects passphrase
  - ✓When generating private/public key pairs, use passphrase
  - ✓ Passphrase is inputted to hash ft. MD5 (SHA-1), Use 128 (160)-bit hash value as key of IDEA
- ❑After use, delete it from system

Message sending (Detailed)



Message receiving (Detailed)

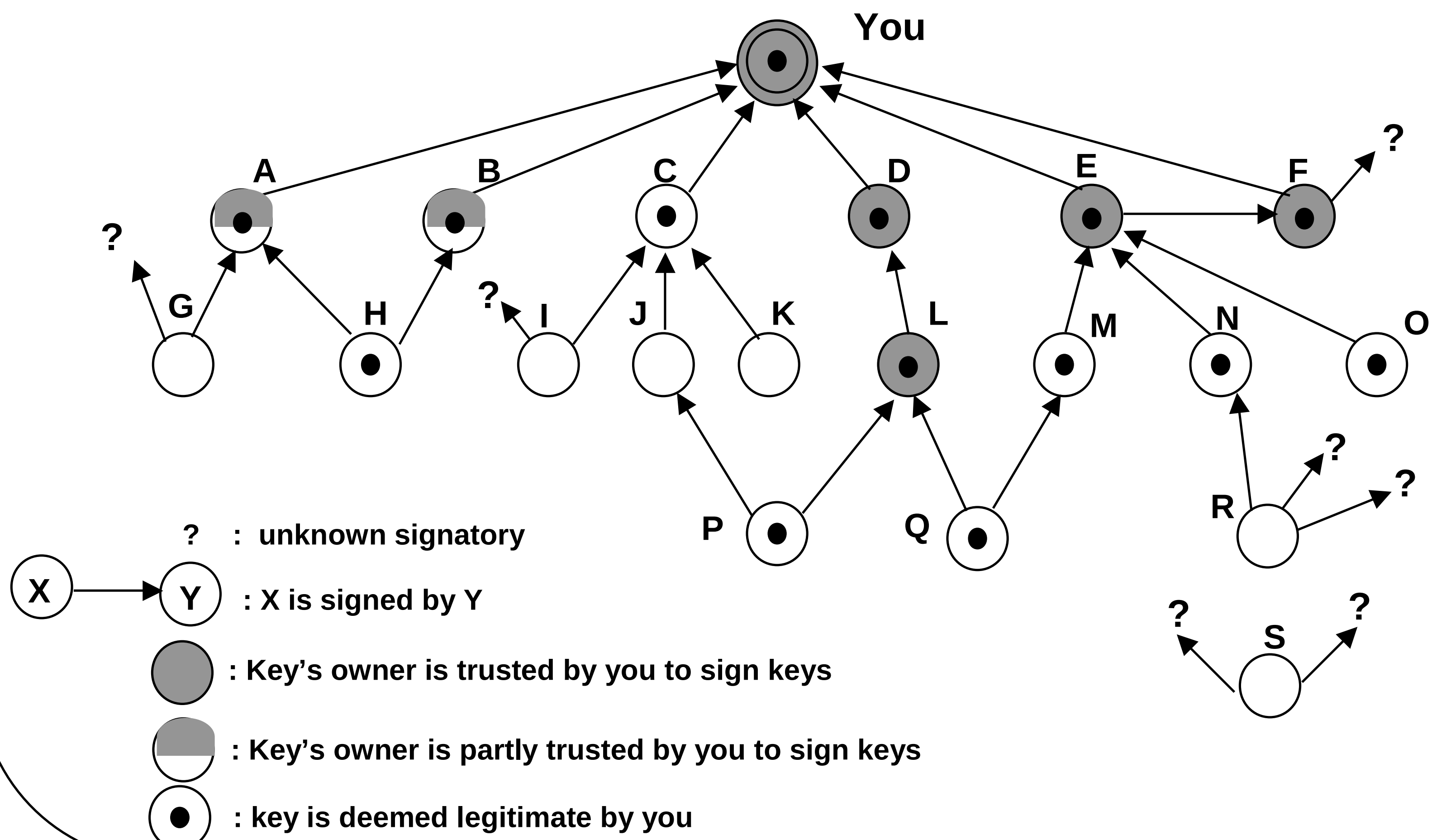


Distribution of Public Key

- Direct delivery (floppy disk, mail,..)
- Sending e-mail and confirm by telephone

- TTP
- CA

PGP's Trust Model



Revocation of Public key

- **Issue public key revocation signature**
  - **Similar form of usual Signature Certificate**
  - **Signature using secret key of public key to be revocated**
  - **Propagate as many as possible**
- **All public keys signed by revocated key**
  - **Make *Owner_trust* and *key_legitimacy* to untrust**