Introduction to Cryptography

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CONTENTS

CONTENTS

WHAT IS CRYPTOGRAPHY?

- Crypto = secret; Graphy = writing
- The art of keeping messages secure
- "Exchanging a lot of small secrets for one big secret"
- Cryptography helps provide:
  - Authentication
  - Data Integrity
  - Privacy
  - Non-Repudiation
- Related areas of study:
  - Cryptanalysis - science of uncovering secrets
  - Cryptology - mathematics of cryptography and cryptanalysis

WHAT IS CRYPTOGRAPHY?

Cryptography Definitions

- Plaintext - The “in the clear” message, prior to encryption
- Ciphertext - Plaintext which has been encrypted
- Key - A secret or protected value used by the encryption algorithm to create ciphertext from plain text.
- Keyspace - The set of all possible keys for a given encryption algorithm.
- Key Management - The process of generating, distributing, storing, and destroying cryptographic keys.
- Algorithm - The method used to encrypt plaintext. The method is not assumed to be secret.
- Protocol - A specified series of steps, performed by two or more parties, in order to accomplish a task.
- Code - Cryptosystem that deals with linguistic units - words, phrases, etc.
- Permutation Cipher - A cipher which “shuffles” or recombines the elements of plaintext (characters or bits) to make ciphertext.
- Substitution Cipher - A cipher which substitutes plaintext (bits, bytes, or other patterns) with something else to make ciphertext.

CRYPTOGRAPHY USES

Military/Diplomacy:

- Strategic and tactical communication
- Secrecy

Banking

- Automated Teller
- Electronic Funds Transfer

Electronic Commerce:

- EDI message authentication and encryption

Data Processing:

- Password Validation
- Verifying Operating System Integrity

CRYPTOGRAPHIC HISTORY

- Diplomacy - 17th Century European Black Chambers
- Commercial Telegraphy
- Military (Signal) Telegraphy
- Radio Communications - W.W.I
- Cipher Machines - W.W.II German Enigma

CRYPTOGRAPHIC PROTOCOLS

- Secret Messages
- Subliminal Channel
- Key Distribution/Key Management
- Secure Hash
- Digital Signatures
  - Designated Confirmer Signatures
  - Undeniable (or non-transferable)
  - Proxy Signature
- Secret Sharing ("Threshold Scheme")
- Fair Coin Flips
- Key Escrow (a type of threshold scheme)
- Zero Knowledge Proofs

PUBLIC VS. PRIVATE KEY

- Private = Symmetric Key
  - Encryption key is same as decryption key
  - Traditional, used for centuries
  - Key management is problematic
  - Computationally fast

PUBLIC VS. PRIVATE KEY

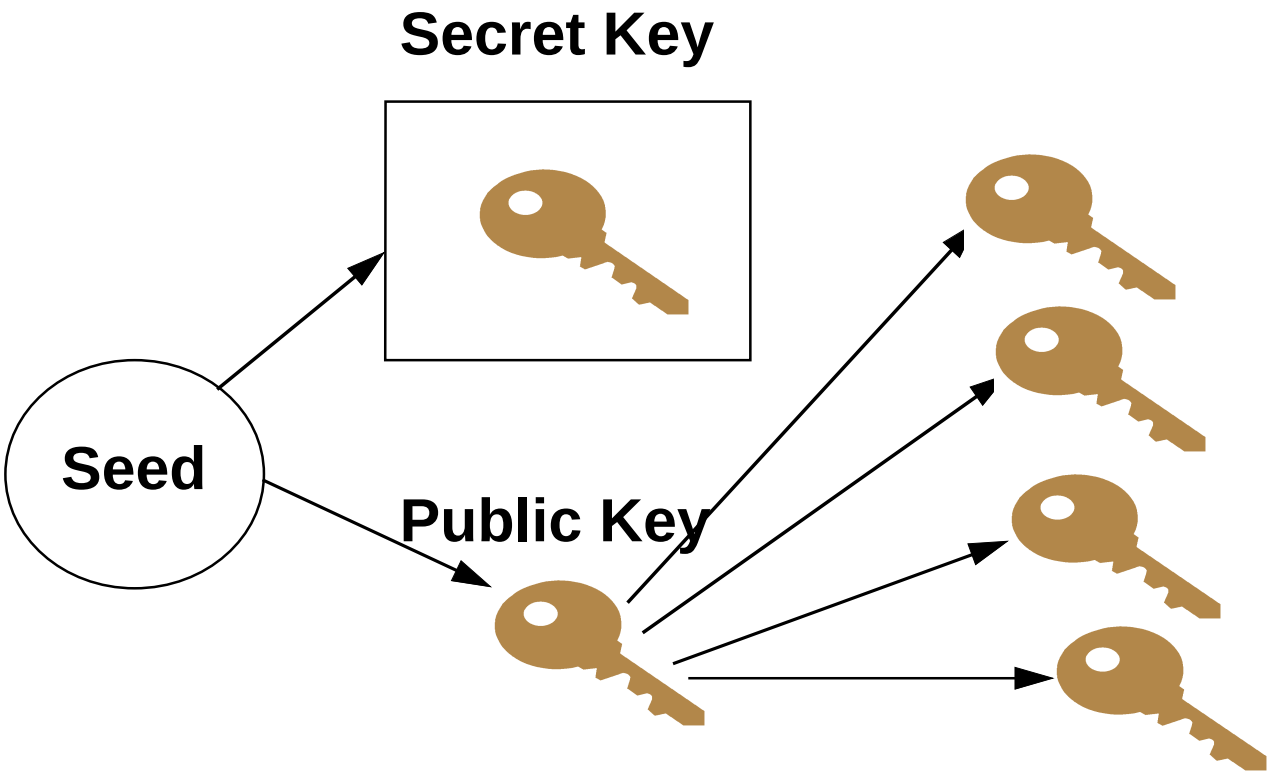
- Public = Asymmetric Key
  - Public discovery in mid 1970's (NSA claims earlier discovery)
  - Encryption key is separate from decryption key
  - Encryption key is publicly distributed, decryption key is secret
  - Simplifies key management
  - Inverse process provides for digital signature
  - Susceptible to "chosen plaintext" attacks
  - Slow, very compute intensive

PUBLIC VS. PRIVATE KEY

- Private Key protocols
  - Key Generation - Results in creation of two mathematically related keys
  - Key Distribution - The public or encryption key is distributed widely. Requires a Certification Authority to prevent key spoofing. Key distribution is otherwise public and unprotected.
  - Encryption - Encryption is done with the public key. Anyone with the public key may encrypt.
  - Decryption - Decryption is done using the private key retained by the owner. This key must be kept secret, or the whole system is compromised

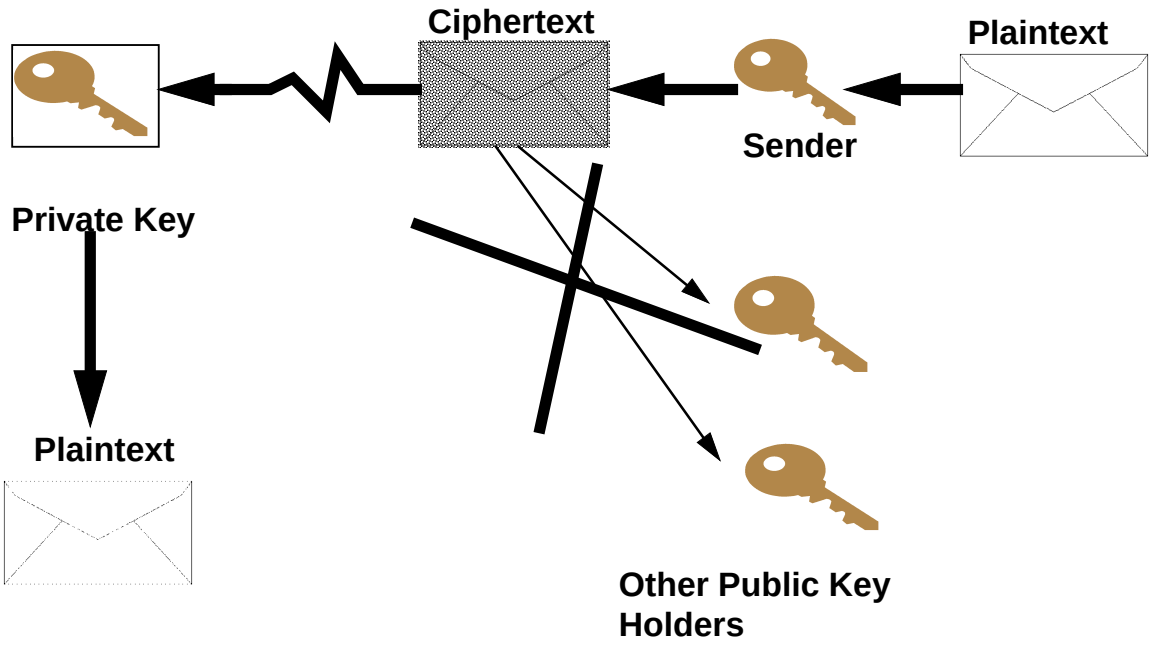
PUBLIC VS. PRIVATE KEY

- Public Key Protocols - Key Generation & Distribution



PUBLIC VS. PRIVATE KEY

- Public Key Protocols - Encryption & Decryption



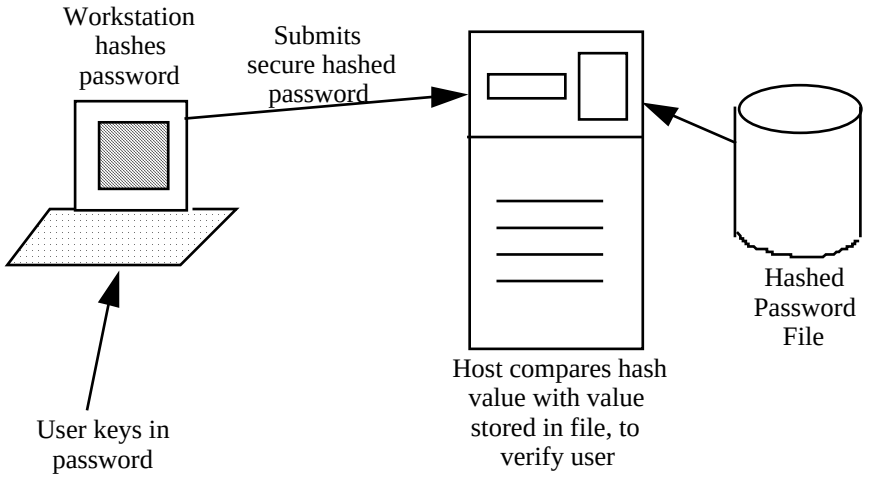
PUBLIC VS. PRIVATE KEY

- More Public Key Protocols - Digital Signatures
  - Key Generation - Same as with encryption
  - Key Distribution - This time the secret key, or the decryption key is distributed. The public or encryption key is kept secret.
  - Message Signing - The sender encrypts with the public key.
  - Signature Validation - The recipient decrypts using the public key. Successful decryption verifies that only the key owner could have created the message.

  To save space and computation time, usually only a message digest or secure checksum is signed. The recipient validates the checksum against that of the plaintext message to verify signature.

PUBLIC VS. PRIVATE KEY

- A Secure Hash Protocol - Password Validation



ENCRYPTION ALOGORITHMS

Method used for generation of ciphertext from plaintext

- Data Encryption Standard (DES)
- RSA public key
- IDEA
- RC5
- Skipjack (used in Clipper chip)
- Digital Signature Algorithm (DSA)
- Secure Hash Algorithms
  - MD5
  - SHA

ENCRYPTION ALOGORITHMS

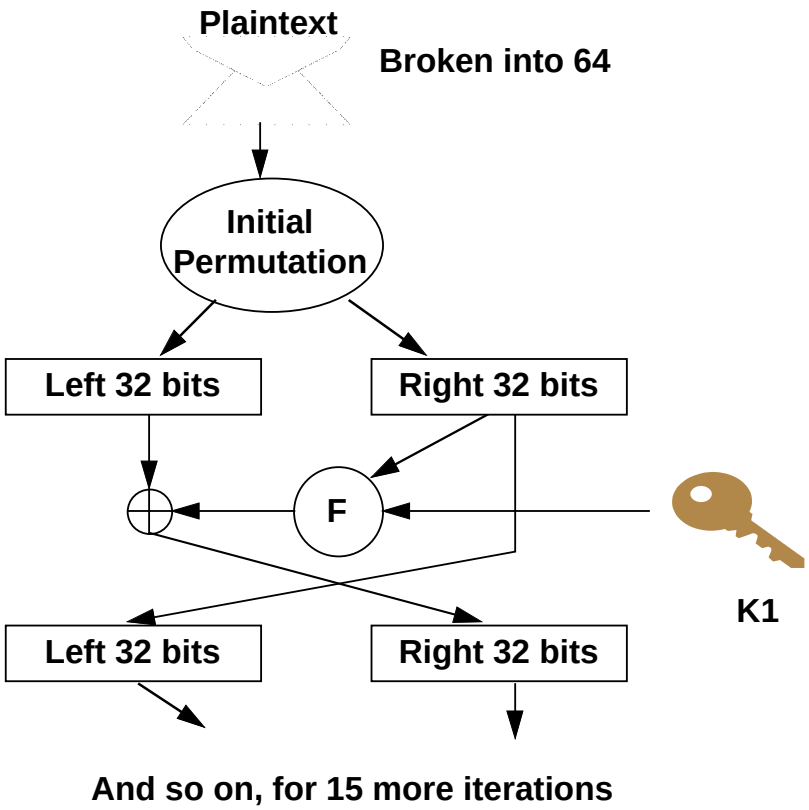
Breaking Encryption

- Passive vs. Active Attacks
- Protocol Subversion
  - "Man in the Middle", third party takeover of key exchange
- Ciphertext Only
- Known Plaintext
- Chosen Plaintext
- Brute Force Key Generation
- Traffic Analysis
- "Rubber Hose" Cryptography
  - Bribery
  - Social Engineering
  - Other

DATA ENCRYPTION STANDARD - DES

- Began as IBM's Lucifer algorithm
- Approved as standards in FIPS Pub 46 and other FIPS documentation
- Most common commercial encryption algorithm.
- Designed for fast hardware implementation, given mid-1970’s technology.
- Combines permutation and substitution in a bitwise fashion against 64-bit blocks of a message.

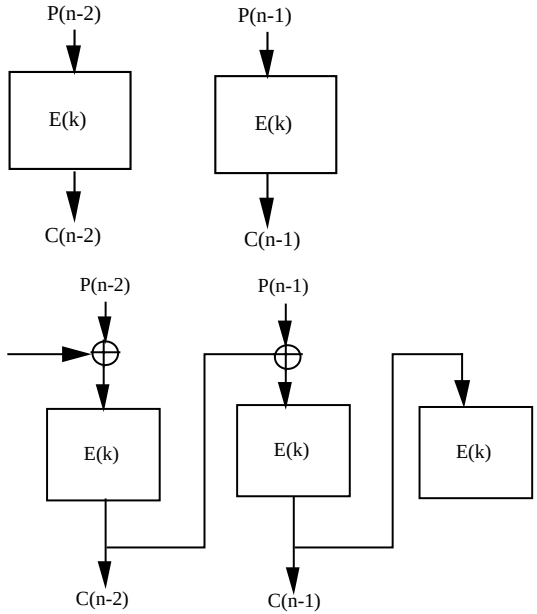
DATA ENCRYPTION STANDARD - DES



DATA ENCRYPTION STANDARD - DES

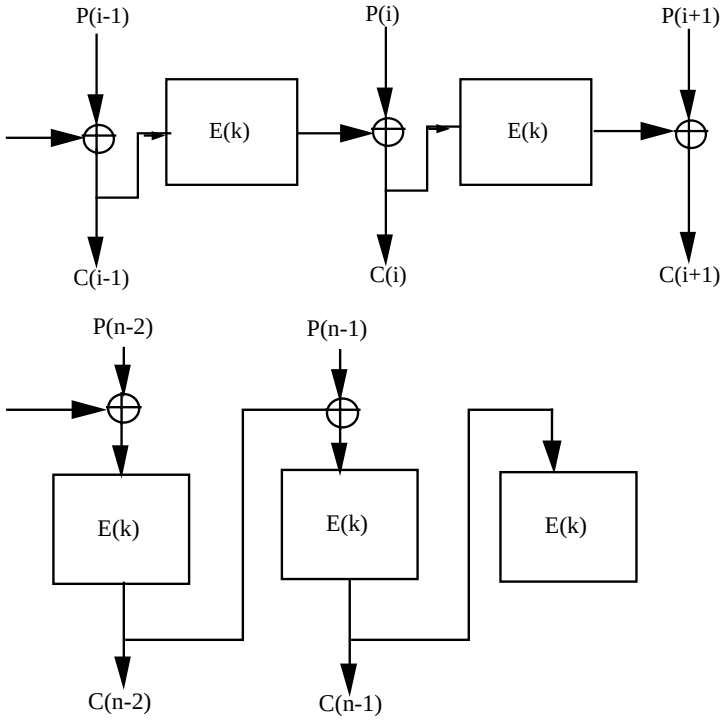
DES Modes

- Block Modes:
  - Electronic Codebook (ECB)
  - Cipher Block Chaining (CBC)



DATA ENCRYPTION STANDARD - DES

- Stream Modes:
  - Cipher Feedback (CFB)
  - Output Feedback (OFB)



DATA ENCRYPTION STANDARD - DES

- Modes have different cryptographic characteristics:
  - Cryptanalysis vulnerabilities
  - Error propagation
  - Speed of encryption/decryption
  - Sequential vs. non-sequential data access

DATA ENCRYPTION STANDARD - DES

DES future

- Limitations of 56 bit key
- Periodic reviews, recertification every 5 years by the National Bureau of Standards
  - 1987 - Proposal to replace with Commercial Comsec Endorsement Program
  - 1993 - Still re-certified, though alternatives to be considered over next 5 years
  - 1998 - ?
- Lack of standard alternative
- Triple DES - interim solution

RSA - PUBLIC KEY ENCRYPTION

Elements of RSA

- RSA = Initials of inventors (Rivest, Shamir, Adelman)
- RSA has been widely licensed by a variety of companies.
- Patents never successfully challenged.
- Patents expire 1999.
- RSA acquired by Security Dynamics in 1996.
- Secrecy is based on the difficulty of finding prime factors of very large numbers.

RSA - PUBLIC KEY ENCRYPTION

Products Using RSA

- RSA has been widely licensed by a variety of companies.
  - ViaCrypt - Commercial version of PGP. Permits Key Escrow.
  - Verisign - A private Certification Authority.
  - Premenos - Templar product uses RSA to conduct secure EDI transactions over the Internet.
  - V-One - Token-based secure transaction over the Internet.
  - Pitney Bowes - Veritas Authentication System, to authenticate printed documents through bar-coded digital signatures.
  - Frontier Technologies - Secure WWW and TCP/IP tools
- RSA public key encryption is embedded in a variety of common software products.
- RSA's BSAFE encryption engine permits developing applications using a variety of strong encryption algorithms.
- PKCS is an industry-wide standard for developing public key applications

PGP - ENCRYPTION FOR THE MASSES

- Freeware, widely available on the Internet
- Combines Public Key (RSA) and Private Key (IDEA) algorithms
- Free version is non-commercial use only per licenses
- Legal issues
  - Patents
  - Export restrictions
- Recently ported to the IBM AS/400 by Steve Glanstein.
- See COMMON Lab session on the use of PGP for an excellent introduction.

AS/400 CRYPTOGRAPHY PRODUCTS

- Cryptographic Support/400
  - Software only
  - Licensed program product, available since AS/400's inception
  - Provides encryption of files and communications
  - Uses DES in Cipher Block Chaining mode
  - Provides key management and key secrecy through the host master key and the cross domain keys
  - Includes Personal Identification Number (PIN) functions (limited)
  - Provides CL command interface for cryptographic functions
- Common Cryptographic Architecture Services/400 (CCAS/400)
  - Software and hardware options included
  - Stores key in IOP tamper resistant module
  - Supports public key encryption
  - Used in environments which require storing key in hardware (banking)
- LU6.2 Session Level Encryption
  - Software only
  - Requires PRPQ and hardware device
  - Easy to use with existing LU6.2 applications

AS/400 CRYPTOGRAPHY PRODUCTS

- Secure Sockets Language
  - Provided in V4R1

AS/400 CRYPTOGRAPHY PRODUCTS

Other Host-based AS/400 Cryptographic Products

- Prime Factors

  - DESCRYPT +

  - DESCRYPT/EDI + - FDESMAC +

- Arkansas Systems - DES-Mate

AS/400 CRYPTOGRAPHY PRODUCTS

Communication Link Encryption

- Modems
  - Western Datacom - DES encryption modems, including 500 Series rack-mounted and 600 series standalone
  - CDI - DES-Guard portable encryptor and a variety of other products
- Routers
  - UUNET - LAN Guardian
- Spread Spectrum in Microwave Communications

AS/400 CRYPTOGRAPHY PRODUCTS

Mass Storage Encryption

- Contemporary Cybernetics - Backup media (tape) encryption

AS/400 CRYPTOGRAPHY PRODUCTS

User Authentication - Replacing the Reusable Password

- S/Key
- Kerberos - Part of OSF Distributed Computing Environment (DCE
- Public Key Encryption
- Time-based Physical Tokens
  - Security Dynamics SecureID product
- Challenge/Response Physical Tokens
  - LeeMah Datacom Security - InfoKey
  - Racal-Guardata - Watchword
  - Information Research Engineering - AX200 Encrypting Token
  - Encotone - TeleID
- Biometrics
  - Veritel - Caller Verification System

SELECTING AND IMPLEMENTING CRYPTOGRAPHY

- Establish business needs and requirements.
- Select products using publicized algorithms, tested by expert cryptanalysts
- Pay careful attention to key generation and management.
- Ensure recovery of data if key lost.
- Ensure solid procedures and policies underlie cryptographic protocols.
- Ensure consistent security architecture throughout - don’t put a steel door on a grass hut.

SECURITY PRODUCTS AND SERVICES

- Starters
  - Applied Cryptography, Bruce Schneier, John Wiley & Sons, New York, ISBN 0-471-11709-9
  - The Codebreakers, David Kahn, Macmillan Company, New York, 1967

- Free with this seminar
  - Cryptography FAQ (diskette)
  - PGP FAQ (diskette)

- AS/400 Products
  - AS/400 Cryptographic Support/400 (SC41-3342-00)

- For "True Propellerheads"
  - Cryptography Theory and Practice, Douglas R. Stinson, CRC Press, Boca Raton, ISBN 0-8493-8521-0
  - Cryptography and Data Security, Dorothy Denning, Addison Wesley, Menlo Park, 1983, ISBN 0-201-10150-5

SECURITY PRODUCTS AND SERVICES