Announcements

A review session is being scheduled for Saturday March 15

Encryption

Encryption encodes information to hide it from everyone else … maintaining your privacy

Maintaining Privacy

To keep information private it must be hidden from "prying" computers

As children, most of us used "secret" codes

Most often the code was a Caesar Cipher -- an alphabetic shift by a constant amount

Clear Text: `ABCDEFGHIJKLMNOPQRSTUVWXYZ`

`Encode` ↓ ↑ `Decode`

Coded Text: `IJKLMNOPQRSTUVWXYZABCDEFGH`

`VW EIZ QV QZIY`

Breaking Caesar Cipher

Fixed substitutions don't work, 'cause letters have a known distribution

- In a large text, count the frequency of each letter, match the results to distribution
- The twelve most frequent letters account for 80% of English text
- ETAOINSHRDLU

`A*ERI*A THE *EAUTI*UL`

Encryption Issue

Traditionally, encryption technology has been "breakable" with effort

- Breakable codes let law enforcement and governments watch criminals and spies
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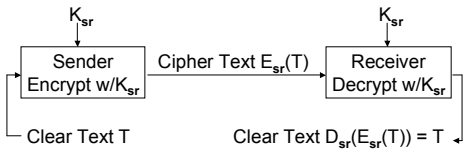
⇒New computer encryption is unbreakable⇐

- It's called "strong encryption" … should it be legal to be able to keep secrets absolutely?

Strong encryption: serious issue of public interest

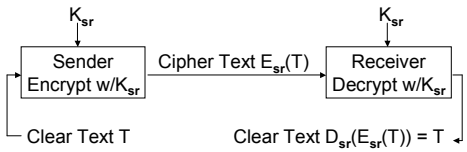
General Encryption Setup

Encryption is most important for when sending information



Problem: Key Exchange

To communicate securely, users must meet before sending/receiving

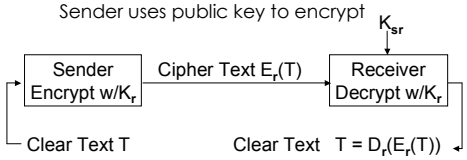


This doesn't work for eCommerce

Revise Encryption Setup

Public Key Encryption is based on publishing the key

Sender uses public key to encrypt



Public Key Encryption

Using the public key, encrypt message

- Divide T, the clear text bytes, into blocks
- Treat each block as a number
- Cube number (raise to 3 pwr), divide by key
- Send the remainder for each block

T: 10001011010111101000001001000010110101010100101

2229	3714	1069	165
2229^3	3714^3	1069^3	165^3
11074654989/K_r	51230158344/ K_r	1221611509/ K_r	4492125/ K_r
25	24	19	0

Public Key Cryptography

Does PKC work? Can't it be cracked?

- Recall definition of divide: $a=b \cdot c + d$

Quotient Remainder

- For example, 50/6 implies $50=6 \cdot 8 + 2$
- The encryption process is a division:

$T^3=K_r \cdot c + d$

so sending c&d determines clear text T

But we only send d!

RSA Encryption

Rivest, Adelman and Shamir invented a PKC scheme called RSA

- The secret is to pick the key, K_r, right
- Pick two prime numbers -- numbers divisible only by themselves and 1 -- that are 2 greater than a multiple of 3 … weird!
- Examples are 5, 11, 17, 23, 29, ...
- $K_r = p \cdot q$ so that it is 129 digits

Follow procedure given, send remainders

How To Recover Message

Compute s=1/3(2(p-1)(q-1)+1) then compute $C^s = K_r \cdot c + T$

* That is …

  The remainders (C) raised to s power equal K_r times some (quotient) c no one cares about plus the original clear text number!

  - So, raise the remainders to s, divide by K_r and PRESTO! the new remainder is the answer

For p=17 and q=23, pq= 391 and s=235

What Makes RSA Work?

Though the numbers get huge, computer can handle them quickly

- These codes are strong because breaking them needs s, which needs p, q, which means factoring K_r
- Factoring is computationally tough -- best methods are only somewhat better than grammar school, "try all small primes"
- Picking 129 digit key, means no computer can factor it … so the code is unbreakable

RSA Challenge

After inventing their scheme (1977), RSA challenged people to break it

- Their first key was broken in 1994 using 1000 computers over 8 months
- Their secret message: THE MAGIC WORDS ARE SQUEAMISH OSSIFRAGE

  Doomed? No. There are many other 129 digit keys, or if people get nervous make 200 digit keys or more … breaking gets harder very fast; encrypt/decrypt doesn't

Is Strong Encryption Smart

Should we allow people to use strong encryption? Or should only breakable codes be legal?

- It hampers law enforcement and security
- Most criminals reveal plans in other ways
- PKC exists and is known, so build in escape
  -- Trap door
  -- Key Escrow
- But are these schemes really secure?