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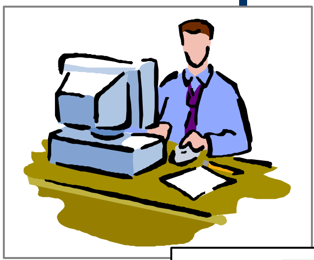

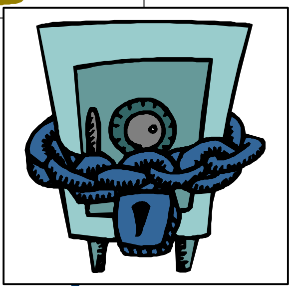

RSA Algorithm and Encryption

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The RSA public-key encryption algorithm works in the following manner:

1. Generation of a public-private key pair.
2. Encryption of a message (plain text) with the public key generated in step 1 to get the cipher-text.
3. Decryption of the cipher-text by using the private key of the corresponding public key generated in step 1.

Step 1:
Generation of a key pair

- Select two large integer primes **p** and **q**.

- Multiply p and q to get a number **n**,

  i.e., **pq** = **n**.

- Obtain ϕ which is the product of **p**-1 and **q**-1

  i.e. $\phi = (\mathbf{p}-1)(\mathbf{q}-1)$.

- Select **e** such that $1<\mathbf{e}<\phi$ and gcd of **e** and ϕ is 1.

- Compute d such that $1<\mathbf{d}<\phi$ and $\mathbf{ed} \equiv 1 \bmod \phi$. This means that the value of **d** must be such that **ed**-1 should be completely divisible by ϕ or $(\mathbf{ed}-1) / \phi$ should be an integer.

The public-key is (**n**, **e**) and the corresponding private key is (**d**, **n**).

Step 2:
Encryption process

Suppose the message to be encrypted is **m**.

The cipher-text **c** is obtained by raising the message to the value of **e** and finding out its modulo **n** i.e.

$$\mathbf{c} = \mathbf{m}^{\mathbf{e}} \bmod \mathbf{n}.$$

Step 3:
Decryption process

Decryption is achieved by raising the cipher-text **c** obtained in step 2 to the value of **d** and finding out its modulo **n** i.e.

$\mathbf{m} = \mathbf{c}^{\mathbf{d}} \bmod \mathbf{n}$.

The security of the RSA cryptosystem is based on the integer factorization problem. Any adversary who wishes to decipher the cipher-text **c** must do so by using the publicly available information (**n**, **e**).

One possible method is to first factor **n**, and then compute ϕ and **d** just as was done in the above mentioned steps. The factoring of n is currently computationally infeasible and therein lies the strength of the RSA cryptosystem.

An Example of the RSA Algorithm

Note this example uses artificially small numbers. In reality **p** and **q** are likely to be at least 100 digits each.

Let us take **p** = 61 and **q** = 53

pq = 3233

Let us choose **e** = 17

Therefore **d** = 2753

The public key is (3233, 17)

The private key is 2753.

To encrypt the plaintext value 123:

Encrypt (123) = (123^17) mod 3233
= 337587917446653715596592958817679803 mod 3233
= 855

To decrypt the cipher text value 855:

decrypt(855) = (855^2753) mod 3233

= 50432888958416068734422899127394466631453878360035509315554967564501
0556286120825599787442454281100543834986542893363849302464514415078
5172091796654782635307099638035387326500896686074771829745822950342
9504079035818459409563779385865989368838083602840132509768620766977
3966753325054282609347573513798806325648263933445309259438556242923
3017519771900169249169128091505960191787601713497254392792156967017
8990213430714646897127961027718137839458696772898693423652403116932
1708926961764372652131566583315871245975980304250314400683788324610
1784830

71758547454725206968892599589254436670143220546954317400228550092386
36942444855973333063051607385302863219302913503745471946757776713579

54965202919790505781532871558392070303159585937493663283548602090830
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04695258866987658669006224024102088466507530263953870526631933584734
81094876156227126037327597360375237388364148088948438096157757045380
08107946980066734877795883758289985132793070353355127509043994817897
90548993381217329458535447413268056981087263348285463816885048824346
58897839333466254454006619645218766694795528023088412465948239275105
77049113329025684306505229256142730389832089007051511055250618994171
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12441601438765069145868196402276027766869530903951314968319097324505
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13638045914237759965220309418558880039496755829711258361621890140359
54234930424749053693992776114261796407100127643280428706083531594582
305946326827861270203356980346143245697021484375 **mod** 3233

= 123

While it is widely believed that breaking the RSA encryption scheme is as difficult as factoring the modulus n, no such equivalence has been proven. The Rabin public-key encryption scheme was the first example of a *provably secure* public-key encryption scheme – the problem faced by a passive adversary of recovering plaintext from some given cipher text is computationally equivalent to factoring.

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