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AN APPROACH TO DEPERSONALIZED IDENTITY, DECENTRALIZED PERSONAL DATA SHARING, AND PASSWORD MANAGEMENT WITH INTEGRATED CRYPTOCURRENCY WALLETS UTILIZING HIERARCHICAL DETERIMINISTIC TREES AND ELLIPTIC CURVE CRYPTOSYSTEMS

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Abstract

This identity ecosystem focuses on maintaining confidentiality using a cryptographic tree-based solution for key and password management. The advent of cryptocurrencies and the increased proliferation of PKE cryptosystems have increased the burden on consumers to manage secure data. In this paper we propose a novel solution for password and key management that incorporates cryptocurrency key pairs, providing the lowest possible number of potential attack vectors while maintaining consumer privacy. Presented is an infrastructure for secure, encrypted, sharing of user data which remains in the control of the issuer and, when combined with a unique implementation of depersonalization technology through hierarchical deterministic trees, provides the smallest possible profile in regard to cryptocurrency transaction data mining. This enables not only a level of increased privacy and security for the consumer and does so in a machine-readable context for the Internet of Things and smart contract applications.

Introduction

Each month seems to bring reports of a data breach of consumer information from a commercial source. While certain cryptocurrency and identity systems offer potential technological solutions, no implementation has been offered which employs these technologies with the experience of "Big Data" levels of behavioral and biostatistical analysis. Combining lessons learned in the healthcare IT field, where well-defined standards are set for biostatistical depersonalization, and the latest developments in elliptic curve cryptography and DSA technology, a novel solution can be derived which not only provides the security and privacy consumers demand but also leaves the consumer in sole control of which entities have access to specific pieces of their personal information. From this solution a truly cryptographically unique, depersonalized identity can be derived from which proof of ownership may be provided on demand.

While not yet in the public consciousness, the increased proliferation of blockchain technology makes such considerations a real and present privacy concern. The amount of data required to utilize cryptocurrency-to-fiat conversion services for the purposes of regulatory compliance is non-trivial, further complicated by the direct linkage to what is assumed to be a "pseudo-anonymous" settlement network. This represents a significant departure from the intended behavior of permissionless cryptocurrency networks and represents a potential threat to the privacy of future counterparties that does not exist in the majority of current fiat settlements. This methodology represents several fundamental changes in the way one considers how commercial entities access their personal information, and does so by providing a means to defeat very effective and popular biostatisitical analysis techniques that have been adapted for behavioral analysis in the Internet age, such as non-parametric inferential statistical analysis and propensity score matching. [1] Such analytical techniques may then be applied as an arbitrary means to discriminate financial services to individuals, limited only by regulatory compliance (if such regulation exists in a given jurisdiction).[2]

Furthermore, a successful solution should seek not to place further burden on, or attempt to fundamentally alter, established consumer and commercial behavior. A number of popular consumer-level security products have established a baseline for consumer expectations and the proposed methodology has been offered with such considerations in mind, such as cross-platform development and browser extension and plugin capability, and does so without creating additional vulnerabilities.

What has emerged is a future-proof and extremely straight forward solution which addresses the security and privacy concerns of both consumers and commercial entities. When one considers the scale of the Target data breach [3] with the publicly available data of the Bitcoin blockchain, and that Bitcoin conversion giant Coinbase at the time of this writing report a collective user base of over 2,900,000 individuals, [4] the problem is quite significant.

Related Work

Depersonalized identity (DI) draws its primary utility from the hierarchical deterministic traversable tree for the generation of public/private key pairs along an elliptic curve as described in Bitcoin Improvement Proposal #32. [5] Though this solution provides a convenient means for traversing public/private key pairs, it is not itself a sufficient identity solution. The application of the same process towards creating a structure for a provable identity suitable for commercial applications requires a protocol for negotiating key specifications between entities in various scenarios and a means for cryptographically secure data sharing. It has, however, demonstrated overall soundness of such a scheme in public code review and numerous successful commercial applications.

Provided a sufficient protocol for key specification exchange is established, the latter concerns are addressed in a means similar to BitTorrent or OpenBazaar: employing a distributed hash table (DHT) in a decentralized, peer-to-peer network for trustless, cloudbased storage of encrypted data. Through the unique implementation of the Kamedlia DHT by the Entangled Python project, information may be deleted from the cloud by network consensus upon request of the issuing authority. Further, a consumable distributed tuple space (DTS) is employed as a peer-to-peer encrypted messaging queue for DHT data operations.

Design

The assumptions and requirements are stated firstly, and in doing so is proposed a NOVEL DEPERSONALIZED IDENTITY SCHEME involving establishing a provably unique, analysis resistant, cryptographic identity and the provisioning of that identity into four distinct applications: personal data sharing, security authentication, website-specific identity management, and cryptocurrency wallets.

Definitions

Identity - A 128-bit string of system-generated entropy. [6] This entropy is used as the mathematical seed for the derivation of a hierarchical deterministic tree (HDT). To protect the HDT ecosystem, a passphrase is required for AES encryption of the entropy bits. 50,000 rounds of SHA-256 hashing are applied to the unencrypted entropy and the resulting first 6 bytes are used as a fingerprint.

Key Specification (“keyspec”) - The map to a particular public/private key. Within this system each keyspec consists of exactly six (6) branches, each branch selected as a random integer value between 0x000000 and 0xFFFFFF providing a provably unique deterministic public/private key pair for each required operation, a suitable universe for one-time use applications, and potential recovery of data if only an entropy is present.

Data Providing Entity (DPE) – The entity provisioning data for consumption, identified by public key.

Intended Consuming Entity (ICE) – Each data provision has an intended entity as the recipient, identified by public key.

Transaction Identity – A keyspec negotiated between the DPE and ICE. The DPE suggests a keyspec, the ICE accepts the keyspec if it is not already in use. If it is in use, the ICE suggests an alternative. The DPE may then accept the suggested keyspec, or reject it with their own suggestion. This process is repeated until a suitable keyspec is found.

Transaction – The provision or revocation of a single point of data by a DPE.

Transaction Set – A collection of transactions between a DPE and ICE. Each transaction set represents the interaction between one individual and one service provider.

1. **Identity specialization**
    - **a.** As each identity is itself a self-contained ecosystem of personal information, each identity may be employed within a specific use case to provide increased resistance to data analysis.
    - **b.** As such, login and transaction information associated with fiat conversions of cryptocurrencies can be separated from economic transactions to purchase goods and services with a single intermediate step (discussed later).
2. **Per-Transaction Set Addressing and Encryption**
    - **a.** Each transaction set involving a DPE and ICE requires per-set addressing for identification purposes. This is achieved through an implementation of the Bitcoin Base58 address system. The address prefix is altered from 0x00 to 0x3C to depart from the protocol and prevent confusion.
    - **b.** As a unique keyspec is negotiated, the PKE pair associated with that keyspec is used to encrypt all data between parties.
3. **Provable data integrity**
    - **a.** Data submitted to the DHT must be independently provable as unaltered by third parties. This is achieved through a transaction structure rendered as:
        - Network address derived from the public key of the ICE (Pb-ICE) for this transaction set.
        - Network address derived from the public key of the DPE (Pb-DPE) for this transaction set.
        - Binary blob of personal data encrypted with Pb-ICE
        - A creation timestamp
        - Recoverable Schnorr signature of DPE (Ss-DPE), which signs binary blob, ICE address, and timestamp.
        - A hash value which is a Merkle root derived from the SHA256 hash values of the previous five values
    - **b.** Prior to consumption, data is validated by matching the Merkle root derived from the collected data. A public key is recovered from the Schnorr signature from which a network address is generated. This address is compared to the Pb-DPE address as origin validation.
    - **c.** The first six bytes of the Merkle root may serve as a data fingerprint.
4. **Provision unique contact information per website**
    - **a.** A simple SMTP relay service will relay email messages sent to a Base58 network address derived from a transaction set keyspec to an address specified by the user.
5. **ECDSA-based authentication**
    - **a.** A negotiated keyspec may then be used as ECDSA-based authentication.
        - **i.** A user requests a login to a website with which a keyspec was previously negotiated.
        - **ii.** The website presents the user with a simple plain English passphrase.

iii. The user signs the passphrase with the PKE pair indicated by the negotiated keyspec and presents the signature to the website.

iv. The website recovers the public key, converts it to a Base58 network address, and compares it to the registration information. Message content is then validated and should both results return a positive result, the user is authenticated.

v. OAuth 1 and OAuth 2 authentication can then be supported, where the user is presented the opportunity to provision data on an as-needed basis and easily integrated into existing authentication systems.

6. **HDT-based cryptocurrency wallets**

a. Each identity may employ a virtually unlimited number of cryptocurrency wallets.

i. A keyspec is selected as the "wallet root".

ii. Additional addresses are generated on demand from the wallet root from its own HDT.

iii. Only the keyspec is stored on disk.

iv. Cryptocurrency wallets can be exported in WIF format for import into other clients.

Implementation

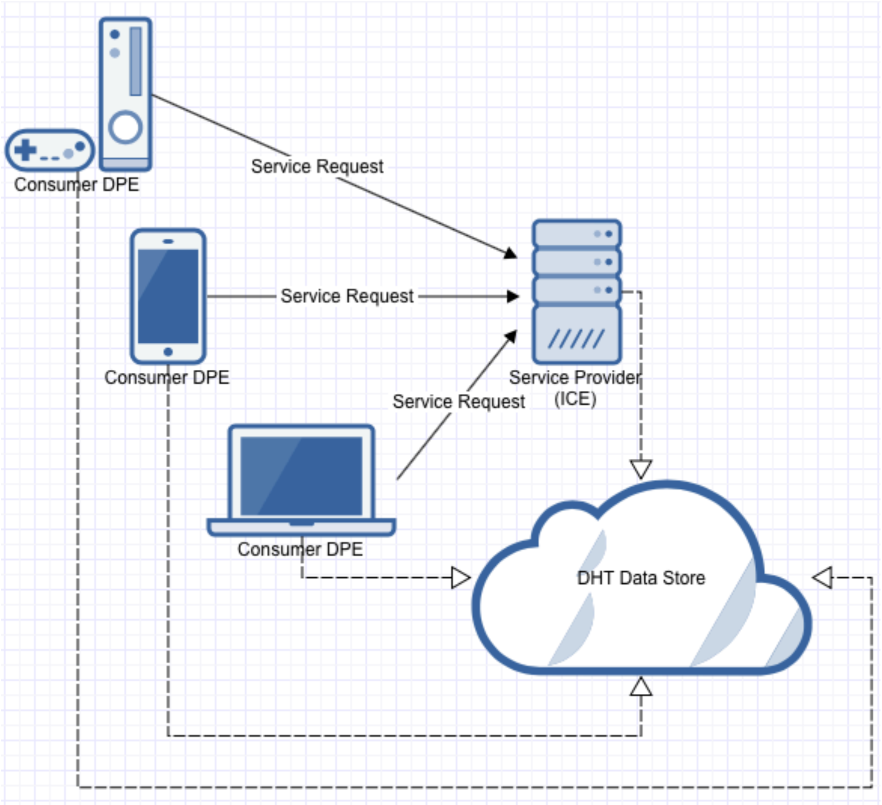


FIGURE 1 - PLATFORM INDEPENDENT SECURE INFORMATION PROVISIONING

The implementation of the described platform independent network topography is presented in Figure 1. The DHT data store is maintained by a peer-to-peer network consisting of ICE service providers.

Conclusion

As blockchain and IoT technology evolves, the need for tools which provide a consistent level of information security and privacy become paramount. The flexibility of the cryptosystems employed in blockchain technology can be effectively repurposed to provide for entirely new paradigms of personal data privacy.

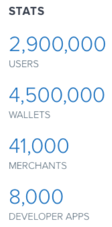
References

[1] http://www.econ.ucla.edu/people/papers/Matzkin/Matzkin616.pdf

[2] http://cointelegraph.com/news/113207/coinbase-is-tracking-how-users-spend-their-bitcoins

[3] http://www.forbes.com/sites/paularosenblum/2014/01/17/the-target-data-breach-is-becoming-a-nightmare/

[4] https://www.coinbase.com/about



STATS

2,900,000
USERS

4,500,000
WALLETS

41,000
MERCHANTS

8,000
DEVELOPER APPS

[5] https://github.com/bitcoin/bips/blob/master/bip-0032.mediawiki

[6] https://tools.ietf.org/html/rfc4086