12th Symposium on Software Performance 2021

Reproducible Benchmarking of Cloud-Native Applications with the Kubernetes Operator Pattern

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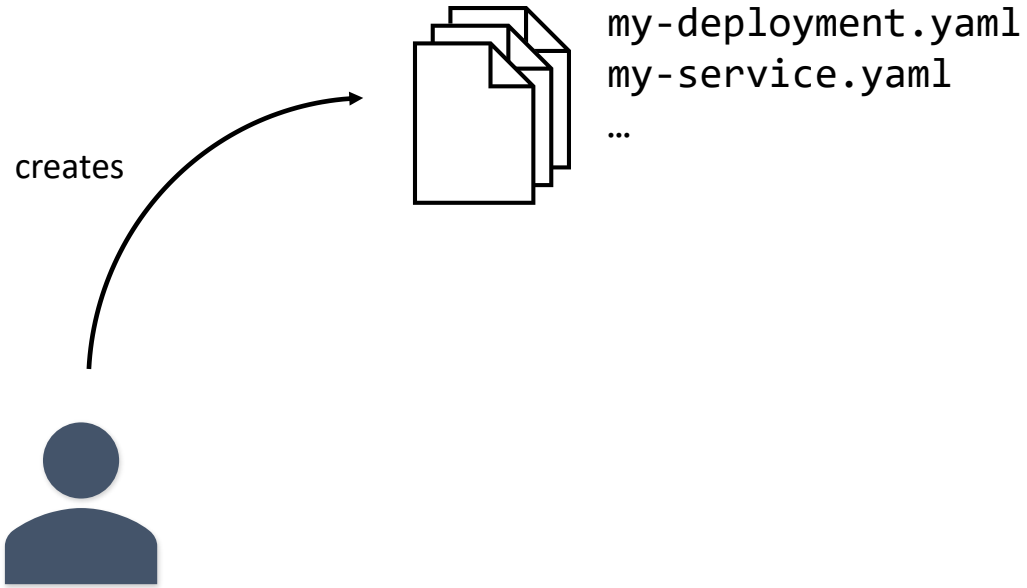
Kiel University
Christian-Albrechts-Universität zu Kiel

Cloud-native Applications in Kubernetes

Cloud-native Applications in Kubernetes



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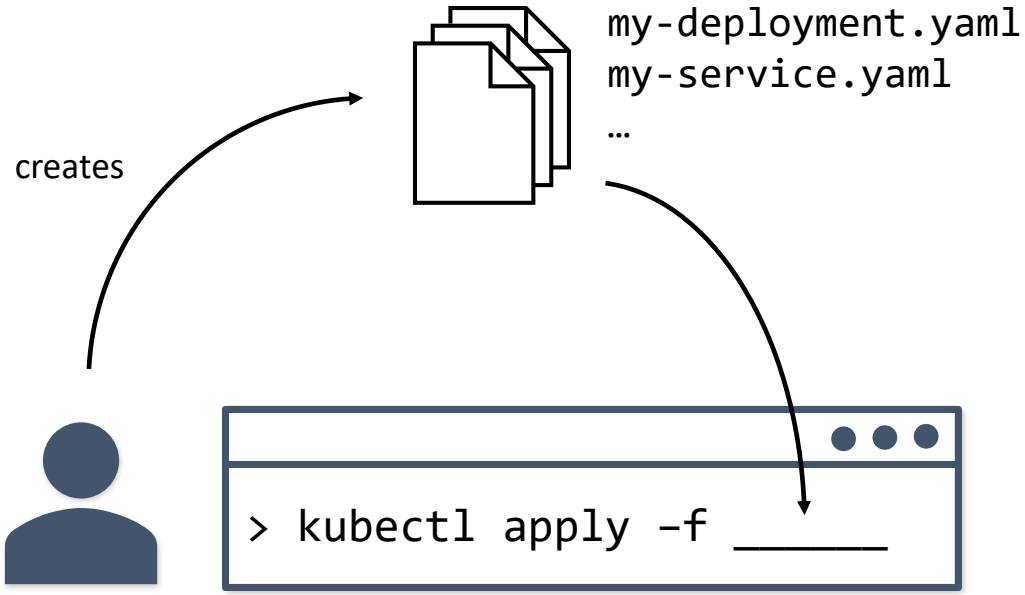

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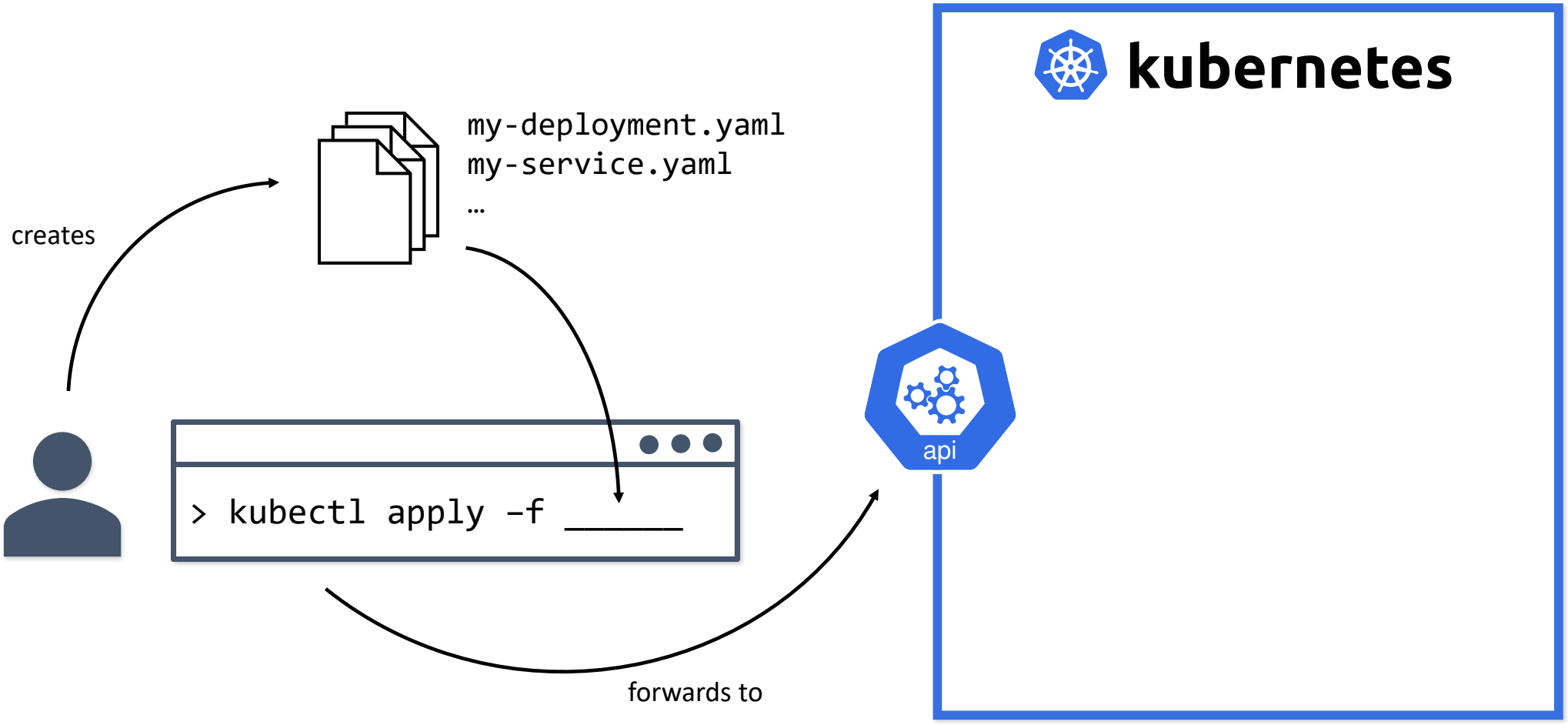

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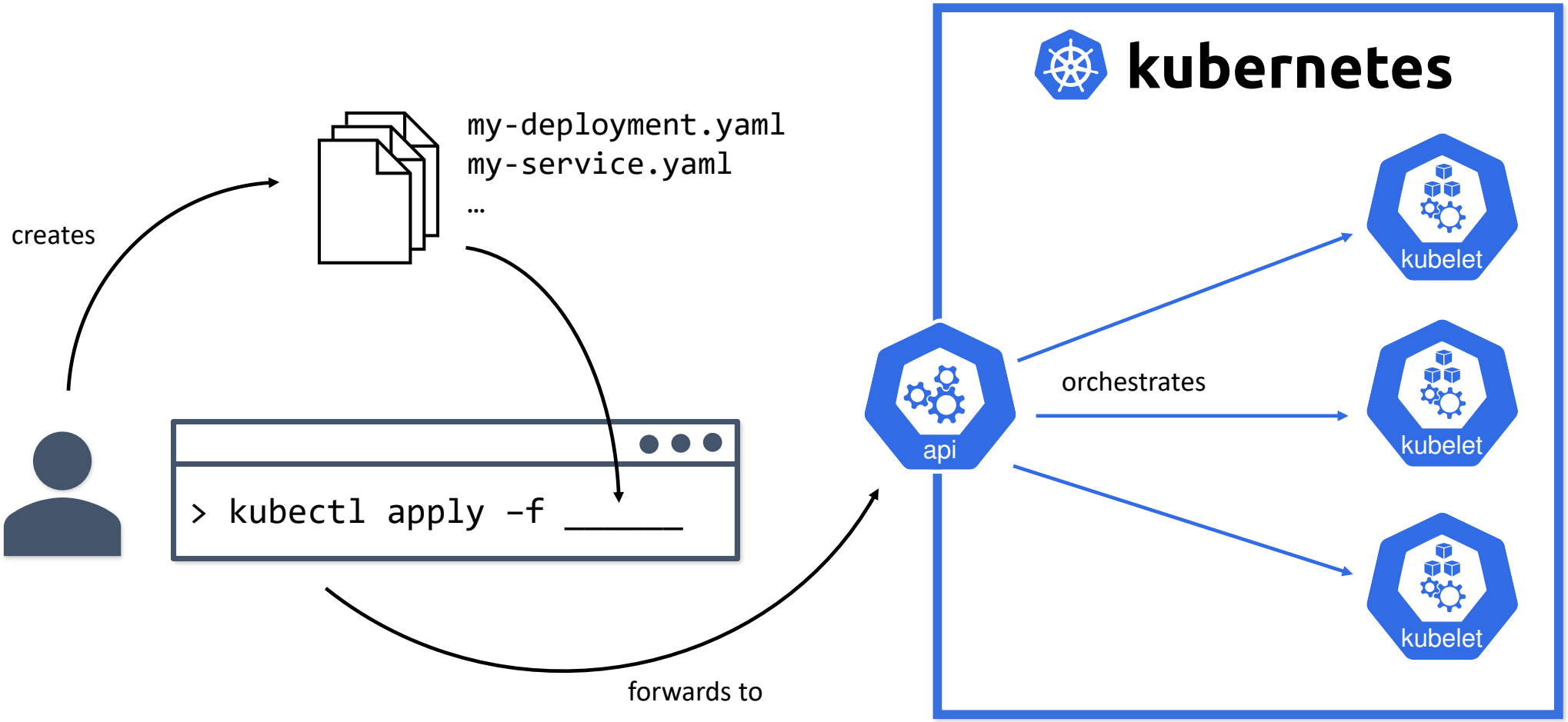

Benchmarking Cloud-native Applications: The Classical Way

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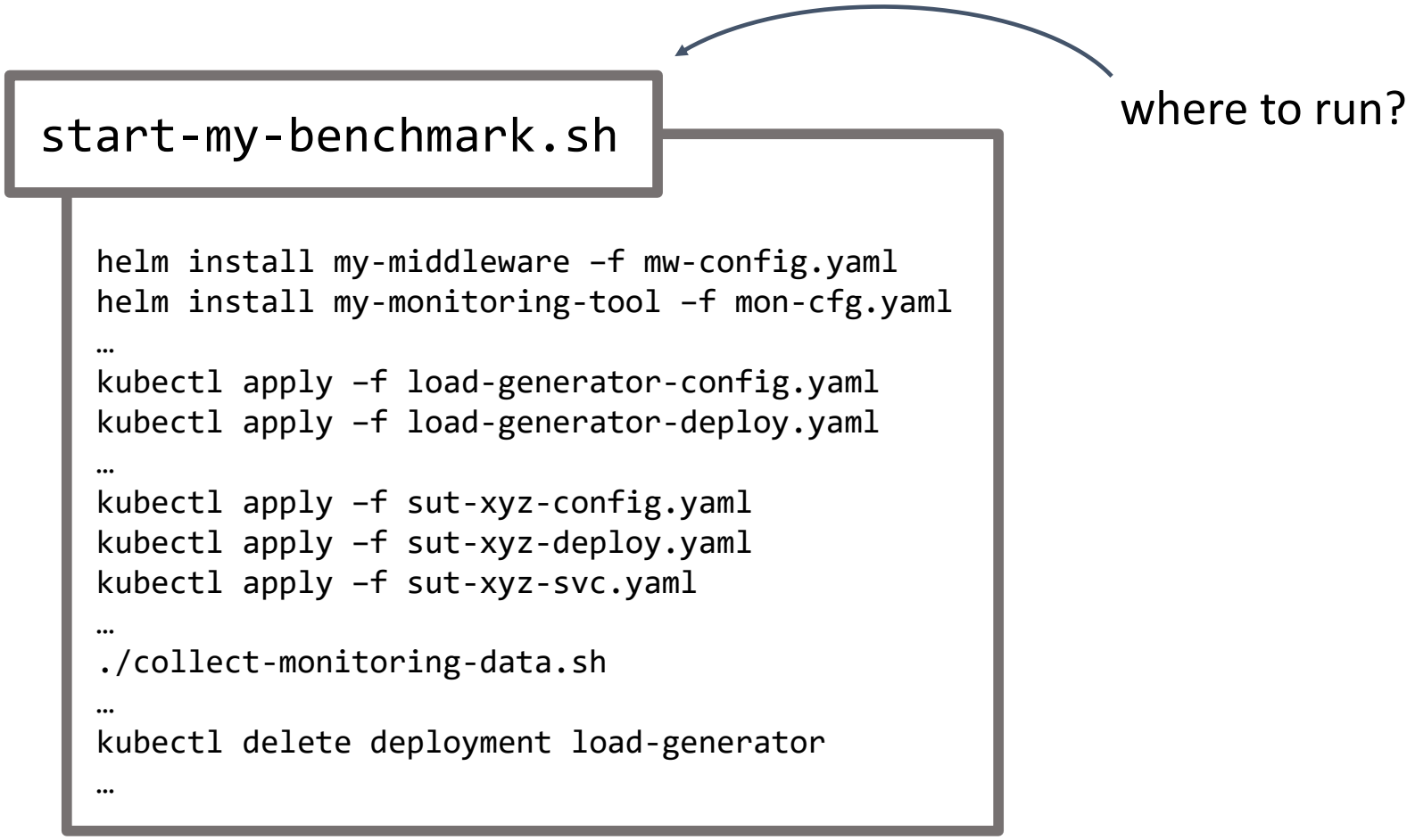

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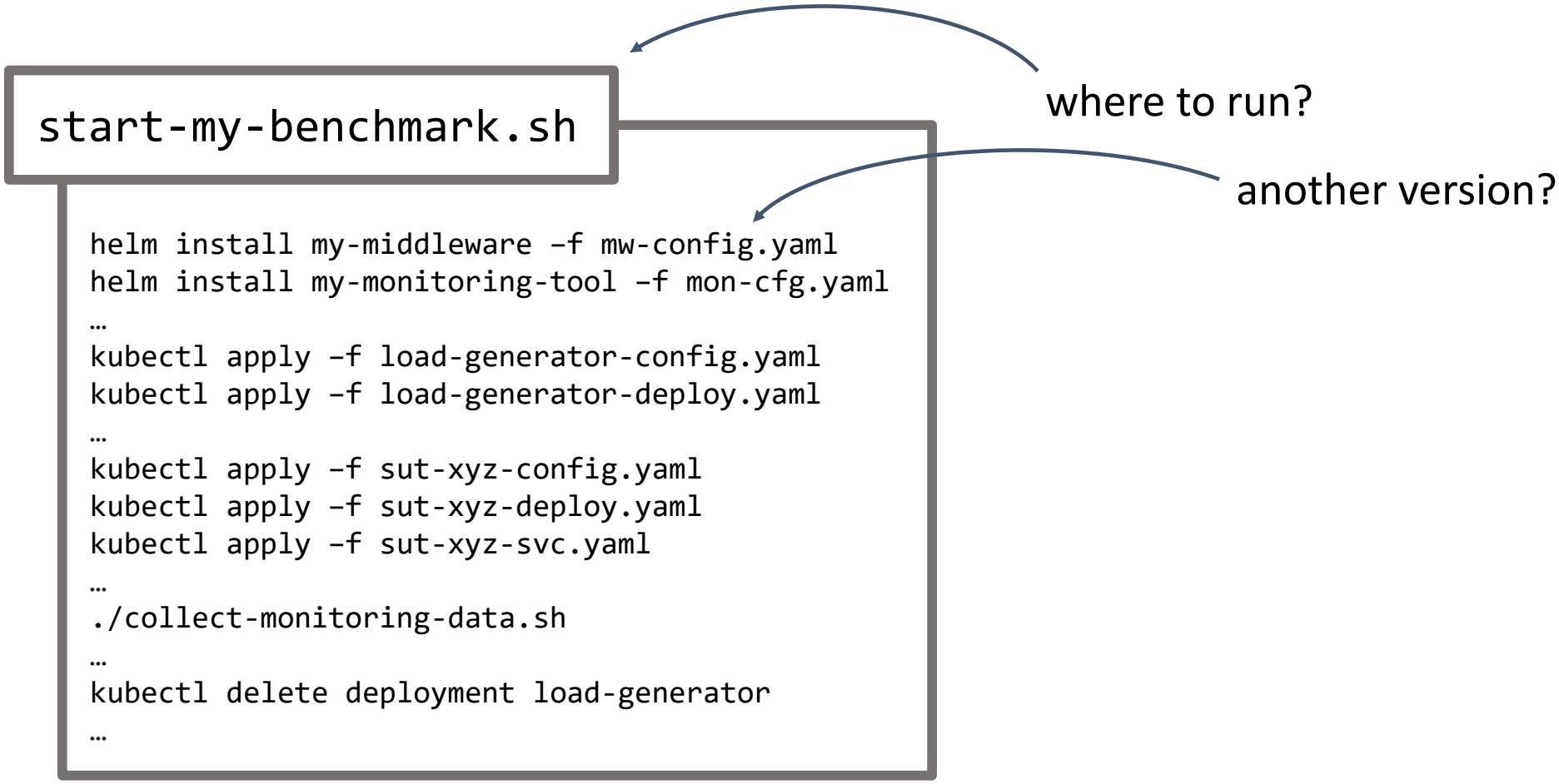

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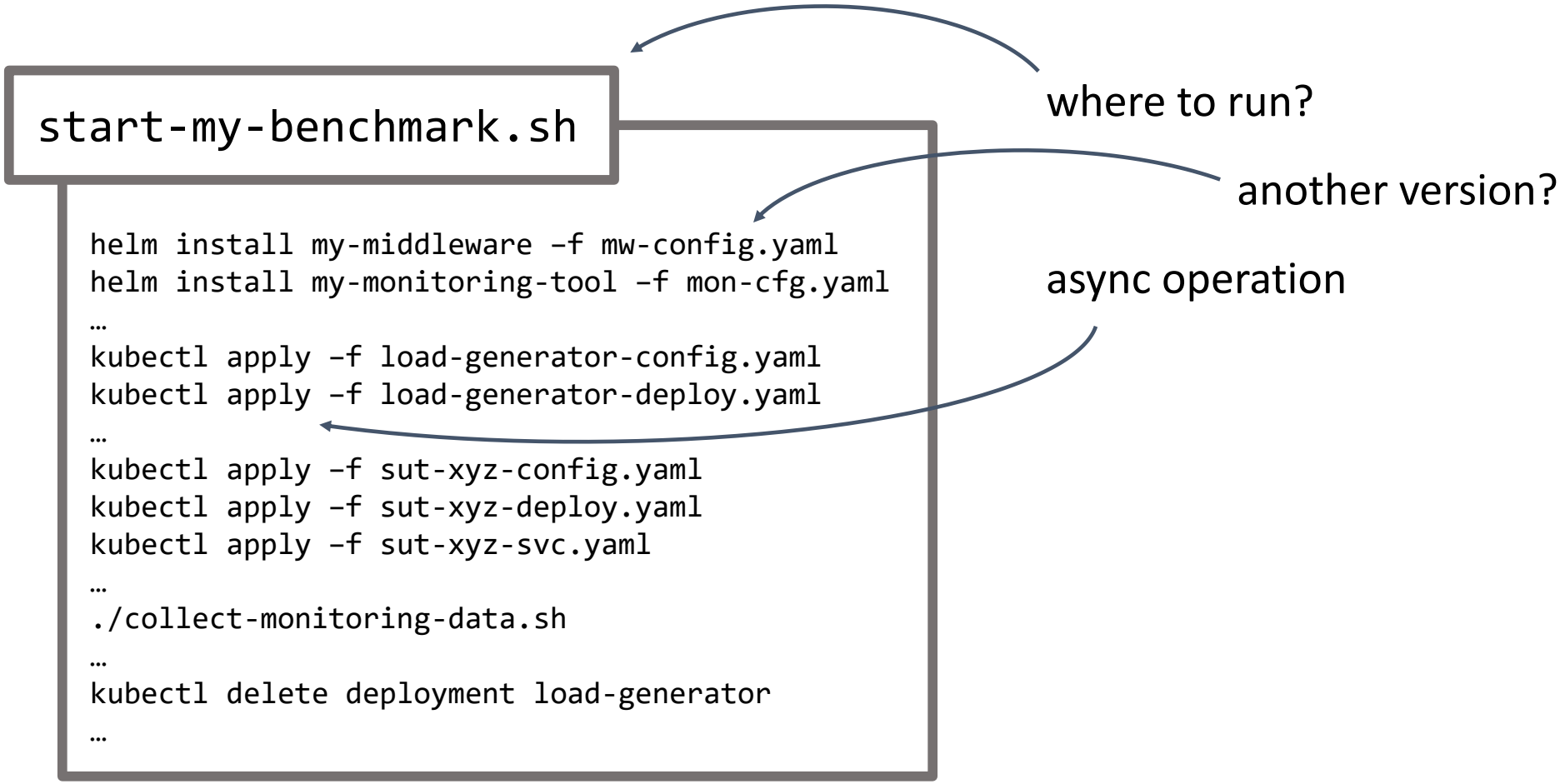

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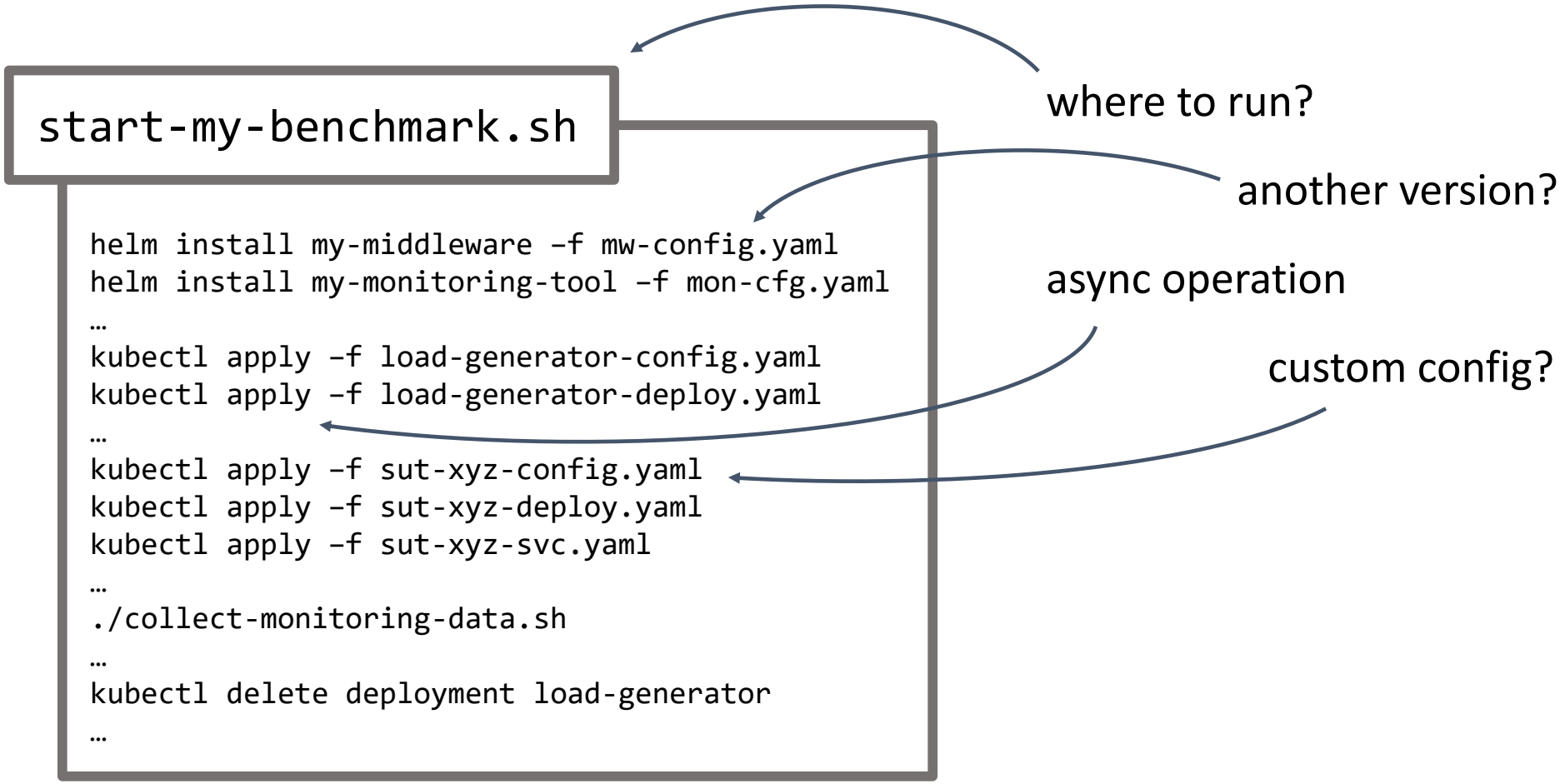

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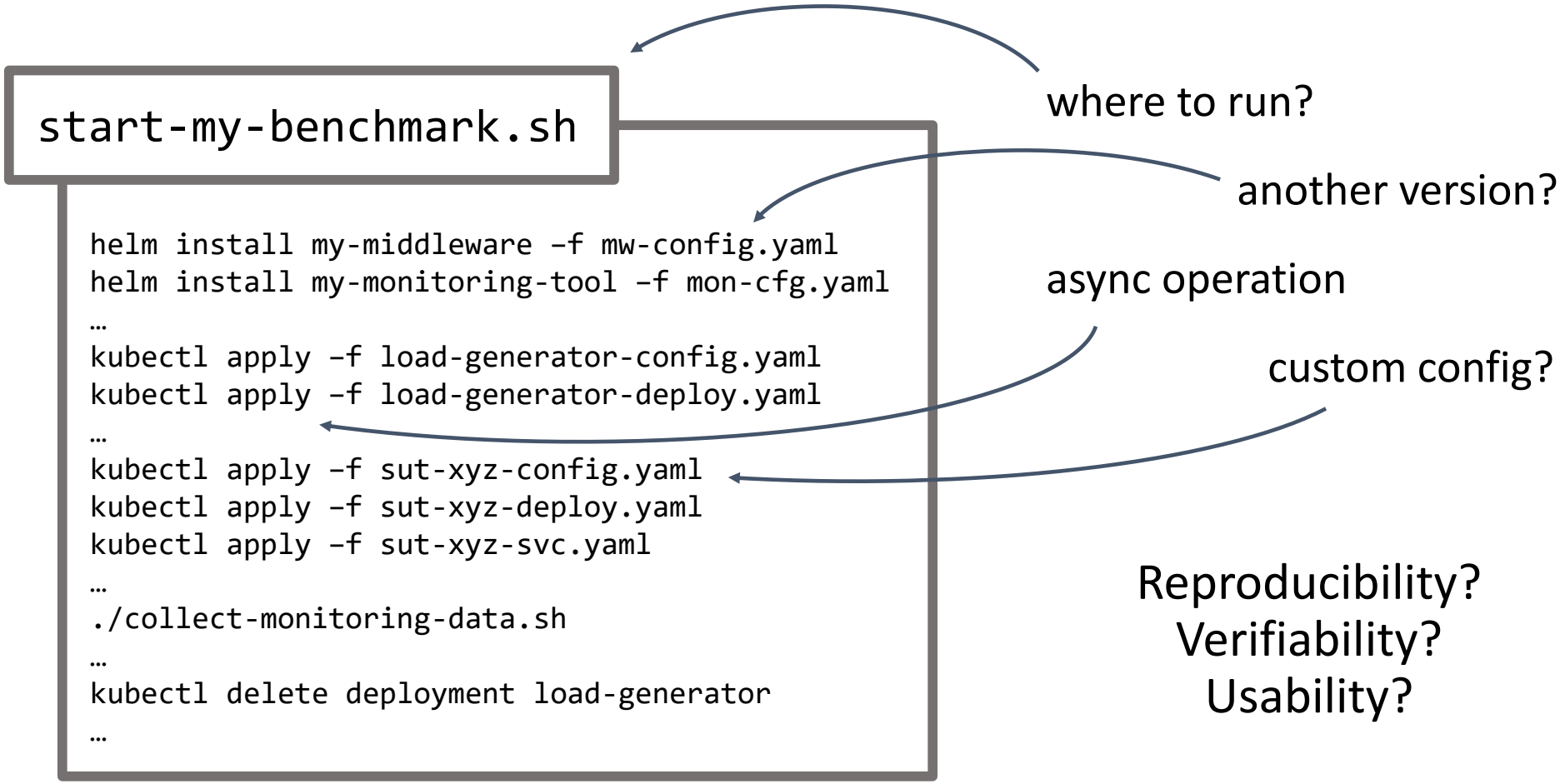

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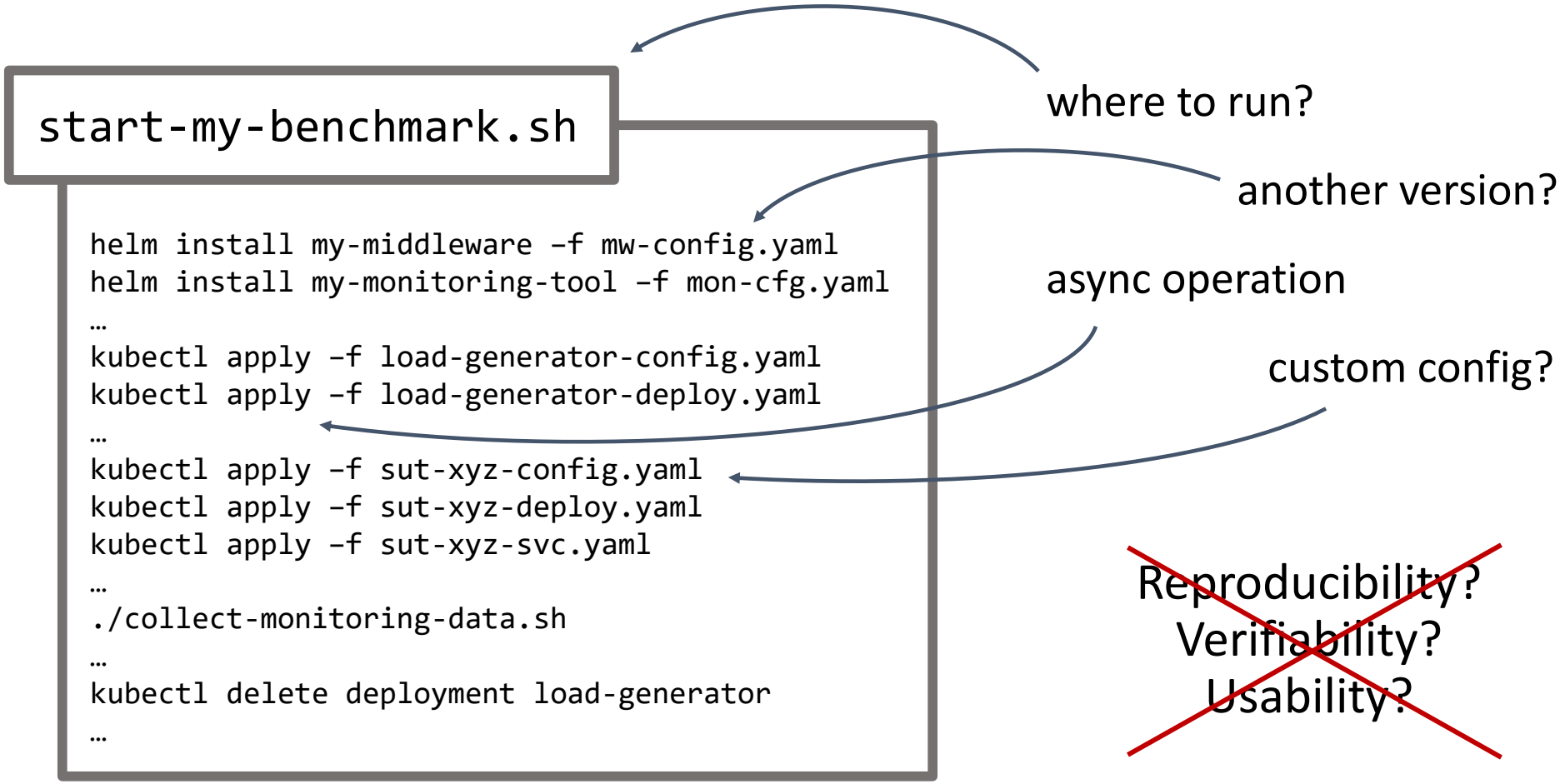

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Use established cloud-native tools

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CLOUD NATIVE
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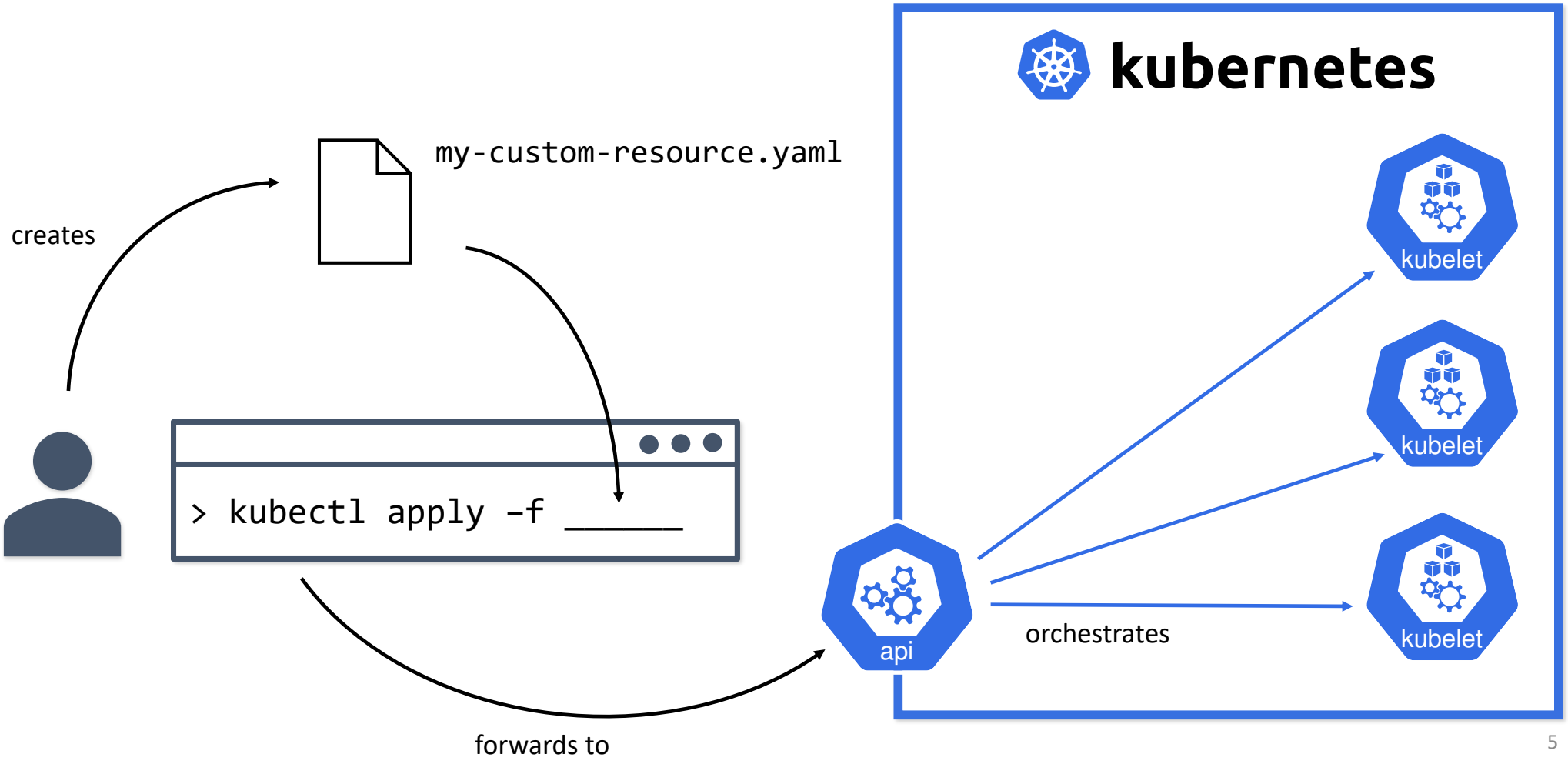
Operator Pattern

The Kubernetes Operator Pattern



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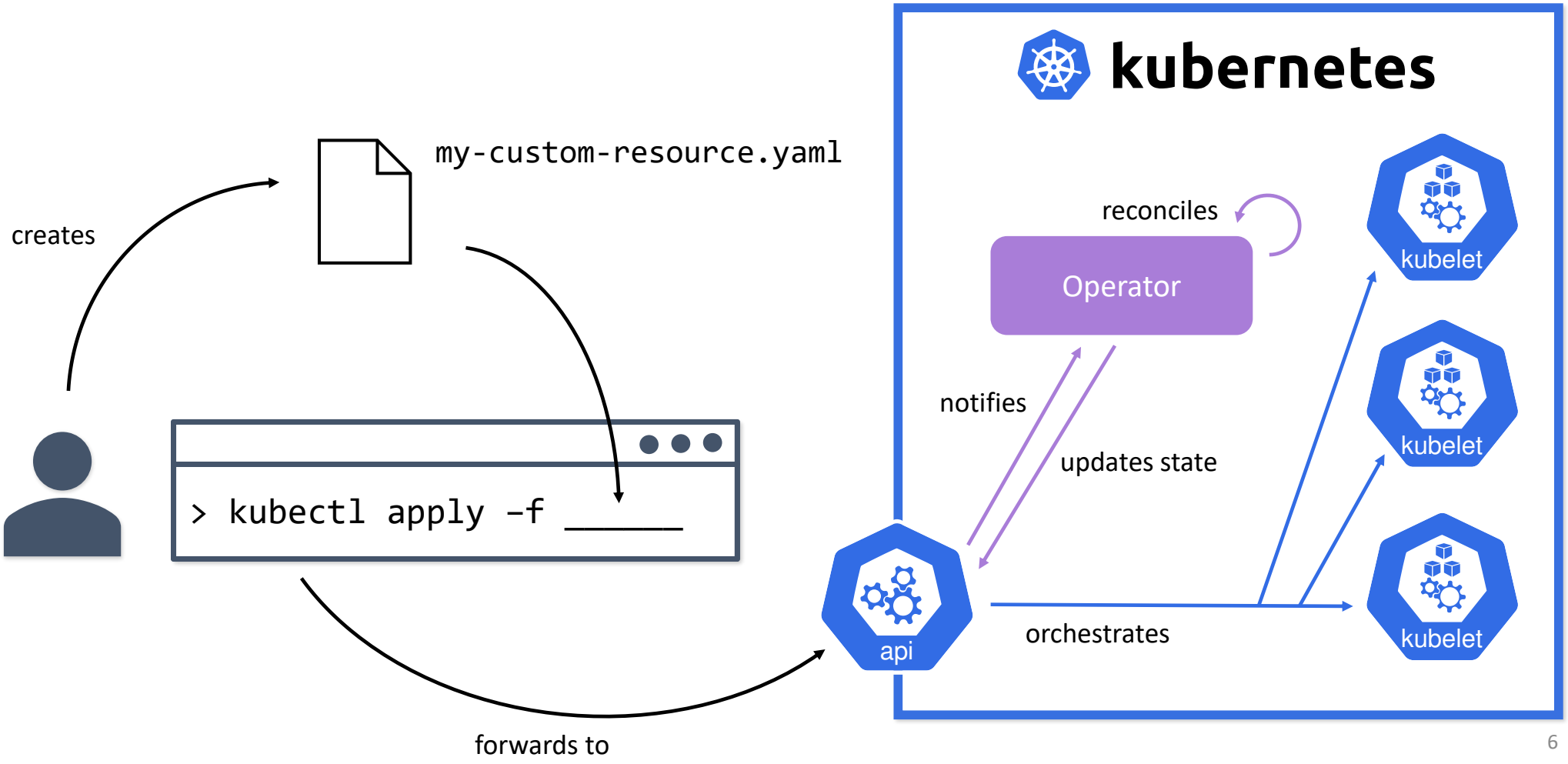
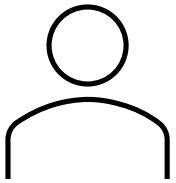
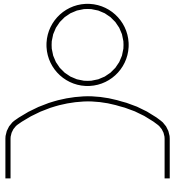


Custom Resource Definitions (CRDs) for Benchmarking



Benchmark Designer



Benchmarker

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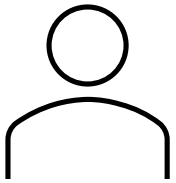
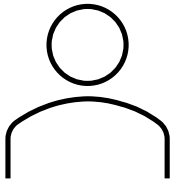


Benchmark Designer

- Expert regarding specific application types or software services
  e.g., researchers, engineers, standardization committees
- Defines how metrics and results can be interpreted to compare different SUTs
- Bundles all of this in a benchmarking tool or for a benchmarking tool



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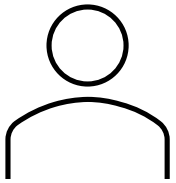

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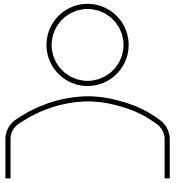
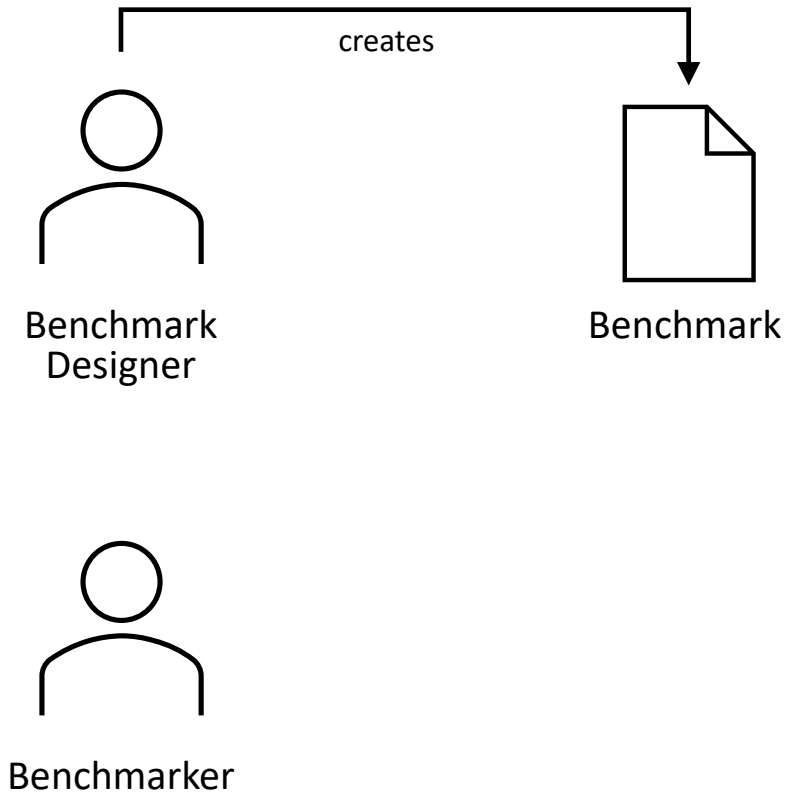


Benchmarker

- Compares and ranks different existing SUTs
- Evaluates new methods tools against a defined standard
- Repeats previous experiments
- Executes existing benchmarks

Custom Resource Definitions (CRDs) for Benchmarking



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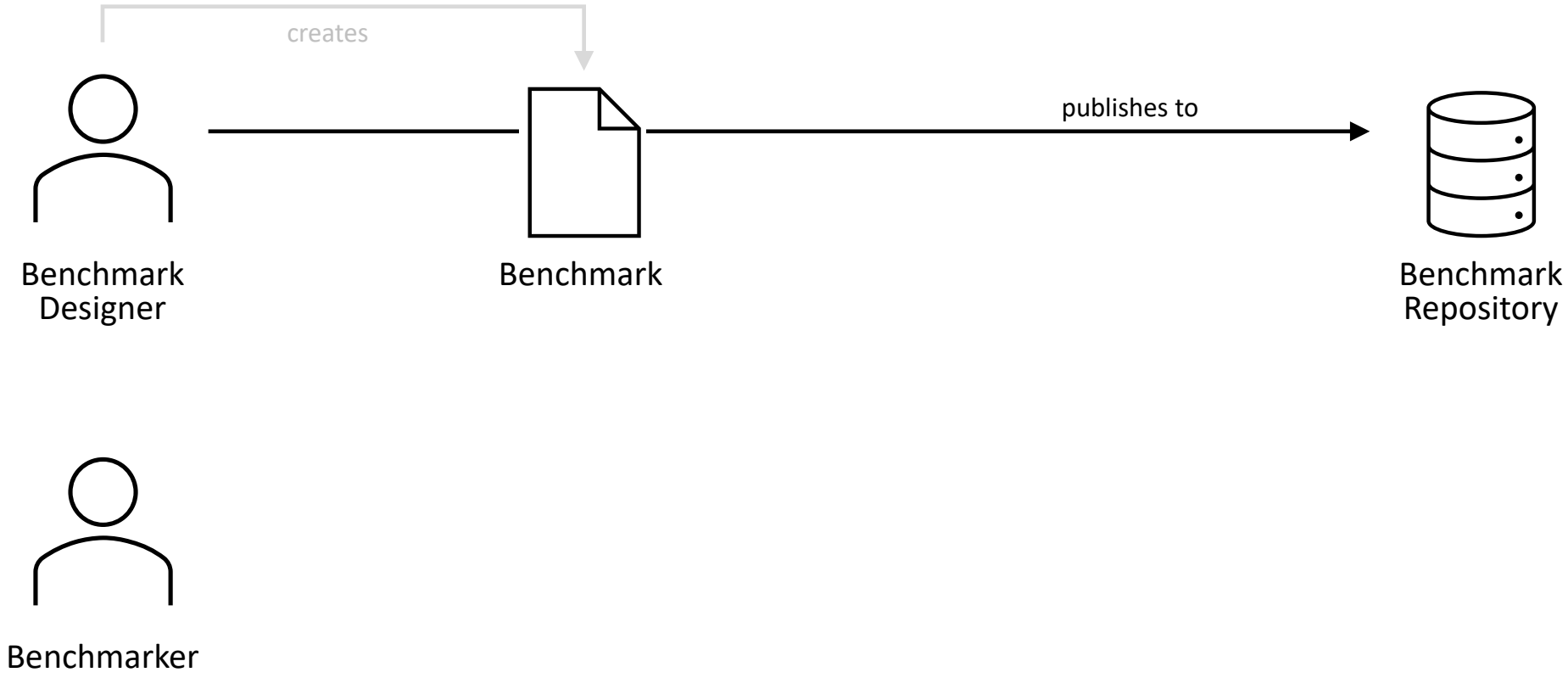

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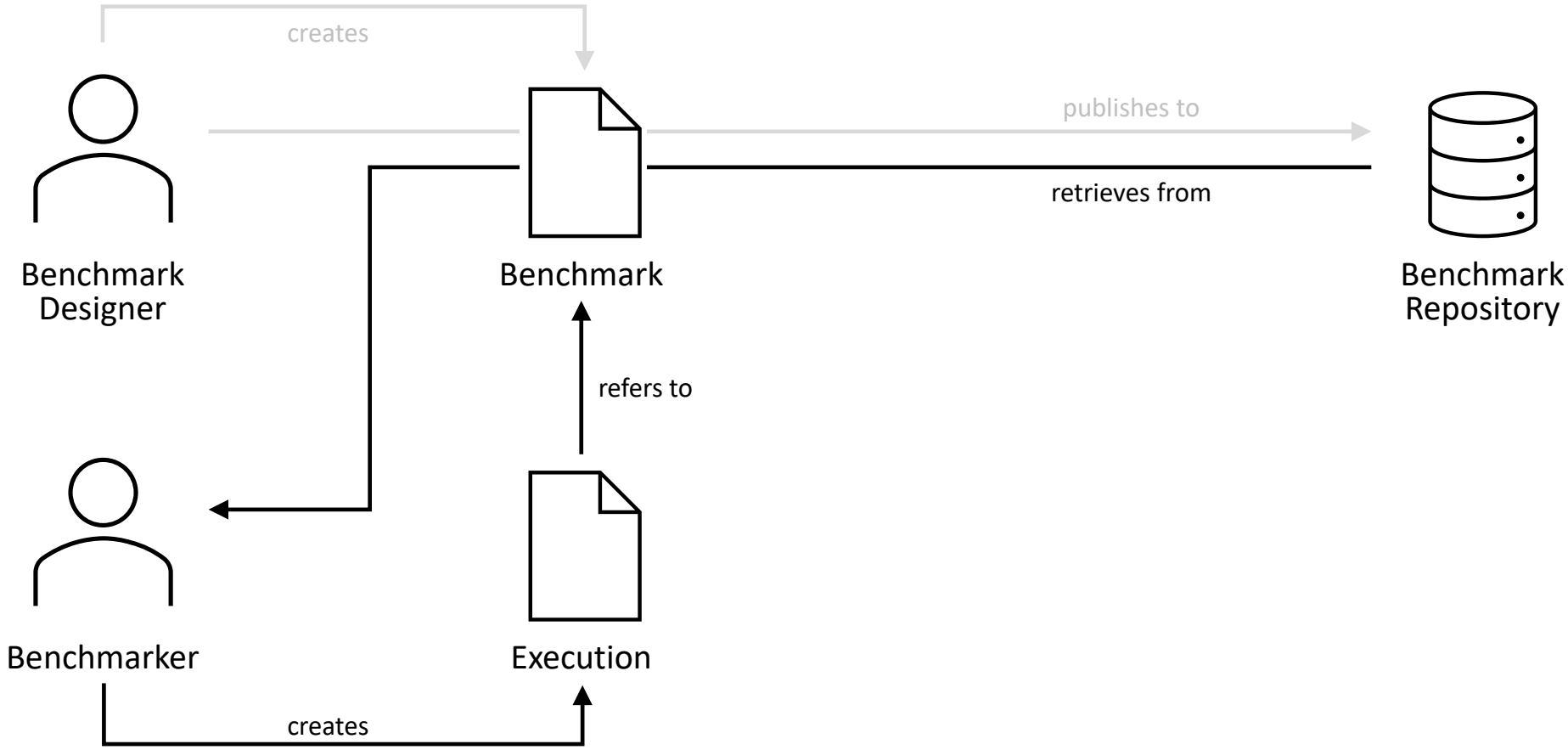

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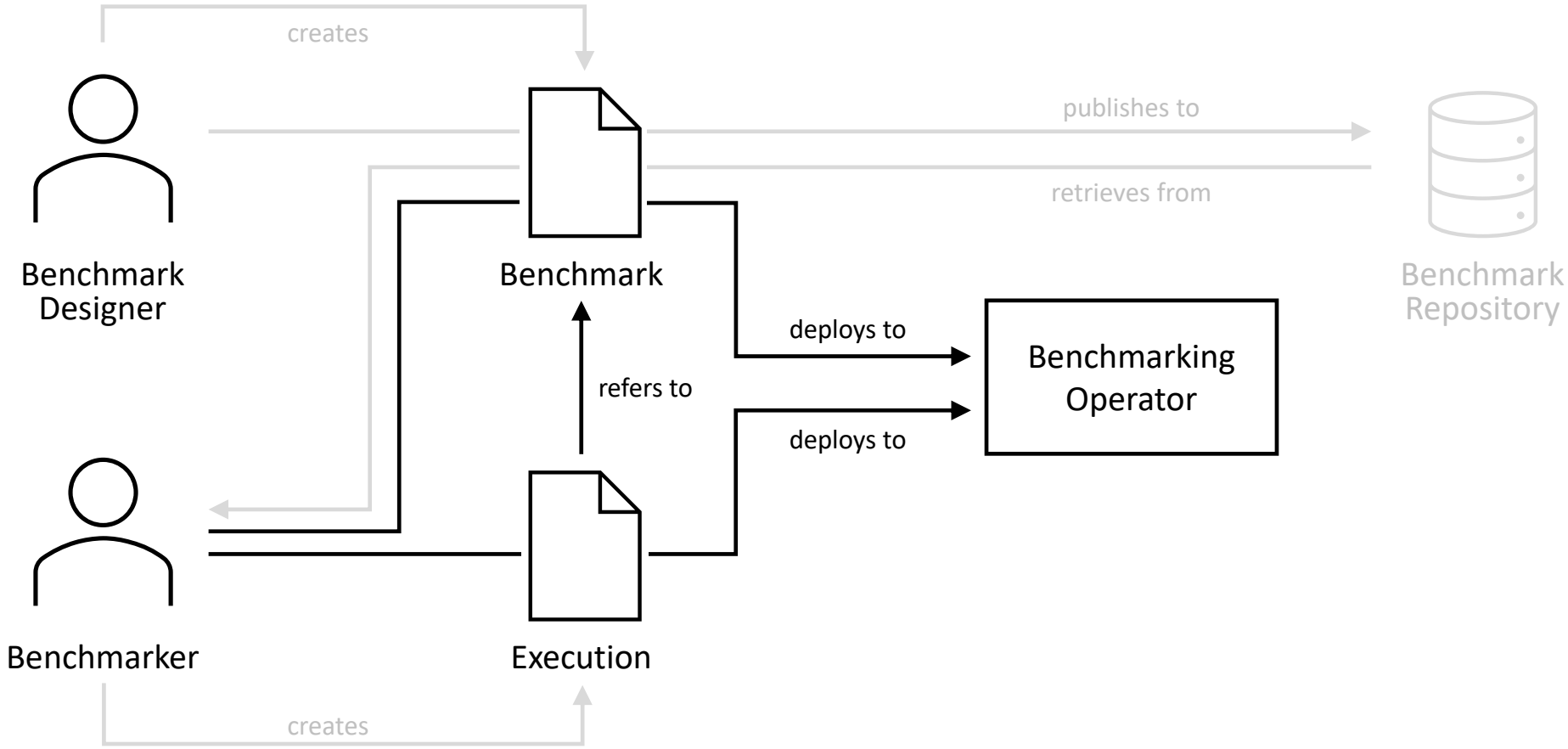

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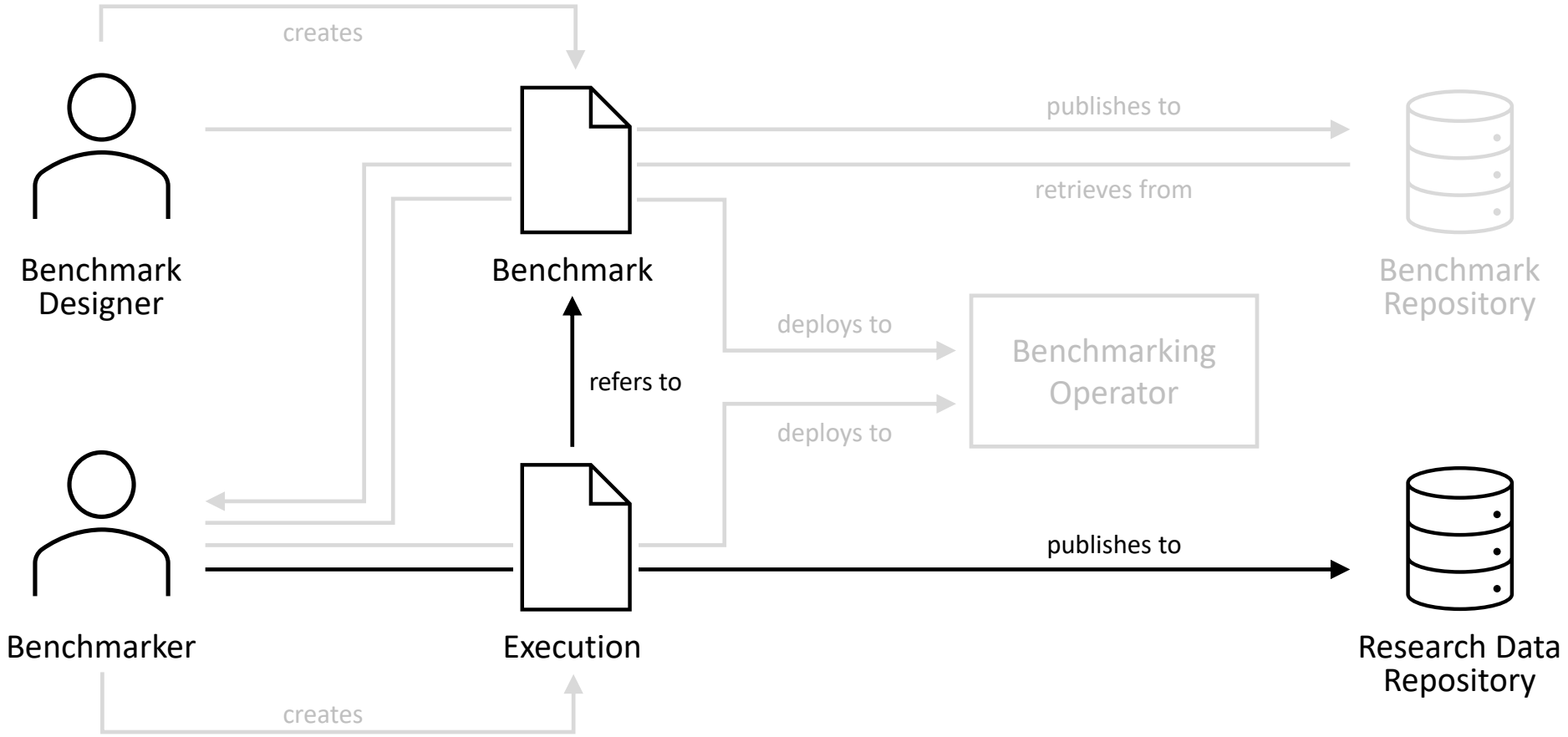

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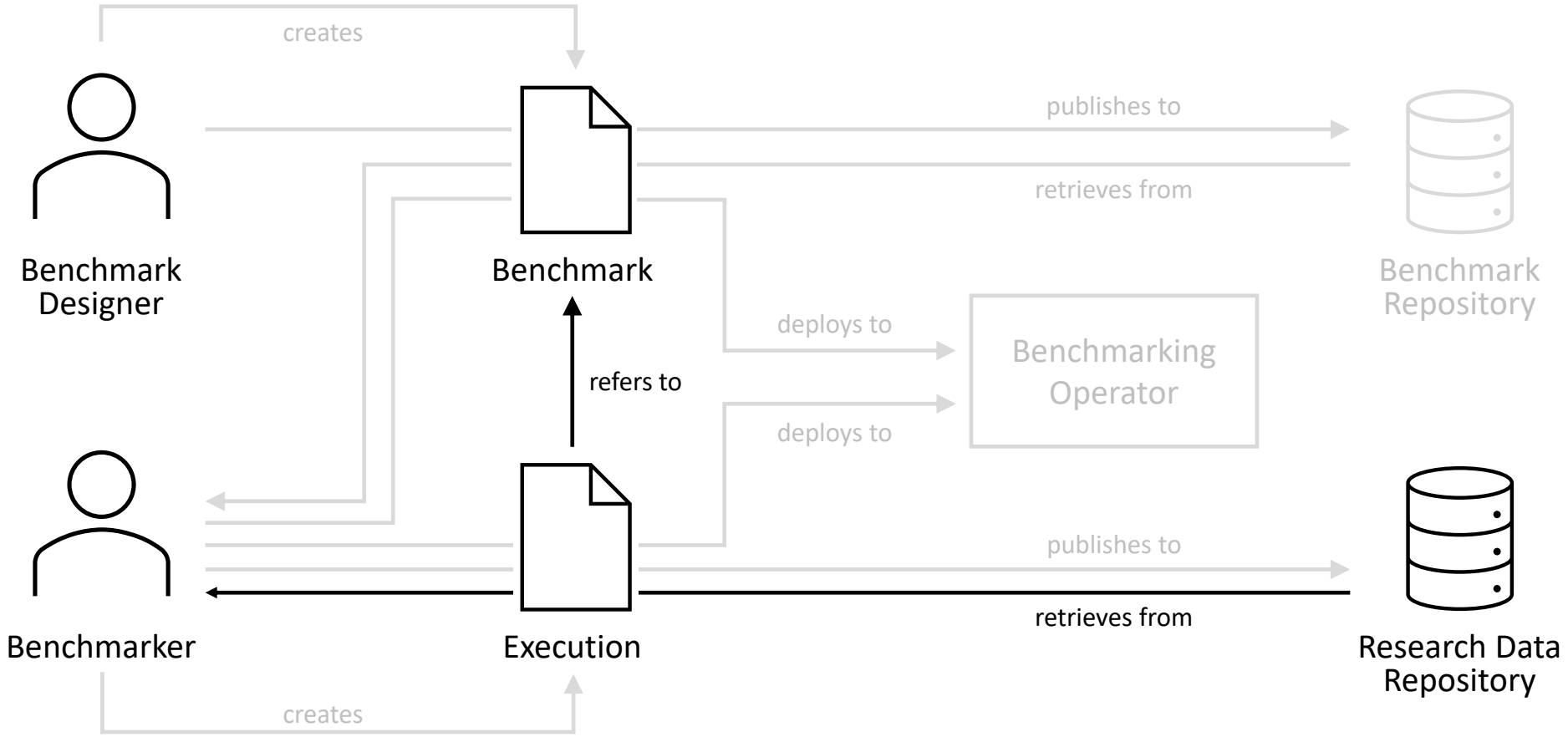
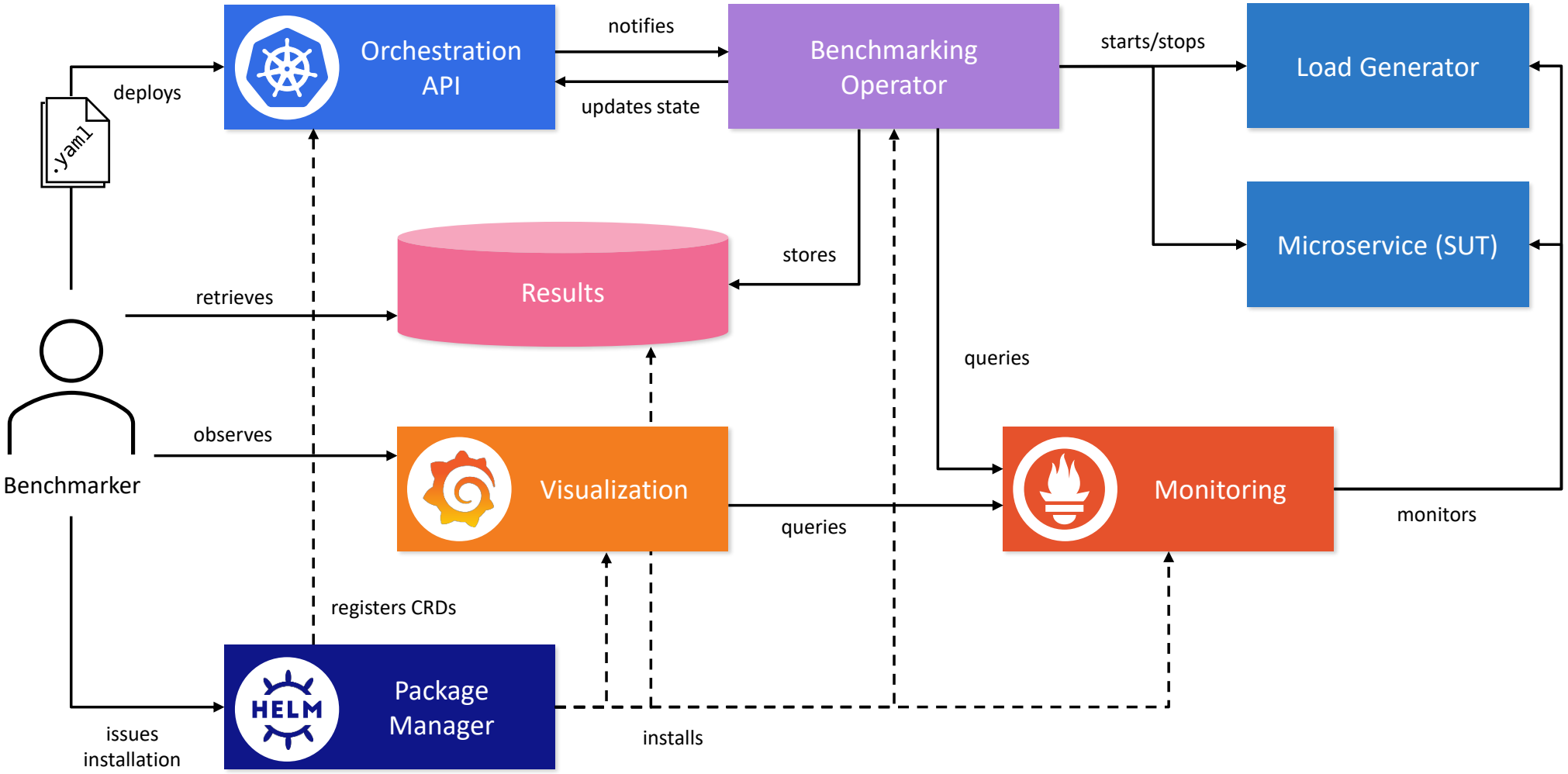
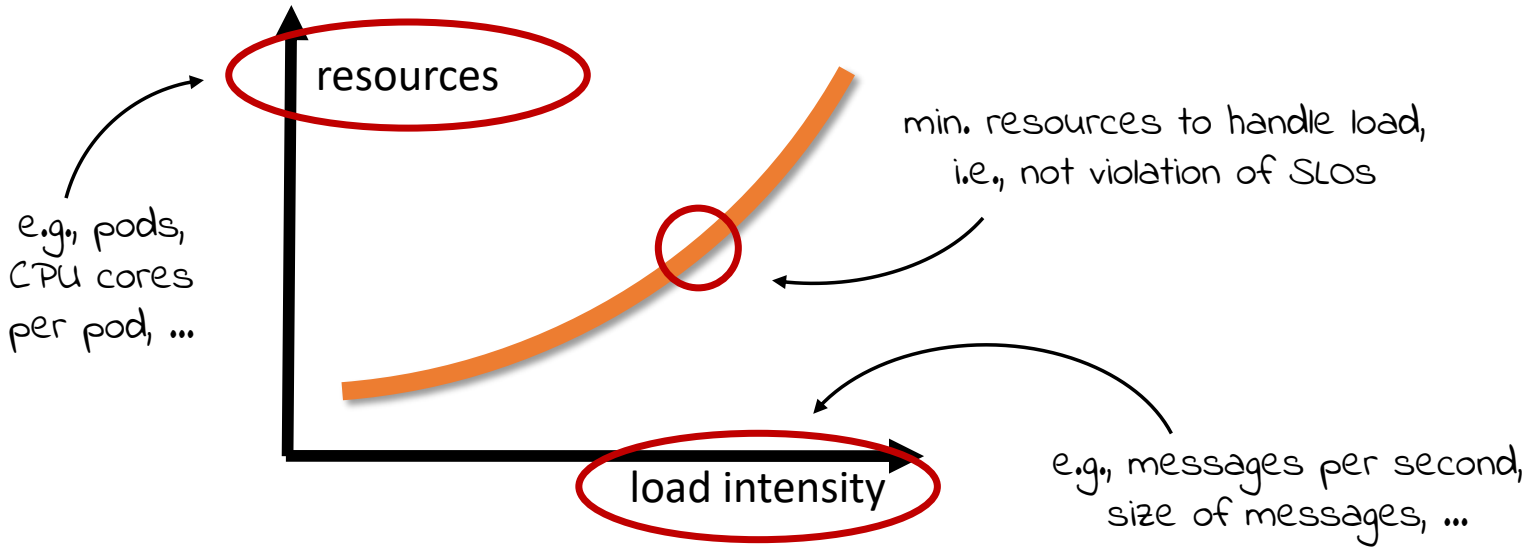


Architecture for a Benchmarking Operator



Scalability Benchmarking with Theodolite

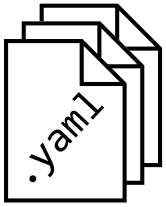


https://github.com/cau-se/theodolite

Theodolite ***Benchmarks***

```yaml
apiVersion: theodolite.com/v1
kind: benchmark
metadata:
  name: uc1-kstreams
spec:
  appResource:
    - "uc1-kstreams-deployment.yaml"
    - "aggregation-service.yaml"
    - "jmx-configmap.yaml"
    - "uc1-service-monitor.yaml"
  loadGenResource:
    - "uc1-load-generator-deployment.yaml"
    - "uc1-load-generator-service.yaml"
  resourceTypes:
    - typeName: "Instances"
      patchers:
        - type: "ReplicaPatcher"
          resource: "uc1-kstreams-deployment.yaml"
  loadTypes:
    - typeName: "NumSensors"
      patchers:
        - type: "EnvVarPatcher"
          resource: "uc1-load-generator-deployment.yaml"
          properties:
            variableName: "NUM_SENSORS"
            container: "workload-generator"
        - type: "NumSensorsLoadGeneratorReplicaPatcher"
          resource: "uc1-load-generator-deployment.yaml"
          properties:
            loadGenMaxRecords: "15000"
  kafkaConfig:
    bootstrapServer: "theodolite-cp-kafka:9092"
    topics:
      - name: "input"
        numPartitions: 40
        replicationFactor: 1
      - name: "theodolite-.*"
        removeOnly: True
```

Theodolite ***Benchmarks***



Kubernetes resources for deploying the benchmark

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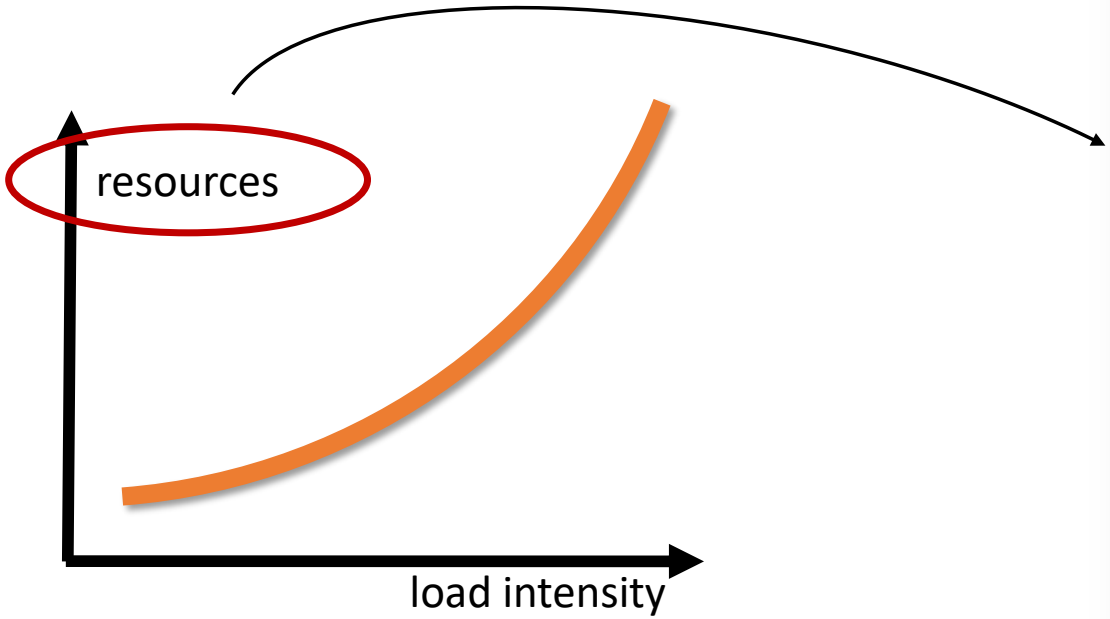


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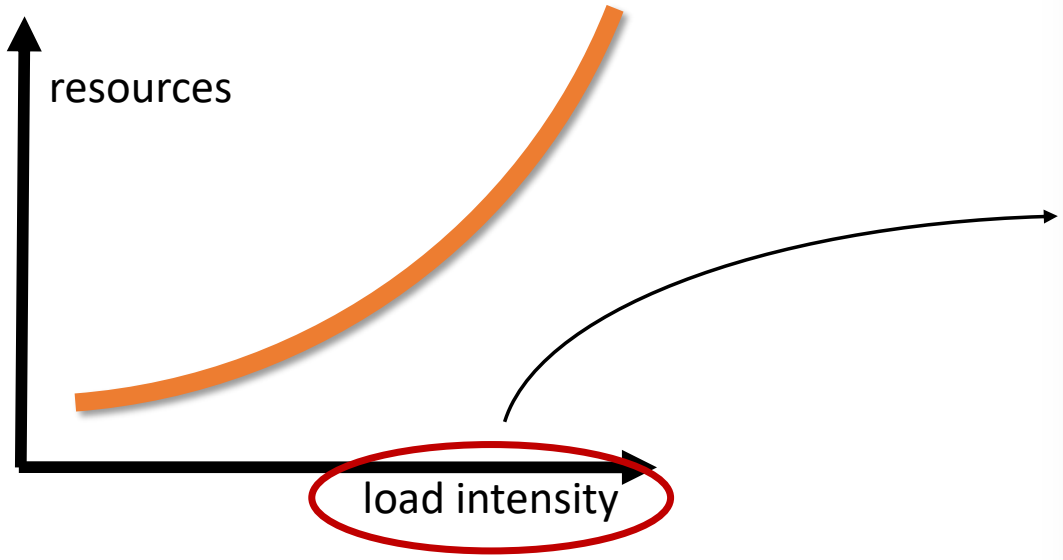


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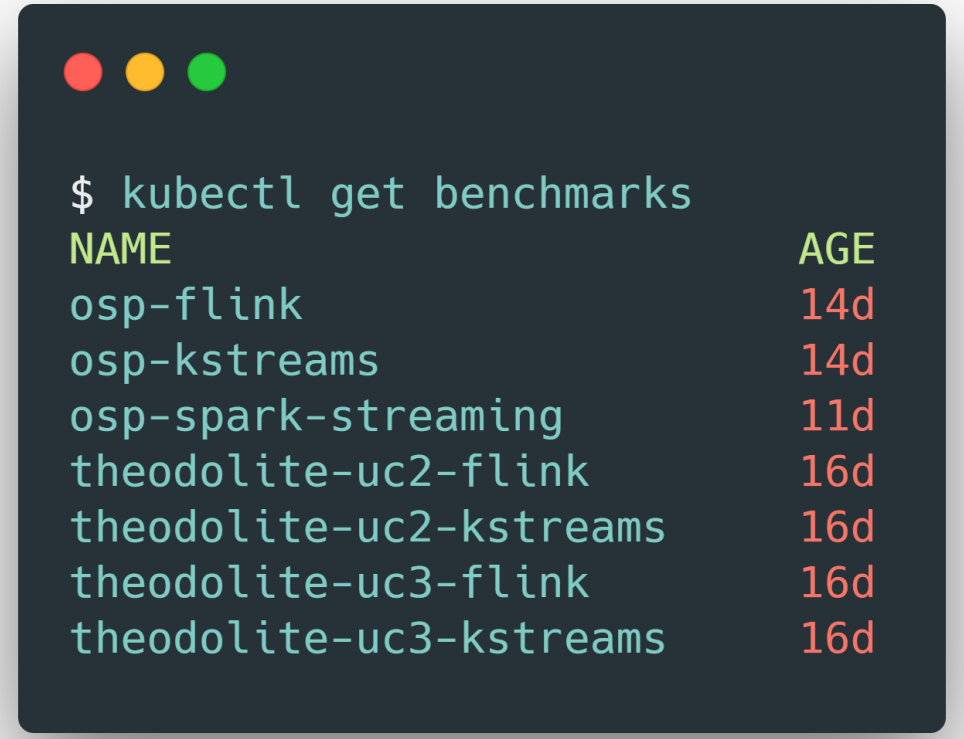

Theodolite ***Executions***

Benchmark

```yaml
apiVersion: theodolite.com/v1
kind: execution
metadata:
  name: theodolite-example-execution
spec:
  benchmark: "uc1-kstreams"
  load:
    loadType: "NumSensors"
    loadValues: [25000, 50000, 75000, 100000, 125000, 150000]
  resources:
    resourceType: "Instances"
    resourceValues: [1, 2, 3, 4, 5]
  slos:
    - sloType: "lag trend"
      prometheusUrl: "http://prometheus-operated:9090"
      offset: 0
      properties:
        threshold: 2000
        externalSloUrl: "http://localhost:80/evaluate-slope"
        warmup: 60 # in seconds
  execution:
    strategy: "LinearSearch"
    duration: 300 # in seconds
    repetitions: 1
    loadGenerationDelay: 30 # in seconds
    restrictions:
      - "LowerBound"
  configOverrides: []
```

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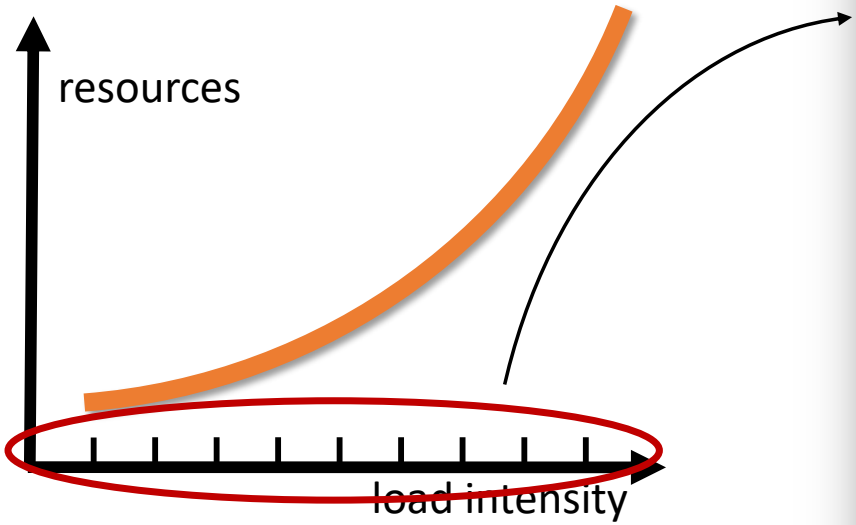


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Prometheus

pandas

SLO evaluation

```yaml
apiVersion: theodolite.com/v1
kind: execution
metadata:
  name: theodolite-example-execution
spec:
  benchmark: "uc1-kstreams"
  load:
    loadType: "NumSensors"
    loadValues: [25000, 50000, 75000, 100000, 125000, 150000]
  resources:
    resourceType: "Instances"
    resourceValues: [1, 2, 3, 4, 5]
  slos:
    - sloType: "lag trend"
      prometheusUrl: "http://prometheus-operated:9090"
      offset: 0
      properties:
        threshold: 2000
        externalSloUrl: "http://localhost:80/evaluate-slope"
        warmup: 60 # in seconds
  execution:
    strategy: "LinearSearch"
    duration: 300 # in seconds
    repetitions: 1
    loadGenerationDelay: 30 # in seconds
    restrictions:
      - "LowerBound"
  configOverrides: []
```

Theodolite ***Executions***

```
$ kubectl get executions
NAME                                STATUS     DURATION   AGE
osp-flink-execution                 PENDING    -          6s
osp-flink-execution-small           RUNNING    2m         2m52s
osp-kstreams-default                FINISHED   11h        10d
osp-kstreams-execution              FINISHED   42m        14d
osp-spark-streaming-execution       FINISHED   8m         11d
uc3-flink-template                  FINISHED   18m        11d
uc3-kstreams-default                FINISHED   10h        10d
uc3-kstreams-default-short          FINISHED   3h         10d
uc3-kstreams-scotty                 FINISHED   4h         10d
uc3-kstreams-scotty-short           FINISHED   2h         10d
```

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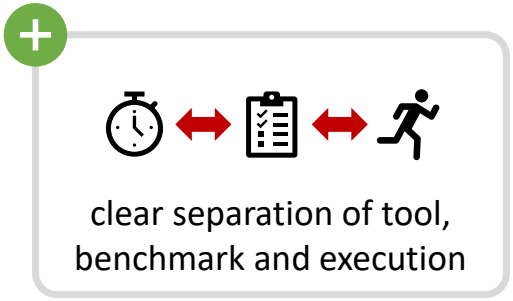

clear separation of tool, benchmark and execution

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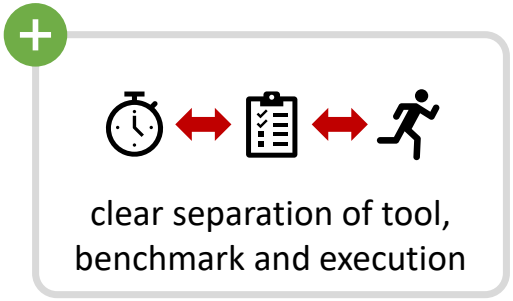

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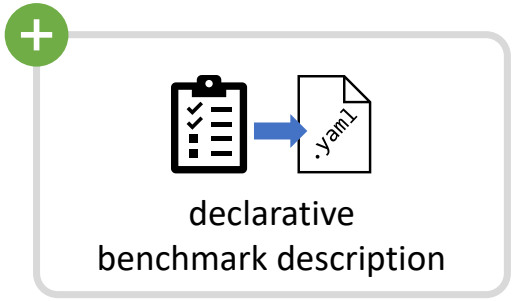

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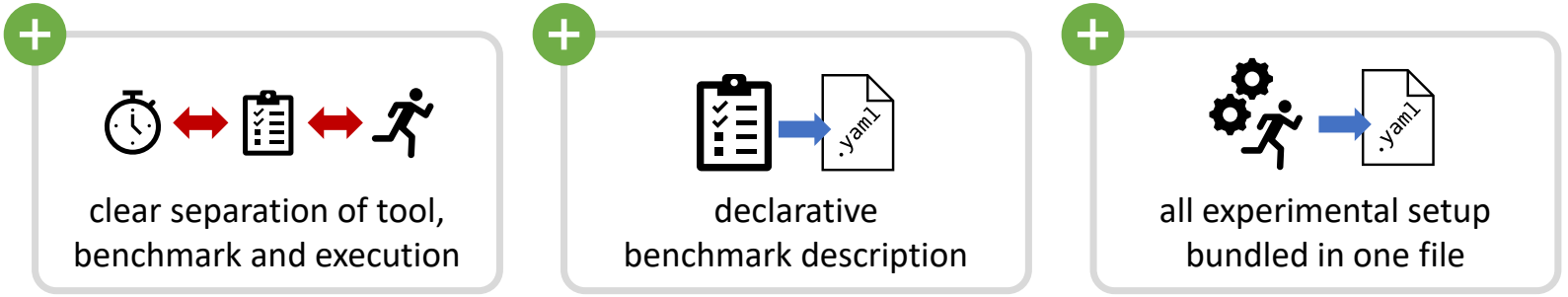

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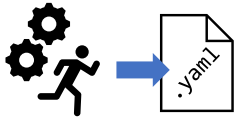

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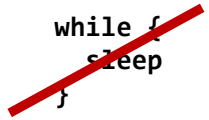

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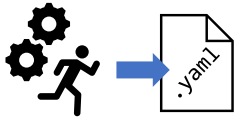

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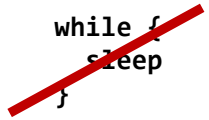

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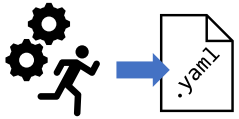

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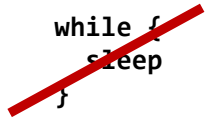

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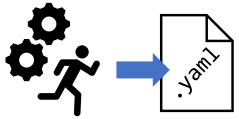

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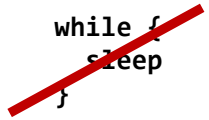

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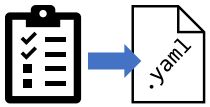

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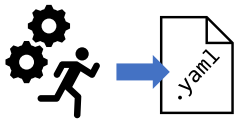

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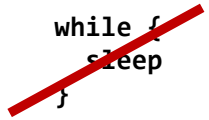

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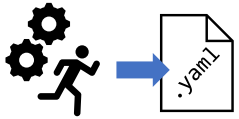

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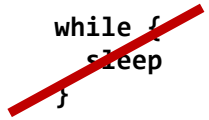

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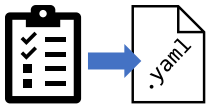

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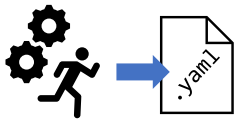

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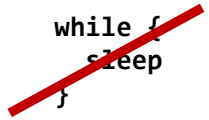

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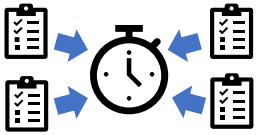

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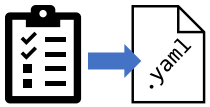

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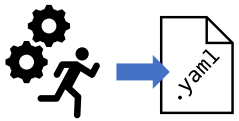

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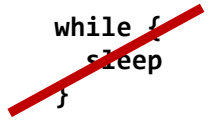

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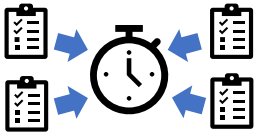

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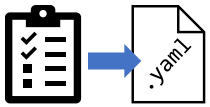

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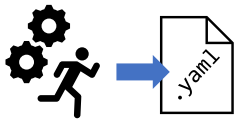

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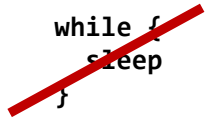

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OPENAPI INITIATIVE

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argo flux

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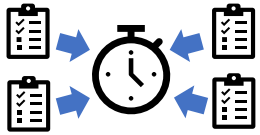

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OPERATOR FRAMEWORK

fabric8

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https://github.com/cau-se/theodolite