Icarus: a Caching Simulator for Information Centric Networking (ICN)

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`http://icarus-sim.github.io`

Outline

- Background and motivation
  - Information Centric Networking (ICN)
  - Evaluating caching performance
- Icarus simulator
  - Architecture and design
  - Modelling tools
  - Performance evaluation
- Summary and conclusions

Information Centric Networking (ICN)

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Main principles:

- Request-response model
- Location-agnostic content addressing
- Secure the content, not the channel
- In-network caching

Overlay vs. In-Network Caching

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- Caching at the chunk-level **not** at the file-level (probably **not** at the packet level either)
  - As contents pass through router-caches they replace existing "old" contents
  - Caching can happen transparently into the network at random or predefined (rendezvous) points

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- Replacement happens at line-speed – what does this imply?
  - Overlay caching depends on centralised (control-plane) co-ordination and management of caches (or de-centralised among very few nodes) – In-network caching does not.

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- Hence: no book-keeping possible
  - Impossible to co-ordinate with other caches, or the control plane – the exact location of contents cannot be known
  - Caching operations happen transparently inside the network
  - Decentralized distribution and replacement of contents in caches

Evaluating Caching Performance

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- Poor scalability

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Scarce availability of open-source implementations of modelling tools for network caching research.

Icarus simulator

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Python-based discrete-event simulator designed for evaluating the performance of:

- Caching and routing strategies
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Non-functional requirements:

- Extensibility
- Scalability

Achieving extensibility

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- Plug-in registration system and extensive use of bridge pattern to provide loose-coupling

```
@register_cache_policy('FOO')
class FooCache(Cache)

    def get(self, k):
        ...

    def put(self, k):
        ...
```

```
# config
    .
    .
POLICIES = [‘LRU‘, 'FOO‘]
    .
    .
    .
```

Achieving extensibility

- Plug-in registration system and extensive use of bridge pattern to provide loose-coupling
- Support for `fnss` and `networkx` tools

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- Parallel execution of experiments
- Minimized disk access during experiment execution

Architecture and design

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Code organized in four loosely-coupled subsystems:

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- Orchestration

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- Scenario generation

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Code organized in four loosely-coupled subsystems:

- Orchestration
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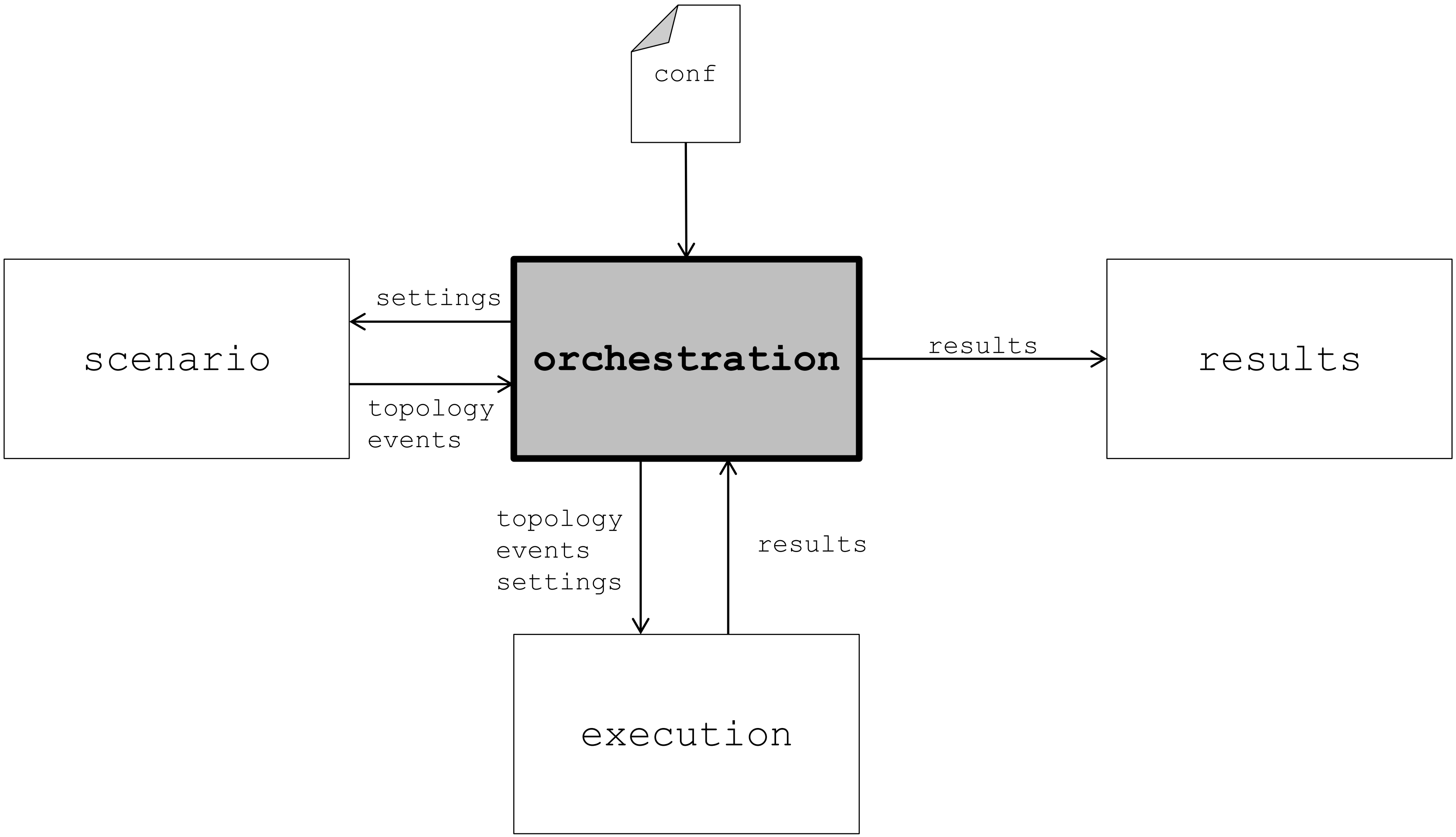
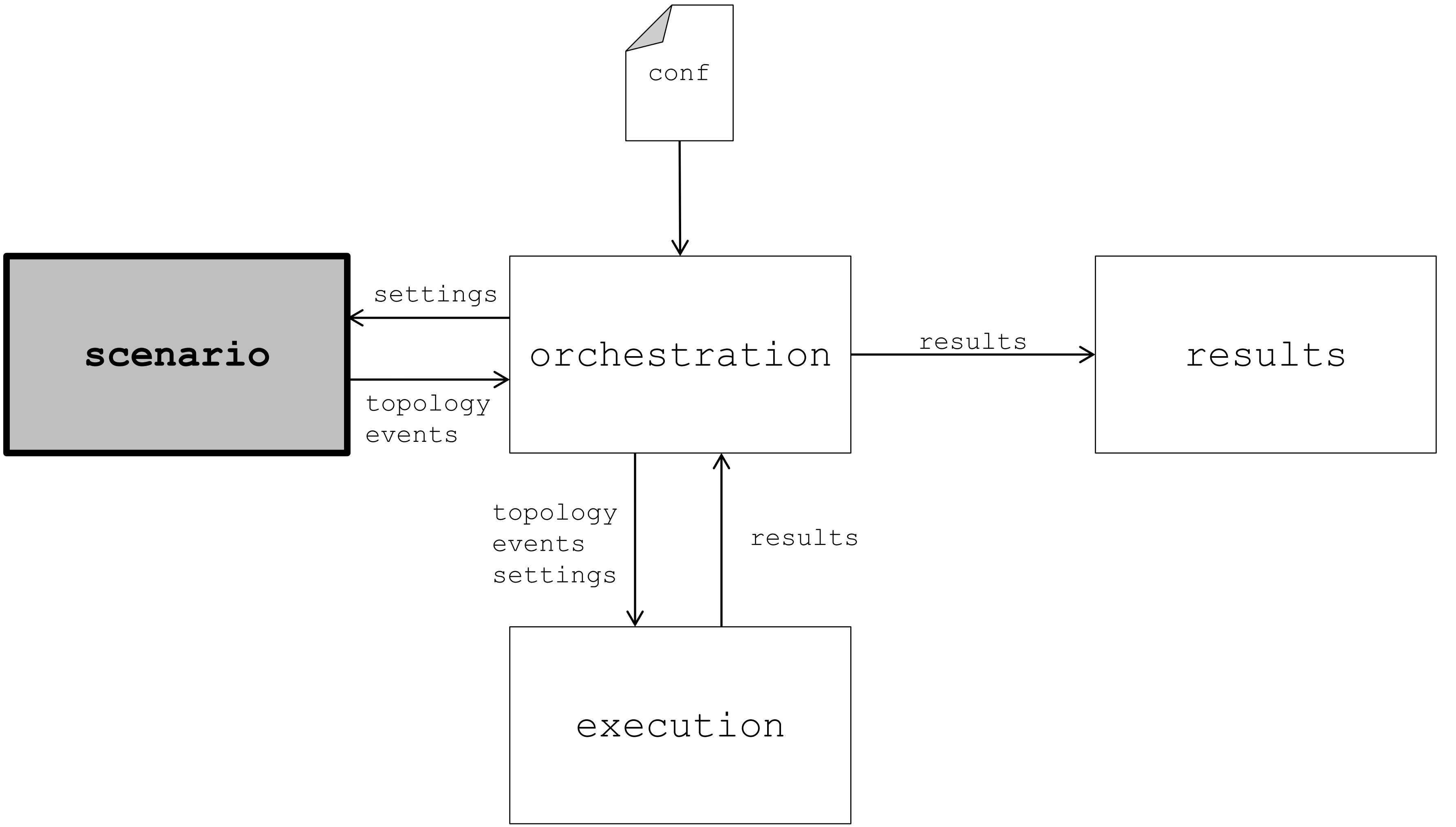
- Results collection and analysis

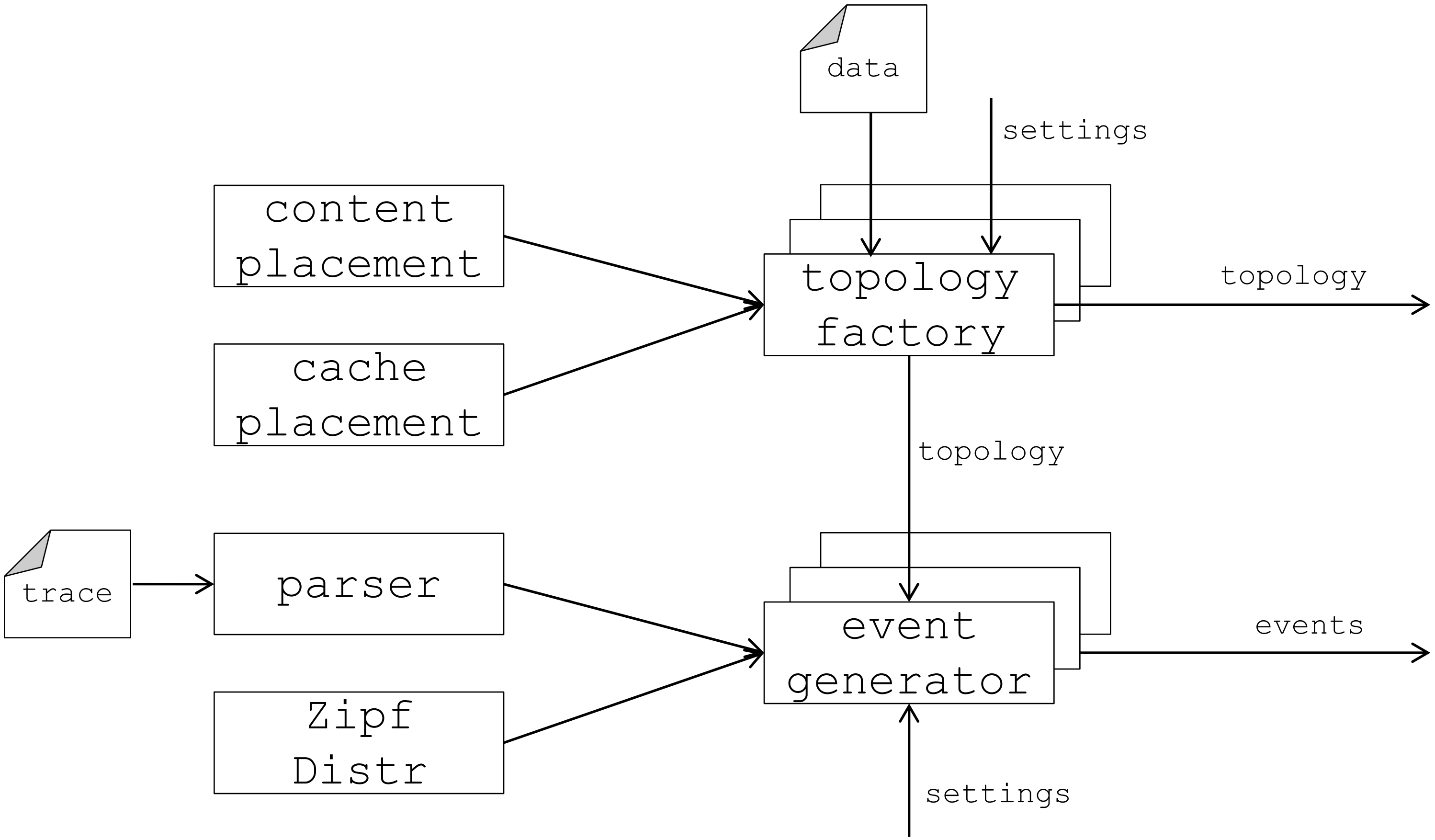
Orchestration



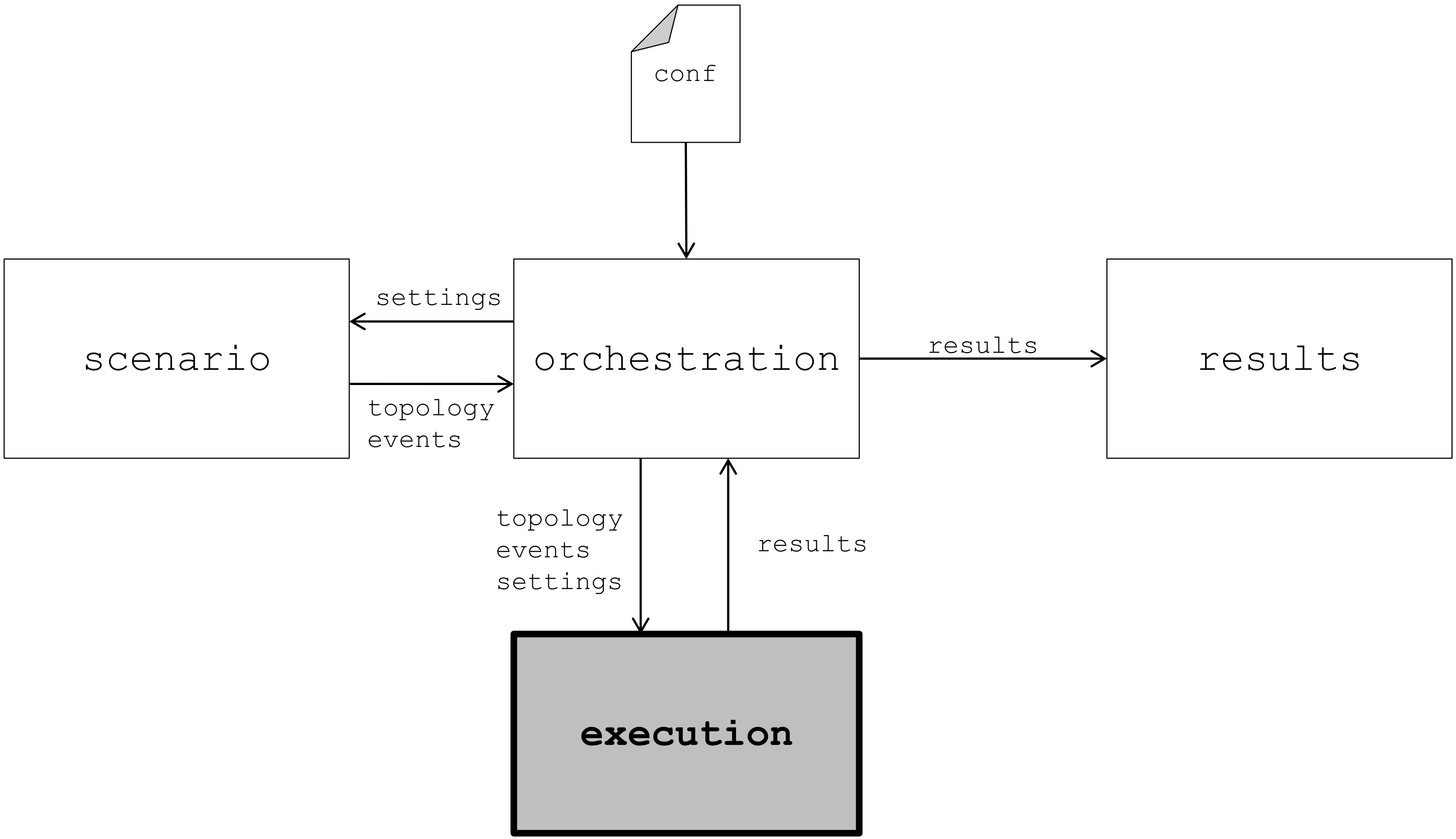
Scenario generation



Scenario generation



Execution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events
orchestration
results
results
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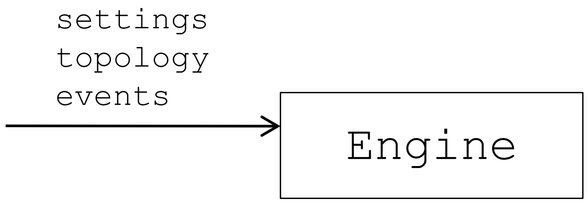
settings
results
execution

Execution

Execution



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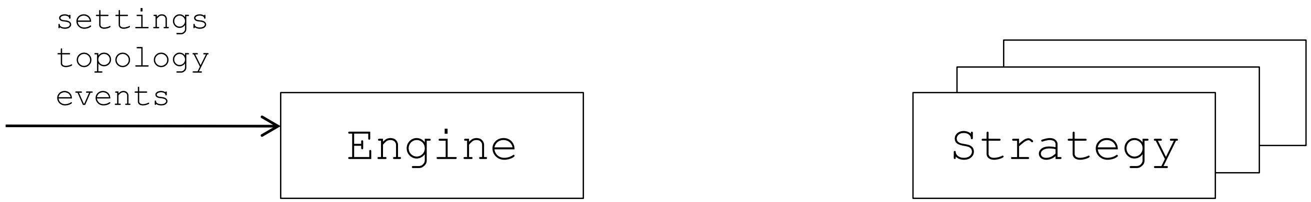

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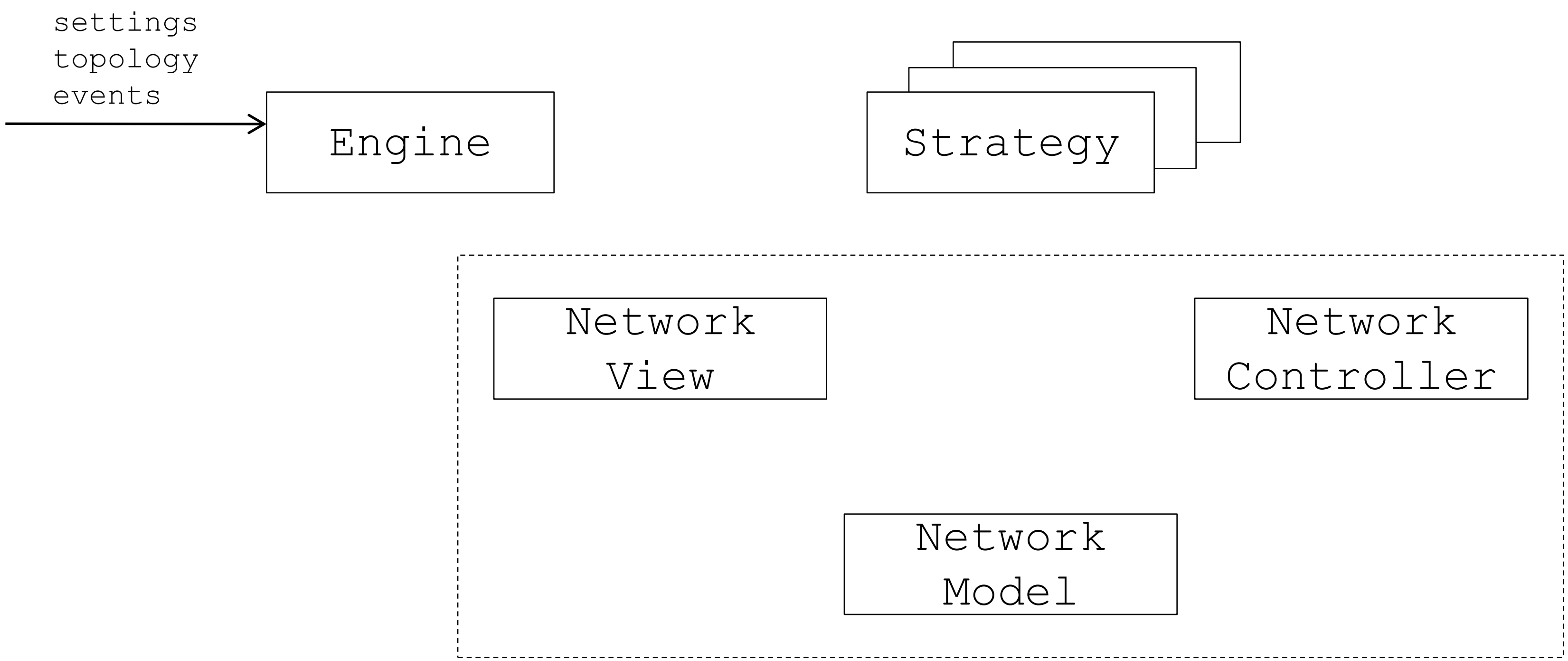
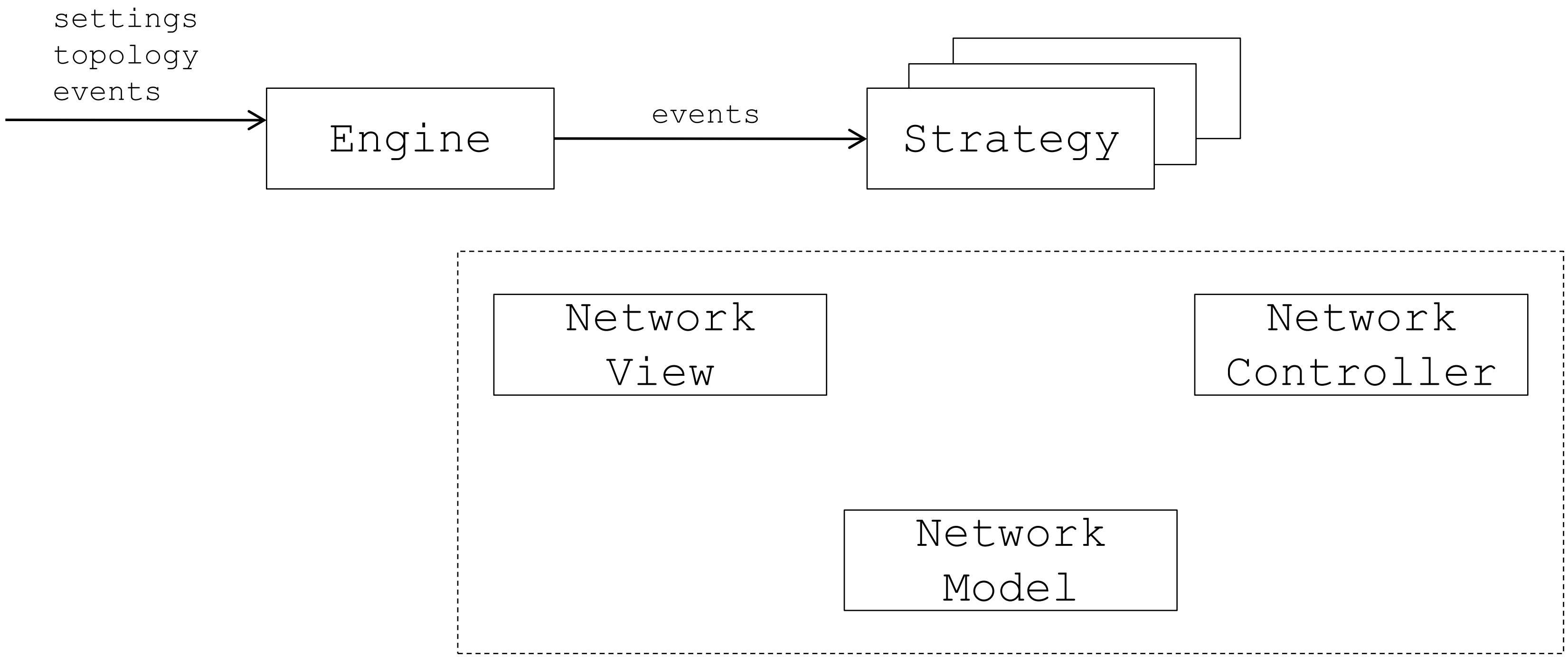

settings
topology
events
Engine
Strategy
Network View
Network Controller
Network Model

Execution



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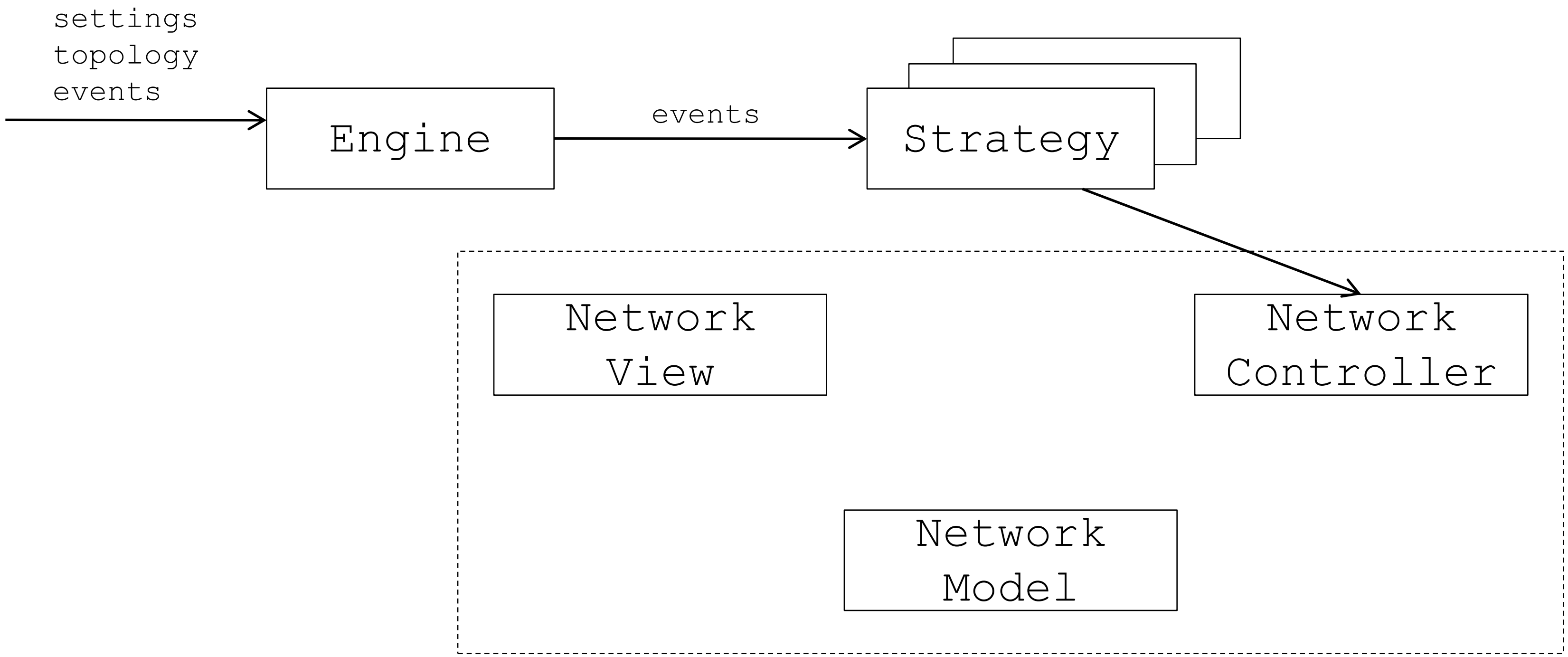

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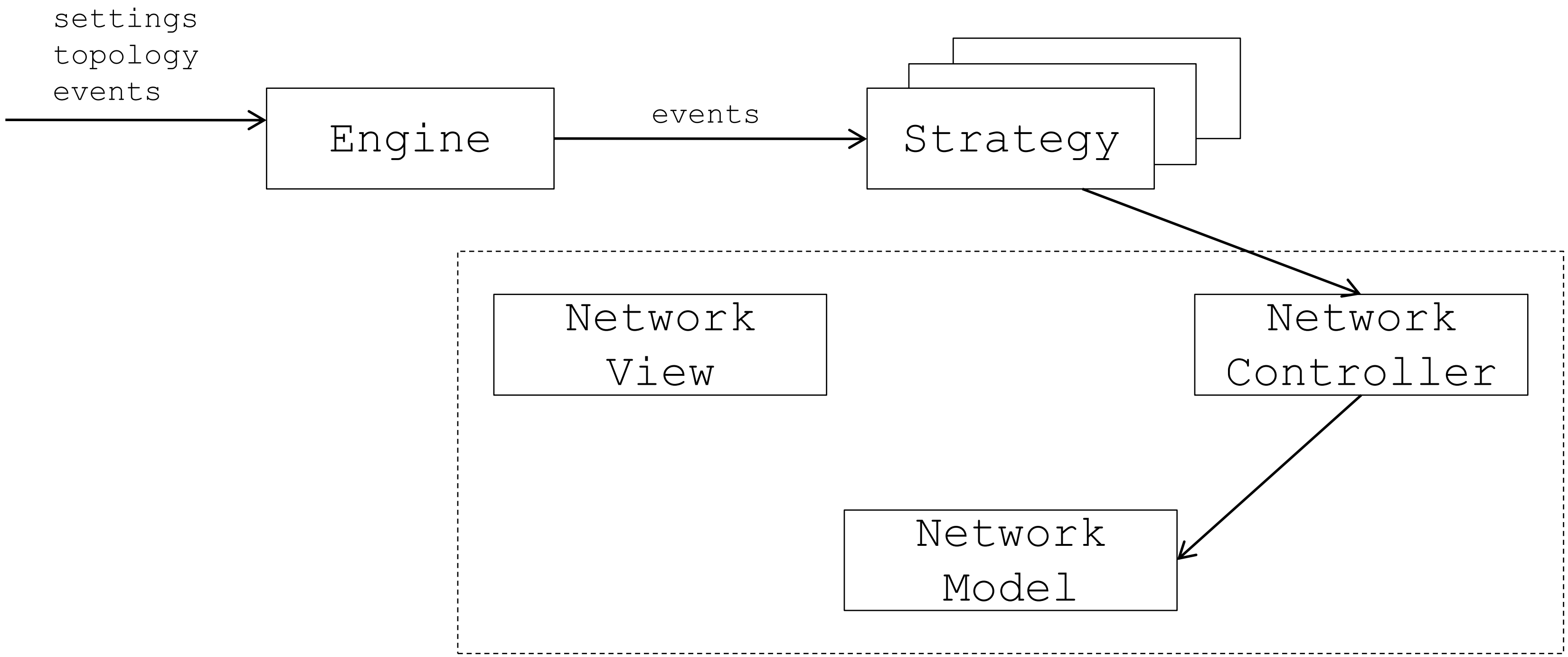
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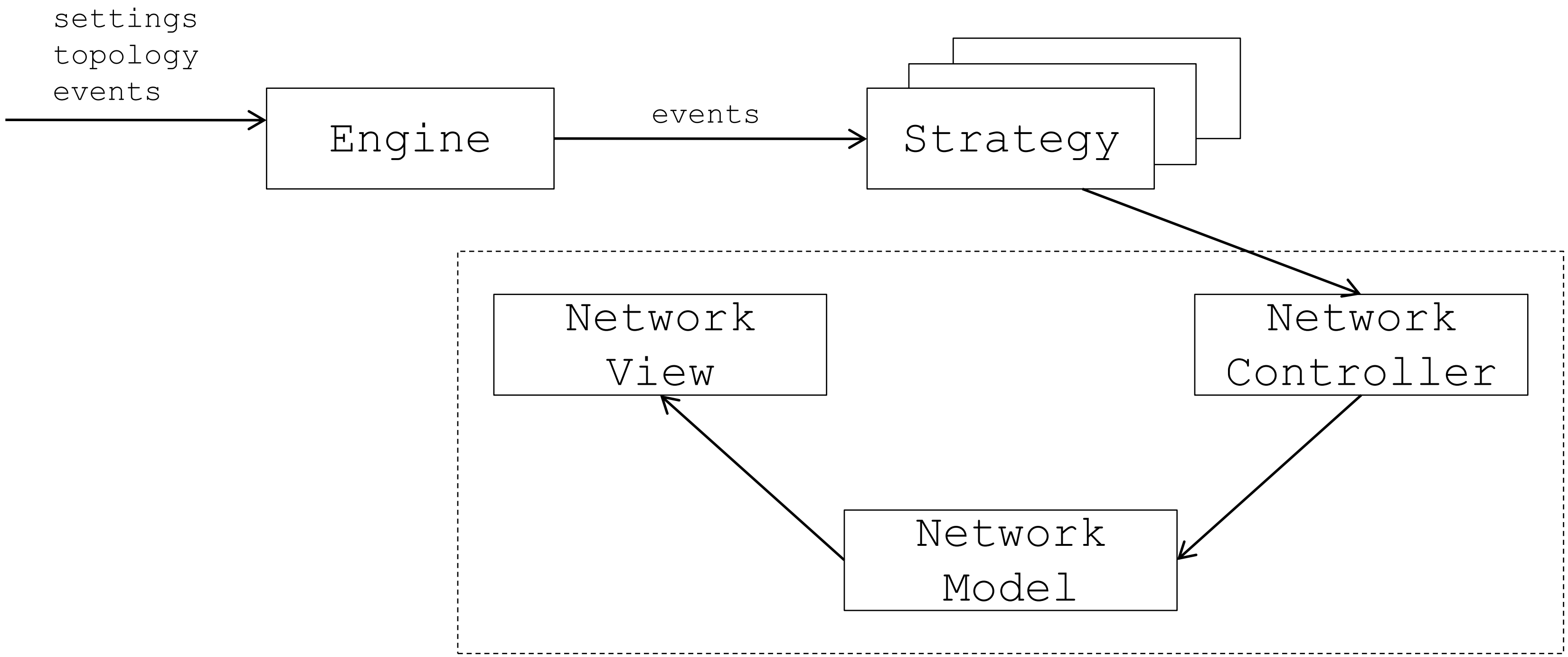
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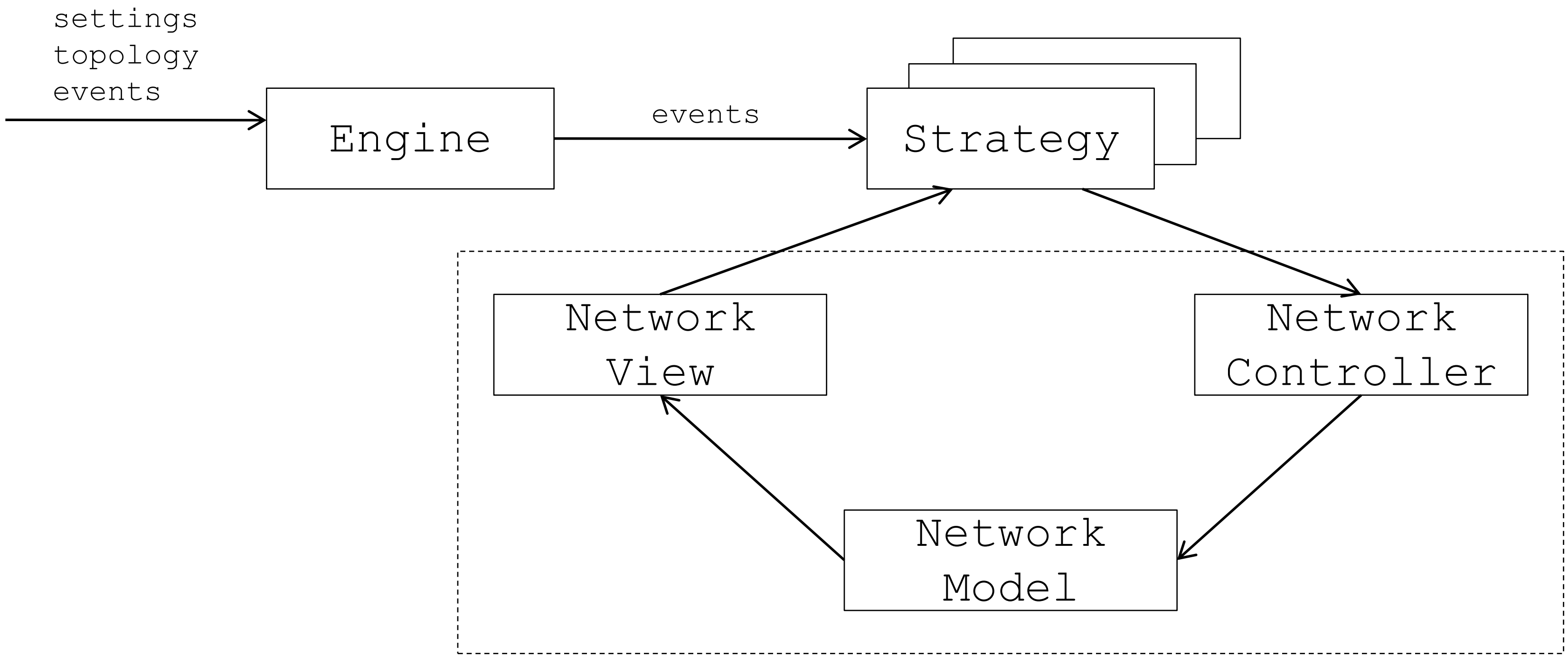

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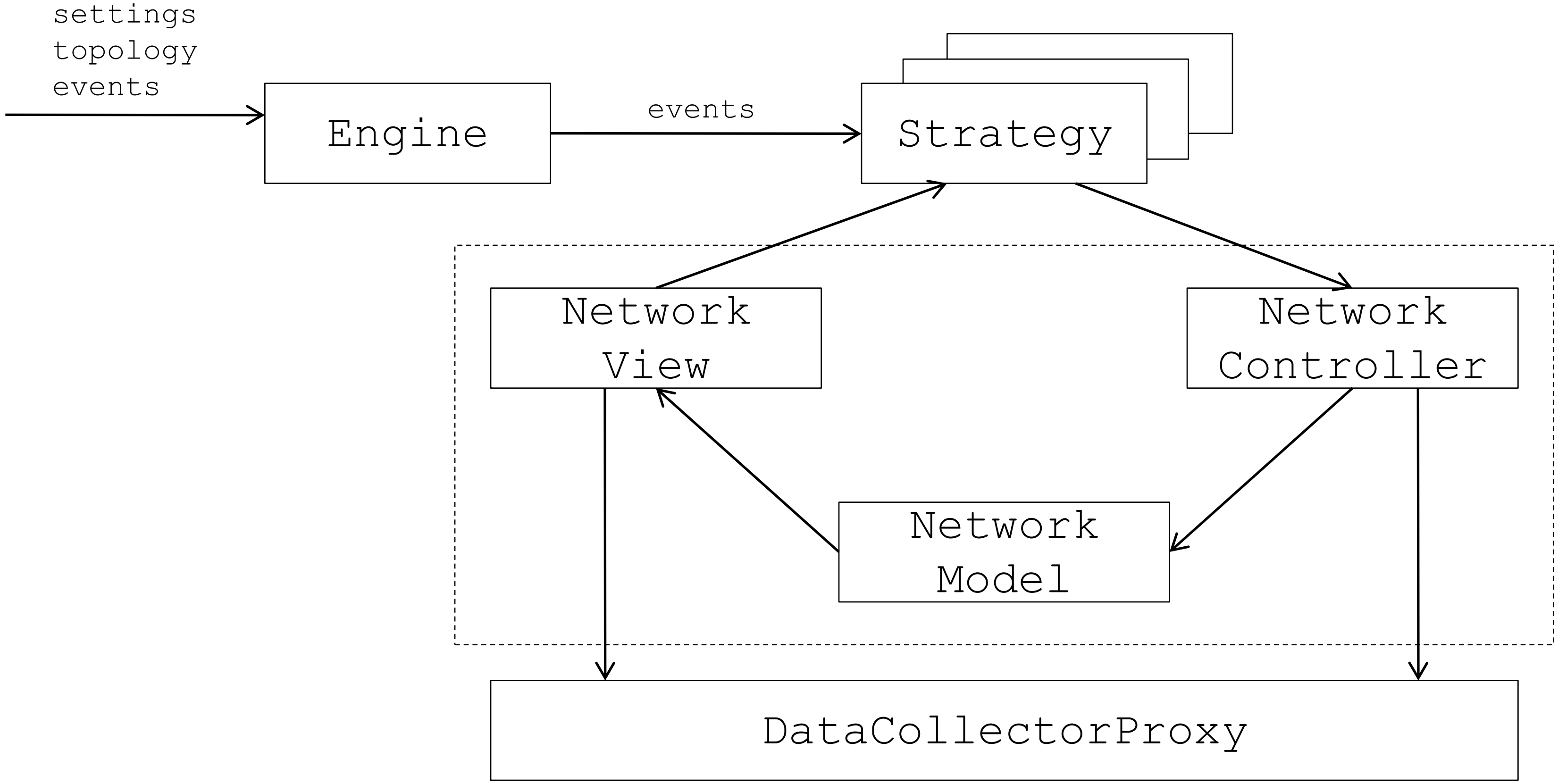
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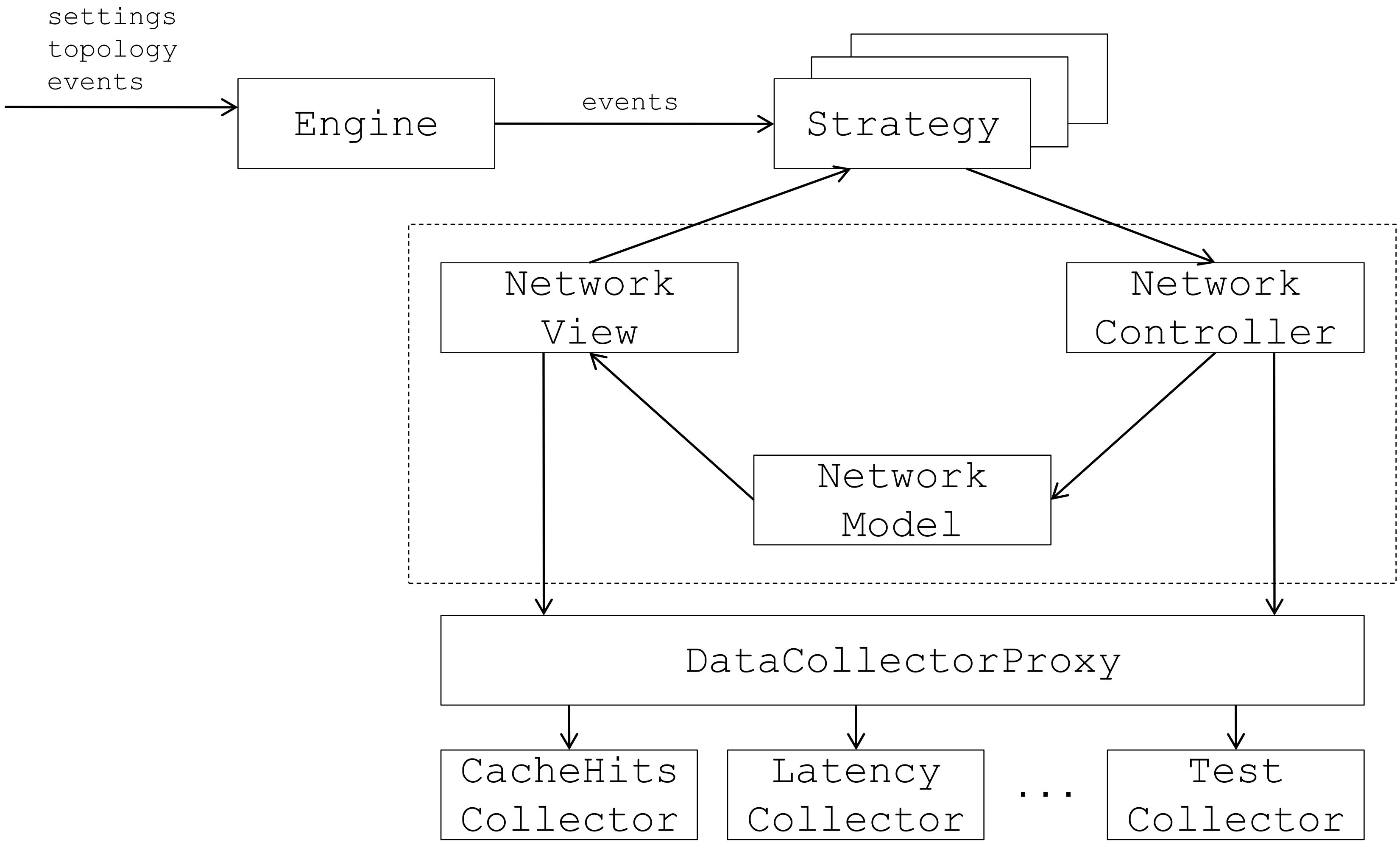
DataCollectorProxy

Execution


settings
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Network View
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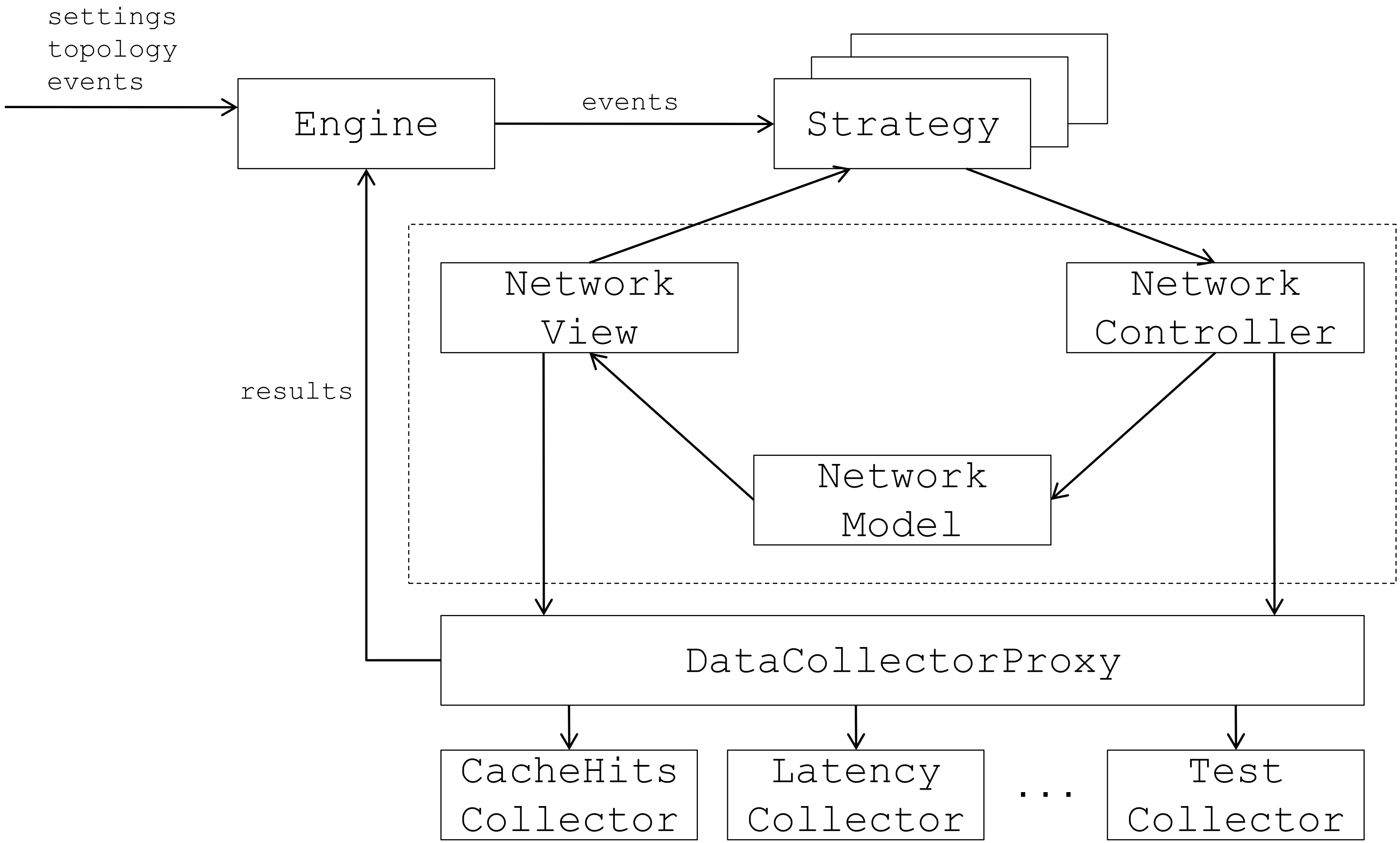
Network Model
DataCollectorProxy
CacheHits Collector
Latency Collector
...
Test Collector

Execution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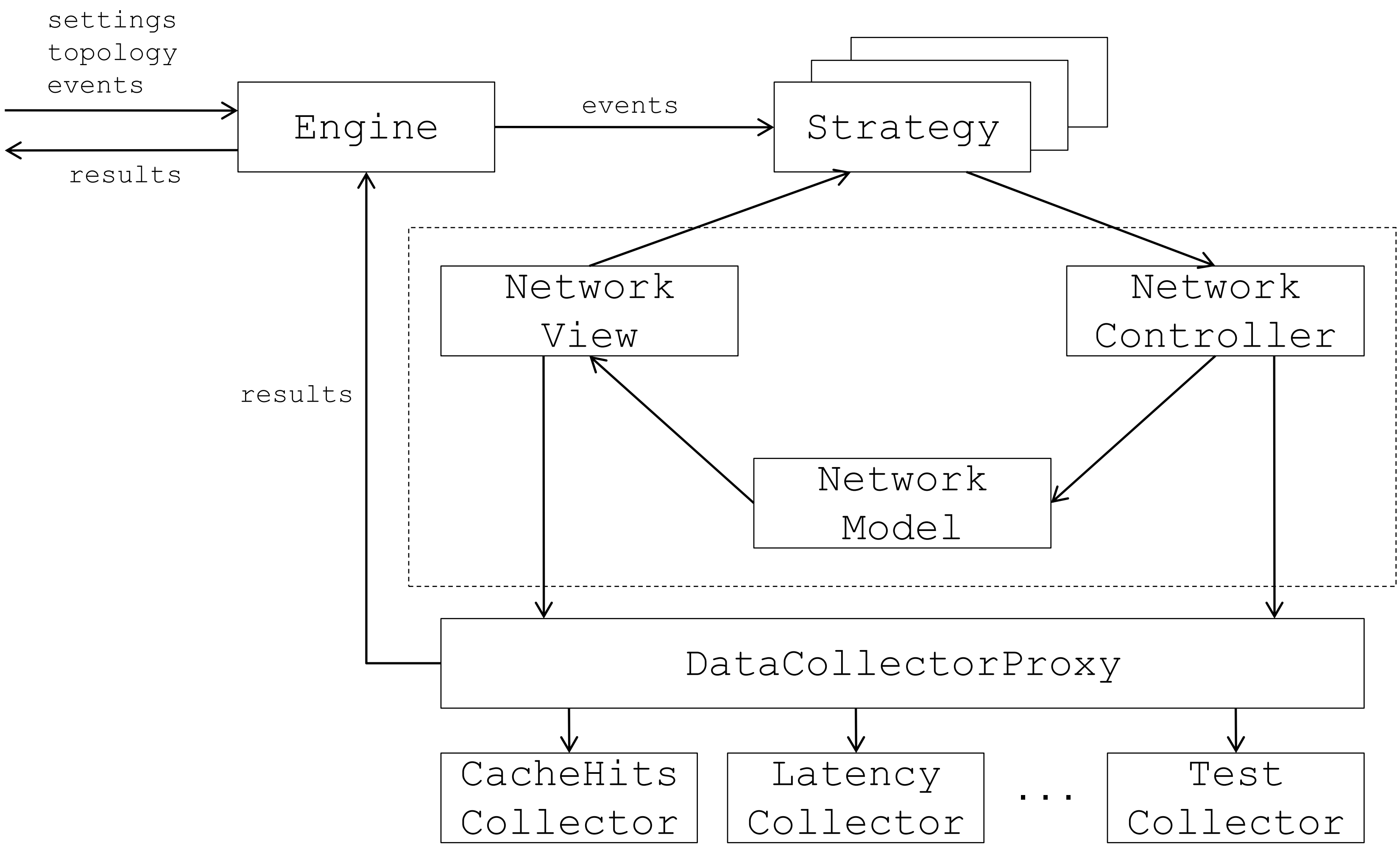
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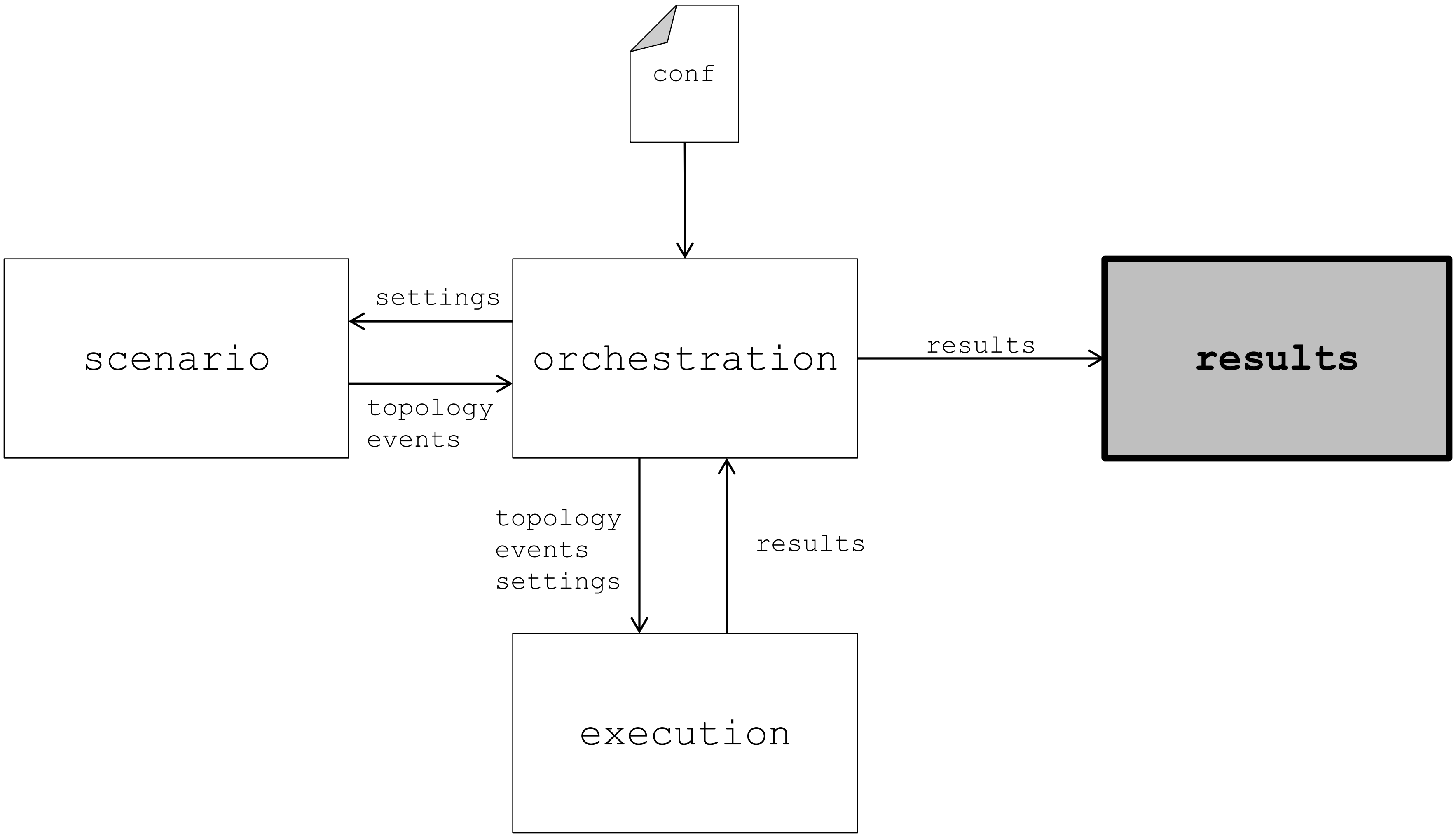
Results collection and analysis



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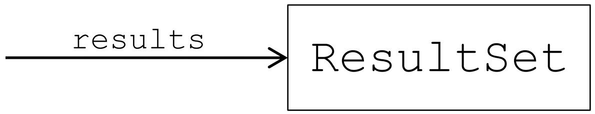

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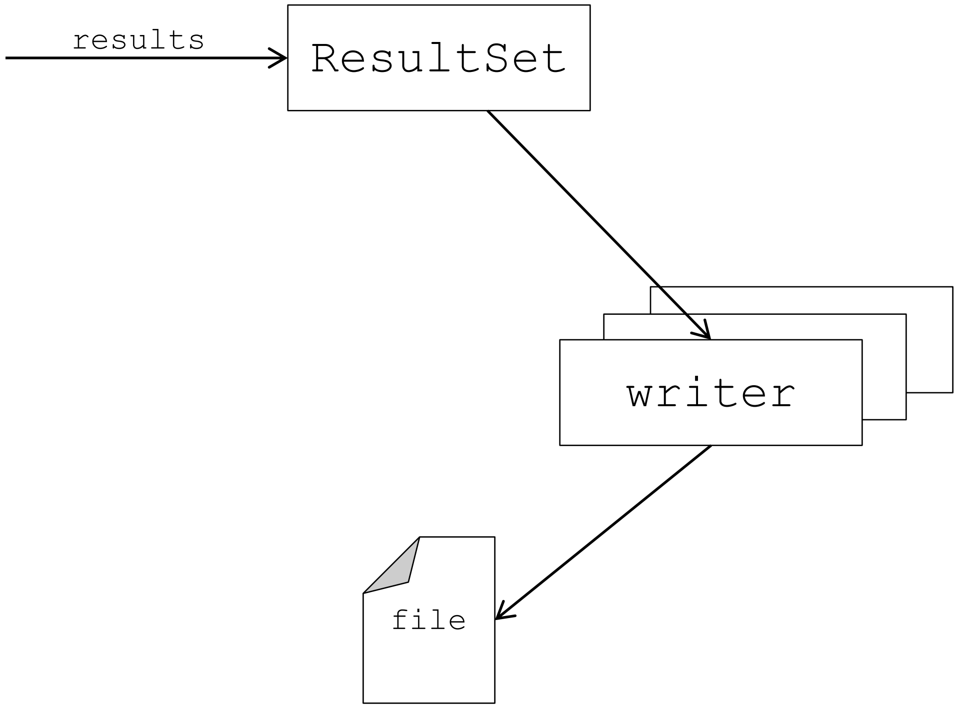

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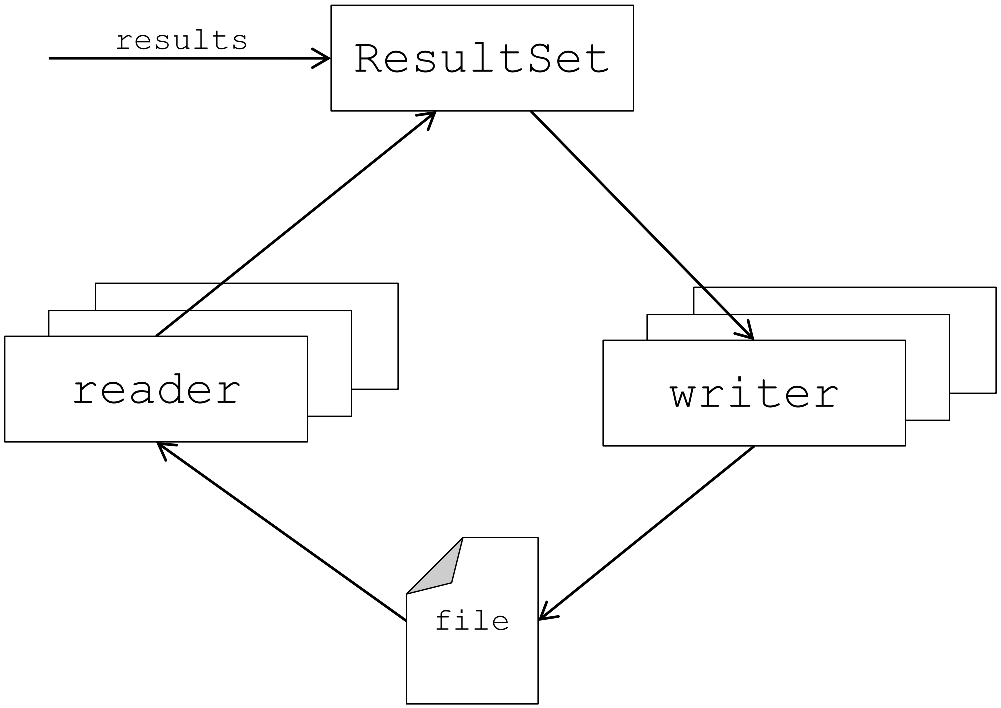

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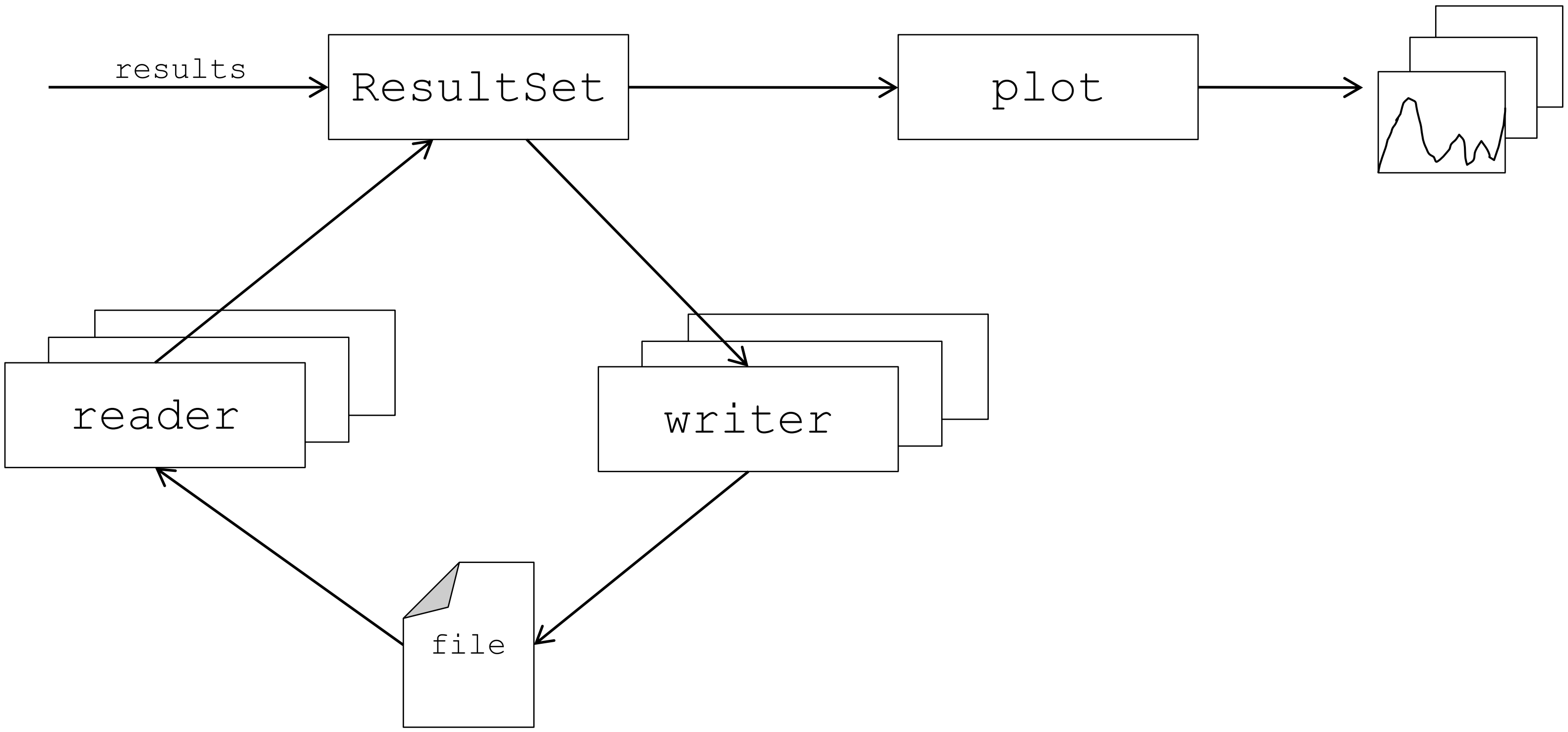

Modelling tools

Cache performance

Workloads

Modelling tools

Cache performance

- Che’s approximation

Workloads

```
>>> import icarus as ics
>>> ics.che_cache_hit_ratio(
          ics.TruncatedZipfDist(alpha=0.8, n=1000).pdf,
          100)
0.36482948293429832
```

Modelling tools

Cache performance

- Che's approximation
- Laoutaris' approximation

Workloads

```
>>> import icarus as ics
>>> ics.laoutaris_cache_hit_ratio(0.7, 1000, 100)
0.359348209359255
```

Modelling tools

Cache performance

- Che’s approximation
- Laoutaris’ approximation
- Optimal hit ratio

Workloads

```
>>> import icarus as ics
>>> ics.optimal_cache_hit_ratio(
          ics.TruncatedZipfDist(alpha=0.8, n=1000).pdf,
          100)
0.52582651157679017
```

Modelling tools

Cache performance

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- Laoutaris' approximation
- Optimal hit ratio
- Numeric hit ratio

Workloads

```
>>> import icarus as ics
>>> ics.numeric_cache_hit_ratio(
          ics.TruncatedZipfDist(alpha=0.8, n=1000).pdf,
          ics.LruCache(100))
0.37861264056574684
```

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Workloads

- Zipf fit

```
>>> import icarus as ics
>>> ics.zipf_fit(ics.TruncatedZipfDist(alpha=0.8, n=1000).pdf)
(0.799999999571759, 1.0)
```

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Workloads

- Zipf fit
- Trace parsers

```
>>> import icarus as ics
>>> ics.parse_wikibench('wikibench.txt')
```

Evaluating scalability

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Scenario:

- Tree topology
- Zipf-distributed content popularity ($\alpha = 0.7$)
- Constant cache/catalogue ratio: 10%
- 500K requests per experiment

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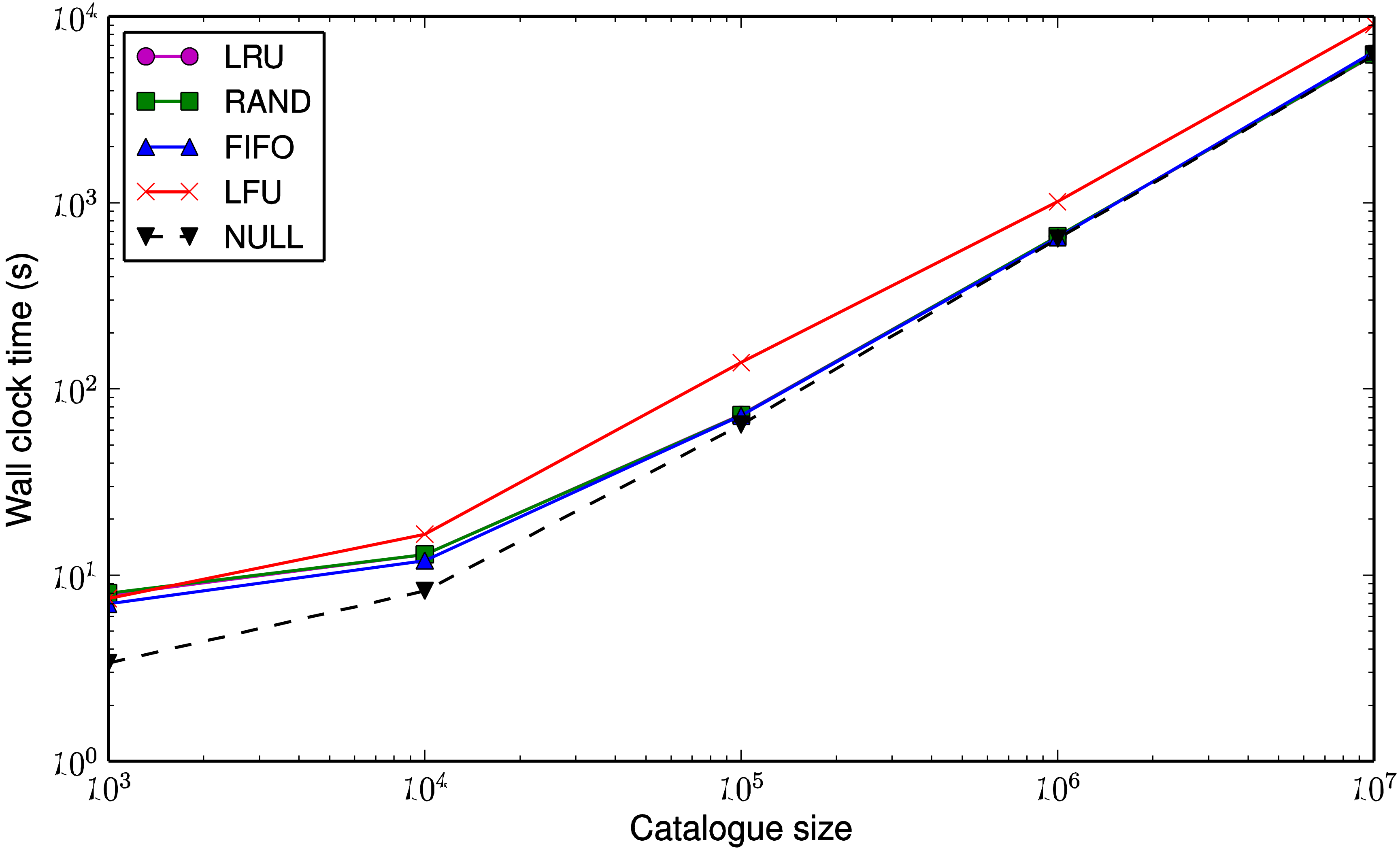
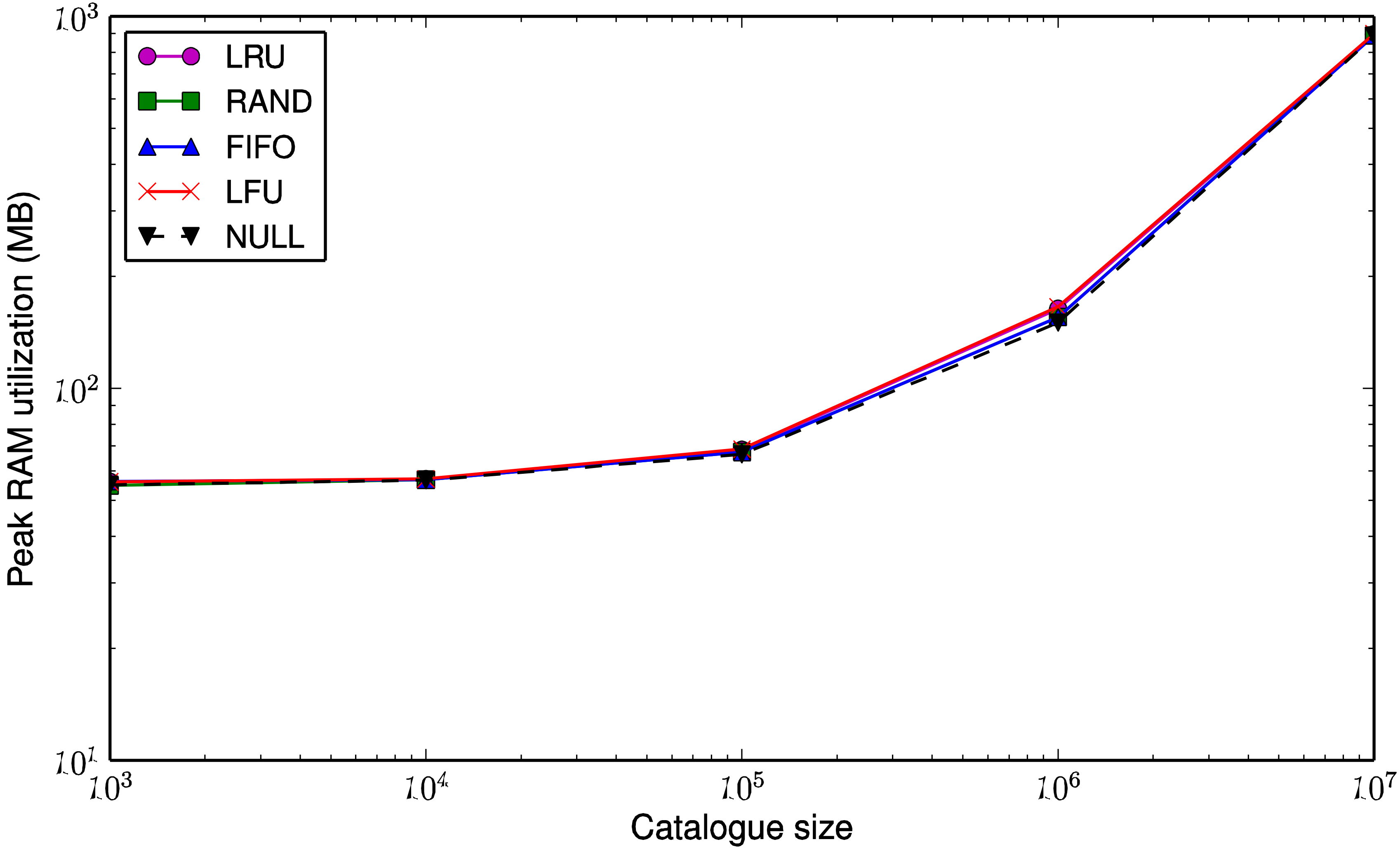
Metrics:

- CPU load and memory utilization vs. content catalogue size

Processing load vs content catalogue size



Memory utilization vs content catalogue size



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- Designed for extensibility and scalability
- Comprises a set of modelling tools for cache performance and workloads analysis

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