Wireless Sensor Network development of security scheme based on Elliptic Curve Cryptography

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Abstract. Wireless sensor network may encounter eavesdropping, message modification, message injection, route spoofing, denial of service, malicious code threats. This paper discusses the application of Elliptic Curve Cryptography in security in wireless sensor networks, discusses a wireless authentication and key agreement protocol based on elliptic curve cryptosystem. The paper proposes development of security scheme on wireless sensor network based on Elliptic Curve Cryptography. Safety examples prove that the proposed algorithm of wireless sensor network is effective.

1. Introduction

A wireless sensor network is a network which consists of a number of sensor nodes that are wirelessly connected to each other. This small, low-cost, low-power, multifunctional sensor nodes can communicate in short distances. Each sensor node consists of sensing, data processing, and communication components. A large number of these sensor nodes collaborate form wireless sensor networks [1]. A WSN usually consists of tens to thousands of such nodes that communicate through wireless channels for information sharing and cooperative processing. To ensure scalability and to increase the efficiency of the network operation, sensor nodes are often grouped into clusters [2][3].

The sensors must be placed in exact locations, since there are a limited number of nodes extracting information from the environment. Furthermore, deployment of these nodes and cables is costly and awkward, requiring helicopters to transport the system and bulldozers to ensure the sensors can be placed in exact positions. There would be large economic and environmental gains if these large, bulky, expensive macro-sensor nodes could be replaced with hundreds of cheap micro-sensor nodes that can be easily deployed. This would save significant costs in the nodes themselves as well as in the deployment of these nodes. These micro-sensor networks would be fault-tolerant, as their sheer number of nodes can ensure that there is enough redundancy in data acquisition that not all nodes need to be functional. Using wireless communication between the nodes would eliminate the need for a fixed infrastructure.

Wireless micro-sensor networks represent a new paradigm for extracting data from the environment. Conventional systems use large, expensive macro-sensors that are often wired directly to an end-user and need to be accurately placed to obtain the data. For example, the oil industry uses large arrays of geophone sensors attached to huge cables to perform seismic exploration for oil. These sensor nodes are very expensive and require large amounts of energy for operation. The most difficult resource constraint to meet is power consumption in wireless sensor networks. The use of wireless sensor networks is increasing day by day and at the same time it faces the problem of energy constraints in terms of limited battery lifetime. As each node depends on energy for its activities, this has become a major issue in wireless sensor networks. The failure of one node can interrupt the entire system or application. Everysensing node can be in active, idle and sleep modes. In active mode, nodes consume energy when receiving or transmitting data. In idle mode, the nodes consume almost the same amount of energy as in active mode. While in sleep mode, the nodes shutdown the radio to save the energy. Energy constraints end up creating computational and storage limitations that lead to a new set of architectural issues. A wireless sensor network platform must provide support for a suite of application-specific protocols that drastically reduce node size, cost, and power consumption for their target application.

The following steps can be taken to save energy caused by communication in wireless sensor networks.

- To schedule the state of the nodes (i.e. transmitting, receiving, idle or sleep).
- Changing the transmission range between the sensing nodes.
- Using efficient routing and data collecting methods.
- Avoiding the handling of unwanted data as in the case of overhearing.

In WSNs, the only source of life for the nodes is the battery. Communicating with other nodes or sensing activities consumes a lot of energy in processing the data and transmitting the collected data to the sink. In many cases (e.g. surveillance applications), it is undesirable to replace the batteries that are depleted or drained of energy [4]. Many researchers are therefore trying to find energy-aware protocols for wireless sensor networks in order to overcome such energy efficiency problems as those stated above.

All the protocols that are designed and implemented in WSNs should provide some real-time support as they are applied in areas where data is sensed, processed and transmitted based on an event that leads to an immediate action. A protocol is said to have real-time support if and only if, it is fast and reliable in its reactions to the changes prevailing in the network. It should provide redundant data to the base station. The base station or sink using the data that is collected among all the sensing nodes in the network. The delay in transmission of data to the sink from the sensing nodes should be small, which leads to a fast response.

Elliptic Curve Cryptography Compared with other public-key cryptosystem. Studies have shown that for elliptic curve cryptography 160bi long has the security key with RSA or DSA keys in the 1024 bit long has the very security. And, in a finite field, there can be a lot of elliptic curve cryptography for the establishment [2]. This paper focuses on Elliptic Curve Cryptography Research and implementation of this project to start in elliptic curve cryptography for existing in-depth study, based on the design and implementation of a safe and efficient elliptic curve cryptosystem.

Distributed key management and hierarchical key management according to the network structure, WSN key management can be divided into distributed key management and hierarchical key management two. Negotiation, node key update is accomplished by using node pre distribution key and mutual cooperation. In the hierarchy of WSN key management, the nodes are divided into several clusters, each cluster has a cluster head strong (cluster head) to take charge of the management of it.

2. Elliptic Curve Cryptography

MOV-based domain reduction method only when the degree of expansion of the definition is appropriate for a small time is embedded is valid. Then baby -step giant-step algorithm's time complexity is # E (Ep) a function of the time index algorithm by # E (Ep) determined parameters.

In the elliptic curve E is on exactly one point [3]. Called the infinity point. Namely (0: I: 0)

with 0. Non-homogeneous coordinates can be expressed in the form of Weierstrass elliptic curve equation:
Let x = X / Z, y = Y / Z. So the original equation into: equation1.

y2+a1 xy+a3Y=X3+a2X2+a4x+a6 (1)

The E algorithm ⊕has the following a rule⊕ for properties: If the line L cross E at point P, Q, R (not necessarily different), then

(1)(P ⊕ Q) ⊕ R = O.

(2)For any P ⊕ E, P ⊕ O = P.

(3)For any P, Q ⊕ E, P ⊕ Q = Q ⊕ P.

(4)Let P ∈ E, there is a point, denoted by - P, so P ⊕-P = O.

For any P, Q, R ∈ E, a (P ⊕ Q) ⊕ R = P ⊕ (Q ⊕ R).

That is to say, E constitute computing the exchange group. Further, if E is defined in

E(K):={(x,y)|y2+a1xy+a3y=x3+a2x2+a4x+a6} ∪{o} is a subgroup of E. Now we give the exact formula for computing group [4].

Let the general Weierstrass elliptic curve equation E: E:={(x,y)|y2+a1xy+a3y=x3+a2x2+a4x+a6} ∪{o}. Let P1=(x1,y1),p2=(x2,y2) are two points on the curve E, then-P1=(x1,-y1-a1x-a3), as is shown by equation2.

$$\begin{cases} \lambda = \dfrac{y_2-y_1}{x_2-x_1} & x_1 \neq x_2 \\ \lambda = \dfrac{3x_1^2+2a_2x_1+a_4-a_1y_1}{2y_1+a_1x_1+a_3} & x_1 = x_2 \end{cases}$$

(2) The following shows the use of SEA algorithm to select a large prime field elliptic curve on security steps. Select a large prime number field of secure elliptic curves. Input: a finite field of size q; Output: the elliptic curve E (a, b), # E (a, b) = nh, n is a large prime factor, n> 2160 and n> 4q. (1)Random GF (p) on an elliptic curve E (a, b):
(2)The SEA algorithm to calculate the # E (a, b); (3)The use of large integer factorization algorithm decomposition # E (a, b), and detection of # E (a, b) whether the decomposition in> 2160 the prime factor n. If not, go back to (1).

Wireless sensor network may encounter eavesdropping, message modification, message injection, route spoofing, denial of service, malicious code threats. In addition, in wireless sensor networks, the concept of security has also changed, the communication security is one of the important part, privacy protection becomes more and more important, and authorized the importance of reduced.

Each based on elliptic curve public key cryptosystem operations, are included by some elliptic curve domain parameters defined on the finite field arithmetic on elliptic curves. Work in SEC1 the ECC draft, as defined by the elliptic curve domain parameters consisting of a six even.

T = (p, a, b, G, n, h)

Where: integer p is a finite field Fp; two elements elliptic curve; G represents a point; n is prime and equal to the point G of order; h=#E(Fp)/n, is called the cofactor.

As the elliptic curve cryptosystem security only with the security of elliptic curve, and therefore, we can select for the establishment of a class of elliptic curve cryptosystems secure in the establishment of such an elliptic curve cryptosystem can guarantee their safety. The security of elliptic curve is the difficulty of solving the ECDLP the decision, which through analysis of existing algorithms to solve a variety of ECDLP, accurately grasp the ECDLP problem solving for design and evaluation of the progress of fast and secure elliptic curve has very important significance. Security of elliptic curve that is resistant to attack a variety of algorithms has been attacks on elliptic curve.

3. For WSN to Achieve Elliptic Curve Cryptosystem

For example: elliptic curve equation E211 (1,1): y2 = x3 + x +1 elliptic curve point group of order 223, integer points on elliptic curves have 222. There is also a point at infinity 0. Take any point V (2,86), and then calculate the point of the elliptical cycle [5]. The basic idea is: use the law of addition operation described above, calculate the value of n nv = 0 is the point v of the cycle (stage). After a calculated n = 223. After verification of the above algorithm. That n = 223 is a prime number, so the point V can be seen as point G.

(1) The calculation of points on elliptic curves

① For each satisfy 0 ≤ x <p of X.

Calculation of X3 + ax + b (mod p);

② For each of the previous step to get the results to determine if it has a square root of P mode. If not, in Ep (a,b) was not found in an x value of this point. If so, there are two square root operations to meet the y value (unless the value is a single y value of zero). These (x, y) value is Ep (a,b) in point.

(2) Points on the elliptic curve calculation cycle

1. Select the ellipse that q (x0, y0);
2. Calculate the q + q + ... + q, nq = 0 makes the establishment of minimum n, if y0 = 0, then. This point is no cycle;
3. Test whether n is prime, if not. Go back to step2.

The implementation scheme based on the elliptic curve encryption and digital signature, and it is first of all to parameters of elliptic curve domain to determine an elliptic curve. But not all are suitable for the elliptic curve encryption, Y2 X3 axes B is a class can be used to elliptic curve cryptography, is also the most simple. Below we select the Y2 X3 ax B as encryption curve us [6]. This curve is defined in the Fq: two satisfying the following conditions is less than P (P is a prime number) of non negative integers a, b: 4A3 27b2 0 (mod p) will meet the following equation (all points x, y), plus infinity ∞, form an elliptic curve.

A current attack of Elliptic Curve Cryptography Algorithms Elliptic curve cryptosystem depends on the security of elliptic curve is defined by the group on the difficulty of the discrete logarithm problem [7]. There are two solutions to the discrete logarithm problem of effective algorithms, namely Shank's baby-step giant-step algorithm and any cyclic group of index algorithms. Shank's baby-step giant- step algorithm is a basic group does not depend on the index algorithm, but it needs to group the order of the largest prime factor of safety index time is O(p), where n is the group F (Fp) order of the largest prime factor, expressed as # E (Fp)

Bob's decryption process: Bob receives Alice's ciphertext (36,189,136), the Executive

1. With the private key d = 112, calculate the point (x2, y2) = d (x1, y1) = 112 (36,189) = (94,129), calculated in Fp = 110.

2. By calculating m = C = 136 * 110 = 1 90, to recover the plaintext data m = 190.

The algorithm has been justified in the use of SEA the number of points after each test whether the selected curve of large prime factor, is a non-regular curve, whether the ultra-strange curve.

4. Application of Elliptic Curve Cryptography in Design Security Scheme for Wireless Sensor Network

At present in the elliptic curve point group is also no one can be found in exponential time algorithms for the solution of the discrete logarithm problem [8]. Therefore, in the premise of the same security people can be formed by elliptic curve order smaller point group set up password system. The amount of keys that the elliptic curve cryptosystem and it is save bandwidth, faster computation speed. These features make the elliptic curve cryptography is very suitable for computing speed and storage space is limited, such as smart card, radio equipment etc.

AIice send message m to Bob, Alice perform:

1. Find Bob's public key (E (Fp), G, n, Q);
2. The m expressed as a domain element m ∈ Fp, m will be expressed as 190;
3. In the interval [1, n-1] select a random number within the k, where select k = 57;
4. Calculated based on Bob's public key point x1, y1) = kG; (k a G addition) was (x1, y1) = 57 (2,86) = (36,189).

Taking full account of ECDLP attack algorithm and based on the analysis above, summed up select safe elliptic curve should follow some principles.

(1)SE selection of non-super singular elliptic curve, without selecting a singular elliptic curves, hyperelliptic curves, and anomalous elliptic curves;

(2)# E is not divisible by qk-1, 1 ≤ k ≤ 20.

Once the two sides have access to each other's public key, obtain information on both sides with his private key encryption [9]. Concrete is realized through its private key and public key by multiplying each other. In order to prevent the leakage of the certificate, the certificate is required to be delivered by encryption mode. In this protocol, the specific approach is: the server will generate a random integer g, then using the symmetric encryption algorithm to (RS, SX) and concatenated string certificate is valid for TS encryption, message encryption to the user end.

The client decrypts the message, access to the server certificate and the random number G. The client then concatenated string has its own certificate and the certificate is valid for encryption, encrypted message to C1, and then sent to the server, as is shown by equation4.

$$x_3 = \begin{cases} \lambda^2 + \lambda + x_1 + x_2 + a & P = Q \\ \lambda^2 + \lambda + a & P = Q \end{cases}$$

Experiments show that, when the nodes in the network number, survivability of this scheme is better than the E -G scheme, but with the increasing number of compromised nodes, and it is the scheme becomes worse. Multiple key spaces of random key pre distribution scheme of Blom single key space scheme allows any network of two nodes can establish pairwise keys, and ensure that the compromised node number is less than the threshold value, the network will not disclose any confidential information. It will expand as the random key pre distribution scheme of multi key space.

Let P, Q are two points on E, L is the line through P and Q (over the tangent point P, if P = Q), R is L and E intersects the third point curve. Let L’ is a straight line through R and Q, then P⊕Q is L' and E intersect the third point.

The session key agreement between km=Qk.x+g user end and the server end, is negotiated by both sides of communication [10]. The parameter Qk is obtained by the user and server's private key and the other's public key together, the private key only within the system based on ECDLP public key generation, transmission, also does not have the safe hidden trouble, at the same time generated by the server by sending a random number G is in encrypted form to the user terminal. Therefore, only the end user and server negotiation can calculate the session key, any one party alone can not calculate the session key, as is shown by equation5.

$$v = \begin{cases} \dfrac{y_1 x_2 - y_2 x_1}{x_2 - x_1} & P \neq Q \\[2ex] \dfrac{-x_1^3 + a_4 x_1 + 2a_6 - a_3 y_1}{2y_1 + a_1 x_1 + a_3} & P = Q \end{cases}$$

Elliptic curve cryptosystem has a maximum security, has been more and more widely used in the field of information security. To further improve the performance of elliptic curve cryptosystem and the application of elliptic curve cryptosystem based on specific environment are two main research

direction of the elliptic curve cryptosystem. This paper mainly discusses the application of ECC system in the wireless network security, authentication and key agreement protocol is suitable for wireless network environment, and the function and security are analyzed and proved.

Summary

Elliptic curve cryptosystem is able to adapt to the future of communications technology and information security technology development of new cryptosystem, its anti-brute-force method is to use a large key space. The safety analysis also attracted national attention cryptologists and the relevant departments and attention, but research results are not great, maybe this can also be seen as elliptic curve cryptography has high strength evidence. The paper presents application of Elliptic Curve Cryptography in design security scheme for wireless sensor network. Therefore, most cryptographers of this cryptosystem are optimistic about the prospects. Currently, it has become a public key cryptosystem in research focus.

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