RADIX DLT

Introduction and experimental analysis

Matteo Berti 2019

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01

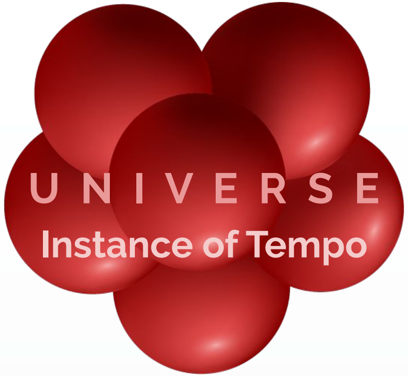
TEMPO

Radix Consensus Algorithm

INTRODUCTION

In 2016 **Daniel Hughes** invented **Tempo**: a novel distributed ledger **architecture** and **consensus algorithm**. This algorithm is **designed to scale**.

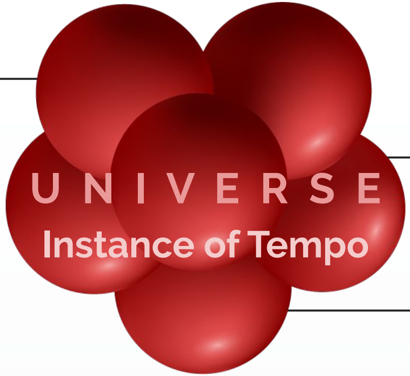
RADIX TEMPO



RADIX TEMPO

PAYLOAD ATOM

A communication, an email, a message.



TRANSFER ATOM

Transfer the ownership of an item, such as currency.

EXOTIC ATOM

Variants created for specific application purposes.

LEDGER ARCHITECTURE

NODE
Local ledger instance

- **STORE ALL** the global ledger
- **STORE PART** of the global ledger

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Local ledger instance

- **STORE ALL** the global ledger
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  - A **subset** of the global ledger is known as a **SHARD**

Nodes can store any **shard**, this enables **IoT devices** to actively participate in a Universe.

LEDGER ARCHITECTURE

To compute which **Shard** an **Atom** belongs:

```
ShardID = HASH(atomDestinationAddress) % ShardSpace
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Increases **redundancy** and **availability** of Atoms.

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Increases **redundancy** and **availability** of Atoms.

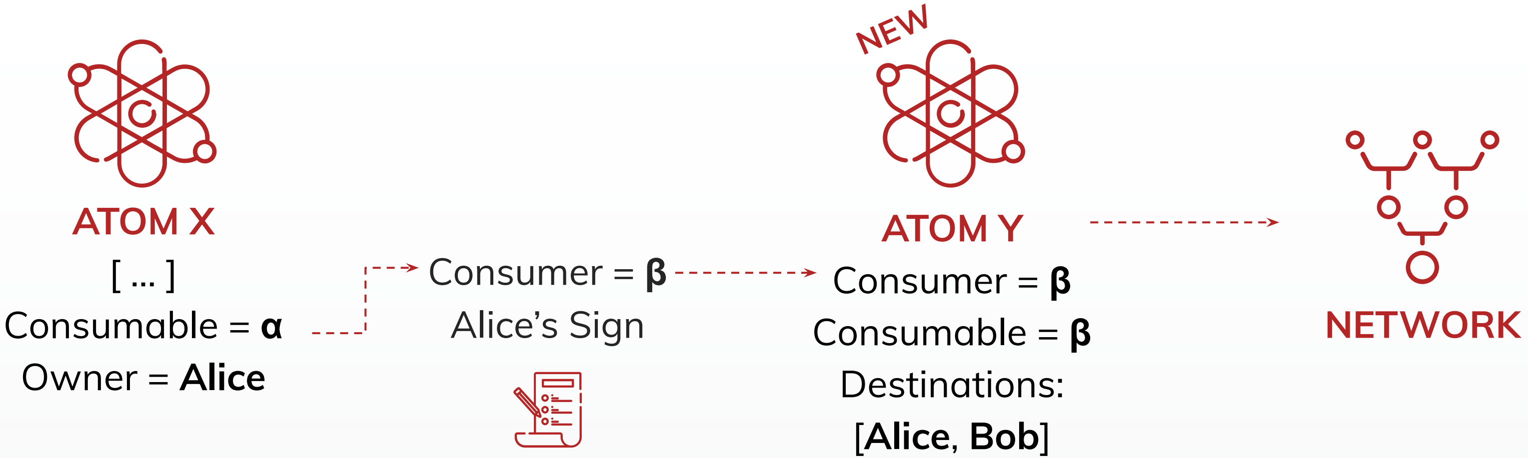
Indeed an Atom that performs an **inter-shard transfer** is present in both the **previous owner**'s and **new owner**'s **shards**.

Eliminates the need for a **global state**.

TRANSFERS

An **owned item** is represented by a **CONSUMABLE**.

OWNERSHIP TRANSFER



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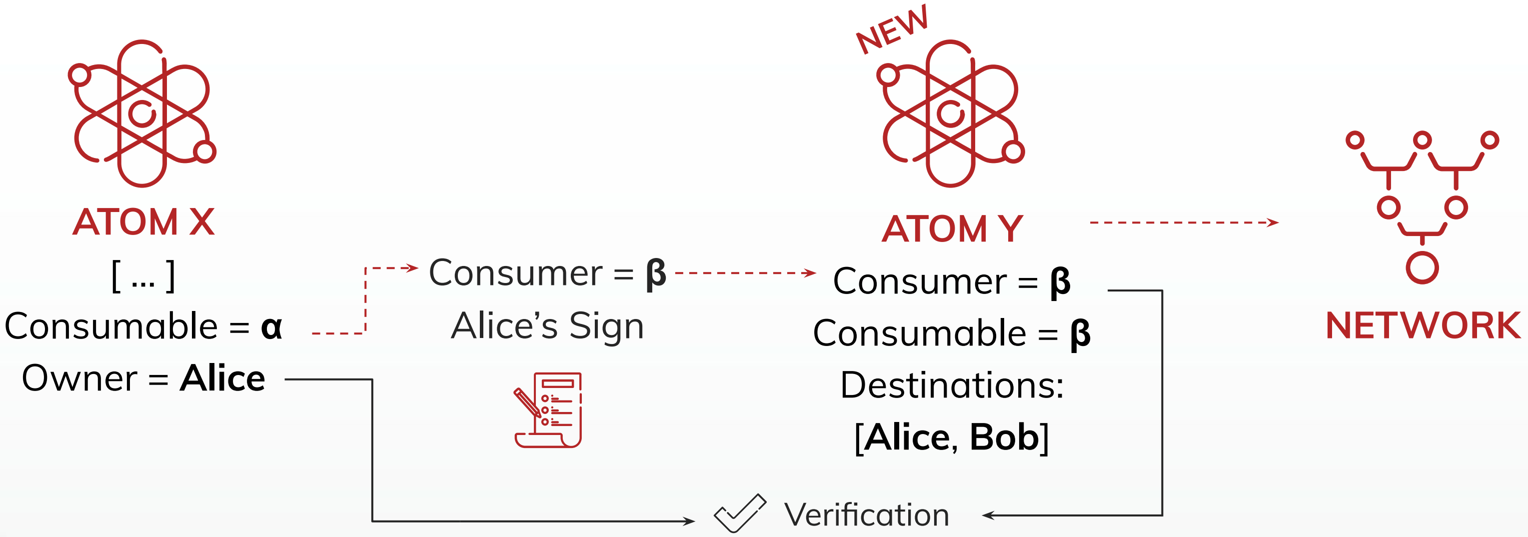

EVENT AVAILABILITY

Atoms are **routed to** the **nodes** that contain the associated shards through a Gossip protocol.

ATOM Y

[…]

Consumable = **β**

Destinations:

[**Alice**, **Bob**]

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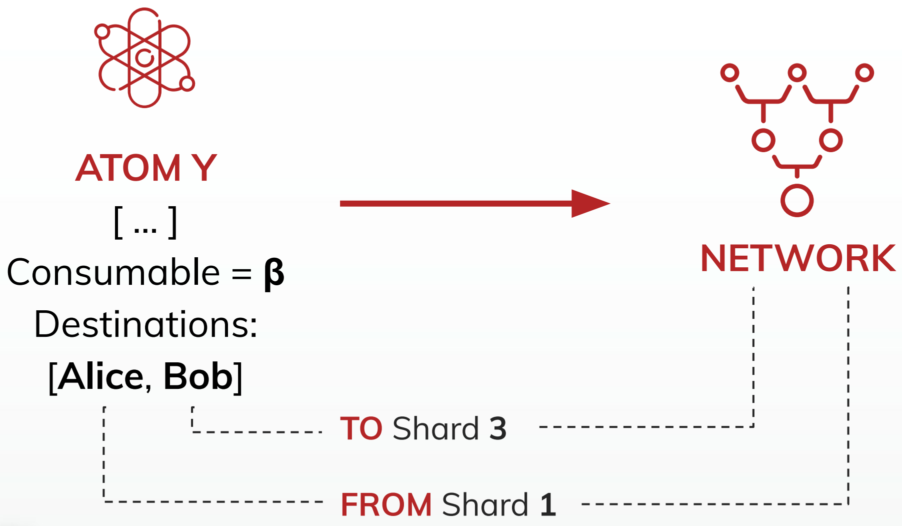

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NETWORK

TO Shard **3**

FROM Shard **1**

Nodes storing **Shard 1** and **Shard 3** need to be aware of the event of:

- Alice's **spend**
- Bob's **receipt**
- **State** of Item (α) consumed

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POST THE EVENT

The **responsibility** of the item's state has transferred from node storing **Shard 1** to those storing **Shard 3**.

LOGICAL CLOCKS

All **nodes** have a **local logical clock**: an **ever-increasing integer** value representing the **number of new events** witnessed by that node.

TEMPORAL PROOF PROVISIONING

Temporal Proof is a solution to the **double spending** problem.

This **proof** is **carried with** the **Atom** along the network.

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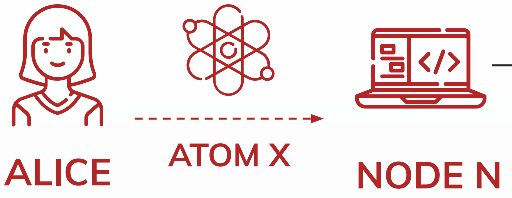

If N owns a copy of **SHARD 1 checks** that the item hasn't been **already spent** by Alice.

If any provable **discrepancy** is found the proof **fails**.

Otherwise, the node will **forward** the request to all **neighbors** storing either **Shard 1** or **3**.

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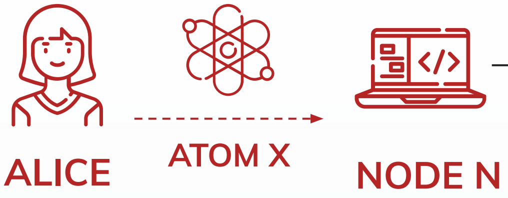

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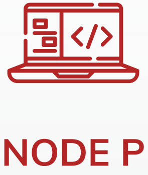

N forwards to **P** a **New Temporal Proof**:
Space-time coordinate: `(l, e, o, n)`

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TEMPORAL PROOF

ALICE

ATOM X

NODE N

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`(1, e, o, n)`

1: logical clock value for the event

e: event hash HASH(Atom)

o: node N id

n: node P id

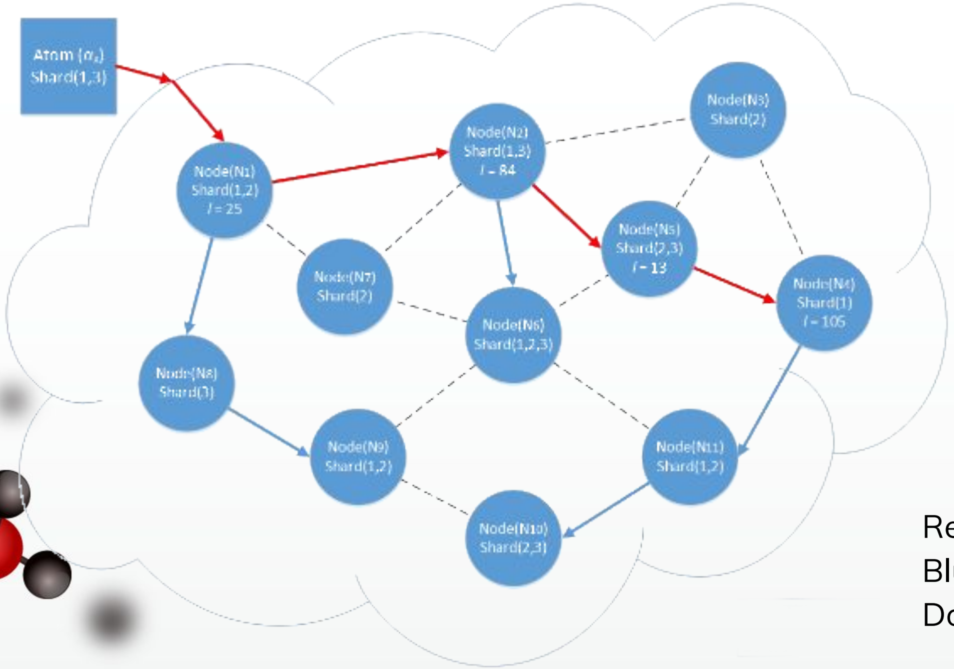
N forwards to **P** a **New Temporal Proof**:
Space-time coordinate: `(1, e, o, n)`

NODE P

TEMPORAL PROOF PROVISIONING

PROVISIONING

Node P validates **Atom X**, appends `(1, e, o, n)` and forward it to **Shard 1** or **3 neighbours**.



Logical Clock	Event	Observer	Next Observer
25	Hash $((Atom(\alpha_X))$	Node $(N1)$	Node $(N2)$
84	Hash $((Atom(\alpha_X))$	Node $(N2)$	Node $(N5)$
13	Hash $((Atom(\alpha_X))$	Node $(N5)$	Node $(N4)$
105	Hash $((Atom(\alpha_X))$	Node $(N4)$	—

Red arrow: PROVISIONING
Blue arrow: GOSSIP
Dotted line: **CONNECTION**

PROVISIONING EFFICIENCY

Provisioning **length** TOO SHORT

Reduces the efficiency of **resolving conflicts**.

Provisioning **length** TOO LONG

Increase the **bandwidth load** and **time** taken.

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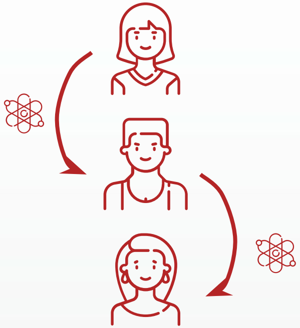
OPTIMIZATION

If **Alice** sends **Item** to **Bob**, and **Bob** then sends **Item** to **Carol**, the nodes involved in Alice → Bob **Temporal Proof** take also part in Bob → Carol transfer.



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When **Atom X** and **Atom Y** conflict there are many scenarios:

1. The pair of **vector clocks** contains a **common node**:

VC(ATOM **X**)		VC(ATOM **Y**)	
A	5	B	10
D	12	G	7
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   a. It can be used an **intermediate node.**

VC(ATOM **X**)		VC(ATOM **Y**)		VC(ATOM **Z**)	
A	5	B	10	J	60
D	12	G	7	S	19
F	34	V	47	T	20
S	17	L	24	V	30

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Indeed:
VC(ATOM X) ≤ VC(ATOM Y)

(Intermediate Atoms could be more than one)

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Commitment Order Determination

For light nodes such as **IoT devices**, commitments are the **only way** to **determine order**.

COMMITMENTS

Nodes declare to the network a **periodic commitment** of **all events** they have seen.

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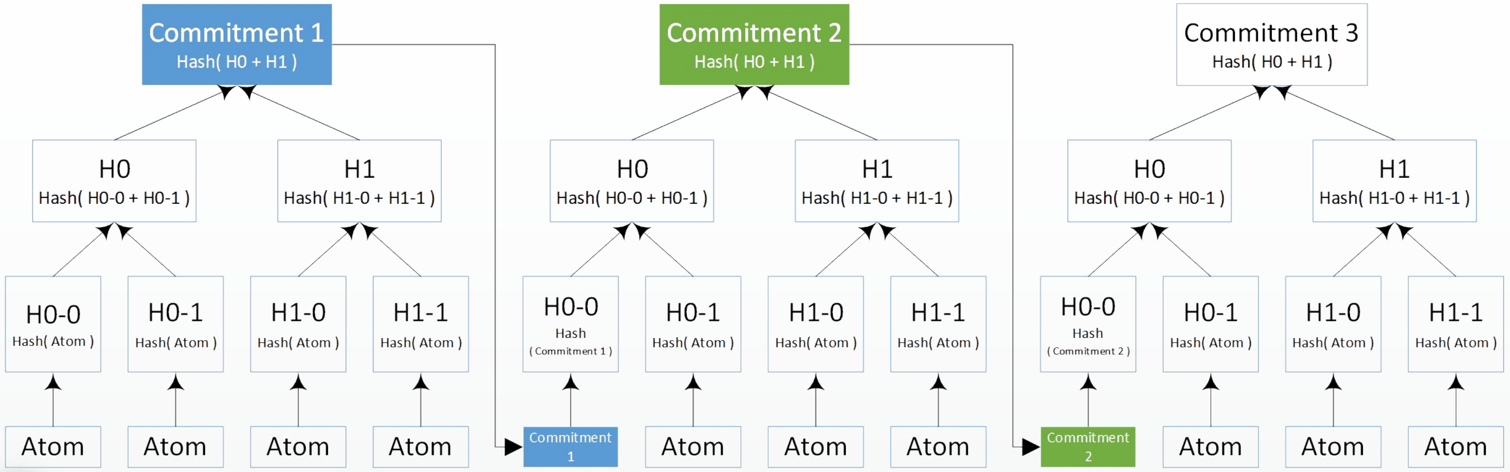
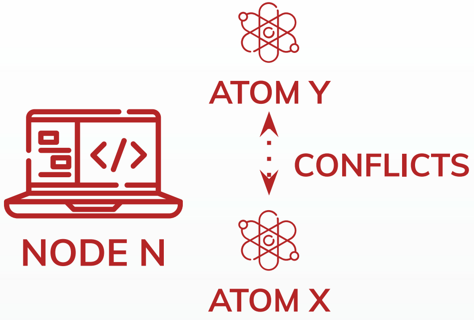
COMMITMENT: a **Merkle Hash** constructed from the **events a node has witnessed since** submitting a **previous commitment**.



COMMITMENTS

If the value of **1** for Commitment 1 was **100** and the value of **1** for Commitment 2 was **200**, then Commitment 1 should contain **100 items**.

If a requesting node is not returned 100 hashes when verifying, **tampering of the logical clock** may have occurred.



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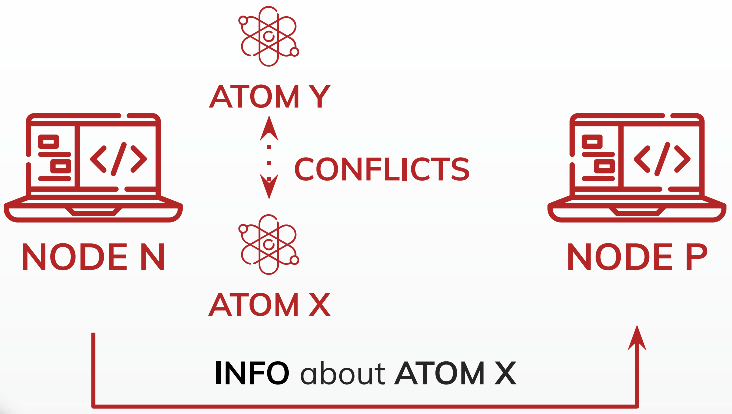

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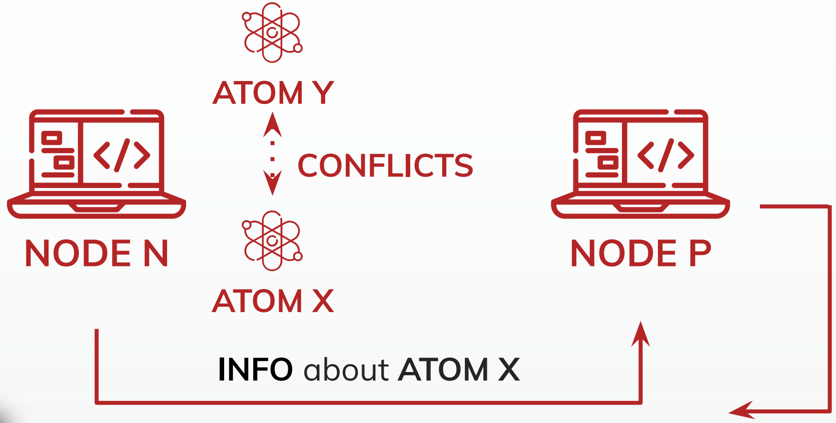
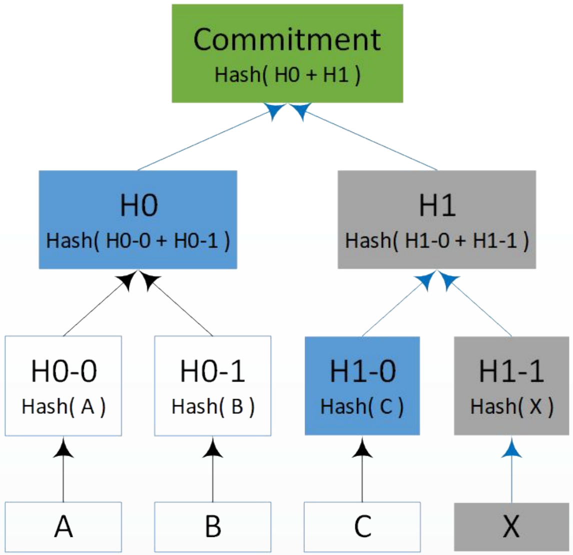


RESPONDS with:

- **COMMITMENT** for **Atom X**
- **SET** of Atoms **βs** witnessed **after Atom X**
- [...]

COMMITMENTS

COMMITMENT VALIDATION



Node N queries **NODE Q** which **delivered** **Atom Y**:

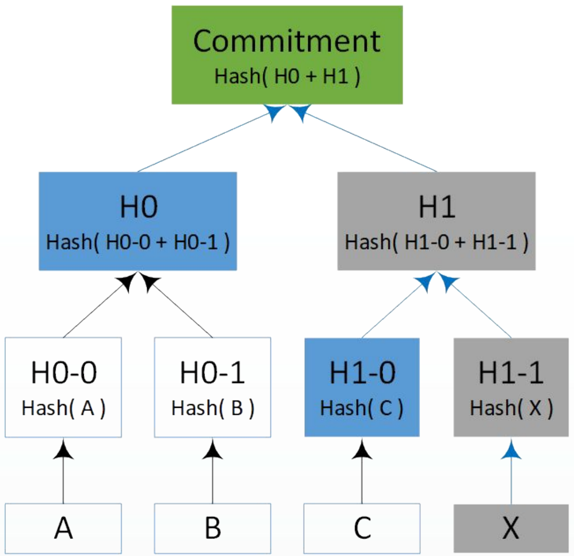
- **COMMITMENT** and for **Atom Y**
- any of the **Atoms βs**
- [...]

This allows **NODE N** to **verify**

	NODE P LC	NODE Q LC
ATOM **X**	45	-
ATOM **Y**	-	465
ATOM s_1	46	-
ATOM s_2	47	441
ATOM s_3	458	-

COMMITMENTS

COMMITMENT VALIDATION



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Therefore **ATOM X** happened **before** **ATOM Y**

02

TESTING ALPHANET

Performance analysis on IoT network simulation

ALPHANET

ALPHANET is the **α-testing network** of Radix DLT.

- 6 Nodes
- 1 User

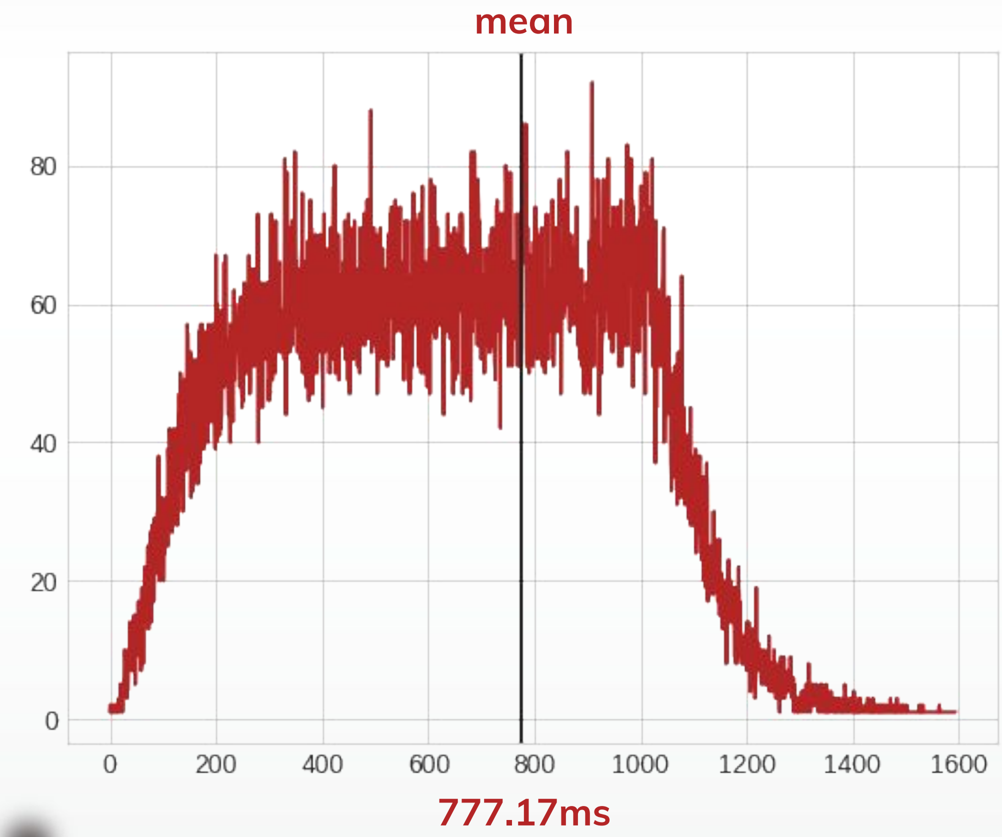
GOAL

Testing the **error rate** and the (mean) **time** required to write and Atom on the ledger.

DESIGN

- Node.js server simulating **10** different **autobuses** writing data on the DLT at certain points in time.
- Run **6 parallel simulations** for **12 times** over a dedicated server (12 hours) ≃ 120 autobuses.

RESULTS



Error rate

2.73%

Mean Confidence Interval

774.68ms ← 777.17ms → 779.65ms

03

TESTING BETANET

Testing tokens on local betanet emulation

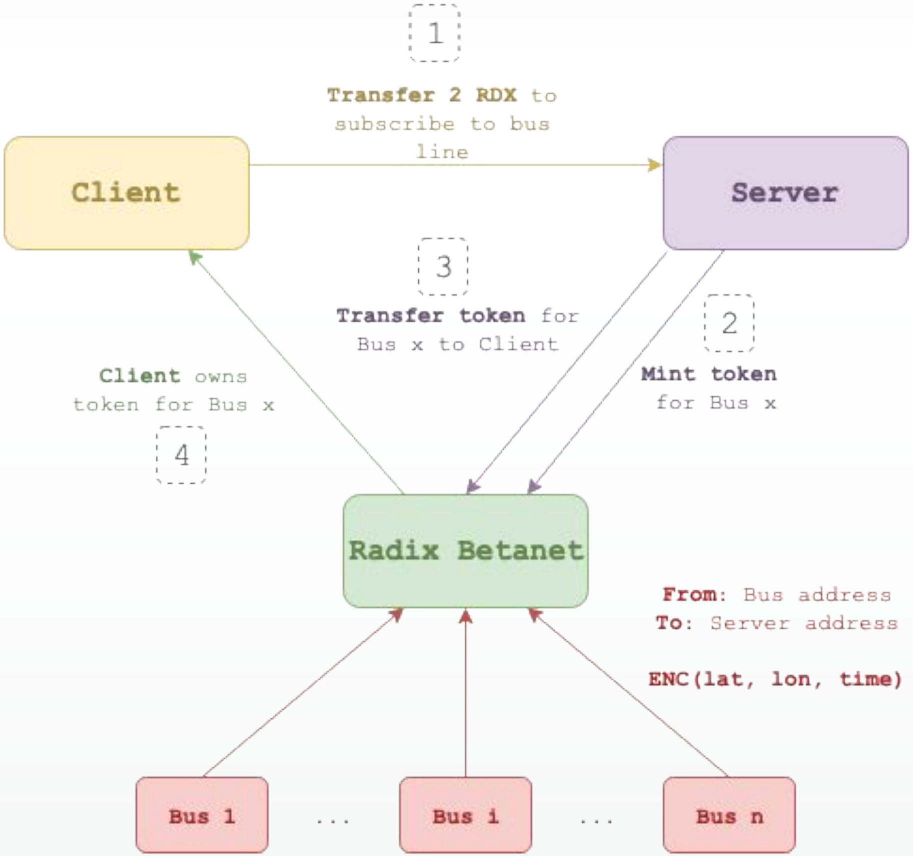
BETANET

BETANET emulated on **local computer** because online betanet will be deployed in December.

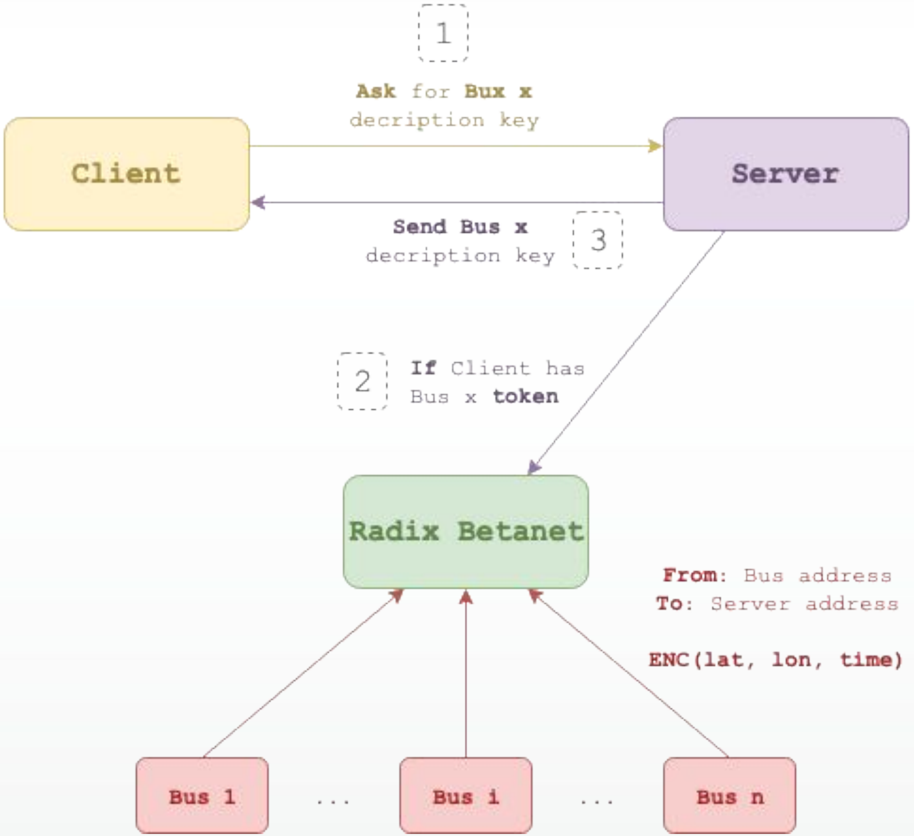
GOAL

- Getting RDX tokens from Faucet account.
- Mint new custom tokens.
- Transfer standard and custom tokens between two accounts.
- Send message and payload atoms between two accounts.
- Security checks (balance, specific tokens in wallet, sufficient funds, ...).
- Local storing of Radix identities.
- Symmetric key cryptography.

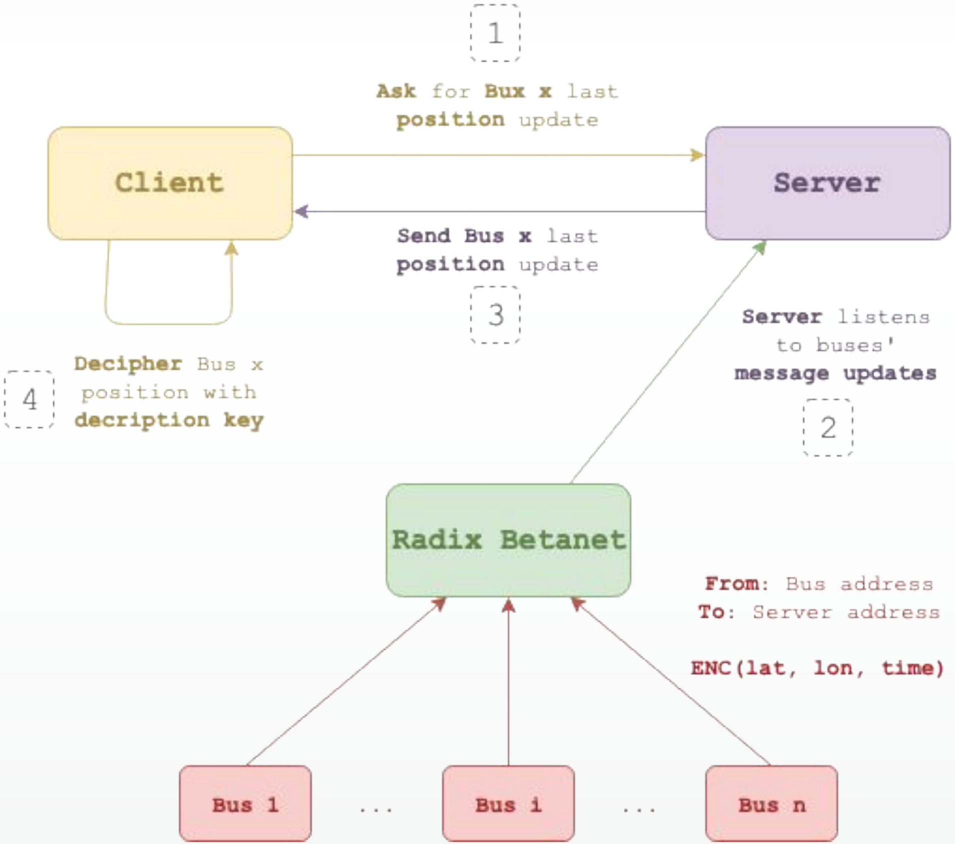
GET BUS TOKEN



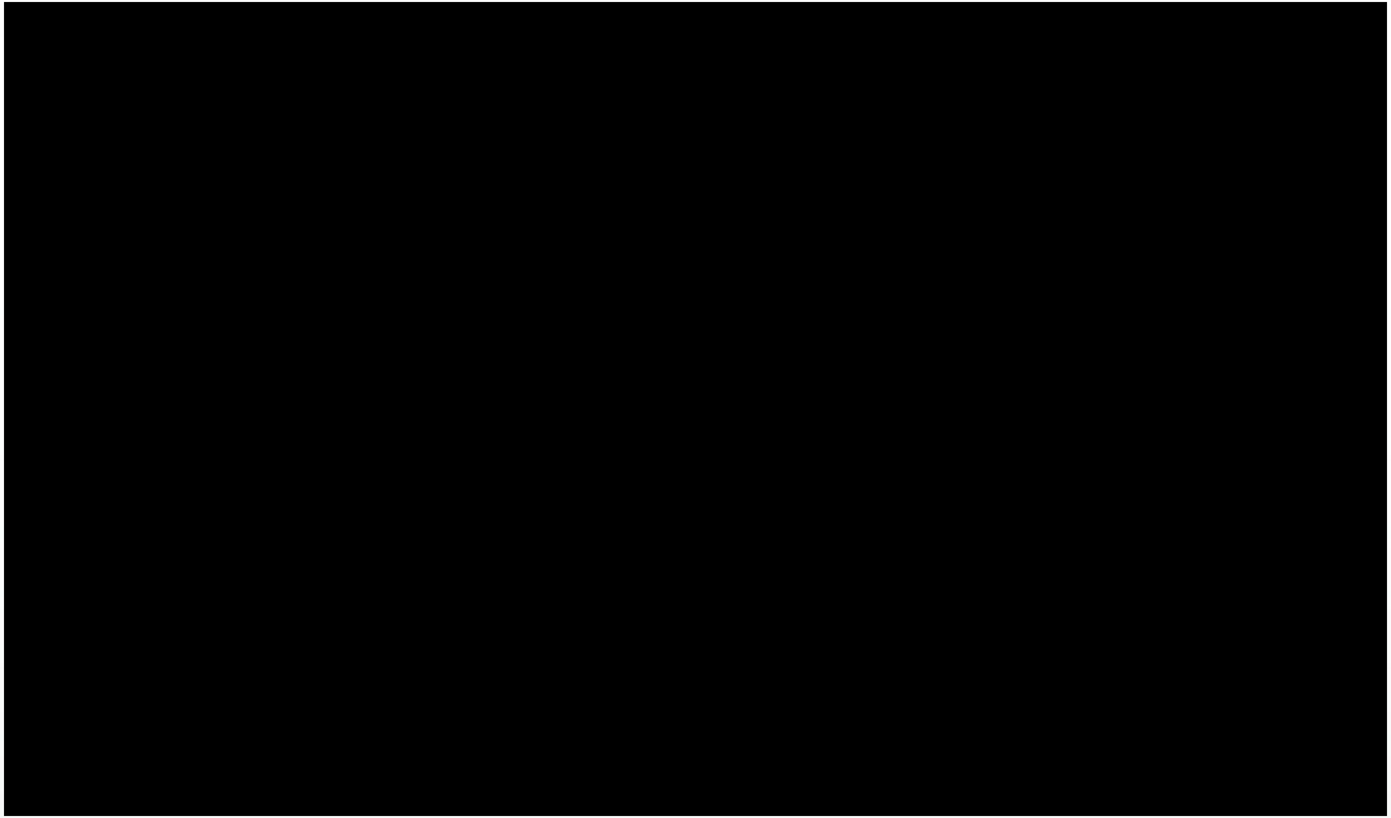
GET DECRYPTION KEY



GET BUS LINE POSITION



EXECUTION



RESEARCH RESOURCES

All material: **github.com/methk > RadixDLT-IoTSimulation**

- Dan Hughes, Radix DLT: Tempo Whitepaper - 2017
- S.Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System - 2008
- V. Buterin, Ethereum Whitepaper - 2014
- L. Lamport, Time, Clocks, and the Ordering of Events in a Distributed System - 1978
- C.J.Fidge, Timestamps in Message-Passing Systems that preserve the Partial Ordering - 1988
- R.C. Merkle, Merkle Tree - 1979