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Secure access of multiple keywords over encrypted data in cloud environment using ECC-PKI and ECC ElGamal

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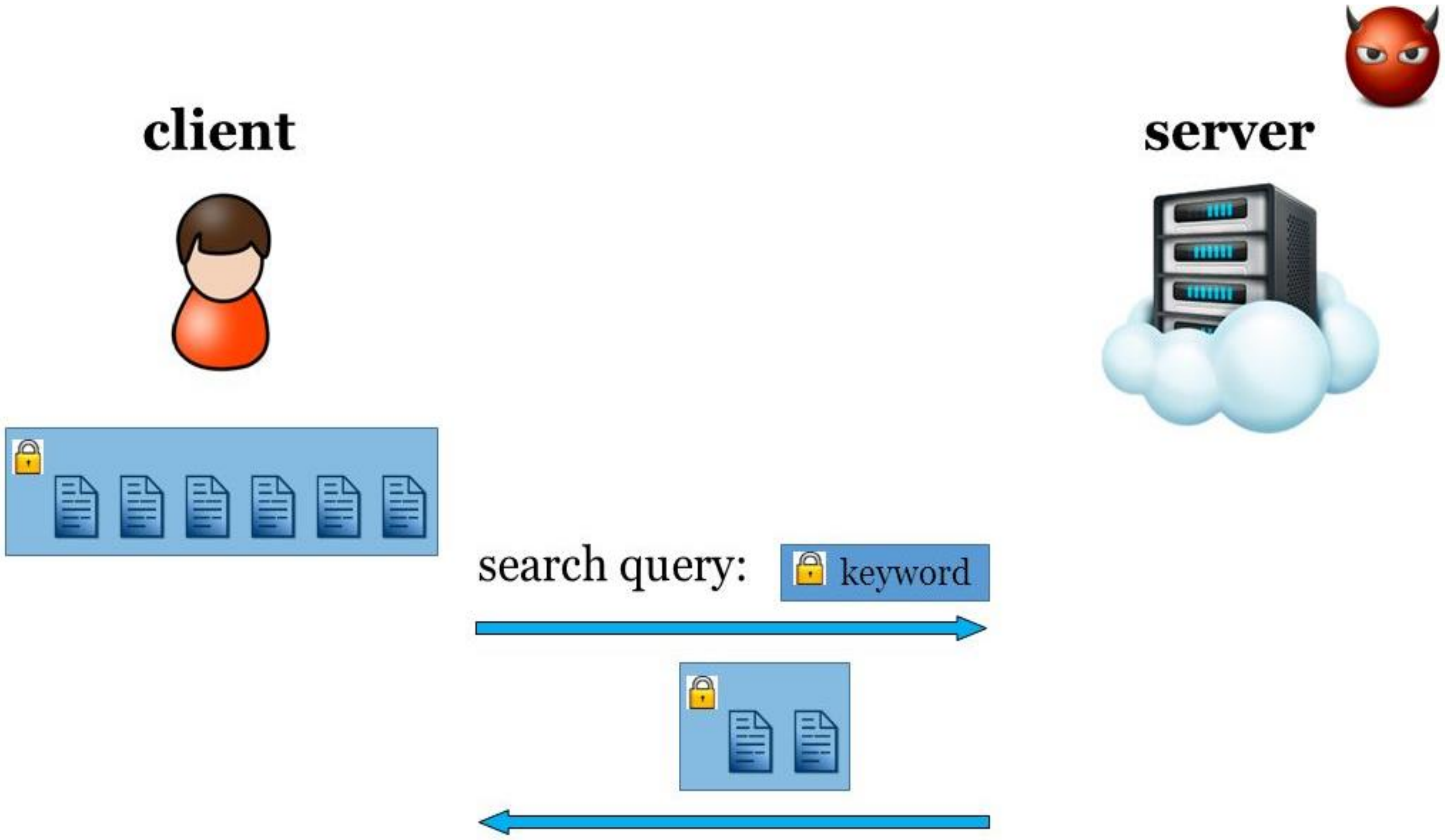
Data Outsourcing over Cloud

Searchable Encryption



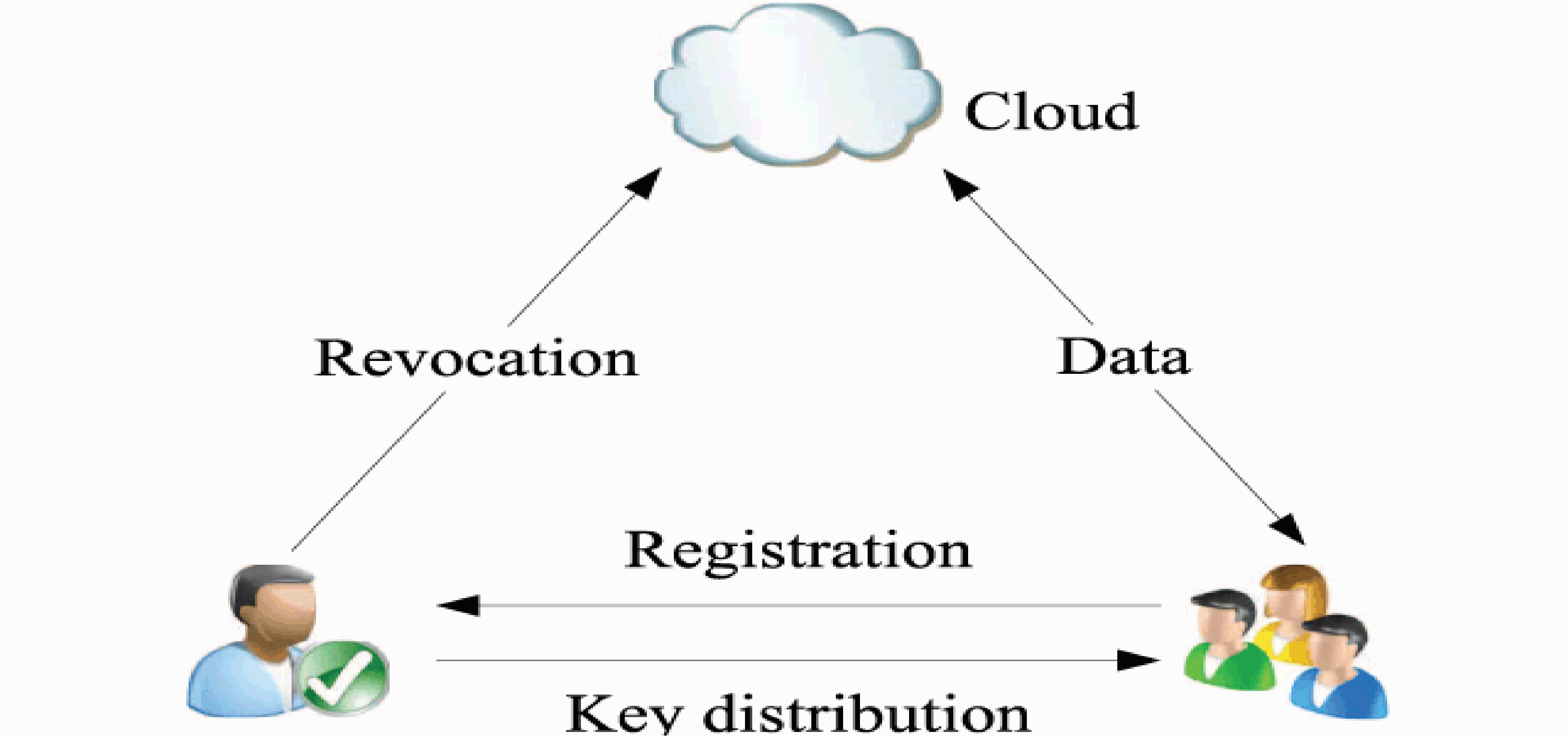
Background: Searchable Encryption

- The searching and responding process of searchable encryption takes place over the encrypted data set and indexes. Performing such process over encrypted data set is constantly complex and harder as compared to normal data set.
- Therefore, the need for effective and secure searchable encryption became a major research problem, and improvement in the existing searchable encryption scheme is still a growing task for the research community.
- Usually, a data user prefers to request for a set of keywords, which actually leads to a more precise closer relation to expected data. More keywords in query help to narrow down the results more accurate.

Background: Searchable Encryption..

- Despite remarkable development in the area of searchable encryption, few unsolved issues are noticeable when deployed to the cloud environment.
- First, keyword privacy and file content privacy both are equally important in searchable encryption.
- Second, honest but curious cloud server or such adversaries can still breach privacy in a scheme which does not have high robustness against the similarity relevance of terms and files.
- Third, traditional public key based schemes have its own computational complexities and limitations that require a serious reconsideration to use. We propose a scheme to overcome the above-mentioned problems.

Key functionaries



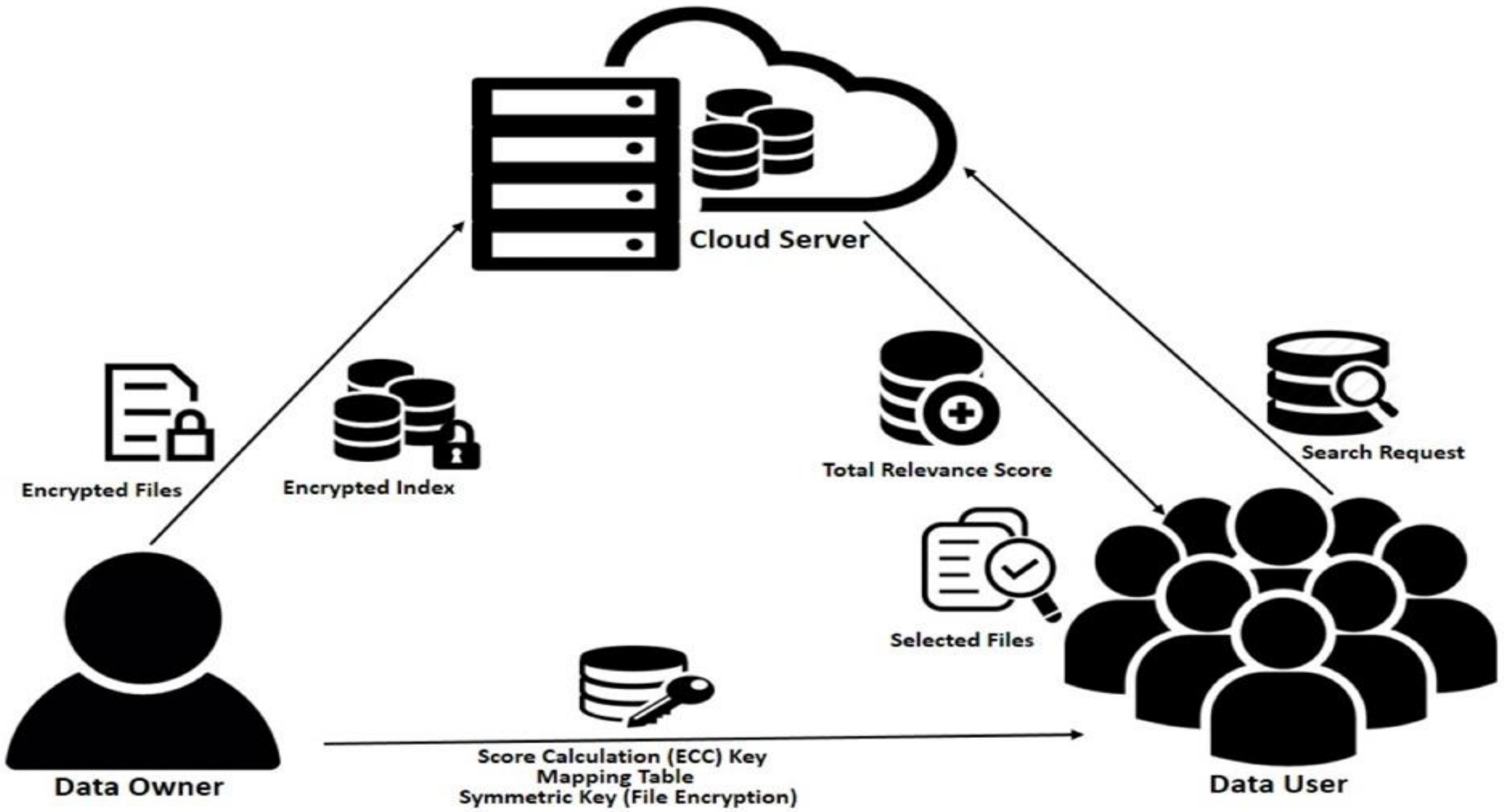
Data Owner

Data User

Basic Consideration

- Design Goal
- Threat Model
- Scoring

Proposed System model



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ECEG and Homomorphism

- Algorithms mentioned here are inspired by standard elliptic curve based ElGamal encryption and decryption algorithms

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Algorithm 1 Algorithm for Message Encoding to the Point over Elliptic Curve E

Input : (m, G)

m: Plain Text Message value

G: The Generator Point of curve E

Output : (P_m)

P_m: Point representation of message m over curve E

Step 1: Initially get the message value m and generator point G

Step 2: Compute the multiplication of message value m with the generator point G;

$P_m = mG$, Where $m \in ZF(p)$

The resultant point P_m ; $P_m \in E$ is corresponding message encoded over that curve E.

Algorithm 2 Elliptic Curve Based ElGamal (ECEG) Encryption

Input : (P_k, P_m)

P_k: Public Key $P_k \in E$

P_m: The Encoded Message

Output : $P_c(C_1, C_2)$

P_c: is a cipher text pair $P_c \in E$

Step 1: Initially selects a random integer $r \in [1, n-1]$, n is order of curve E , $n \bigcirc E$.

Step 2: Compute $C_1 = rG$

Step 3: Encrypt message point with the public key $C_2 = P_m + rP_k$

Step 4: Return $P_c(C_1, C_2)$, is associated cipher-text pair.

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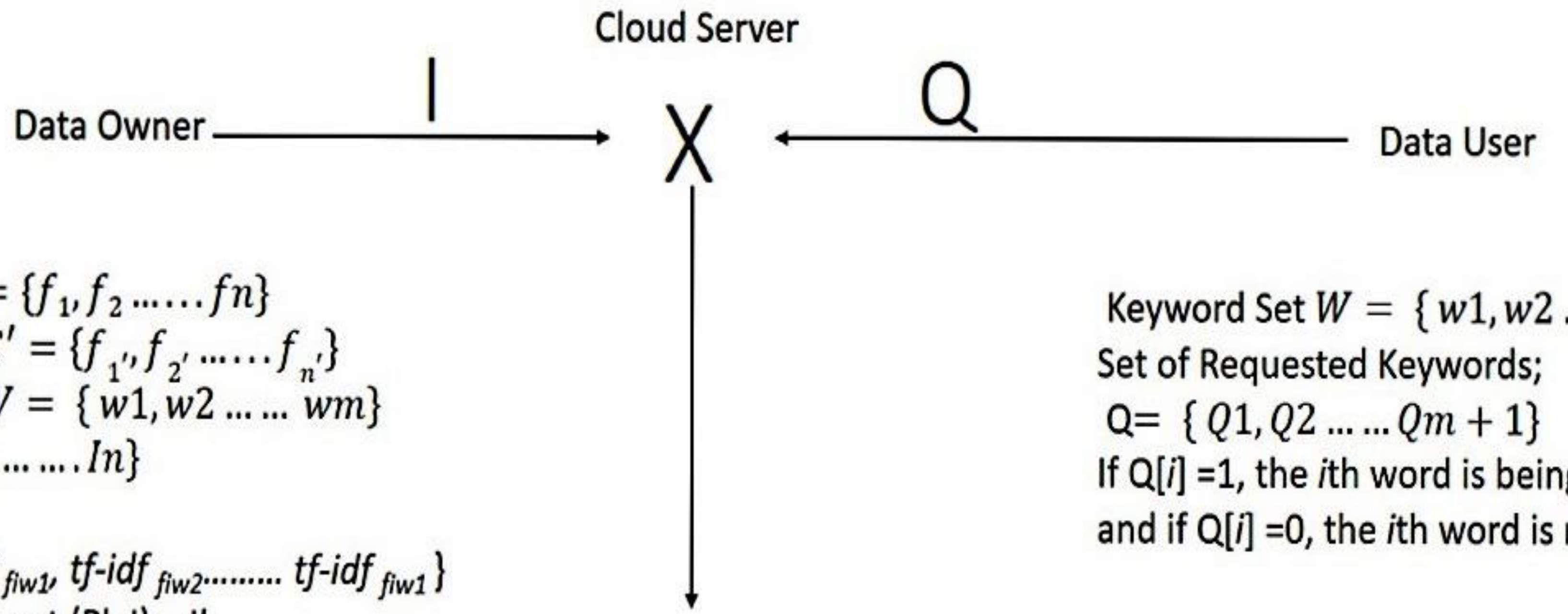
System Scheme



Set of files $C = \{f_1, f_2 \ldots\ldots fn\}$
Encrypted C; $C' = \{f_{1'}, f_{2'} \ldots\ldots f_{n'}\}$
Keyword Set $W = \{w1, w2 \ldots\ldots wm\}$
Index $I = \{Ii, \ldots\ldots In\}$
Where,
Ii= { FIDi, tf-idf $_{fiw1}$, *tf-idf* $_{fiw2}$……… *tf-idf* $_{fiw1}$ }
Encrypted Encrypt (Pk,I) = I'

Keyword Set $W = \{w1, w2 \ldots\ldots wm\}$
Set of Requested Keywords;
Q= $\{Q1, Q2 \ldots\ldots Qm + 1\}$
If Q[*i*] =1, the *i*th word is being requested;
and if Q[*i*] =0, the *i*th word is not requested.

$$S = I'.Q$$

$$S = \{(FID1, r1)\ (FID2, r2)\ \ldots\ldots\ldots\ldots\ (FIDn, rn)\}$$

Where, $ri = r_{fiQ} = Ii.Q$

Proof of Additive Homomorphism

- lets consider there are two (2) keywords requested, and for a file score of w_1 is encoded to point Pm_1, and w_2 is to corresponding point Pm_2.
- The encryption of Pm_1 and Pm_2 returns cipher-text Pc_1 and Pc_2.

Where;

$Encrypt(p_k, Pm_1) = Pc_1(C_{1a}, C_{1b})$

$Encrypt(p_k, Pm_2) = Pc_2(C_{2a}, C_{2b})$

Where:

$C_{1a} = r_1 G$

$C_{1b} = Pm_1 + r_1 P_k$

$C_{2a} = r_2 G$

$C_{2b} = Pm_2 + r_2 P_k$

For additive homomorphism:

$Decrypt(Pc_1 + Pc_2) = Pm_1 + Pm_2$

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Proof of Additive Homomorphism Contd..

Proof:

$Pc_1 + Pc_2 = (C_{1a}, C_{1b}) + (C_{2a}, C_{2b})$

$= (r_1 G, Pm_1 + r_1 P_k) + (r_2 G + Pm_2 + r_2 P_k)$

Where, r_1 and r_2 are random number generated for corresponding message encryption, in Algorithm 2.

$= (r_1 G + r_2 G), (Pm_1 + r_1 P_k + Pm_2 + r_2 P_k)$

$= (r_1 + r_2)G, (Pm_1 + Pm_2) + (r_1 + r_2)P_k$

$Decrypt(Pc_1 + Pc_2)$:

Take $(r_1 + r_2)G$, multiply it with Private key k

$= (r_1 + r_2)G_k$

Add inverse of $(r_1 + r_2)G_k$ with $(Pm_1 + Pm_2) + (r_1 + r_2)P_k$

$= -(r_1 + r_2)G_k + (Pm_1 + Pm_2) + (r_1 + r_2)P_k$

From KeyGen(k, P_k) we know Public Key $P_k = k_G$

$= Pm_1 + Pm_2$

Here Proved:

$Decrypt(Pc_1 + Pc_2) = Pm_1 + Pm_2$

Conclusion and Future Scope

- In this paper, we tried to solve the issues of multi-keyword search over encrypted data.
- We aim to develop a scheme which should provide the correctness of results while maintaining the query and data privacy.
- We attained it by using Elliptic curve based ECEG algorithm. This scheme offers benefits of additive homomorphism together with an ECC level of security.
- Because of ECC and binary query vector used in the scheme, this fits suitable for the devices with limited computational capacity.
- This scheme opens up scope for lots of future work, as ECEG is used the very first time for this purpose.

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Thank You