Decentralised location verification system

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B.A.(Mod.) Computer Science
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Problem

Design and evaluate a decentralised system that allows participants to prove their location.

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- Capable of running on mobile devices.

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There are no known existing decentralised location proof systems.

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There are existing *distributed* location proof systems, with different interesting approaches.

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HP Laboratories

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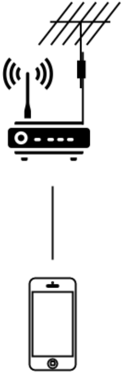

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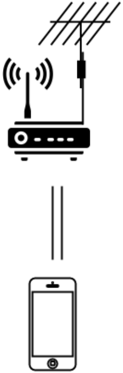

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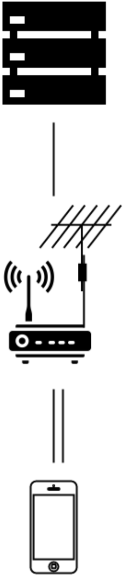

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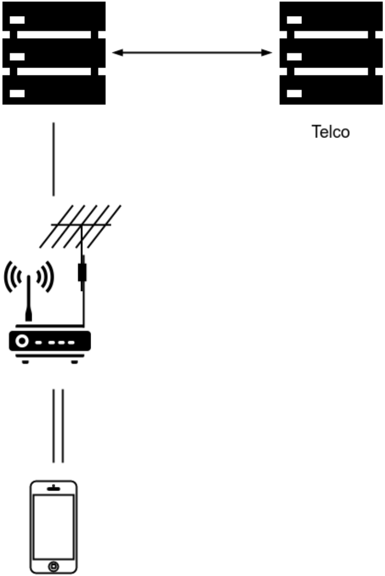

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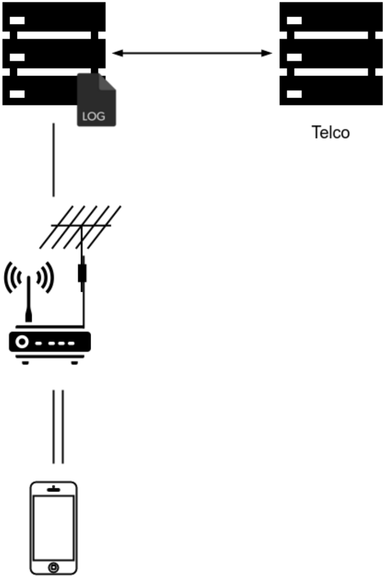

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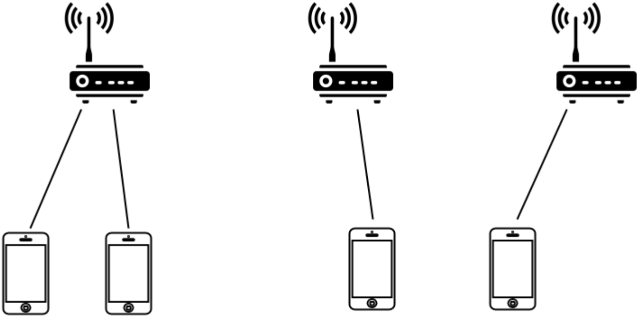

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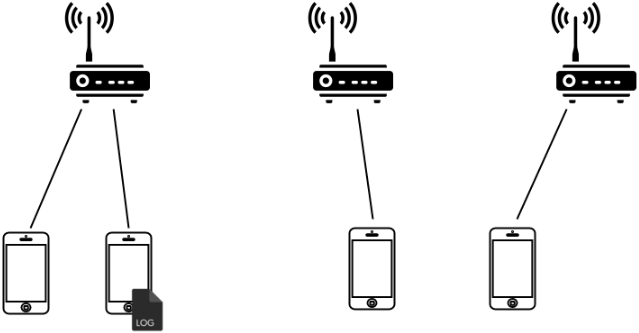

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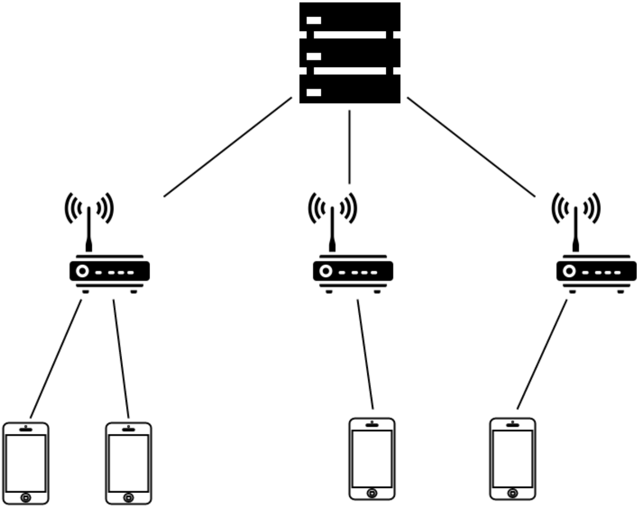

Background

Who, When. and Where?

Who, When, and Where?
University of Alabama.

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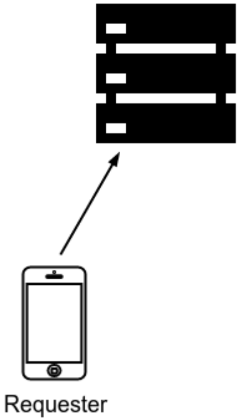

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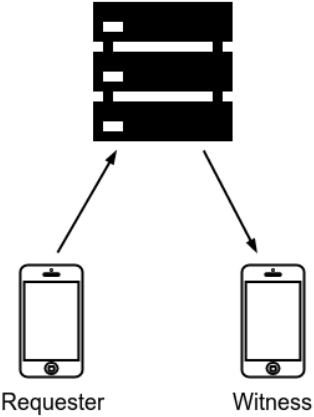

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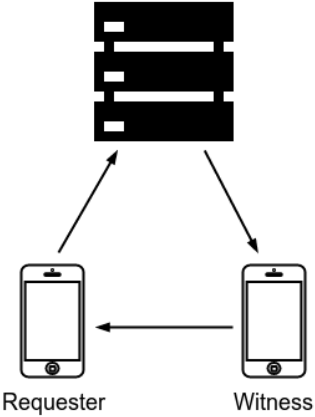

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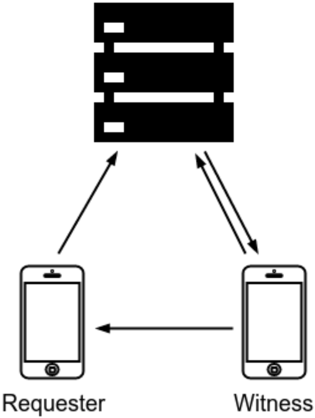

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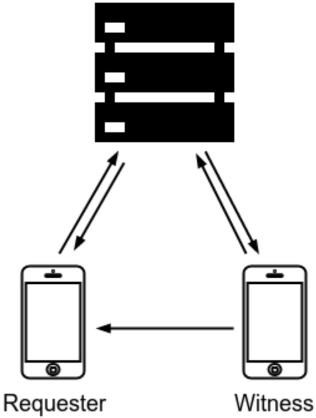

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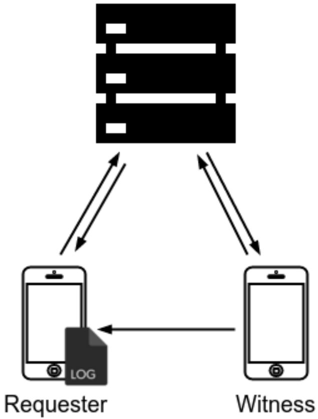

Problem

Issues

A decentralised location proof system needs a way of:

- Creating, storing, and providing access to location proofs.
- Detecting fake location proofs.
- Allowing users full control over their own privacy.

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- Creating, storing, and providing access to location proofs.
- Detecting fake location proofs.
- Allowing users full control over their own privacy.

Without any central resource to store data or manage the system.

Background

Blockchain

A blockchain is a decentralised, tamper-proof, append-only ledger.

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A blockchain is a decentralised, tamper-proof, append-only ledger.

Allows transaction records to be stored publicly and permenantly, without use of a central authority.

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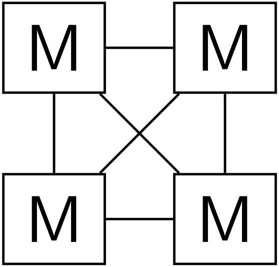

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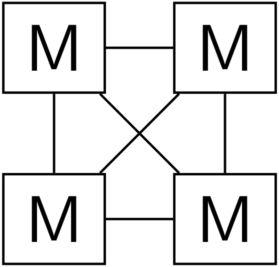
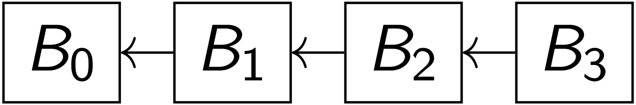




Background

Blockchain

Decentralised, tamper-proof method of storing location proofs.

Design

3 distinct entities:

- Mobile node 📱
- Miner node M
- Verifier node 🏛

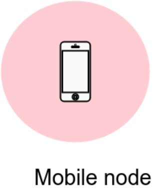
Design

Overview

Mobile node

Design

Overview



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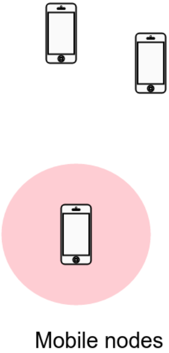

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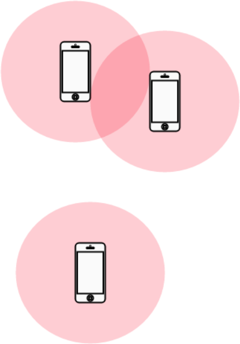

Mobile nodes

Design

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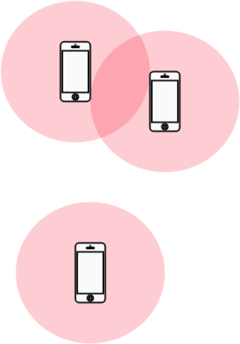

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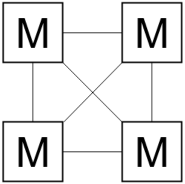

Miner nodes

Design

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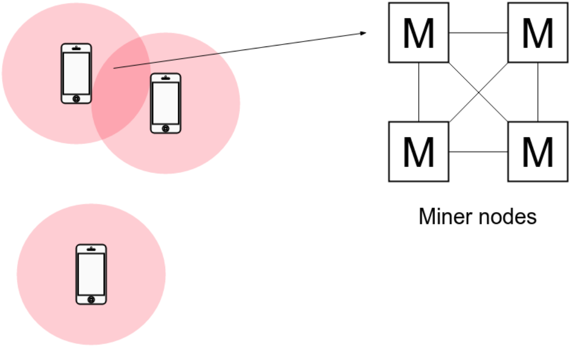

Miner nodes

Mobile nodes

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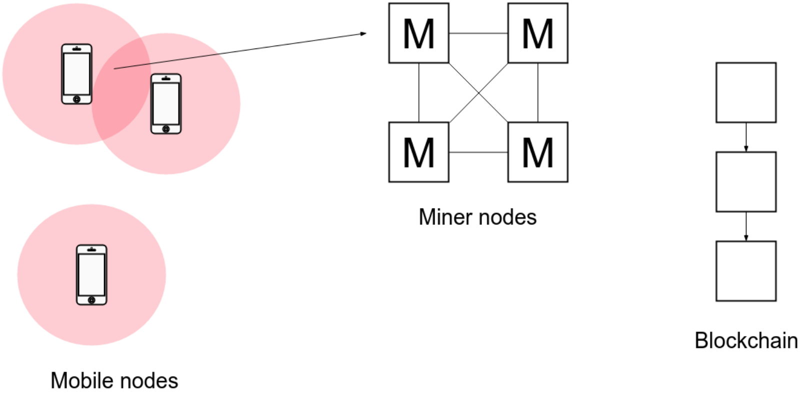

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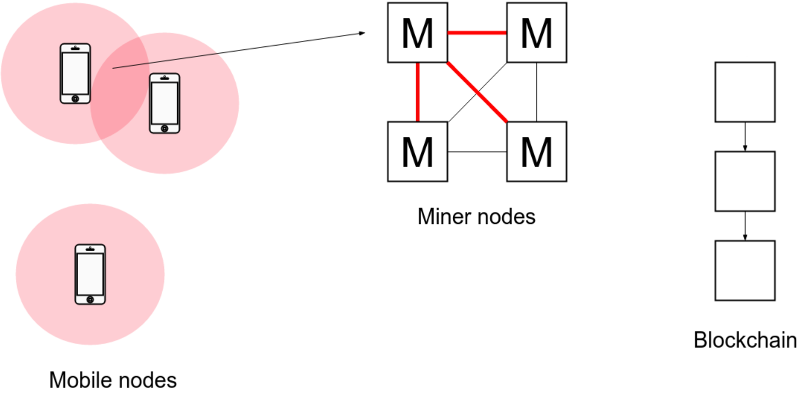

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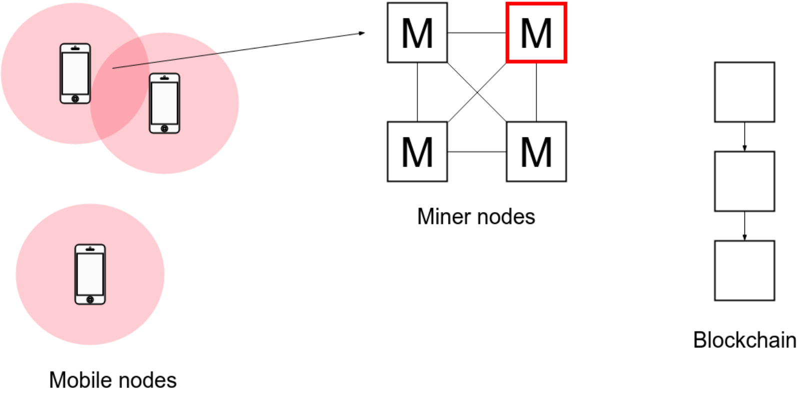

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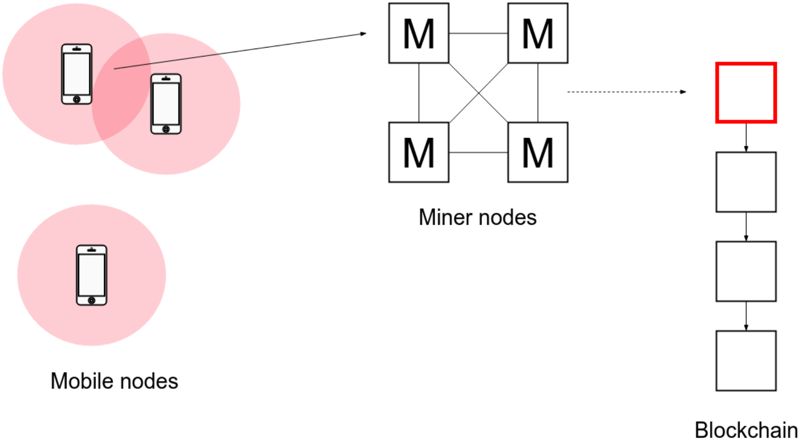

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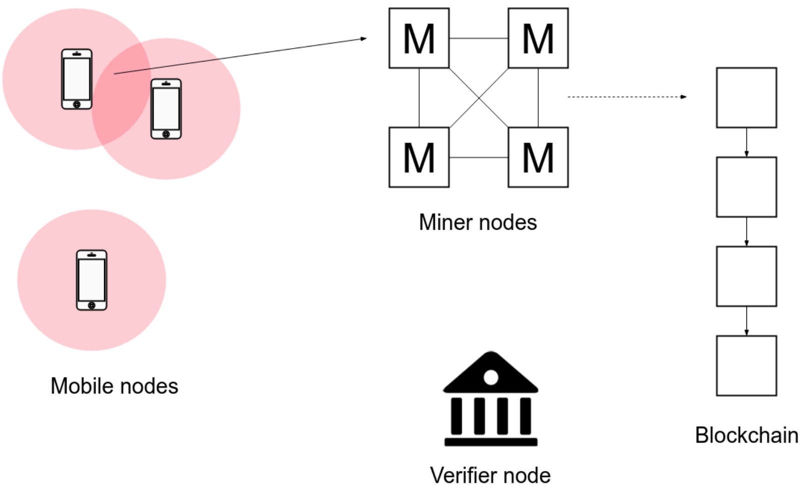

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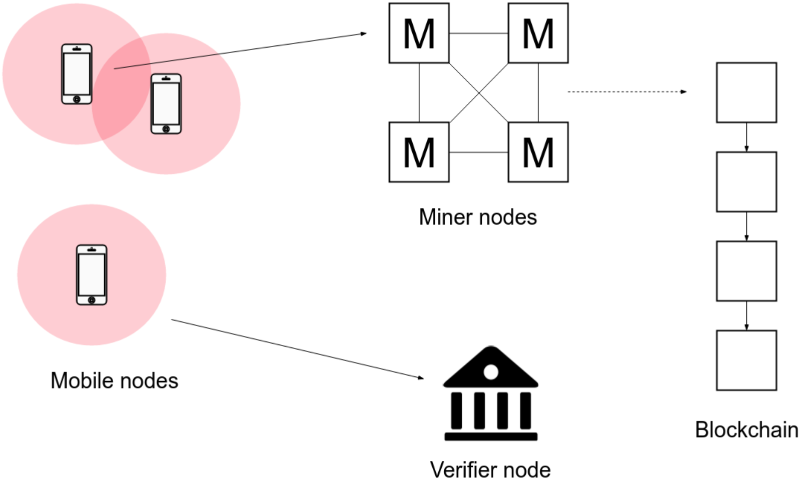

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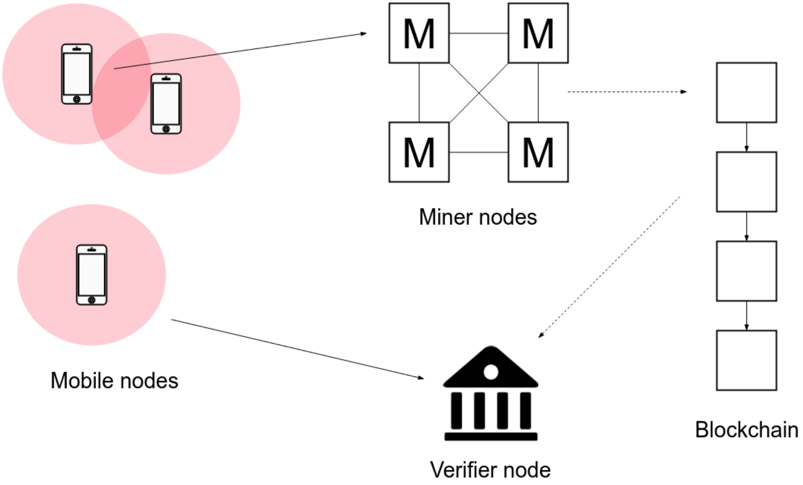

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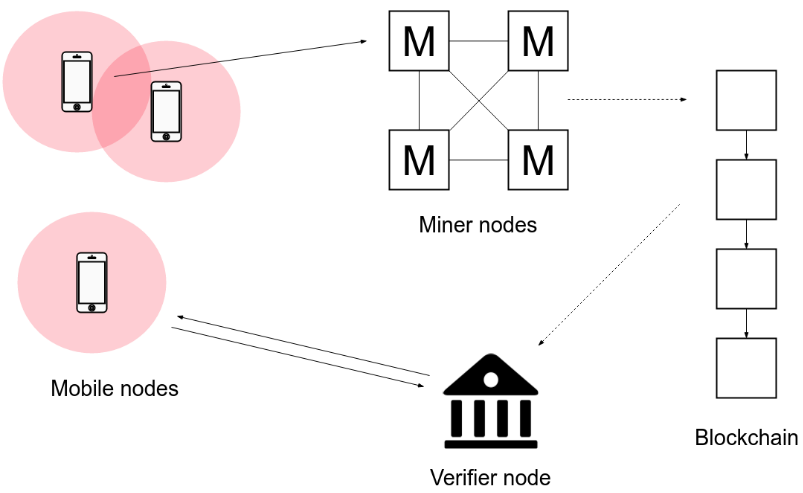

Problem

A system that allows participants to verify a users claimed location.

Goals:

- Privacy protecting.
- False location claims must be detectable.
- Cannot rely on any centralised resources.
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Design

Identities

Used to **anonymously** identify a node in a transaction.

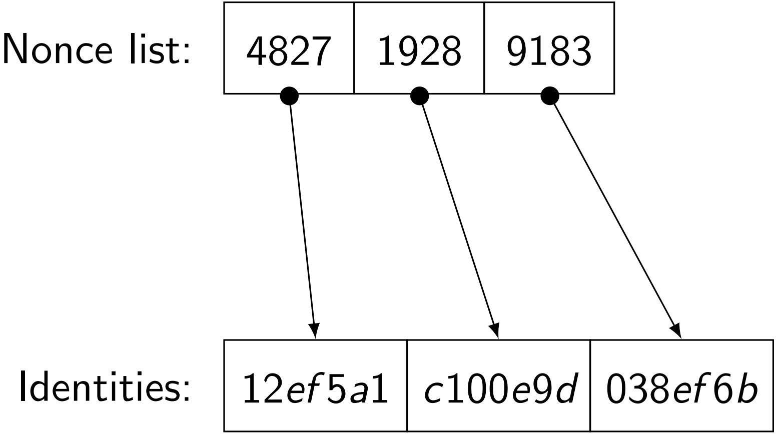
Every node generates a new identity for each transaction, making it untrackable.

Balancing goals:

- False location claims must be detectable.
- Privacy protecting.

Design

Identities: Nonce Lists

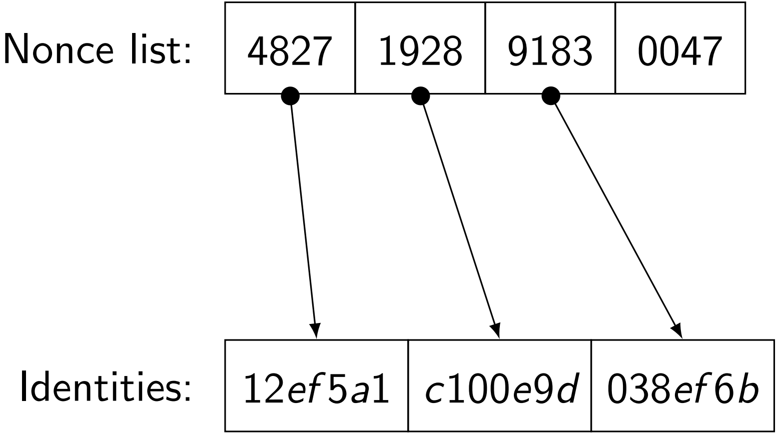


Nonce list: 4827 | 1928 | 9183

Identities: $12ef5a1$ | $c100e9d$ | $038ef6b$

Design

Identities: Nonce Lists



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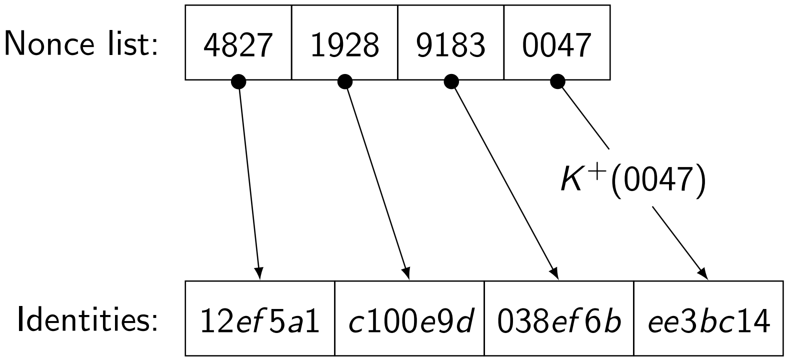

Nonce list:	4827	1928	9183	0047
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$K^+(0047)$

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Identities: Duplication

Identity duplication unavoidable in a scalable decentralised system.

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ID	**Contents**
...	
ffa0	
ffa1	
ffa2	T_{A4}
ffa3	
ffa4	T_{B87}
...	

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ffa1	
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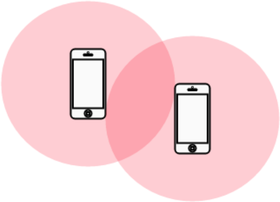
ffa3	
ffa4	T_{B87}
...	

Design

Transactions

Transactions are created when two mobile nodes physically meet.

- Ad-hoc bluetooth connection between the nodes.



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Node A will create the following transaction after meeting node B:

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Two main properties:

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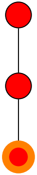

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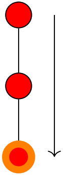

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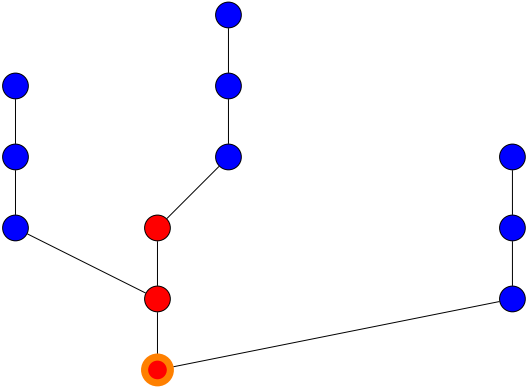

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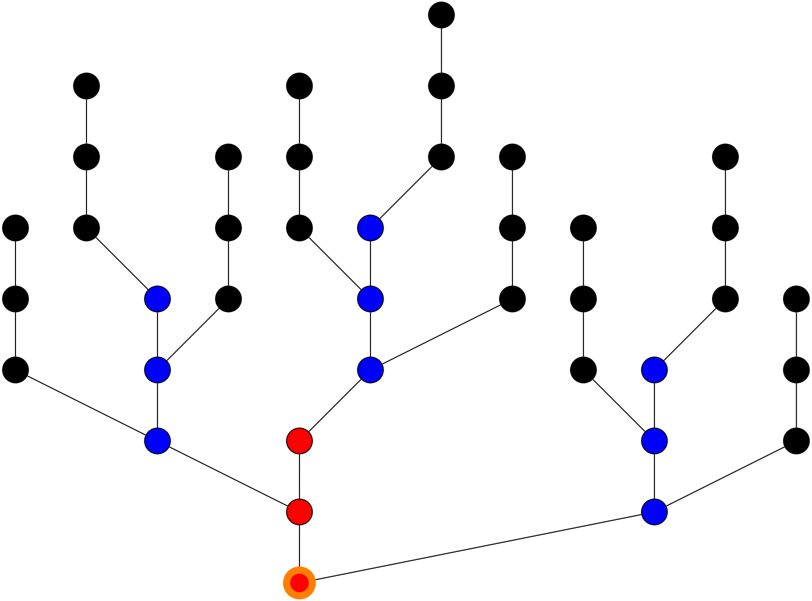

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Published transactions split into two parts: Link and Transaction

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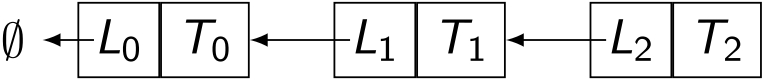

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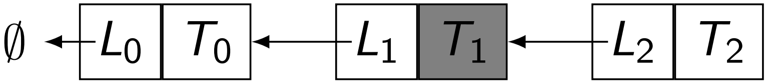

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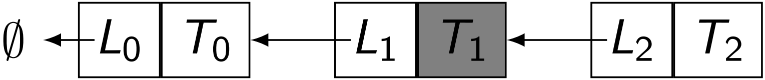

Two *Key Lists*: KL_{AT} and KL_{AL}.

Design

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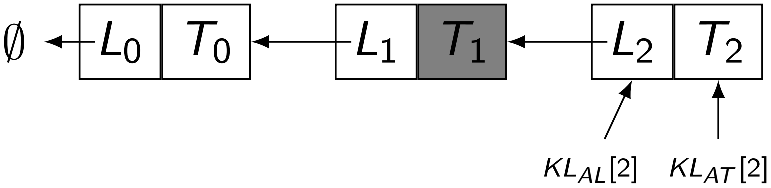

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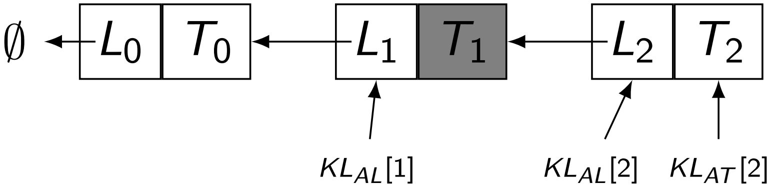

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Node A will then publish the following to the blockchain:

$$P_{An} = ID_{An}|KL_{AL}[n](ID_{An-1}|ts_A)|T_{An}$$

Design

Verification

Mobile node needs to provide Verifier node with:

- ID of most recent transaction.
- Key Packet for *n* most recent transactions.
- Nonce list for *n* most recent IDs.
- Public key.

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Evaluation

Case-based evaluation.

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Two kinds of case-based evaluation:

- Desirable properties.
- Threats.

Evaluation

Desirable properties

OTIT defines 8 desirable properties of a location proof system:

- Chronological.
- Order-preserving.
- Verifiable.
- Tamper evident.
- Privacy preserved.
- Selective in-sequence privacy.
- Privacy protected chronology.
- Convenience and derivablilty.

Evaluation

Threats

A number of papers have gathered threats to evaluate their models against:

- Dishonest users.
- Malicious intruders.
- Curious users.
- Malicious applications.
- False timestamping.
- Implication.
- Proof switching.
- Relay attack.
- Eavesdroppers.
- Wormhole attacks.
- False presence.
- False assertion.
- Denial of presence.
- Denial of witness's presence.
- Privacy violation.
- ~~Weak identities.~~
- ~~Sybil attack.~~

Evaluation

Threats - Weak identities

I assume that private keys and nonce lists are never shared.

Evaluation

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Mitigations:

- Introduce identity creation penalty.
- Web of trust.
- Secret verification techniques.

Conclusion

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Resilient against every other known attack.

- Sybil attack can be heavily mitigated against.
- Decentralised solution to Sybil attack may be found in future.

Future work

Further study into advanced Verification techniques.

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Build it!