Development of Compute Cluster Simulator

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Introduction

Testing of cluster scheduling algorithms

- Compute clusters are widely used for complex calculations.
- Scheduling algorithms are crucial for their performance.
- These algorithms are the subject of active research.

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> Using real clusters is expensive and time-consuming.

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⇓

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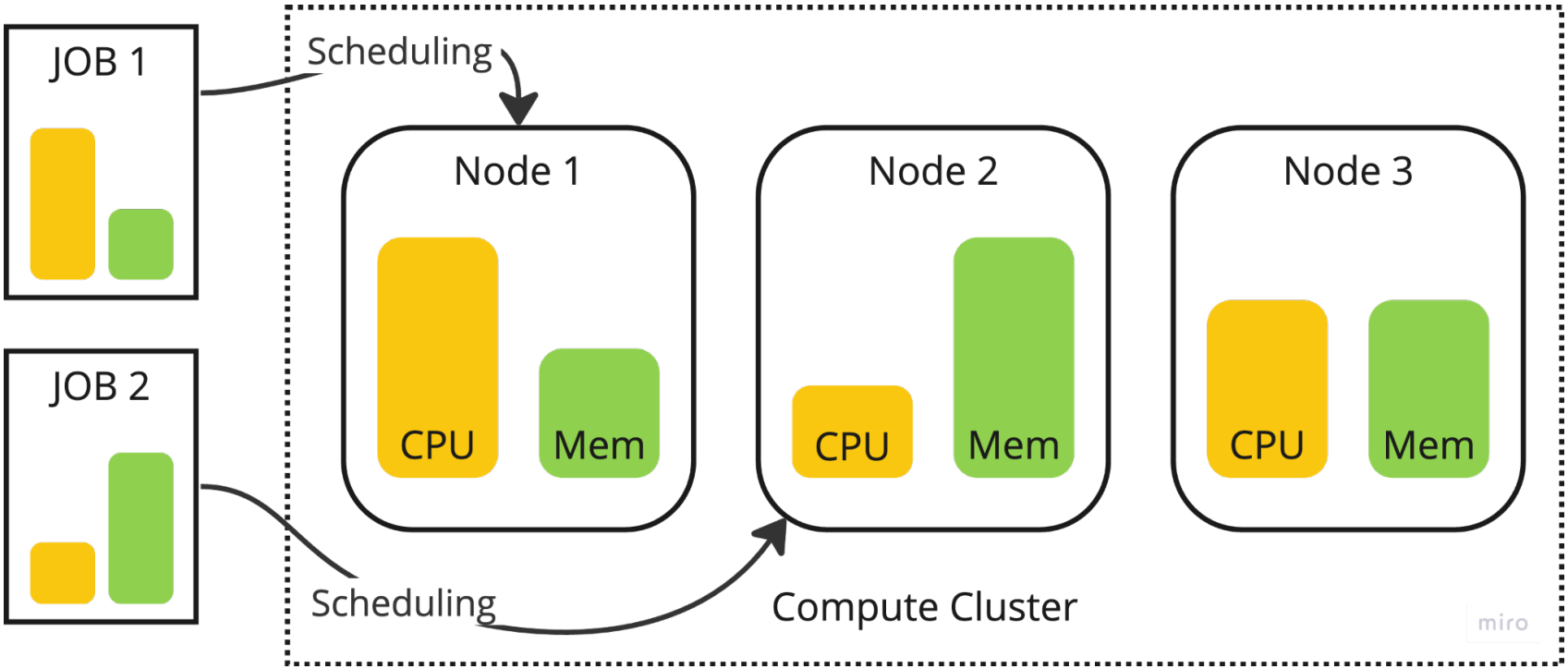
✓ **Simulators** are used for effective development.

Introduction

Cluster architecture



Simple model of cluster architecture

Introduction

Two approaches for simulation

`Standard Workload Format (SWF)`

- CPU/memory resources

`Custom workloads`

- CPU/memory/disk/network resources

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Two approaches for simulation

`Standard Workload Format (SWF)`

- CPU/memory resources
- Given execution time and resources
- Workload is calculated

`Custom workloads`

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- Given workload and resources
- Execution time is calculated

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Two approaches for simulation

`Standard Workload Format (SWF)`

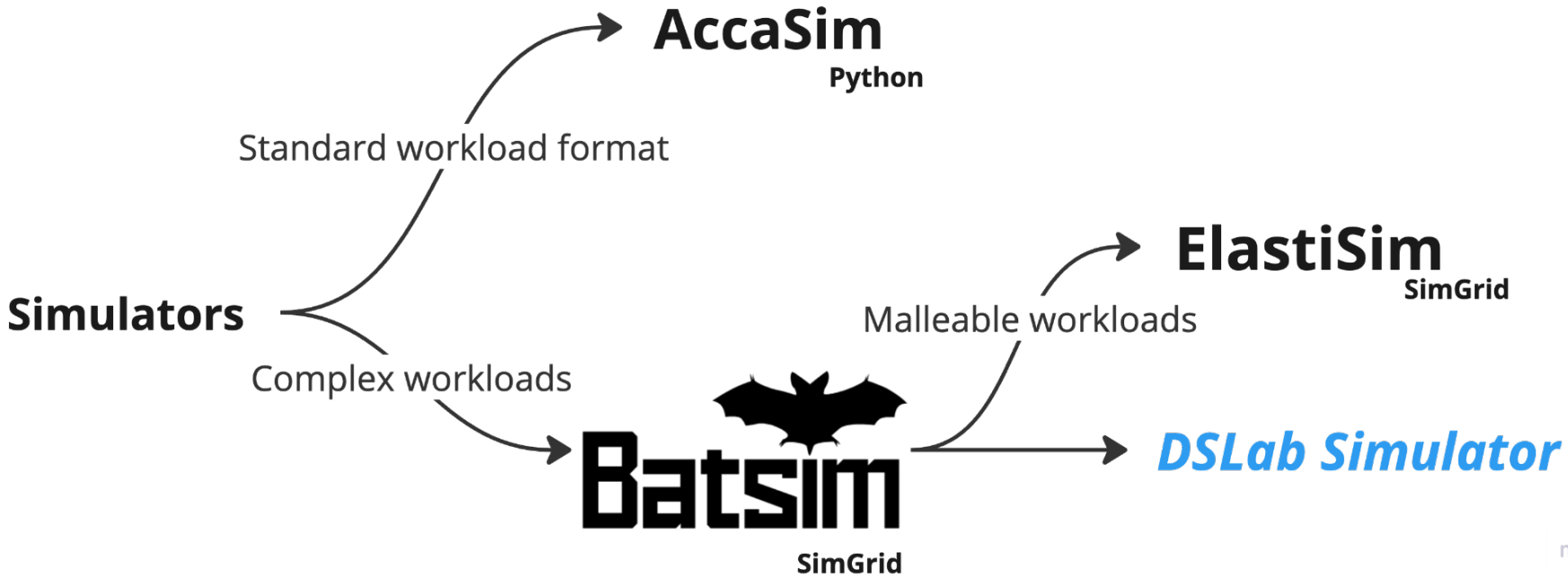
- CPU/memory resources
- Given execution time and resources
- Workload is calculated
- Used in famous cluster traces (e.g. Google traces)

`Custom workloads`

- CPU/memory/disk/network resources
- Given workload and resources
- Execution time is calculated
- NDA

Literature Review

Existing Simulators



Existing cluster simulators

Literature Review

BatSim

- Based on SimGrid simulator platform.
- Supports SWF and custom workloads defined as JSON profile.
- Supports connecting scheduling algorithms using inter-process communication.

Literature Review

BatSim Workload format

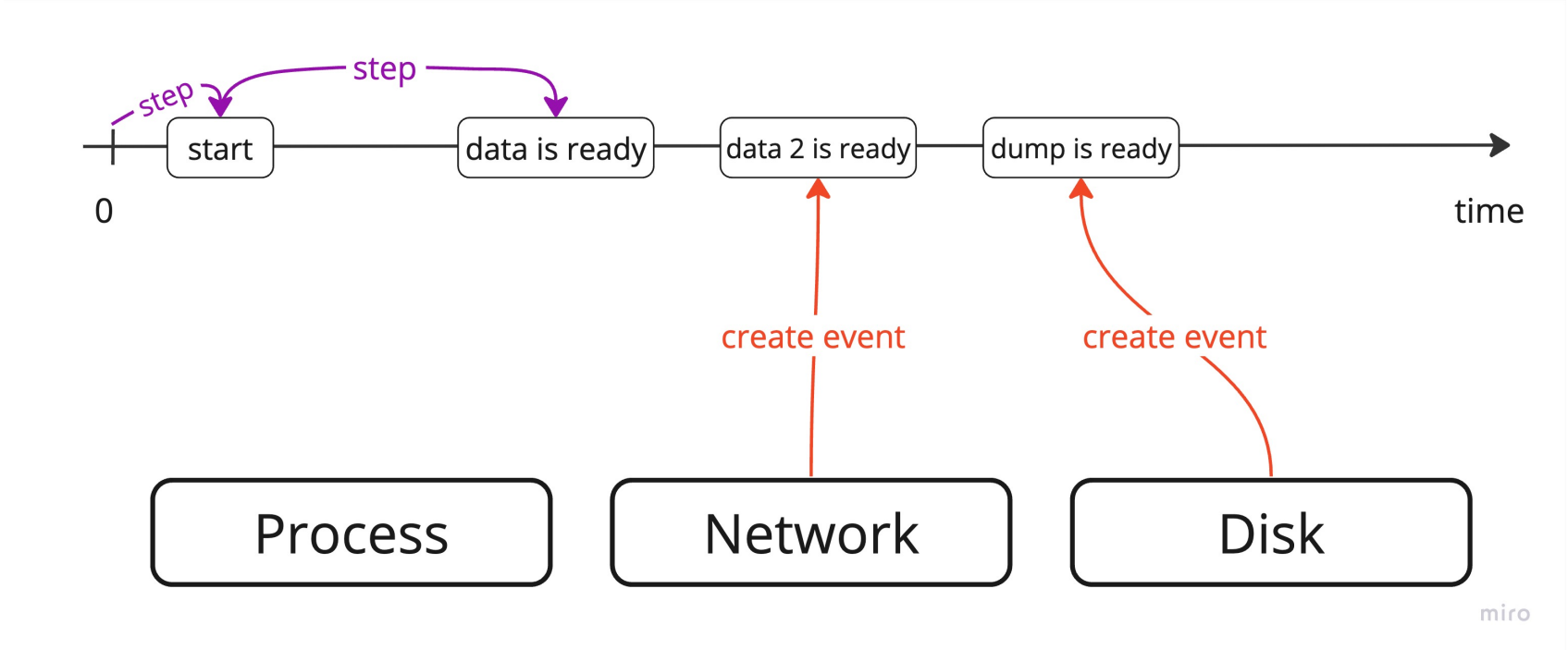
```
"jobs": [
  {"id": "job1",  ...  "res": 4, "profile": "sequence"},
],

"profiles": {
  "homogeneous": {
    "type": "parallel_homogeneous",
    "cpu": 10e6,
    "com": 1e6
  },
  "sequence": {
    "type": "composed",
    "repeat" : 4,
    "seq": ["simple","homogeneous","simple"]
  },
}
```

Methods

DSLab

- Fast & scalable simulation platform
- Written in Rust
- Provides models of compute/network/storage



Discrete-event modeling in DSLab

Methods

Asynchronous event management. Rust futures combiners

```rust
async fn process_task(&self, req:
    TaskRequest) {
  let mut task = TaskInfo {req};

  self.download_data(&task).await;
  self.read_data(&task).await;
  self.run_task(&task).await;
  self.write_data(&task).await;
  self.upload_result(&task).await;
}
```

Example of sequent task execution

```rust
async fn run(&self, args: JobArgs)
  futures::join!(
    self.download_data(args.node_1)
    self.download_data(args.node_2)
  )
}
```

Example of parallel tasks execution

Methods

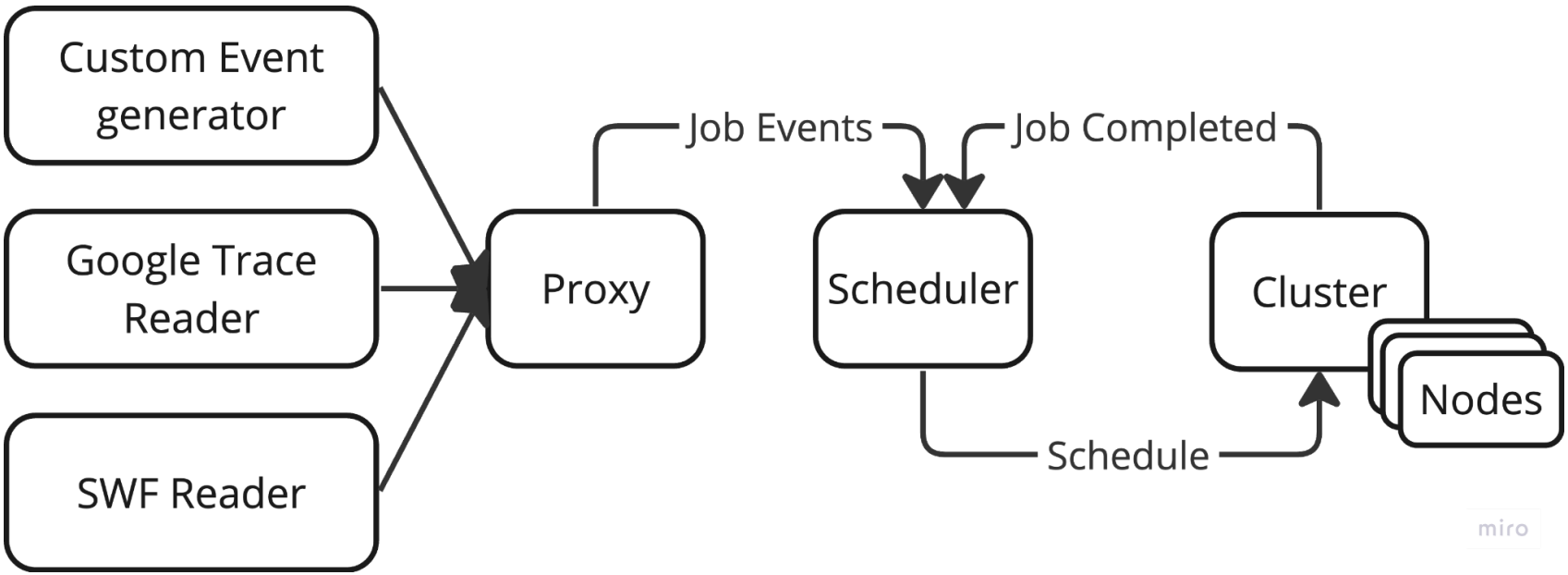
JobProfile trait

```
pub trait JobProfile {
  async fn run(self: Box<Self>, ctx: JobContext)
}
```

Job trait description

Methods

Simulator architecture



Simulator architecture

Expected Results

Fast and scalable compute cluster simulator

- ✓ `SWF`-based simulation
- Custom workload simulation
- Support reading workload traces from popular sources (Google, Alibaba)
- Support for collecting metrics during the simulation and writing them to a file with the results
- High performance, support for cluster modeling from 1-10K servers

References

1. The standard workload format specification. https://www.cs.huji.ac.il/labs/parallel/workload/swf.html
2. Dslab repository. https://github.com/osukhoroslov/dslab
3. BatSim docs. https://batsim.readthedocs.io/en/latest/