# Digital Signatures and PKI

**Centre for Development of Advanced Computing (C-DAC)**
**Bangalore**

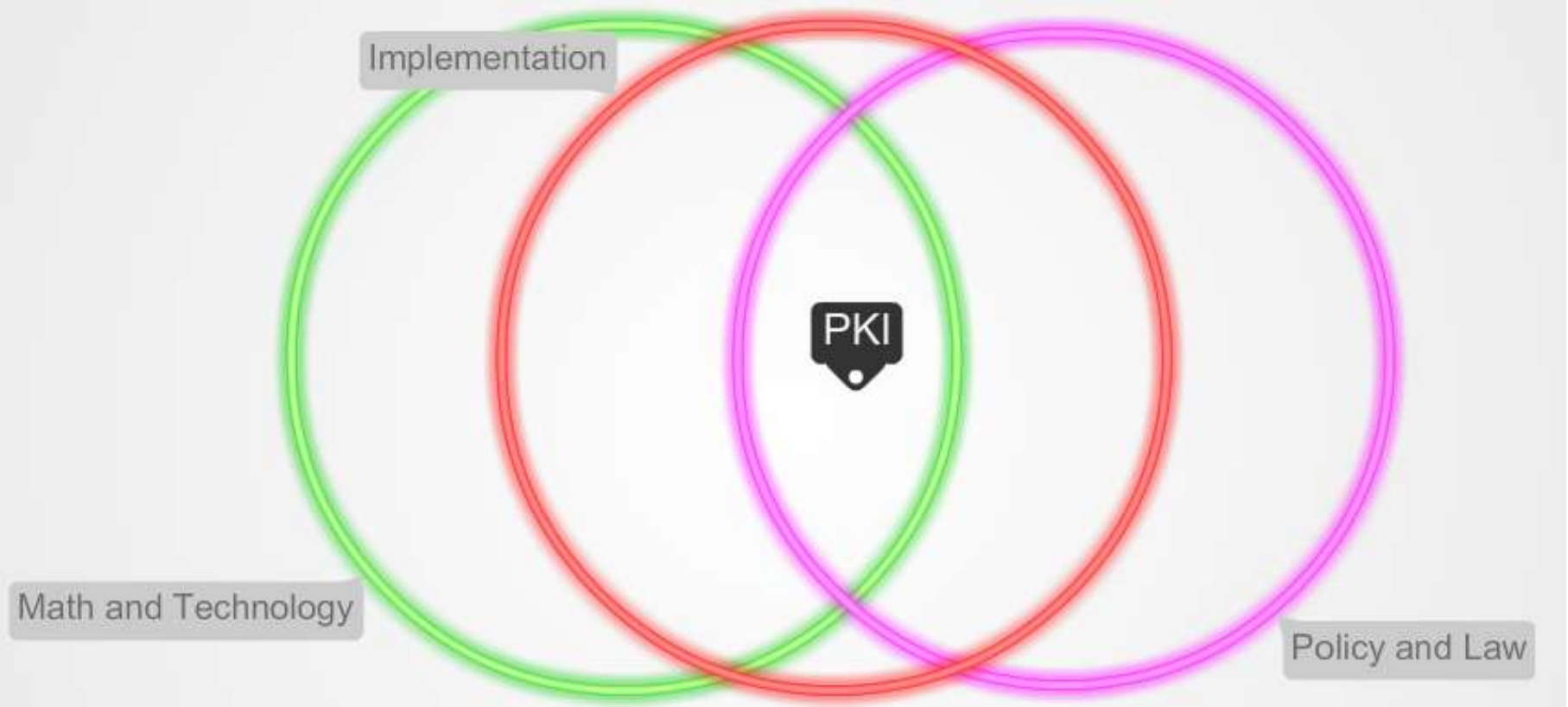
***Under the Aegis of***

**Controller of Certifying Authorities (CCA)**
**Government of India**

# Agenda

- ✓Dimensions of PKI
- ✓Paper World Vs Electronic World
- ✓Why Digital Signature?
- ✓What is Digital Signature?
- ✓Achieving Confidentiality
- ✓Digital Signature Use Cases
- ✓Summary

# Dimensions of PKI



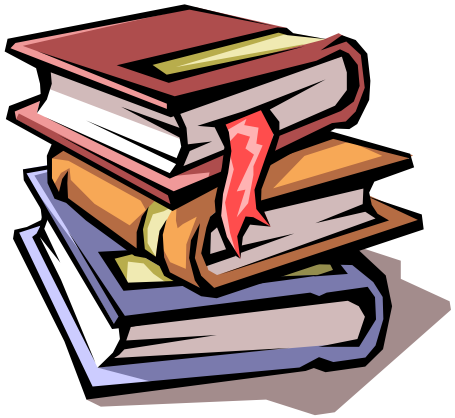

- PKI – Public Key Infrastructure ecosystem is an intersection of:
  - Cryptography (Math) & Technology – Cryptographers/Researchers
  - Policy & Law – PKI System & Users
  - Implementation – PKI System Developer

# Technology Perspective

# Paper Records v/s Electronic Records

# Paper Records v/s Electronic Records

| | Paper Record | Electronic Record |
|---|---|---|
| Document Form | Physical | Digital |
| Very easy to make copies | No | Yes |
| Very fast distribution | No | Yes |
| Archival and Retrieval | Challenging | Easy |
| Copies are as good as original | No. Copies are easily distinguishable | Yes |
| Easily modifiable | No | Yes |
| Environmental Friendly | No | Yes |



# Trust-worthiness in Transactions

The following properties must be assured:

**Privacy (Confidentiality):** Ensuring that only Authorized persons should read the Data/Message/Document

**Authenticity:** Ensuring that Data/Message/Document are genuine

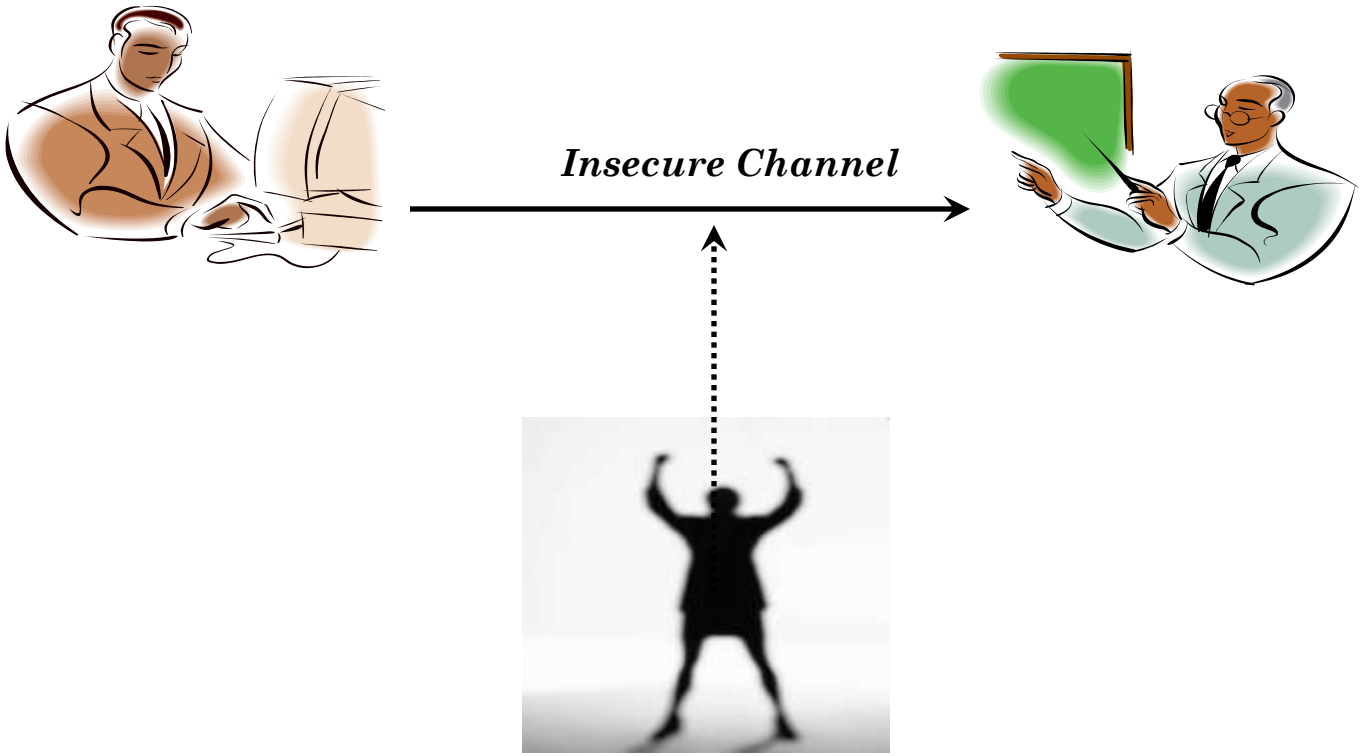
**Integrity** : Ensuring that Data/Message/Document are unaltered by unauthorized person during transmission

**Non-Repudiation:** Ensuring that one party of a transaction cannot deny having sent a message

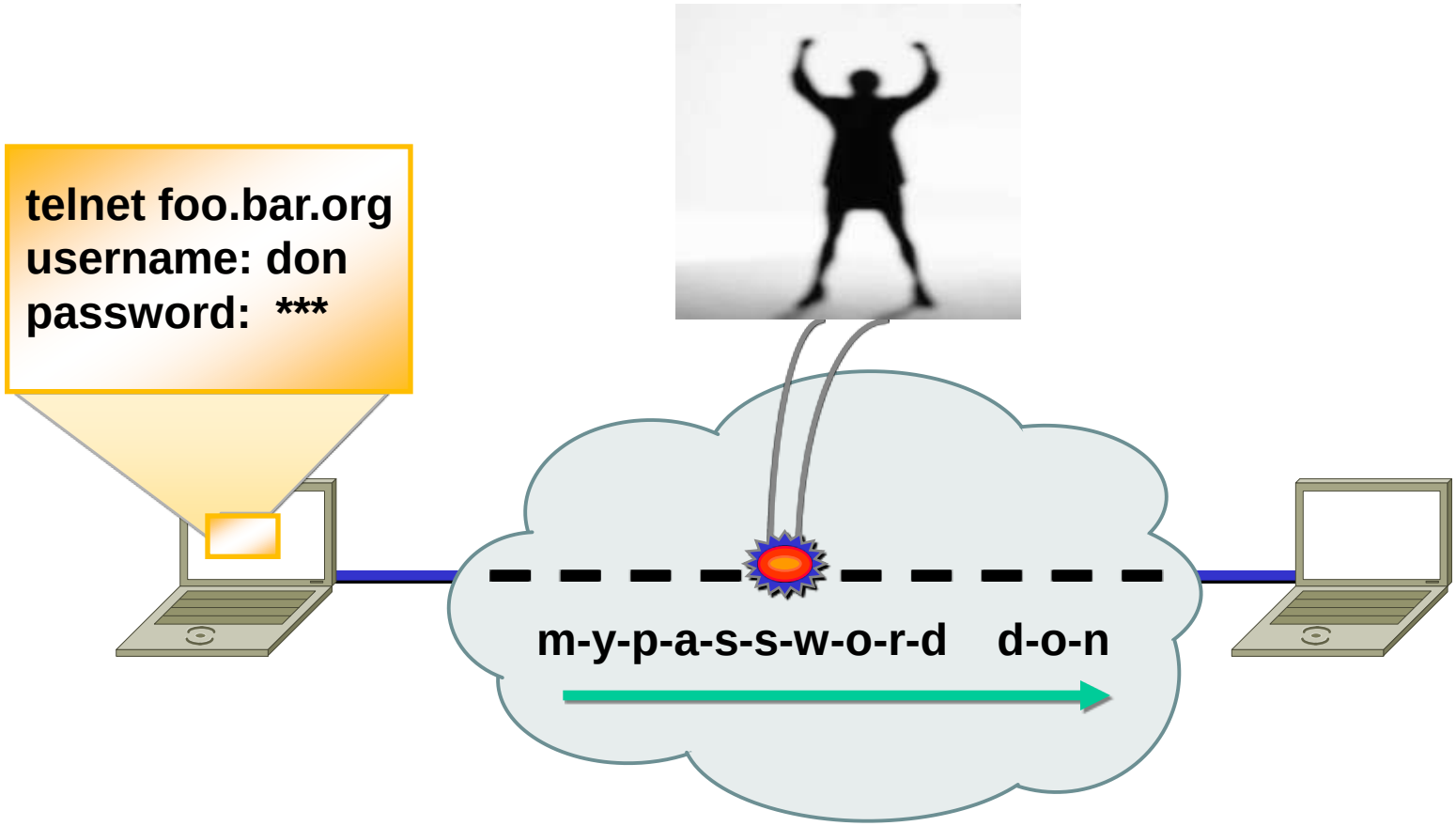
# Paper Records v/s Electronic Records

| | Paper Record | Electronic Record |
|---|---|---|
| Privacy (Confidentiality) | Sealed Envelope | Digital Envelope |
| Authenticity | Hand Signature | Digital Signature |
| Integrity | Hand Signature | Digital Signature |
| Non-Repudiation | Hand Signature<br>but it is Challenging | Digital Signature |

# The Scenario



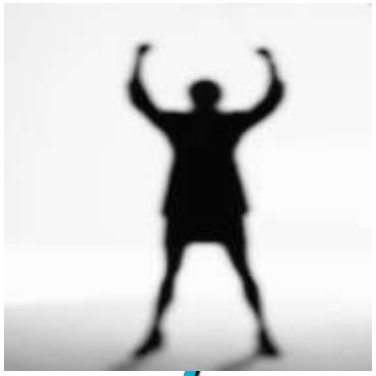
# Threats: Packet Sniffing



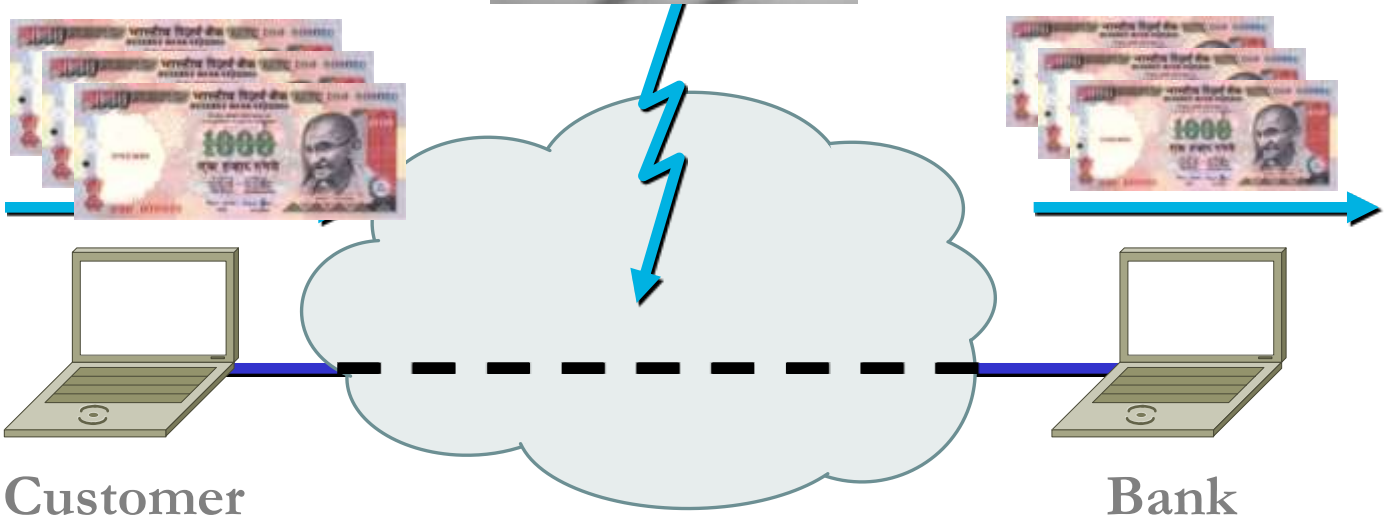

**Breach of Confidentiality**

# Threats: Data Alteration

Deposit 1,00,000
in Veeru's Account

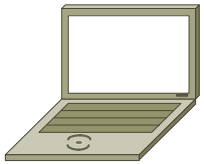


Deposit 1 in Veeru's
Account and 99,999 in
Gabbar's Account



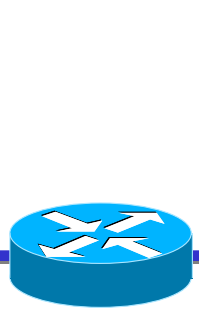

**Breach of Integrity**

# Threats: Spoofing



Gabbar

I'm Veeru
Send Me all Corporate
Correspondence
with 'abc'.



Jai

Veeru

**Breach of Authenticity**

# Why Digital Signature?

# Why Digital Signatures?

- To provide **Authenticity, Integrity and Non-repudiation** to electronic documents
- To enable the use of Internet as the safe and secure medium for e-Commerce and e-Governance

# Mathematical Perspective

# Major Components of Digital Signature

- Major cryptographic components for creating Digital Signature are:
  - Hash Functions
  - Asymmetric Key Cryptography

# Hash Function

- A hash function is a cryptographic mechanism that operates as one-way function
  - Creates a digital representation or "fingerprint“ (Message Digest)
  - Fixed size output
  - Change to a message produces different digest

Examples : MD5 , Secure Hashing Algorithm (SHA)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# Hash - Example

Hi Jai,

I will be in the park at

3 pm

Veeru

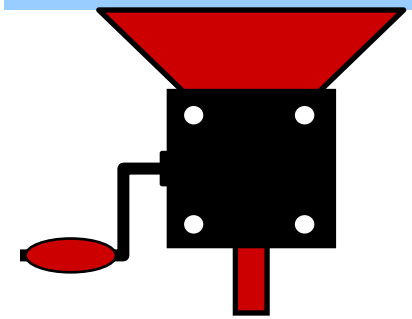
**Message**

Hi Jai,

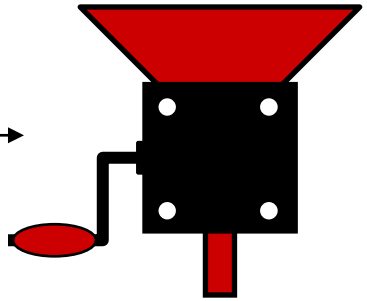
I will be in the park at

8 pm

Veeru



Hash Algorithm



**Message Digest**

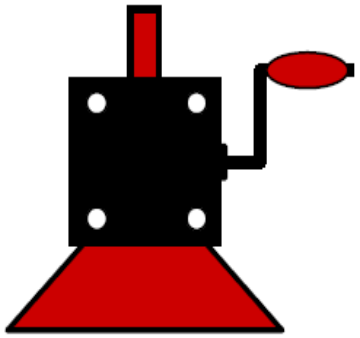
cfa2ce53017030315fde705b9382d9f4

d4216ytf6b9385fe502b165dfe8cec17

**Digests are Different**

# Hash – One-way

cfa2ce53017030315fde705b9382d9f4



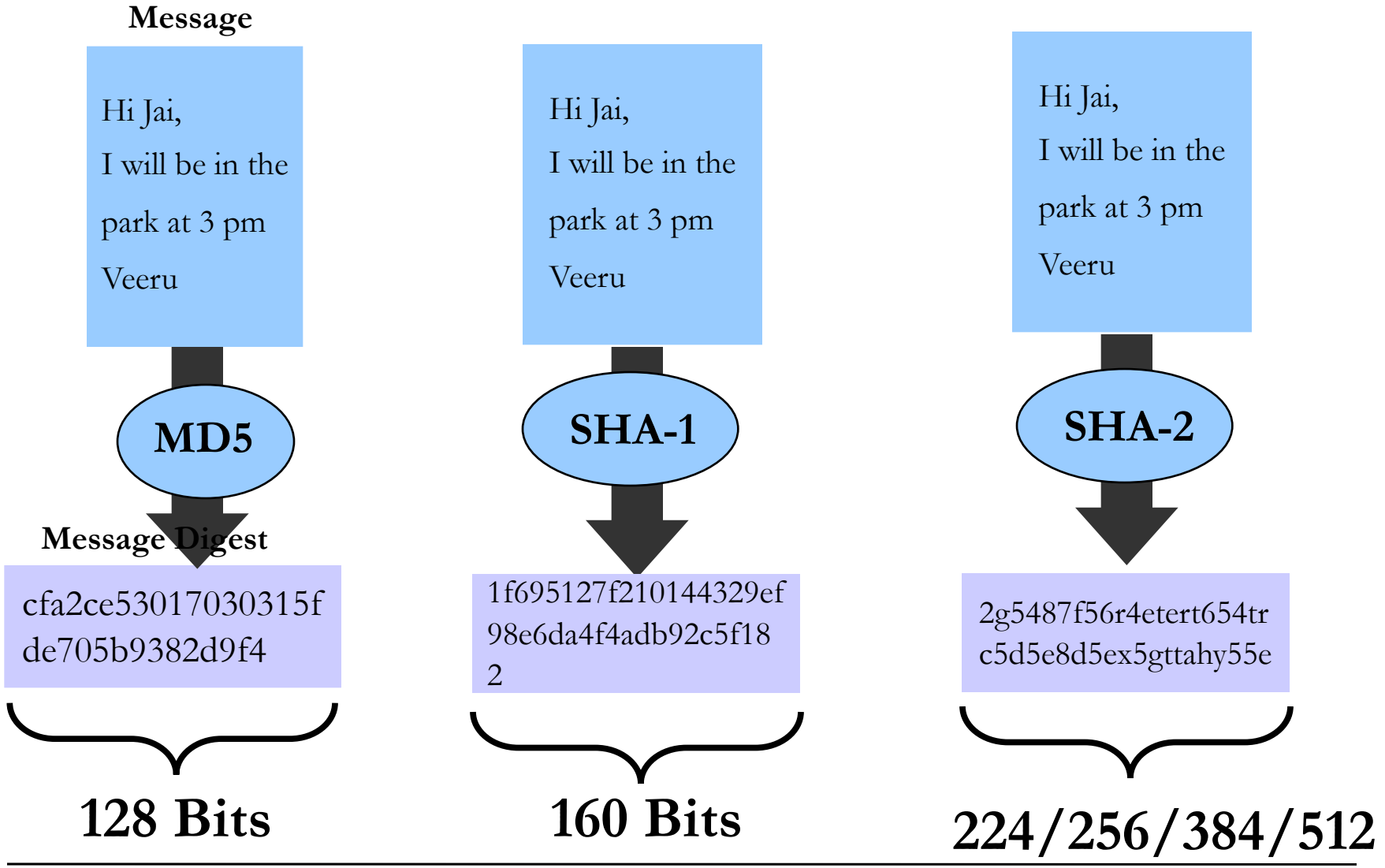
Hi Jai

I will be in the park at

**3 pm**

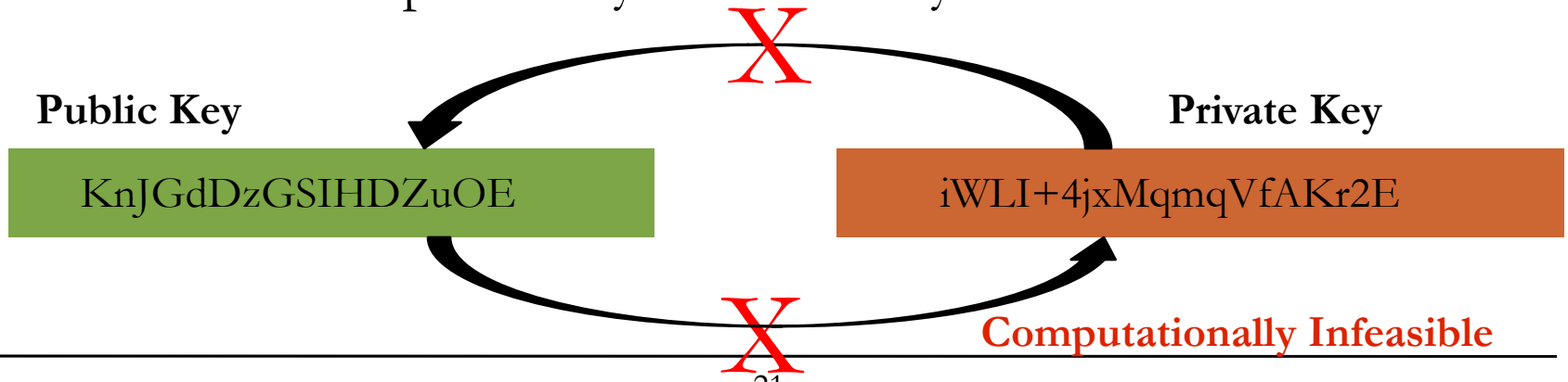
Veeru

# MD5 and SHA


Message
Hi Jai,
I will be in the
park at 3 pm
Veeru
MD5
Message Digest
cfa2ce53017030315f
de705b9382d9f4
128 Bits
Hi Jai,
I will be in the
park at 3 pm
Veeru
SHA-1
1f695127f210144329ef
98e6da4f4adb92c5f18
2
160 Bits
Hi Jai,
I will be in the
park at 3 pm
Veeru
SHA-2
2g5487f56r4etert654tr
c5d5e8d5ex5gttahy55e
224/256/384/512

# Asymmetric Key Cryptography

- Also called as Public Key Cryptography
- Uses a related key pair wherein one is Private key and another is Public key
  - One for encryption, another for decryption
- Knowledge of the *encryption* key doesn't give you knowledge of the *decryption* key
- A tool generates a related key pair (public & private key)
  - Publish the public key in a directory



# RSA Key pair

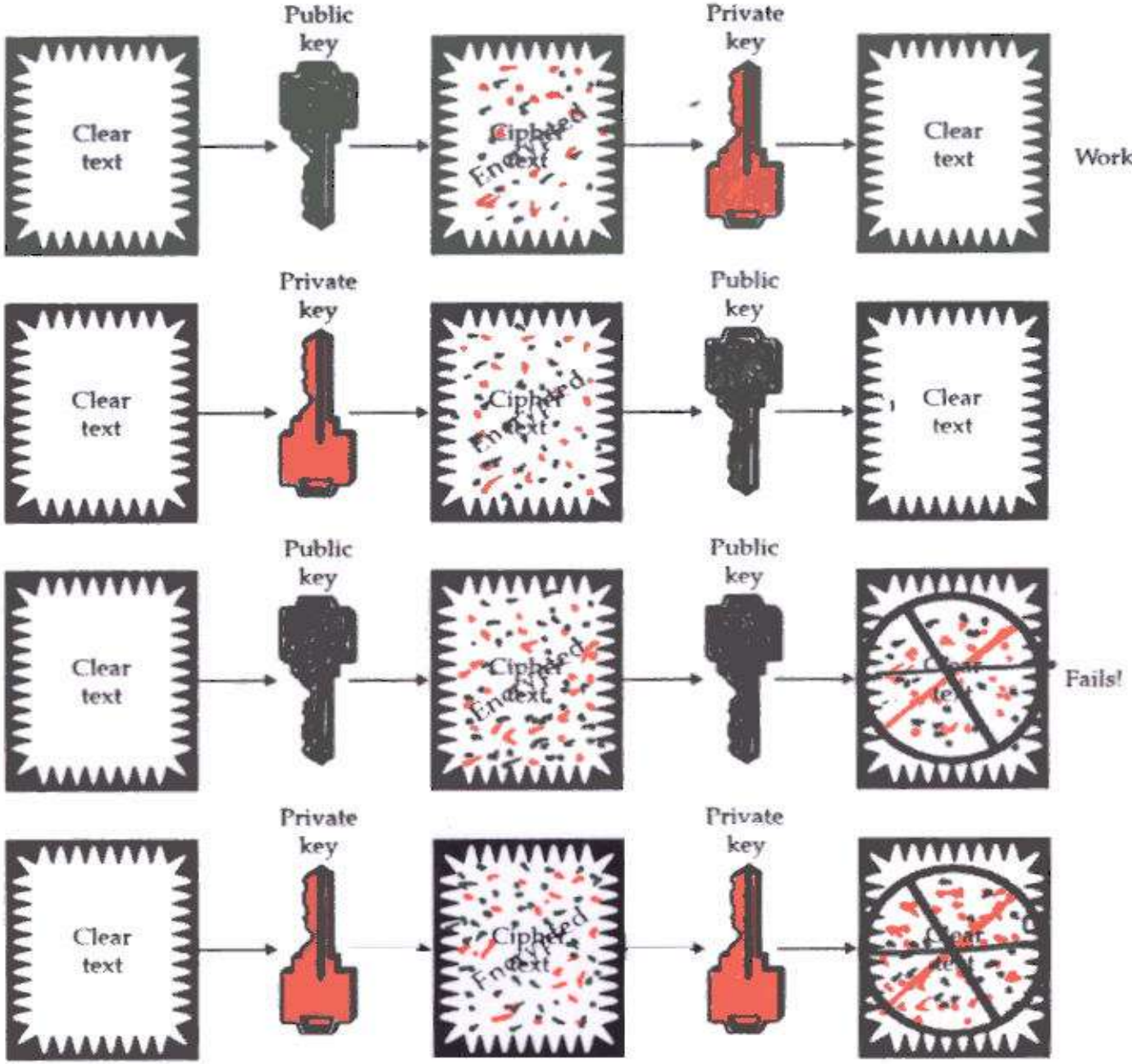
(including Algorithm identifier) [2048 bit]

## Private Key

```
3082 010a 0282 0101 00b1 d311 e079 5543 0708 4ccb 0542 00e2 0d83
463d e493 bab6 06d3 0d59 bd3e c1ce 4367 018a 21a8 efbc ccd0 a2cc
b055 9653 8466 0500 da44 4980 d854 0aa5 2586 94ed 6356 ff70 6ca3
a119 d278 be68 2a44 5e2f cfcc 185e 47bc 3ab1 463d 1ef0 b92c 345f
8c7c 4c08 299d 4055 eb3c 7d83 deb5 f0f7 8a83 0ea1 4cb4 3aa5 b35f
5a22 97ec 199b c105 68fd e6b7 a991 942c e478 4824 1a25 193a eb95
9c39 0a8a cf42 b2f0 1cd5 5ffb 6bed 6856 7b39 2c72 38b0 ee93 a9d3
7b77 3ceb 7103 a938 4a16 6c89 2aca da33 1379 c255 8ced 9cbb f2cb
5b10 f82e 6135 c629 4c2a d02a 63d1 6559 b4f8 cdf9 f400 84b6 5742
859d 32a8 f92a 54fb ff78 41bc bd71 28f4 bb90 bcff 9634 04e3 459e
a146 2840 8102 0301 0001
```

## Public Key

```
3082 01e4 f267 0142 0f61 dd12 e089 5547 0f08 4ccb 0542 00e2 0d83 463d
e493 bab6 0673 0d59 bf3e c1ce 4367 012a 11a8 efbc ccd0 a2cc b055 9653
8466 0500 da44 4980 d8b4 0aa5 2586 94ed 6356 ff70 6ca3 a119 d278 be68
2a44 5e2f cfcc 185e 47bc 3ab1 463d 1df0 b92c 345f 8c7c 4c08 299d 4055
eb3c 7d83 deb5 f0f7 8a83 0ea1 4cb4 3aa5 b35f 5a22 97ec 199b c105 68fd
e6b7 a991 942c e478 4824 1a25 193a eb95 9c39 0a8a cf42 b250 1cd5 5ffb
6bed 6856 7b39 2c72 38b0 ee93 a9d3 7b77 3ceb 7103 a938 4a16 6c89 2aca
da33 1379 c255 8ced 9cbb f2cb 5b10 f82e 6135 c629 4c2a d02a 63d1 6559
b4f8 cdf9 f400 84b6 5742 859d 32a8 f92a 54fb ff78 41bc bd71 28f4 bb90
bcff 9634 04de 45de af46 2240 8410 02f1 0001
```


Public key
Private key
Clear text
Ciphered Text
Clear text
Works!
Private key
Public key
Clear text
Ciphered Text
Clear text
Public key
Public key
Clear text
Ciphered Text
Fails!
Private key
Private key
Clear text
Ciphered Text

# Matrix of Knowledge of Keys

| Key details | *A* should know | *B* should know |
|---|---|---|
| A's private key | Yes | No |
| A's public key | Yes | Yes |
| B's private key | No | Yes |
| B's public key | Yes | Yes |

# Implementation Perspective

# Digital Signature

# Hand Signature Vs Digital Signature

- A ***Hand Signature*** on a document is
  - a **unique pattern** dependant on some secret known only to the signer and
  - **Independent of the content** of the message being signed
- A ***Digital signature*** of a message is
  - **a number** dependent on some secret known only to the signer and
  - **Dependent on the content** of the message being signed
- Properties of Signatures
  - Must be verifiable
  - Provide Authentication
  - Provide Data Integrity
  - Provide Non-repudiation

# What is Digital Signature?

- Hash value of a message when encrypted with the private key of a person is his digital signature on that e-Document
  - Digital Signature of a person therefore **varies from document to document** thus ensuring authenticity of each word of that document.
  - As the public key of the signer is known, anybody can verify the message and the digital signature

# Creating Digital Signature

- Key pairs of every individual
  - ***Public key*** : known to everyone
  - ***Private key*** : known only to the owner
- To ***digitally sign*** an electronic document the signer uses his/her ***Private key***
- To ***verify*** a digital signature the verifier uses the signer's ***Public key***

Achieving

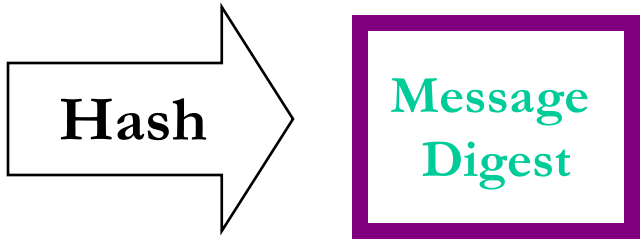
**Authenticity**, **Integrity** and

**Non-Repudiation**

using Digital Signatures

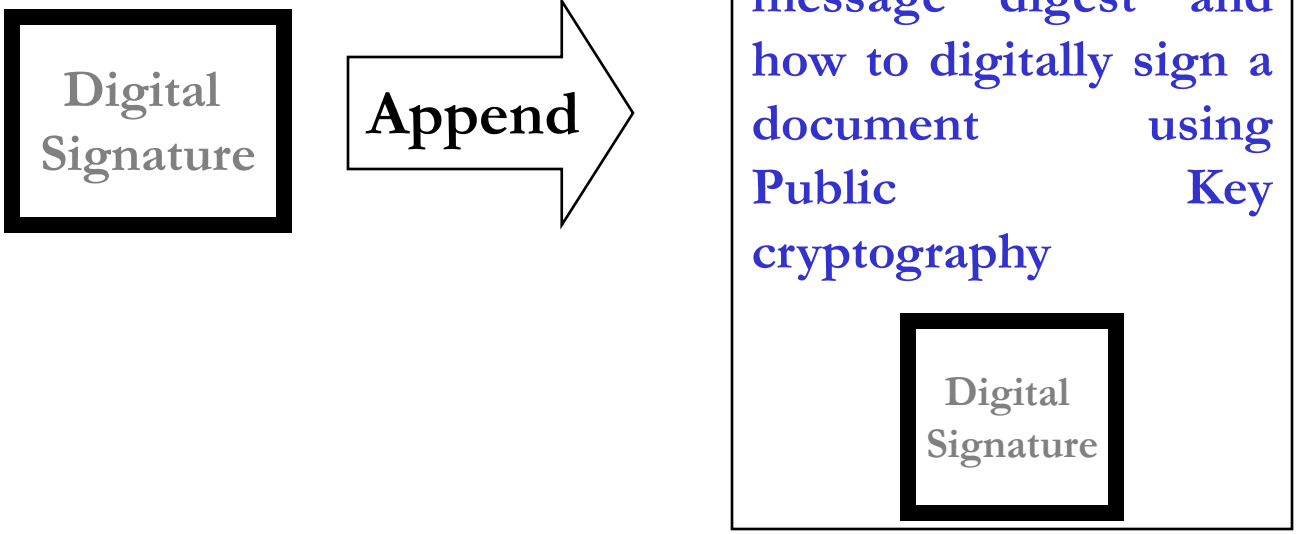
# Digital Signing – Step 1

This is an example of how to create a message digest and how to digitally sign a document using Public Key cryptography

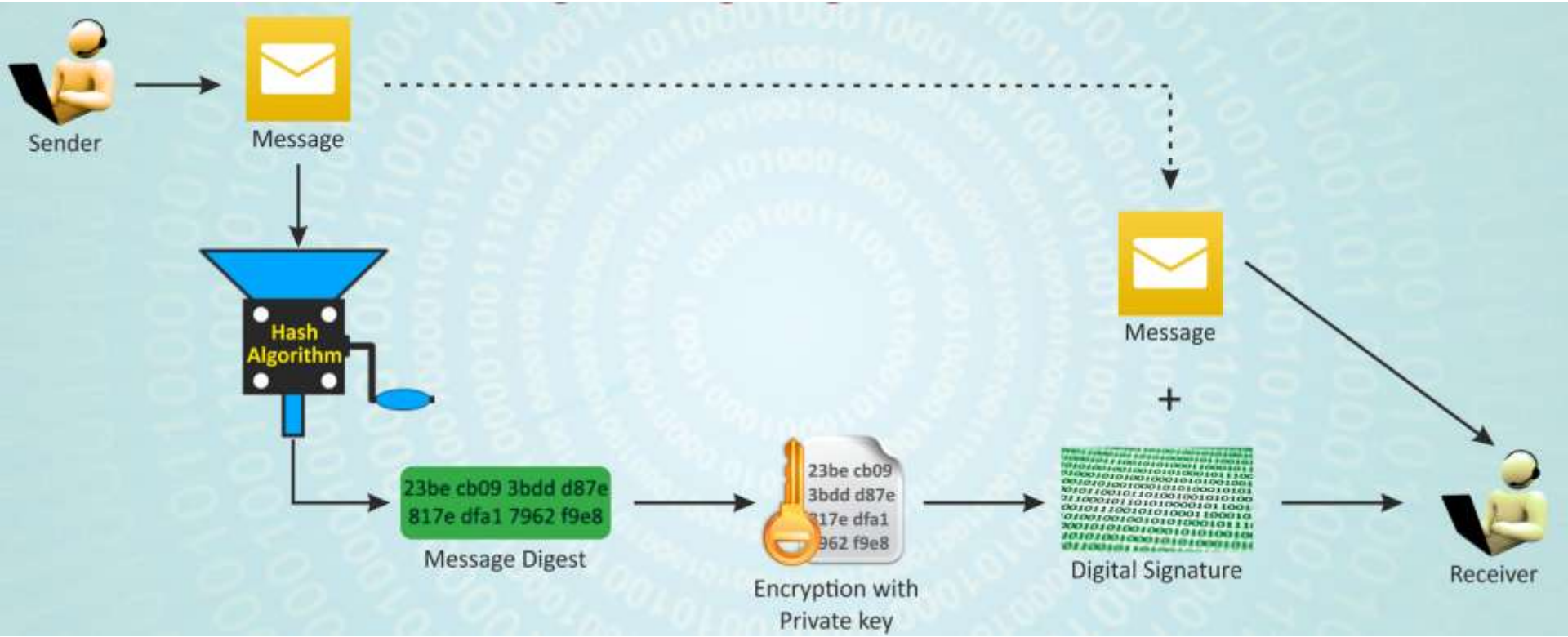


# Digital Signing – Step 2

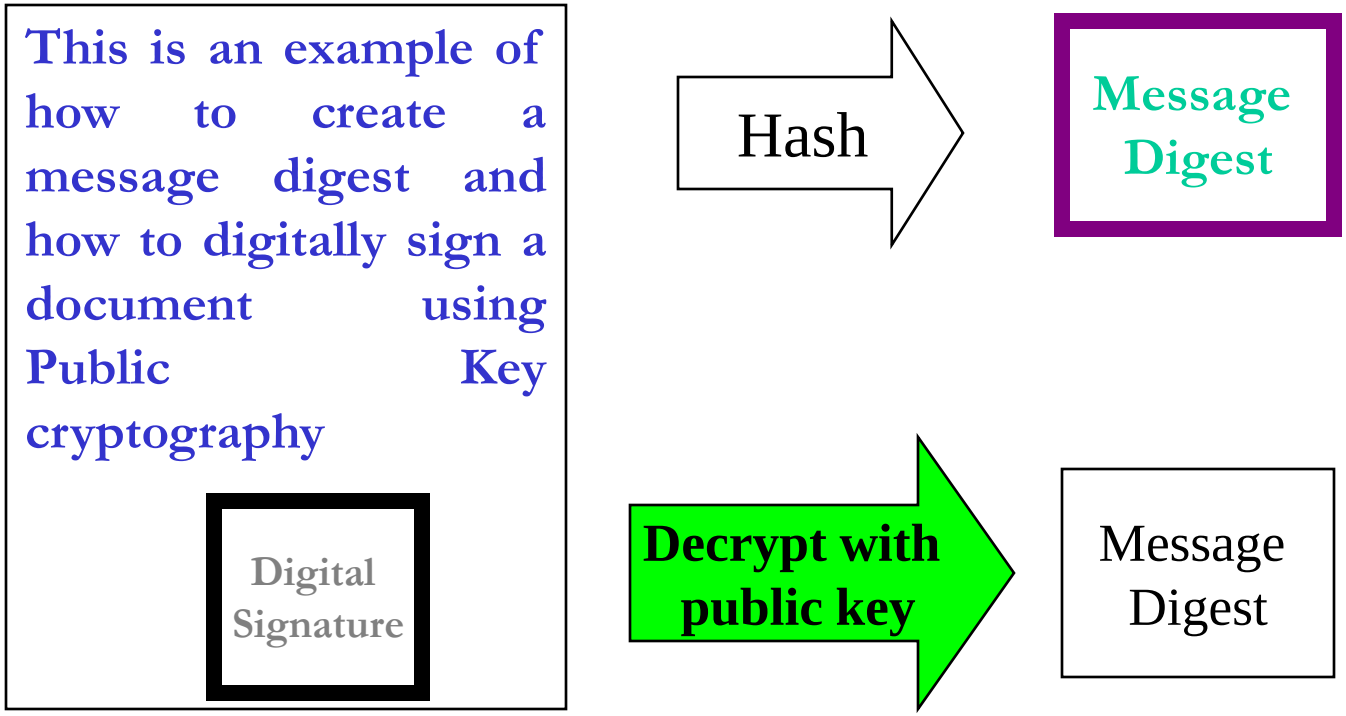
# Digital Signing – Step 3



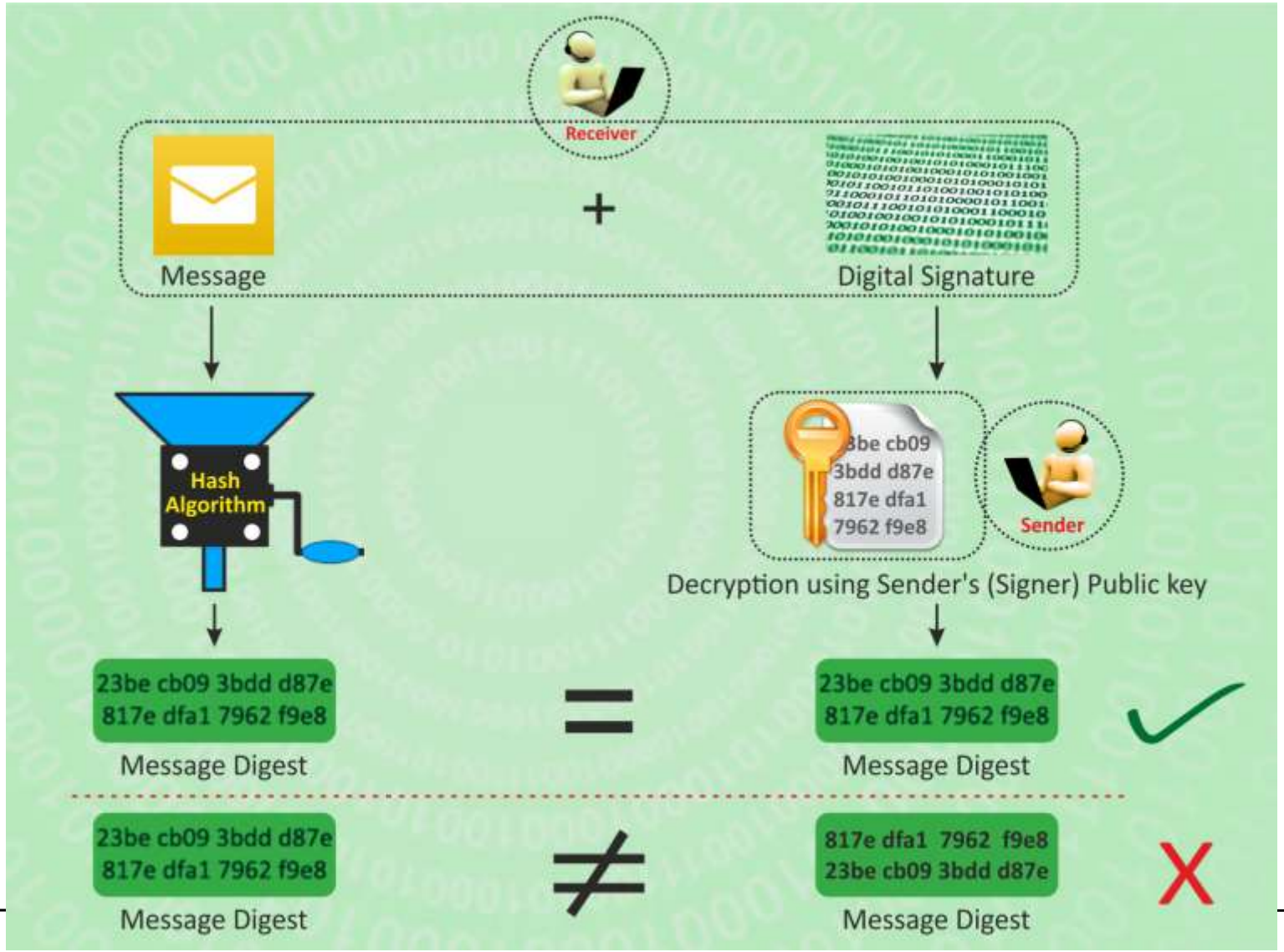
# Digital Signing Process



# Digital Signature Verification



# Digital Signature Verification



# General Conventions

- Signing – Private Key of the Signer
- Verification – Public Key of the Signer

# Digital Signatures - Examples

I agree

efcc61c1c03db8d8ea8569545c073c814a0ed755

My place of birth is Gwalior.

fe1188eecd44ee23e13c4b6655edc8cd5cdb6f25

I am 62 years old.

0e6d7d56c4520756f59235b6ae981cdb5f9820a0

I am an Engineer.

ea0ae29b3b2c20fc018aaca45c3746a057b893e7

I am a Engineer.

01f1d8abd9c2e6130870842055d97d315dff1ea3

- These are digital signatures of same person on different documents

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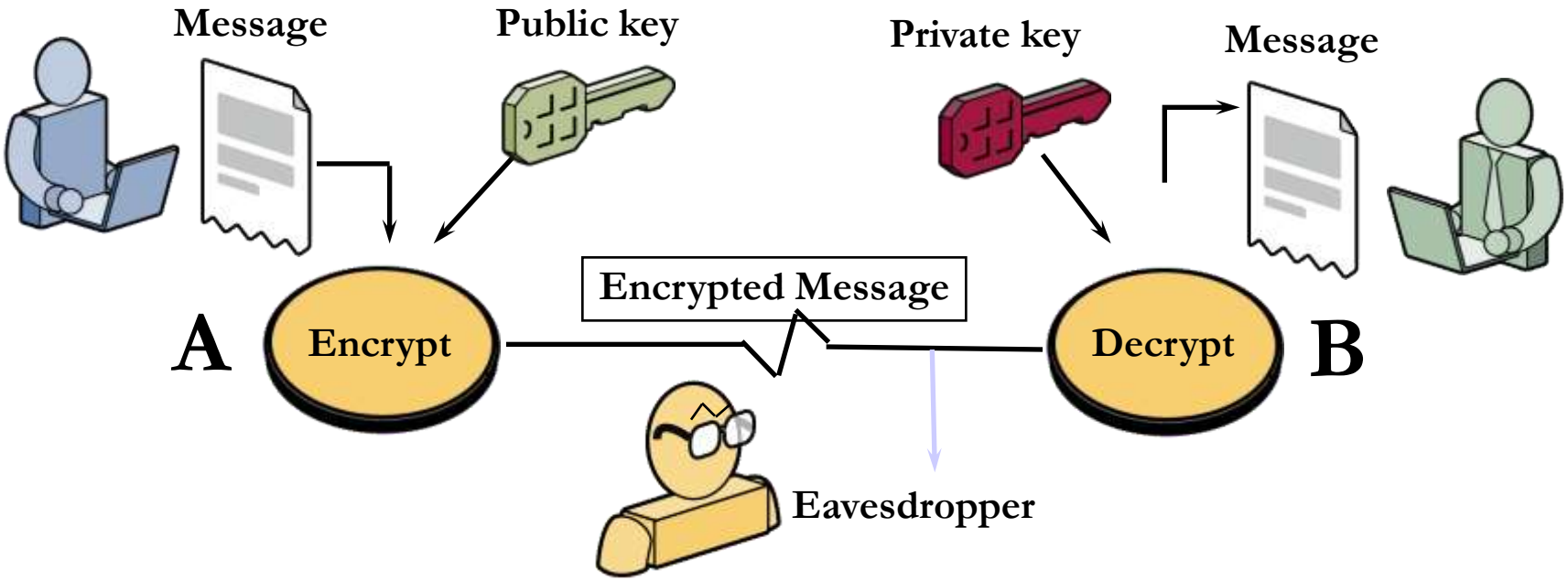
- **Digital Signatures are numbers**
- **They are content and signer dependent**



# Achieving Confidentiality

# Asymmetric Key Encryption - Confidentiality



# General Conventions

- Encryption – Public Key of the Receiver
- Decryption – Private Key of the Receiver

# Present Digital Signature Implementations in India

# PKI enabled Applications

| | | |
|---|---|---|
| 1 | **e-Invoice** | **(B2C)** |
| 2 | **e-Tax Filing** | **(G2C)** |
| 3 | **e-Customs** | **(G2B)** |
| 4 | **e-Passport** | **(G2C) -** Presently in India, the Ministry of External Affairs has started issuing e-Passports in Karnataka state with the fingerprints and the digital photo of applicant |
| 5 | **e-Governance** | **Bhoomi (G2C)**<br>a PKI enabled registration and Land Records Services offered by Govt. of Karnataka to the people. All the land records and certificates issued are digitally signed by the respective officer |
| 6 | **e-Payment** | **(B2B) -** In India, currently between banks fund transfers are done using PKI enabled applications whereas between customers and vendors such as online shopping vendor the payment is done through SSL thereby requiring the vendor to hold DSC ) |

# PKI enabled Applications

| | | |
|---|---|---|
| 7 | **e-Billing** | **(B2C)** -The electronic delivery and presentation of financial statement, bills, invoices, and related information sent by a company to its customers) |
| **8** | **e-Procurement** | **G2B , B2B** |
| 9 | **e-Insurance Service** | **(B2C) -** Presently the users are getting the E-Premium Receipts etc. which is digitally signed by the provider |

# Other Implementations

- DGFT - Clearance of goods are now initiated by exporters through push of a button and in their offices;
  - Previously it used to take days; and requests are now cleared within 6 hours
- Indian Patent office has implemented e-filing of patents and allows only use of Class-3 Certificates
  - Around 30% of e-filing of patents is happening now, among the total filings.

# C-DAC Activities in PKI Domain

- PKI Knowledge Dissemination Program
  - An effort to spread awareness and build competencies in the domain across the country
- PKI Body of Knowledge
  - To develop a BoK with inputs from various sections of users
    - Researchers – Algorithms and new directions in PKI
    - Developers – PKI Administration and implementation issues
    - Policy Makers - Laws
    - End Users and Applications

# Summary

- PKI is an ecosystem comprising of Technology, Policy and Implementations
  - Digital Signatures provide **A**uthenticity, **I**ntegrity, and **N**on-Repudiation for electronic documents & transactions
  - Asymmetric Key system enables **C**onfidentiality
- General Conventions
  - Signing – Private Key of the Signer
  - Verification – Public Key of the Signer
  - Encryption – Public Key of the Receiver
  - Decryption – Private Key of the Receiver

# References


- Cryptography and Network security – principles and practice William Stallings
- Applied Cryptography, Second Edition: Bruce Schneier
- Ryder, Rodney D, Guide to Cyber Laws, 3rd Edition, Wadhwa & Company, New Delhi 2007
- Handbook of Applied Cryptography, by Menezes
- Cryptographic Techniques for N/w Security
- http://campustechnology.com/articles/39190_2
- http://csrc.nist.gov/
- http://www.productivity501.com/digital-signatures-encryption/4710/
- http://www.arx.com/digital-signatures-faq
- http://www.asclonline.com/images/d/d4/Simple_Guide_to_Digital_Signatures.pdf
- http://www.asianlaws.org/library/infosec/obtaining-digital-signature-certificate.pdf
- http://cca.gov.in/
- www.seekha.in/events/pki - for slides and resources



# Thank You