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SciSpace

Towards a Serverless-Style Cloud Service for Scientific Data Lifecycle Management

(Part of the project SCIBDS)

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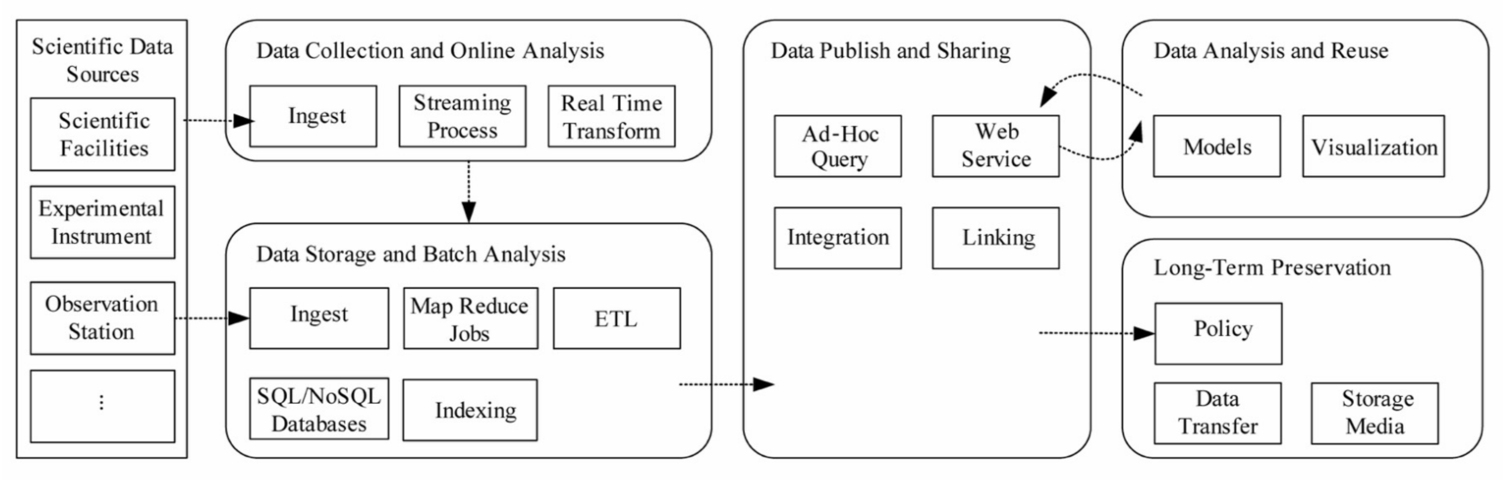
Outline

- Data Lifecycle Management
  - What is
  - Traditional Approach
  - Serverless Approach
- SciSpace: Our Serverless Solution
  - Space: The Unified Serverless UI
  - Packone (Part I): Make Engine Elastic
  - Packone (Part II): Make URI Highly Available
- Conclusion

What is The Data Lifecycle Management



Scientific Data Sources

Scientific Facilities

Experimental Instrument

Observation Station

⋮

Data Collection and Online Analysis

Ingest

Streaming Process

Real Time Transform

Data Storage and Batch Analysis

Ingest

Map Reduce Jobs

ETL

SQL/NoSQL Databases

Indexing

Data Publish and Sharing

Ad-Hoc Query

Web Service

Integration

Linking

Data Analysis and Reuse

Models

Visualization

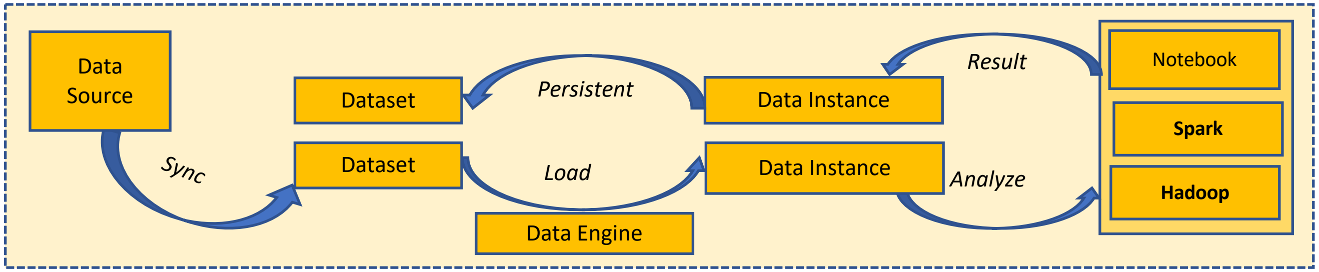
Long-Term Preservation

Policy

Data Transfer

Storage Media

Rethink:



Data Source

Sync

Dataset

Dataset

Persistent

Load

Data Engine

Data Instance

Data Instance

Result

Analyze

Notebook

Spark

Hadoop

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Data Lifecycle Management: The Traditional Approach

- Data sources and scientists are scattered in different locations/clouds
  - data analysis always need to access remote data stores
  - data trans between Heterogenous Infrastructure are complicated
- No unified data lifecycle management environment
  - Scientists need to using different level UI to access data or computing powers
    - SSH/FTP/HDFS/S3/
  - Dataset or analysis results can hardly be referenceable by peers

Data Lifecycle Management: The Serverless Approach

What

- A unified data lifecycle management environment
  - Data Sync/Load/Share
  - Data Query/Analysis
- Server location is insignificant
- Server login is not required

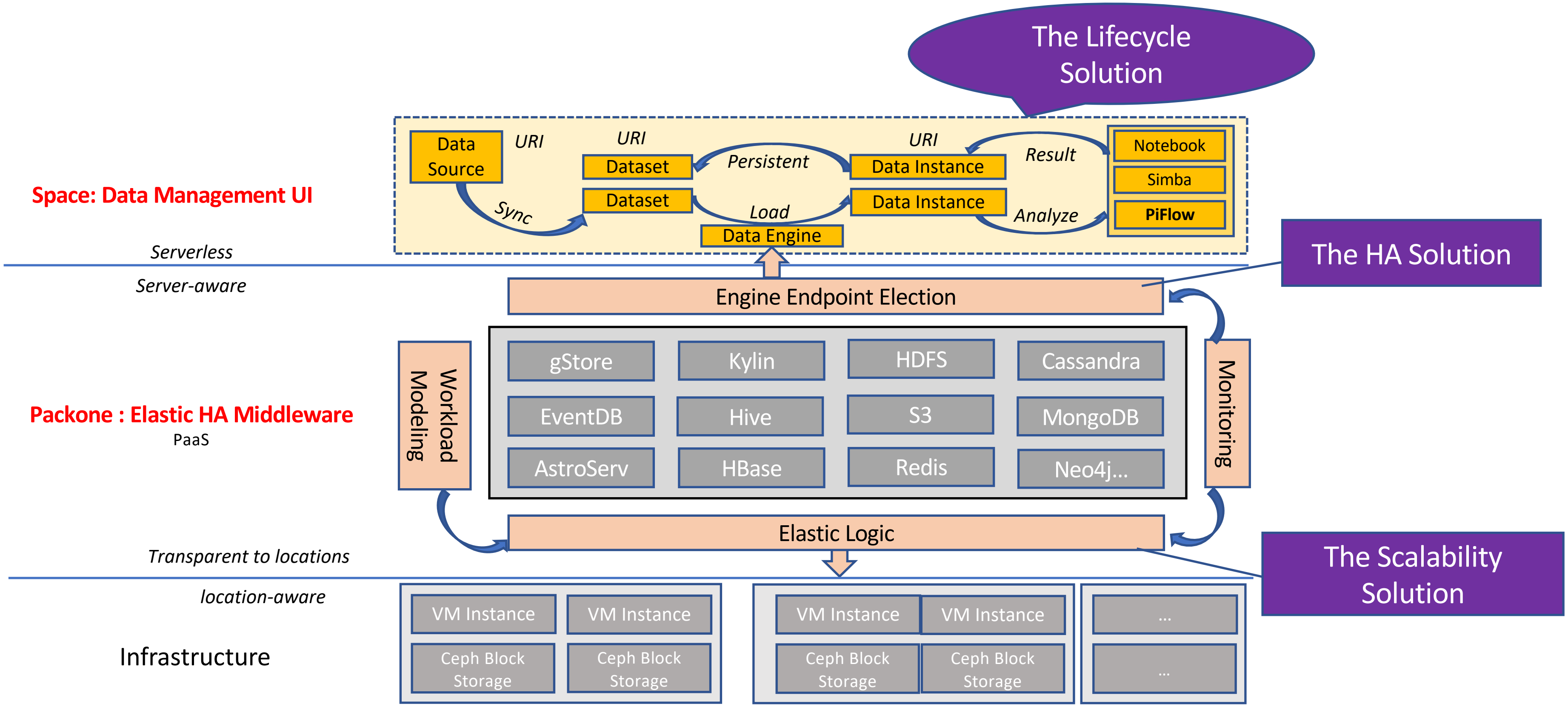
Advantages

- Liberate Scientists

Challenges

- The lifecycle challenge
  - How to takeover data lifecycle management
    - without direct interactions with underlying servers
- The scalability challenge
  - How to automatically scale computing infrastructure
    - to meet the performance constraints
- The HA challenge
  - How to tolerant server failures
    - to keep service highly available

SciSpace: Our Serverless Data Lifecycle Management Service



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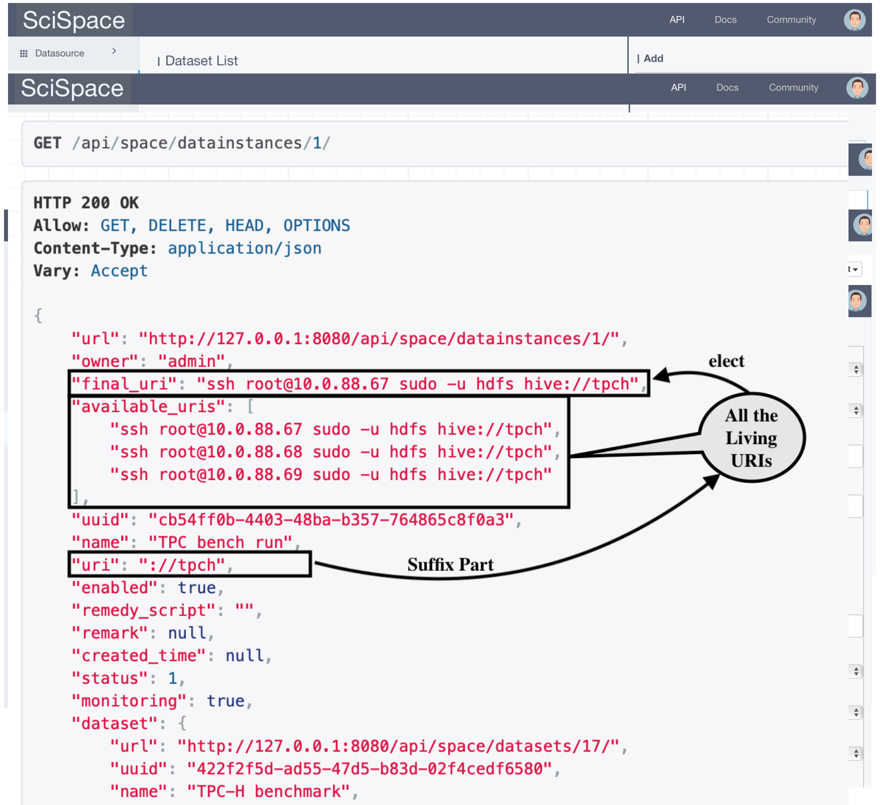
Space: The Unified Serverless UI

- Easy to share dataset
- Dataset can be loaded into data instances multiple times
- Using the URI field to talk with each other.
- Monitor underlying computing resource located anywhere

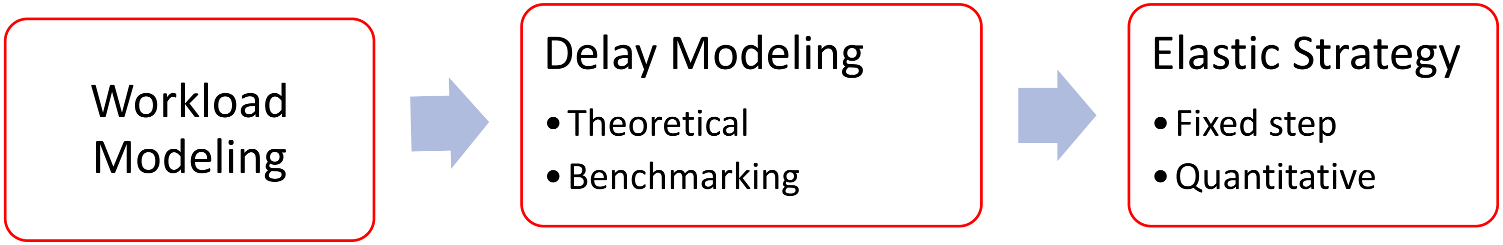


```
GET /api/space/datainstances/1/

HTTP 200 OK
Allow: GET, DELETE, HEAD, OPTIONS
Content-Type: application/json
Vary: Accept

{
    "url": "http://127.0.0.1:8080/api/space/datainstances/1/",
    "owner": "admin",
    "final_uri": "ssh root@10.0.88.67 sudo -u hdfs hive://tpch",
    "available_uris": [
        "ssh root@10.0.88.67 sudo -u hdfs hive://tpch",
        "ssh root@10.0.88.68 sudo -u hdfs hive://tpch",
        "ssh root@10.0.88.69 sudo -u hdfs hive://tpch"
    ],
    "uuid": "cb54ff0b-4403-48ba-b357-764865c8f0a3",
    "name": "TPC bench run",
    "uri": "://tpch",
    "enabled": true,
    "remedy_script": "",
    "remark": null,
    "created_time": null,
    "status": 1,
    "monitoring": true,
    "dataset": {
        "url": "http://127.0.0.1:8080/api/space/datasets/17/",
        "uuid": "422f2f5d-ad55-47d5-b83d-02f4cedf6580",
        "name": "TPC-H benchmark",
```

Packone: Make Engine Elastic



Workload Modeling

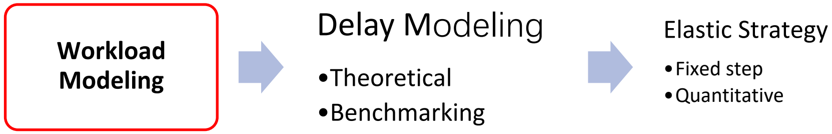
Delay Modeling

- Theoretical
- Benchmarking

Elastic Strategy

- Fixed step
- Quantitative

Packone: Make Engine Elastic

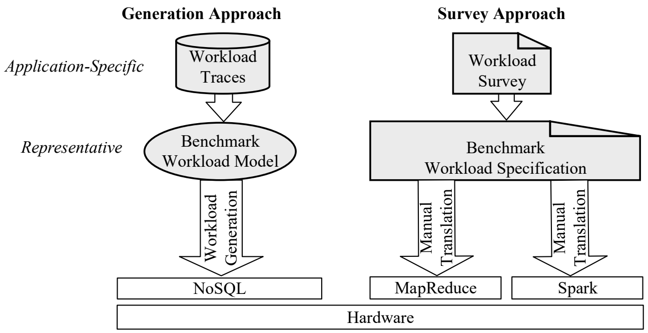


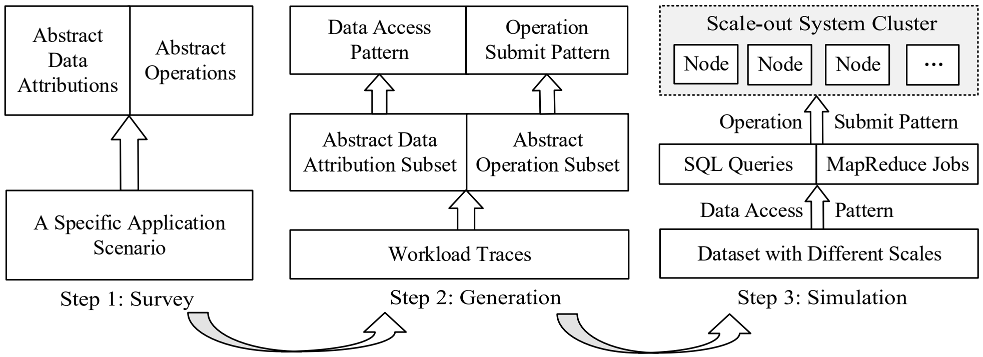
Workload Modeling

Delay Modeling
- Theoretical
- Benchmarking

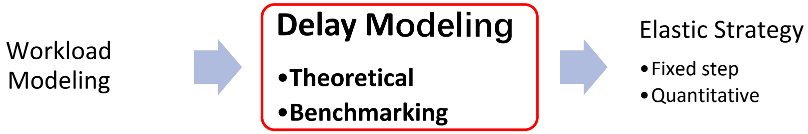
Elastic Strategy
- Fixed step
- Quantitative

- Survey Approach
  - Portable but easy to be retired
- Generation Approach
  - Up to date but engine dependent
- Our Evolutionary Approach
  - Portable
  - Up to date
  - Engine independent





Packone: Make Engine Elastic

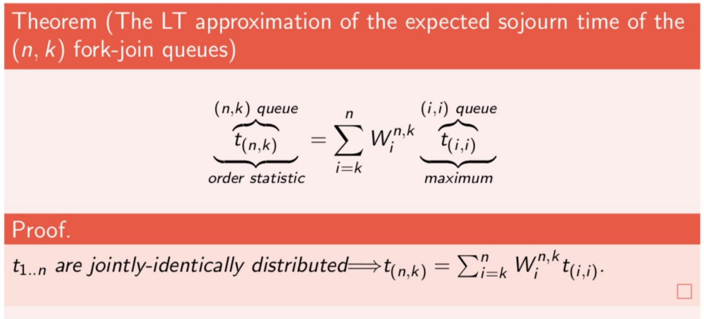


Workload Modeling

Delay Modeling
- Theoretical
- Benchmarking

Elastic Strategy
- Fixed step
- Quantitative

- **Theoretical**: LT approx. depicted how node qty. replication factor & consistency level affect the operation delay

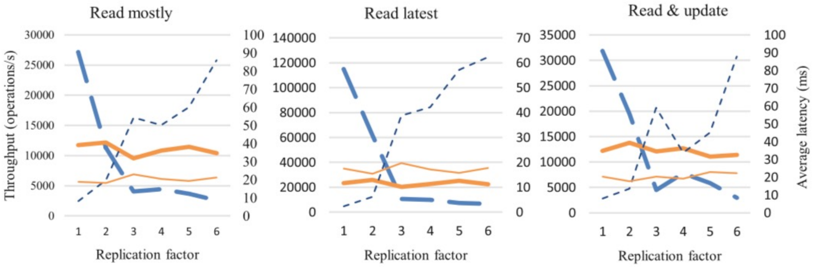


Theorem (The LT approximation of the expected sojourn time of the (n, k) fork-join queues)

$$\underbrace{\overbrace{t_{(n,k)}}^{(n,k)\text{ queue}}}_{\text{order statistic}} = \sum_{i=k}^{n} W_i^{n,k} \underbrace{\overbrace{t_{(i,i)}}^{(i,i)\text{ queue}}}_{\text{maximum}}$$

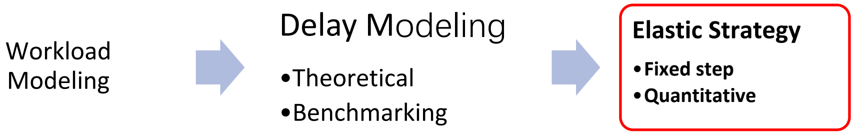
Proof.

$t_{1..n}$ are jointly-identically distributed $\Longrightarrow t_{(n,k)} = \sum_{i=k}^{n} W_i^{n,k} t_{(i,i)}$. □



- **Benchmarking** gives the real delay of the target engine
- **Real-life delay ≈ {Benchmarking@Workload Model} × Theoretical**

Packone: Make Engine Elastic



Workload Modeling

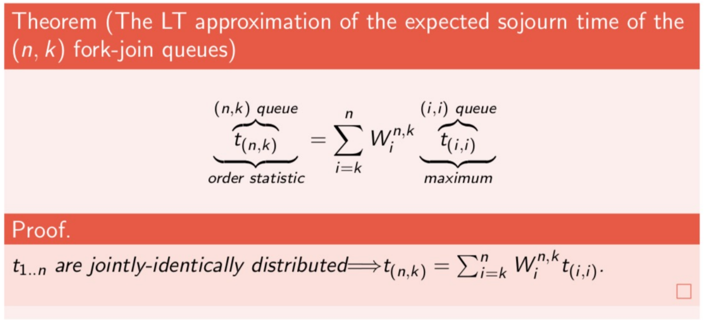
Delay Modeling

- Theoretical
- Benchmarking

Elastic Strategy

- **Fixed step**
- **Quantitative**

- Elastic Strategies to keep a satisfactory delay
  - Fixed Step: Easy to employ but low-precision
  - Quantitative: Fast-forward but hard to calculate
  - Our Mixed Strategy
    - Beginning: Fixed Step
    - Ending: Quantitative



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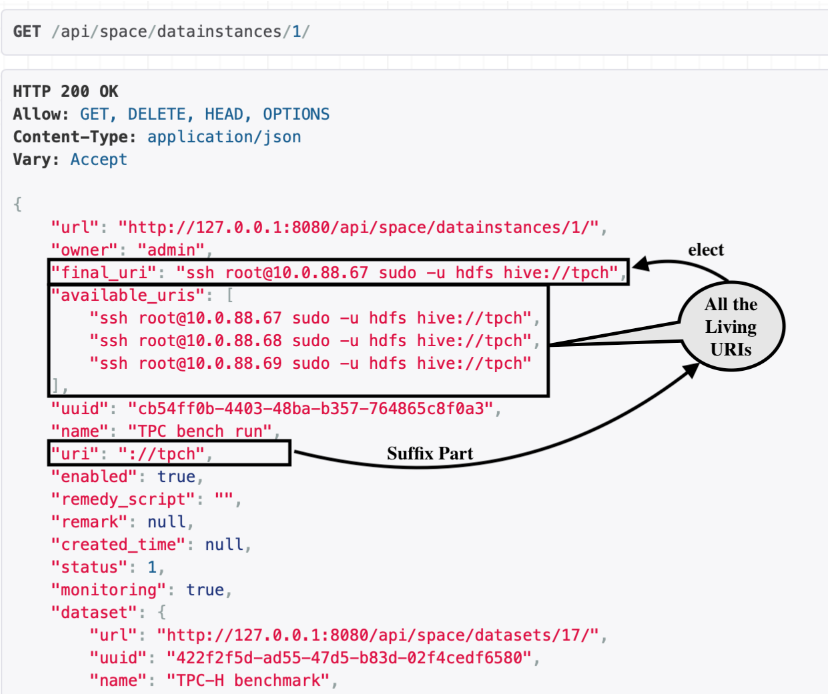
Proof.

$t_{1..n}$ *are jointly-identically distributed* $\Longrightarrow t_{(n,k)} = \sum_{i=k}^{n} W_i^{n,k} t_{(i,i)}$. □

Packone: Make URI Highly Available

- Restful API
- Realtime available URI set
- URI Election Strategy
  - Naïve: Pick out the 1st living one
  - Load balance (TODO)
  - Round Robin (TODO)



```
GET /api/space/datainstances/1/
```

```
HTTP 200 OK
Allow: GET, DELETE, HEAD, OPTIONS
Content-Type: application/json
Vary: Accept

{
    "url": "http://127.0.0.1:8080/api/space/datainstances/1/",
    "owner": "admin",
    "final_uri": "ssh root@10.0.88.67 sudo -u hdfs hive://tpch",
    "available_uris": [
        "ssh root@10.0.88.67 sudo -u hdfs hive://tpch",
        "ssh root@10.0.88.68 sudo -u hdfs hive://tpch",
        "ssh root@10.0.88.69 sudo -u hdfs hive://tpch"
    ],
    "uuid": "cb54ff0b-4403-48ba-b357-764865c8f0a3",
    "name": "TPC bench run",
    "uri": "://tpch",
    "enabled": true,
    "remedy_script": "",
    "remark": null,
    "created_time": null,
    "status": 1,
    "monitoring": true,
    "dataset": {
        "url": "http://127.0.0.1:8080/api/space/datasets/17/",
        "uuid": "422f2f5d-ad55-47d5-b83d-02f4cedf6580",
        "name": "TPC-H benchmark",
```

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Conclusion

- Traditional approach
  - Scattered dataset and computing resources
  - Complicated and difficult
  - Poorly referenceable
- Serverless Approach
  - The lifecycle challenge
  - The scalability challenge
  - The HA challenge
- SciSpace: Our Serverless Data Lifecycle Management Service
  - Space: The Unified Serverless UI
  - Packone Make Engine Elastic and URI Highly Available

References

- J Li , Z Shen, and X Meng. Scientific Big Data Management: Concepts, Technologies and System.
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Thanks!

Q & A