Implementation of Diffie-Hellman Algorithm

Difficulty Level : Medium • Last Updated : 24 Oct, 2021

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 has equivalent security attained by 3072-bit RSA cryptography).

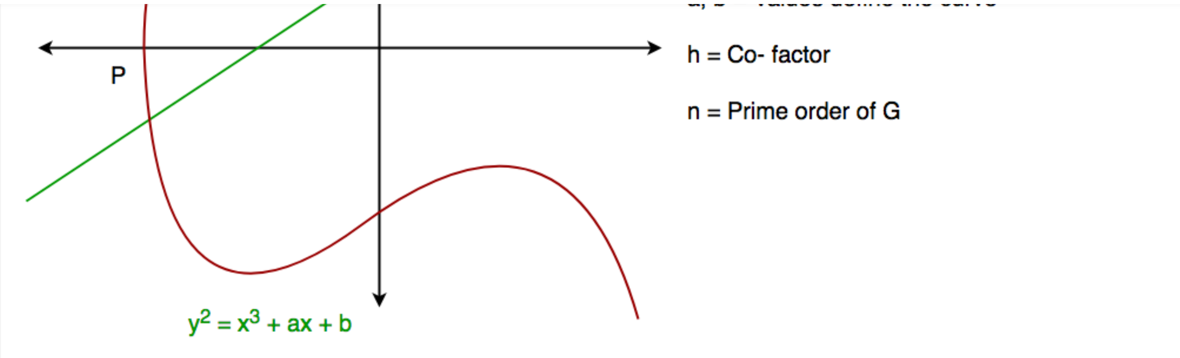
For a better understanding of Elliptic Curve Cryptography, it is very important to understand the basics of the Elliptic Curve. An elliptic curve is a planar algebraic curve defined by an equation of the form

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

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

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 can intersect almost 3 points when a straight line is drawn intersecting the curve. As we can see, the elliptic curve is symmetric about the x-axis. This property plays a key role in the algorithm.



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

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

$x = G^a mod P$ $y = G^b mod P$

Exchange of generated keys takes place

Key received = y key received = x

Generated Secret Key = Generated Secret Key =

$k_a = y^a mod P$ $k_b = x^b mod P$

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 =
```

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

Implementation:

C

```c
/* 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 primitive 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
```

```
    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;
}
```

Java

```
// This program calculates the Key for two persons
// using the Diffie-Hellman Key exchange algorithm
class GFG{

// Power function to return value of a ^ b mod P
private static long power(long a, long b, long p)
{
    if (b == 1)
        return a;
    else
        return (((long)Math.pow(a, b)) % p);
}

// Driver code
public static void main(String[] args)
{
    long P, G, x, a, y, b, ka, kb;

    // Both the persons will be agreed upon the
    // public keys G and P

    // A prime number P is taken
    P = 23;
    System.out.println("The value of P:" + P);

    // A primitive root for P, G is taken
    G = 9;
    System.out.println("The value of G:" + G);

    // Alice will choose the private ke
```

```
        // Bob will choose the private key b
        // b is the chosen private key
        b = 3;
        System.out.println("The private key b for Bob:" + b);

        // Gets the generated key
        y = power(G, b, P);

        // 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

        System.out.println("Secret key for the Alice is:" + ka);
        System.out.println("Secret key for the Bob is:" + kb);
    }
    }

    // This code is contributed by raghav14
```

Python3

```
from random import randint

if __name__ == '__main__':

    # Both the persons will be agreed upon the
    # public keys G and P
    # A prime number P is taken
    P = 23

    # A primitive root for P, G is taken
    G = 9


    print('The Value of P is :%d'%(P))
    print('The Value of G is :%d'%(G))

    # Alice will choose the private key a
    a = 4
```

```
    b = 3
    print('The Private Key b for Bob is :%d'%(b))

    # gets the generated key
    y = int(pow(G,b,P))


    # Secret key for Alice
    ka = int(pow(y,a,P))

    # Secret key for Bob
    kb = int(pow(x,b,P))

    print('Secret key for the Alice is : %d'%(ka))
    print('Secret Key for the Bob is : %d'%(kb))
```

Javascript

```
<script>

// This program calculates the Key for two persons
// using the Diffie-Hellman Key exchange algorithm

// Power function to return value of a ^ b mod P
function power(a, b, p)
{
    if (b == 1)
        return a;
    else
        return((Math.pow(a, b)) % p);
}

// Driver code
var P, G, x, a, y, b, ka, kb;

// Both the persons will be agreed upon the
// public keys G and P

// A prime number P is taken
P = 23;
document.write("The value of P:" + P + "<br>");
```

```
// a is the chosen private key
a = 4;
document.write("The private key a for Alice:" +
               a + "<br>");

// Gets the generated key
x = power(G, a, P);

// Bob will choose the private key b
// b is the chosen private key
b = 3;
document.write("The private key b for Bob:" +
               b + "<br>");

// Gets the generated key
y = power(G, b, P);

// 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

document.write("Secret key for the Alice is:" +
               ka + "<br>");
document.write("Secret key for the Bob is:" +
               kb + "<br>");

// This code is contributed by Ankita saini

</script>
```

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
```

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