ECE 297:11 - Lecture 1

Security Services

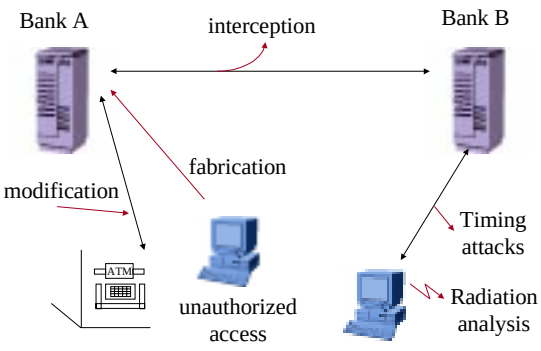
Basic Concepts of Cryptology

Need for *information security*

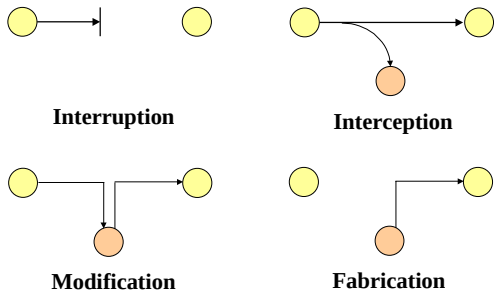
- widespread use of data processing equipment:
  computer security
- widespread use of computer networks and distributed computing systems:
  network security

Security Threats and Security Services

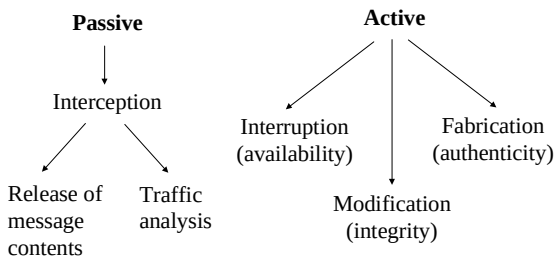
Security Threats in Banking Systems



Network Security Threats (1)



Network Security Threats (2)



Security services

Protecting data

in transit

- **confidentiality**
- **integrity**
- **authentication**
- **non-repudiation**

at rest

- **access control**
  - **identification**
  - **authorization**
  - **auditing**
- **availability**

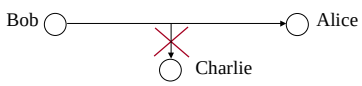
Identification (User Authentication)

On the basis of

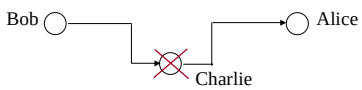
- **what you know** (passwords, PINs)
- **what you have** (magnetic card, smart card)
- **what you are** (fingerprints, handprints, voiceprints, keystroke timing, signatures, retinal scanners)

Basic Security Services (1)

1. Confidentiality



2. Message integrity



3. Message authentication

Basic Security Services (2)

4. Non-repudiation
- of sender - of receiver - mutual

Technique: *digital signature*

Signature

DIGITAL

```
A6E3891F2939E38C745B
25289896CA345BEF5349
245CBA653448E349EA47
```

HANDWRITTEN

Main Goals:
- unique identification
- proof of agreement to the contents of the document

Handwritten and digital signatures

Common Features

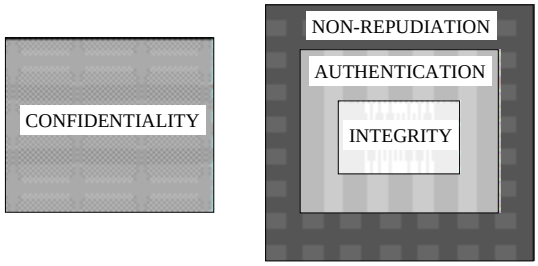
Handwritten signature	Digital signature
1. Unique	
2. Impossible to be forged	
3. Impossible to be denied by the author	
4. Easy to verify by an independent judge	
5. Easy to generate	

Handwritten and digital signatures

Differences

Handwritten signature	Digital signature
6. Associated physically with the document	6. Can be stored and transmitted independently of the document
7. Almost identical for all documents	7. Function of the document
8. Usually at the last page	8. Covers the entire document

Relations among security services



Basic Concepts of Cryptology

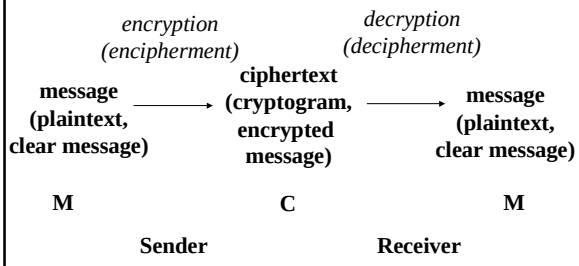
CRYPTOLOGY

CRYPTOGRAPHY **CRYPTANALYSIS**

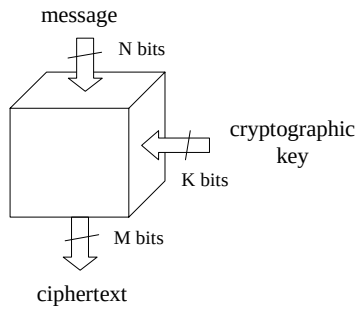
from Greek

cryptos - hidden, secret
logos - word
graphos - writing

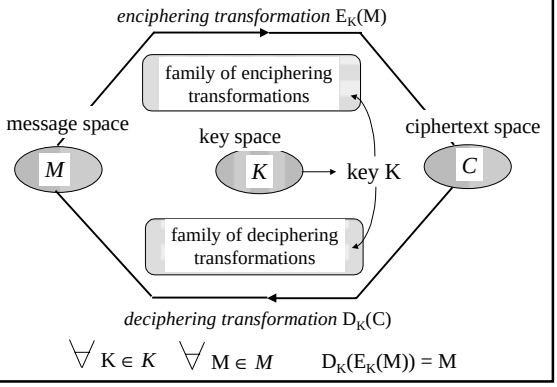
Basic Vocabulary



Cryptosystem (Cipher)



Definition of a cryptosystem (cipher)



$\forall K \in K \quad \forall M \in M \qquad D_K(E_K(M)) = M$

Substitution Cipher

Key = $\begin{pmatrix} a & b & c & d & e & f & g & h & i & j & k & l & m & n & o & p & q & r & s & t & u & v & w & x & y & z \\ f & q & i & s & h & n & c & v & j & t & y & a & u & w & d & r & e & x & l & b & m & z & o & g & k & p \end{pmatrix}$

enciphering

TO BE OR NOT TO BE
↓↓ ↓↓ ↓↓ ↓↓↓ ↓↓ ↓↓
BD QH DX WDB BD QH

deciphering

BD QH DX WDB BD QH
↓↓ ↓↓ ↓↓ ↓↓↓ ↓↓ ↓↓
TO BE OR NOT TO BE

Number of keys = $26! \approx 4 \cdot 10^{26}$

Kerckhoff's principle

The security of a cipher MUST NOT depend on anything that cannot be easily changed

A. Kerckhoff, 1883

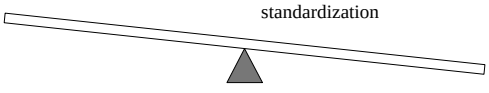
Unpublished vs. published algorithm?

Unpublished algorithm

1. Cryptanalysis must include recovering the algorithm
2. Smaller number of users, smaller motivation to break
3. Unavailable for other countries

Published algorithm

1. The only reliable way of assessing cipher security
2. Prevents backdoors hidden by designers
3. Large number of implementations = low cost + high performance
4. No need for anti-reverse-engineering protection
5. Software implementations
6. Domestic and international standardization



Fundamental Tenet of Cryptography

If lots of smart people have failed to solve a problem, then it probably will not be solved anytime soon.

Security of unpublished ciphers

Commercial packages cracking unpublished encryption schemes built-in:

- MS Word, MS Excel, MS Money
- Word-Perfect, ProWrite, Data Perfect
- Lotus 1-2-3, Symphony, Quattro-Pro
- Paradox, Semantec's Q&A
- PKZip

Time: 1-2 minutes

Price: ~ $200

Companies: Access Data
Crak Software

Passwords recovered even for empty files!

Access Data – DNA: Distributed Network Attack

- client-server application
- DNA client runs in the background, only taking unused processor time
- performs an exhaustive key search on ***Office '97*** and ***Office 2000*** encrypted documents

Expected recovery times (200 MHz, Intel machines):

Product	***Maximum Time***	***Expected***
25 Client Network	16 Days	8 Days
50 Client Network	8 Days	4 Days
100 Client Network	4 Days	2 Days
500 Client Network	20 Hours	10 Hours
1,000 Client Network	10 Hours	5 Hours

Breaking ciphers used in GSM (1)

GSM - world's most widely used mobile telephony system
- 51% market share of all cellular phones, both analog and digital
- over 215 million subscribers in America, Europe, Asia, Africa, and Australia
- In the US, GSM employed in the "Digital PCS" networks of Pacific Bell, Bell South, Omnipoint, etc.

Two voice *encryption algorithms*:
A5/1 and A5/2
encrypt voice between the cellphone and the base station

Breaking ciphers used in GSM (2)

Both voice encryption algorithms
- never published
- designed and analyzed by the secretive "SAGE" group (part of ETSI – European Telecommunications Standard Institute)
- A5/1 believed to be based on the modified French naval cipher

Both algorithms reverse-engineered by
"Marc Briceno" with the Smartcard Developer Association
published by the Berkeley group
A5/1 in May 1999,
A5/2 in August 1999

Breaking ciphers used in GSM (3)

Published attacks

A5/2

August 1999, Ian Goldberg and David Wagner, U.C. Berkeley

Number of operations in the attack ~ 2^{16}

A5/1

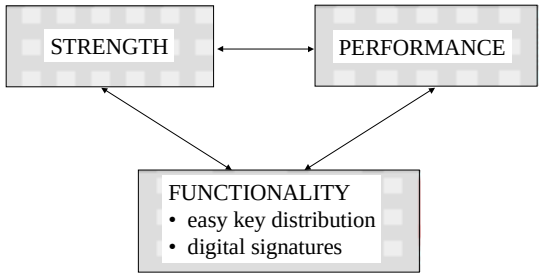
May 1999, Jovan Golic

Number of operations in the attack ~ 2^{40}

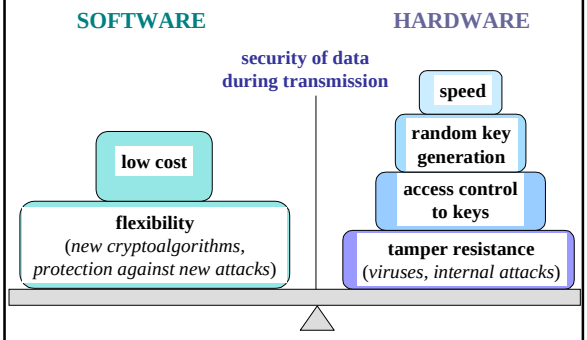
December 1999, Alex Biryukov and Adi Shamir

Less than **1 second** on a single PC with 128 MB RAM and two 73 GB hard disks.
Based on the analysis of the A5/1 output during the first two minutes of the conversation.

Features required from today's ciphers



Software or hardware?



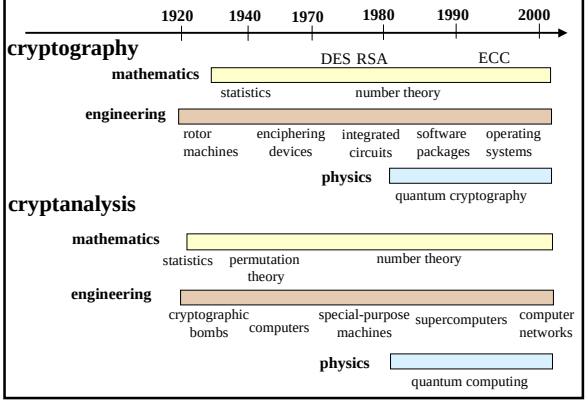
Basic hardware implementations of cryptography

- VLSI chip
- smart card
- PCMCIA card
- cryptographic card
- stand-alone cryptographic device

Applications most suitable for hardware implementations

- hardware accelerators for security gateways and routers
- wireless communications
- universal smart cards for electronic commerce
- electronic wallet
- Certificate Authority - center for registration of public keys
- key-escrow cryptography
- military devices
- high-grade security devices

Evolution of cryptography and cryptanalysis



NSA

National Security Agency
(also known as "No Such Agency"
or "Never Say Anything")

Created in 1952 by president Truman

Goals:

- designing strong ciphers (to protect U.S. communications)
- breaking ciphers (to listen to non-U.S. communications)

Budget and number of employees kept secret
Largest employer of mathematicians in the world
Larger purchaser of computer hardware

RSA Security Inc.

- patents for RSA, RC5, RC6 and other cryptographic algorithms
- over 500 mln users of the basic cryptographic library BSAFE
- RSA Laboratory
- RSA Conference
- spin-off companies
  VeriSign - Public Key Infrastructure

Companies introducing security into their products/services

software
Lotus
Microsoft
Netscape
Novell
Oracle
Intuit

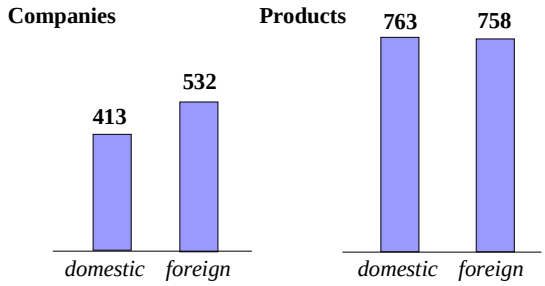
hardware
IBM
Motorola
Intel
Compaq
Sun
Hewlett-Packard

telecom
AT&T
Worldcom
Nothern Telecom

finances
Visa
Mastercard
Verifone

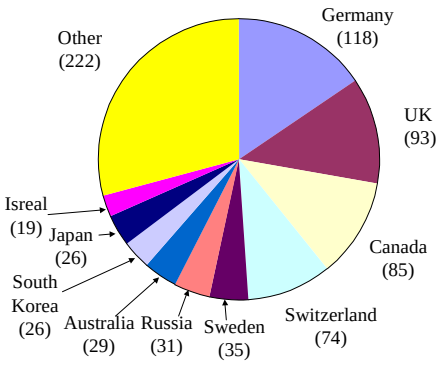
Worldwide Survey of Cryptographic Products

NAI Labs, June 2001

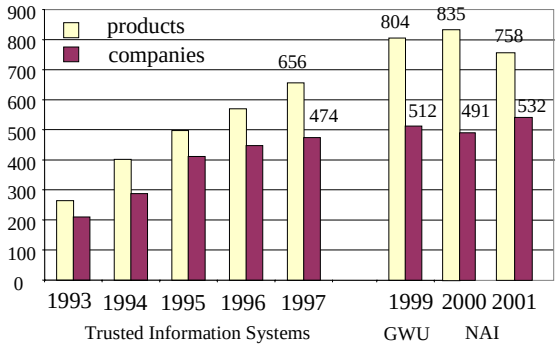


Foreign products developed in 43 countries distributed in at least 76 countries

Foreign Cryptographic Products



Increase in the number of foreign cryptographic products and companies



American and international standards regarding public key cryptography