



Cryptography

Module 18

Unmask the **Invisible Hacker.**



Market Survey 2014: The Year of Encryption



60% of those survey said that Edward Snowden revelations have made them more aware of data security



100% of those not interested in security systems admitted to regularly sharing sensitive/ confidential data with external third parties



Among the 60%, approximately **70%** have been directly influenced to look at new data security systems



Over **2/3** of people felt that government certification combined with ease of use would be deciding factors when selecting a data security solution



94% of people looking to invest in new systems are specifically examining secure (encryption) electronic data security systems



One in two people now perceive the Cloud to be less secure as result of Snowden



Only **17%** of those surveyed said their existing secure information sharing system was easy to use



One third of those surveyed were not that upcoming EU DPA reforms would impact the way they or their organization handles and protects data

<http://www.egress.com>

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Case Study: Heartbleed



Heartbleed is a security flaw in the **OpenSSL** cryptographic software library, which allows data traversal over **SSL/TLS in plain-text**

Heartbleed exploits a built-in feature of OpenSSL called **heartbeat**

Attackers exploit this vulnerability to get information such as OpenSSL **private** keys, OpenSSL **secondary** keys, up to **64kb of memory** from the affected server, **usernames** and **passwords**, etc.

Versions of OpenSSL affected by Heartbleed include **1.0.1 to 1.0.1f**

Updating OpenSSL to version 1.0.1g or higher resolves the vulnerability

```

root@root: ~
File Edit View Search Terminal Help


msf auxiliary(openssl_heartbleed) > exploit

[*] 10.0.0.3:443 - Sending Client Hello...
[*] 10.0.0.3:443 - Sending Heartbeat...
[*] 10.0.0.3:443 - Heartbeat response, 65551 bytes
[*] 10.0.0.3:443 - Heartbeat response with leak
[*] 10.0.0.3:443 - Printable info leaked: SslLxx8af"198532ED/Atml+xml,application/xml;
q=0.9,image/webp,*/*;q=0.8User-Agent: Mozilla/5.0 (Windows NT 6.0; WOW64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/36.0.1985.125 Safari/537.36Referer: https://lo
calhost/owncloud/Accept-Encoding: gzip,deflate,sdchAccept-Language: en-US,en;q=0.8Co
okie: ocqh3y3kxnm=fm4286uohaf9lpoingh41qib8265frfm;en;q=0.8Cookie: ocqh3y3kxnm=6c
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08c)+bm+Y-Fc;"/Yb65Ule?)"_V=L=[z7HMH9W]zv'9NL'!<-6;,<0=6>]V:142s64v)VyHzM$433FE
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"6.VK474r,/"B.033=AzvIr6:/F;70%[6 ]MPR7x'e7a%kgkG[d/p Cdg/XsrgVlwig9!r;xk!B4d4];
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```

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Case Study: Poodlebleed



- 
- Poodlebleed (**Padding Oracle On Downgraded Legacy Encryption**) is a security vulnerability in the design of SSL 3.0
 - Attacker exploits this vulnerability to **decrypt ciphertext in transit** between a server and a browser, by means of padding oracle side-channel attack
 - **Countermeasures:**
 - Completely **disable SSL 3.0** on the client side and the server side
 - Implement **anti-POODLE record splitting**



<https://poodlebleed.com>

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Module Objectives



- Understanding Cryptography Concepts
- Overview of Encryption Algorithms
- Cryptography Tools
- Understanding Public Key Infrastructure (PKI)



- Understanding Email Encryption
- Understanding Disk Encryption
- Understanding Cryptography Attacks
- Cryptanalysis Tools



Module Flow



1
**Cryptography
Concepts**

2
**Encryption
Algorithms**

3
**Cryptography
Tools**

4
**Public Key
Infrastructure
(PKI)**

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**Email
Encryption**

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**Disk
Encryption**

7
**Cryptography
Attacks**

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**Cryptanalysis
Tools**

Cryptography



01

Cryptography is the **conversion of data** into a scrambled code that is decrypted and sent across a private or public network



02

Cryptography is used to protect confidential data such as **email messages**, chat sessions, **web transactions**, personal data, **corporate data**, e-commerce applications, etc.



03

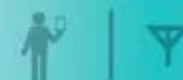
Objectives

- Confidentiality
- Integrity

- Authentication
- Non-repudiation



04

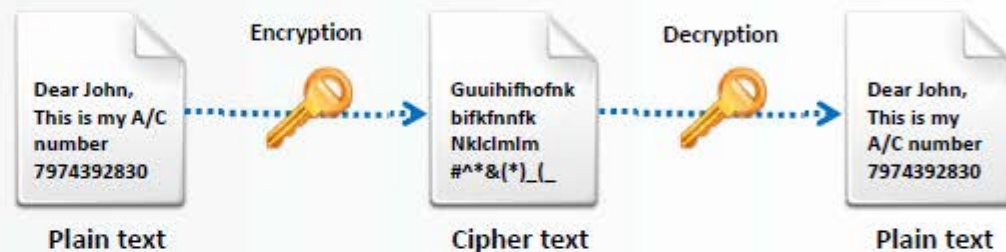


Types of Cryptography



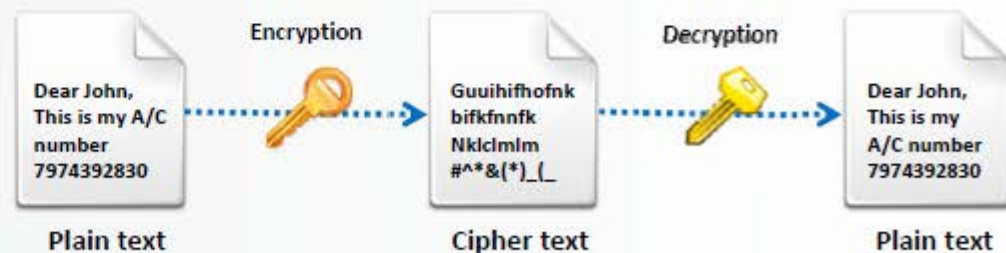
Symmetric Encryption

Symmetric encryption (secret-key, shared-key, and private-key) **uses the same key** for encryption as it does for decryption



Asymmetric Encryption

Asymmetric encryption (public-key) **uses different encryption keys** for encryption and decryption. These keys are known as public and private keys



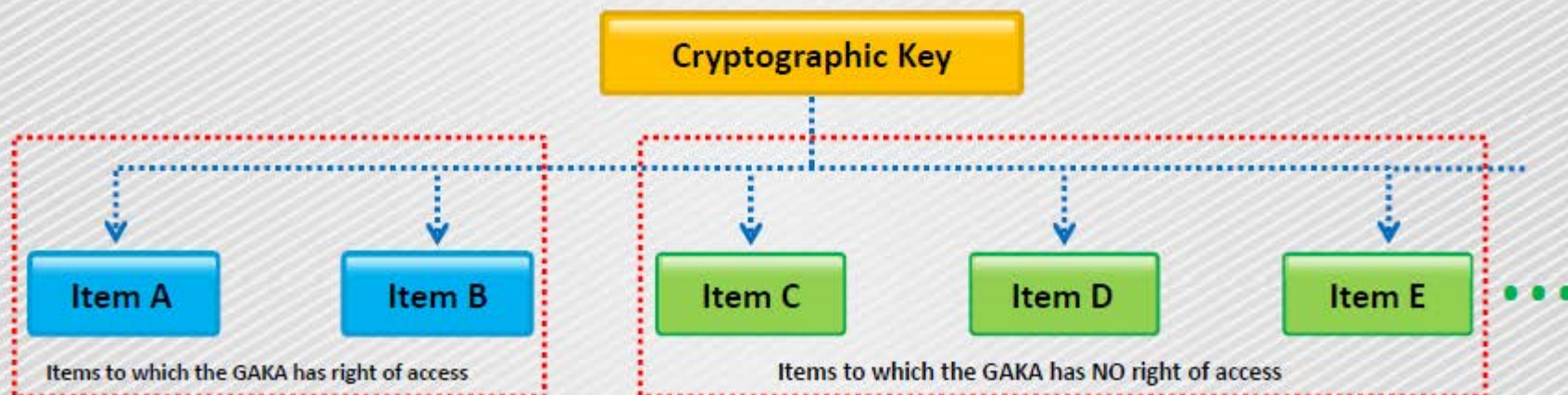
Government Access to Keys (GAK)



Government Access to Keys means that software companies will give **copies of all keys**, (or at least enough of the key that the remainder could be cracked) to the government

The government promises that they will hold on to the keys in a **secure way**, and will only use them when a **court issues a warrant** to do so

To the government, this issue is similar to the **ability to wiretap phones**



Module Flow



1

**Cryptography
Concepts**

2

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(PKI)**

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Encryption**

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**Cryptanalysis
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Ciphers



Ciphers are **algorithms** used to encrypt or decrypt the data

Modern Ciphers

Classical Ciphers

Substitution cipher

A block of plaintext is replaced with ciphertext

Transposition cipher

The letters of the plaintext are shifted about to form the cryptogram

Based on the type of key used

Private Key

Same key is used for encryption and decryption

Public Key

Two different keys are used for encryption and decryption

Based on the type of input data

Block Cipher

Encrypts block of data of fixed size

Stream Cipher

Encrypts continuous streams of data

Data Encryption Standard (DES)



The algorithm is designed to **encipher** and **decipher** blocks of data consisting of **64 bits** under control of a 56-bit key



DES is the **archetypal block cipher** — an algorithm that takes a fixed-length string of plaintext bits and transforms it into a ciphertext bitstring of the same length



Due to the **inherent weakness** of DES with today's technologies, some organizations repeat the process three times (3DES) for added strength, until they can afford to update their equipment to AES capabilities

Advanced Encryption Standard (AES)



AES Pseudocode

AES is a **symmetric-key** algorithm for securing sensitive but unclassified material by U.S. government agencies

AES is an **iterated block cipher**, which works by repeating the same operation **multiple** times

It has a **128-bit** block size, with key sizes of 128, 192, and 256 bits, respectively for AES-128, AES-192, and AES-256

```
Cipher (byte in[4*Nb], byte out[4*Nb],  
word w[Nb*(Nr+1)])  
begin  
    byte state[4,Nb]  
    state = in  
    AddRoundKey(state, w)  
    for round = 1 step 1 to Nr-1  
        SubBytes(state)  
        ShiftRows(state)  
        MixColumns(state)  
        AddRoundKey(state, w+round*Nb)  
    end for  
    SubBytes(state)  
    ShiftRows(state)  
    AddRoundKey(state, w+Nr*Nb)  
    out = state  
end
```

RC4, RC5, RC6 Algorithms



RC4

A variable **key size stream cipher** with byte-oriented operations, and is based on the use of a random permutation



RC5

It is a **parameterized algorithm** with a variable block size, a variable key size, and a variable number of rounds. The key size is **128-bits**

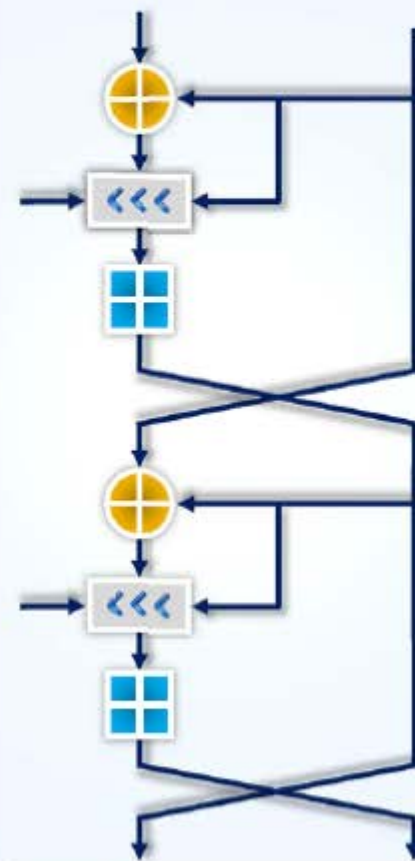


RC6

RC6 is a **symmetric key block cipher** derived from RC5 with two additional features:

- Uses **Integer multiplication**
- Uses **four 4-bit working registers** (RC5 uses two 2-bit registers)

RC5 Algorithm



The DSA and Related Signature Schemes



Digital Signature Algorithm

FIPS 186-2 specifies the Digital Signature Algorithm (DSA) that may be used in the **generation and verification of digital signatures** for sensitive, unclassified applications

Digital Signature

The digital signature is **computed using a set of rules** (i.e., the DSA) **and a set of parameters** such that the identity of the signatory and integrity of the data can be verified

Each entity creates a public key and corresponding private key

1. Select a prime number q such that $2^{159} < q < 2^{160}$
2. Choose t so that $0 \leq t \leq 8$
3. Select a prime number p such that $2^{511+64t} < p < 2^{512+64t}$ with the additional property that q divides $(p-1)$
4. Select a generator α of the unique cyclic group of order q in \mathbb{Z}_p^*
5. To compute α , select an element g in \mathbb{Z}_p^* and compute $g^{(p-1)/q} \bmod p$
6. If $\alpha = 1$, perform step five again with a different g
7. Select a random a such that $1 \leq a \leq q-1$
8. Compute $y = \alpha^a \bmod p$



The public key is (p, q, α, y) . The private key is a .

RSA (Rivest Shamir Adleman)



RSA is an **Internet encryption and authentication system** that uses an algorithm developed by Ron Rivest, Adi Shamir, and Leonard Adleman



01



RSA encryption is widely used and is one of the **de-facto encryption standard**



02



It uses **modular arithmetic** and **elementary number theories** to perform computations using two large prime numbers



03



The RSA Signature Scheme



Algorithm Key generation for the RSA signature scheme

SUMMARY: each entity creates an RSA public key and a corresponding private key. Each entity A should do the following:

1. Generate two large distinct random primes p and q , each roughly the same size.
2. Compute $n = pq$ and $\phi = (p - 1)(q - 1)$.
3. Select a random integer e , $1 < e < \phi$, such that $\gcd(e, \phi) = 1$.
4. Use the extended Euclidean algorithm (Algorithm 2.107) to compute the unique integer d , $1 < d < \phi$, such that $ed \equiv 1 \pmod{\phi}$.
5. A 's public key is (n, e) ; A 's private key is d .



Algorithm RSA signature generation and verification

SUMMARY: entity A signs a message $m \in \mathcal{M}$. Any entity B can verify A 's signature and recover the message m from the signature.

1. *Signature generation.* Entity A should do the following:
 - (a) Compute $\tilde{m} = R(m)$, an integer in the range $[0, n - 1]$.
 - (b) Compute $s = \tilde{m}^d \pmod{n}$.
 - (c) A 's signature for m is s .
2. *Verification.* To verify A 's signature s and recover the message m , B should:
 - (a) Obtain A 's authentic public key (n, e) .
 - (b) Compute $\tilde{m} = s^e \pmod{n}$.
 - (c) Verify that $\tilde{m} \in \mathcal{M}_R$; if not, reject the signature.
 - (d) Recover $m = R^{-1}(\tilde{m})$.

Example of RSA Algorithm



$P = 61$ \leq first prime number (destroy this after computing E and D)
 $Q = 53$ \leq second prime number (destroy this after computing E and D)
 $PQ = 3233$ \leq modulus (give this to others)
 $E = 17$ \leq public exponent (give this to others)
 $D = 2753$ \leq private exponent (keep this secret!)

Your **public key** is (E,PQ).

Your **private key** is D.

The encryption function is: $\text{encrypt}(T) = (T^E) \bmod PQ$
 $= (T^{17}) \bmod 3233$

The decryption function is: $\text{decrypt}(C) = (C^D) \bmod PQ$
 $= (C^{2753}) \bmod 3233$

To encrypt the plaintext value 123, do this:

$\text{encrypt}(123) = (123^{17}) \bmod 3233$
 $= 337587917446653715596592958817679803 \bmod 3233$
 $= 855$

To decrypt the cipher text value 855, do this:

$\text{decrypt}(855) = (855^{2753}) \bmod 3233$
 $= 123$



Message Digest (One-way Hash) Functions



Document



Message Digest Function



a14092af948b938569584e5b8d8d307a

Hash Value

Hash functions **calculate a unique fixed-size bit string** representation called a message digest of any arbitrary block of information



If any given bit of the function's input is changed, every output bit has a **50 percent** chance of changing



It is computationally infeasible to have two files with the **same message digest value**



Note: Message digests are also called one-way hash functions because they cannot be reversed

Message Digest Function: MD5



MD5 Algorithm



MD5 algorithm takes a message of arbitrary length as input and outputs a 128-bit fingerprint or message digest of the input



MD5 is not collision resistant, use of latest algorithms such as SHA-2 and SHA-3 is recommended

MD5 hash is a 32-digit hexadecimal number

It is still deployed for digital signature applications, file integrity checking and storing passwords



Quick Checksum Verifier



<http://www.bitdreamers.com>

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Secure Hashing Algorithm (SHA)



It is an algorithm for generating cryptographically secure one-way hash, published by the **National Institute of Standards and Technology** as a **U.S. Federal Information Processing Standard**

SHA1

It produces a **160-bit digest** from a message with a maximum length of **(264 – 1) bits**, and resembles the MD5 algorithm

SHA2

It is a family of two similar hash functions, with different block sizes, namely **SHA-256** that uses **32-bit words** and **SHA-512** that uses **64-bit words**

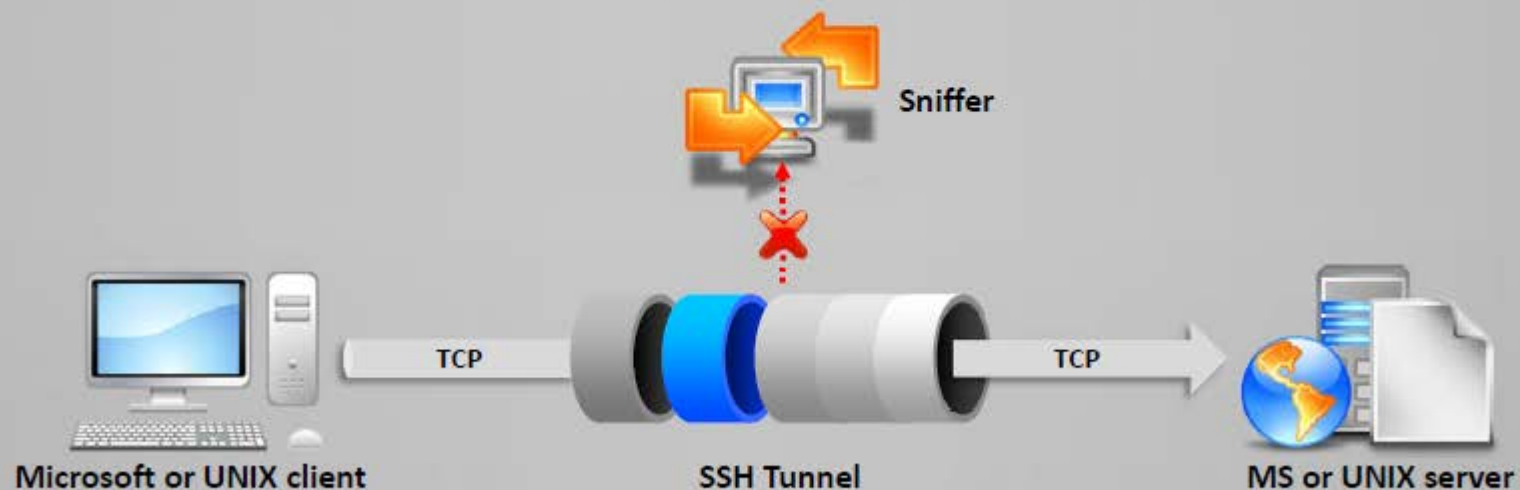
SHA3

SHA-3 uses the **sponge construction** in which message blocks are **XORed** into the initial bits of the state, which is then invertibly permuted

What is **SSH** (Secure **Shell**)?



- 1 SSH is a secure replacement for **telnet** and the **Berkeley remote-utilities** (rlogin, rsh, rcp, and rdist)
- 2 It provides an **encrypted channel** for remote logging, command execution and file transfers
- 3 Provides strong **host-to-host and user authentication**, and secure communication over an insecure Internet



Note: SSH2 is a more secure, efficient, and portable version of SSH that includes SFTP, an SSH2 tunneled FTP

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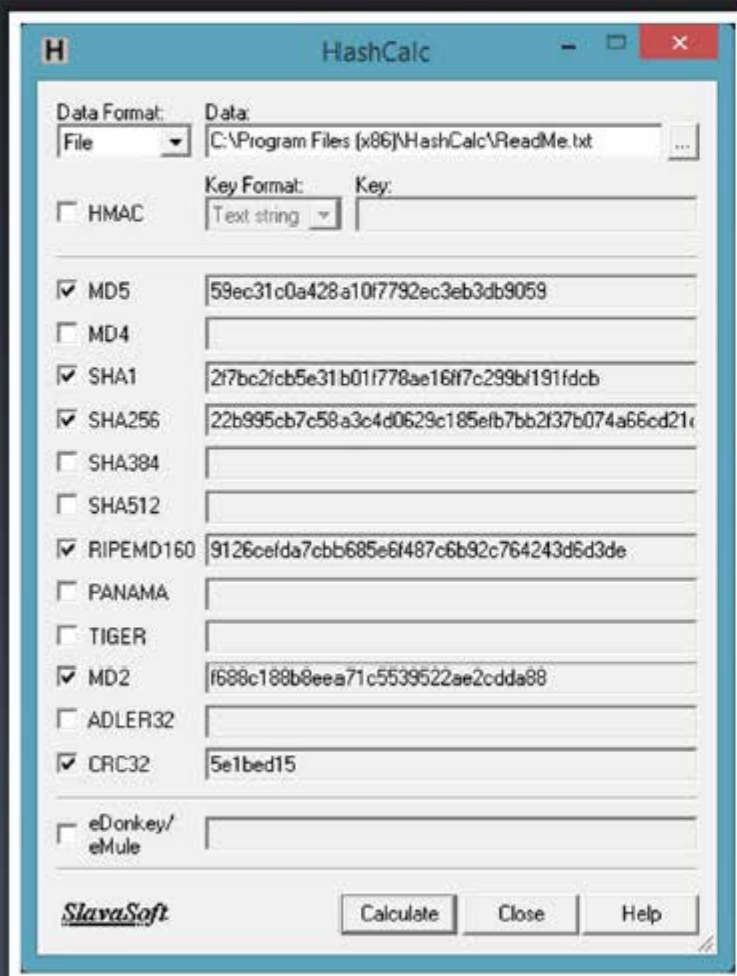
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**Cryptography
Attacks**

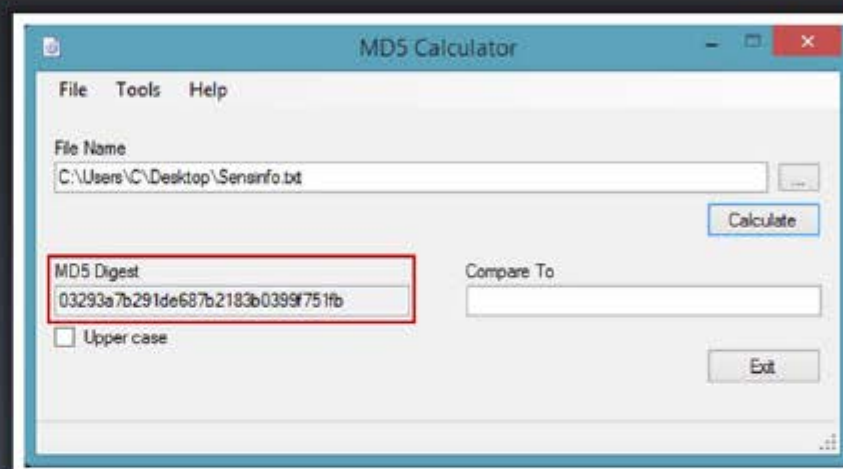
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**Cryptanalysis
Tools**

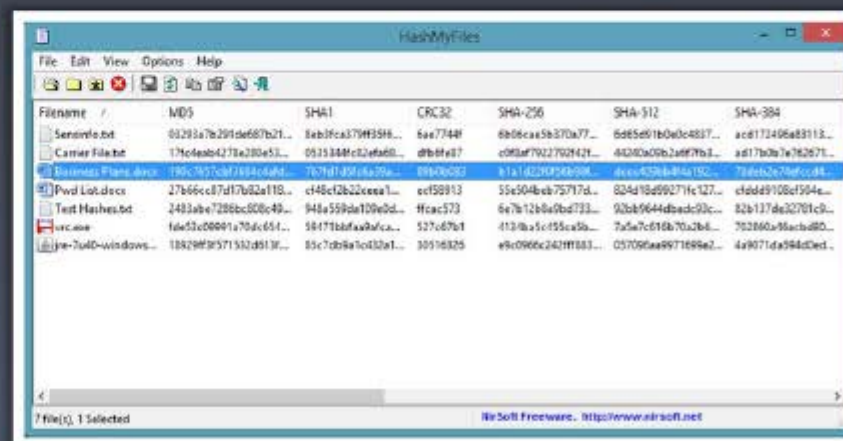
MD5 Hash Calculators: HashCalc, MD5 Calculator and HashMyFiles



<http://www.slavasoft.com>



<http://www.bullzip.com>



<http://www.nirsoft.net>

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Hash Calculators for Mobile: MD5 Hash Calculator, Hash Droid, and Hash Calculator



MD5 Hash Calculator



<http://md5calculator.chromefans.org>

Hash Droid



<https://play.google.com>

Hash Calculator

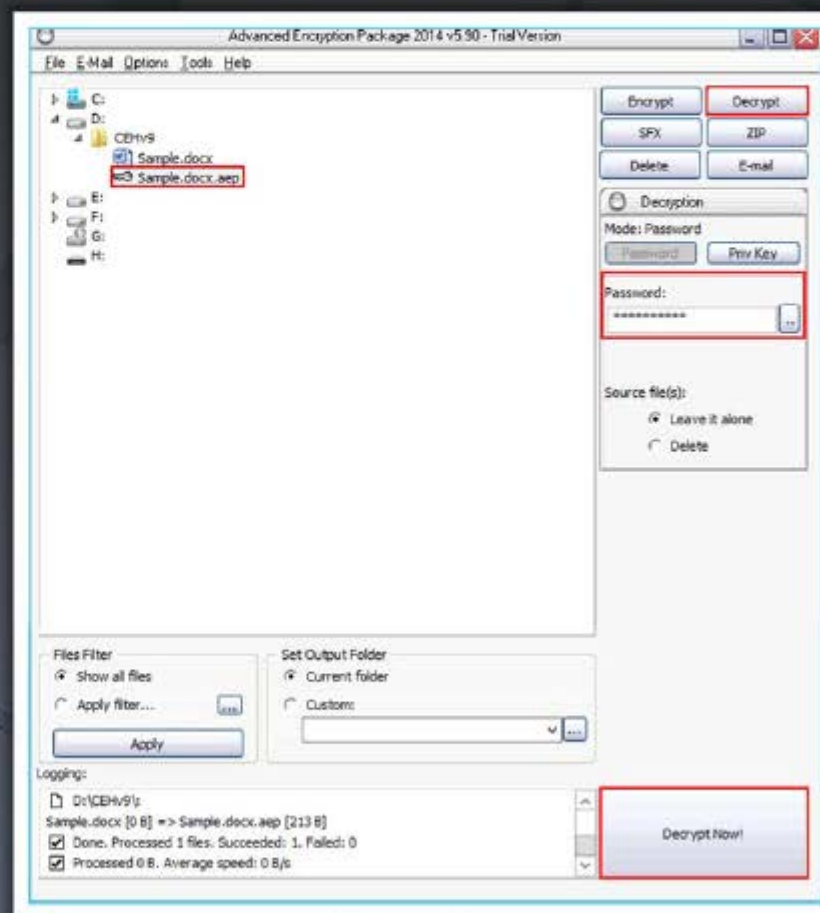
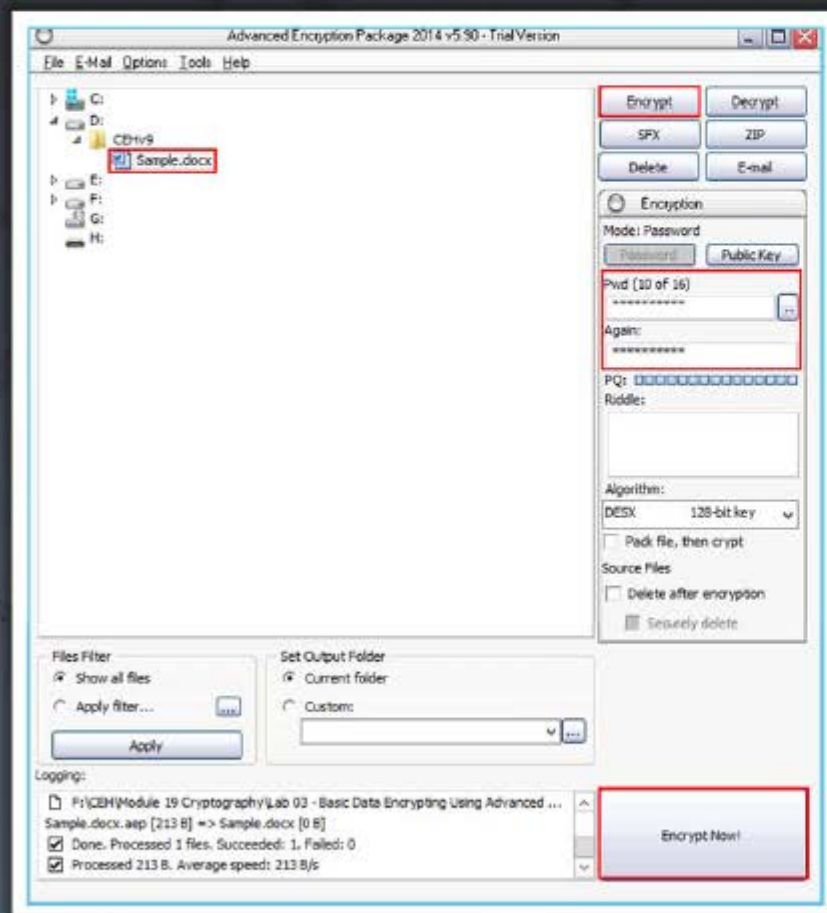


<https://play.google.com>

Cryptography Tool: Advanced Encryption Package 2014



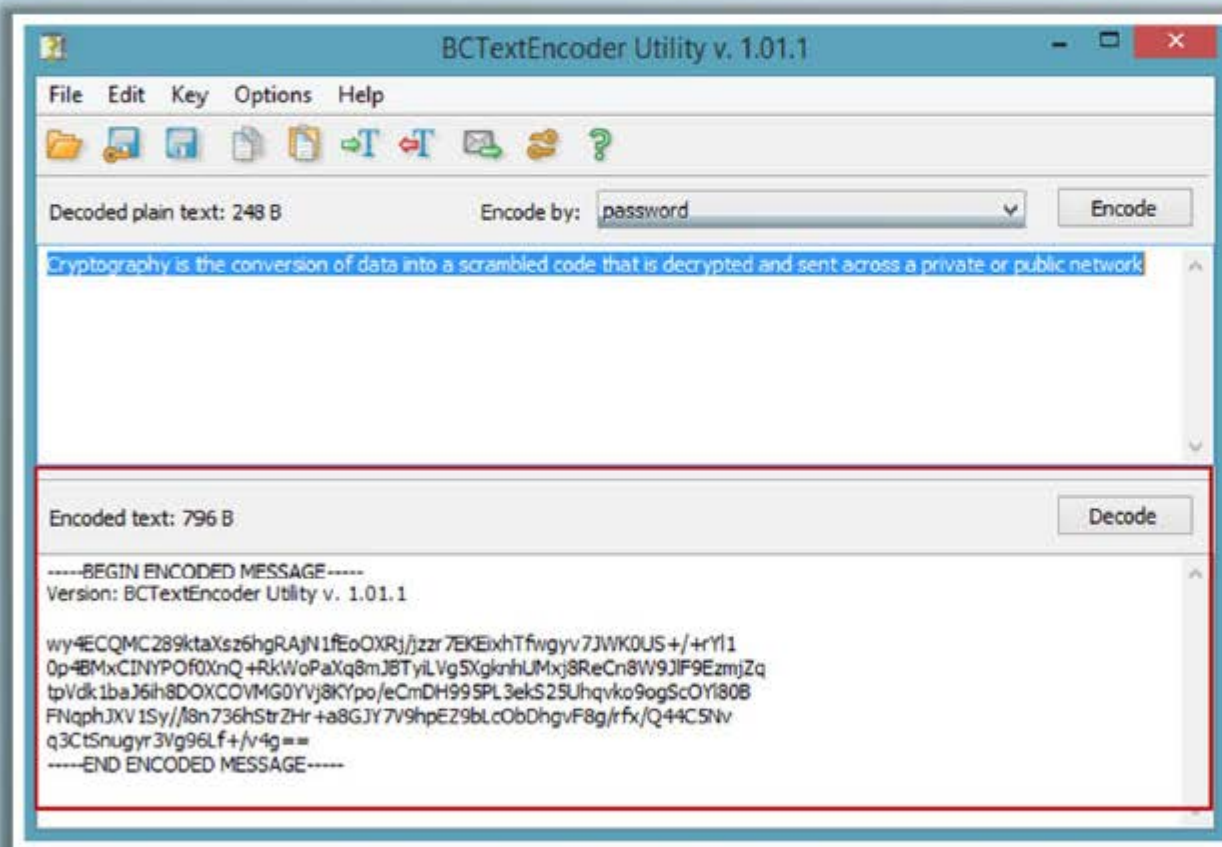
- Advanced Encryption Package 2014 file encryption software supports **symmetric and asymmetric encryption**



<http://www.aepro.com>

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Cryptography Tool: **BCTextEncoder**



<http://www.jetico.com>

- BCTextEncoder encrypts **confidential text** in your **message**
- It uses strong and approved symmetric and public key algorithms for **data encryption**
- It uses public key encryption methods as well as **password-based encryption**



Cryptography Tools



AutoKrypt

<http://www.hiteksoftware.com>



NCrypt XL

<http://www.littlelite.net>



**Cryptainer LE Free
Encryption Software**

<http://www.cypherix.com>



ccrypt

<http://ccrypt.sourceforge.net>



Steganos LockNote

<https://www.steganos.com>



WinAES

<http://fatlyz.com>



AxCrypt

<http://www.axantum.com>



EncryptOnClick

<http://www.2brightsparks.com>



CryptoForge

<http://www.cryptoforge.com>



GNU Privacy Guard

<http://www.gnupg.org>

Cryptography Tools for Mobile: **Secret Space Encryptor**, **CryptoSymm**, and **Cipher Sender**

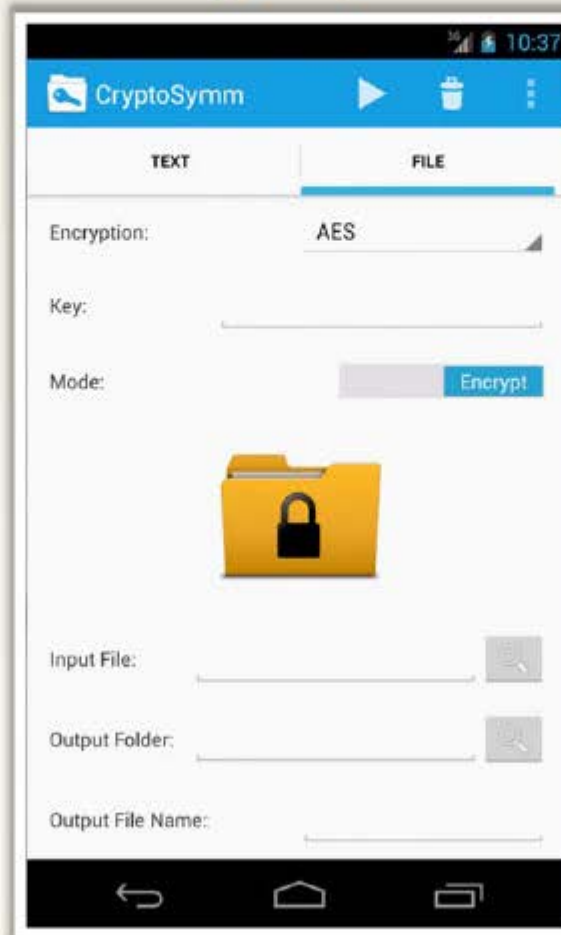


Secret Space Encryptor



<http://www.paranoiaworks.mobi>

CryptoSymm



<https://play.google.com>

Cipher Sender



<https://play.google.com>

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Module Flow



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**Cryptography
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**Public Key
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**Email
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**Disk
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Public Key Infrastructure (PKI)



Public Key Infrastructure (PKI) is a **set of hardware, software, people, policies, and procedures** required to create, manage, distribute, use, store, and revoke **digital certificates**

Components of PKI

1

Certificate Management System

Generates, distributes, stores, and verifies certificates

2

Digital Certificates

Establishes credentials of a person when doing online transactions

3

Validation Authority (VA)

Stores certificates (with their public keys)

4

Certificate Authority (CA)

Issues and verifies digital certificates

5

End User

Requests, manages, and uses certificates

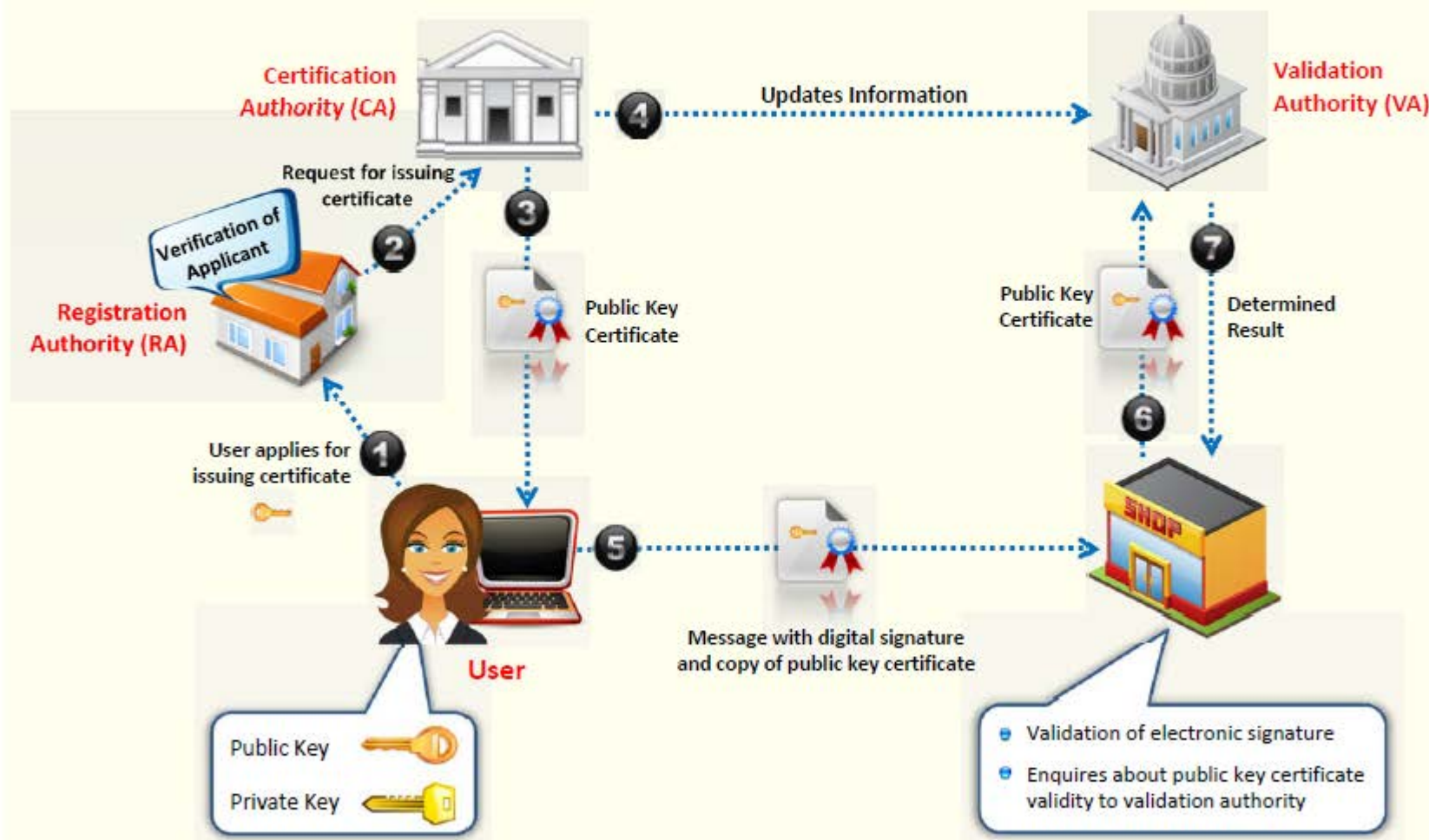
6

Registration Authority (RA)

Acts as the verifier for the certificate authority

Public Key Infrastructure (PKI)

(Cont'd)



Certification Authorities



COMODO
Creating Trust Online

Products Home & Basic Office Business & Enterprise Partners Social Media

The First To Bring You a Full Line of 2048-bit Certificates

Comodo brings you next generation compliance today with our line of 2048-bit SSL.

Explore Our SSL Certificates

- Secure Subdomains
- Secure Websites
- Secure Mail Server
- Secure Code Signing

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Products Partners Support Resources My Account

The most visible sign of web site security

Show your customers your site is safe with Extended Validation SSL.

[Learn more](#)

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- Buy SSL Certificates
- Buy Code Signing

White Paper
Understanding SSL Certificates

Manage Multiple Certificates
Manage certificates across any size organization with ease!

Not all SSL is the Same
Compare Thawte to other SSL providers and see the difference!

<http://www.thawte.com>

Symantec VeriSign Authentication Services

Products & Services Partners Support My Account

Norton SECURED
powered by VeriSign

Same check. New name. Still the gold standard.

The same security, services and support you've come to trust from VeriSign are now brought to you by Symantec.

What it means for you >

BUY SSL Certificates
BUY Symantec Safe Site
BUY Code Signing
TRY Free Trial
RENEW Renew SSL Certificates
SIGN IN Trust Center

Trust from Search to Browse to Buy
Boost your site traffic and conversions with powerful trust features. Free with every SSL Certificate.

Protect Your Site. Grow Your Business.
New features from Symantec SSL make your Web site easy to trust and easy to secure.

VERISIGN
Cyber security and availability products your business relies on.

- Managed CRLs
- OV SSL Protection
- Code Signing
- Domain Name Services

are available from VeriSign at VeriSign.com

<http://www.symantec.com>

Entrust

SECURITY ON: SSL
Entrust Discovery

Find, inventory and manage ALL certificates across ALL your systems and environments

> Why Entrust > Products > Support > Partners > About Us > My Account

Phone Blog Email

Go Wild!
New Product SSL Packages
From **\$725/year**
[Buy Now](#) [Learn More](#)

EV Multi-Domain SSL Certificates
From **\$373/year**
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OV Multi-Domain SSL Certificates
From **\$249/year**
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Advantage SSL Certificates
From **\$186/year**
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Standard SSL Certificates
From **\$155/year**
[Buy Now](#) [Learn More](#)

- Wildcard Domain Email
- Wildcard Domain Email
- Code Signing Certificates
- Appl. Code Signing Certificates
- Certificate Management Service
- Certificate Discovery

<http://www.entrust.net>

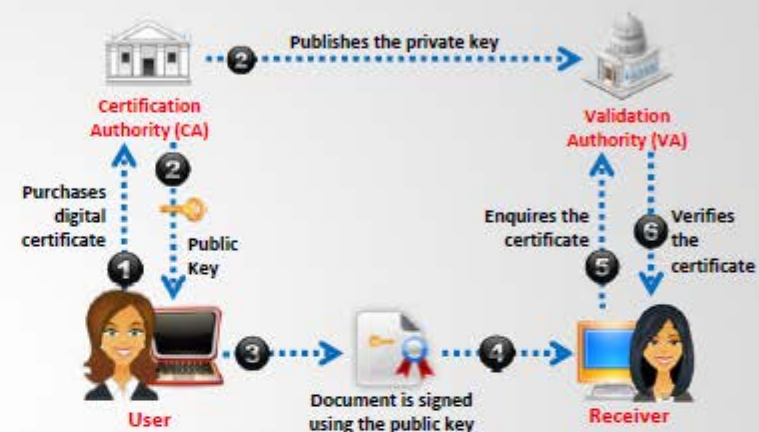
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Signed Certificate (CA) Vs. Self Signed Certificate



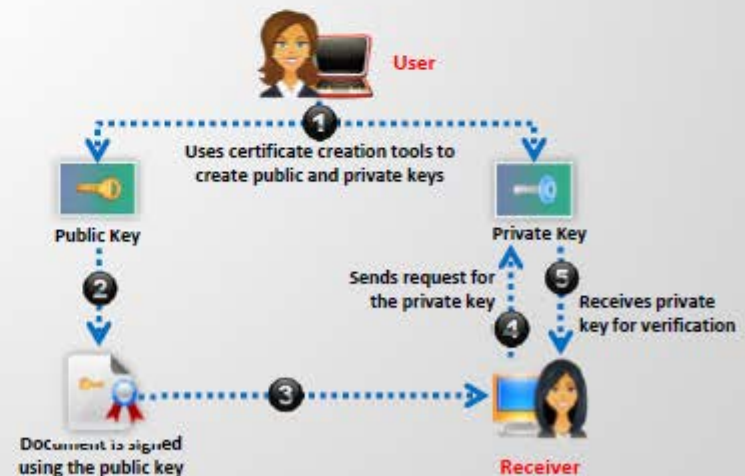
Signed Certificate

- User approaches a trustworthy **Certification Authority (CA)** and purchases digital certificate
- User gets the **public key** from the CA, he signs the document using it
- The signed document is delivered to the receiver
- The receiver can verify the certificate by enquiring in **Validation Authority (VA)**
- VA verifies the certificate to the receiver but it does not **share private key**



Self-signed Certificate

- User creates public and private keys using a tool such as **Adobe Reader, Java's keytool, Apple's Keychain**, etc.
- User uses public key to **sign the document**
- The **self-signed document** is delivered to the receiver
- The receiver request the user for his **private key**
- User **shares the private key** with the receiver



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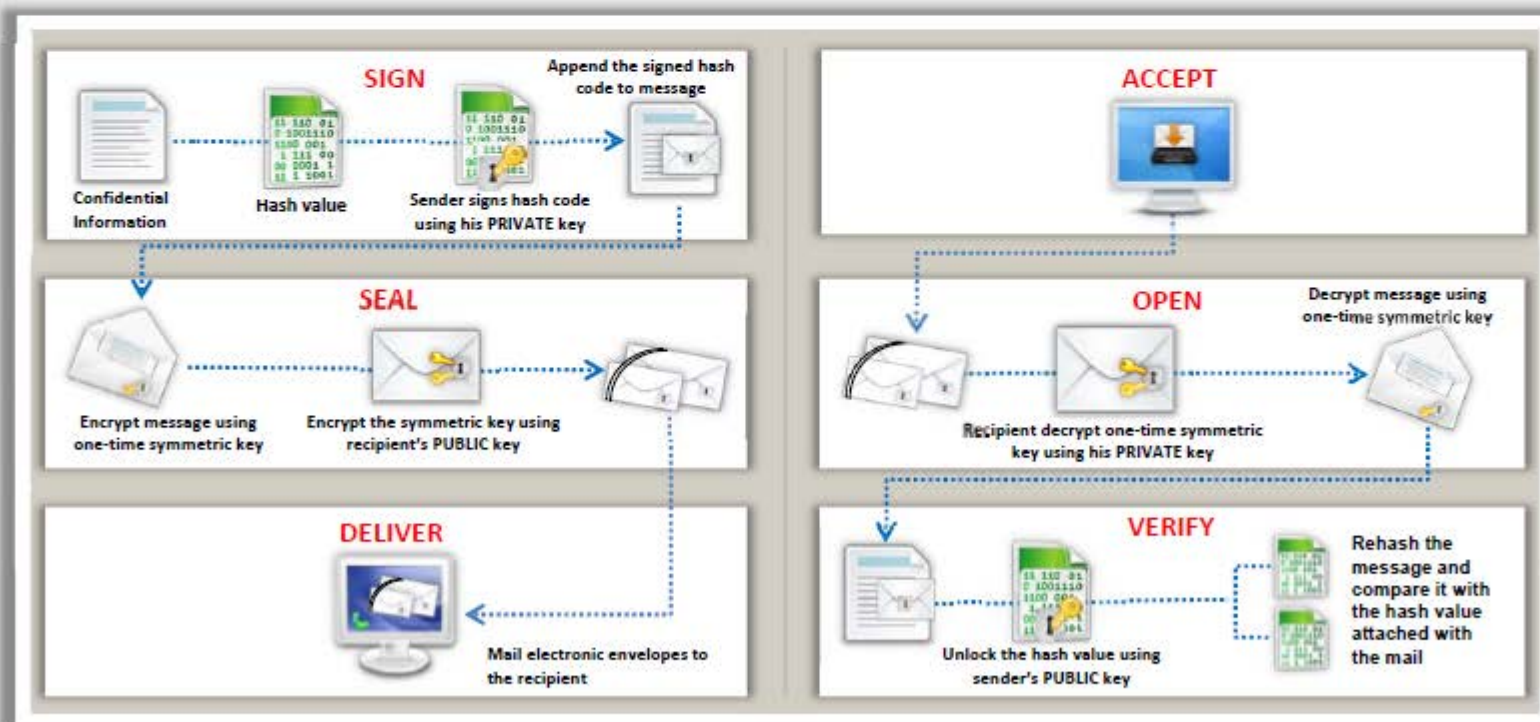
Digital Signature

**1**

Digital signature used asymmetric cryptography to simulate the security properties of a **signature in digital, rather than written form**

2

A digital signature may be further protected, by **encrypting the signed email** for confidentiality

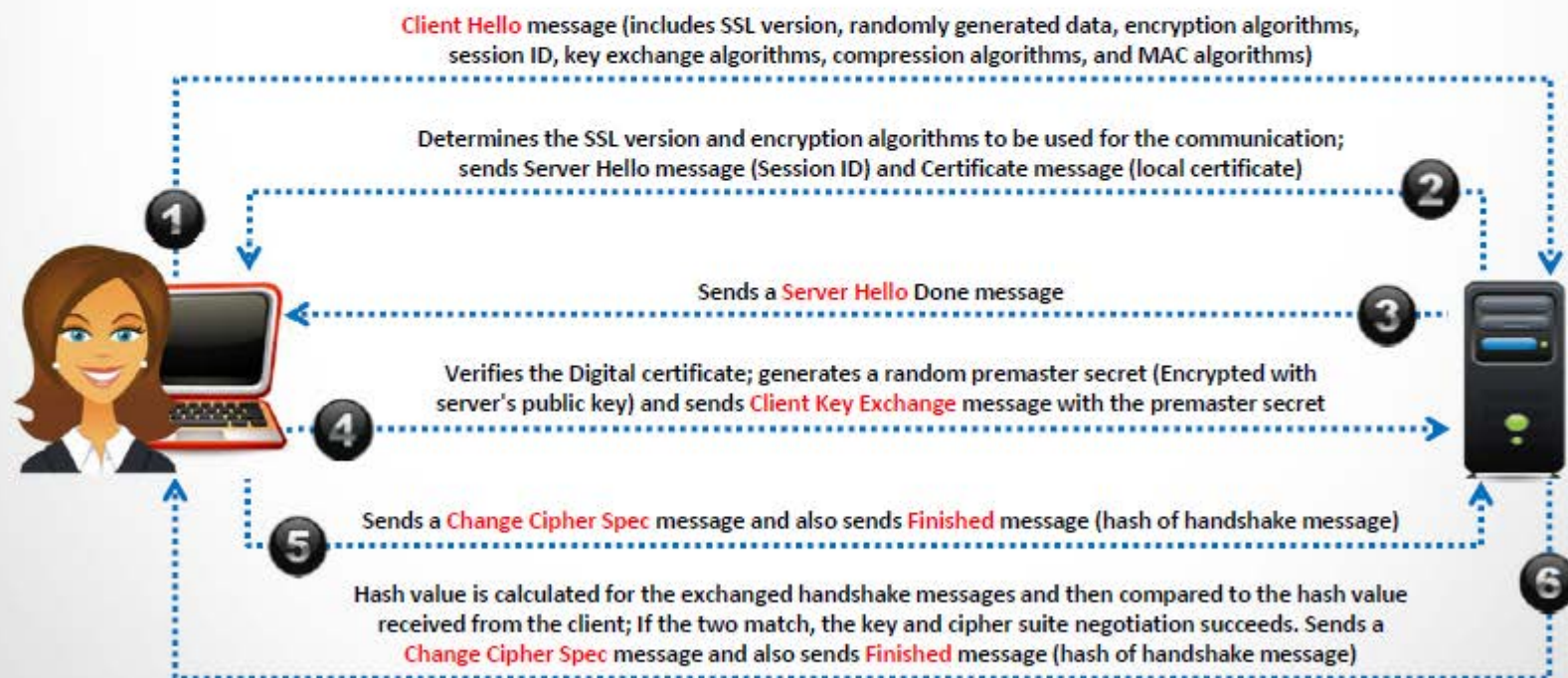


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SSL (Secure Sockets Layer)



- SSL is an application layer protocol developed by Netscape for **managing the security** of a message transmission on the Internet
- It uses **RSA asymmetric (public key) encryption** to encrypt data transferred over SSL connections



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Transport Layer Security (TLS)



- TLS is a protocol **to establish a secure connection** between a client and a server and ensure privacy and integrity of information during transmission
- It uses the RSA algorithm with 1024 and 2048 bit strengths

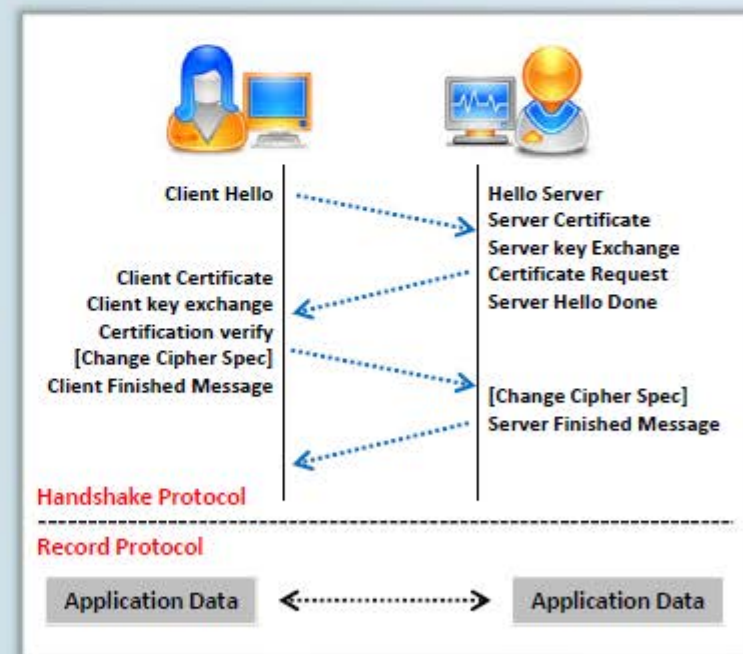


TLS Handshake Protocol

It allows the client and server to authenticate each other, select encryption algorithm, and exchange symmetric key prior to data exchange

TLS Record Protocol

It provides secured connections with an encryption method such as Data Encryption Standard (DES)



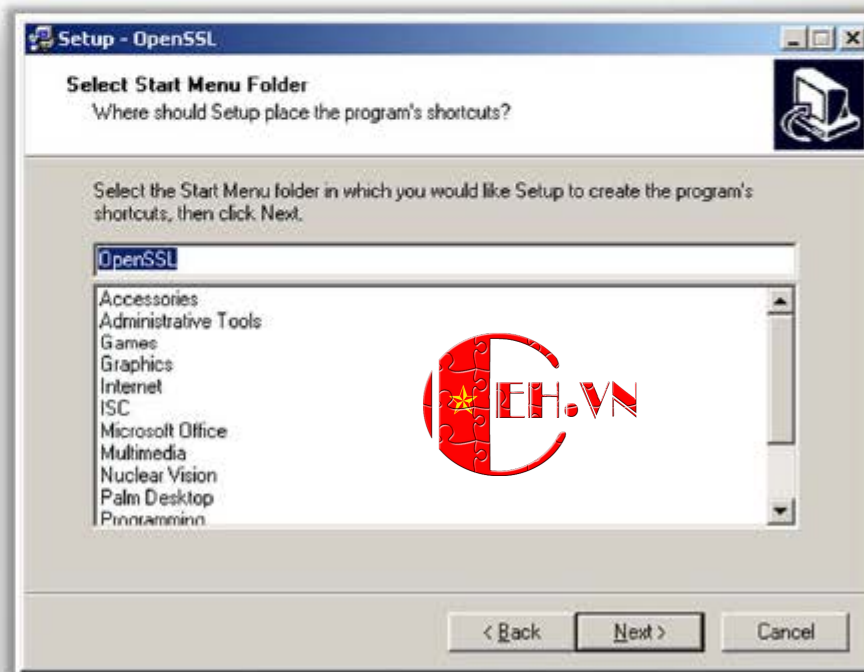
Cryptography Toolkit: OpenSSL



- OpenSSL is an open source cryptography toolkit implementing the **Secure Sockets Layer (SSL v2/v3)** and **Transport Layer Security (TLS v1)** network protocols and related cryptography standards required by them
- The openssl program is a command line tool for using the various **cryptography functions** of OpenSSL's crypto library from the shell

OpenSSL can be used for:

- Creation and management of private keys, public keys and parameters
- Public key cryptographic operations
- Creation of X.509 certificates, CSRs and CRLs
- Calculation of Message Digests
- Encryption and Decryption with Ciphers
- SSL/TLS Client and Server Tests
- Handling of S/MIME signed or encrypted mail
- Time Stamp requests, generation and verification



<https://www.openssl.org>

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Cryptography Toolkit: **Keyczar**



- Keyczar is an open source cryptographic toolkit designed to make it easier and safer for developers to use **cryptography in their applications**
- It **supports authentication** and **encryption** with both symmetric and asymmetric keys

<http://www.keyczar.org>



Features

- Key rotation and versioning
- Safe default algorithms, modes, and key lengths
- Automated generation of initialization vectors and ciphertext signatures
- Java, Python, and C++ implementations
- International support in Java

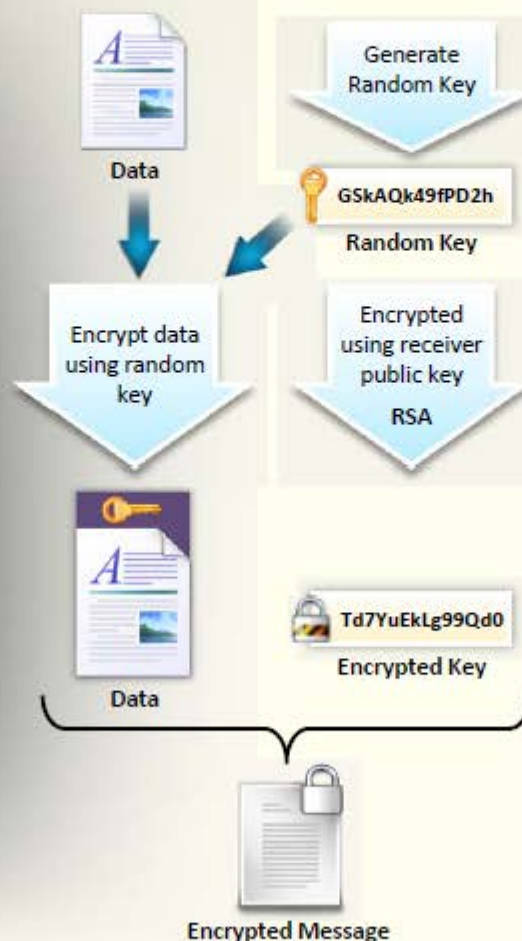
Pretty Good Privacy (PGP)



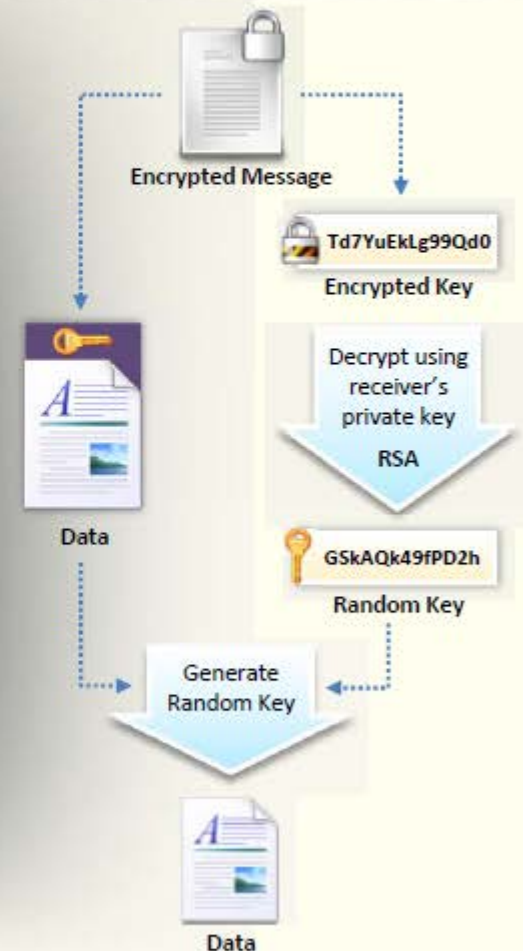
Pretty Good Privacy

- PGP (Pretty Good Privacy) is a protocol used to **encrypt** and **decrypt** data that provides **authentication** and **cryptographic privacy**
- PGP is often used for data **compression**, **digital signing**, encryption and decryption of **messages**, **emails**, **files**, **directories**, and to enhance privacy of email communications
- PGP combines the best features of both **conventional** and **public key cryptography** and is therefore known as **hybrid cryptosystem**

PGP Encryption



PGP Decryption



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Disk Encryption



01

Confidentiality

Disk encryption protects **confidentiality of the data** stored on disk by converting it into an unreadable code using disk encryption software or hardware

Privacy

Passphrase

Hidden Volumes



02

Encryption

Disk encryption works in a similar way as **text message encryption** and protects data even when the OS not active

Volume Encryption



03

Protection

With the use of an encryption program for your disk, you can **safeguard any information** to burn onto the disk, and keep it from falling into the wrong hands

Blue Ray

DVD

Backup

Disk Encryption Tools: Symantec Drive Encryption and GiliSoft Full Disk Encryption

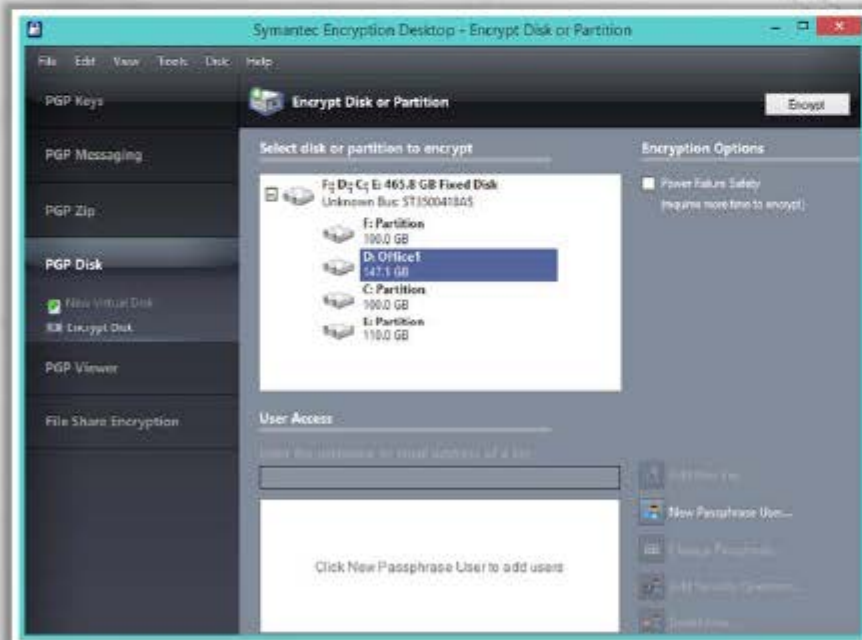


Symantec Drive Encryption

- Symantec Drive Encryption provides **full disk encryption** for all data (user files, swap files, system files, hidden files, etc.) on desktops, laptops, and removable media
- It protects data from **unauthorized access**

GiliSoft Full Disk Encryption

- GiliSoft Full Disk Encryption's offers encryption of all **disk partitions**, including the system partition
- It **provides automatic security** for all information on endpoint hard drives, including user data, operating system files and temporary and erased files



<http://www.symantec.com>



<http://www.gillsoft.com>

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Disk Encryption Tools



DriveCrypt

<http://www.securstar.com>



east-tec SafeBit

<http://www.east-tec.com>



ShareCrypt

<http://www.securstar.com>



DiskCryptor

<http://diskcryptor.net>



PocketCrypt

<http://www.securstar.com>



alertsec

<http://www.alertsec.com>



Rohos Disk Encryption

<http://www.rohos.com>



Cryptainer LE

<http://www.cypherix.com>



R-Crypto

<http://www.r-tt.com>



DriveCrypt Plus Pack

<http://www.securstar.com>

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Cryptography Attacks



- Cryptography attacks are based on the assumption that the cryptanalyst has access to the **encrypted information**



Ciphertext-only attack



Chosen-key attack



Known-plaintext attack



Adaptive chosen-plaintext attack



Chosen-plaintext



Timing attack



Chosen - ciphertext attack



Rubber hose attack

Cryptography Attacks

(Cont'd)



Ciphertext-only Attack

Attacker has access to the cipher text; goal of this attack to **recover encryption key** from the ciphertext

Adaptive Chosen-plaintext Attack

Attacker makes a **series of interactive queries**, choosing subsequent plaintexts based on the information from the previous encryptions

Chosen-plaintext Attack

Attacker **defines his own plaintext**, feeds it into the cipher, and analyzes the resulting ciphertext

Known-plaintext Attack

Attacker has **knowledge of some part of the plain text**; using this information the key used to generate ciphertext is deduced so as to decipher other messages

Cryptography Attacks

(Cont'd)



Chosen-ciphertext Attack

Attacker obtains the plaintexts corresponding to an **arbitrary set** of ciphertexts of his own choosing



Extraction of cryptographic secrets (e.g. the password to an encrypted file) from a person by **coercion or torture**

Rubber Hose Attack

Chosen-key Attack

A **generalization** of the chosen-text attack



It is based on repeatedly measuring the **exact execution times** of modular exponentiation operations

Timing Attack

Code Breaking Methodologies



Trickery and Deceit

It involves the use of **social engineering techniques** to extract cryptography keys



Brute-Force

Cryptography keys are discovered by **trying every possible combination**



One-Time Pad

A one-time pad contains many **non-repeating groups of letters** or number keys, which are chosen randomly



Frequency Analysis

- It is the study of the frequency of letters or groups of letters in a **ciphertext**
- It works on the fact that, in any given stretch of written language, certain letters and **combinations of letters** occur with varying frequencies



Brute-Force Attack



Attack Scheme

Defeating a cryptographic scheme by **trying a large number of possible keys** until the correct encryption key is discovered



Brute-Force Attack

Brute-force attack is a **high resource and time intensive process**, however, more certain to achieve results



Success Factors

Success of brute force attack depends on **length of the key**, **time constraint**, and **system security mechanisms**

Power/Cost	40 bits (5 char)	56 bit (7 char)	64 bit (8 char)	128 bit (16 char)
\$ 2K (1 PC. Can be achieved by an individual)	1.4 min	73 days	50 years	10 ²⁰ years
\$ 100K (this can be achieved by a company)	2 sec	35 hours	1 year	10 ¹⁹ years
\$ 1M (Achieved by a huge organization or a state)	0.2 sec	3.5 hours	37 days	10 ¹⁸ years

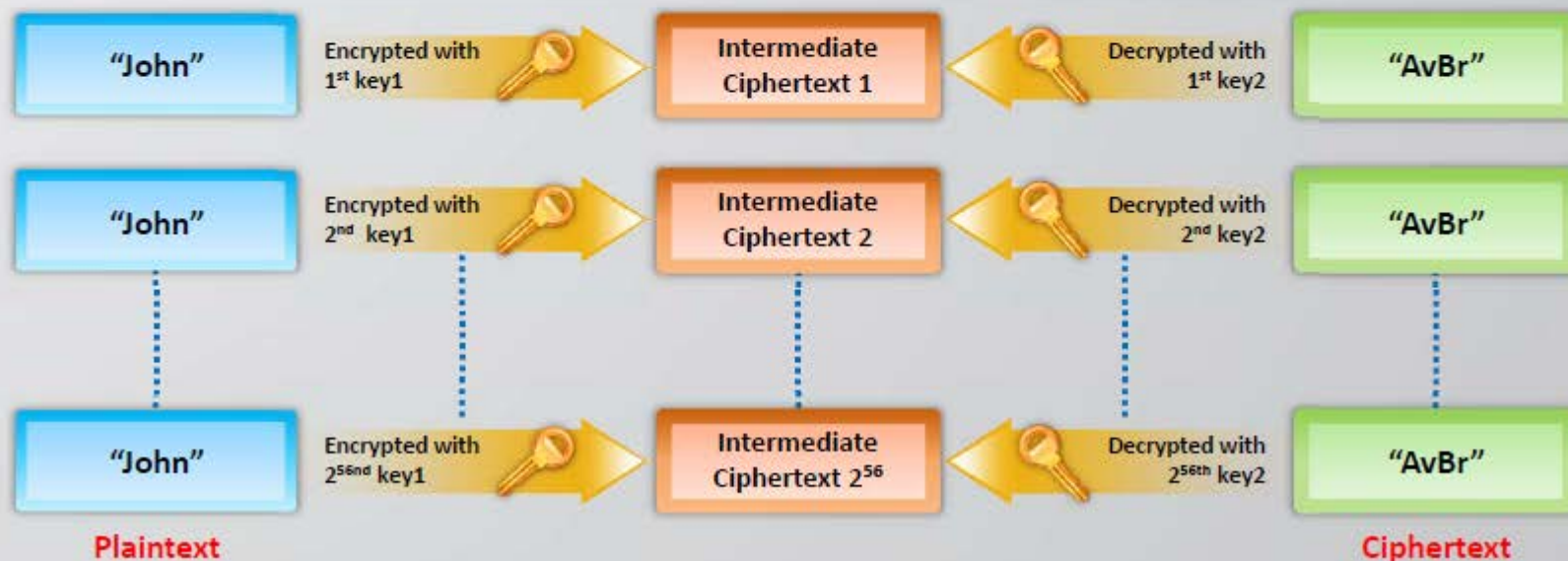
Estimate Time for Successful Brute-force Attack

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Meet-in-the-Middle Attack on Digital Signature Schemes



- The attack works by **encrypting from one** end and **decrypting from the other end**, thus meeting in the middle
- It can be used for **forging signatures** even on digital signatures that use multiple-encryption scheme



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Side Channel Attack

**01**

Side channel attack is a **physical attack** performed on a cryptographic device/ cryptosystem to gain sensitive information

02

Cryptography is generally **implemented in hardware or software** which runs on physical devices such as semi-conductors

03

These semi-conductor devices include **resistor, transistor** and so on

04

These physical devices are affected by various **environmental factors** that include: power consumption, electro-magnetic field, light emission, timing and delay, and sound

05

In Side Channel attack, an attacker **monitors these channels (environmental factors)** and try to acquire the information useful for cryptanalysis

06

The information collected in this process is termed as **side channel information**

07

Side Channel Attacks (SCA) are **no way related to traditional/ theoretical form of attacks** like brute force attack

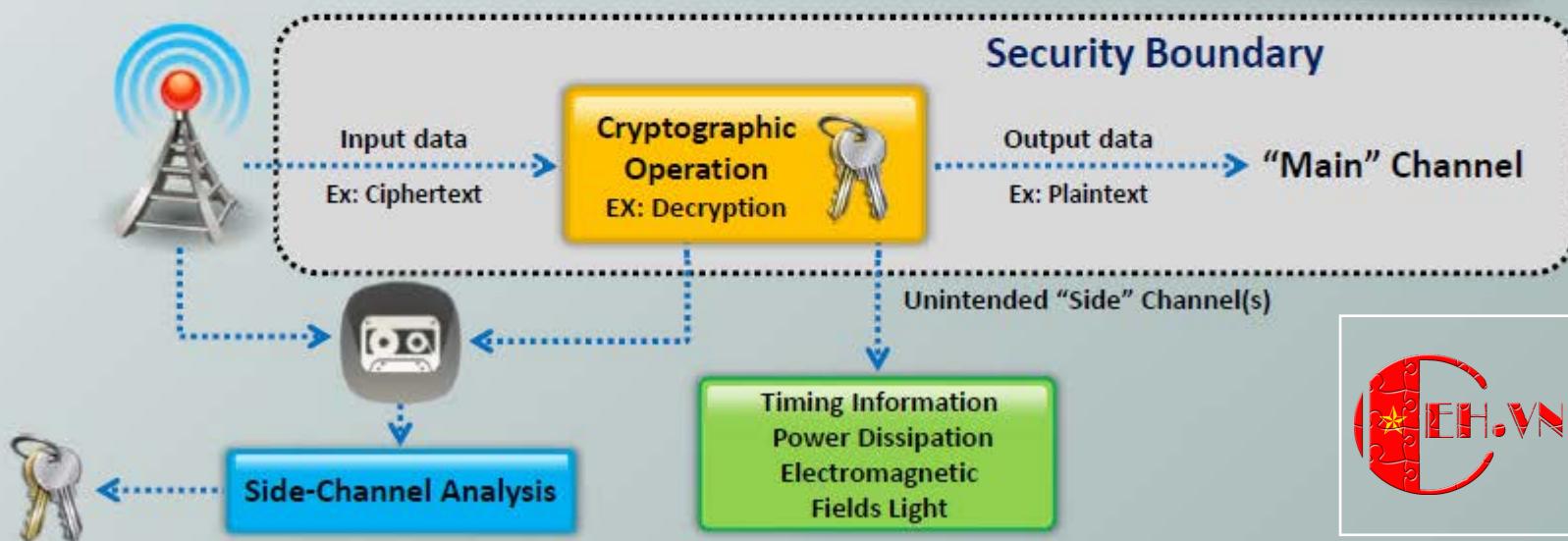
08

The concept of SCA is **based on the way, the cryptographic algorithms are implemented**, rather than at the algorithm itself

Side Channel Attack - Scenario



- Assume that an encrypted data is to be decrypted and displayed a plain text, inside a **trusted zone**
- At the time of decryption in a cryptosystem, **physical environmental factors** such as timing, power dissipation etc., acting on the components of a computer are recorded by an attacker
- The attacker analyzes this information in an attempt **to gain useful information** for cryptanalysis



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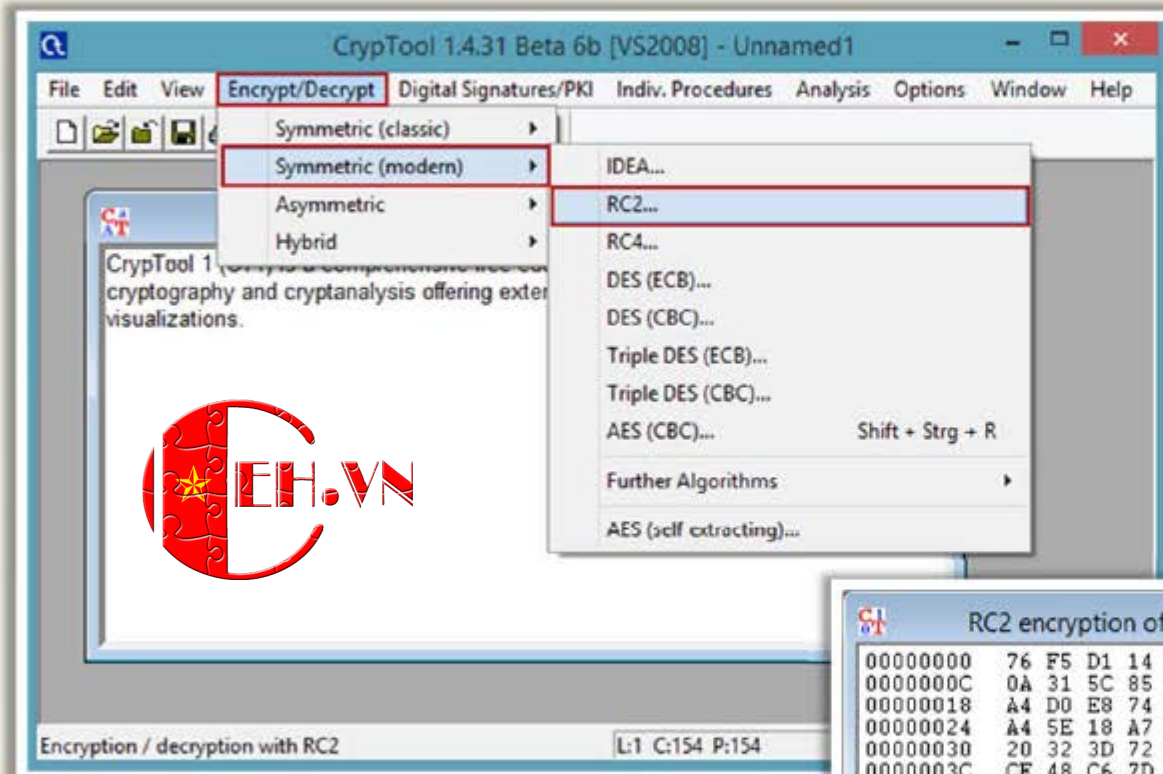
7

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Cryptanalysis Tool: CrypTool

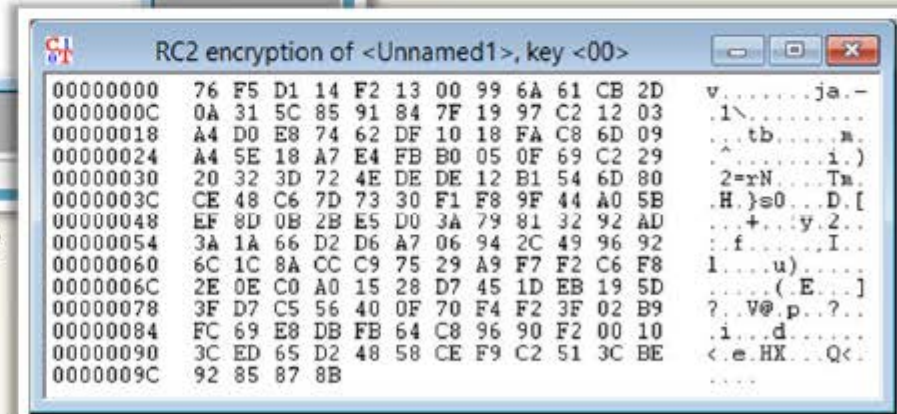


<http://www.cryptool.org>

■ CrypTool is a free e-learning program in the area of **cryptography** and **cryptoanalysis**

■ Subprojects of CrypTool:

- CrypTool 1 (CT1)
- CrypTool 2 (CT2)
- JCrypTool (JCT)
- CrypTool-Online (CTO)



Cryptanalysis Tools



CryptoBench

<http://www.addario.org>



AlphaPeeler

<http://alphapeeler.sourceforge.net>



Jipher

<http://cipher.org.uk>



Draft Crypto Analyzer

<http://www.literatecode.com>



Ganzúa

<http://ganzua.sourceforge.net>



**Linear Hull Cryptanalysis of
PRESENT**

<http://www.ecrypt.eu.org>



Crank

<http://crank.sourceforge.net>



mediggo

<http://code.google.com>



EverCrack

<http://evercrack.sourceforge.net>



SubCypher

<http://www.esclapiusllc.com>

Online MD5 Decryption Tools

**MD5 Decrypt**<http://www.md5decrypt.org>**OnlineHashCrack.com**<http://www.onlinehashcrack.com>**MD5Cracker**<http://md5crack.com>**HashKiller.co.uk**<http://www.hashkiller.co.uk>**MD5 Decrypter**<http://www.md5online.org>**Md5.My-Addr.com**<http://md5.my-addr.com>**Hash Cracker**<http://www.hash-cracker.com>**cmd5.org**<http://www.cmd5.org>**MD5Decrypter**<http://www.md5decrypter.com>**CrackStation**<https://crackstation.net>

Module Summary



- ☐ Cryptography is the conversion of data into a scrambled code that is decrypted and sent across a private or public network
- ☐ Symmetric encryption uses the same key for encryption as it does for decryption and asymmetric encryption uses different encryption keys for encryption and decryption
- ☐ Ciphers are algorithms used to encrypt or decrypt the data
- ☐ Hash functions calculate a unique fixed-size bit string representation called a message digest of any arbitrary block of information
- ☐ Public Key Infrastructure (PKI) is a set of hardware, software, people, policies, and procedures required to create, manage, distribute, use, store, and revoke digital certificates
- ☐ Digital signature used asymmetric cryptography to simulate the security properties of a signature in digital, rather than written form
- ☐ Disk encryption protects confidentiality of the data stored on disk by converting it into an unreadable code using disk encryption software or hardware
- ☐ Cryptography attacks are based on the assumption that the cryptanalyst has access to the encrypted information

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