Blockchains Meet Distributed Hash Tables:
Decoupling Validation from State Storage

Matteo Bernardini, Diego Pennino, and Maurizio Pizzonia

The problem

The problem

Scalability

The problem

Scalability

Consensus

The problem

Scalability

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Storage

Problems:

The problem

Scalability

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Problems:

- *Time of Synchronization*

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- *Time of Synchronization*
- *Storage capacity*

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Problems:

- *Time of Synchronization*
- *Storage capacity*
- *Validation needs Storage*

Overview of our work

Full Node divided into two roles:

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1. **Storage role**:
   - ✓ tunable occupied space

Main idea:
a partitioned Ledger

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Full Node divided into two roles:

1. **Storage role**:
   - ✓ tunable occupied space

Main idea:
a partitioned Ledger

2. **Validation role**:
   - ✓ small chain with a constant size

Main idea:
validation from a secure starting point which **IS NOT** the local ledger

Storage Role

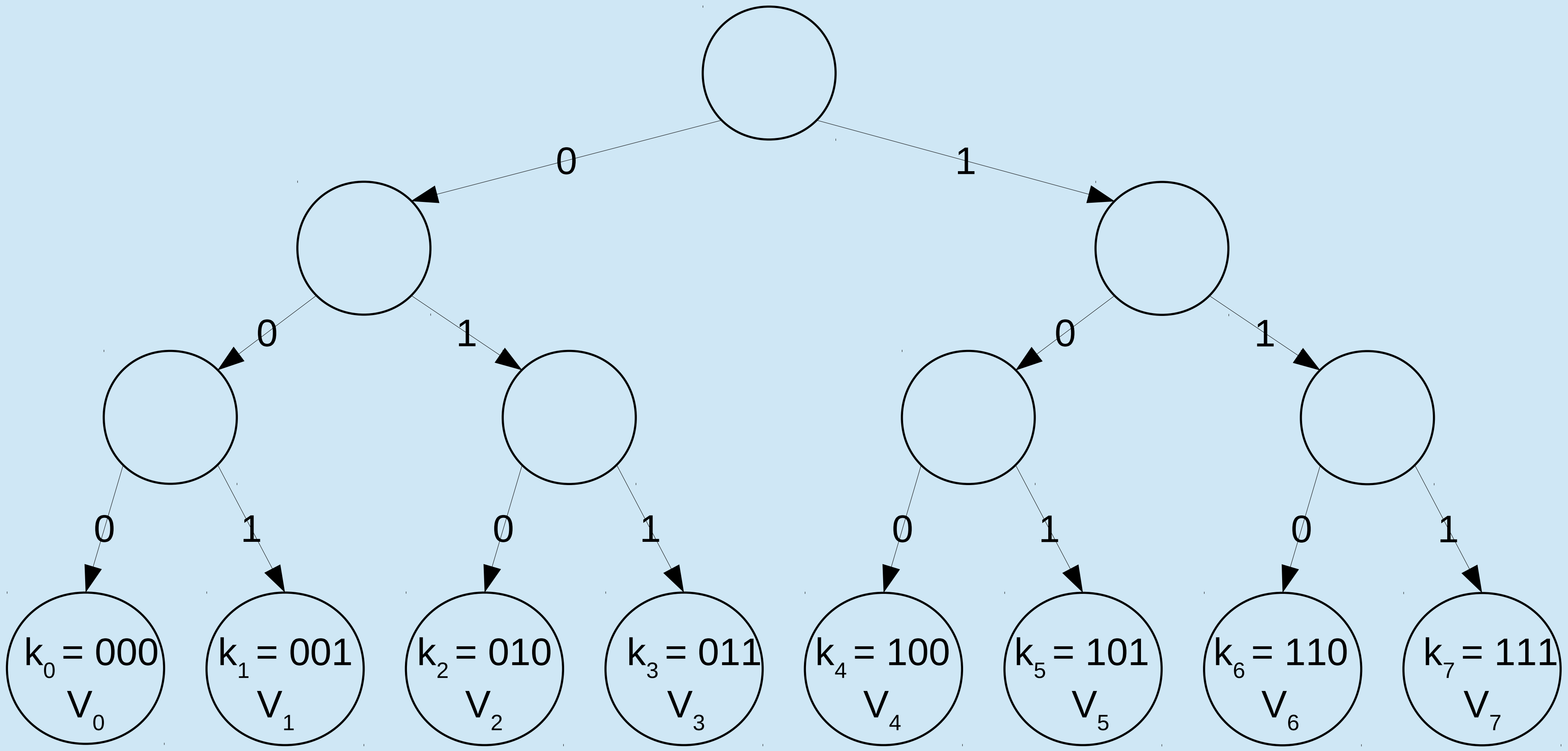
Ethereum Storage Role: *the Ledger*

k_0 = 000	k_1 = 001	k_2 = 010	k_3 = 011	k_4 = 100	k_5 = 101	k_6 = 110	k_7 = 111
V_0	V_1	V_2	V_3	V_4	V_5	V_6	V_7

State elements

Ethereum Storage Role: *the Ledger*

Prefix tree



State elements

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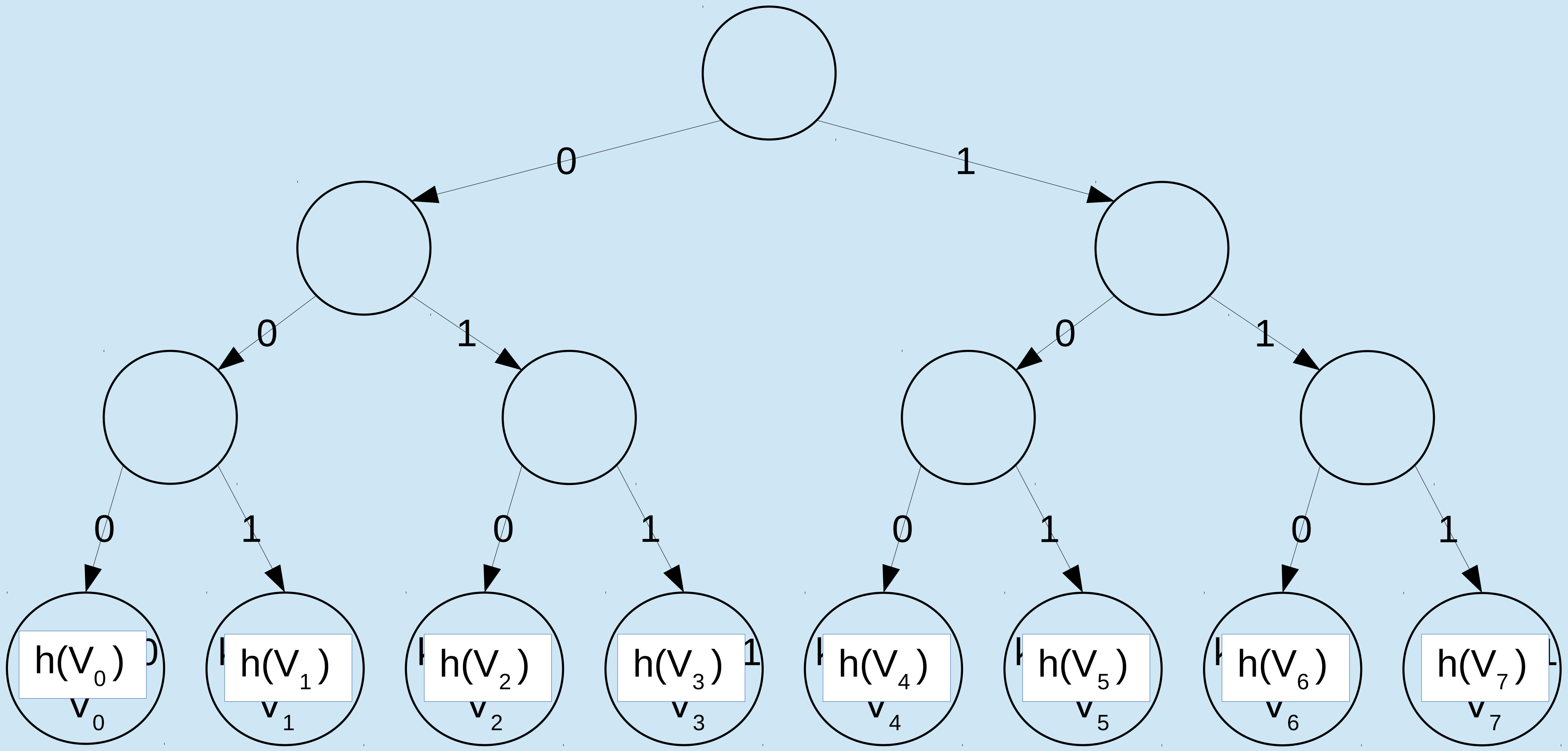
*Prefix tree - **Merkle Hash Tree** (MHT)*



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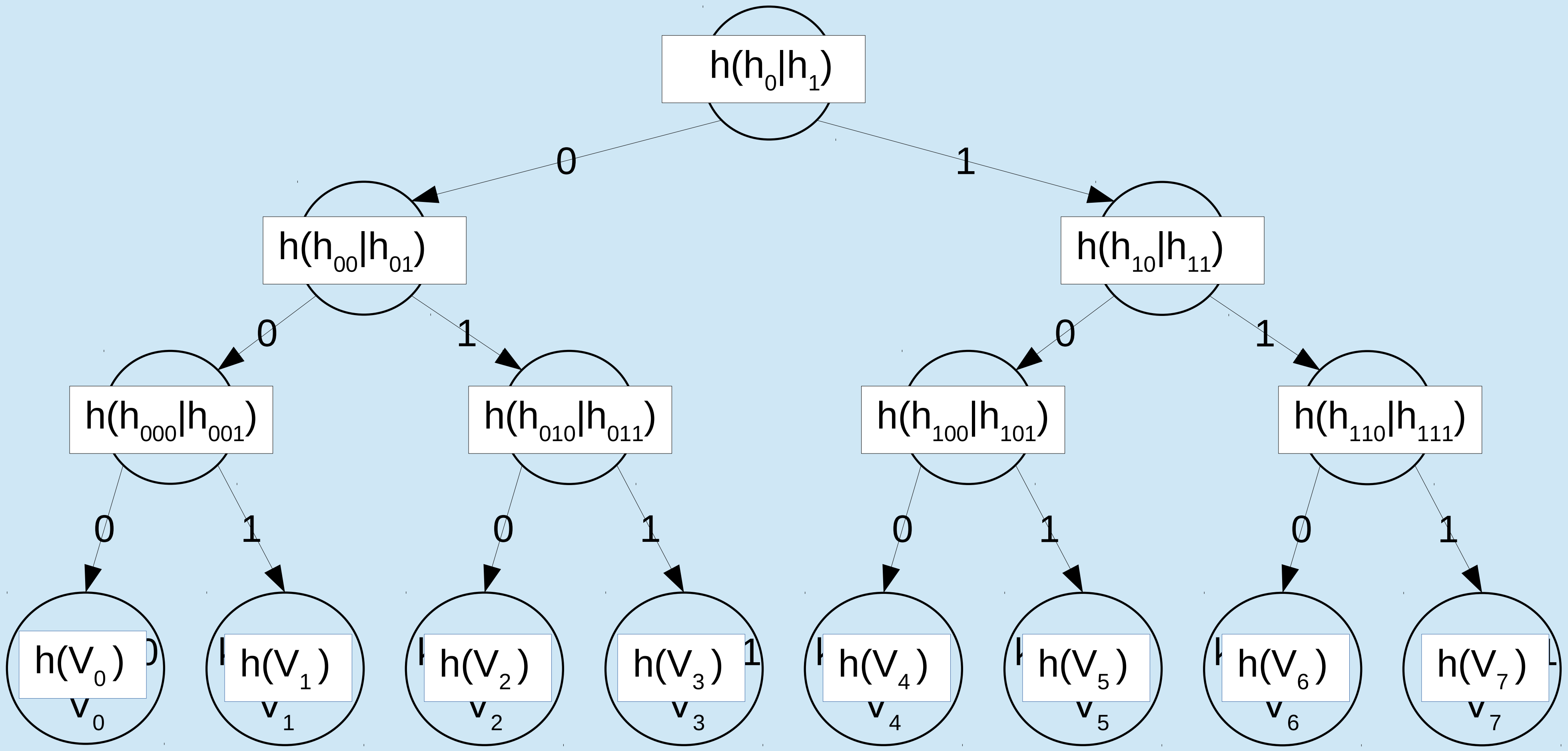
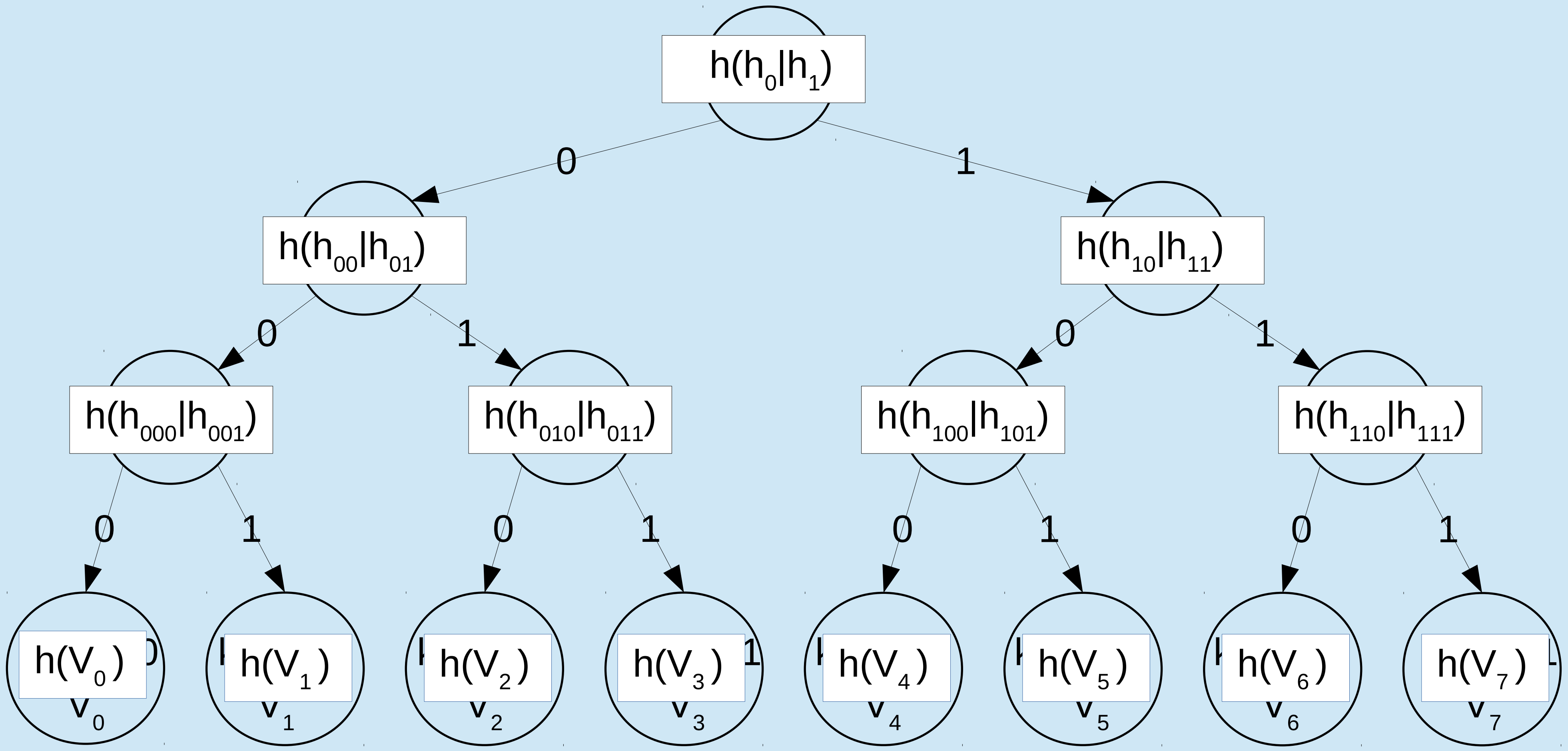


Ethereum Storage Role: *the Ledger*

MHT *- the proof*



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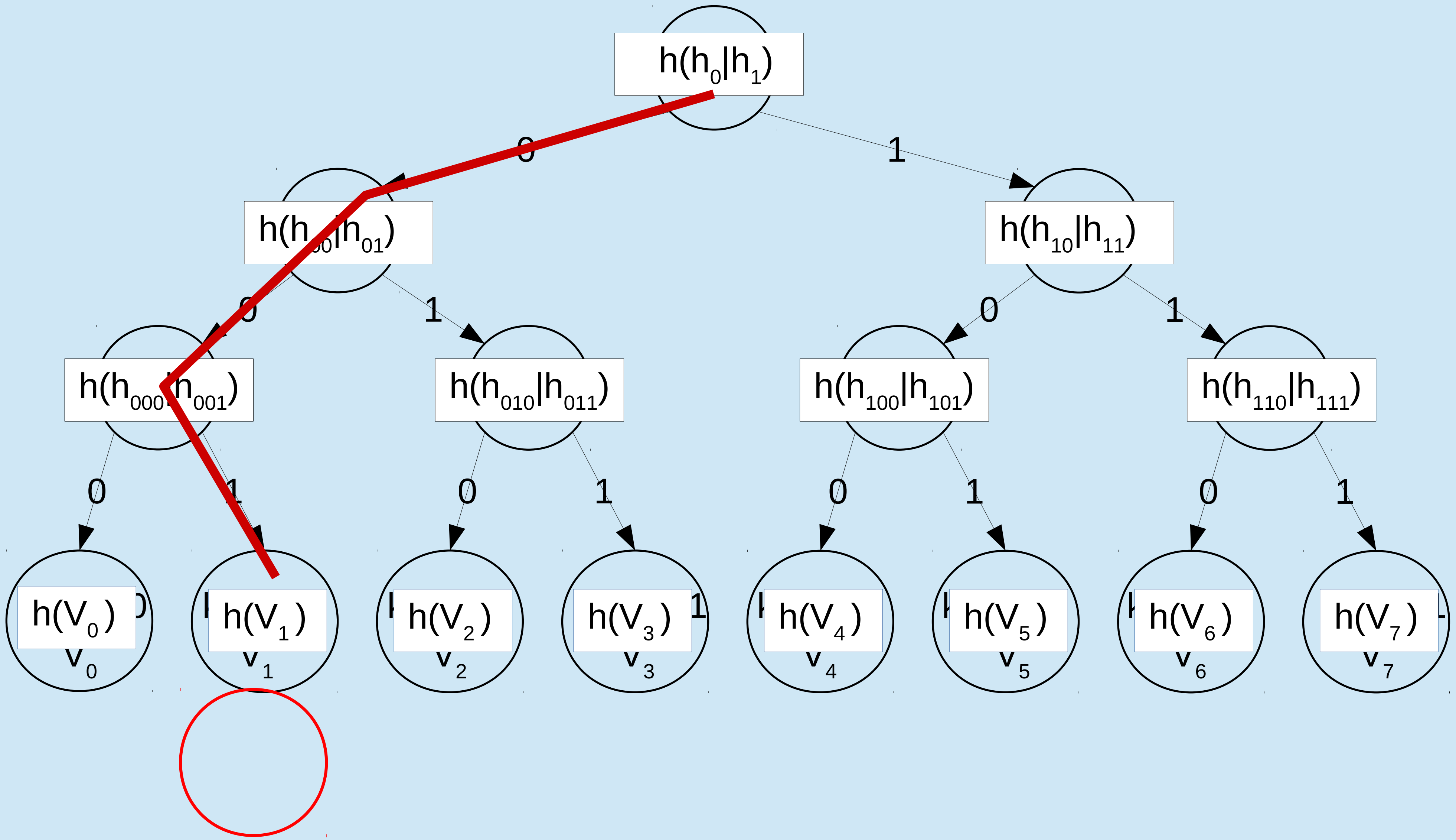

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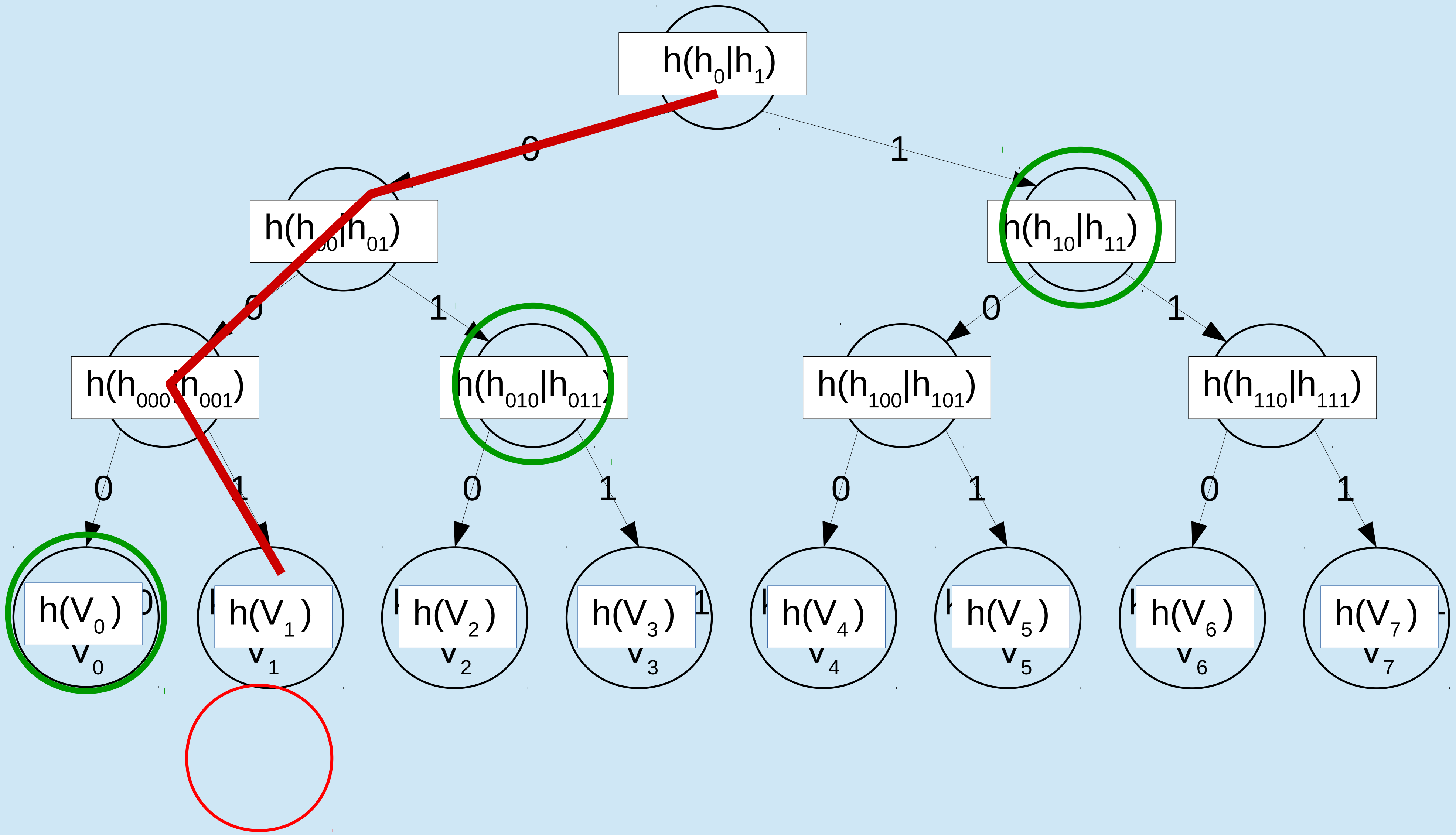
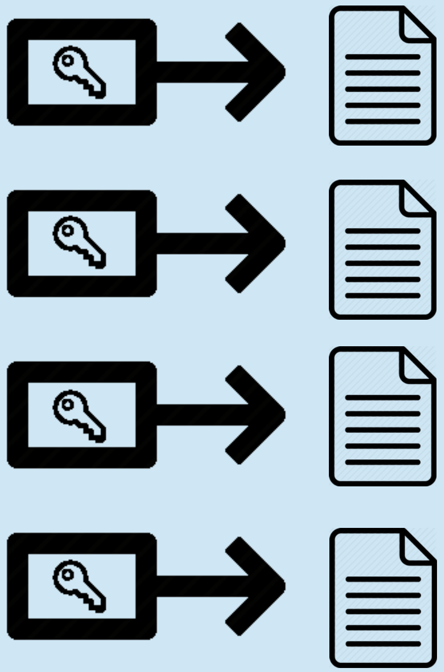


Storage Role of a Node: **Distributed Hash Table (DHT)**

Hash table (key-value)



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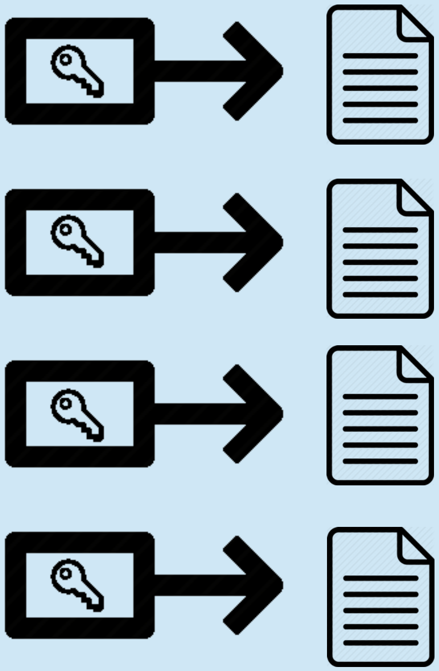

P2P

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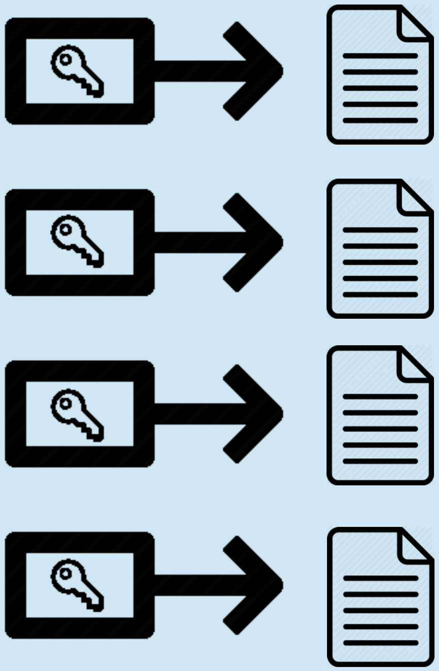

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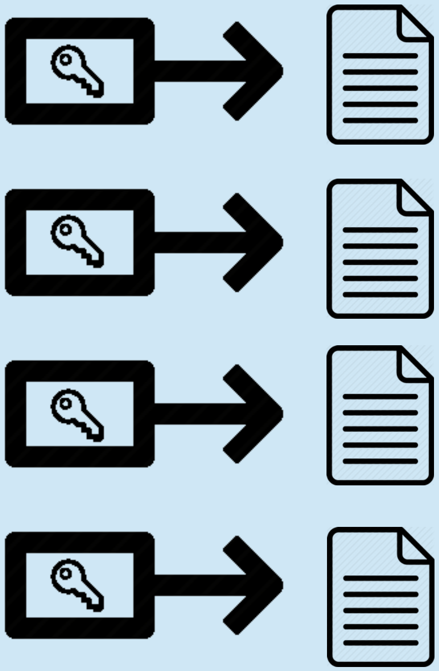

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- *put*(k,v)
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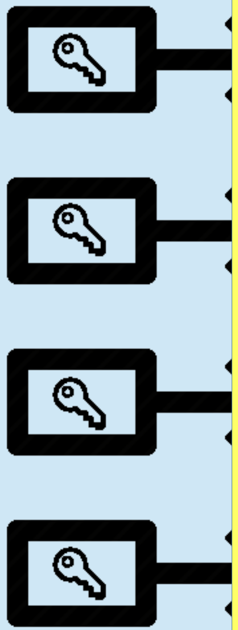

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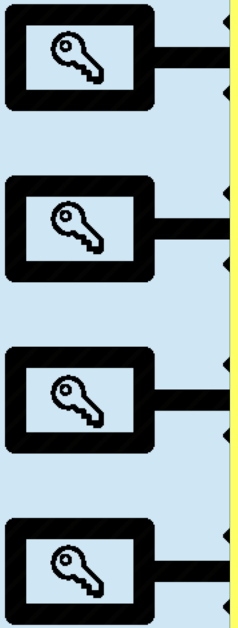
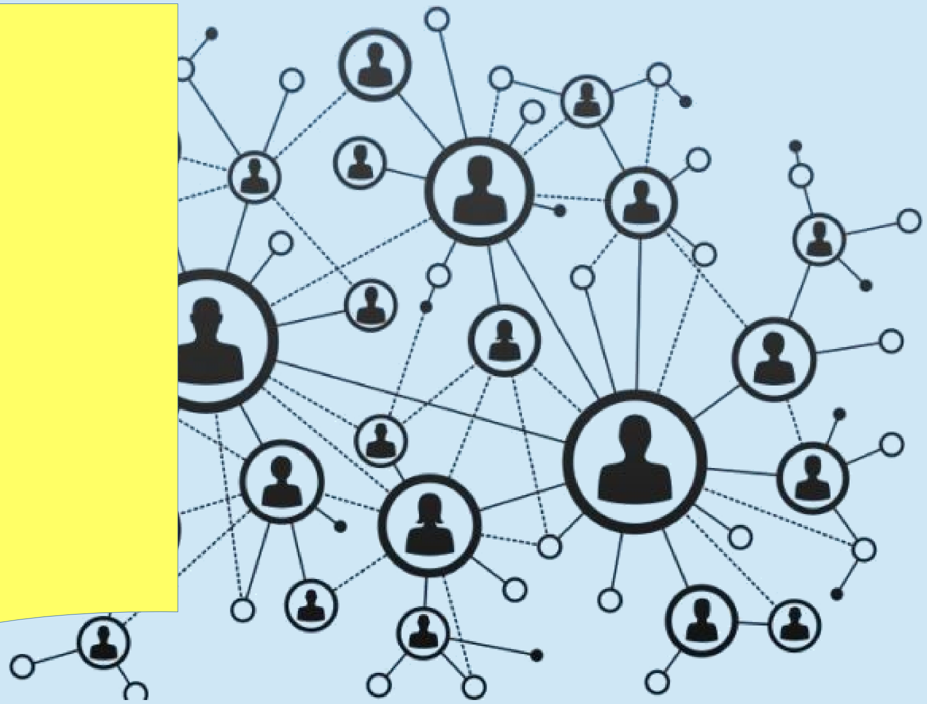


Properties:

- Autonomy and decentralization



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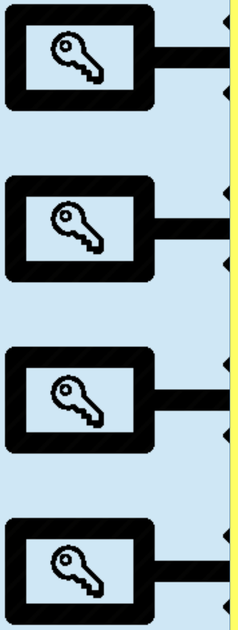

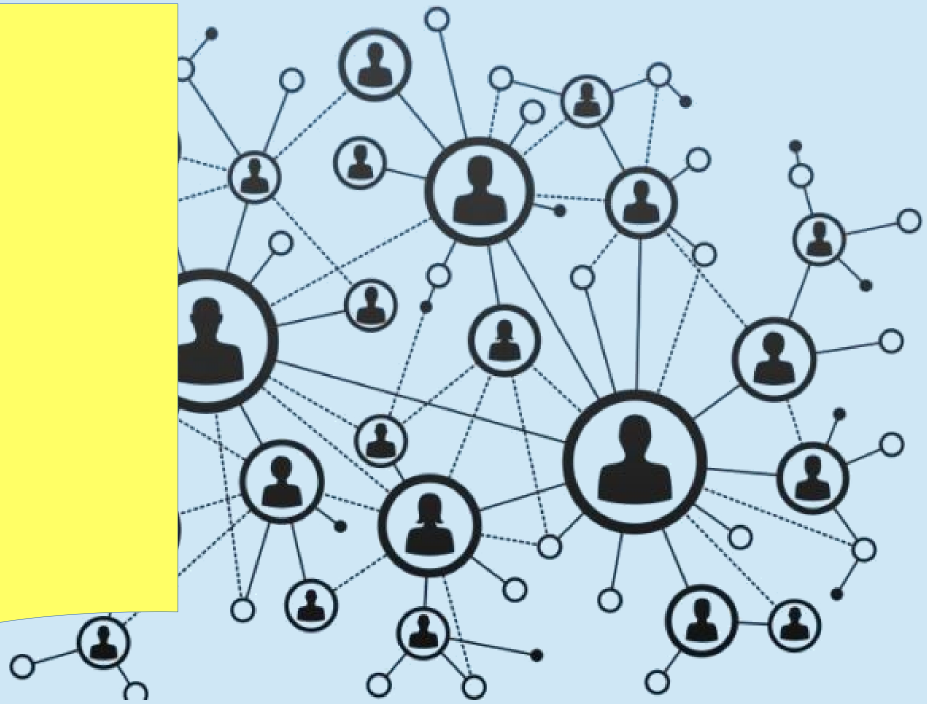

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- Autonomy and decentralization
- Fault tolerance

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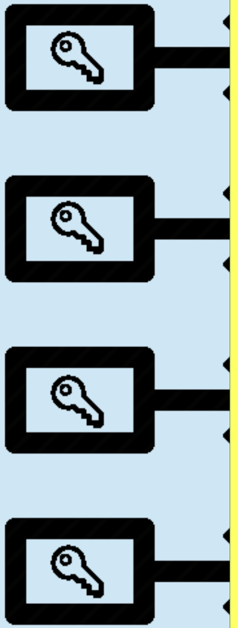
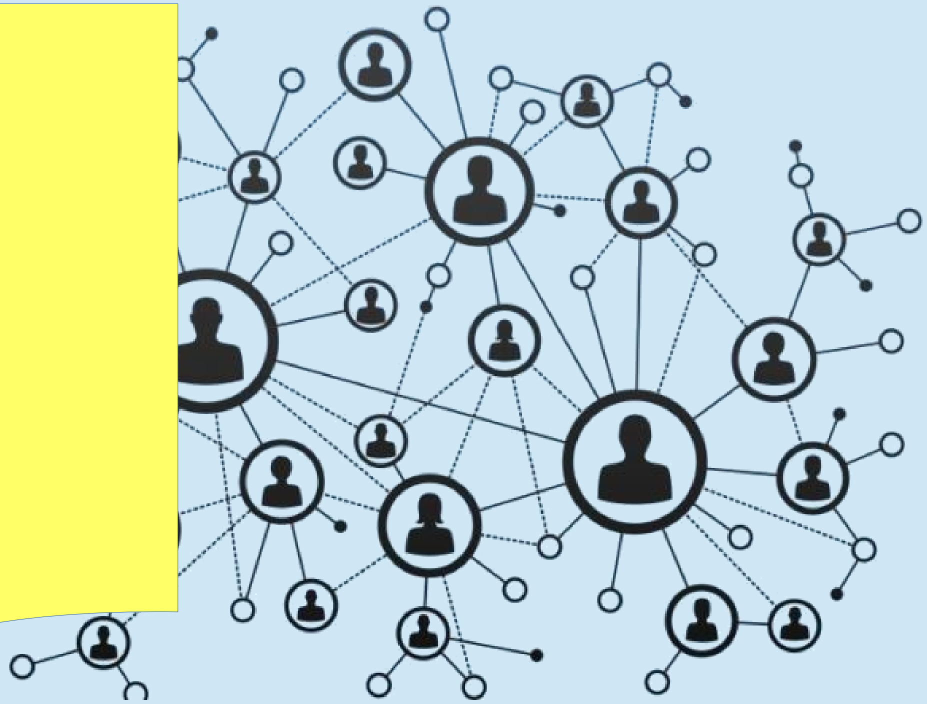


Properties:
- Autonomy and decentralization
- Fault tolerance
- Scalability



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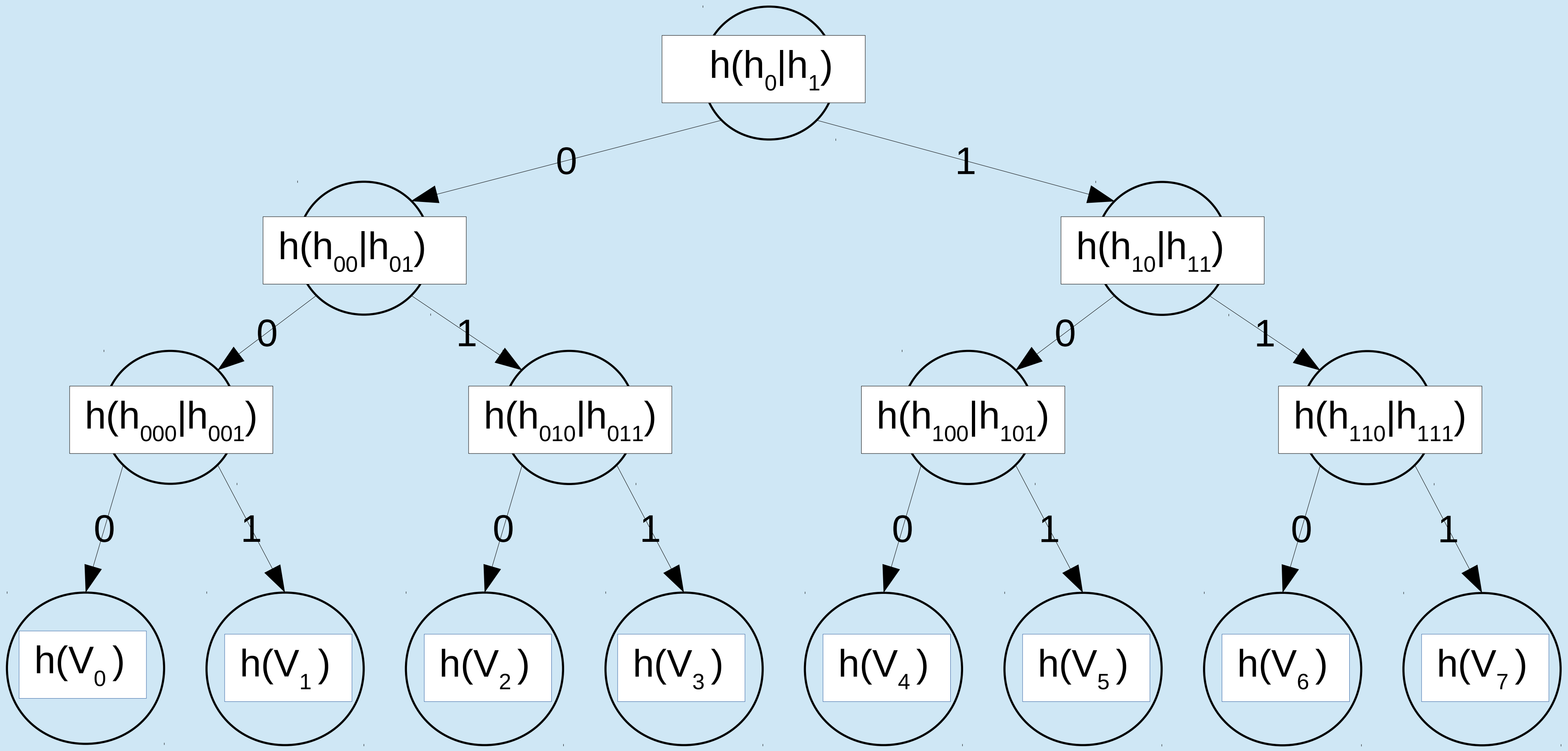
OUR Storage Role: *the small Ledger*

MHT + DHT = ***pruned Authenticated Data Structure*** *(pADS)*



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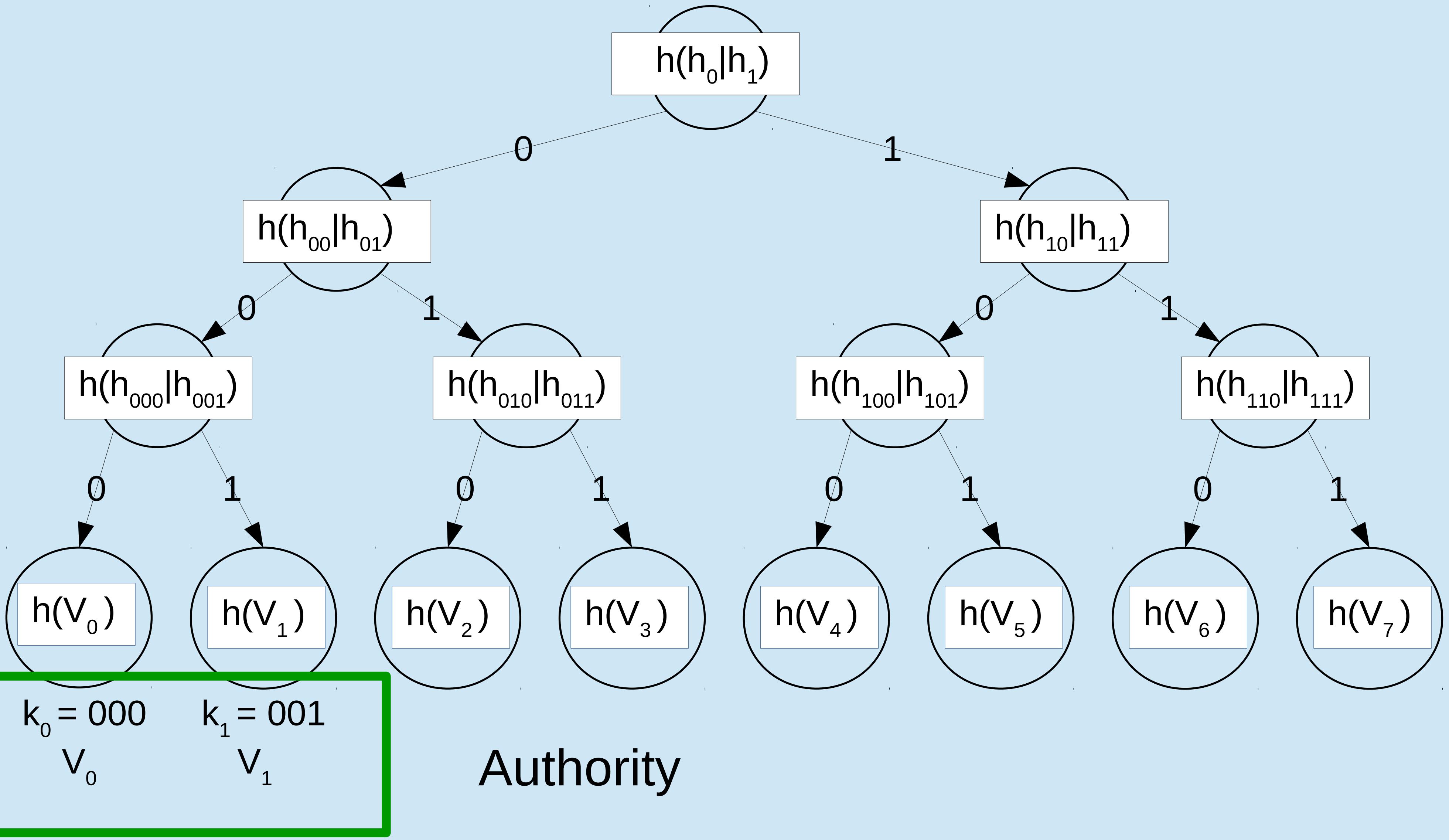

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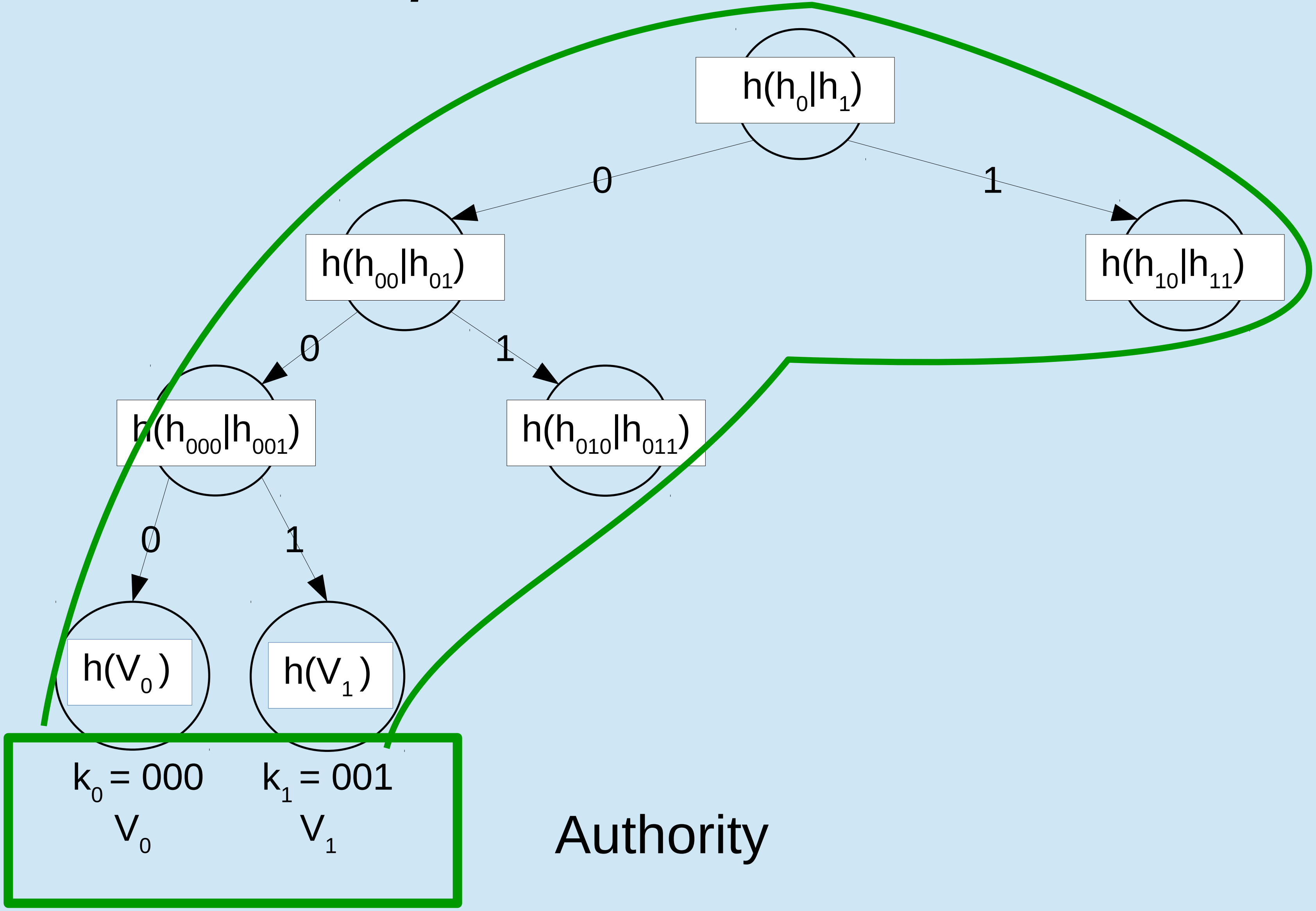
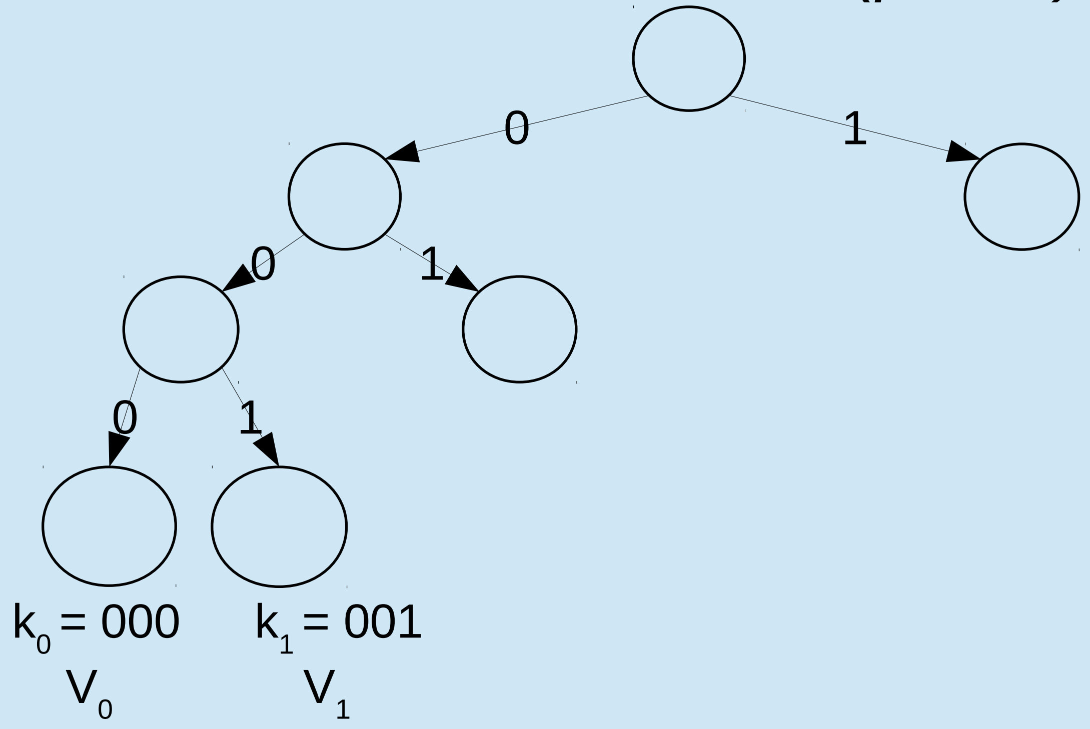


Authority

OUR Storage Role: *the small Ledger*

pruned Authenticated Data Structure *(pADS)*



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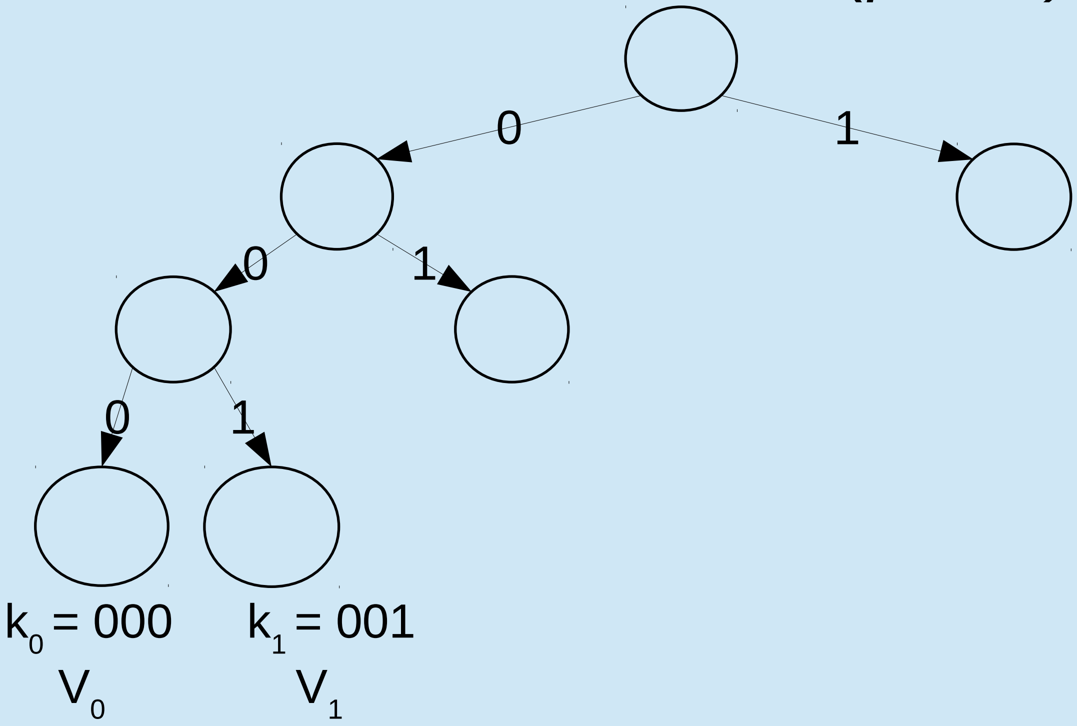

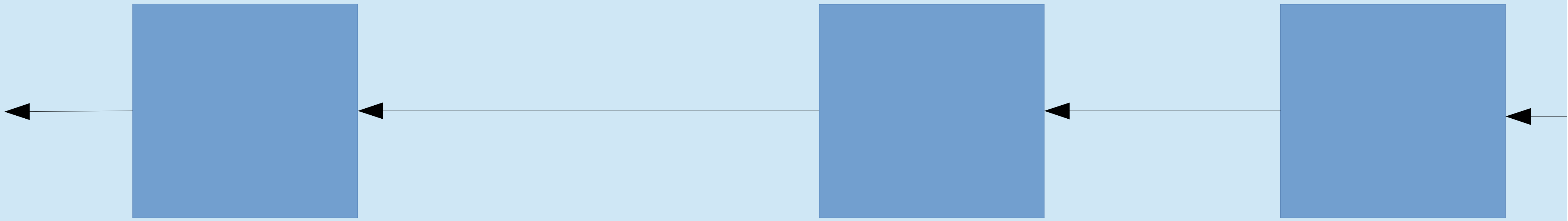

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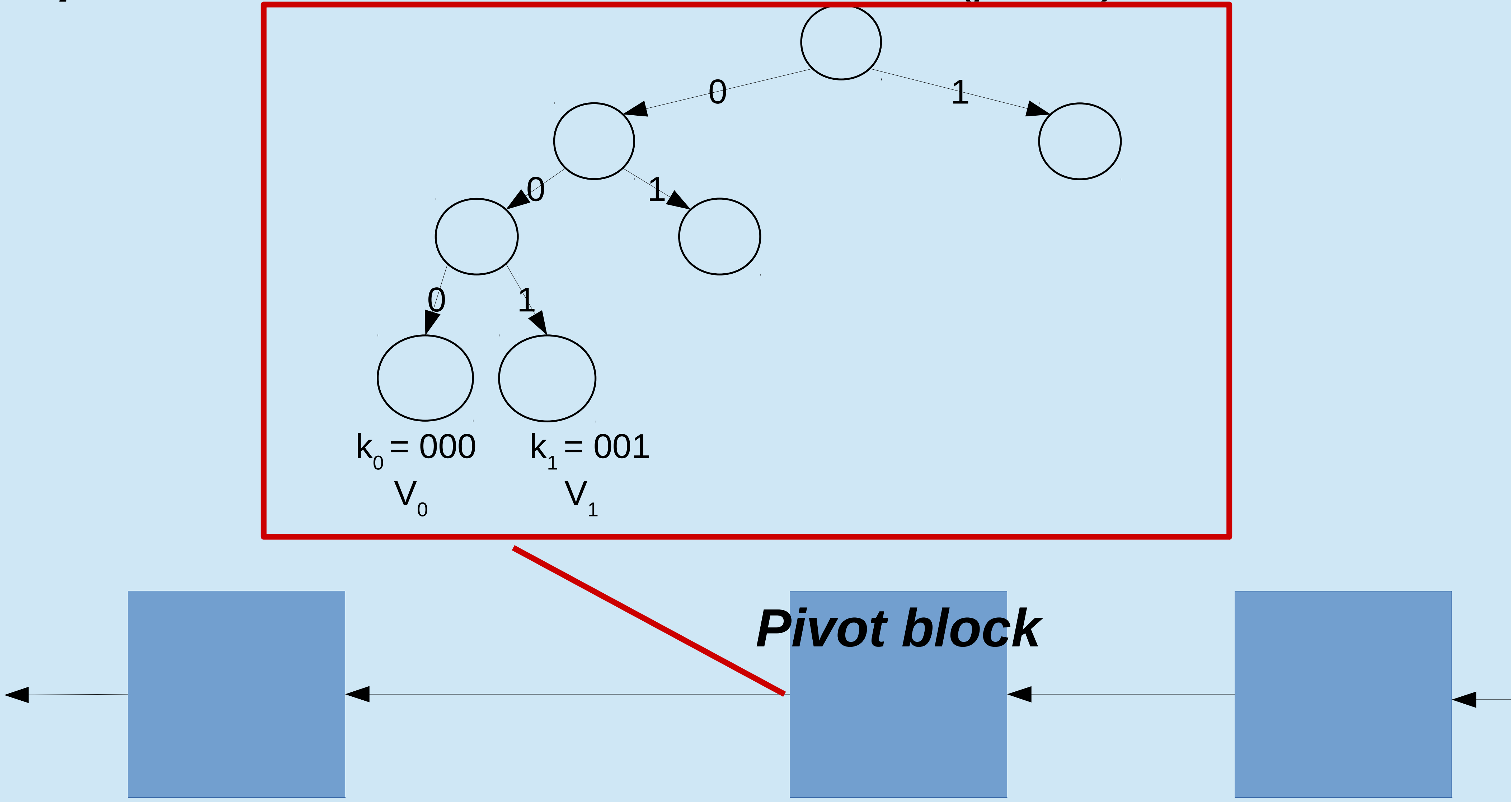

OUR Storage Role: ***Transaction***

Traditional Transaction

- *Sender(s)*
- *Receiver(s)*
- *Operation(s)*
- *Signature(s)*

Key 'a':

→ *Value*

→ *Proof*

→ *number of blo*

Key 'b':

→ *Value*

→ *Proof*

→ *number*

Key 'c':

→ *Value*

→ *Proof*

→ *n. pivot block*

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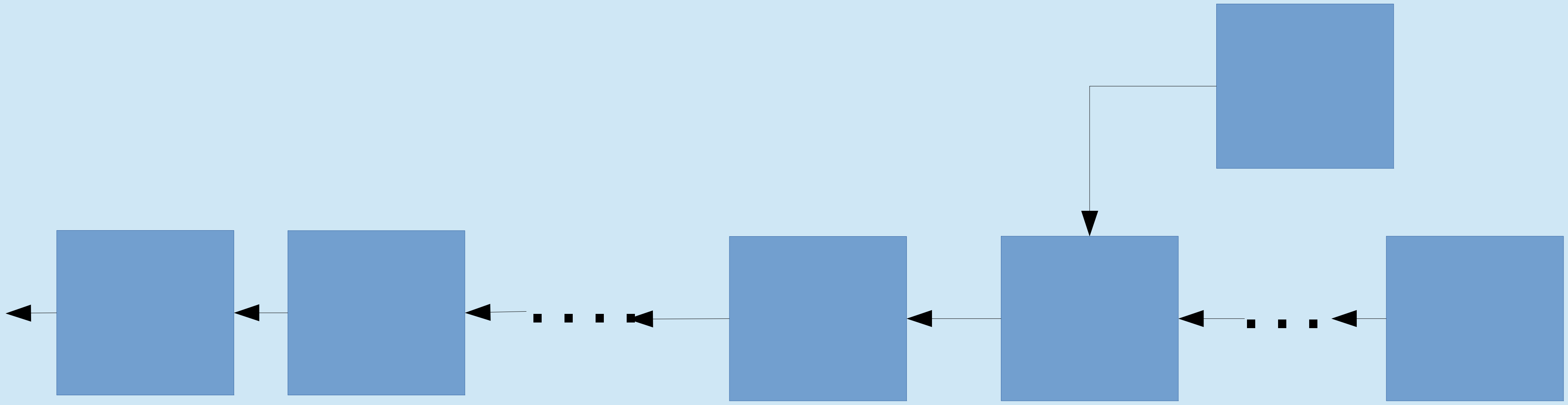
Validation Role

OUR Validation Role: ***truncated*** *blockchain*



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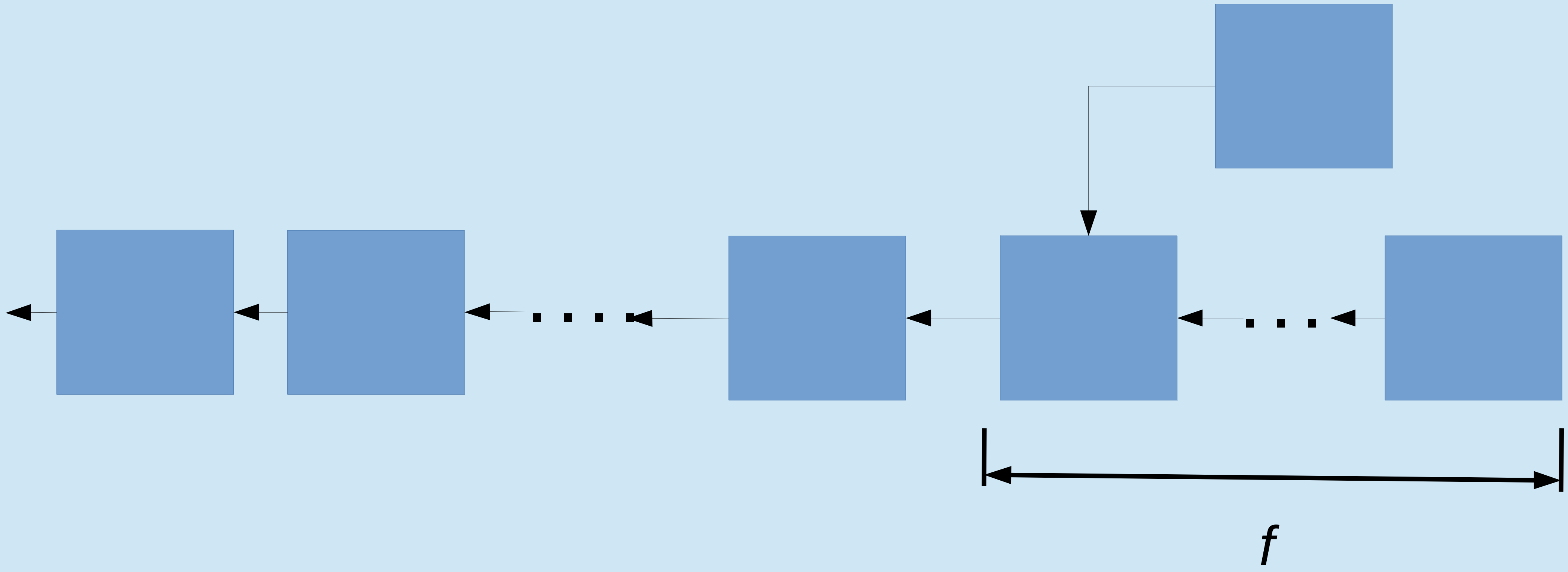
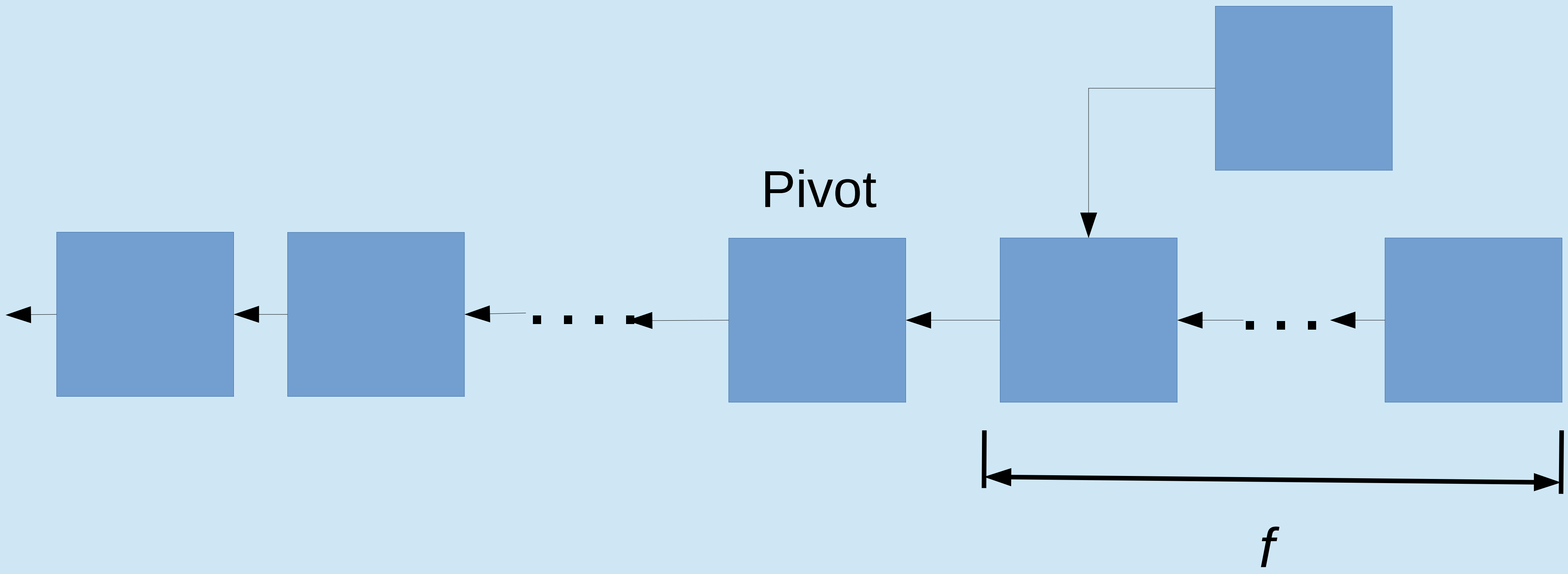


OUR Validation Role: ***truncated** blockchain*



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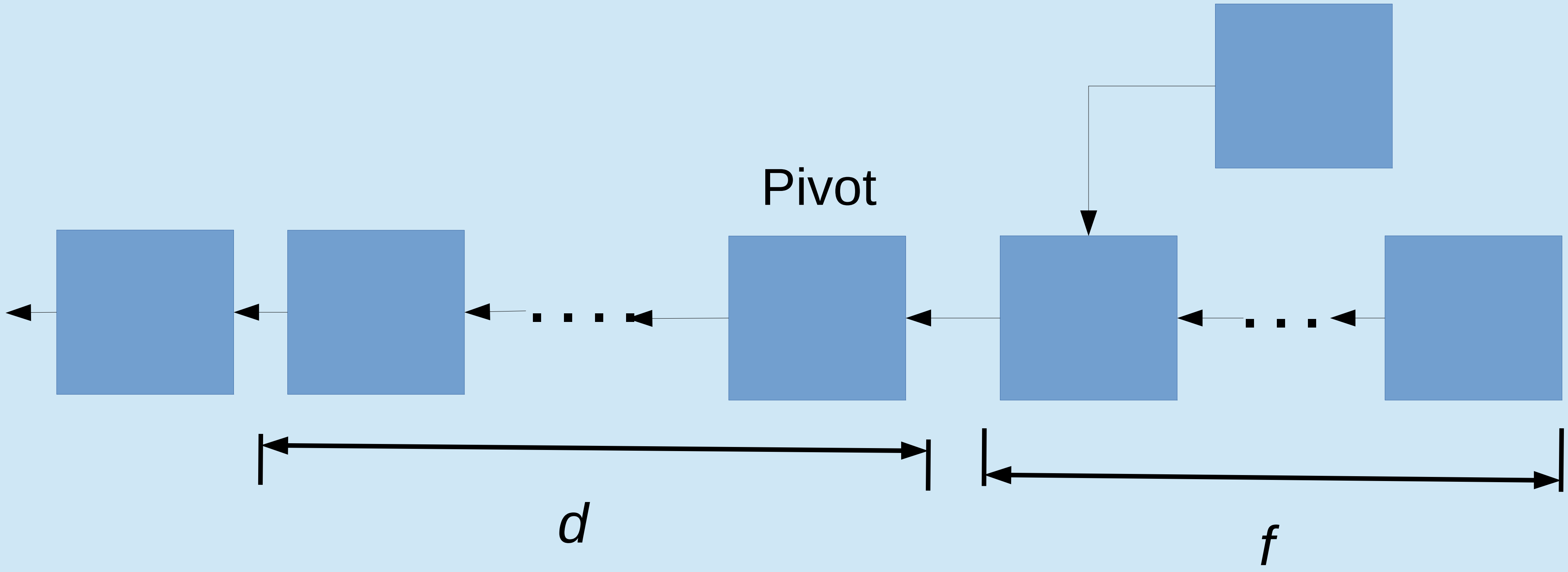

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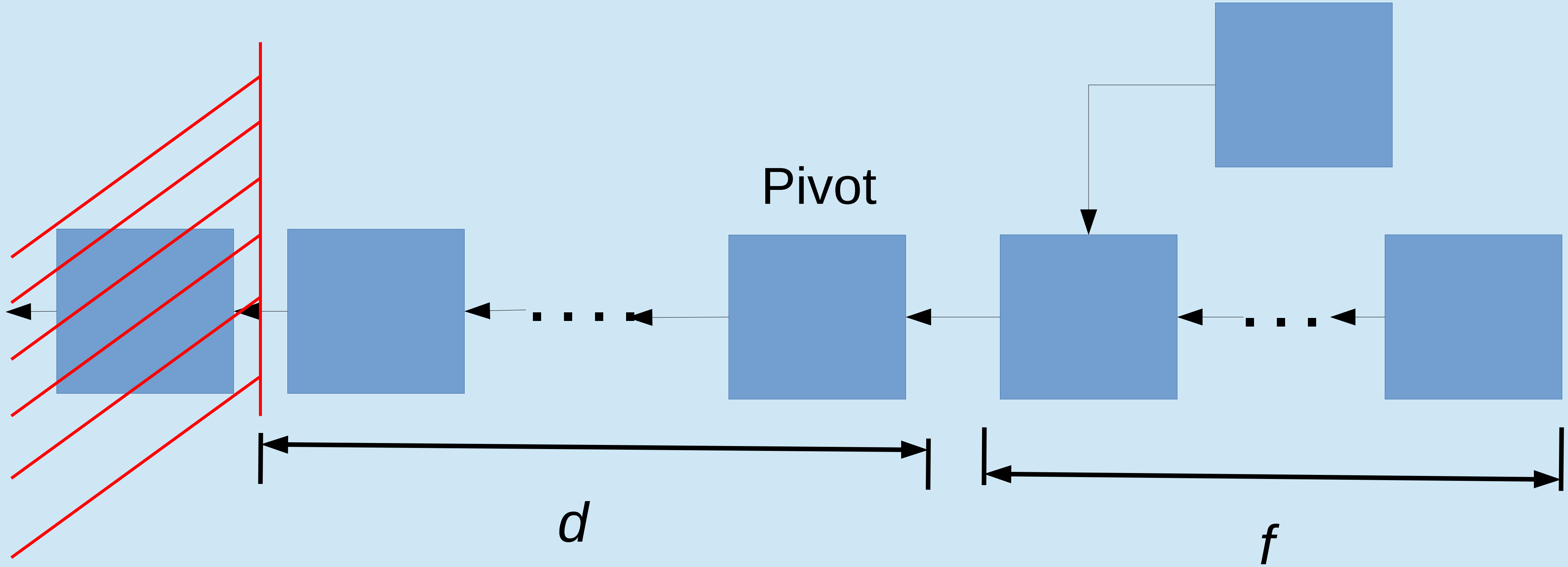
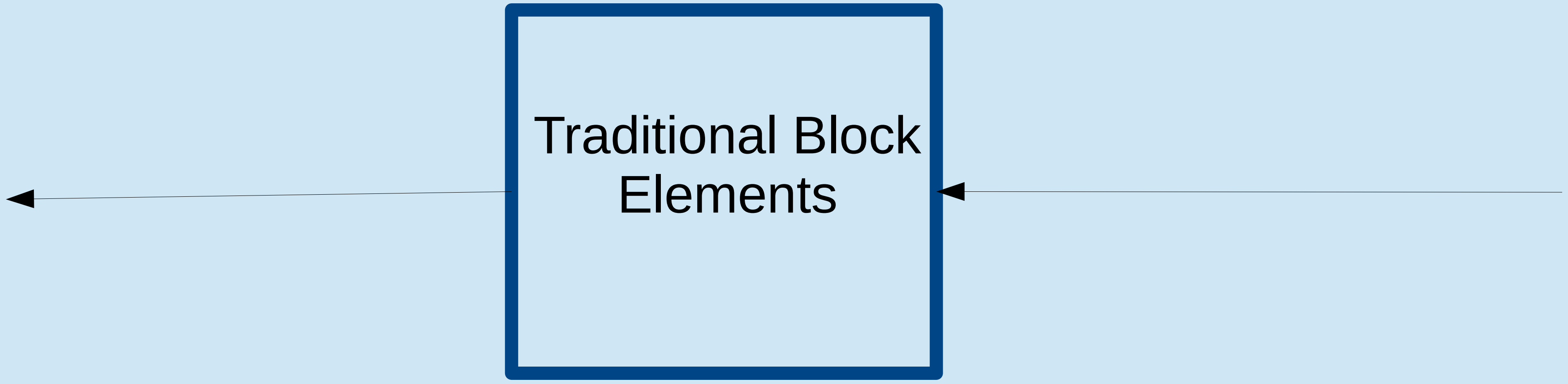


OUR Validation Role: *block schema*



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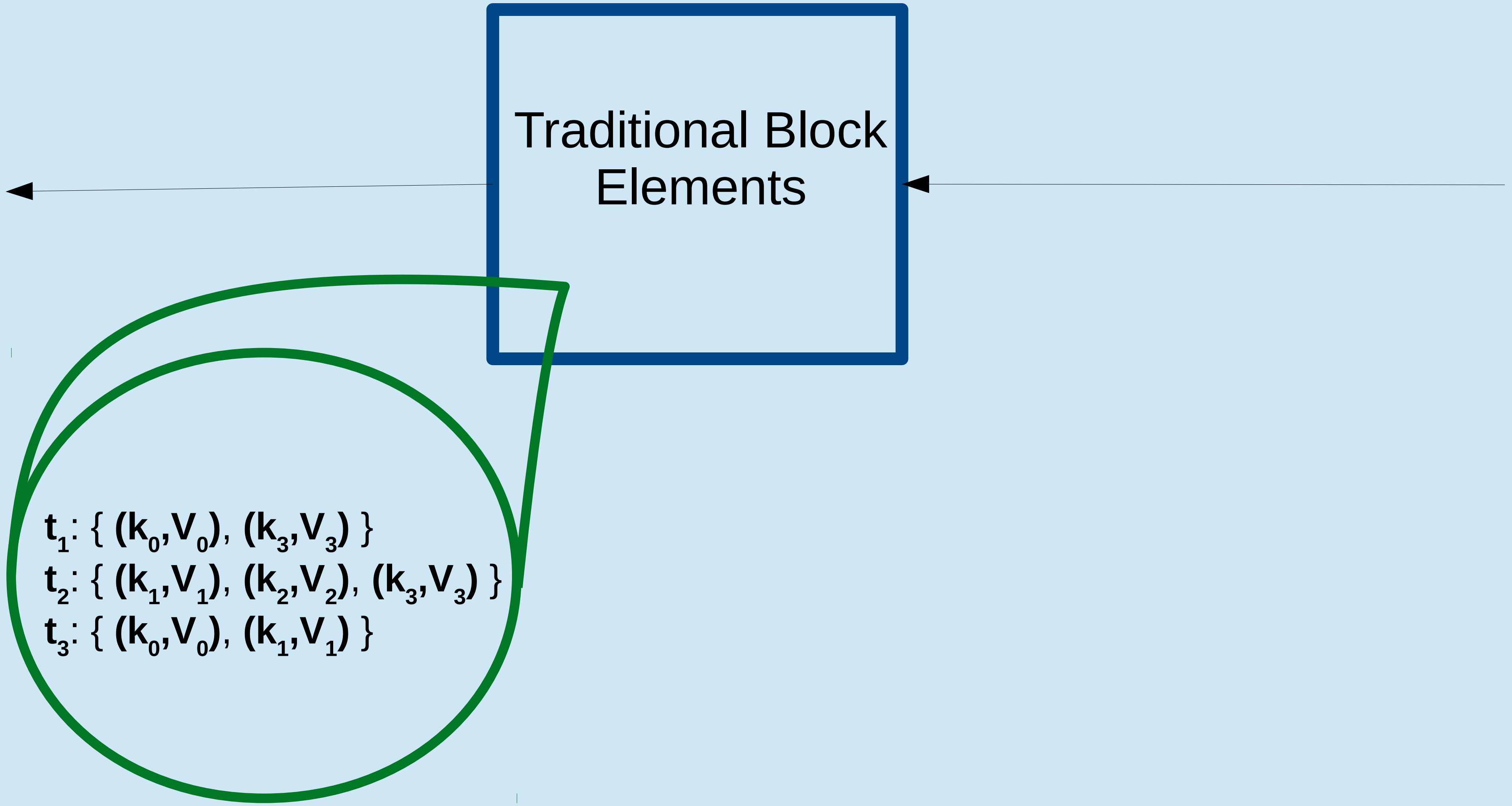
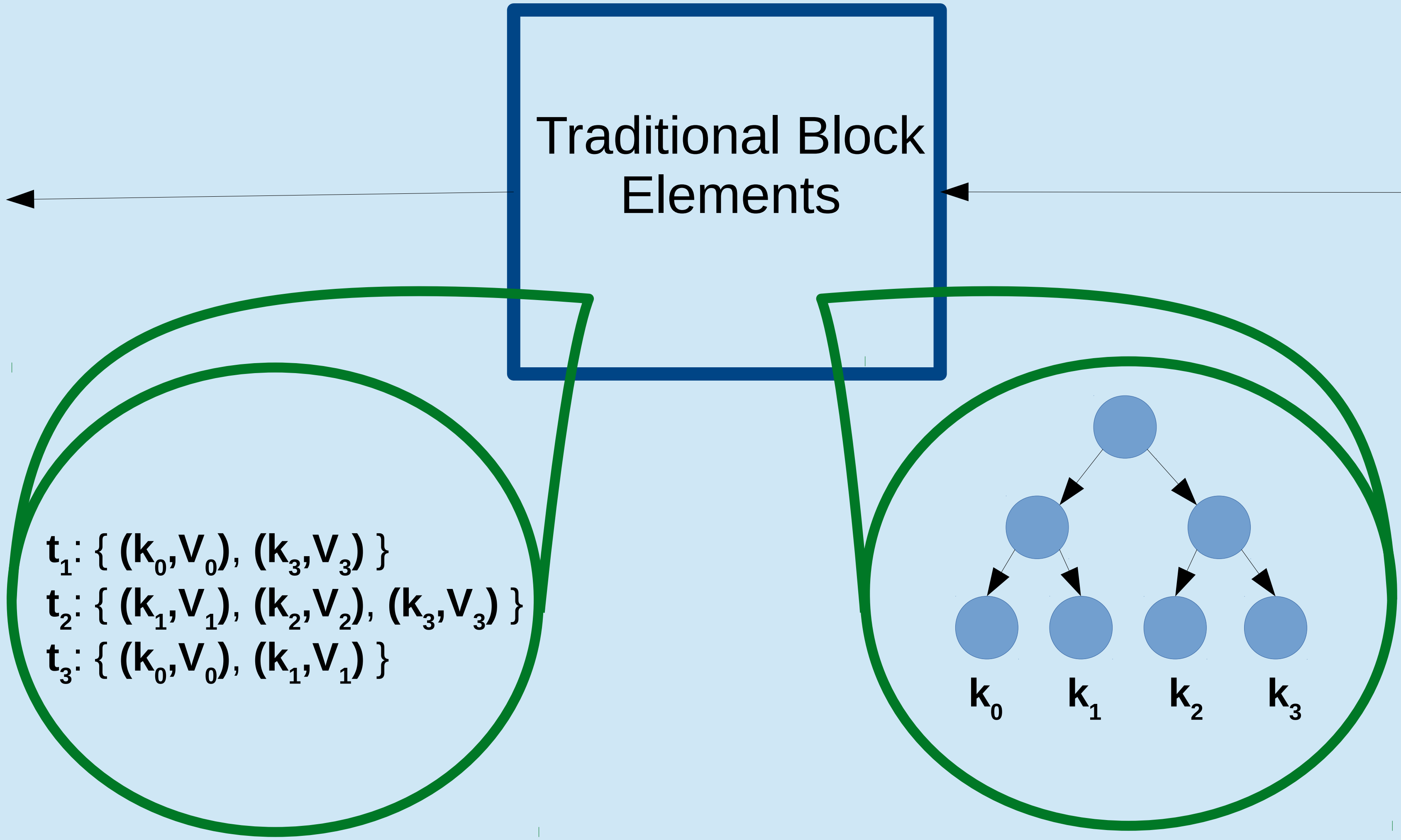


t_1: { (k_0,V_0), (k_3,V_3) }
t_2: { (k_1,V_1), (k_2,V_2), (k_3,V_3) }
t_3: { (k_0,V_0), (k_1,V_1) }

keys involved in transactions with their values

OUR Validation Role: *block schema*



Traditional Block Elements
t_1: { (k_0,V_0), (k_3,V_3) }
t_2: { (k_1,V_1), (k_2,V_2), (k_3,V_3) }
t_3: { (k_0,V_0), (k_1,V_1) }
k_0
k_1
k_2
k_3

keys involved in transactions with their values

pADS **τ**

OUR Validation Role: **Validation** *block*

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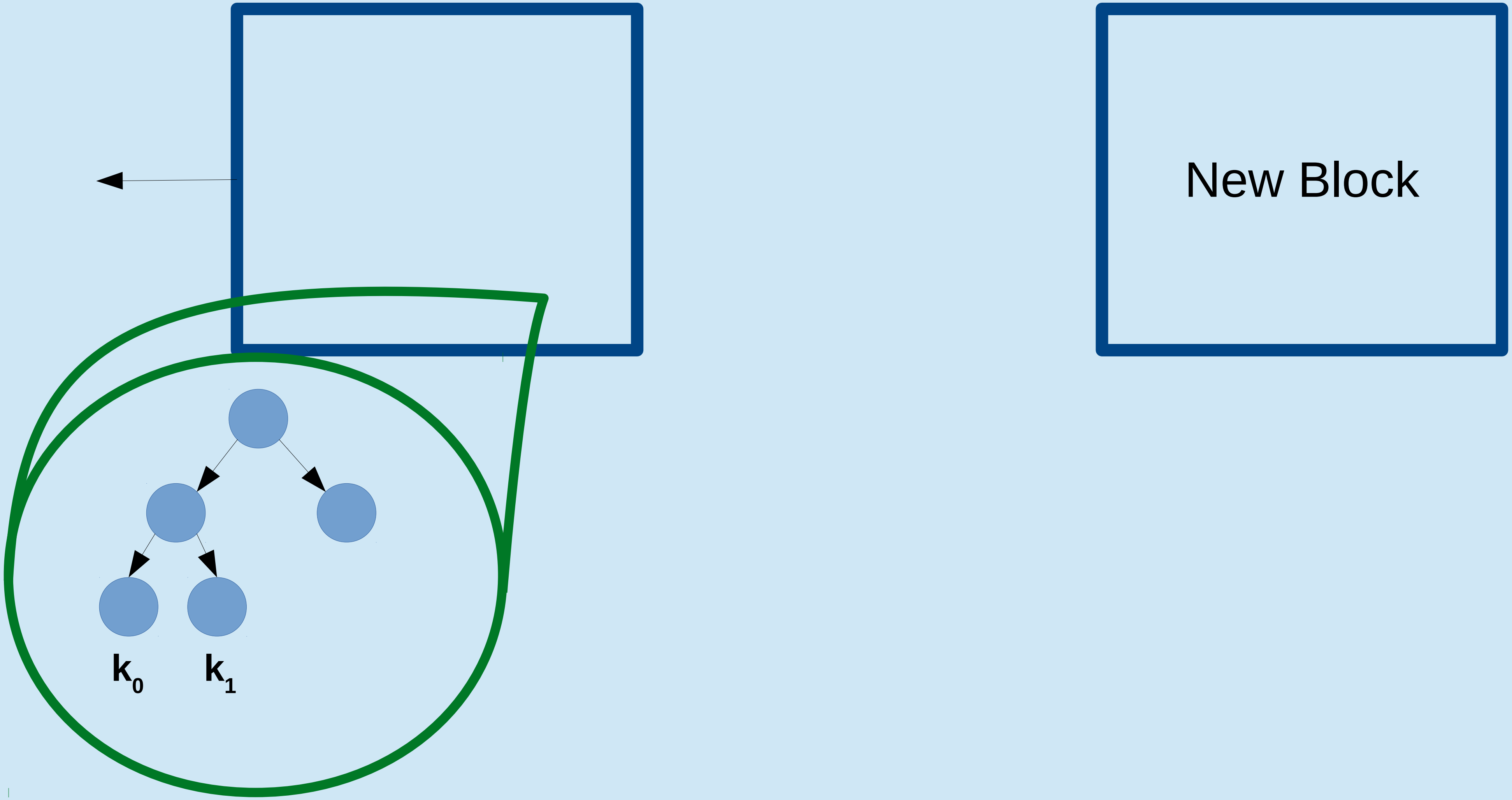

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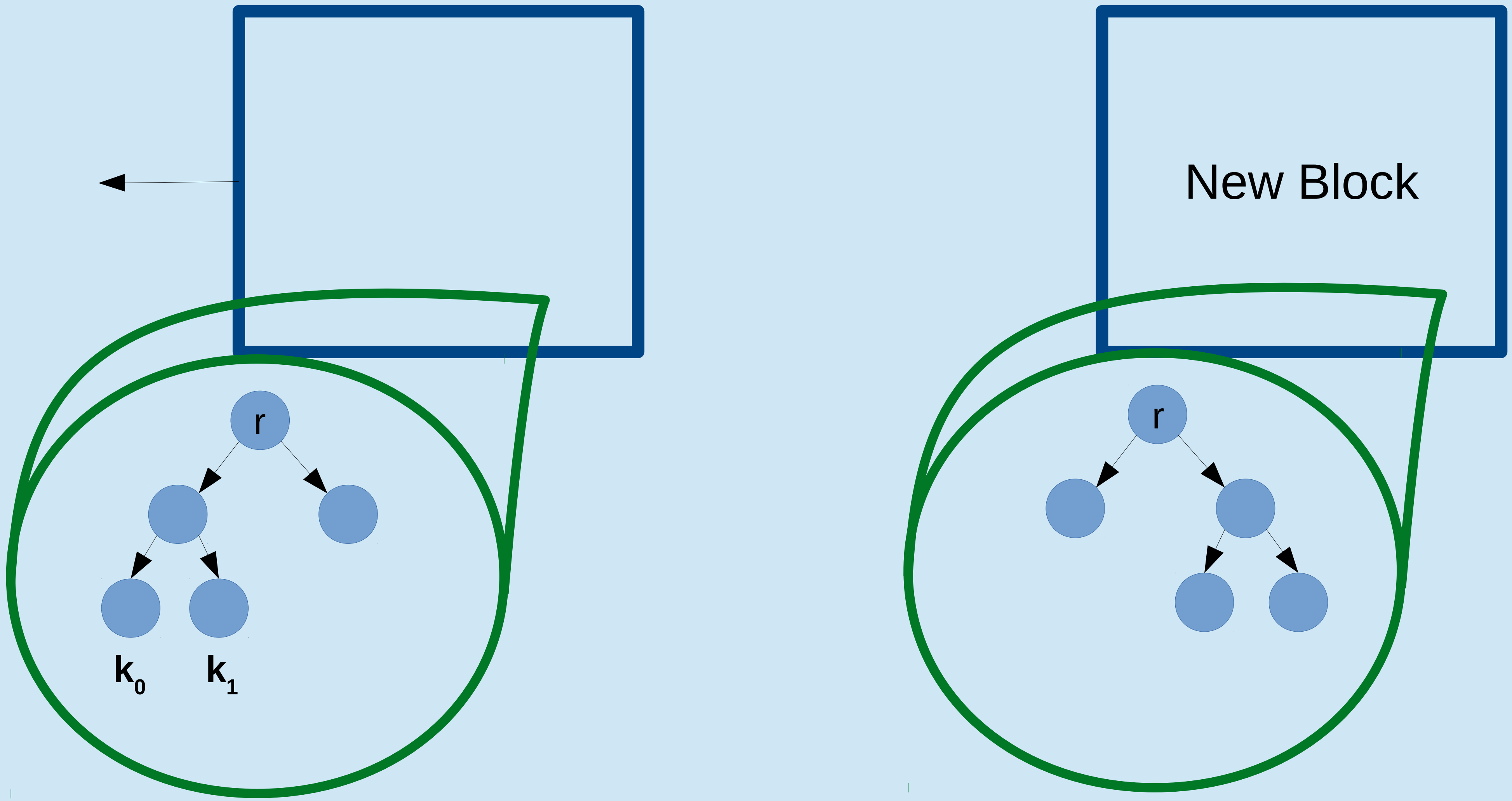

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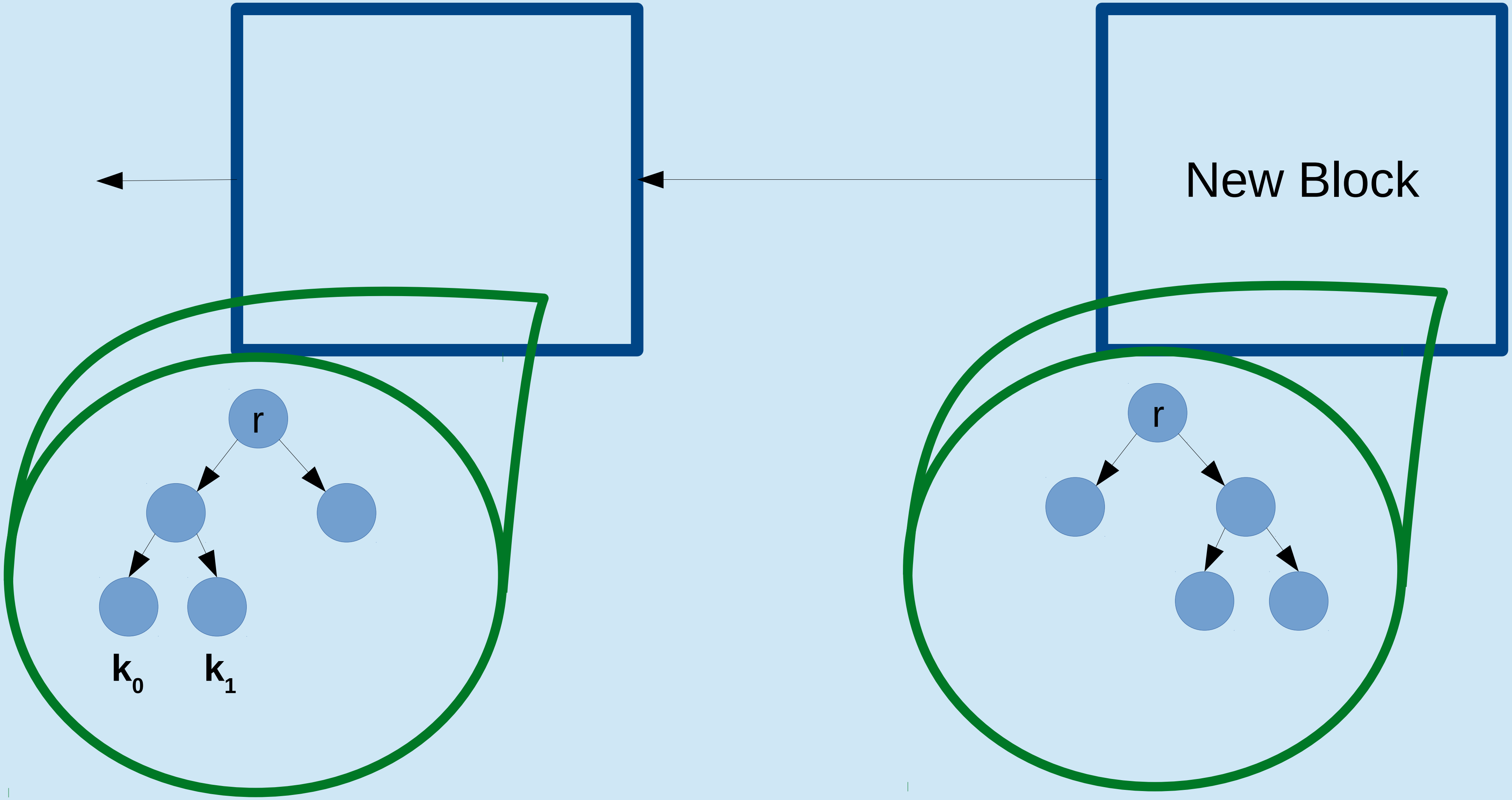

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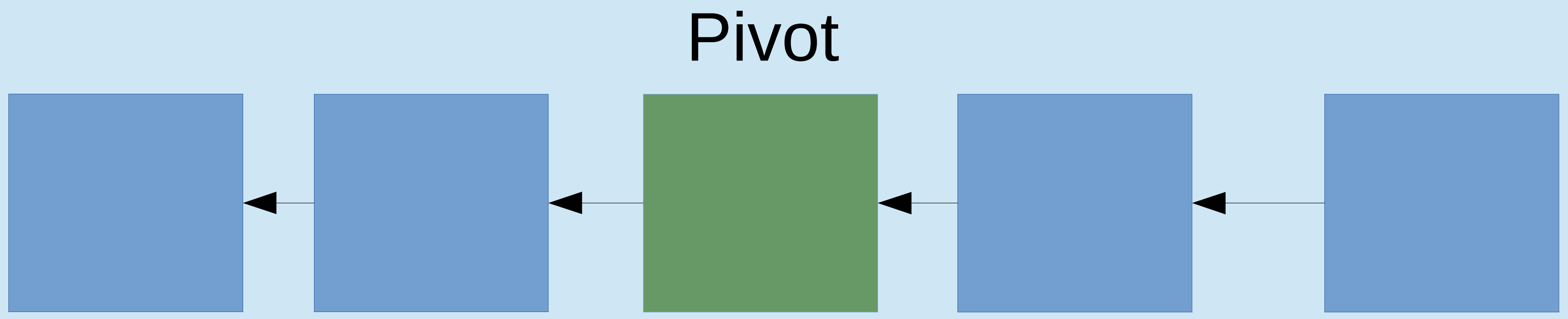

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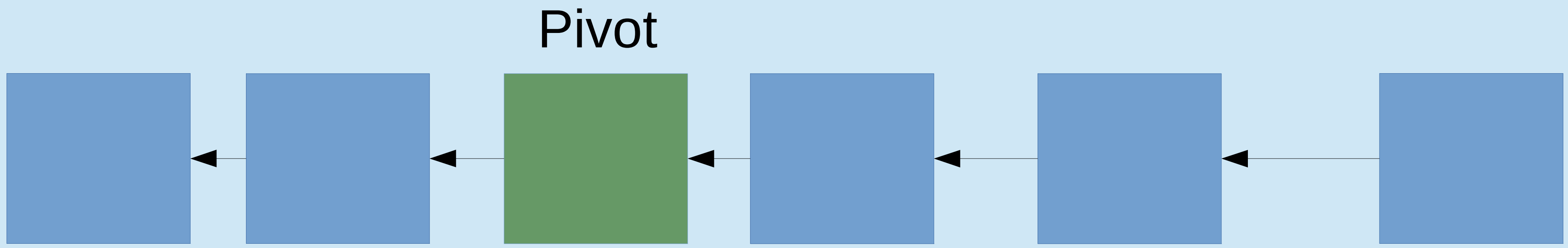

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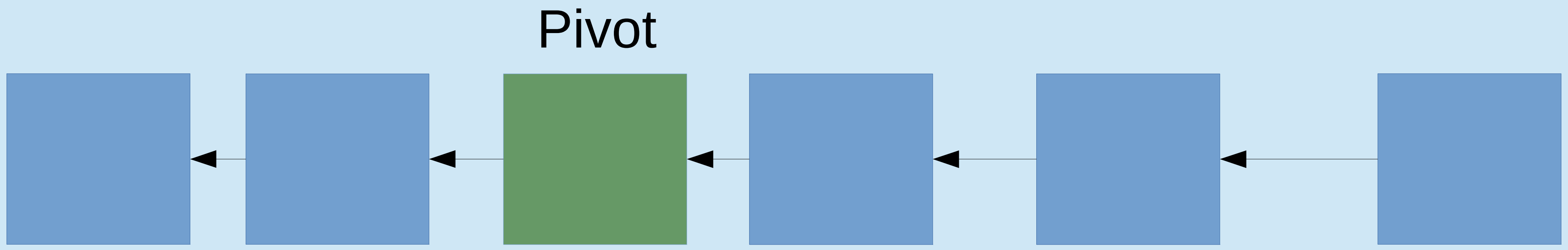

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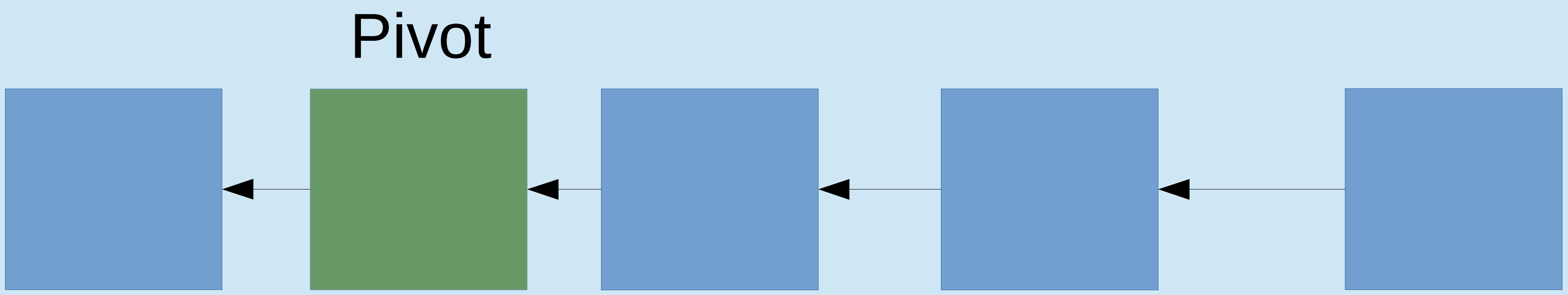
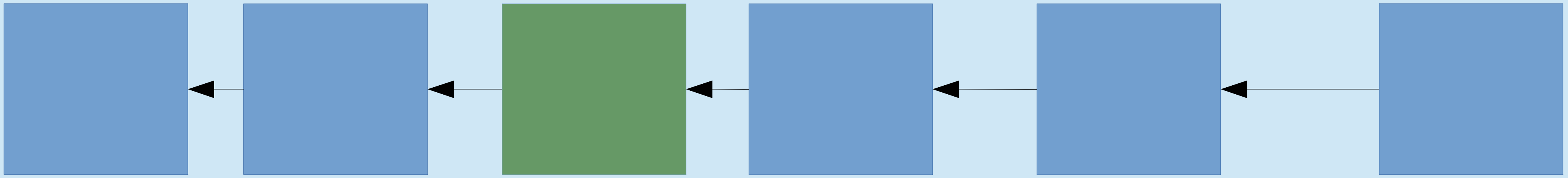


OUR Validation Role: **Mining** *block*



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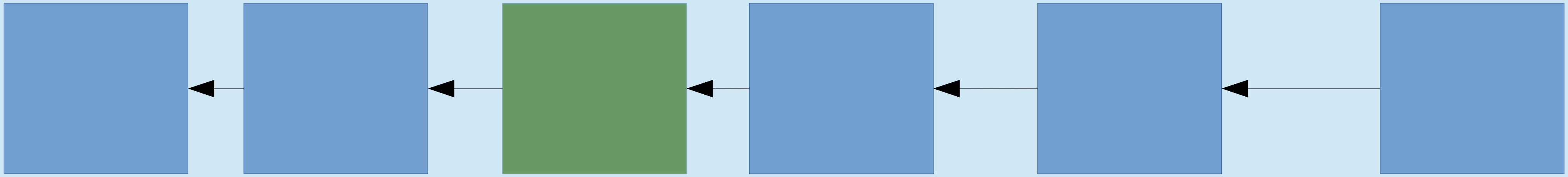

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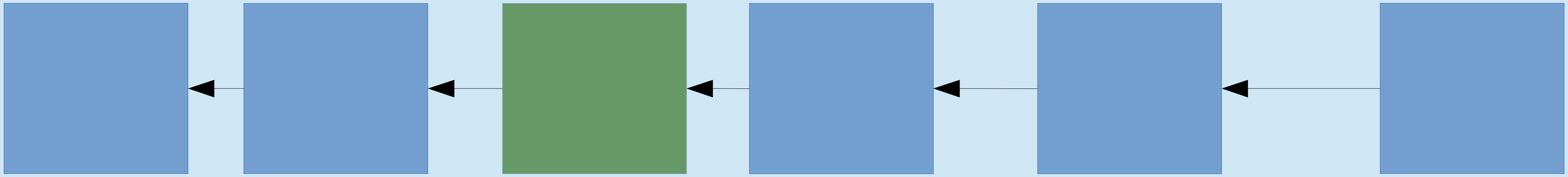

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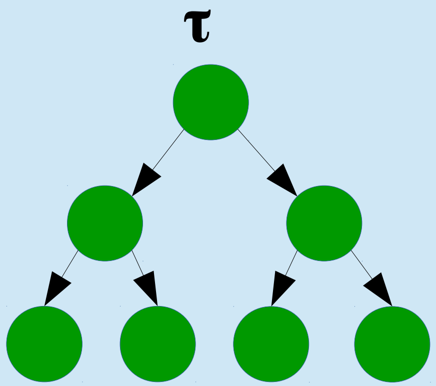

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5. All nodes validate the new block and update their pivot block
6. DHT nodes that are authority for keys involved in the new block also update their pADS

Conclusion and Future works

- Store a small amount of data **(pADS, DHT, truncated chain)**
- Validation without Ledger **(proof and pivot)**
- First synchronization of a node performed in less than a minute

➔ implementation of this approach
➔ extensive tests

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Thank you
for your attention