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RIoE
Rights of Internet of Everything

Towards Decentralized Complex Queries over Distributed Ledgers: a Data Marketplace Use-case

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Overview

Introduction

Distributed Ledger Technologies (DLT) and Decentralized File Storages (DFS)

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- secure transactions between **untrusted parties** through consensus mechanisms
- high data **availability**
- ability to automate and enforce processes (through smart contracts)

Query Issues

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2) there are **no diffused efficient mechanisms to query** a certain type of data, that do not involve **centralization** (e.g. index data in a central database)

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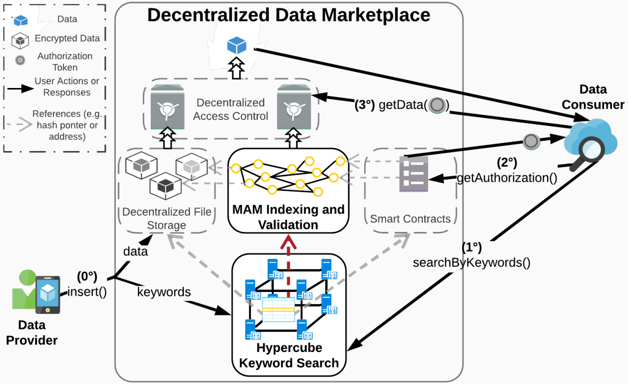
- **Distributed Hash Table (DHT)** as a layer placed over DLTs: DHT $\rightarrow$ distributed data structure that maps "**keys**" into "**values**".
- **Hypercube** to organise the topological structure of such a DHT network.

Use Case

Decentralized Data Marketplace Use Case



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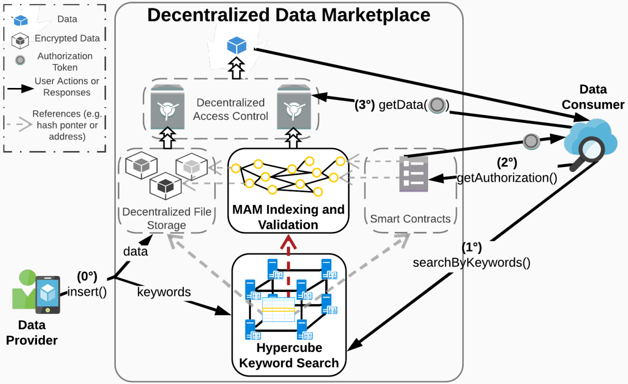

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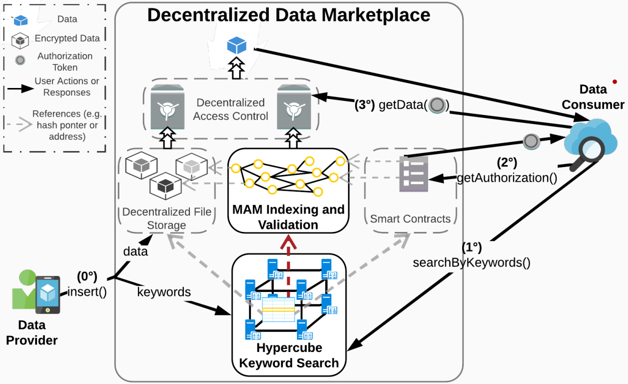

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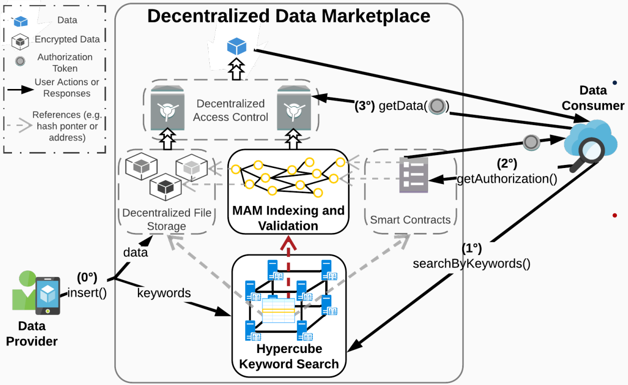

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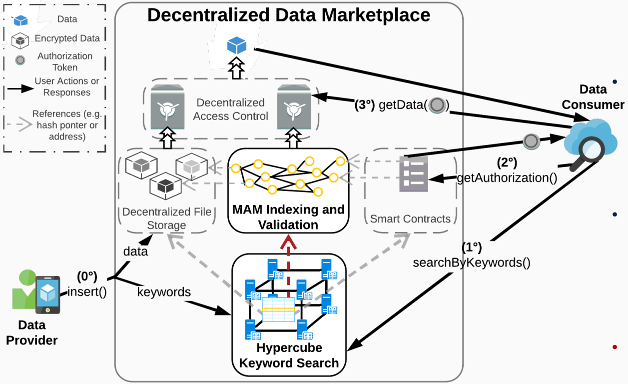

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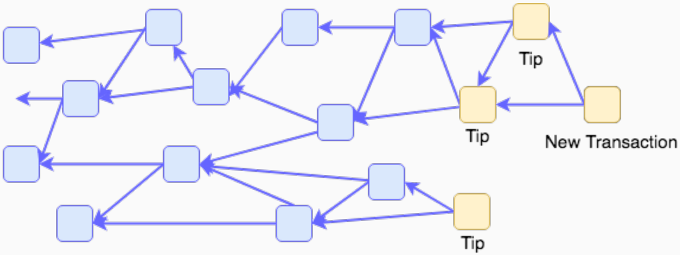
- A **DLT** such as **IOTA** enable the data indexing and validation (in form of hash pointers)

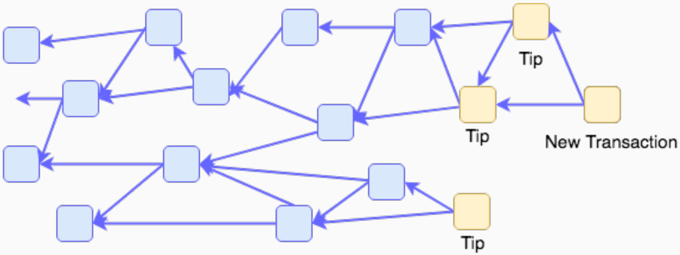
IOTA Masked Authentication Messaging Channels

- **IOTA** → network of nodes that holds a distributed ledger where transactions are validated without fees



IOTA Masked Authentication Messaging Channels

- IOTA → network of nodes that holds a distributed ledger where transactions are validated without fees
- Masked Authenticated Messaging (MAM) → communication protocol that adds the functionality to emit and access an encrypted data channels over IOTA



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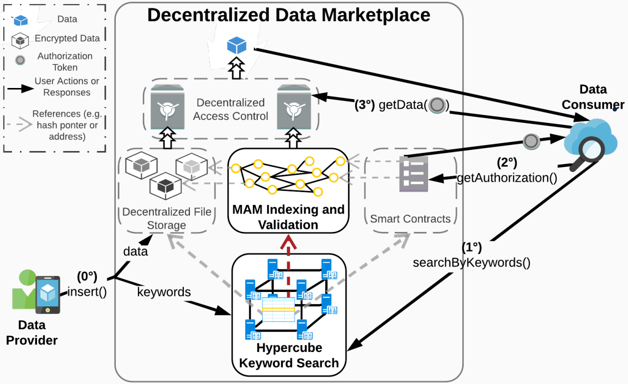
- in our system every single message is indexed by a **keyword set**, that is then exploited to search for specific kinds of contents ⇒

Decentralized Data Marketplace Use Case

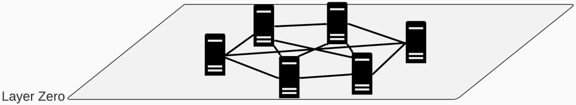


A distributed mechanism for the search of data is in charge of associating keywords to addresses or references stored in DLTs, smart contracts and DFS.

Hypercube DHT

Layer Two Lookup Scheme

- DLT **P2P Network**



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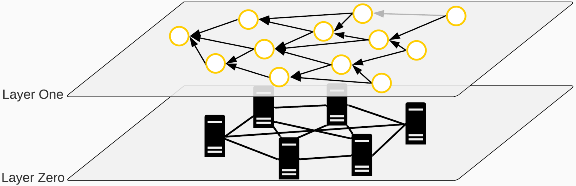

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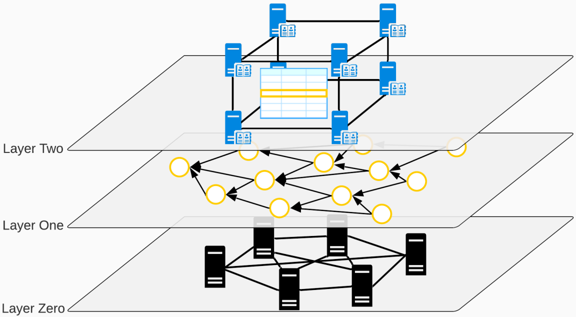
- Layer two solution → MAM messages associated to a **keyword set** in a DHT



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- E.g.: $o = MAM\ msg\ indexed\ by\ QEZ...OBX\ root,\ K = \{temperature, celsius\}$
  $h(temperature) = 3, h(celsius) = 5$
  K is represented by $u = 000101 \Rightarrow$ **DHT stores (000101,*QEZ...OBX*)**

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- to find out how far apart two vertices u and v are $\rightarrow \boldsymbol{HammingDistance}(u, v) = \sum_{i=0}^{r-1}(u_i \oplus v_i)$, $\oplus$ is the XOR operation and u_i is the bit at the i-th position.

Multiple Keywords Search

- **Pin Search** - $\{o \in O \mid K_o = K\}$
  gets all and only the objects associated with a keyword set K
  e.g. *pinSearch({temperature, celsius})* = (*000**101**,QEZ...OBX*), (*000**101**,IHU...9HZ*), ...

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- **Superset Search** - $\{o \in O \mid K_o \supseteq K\}$
  also gets objects that can be described by keywords sets that include K
  e.g. *superSetSearch({temperature, celsius})* = (*000**101**,QEZ...OBX*), (*000**111**,XTL...A9Z*), ...

Performance Evaluation

Test Setup

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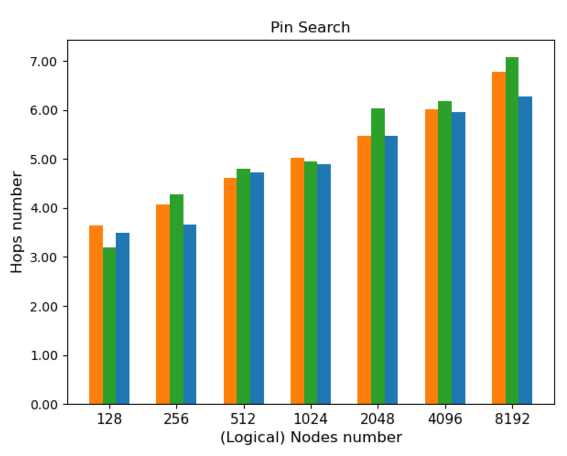
- For each type of test $\rightarrow$ 50 repetitions

Pin Search Results



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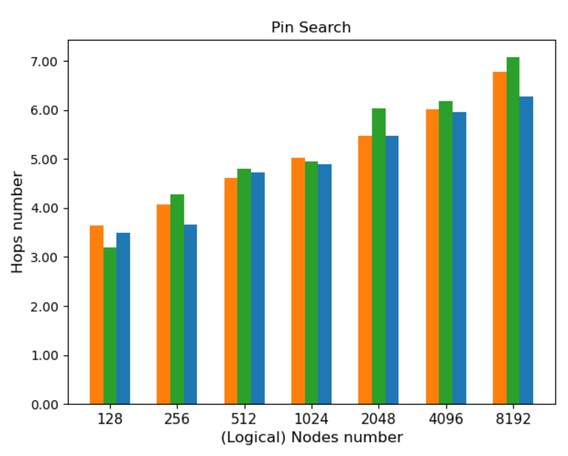

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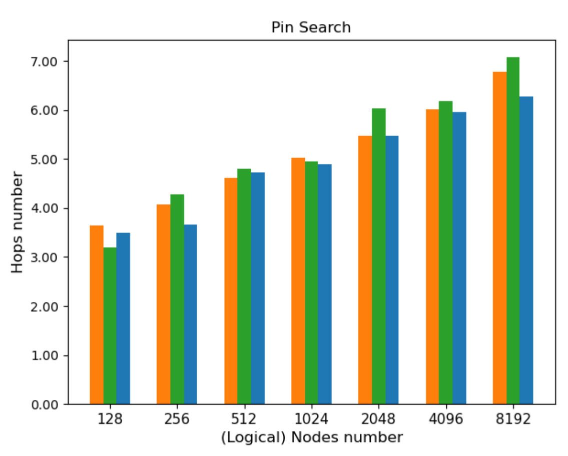

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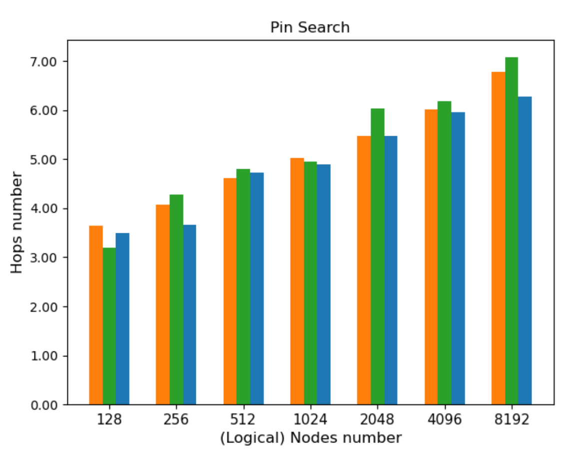

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- from about 3.5 for 128 nodes ($r = 7$)
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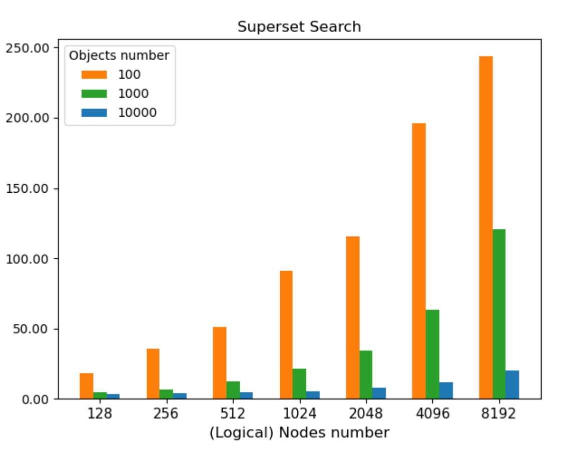
- order of the **logarithm of the hypercube logical nodes number** $\rightarrow \frac{\log(n)}{2} = \frac{r}{2}$

Superset Search Results



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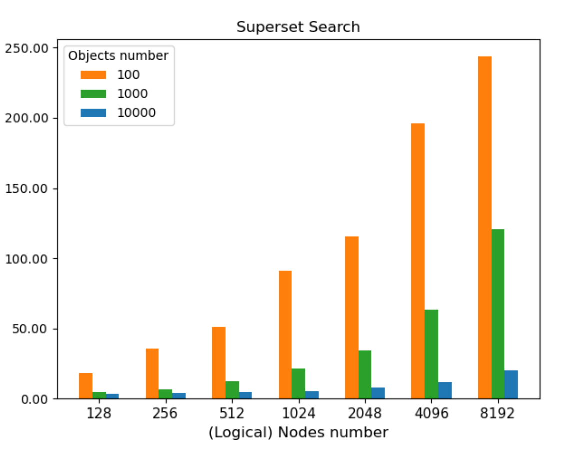

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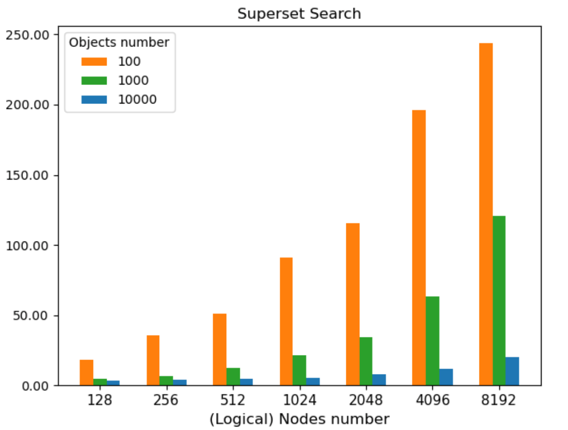

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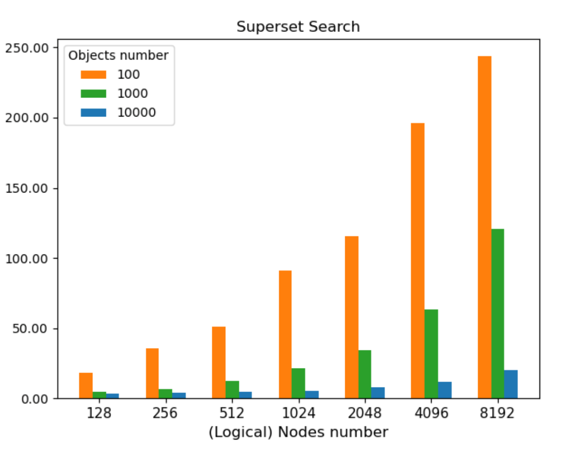

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- order of $\frac{\log(n)}{2} + l$, where l can be set as limit of the nodes number

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- Efficient **trade-off between memory space and response time**