Vanguard Security and Compliance 2013

Session AST9: Cryptography 101: An Introduction to Security Basics

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IBM Canada

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Introduction to Cryptography

- What is cryptography?
- Why cryptography?
- Cryptography & main use

What is Cryptography

- **Cryptography** (or cryptology; from Greek κρυπτός, *kryptos*, "hidden, secret"; and γράφω, *gráphō*, "I write", or -λογία, *-logia*, respectively) is the practice and study of hiding information. In modern times cryptography is considered a branch of both mathematics and computer science and is affiliated closely with information theory, computer security and engineering.

From Wikipedia

Cryptography

- "Secret Writing"
- The practice and study of hiding or securing information
- Currently closely aligned with mathematical theory

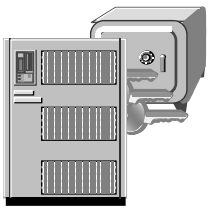
Cryptography – In Perspective

Cryptography is the study of transforming information into a form that obscures its meaning.

- Most cryptographic systems consist of
  - a cryptographic engine(s) which performs algorithm(s)
  - keys
  - some cryptographic macros or APIs

- *Cryptographic Engine Software versus Hardware?*

A matter of security...



Identifying The Problems

- Health Insurance Portability and Accountability Act of 1996 (HIPAA)
- California SB 1386
- Gramm-Leach Bliley Act (GLB)
- Sarbanes-Oxley (SOX)
- **Payment Card Industry (PCI)**

VISA CISP

- VISA introduces Cardholder Information Security Program June 2001
  - Designed to assist merchants in providing secure transaction processing, protecting customer data
- VISA, MasterCard, American Express, Discover, JCB combine to draft **PCI-DSS** Sept 2006
- Compliance mandatory June 2007

Cryptographic Standards

- CCA (Common Cryptographic Architecture)
- PKCS (Public-Key Cryptography Standards)
- INTEL CDSA (Common Data Security Architecture)
- ANSI (American National Standards Association)
- ISO (International Organization for Standardization)
- FIPS (Federal Information Processing Standards)

The Need

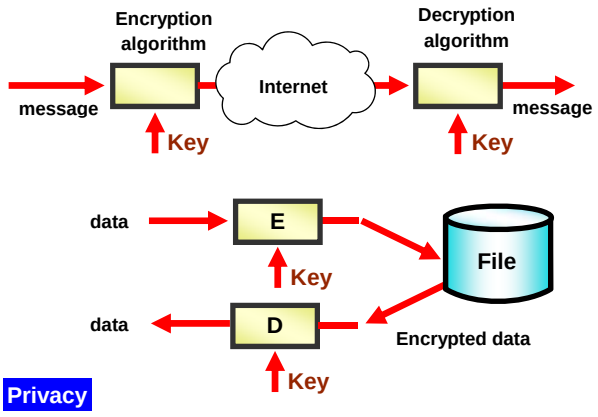
- Traditionally: to hide the meaning of transferred or stored data, but also used to establish:
  - Data confidentiality (Not disclosure)
  - Data integrity (No alteration)
  - Authentication (Identity Verification)
- A required facility today for personal or industrial computing
- Hardware Cryptography
  - Offload cryptographic computation workload
    - Some algorithms consumes huge amounts of MIPS
  - Increased performance
    - Speed of computation by specialized coprocessors
  - Security
    - Always more secure than a software implementation
    - Can implement very sophisticated protection of secrets, depending on device

What **CAN** Encryption Do?

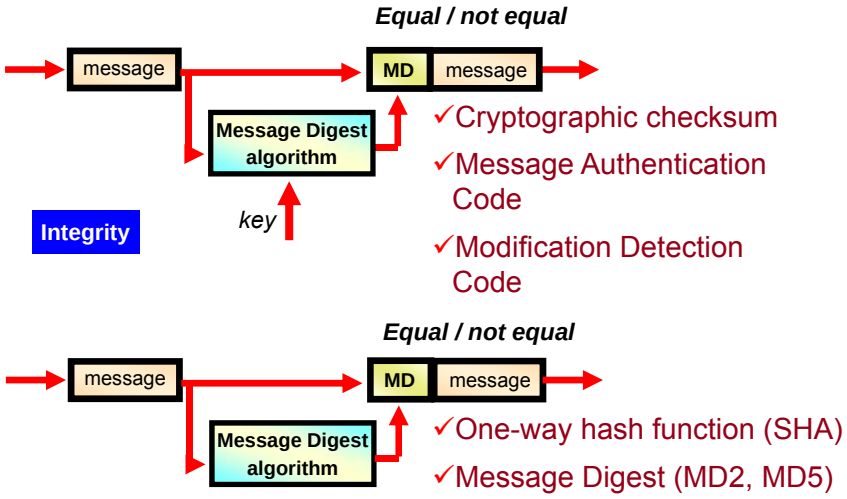
- Encryption / Decryption
  - **Privacy** - To protect the contents of data from others
- Message Digests and Hashing
  - **Data Integrity** - To allow verification that data is received was the same as the data that was sent
- Personal Identification Numbers
  - **Identification** - To associate a person with data/objects based on knowledge they have and that is associated with that data or object.
- Proof of Origin (**non-repudiation**)
  - Digital Signatures

.

What is Cryptography? Encryption



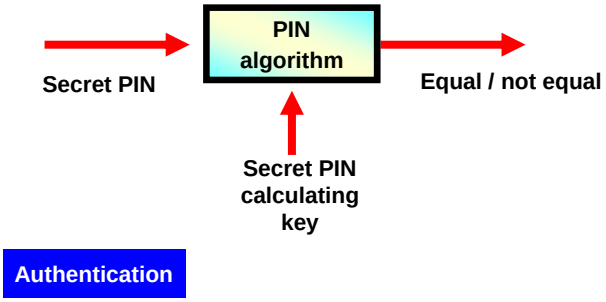
What Else? Message Digests or Hashes



- ✓Cryptographic checksum
- ✓Message Authentication Code
- ✓Modification Detection Code

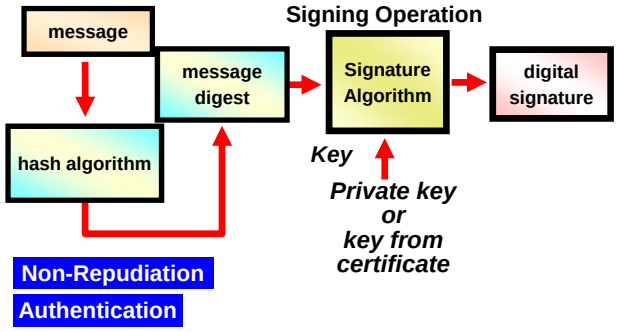
- ✓One-way hash function (SHA)
- ✓Message Digest (MD2, MD5)

What Else? PINs



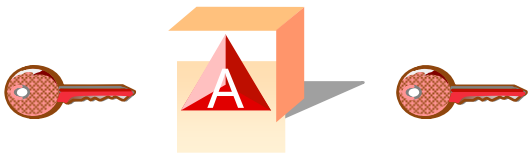
What Else? Signatures

Signatures are a way to securely associate someone with data they send.



Symmetric (Secret Key) Algorithms

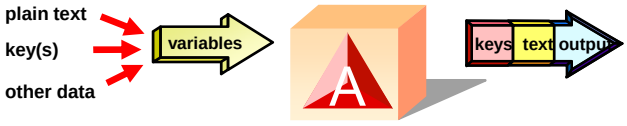
- **Secret Keys** characterized by identical key values in key pair generation
- Examples:
  - **Block Ciphers**
    - DEA or **DES**, Data Encryption Algorithm or Data Encryption Standard
    - **Triple-DES**, DES but using 3 key values rather than 1
      - NIST says good until 2030
    - **IDEA,** International Data Encryption Algorithm (used in PGP)
    - **RC2**
    - **AES**
  - **Stream Ciphers**
    - **RC4**
    - **One Time Pad**



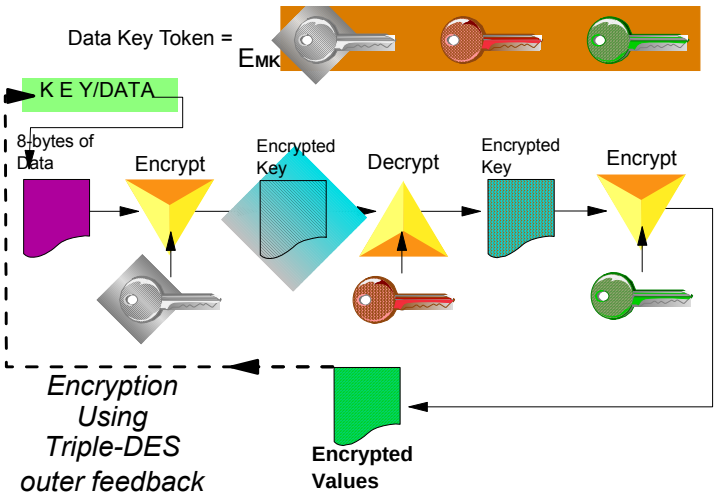
March 2001

Cryptographic Algorithms

- Formula used to transform the plain data or readable text into cipher text or encrypted text
- Formulas well documented so a key is the mechanism that makes the output of any formula different from other output of the same formula
- Algorithms can sometimes have other variables as input to further distinguish the output of the formula



Data Confidentiality – Why TDES



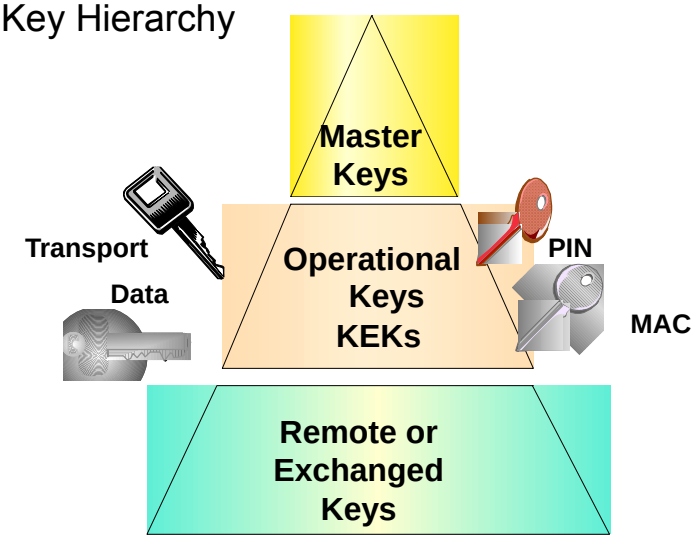
Rijndael (AES)

- Named after its creaters, two Belgian cryptographers, Joan Daemen and Vincent Rijmen
- AES - Advanced Encryption Standard
- 128 bit key 3.4X10**38 (340 Undecillion)
- 192 bit key 6.2X10**57 (6.2 Octodecillion)
- 256 bit key 1.1X10**77 (almost a Googol)
- Given 2**55 DES cycles per second (recover any key in 1 second)
- 149 trillion years to recover 128 bit AES.
- Web Site http://csrc.nist.gov/encryption/aes/

Keys

- String of hexadecimal numbers which can be entered as alphanumeric characters
- Symmetric keys are usually 8-bytes in length with the high-order bits serving as a parity bit. (8x8 = 64-8 = 56 bits)
- Asymmetric keys are usually 128-bytes in length or 1024-bits
- Example of single length DES key
  - 332137D1, hex value of x'F3F3F2F1F3F7C4F1'
  - or 3AK2P7D1, hex value of x'F3C1D2F2D7F7C4F1'
- Keys are sometimes protected under a host secret key called a Master Key

DES Key Hierarchy



Clear Key vs Encrypted (Secure) Key

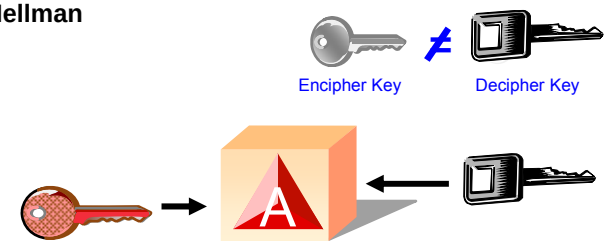
- Clear Key
  - C'TESTKEY1' or X'E3C5E2E3D2C5E8F1'
  - **SPEED! (40X-100X)**
  - SSL, Encryption Facility, DB2/IMS Encryption
- Encrypted (Secure) Key
  - e_{mk}(TESTKEY1) = X'C7E24CA92F4AB03E'
  - e_{kek}(TESTKEY1) = x'76B5C7EF973267CC'
  - **ADITIONAL SECURITY**
  - ATM, POS, PIN

Performance vs. Strong Security

- Hardware Cryptography
  - Offload cryptographic computation workload
    - Some algorithms consume huge amounts of MIPS
  - Increased performance
    - Speed of computation by specialized coprocessors
  - Security
    - More secure than a software implementation
    - Can implement very sophisticated protection of secrets, depending on device

Asymmetric Algorithms

- Characterized by unique key values in key pair generation
- Examples:
  - **RSA,** Rivest Shamir and Adleman
  - **Diffie-Hellman**



Asymmetric Key Usage

- **Private Key** is used for functions required to confirm ownership or origin
  - Signature, my signature = my private key
  - My private is not shared, only I could have produced signature


Private Key

- **Public Key** is used for functions required to maintain privacy or ensure understanding by a single person
  - Encryption, data with public key of Ernie
  - Only Ernie can decipher data


Public Key

- **Digital Signature** Processing
  - Private Key used to create Signature
- **Symmetric Key** Distribution
  - Public Key used to encrypt key value

Public Key Cryptography

- Mathematically related key pair
- Very large prime numbers over 100 digits long
  - Generate 2 prime numbers — **P = 7 Q = 17**
  - Multiply the prime numbers — **7 x 17 = 119 = N**
  - N is first part of Public Key (Modulus) — **Public Key 119 E**
  - N is first part of Private Key — **Private Key 119 D**
  - Select odd number; this is second part of public key (Exponent) — **Public Key 119 5**
  - Second part of private key = (P-1) x (Q-1) x (E-1) — **(7-1) x (17-1) x (5-1) = 384**
    Add 1 to result — **384 + 1 = 385**
    Divide by E = D — **Private Key 119 77**
- Convert characters to numeric
  - e.g.. a=1, b=2, c=3.....
  - SELL becomes 19 5 12 12

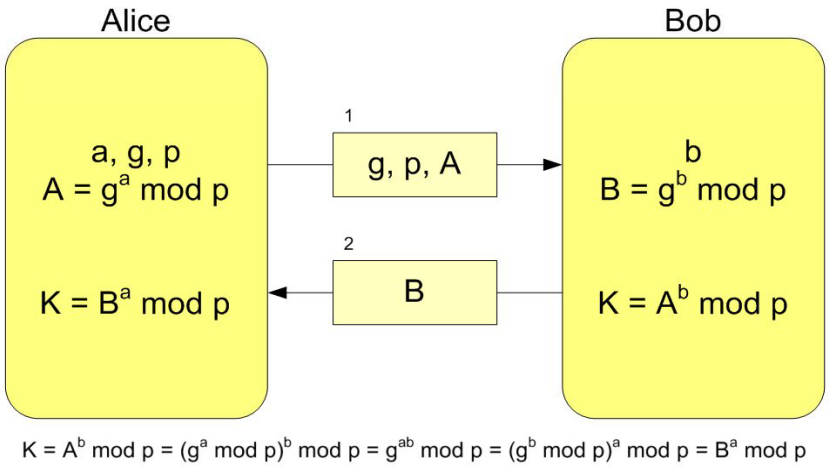
Encipher Message

- P = 7; Q = 17; N = 119; E = 5; D = 77
- Public Key = N E = 119 5
- Private Key = N D = 119 77
- Convert characters to numeric
  - e.g.. a=1, b=2, c=3.....
  - SELL becomes 19 5 12 12
- Character raised to power E "S" = 19; 19**5 = 2476099
- Divide by first part of Public Key 2476099 / 119 = 20807 and Remainder is enciphered character remainder 66 = eKP(S)

Decipher Message

- P = 7; Q = 17; N = 119; E = 5; D = 77
- Public Key = N E = 119 5
- Private Key = N D = 119 77
- a=1, b=2, c=3.....
  - SELL becomes 19 5 12 12
- Character raised to power E
- Remainder raised to power D 66 ** 77 = 1273.....
- Result divided by first part of Private Key 1273..... / 119 = 1069 and Public Key remainder of 19
- Remainder is numeric equivalent 19 = "S" of character sent

Diffie-Hellman



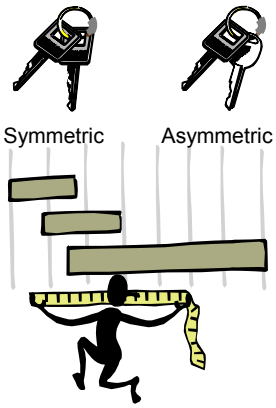
$K = A^b \bmod p = (g^a \bmod p)^b \bmod p = g^{ab} \bmod p = (g^b \bmod p)^a \bmod p = B^a \bmod p$

Diffie-Hellman

Alice	Bob
p prime	p prime
g generator < p	g generator <p
$A=g^a \bmod p$	$B=g^b \bmod p$
generate a	generate b
exchange $g^a \bmod p$ (A)	exchange $g^b \bmod p$ (B)
calculate $g^{ab} \bmod p$	calculate $g^{ba} \bmod p$
$g^{ab}=g^{ba}=K$	$g^{ab}=g^{ba}=K$

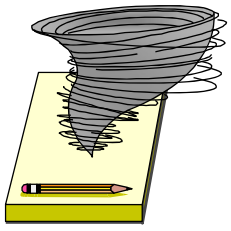
Basic Crypto Mechanisms

- Encryption/Decryption
  - Algorithms
  - Key Lengths
- Hashes and Digests
  - **SHA-1 SHA-256** and **MD5**
  - **Message Authentication (MAC)**
    HMAC
  - Modification Detection



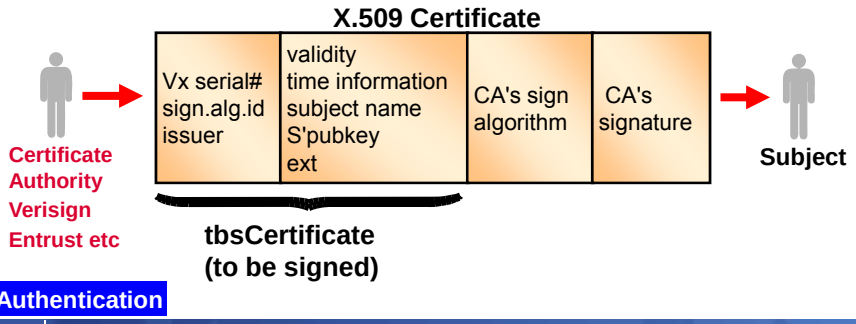
Complex Mechanisms: Signatures and Certificates

- Signatures
  - Algorithms
    - **ANSI** X9.30 - Digital Signature Standard
    - **ISO** 9796 - Rivest Shamir and Adleman
    - RSA DSI **PKCS** 1.0 & 1.1
  - $e_{\text{private key}}$(Hash)
- **Certificates**
  - **X 509.3**
  - Hashing + Signatures

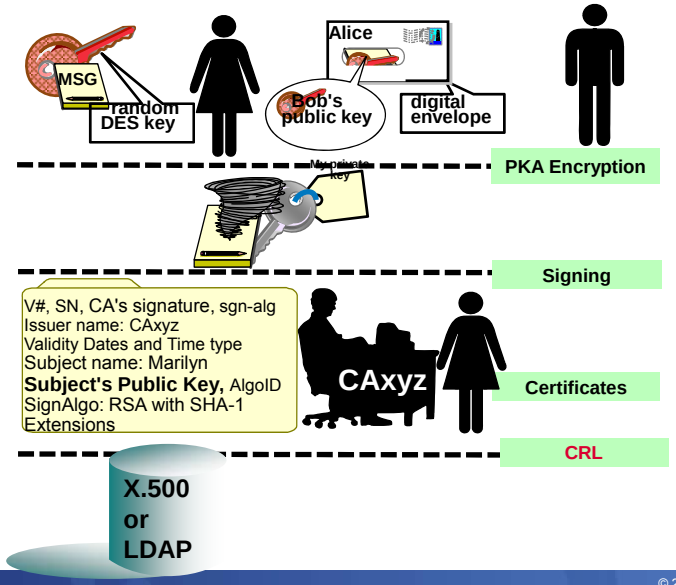


Certificates

- Certificates are a way of securely identifying someone. Most are based on the standard structure X.509 v3
- Certificates are encoded using DER rules (X.209)
- ASN.1 (Abstract Syntax Notation)DER encoding is a tag, length, value encoding system for each element.



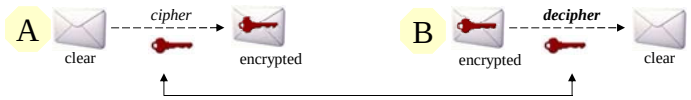
Complex Ideas: Signatures and Certificates



Reminder: Encryption of data

- **Symmetric encryption**

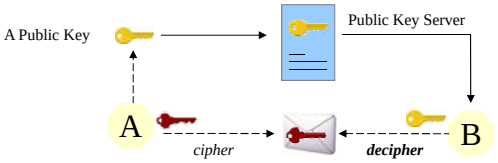
Confidentiality



- **Asymmetric encryption**

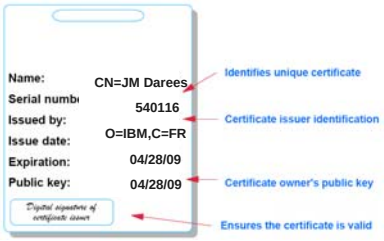
Confidentiality

Authentication



Reminder: Public Certificate

- Digital document that gives evidence that a public key belongs to whom it may concern. It contains at least the information listed below
  - Public Key
  - Certificate owner's Identity
  - Expiration Date
  - Signature from a third party
  - An utilization type

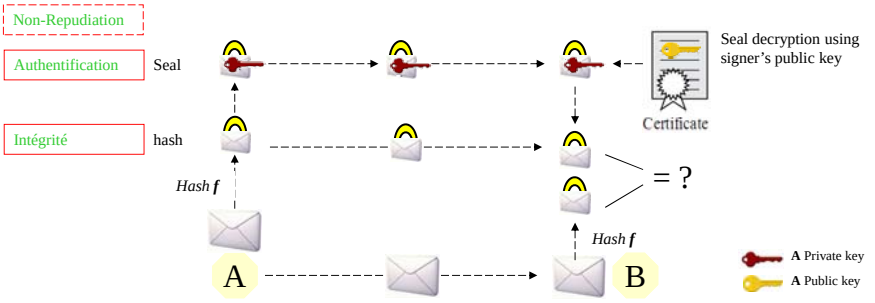


- Data which can be manipulated by computers
- Based on a norm : X509
  - Universal understanding and utilisation

Reminder : Hash & Digital signature

- **Hash function** is any well-defined procedure or mathematical function that converts a large, possibly variable-sized amount of data into a small datum, usually a single integer that may serve as an index to an array. The values returned by a hash function are called hash values, hash codes, hash sums, checksums or simply hashes.

- A **digital signature** is a mathematical scheme for demonstrating the authenticity of a digital message or document. A valid digital signature gives a recipient reason to believe that the message was created by a known sender, and that it was not altered in transit.



Cryptographic Algorithms and their main use

DES (56 bits)
T-DES (168 bits)
AES (128 bits)
* AES (192, 256 bits)

> Symmetric algorithms (Shared Secret Key)
Confidentiality of data

Data transfer (VPN, SSL/TLS, ..)
Data storage (database, archives, …)

ECC (New)
RSA (512, 1024, 2048, 4096 bits)
DSA (512, 1024 bits)

Authentication, key distribution
(VPN, SSL/TLS handshake, ..)

Private
Public

> Asymmetric algorithms (Public Key Cryptography)
Digital signature
Confidentiality of key

> Cryptographic "checksum" with one way algorithms
Integrity of data

Performed in hardware in System z10 EC/BC

MD5 (128-bit hash)
MAC, MDC
SHA-1(160-bit hash)
SHA-256 (256-bit hash)
SHA-384 , SHA-512

Data transfer (VPN, SSL/TLS, ..)
Data storage (database, archives, …)

Some Cryptographic Best Practices

- Multi custody of keying material
- Key custodians from separate business areas
- Change keys on a scheduled basis
  - Or upon suspected compromise
  - Or termination of key custodian(s)
- Unique key per device
- Backup copies of keys
- DR testing, hardware validation
- DES use of double or triple length keys
- AES 256 bit
- HASH alone is not secure
  - MAC using shared secret keys or Signatures

Some Cryptographic Best Practices…

- Do not knowingly reuse keys
- Force key separation
  - Unique MAC, DATA, PIN
- Do not encrypt everything with the same key
  - Use expiry date MMYY?
    - Credit Card issue cycle is 3 years
    - 36 MMYY per cycle
    - 36 PIN, CVV/CVC, CVV2/CVC2 keys
- Protect PIN DECimalizationTABle

References

- ATS TechDocs Web Site
  - http://www-1.ibm.com/support/techdocs/atsmastr.nsf
    - search on CRYPTO
- IBM Web Libraries
  - http://www-1.ibm.com/servers/eserver/zseries/zos/bkserv/
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Questions

Programming can be fun, so can cryptography; however they should not be combined.

--Kreitzberg and Shneiderman