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Implementation of Diffie-Hellman Algorithm

Background

Elliptic Curve Cryptography (ECC) is an approach to public-key cryptography, based on the algebraic structure of elliptic curves over finite fields. ECC requires a smaller key as compared to non-ECC cryptography to provide equivalent security (a 256-bit ECC security have an equivalent security attained by 3072-bit RSA cryptography).

For a better understanding of Elliptic Curve Cryptography, it is very important to understand the basics of Elliptic Curve. An elliptic curve is a planar algebraic curve defined by an equation of the form

$$y^2 = x^3 + ax + b$$

where 'a' is the co-efficient of x and 'b' is the constant of the equation

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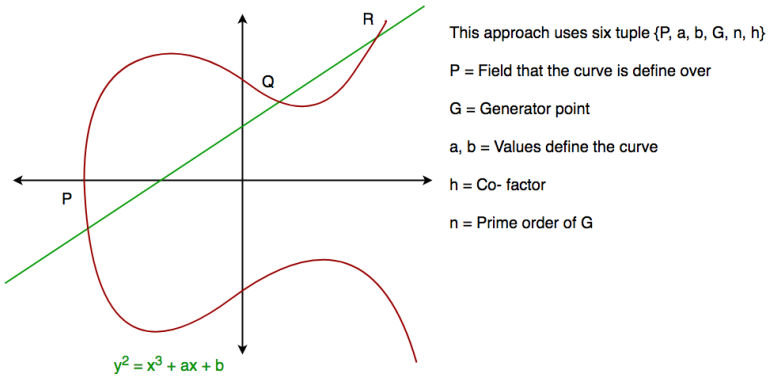
The curve is non-singular; that is its graph has no cusps or self-intersections (when the characteristic of the co-efficient field is equal to 2 or 3).
In general, an elliptic curve looks like as shown below. Elliptic curves could intersect atmost 3 points when a straight line is drawn intersecting the curve. As we can see that elliptic curve is symmetric about the x-axis, this property plays a key role in the algorithm.



This approach uses six tuple {P, a, b, G, n, h}

P = Field that the curve is define over

G = Generator point

a, b = Values define the curve

h = Co- factor

n = Prime order of G

Diffie-Hellman algorithm

The Diffie-Hellman algorithm is being used to establish a shared secret that can be used for secret communications while exchanging data over a public network using the elliptic curve to generate points and get the secret key using the parameters.

- For the sake of simplicity and practical implementation of the algorithm, we will consider only 4 variables one prime P and G (a primitive root of P) and two private values a and b.
- P and G are both publicly available numbers. Users (say Alice and Bob) pick private values a and b and they generate a key and exchange it publicly, the opposite person received the key and from that generates a secret key after which they have the same secret key to encrypt.

Step by Step Explanation

ALICE	BOB
Public Keys available = P, G	Public Keys available = P, G
Private Key Selected = a	Private Key Selected = b
Key generated = $x = G^a mod P$	Key generated = $y = G^b mod P$
Exchange of generated keys takes place	
Key received = y	key received = x
Generated Secret Key = $k_a = y^a mod P$	Generated Secret Key = $k_b = x^b mod P$
Algebraically it can be shown that $k_a = k_b$	
Users now have a symmetric secret key to encrypt	

Example

```
Step 1: Alice and Bob get public numbers P = 23, G = 9

Step 2: Alice selected a private key a = 4 and
        Bob selected a private key b = 3

Step 3: Alice and Bob compute public values
Alice:    x =(9^4 mod 23) = (6561 mod 23) = 6
        Bob:    y = (9^3 mod 23) = (729 mod 23)  = 16

Step 4: Alice and Bob exchange public numbers

Step 5: Alice receives public key y =16 and
        Bob receives public key x = 6

Step 6: Alice and Bob compute symmetric keys
        Alice:  ka = y^a mod p = 65536 mod 23 = 9
        Bob:    kb = x^b mod p = 216 mod 23 = 9

Step 7: 9 is the shared secret.
```

Implementation:

```
/* This program calculates the Key for two persons
using the Diffie-Hellman Key exchange algorithm */
#include<stdio.h>
#include<math.h>

// Power function to return value of a ^ b mod P
long long int power(long long int a, long long int b,
                                    long long int P)
{
    if (b == 1)
        return a;
```

```
    else
        return (((long long int)pow(a, b)) % P);
}

//Driver program
int main()
{
    long long int P, G, x, a, y, b, ka, kb;

    // Both the persons will be agreed upon the
        // public keys G and P
    P = 23; // A prime number P is taken
    printf("The value of P : %lld\n", P);

    G = 9; // A primitve root for P, G is taken
    printf("The value of G : %lld\n\n", G);

    // Alice will choose the private key a
    a = 4; // a is the chosen private key
    printf("The private key a for Alice : %lld\n", a);
    x = power(G, a, P); // gets the generated key

    // Bob will choose the private key b
    b = 3; // b is the chosen private key
    printf("The private key b for Bob : %lld\n\n", b);
    y = power(G, b, P); // gets the generated key

    // Generating the secret key after the exchange
        // of keys
    ka = power(y, a, P); // Secret key for Alice
    kb = power(x, b, P); // Secret key for Bob

    printf("Secret key for the Alice is : %lld\n", ka);
    printf("Secret Key for the Bob is : %lld\n", kb);

    return 0;
}
```

Output

```
The value of P : 23
The value of G : 9

The private key a for Alice : 4
The private key b for Bob : 3

Secret key for the Alice is : 9
Secret Key for the Bob is : 9
```

This article is contributed by **Souvik Nandi**. If you like GeeksforGeeks and would like to contribute, you can also write an article using contribute.GeeksforGeeks.org or mail your article to contribute@GeeksforGeeks.org. See your article appearing on the GeeksforGeeks main page and help other Geeks.

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