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Ministry of Electronics & Information Technology
Government of India

G20 भारत 2023 INDIA

IEEE COMPUTER SOCIETY Bangalore Chapter

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4TH INTERNATIONAL CONFERENCE ON

PUBLIC KEY INFRASTRUCTURE AND ITS APPLICATIONS (PKIA 2023)

SEPTEMBER 8-9TH, 2023

An ECC based Anonymous Authentication Protocol for Internet of Things

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Outline

- Introduction
- IoT Security
- Elliptic Curve Cryptography
- Proposed Authentication Protocol
- Security and comparative analysis
- Conclusion

Introduction

- Advancement of wireless communication and information technologies has resulted in a rapid development of the Internet of Things (IoTs).
- In IoT devices all data is transferred through a network between sensing devices, remote users and up to cloud storages.
- The rapid growth in the number of IoTs devices, the heterogeneity and complexity of networks have made authentication has a challenging task.
- The simple and low cost nature of IoT devices makes them an attractive target for spoofing or impersonation attacks.
- There are malicious attacks also possible such as impersonation, replay, denial of service, and man-in-the-middle attack.

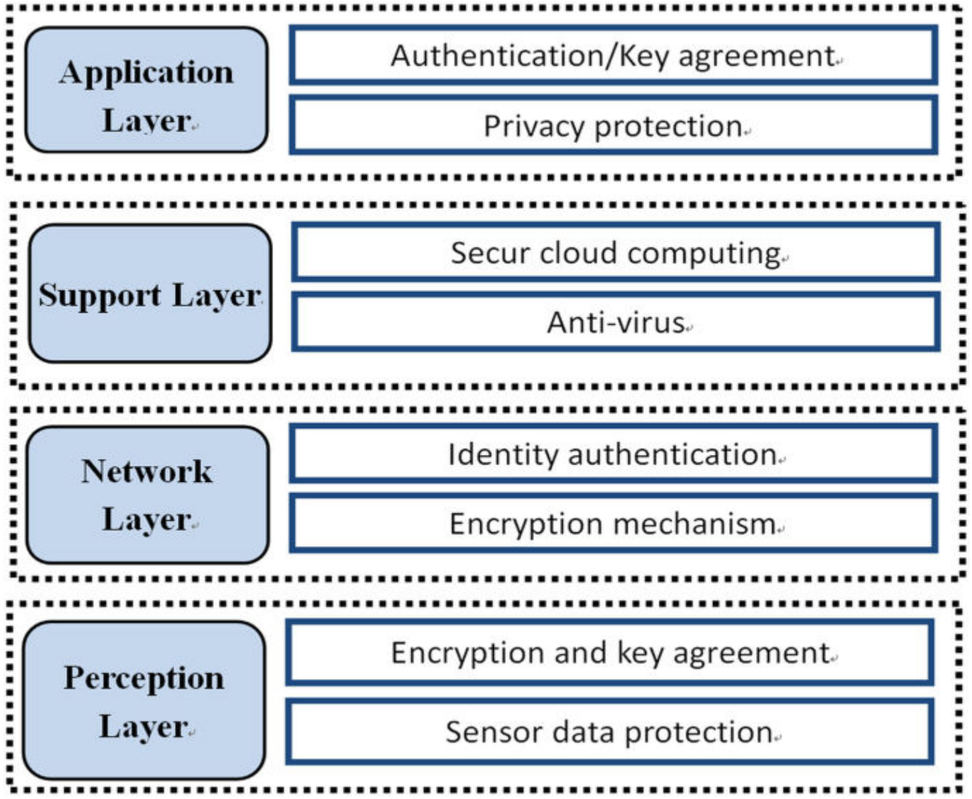
Motivation and contribution

- An efficient, secure, and lightweight remote-user authentication-based solution for an IoT environment is necessary.

- Mutual authentication is considered as a key element for successfully accessing various IoT services when it comes to network privacy and security.

- To address this, we propose to design an ECC based anonymous authenticated protocol for internet of things that enables the mutual authentication between users and gateway device.

- The proposed protocol ensures the confidentiality of identity by revealing it exclusively to the server for authentication. No adversary can find the user identity.



IoT Security Architecture

Elliptic curve cryptography-ECC

- The security of ECC is based on the difficulty of the elliptic curve discrete logarithm problem (ECDLP). The ECDLP is to find k for given values of P and Q in the equation Q = kP. Finding the value of k is hard problem.
- ECC based on elliptic curves and requires smaller keys compared to non-elliptic curves cryptography like RSA.
- An elliptic curve E_{Fp}over a finite field $F_p$is defined as the set of all $(x,y) \in F_p$such that $y^2 = x^3 + ax + b$, where $a,b \in F_p$and $4a^3 + 27b^2 \neq 0$, along with a distinguished point at infinity which is denoted by O.

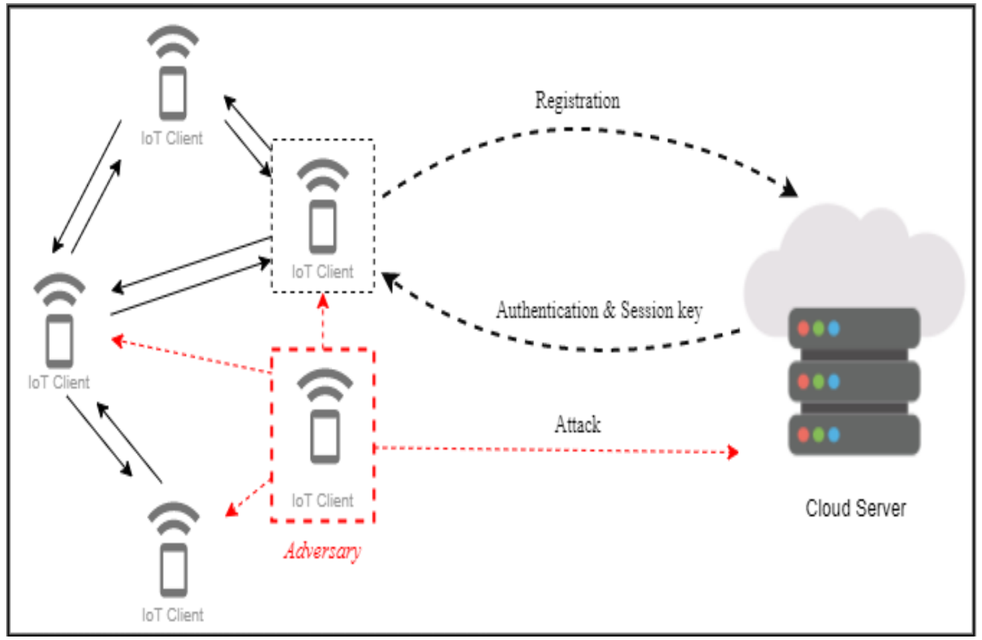
ECC selection criteria

- *Smaller Key Sizes: ECC keys are much shorter than RSA or DSA keys of equivalent strength.*
- *Faster Encryption and Decryption: ECC algorithms are faster than RSA and DSA algorithms.*
- *Lower Power Consumption: it can help to extend battery life on mobile and IoT devices.*
- *Bandwidth Efficiency: Smaller key sizes also mean that less data needs to be transmitted over the network*

Proposed Authentication Protocol

1. System Model

- The IoT environment scenario consists of two communication parties server S and the IoT device D trying to communicate with authentication in the network.
- An Adversary A with defined capabilities(Dolev-Yaos model) in the IoT network having the access of the communication in the network.



IoT network Scenario

- The server S having enough resources is responsible for allowing genuine device for communication.
- If user wants to communicate with server , it must pass the authentication process.
- The S sends a challenge message to the IoT device , then it authenticated by S and generates a session key once it receives the challenge message. Both S and device D eventually agreed on a shared session key.

Proposed Authentication protocol Construction

The protocol is carried out in three phases:

Registration phase:

- *At the first step of this phase ,a random nonce ns is selected by server(S) as its private key and calculates the curve point G_s as $G_s = n_s G$.*
- *The server selects the random number nd for every device D_i that request to register on server and verifies with $R_d = n_d G$.*
- *The corresponding values R_d,n_d for each device D_i are stored in the database.*
- *Each device stores G_s value in the memory*

Algorithm 2 REGISTRATION

Server (S)	**Device** (D_i)
1: Server generates randomly n_s (Secret Key)	
2: Calculate the curve point $G_s \ni G_s = n_s \times G$	
	3: D_i randomly generates r_i
	4: Compute $ID_i = r_i \times D_i$
	5: Send $\langle ID_i \rangle$ to Server S
6: Choose Random n_d *for each* $D_i \ni 1 \leq d \leq i$	
7: Compute $R_d = n_d \times G$; $1 \leq d \leq i$	
8: Stores $(n_s, G_s, n_d, R_d,)$	
9: Send $\langle G_s, n_d, R_d \rangle$ to each D_i	
	10: Stores (G_s, n_d, R_d)

Construction-Contd...

Login phase:

The authentication phase requires Message exchanges and computations between the device and the server as described in the following steps:

- *To begin the authentication process, the device D_i generates a random number ri and computes its identity as $ID_i = (r_i \oplus D_i)$ sends a request to the server as < Req; ID_i >.*

Algorithm 3 LOGIN

Server (S)	**Device** (D_i)
	1: Send $\langle ID_i \rangle$ to Server S
2: S retrieves respective n_d & R_d	
3: S randomly chooses n_1	
4: Compute $R_1 = n_1 \times G$	
5: Compute $R_1{}' = n_s \times R_1$ $\quad \therefore R_1{}' = n_1 \times n_s \times G$	
6: Send $\langle R_1{}' \rangle$ to D_i	

Construction-Contd...

Authentication phase:

Algorithm 4 AUTHENTICATION

Server (S)	Device (D_i)
	1: D_i randomly generates n_2
	2: Compute $R_2 = n_2 \times G$
	3: Compute $R_3 = n_2 \times R_1{}'$
	4: Compute $R_4 = n_2 \times R_d$
	5: Compute Authentication Parameter $V = H(R_3 + R_4)$
	6: Send $\langle V, R_2 \rangle$ to Server S
7: Compute $V' = H(n_1 \times n_s \times R_2 + n_d \times R_2)$	
8: **if** $V == V'$ **then**	
9: Authentication Successful	
10: S randomly selects n_3	
11: Compute $R_5 = n_3 \times G$	
12: Compute $V_1 = H(n_3 \times R_d)$	
13: Compute $SK = H(R_2 \times n_3 \|\| R_d)$	
14: Send $\langle V_1, R_5 \rangle$ to D_i	
15: **else**	
16: Authentication Failed	
17: **end if**	
	18: Compute $V_1{}' = H(n_d \times R_5)$
	19: **if** $V_1 == V_1{}'$ **then**
	20: Authentication Successful
	21: $SK' = H(R_2 \times n_3 \|\| R_d)$
	22: **else**
	23: Authentication Failed
	24: **end if**

Verification Proof

Server side Verification

$V' = H(n_1 \times n_s \times R_2 + n_d \times R_2)$

$V' = H(n_1 \times n_s \times n_2 \times G + n_d \times n_2 \times G)$

$V' = H(n_2 \times R_1' + n_2 \times R_d) \quad \because R_1' = n_s \times n_1 \times G \quad \because R_d = n_d \times G$

$V' = H(R_3 + R_4) = V$

$\therefore V' = V$

Device side Verification

$V_1' = H(n_d \times R_5)$

$V_1' = H(n_d \times n_3 \times G) \quad \because R_5 = n_3 \times G$

$V_1' = H(n_3 \times R_d) = V_1 \quad \because R_d = n_d \times G$

$\therefore V_1' = V_1$

Session Key Verification

$SK' = H(R_2 \times n_3 \,||\, R_d) = SK$

$\therefore SK' = SK$

Security and Comparative analysis

- *The security level of existing ECC-based authentication protocols are analyzed and Understood that most of the existing protocols are vulnerable to the trace ability attack.*

- *The robustness of the proposed protocol is evaluated based on formal analysis method using widely accepted approaches based on AVISPA tool.*

Scheme	Method	P1	P2	P3	P4	P5
Liao and Hsiao [2]	ECC	X	✓	X	X	X
KS [4]	ECC+Hash	X	X	X	X	X
CWS [7]	ECC+Hash	✓	✓	X	✓	X
KKD [32]	ECC+Hash	X	✓	X	✓	X
WCF [25]	ECC+Hash	X	✓	✓	✓	X
T.M.Butt[23]	ECC+Hash	✓	X	X	X	X
Our method	**ECC+Hash**	✓	✓	✓	✓	✓

P1-MIM attack,P2-Replay attack,P3-Impersonation attack,
P4-Message Integrity attack, P5-Traceability attack.
✓- Resistant, X - Non-resistant.

Conclusion and Future work

- *The ECC based authentication is considered for protocol due to its less memory requirements and computational power, eventually suitable for IoT environment.*

- *We proposed a authentication protocol and the security analysis demonstrates that the proposed protocol is provably secure and meets the requirements for security in an IoT environment.*

- *Our future plan is work on lightweight authenticated key agreement protocol for IoT environments.*

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