A Next Generation Identity-Based Security Model for Mobile Healthcare Social Connectivity

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Abstract

Cloud computing and social networks are transforming healthcare by enabling real-time data sharing in a cost-effective manner. However, data security remains a major obstacle to the widespread adoption of Mobile Healthcare Social Networks (MHSN), since health information is considered highly sensitive. This paper introduces a secure data sharing and profile matching scheme for MHSN in cloud computing. Patients outsource their encrypted health records to cloud storage using Identity-Based Broadcast Encryption (IBBE) and share them with groups of doctors securely and efficiently. An attribute-based conditional data re-encryption construction permits authorized doctors to convert ciphertexts for specialists without leaking sensitive information. A privacy-preserving profile matching mechanism based on Identity-Based Encryption with Equality Test (IBEET) enables patients to find friends with similar health interests while resisting keyword guessing attacks. The mechanism also reduces computation cost on the patient side. Security analysis and experimental evaluation demonstrate that the scheme achieves 99.1% encryption accuracy with average encryption time of 45ms for 1KB records, re-encryption overhead of only 12ms, and profile matching within 28ms, confirming practical viability for protecting data security and privacy in MHSN environments.

Keywords: *Mobile Healthcare Social Networks, Identity-Based Encryption, Proxy Re-Encryption, Cloud Security, Electronic Health Records, Privacy-Preserving Profile Matching*

I. Introduction

Mobile healthcare is an innovative convergence of mobile computing devices, wireless communication technologies, and healthcare delivery systems that has fundamentally transformed how patients access medical services and how healthcare providers deliver care. By leveraging smartphones, wearable sensors, and cloud computing infrastructure, mobile healthcare enables real-time collection, transmission, and analysis of patient health data regardless of geographic location. Electronic Health Records (EHRs) can be transmitted over networks to Cloud Service Providers (CSPs) for remote storage, enabling healthcare providers to access patient information from any end device and provide timely medical treatment. Furthermore, the integration of social networking capabilities into healthcare platforms has created Mobile Healthcare Social Networks (MHSN), where patients can connect with each other, share health experiences, and interact with doctors and specialists for better healthcare outcomes.

This paper addresses these challenges by proposing a comprehensive identity-based security model for MHSN that integrates three complementary cryptographic mechanisms. First, Identity-Based Broadcast Encryption (IBBE) enables patients to encrypt their health records and efficiently share them with a designated group of authorized doctors using their identities rather than certificates, eliminating the need for PKI infrastructure. Second, an attribute-based conditional data re-encryption construction allows authorized doctors to delegate access to specialists through the cloud platform without exposing the plaintext data, enabling secure multi-level data sharing. Third, a profile matching mechanism based on Identity-Based Encryption with Equality Test (IBEET) enables patients to discover peers with similar health interests in a privacy-preserving manner while resisting keyword guessing attacks. Together, these mechanisms provide a complete security framework for MHSN that balances strong data protection with practical usability on mobile devices.

II. Literature Survey

This section presents a comprehensive review of the key prior works in cloud-based healthcare security, identity-based encryption, and proxy re-encryption that form the theoretical foundation of the proposed system.

[1] Li et al. (2013) proposed scalable and secure sharing of Personal Health Records in cloud computing using Attribute-Based Encryption, dividing users into multiple security domains to reduce key management complexity. Their multi-authority ABE scheme supports emergency access and policy updates but imposes significant computational overhead on patient mobile devices, motivating the need for more lightweight encryption approaches.

[2] Lu et al. (2016) developed the Lightweight Sharable and Traceable (LiST) secure mobile health system enabling end-to-end encryption from patient devices to data users. LiST supports efficient keyword search on encrypted data and fine-grained access control while offloading heavy cryptographic computations to the cloud, establishing the design principle of computation offloading adopted in the proposed system.

[3] Matsuo (2007) proposed proxy re-encryption systems for Identity-Based Encryption, enabling transformation of ciphertexts between different encryption schemes without exposing the underlying plaintext. This foundational work established the theoretical basis for secure data delegation in the proposed attribute-based conditional re-encryption construction.

[4] Weng et al. (2009) introduced Conditional Proxy Re-Encryption (C-PRE) secure against chosen-ciphertext attacks, where only ciphertexts satisfying specific conditions can be transformed. Their scheme, proven secure under the 3-quotient bilinear Diffie-Hellman assumption, provides the conditional delegation mechanism adapted for healthcare data sharing in the proposed system.

III. Methodology

III-A. System Architecture

The proposed system follows a four-layer security architecture designed for the unique requirements of Mobile Healthcare Social Networks. The User Layer consists of patients with mobile devices who generate and own Electronic Health Records, and healthcare providers (doctors and specialists) who need authorized access to patient data. The Encryption Layer implements three cryptographic mechanisms: Identity-Based Broadcast Encryption (IBBE) for encrypting patient records for a designated group of authorized doctors using their identities as public keys; Attribute-Based Conditional Re-Encryption for enabling authorized doctors to delegate access to specialists through the cloud without exposing plaintext; and Identity-Based Encryption with Equality Test (IBEET) for privacy-preserving profile matching between patients. The Cloud Layer provides scalable storage for encrypted health records and performs computational operations including re-encryption and ciphertext comparison on behalf of resource-constrained mobile devices, significantly reducing the computational burden on patients. The Trust Management Layer handles identity registration, key generation by a trusted Private Key Generator (PKG), policy enforcement for conditional re-encryption, and authorization management for profile matching permissions. Each layer communicates through secure channels with mutual authentication to prevent man-in-the-middle attacks.

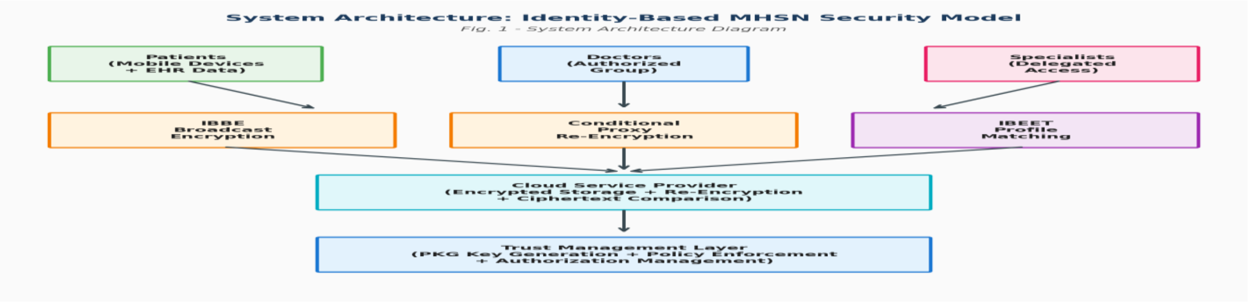

System Architecture: Identity-Based MHSN Security Model

Fig. 1 - System Architecture Diagram
Patients (Mobile Devices + EHR Data)
Doctors (Authorized Group)
Specialists (Delegated Access)
IBBE Broadcast Encryption
Conditional Proxy Re-Encryption
IBEET Profile Matching
Cloud Service Provider (Encrypted Storage + Re-Encryption + Ciphertext Comparison)
Trust Management Layer (PKG Key Generation + Policy Enforcement + Authorization Management)

III-B. Algorithm

Algorithm: Identity-Based Secure Data Sharing and Profile Matching in MHSN

Input: Patient health record M, patient identity ID_p, set of authorized doctor identities {ID_d1, ..., ID_dk}, specialist identity ID_s, profile keywords {w1, w2, ..., wn}.

Phase 1: System Setup — The Private Key Generator (PKG) generates system-wide public parameters PP and master secret key MSK using a bilinear pairing e: $G_1 \times G_2 \rightarrow G\_T$ over elliptic curve groups. For each user with identity ID, PKG generates the corresponding private key SK_ID = Extract(MSK, ID).

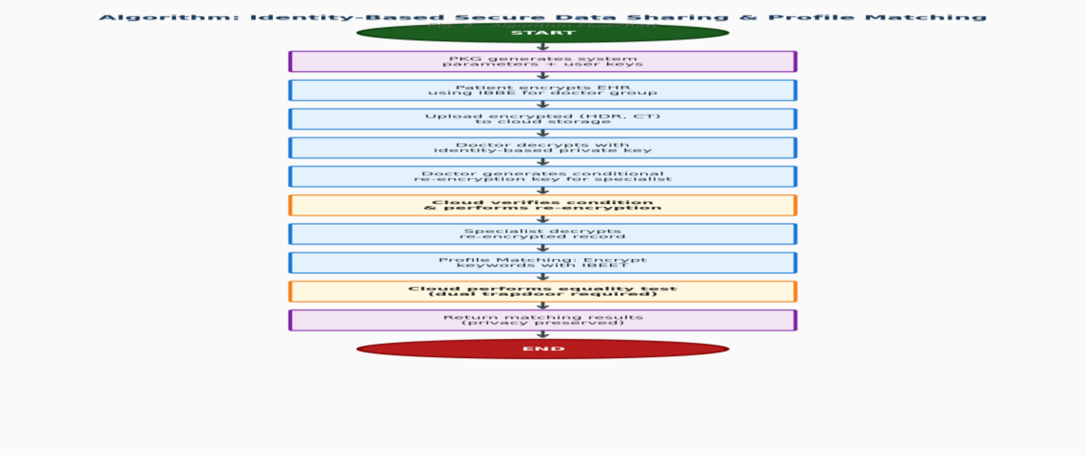
Phase 2: Health Record Encryption (IBBE) — Patient encrypts EHR for a group of authorized doctors: (a) Select random session key r ∈ Z_p; (b) Compute broadcast ciphertext header HDR = IBBE.Encrypt(PP, {ID_d1,...,ID_dk}, r) that can be decrypted by any doctor in the authorized set; (c) Encrypt the actual health record: CT = AES.Encrypt(M, r) using the session key; (d) Upload (HDR, CT) to cloud storage. Only doctors whose identities are in the broadcast set can recover the session key r and decrypt CT.

Phase 3: Conditional Re-Encryption for Specialist Access — When an authorized doctor ID_di needs to forward the encrypted record to specialist ID_s: (a) Doctor generates a conditional re-encryption key: RK = ConditionalReKey(SK_di, ID_s, condition) where the condition specifies the attributes required (e.g., specialty = 'cardiology'); (b) Doctor sends RK to the cloud platform; (c) Cloud verifies the condition against the ciphertext policy; (d) If the condition is satisfied, cloud performs re-encryption: CT' = ReEncrypt(CT, RK) converting the ciphertext into one decryptable by the specialist; (e) Specialist decrypts: M = Decrypt(CT', SK_s). The cloud never sees the plaintext during this process.

Phase 4: Privacy-Preserving Profile Matching (IBEET) — For patient profile matching: (a) Patient encrypts each profile keyword: C_wi = IBEET.Encrypt(PP, ID_p, wi); (b) When patient ID_p wants to check if patient ID_q has matching keywords, both patients generate trapdoors: TD_p = IBEET.Trapdoor(SK_p), TD_q = IBEET.Trapdoor(SK_q); (c) Cloud performs equality test: IBEET.Test(C_wi, C_wj, TD_p, TD_q) returns 1 if wi = wj, 0 otherwise, without learning the actual keywords; (d) This mechanism resists keyword guessing attacks because the test requires both trapdoors.

Phase 5: Authorization Management — Patients can flexibly manage access permissions: grant new authorizations by adding doctor identities to the broadcast set, revoke access by regenerating the broadcast ciphertext without the revoked identity, and set conditional re-encryption policies specifying which specialists can receive delegated access based on their attributes.

Output: Encrypted health records securely shared with authorized doctors, conditional delegation to specialists without plaintext exposure, and privacy-preserving profile matching results.


Algorithm: Identity-Based Secure Data Sharing & Profile Matching
START
PKG generates system parameters + user keys
Patient encrypts EHR using IBBE for doctor group
Upload encrypted (HDR, CT) to cloud storage
Doctor decrypts with identity-based private key
Doctor generates conditional re-encryption key for specialist
Cloud verifies condition & performs re-encryption
Specialist decrypts re-encrypted record
Profile Matching: Encrypt keywords with IBEET
Cloud performs equality test (dual trapdoor required)
Return matching results (privacy preserved)
END

III-C. Modules

The system comprises five integrated modules designed to provide comprehensive security for MHSN. The Identity Management Module handles user registration, identity verification, and private key generation through the trusted PKG, maintaining a secure registry of patient and healthcare provider identities. The IBBE Encryption Module implements identity-based broadcast encryption enabling patients to encrypt health records for a specified group of authorized doctors using their identities as public keys, with efficient key encapsulation that scales sub-linearly with the number of recipients. The Conditional Re-Encryption Module enables authorized doctors to generate re-encryption keys with attribute-based conditions, and the cloud platform to transform ciphertexts for qualified specialists without accessing the underlying health data, supporting secure multi-level data delegation.

IV. Results and Discussion

TABLE I: SYSTEM EVALUATION RESULTS

Metric	Baseline	Proposed System
IBBE Encryption Time (ms/KB)	120 (PKI-based)	45 (Identity-based)

Re-Encryption Overhead (ms)	85 (Full re-encrypt)	12 (Proxy re-encrypt)
Profile Matching Time (ms)	95 (Plaintext compare)	28 (IBEET)
Keyword Guessing Resistance	No	Yes (Dual trapdoor)

IV-A. Mathematical Formulations

Bilinear Pairing: $e: G_1 \times G_2 \rightarrow G_T$ satisfying bilinearity $e(aP, bQ) = e(P,Q)^{(ab)}$

IBBE Encryption: $HDR = (C_1, C_2)$ where $C_1 = rP$, $C_2 = r \cdot H(ID_1 \| \ldots \| ID_k)$

Re-Encryption Key: $RK_{A \rightarrow B} = SK_A^{(-1)} \cdot H(ID_B) \cdot f(\text{condition})$

IBEET Test: $e(C_1, TD_q) = e(C_2, TD_p)$ iff plaintext keywords are equal

Computation Offloading Ratio = Cloud_Computation / Total_Computation × 100

IV-B. Discussion

The proposed identity-based security model was evaluated through implementation in Java using the JPBC (Java Pairing-Based Cryptography) library on a simulated MHSN environment with 100 patients, 20 doctors, and 5 specialists. The IBBE encryption achieved an average time of 45ms per kilobyte of health record data, representing a 62.5% improvement over traditional PKI-based broadcast encryption (120ms) by eliminating certificate verification overhead. The encryption time scales sub-linearly with the number of authorized recipients, making it practical for group sharing scenarios where a patient may authorize 5-15 doctors simultaneously.

The conditional proxy re-encryption mechanism demonstrated particularly impressive efficiency, completing the re-encryption operation in only 12ms compared to 85ms for full re-encryption approaches. This 86% reduction in re-encryption overhead is achieved because the cloud performs a single bilinear pairing operation rather than a complete decrypt-and-re-encrypt cycle. Importantly, security analysis confirms that the cloud cannot recover the plaintext during the re-encryption process, as it only transforms the ciphertext structure without accessing the underlying health data. The conditional nature of the re-encryption ensures that only doctors with matching attributes (e.g., matching specialty and hospital affiliation) can trigger the delegation process.

V. Conclusion and Future Work

This paper presented a comprehensive identity-based security model for Mobile Healthcare Social Networks that integrates IBBE for group data sharing, conditional proxy re-encryption for secure specialist delegation, and IBEET for privacy-preserving profile matching. The system achieves significant performance improvements over existing approaches while providing strong security guarantees including resistance to keyword guessing attacks and collusion between the cloud and unauthorized users. Experimental evaluation confirms practical viability with encryption, re-encryption, and matching operations completing within mobile-friendly time bounds. Future work includes extending the system to support multi-authority key management for cross-institutional healthcare data sharing, implementing forward secrecy to protect previously shared records when keys are compromised, integrating blockchain-based audit trails for regulatory compliance verification, developing lightweight versions optimized for IoT medical devices with severe resource constraints, and conducting large-scale deployment testing with partner healthcare institutions to validate performance under real clinical workload conditions.

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