Towards General-Purpose Resource Management in Shared Cloud Services

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Shared-tenant cloud services

Processes service requests from multiple clients

- ✓ Great for cost and efficiency
- ✗ Performance is a challenge

Aggressive tenants and system maintenance tasks

↓

Resource starvation and bottlenecks

↓

Degraded performance, Violated SLOs, system outages

Shared-tenant cloud services

Ideally

manage resources to provide end-to-end guarantees and isolation

Challenge

OS/hypervisor mechanisms insufficient

- ✗ Shared threads & processes
- ✗ Application-level resource bottlenecks (locks, queues)
- ✗ Resources across multiple processes and machines

Today

lack of guarantees, isolation

some ad-hoc solutions

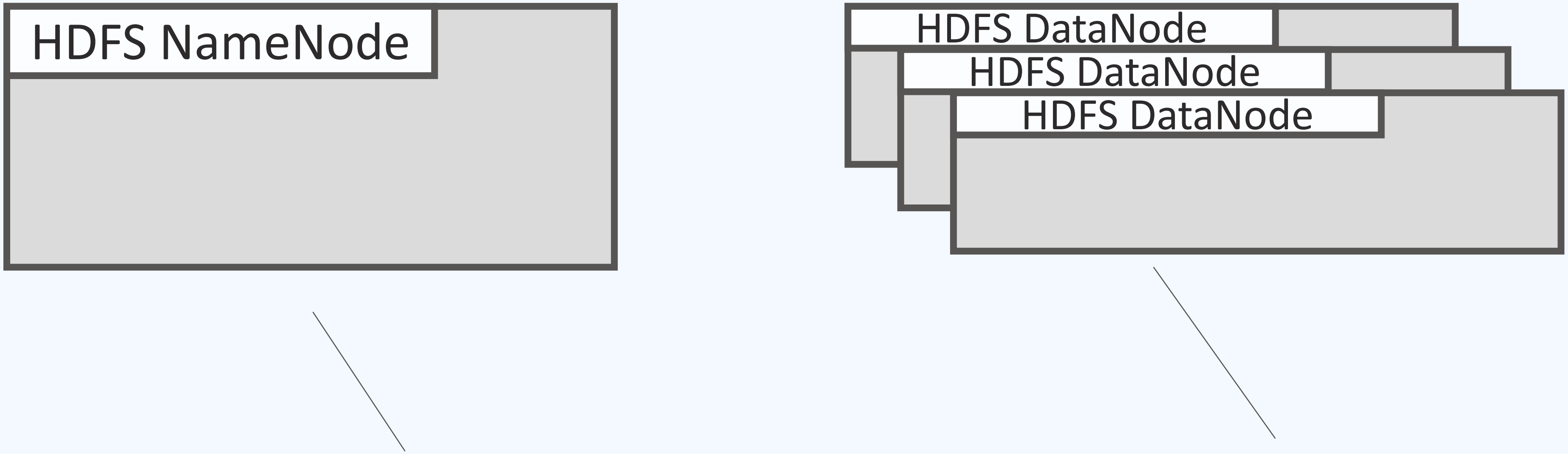
This paper

- 5 design principles for resource policies in shared-tenant systems

- *Retro* – prototype for **principled** resource management

- Preliminary demonstration of Retro in HDFS

Hadoop Distributed File System (HDFS)



HDFS NameNode

HDFS DataNode

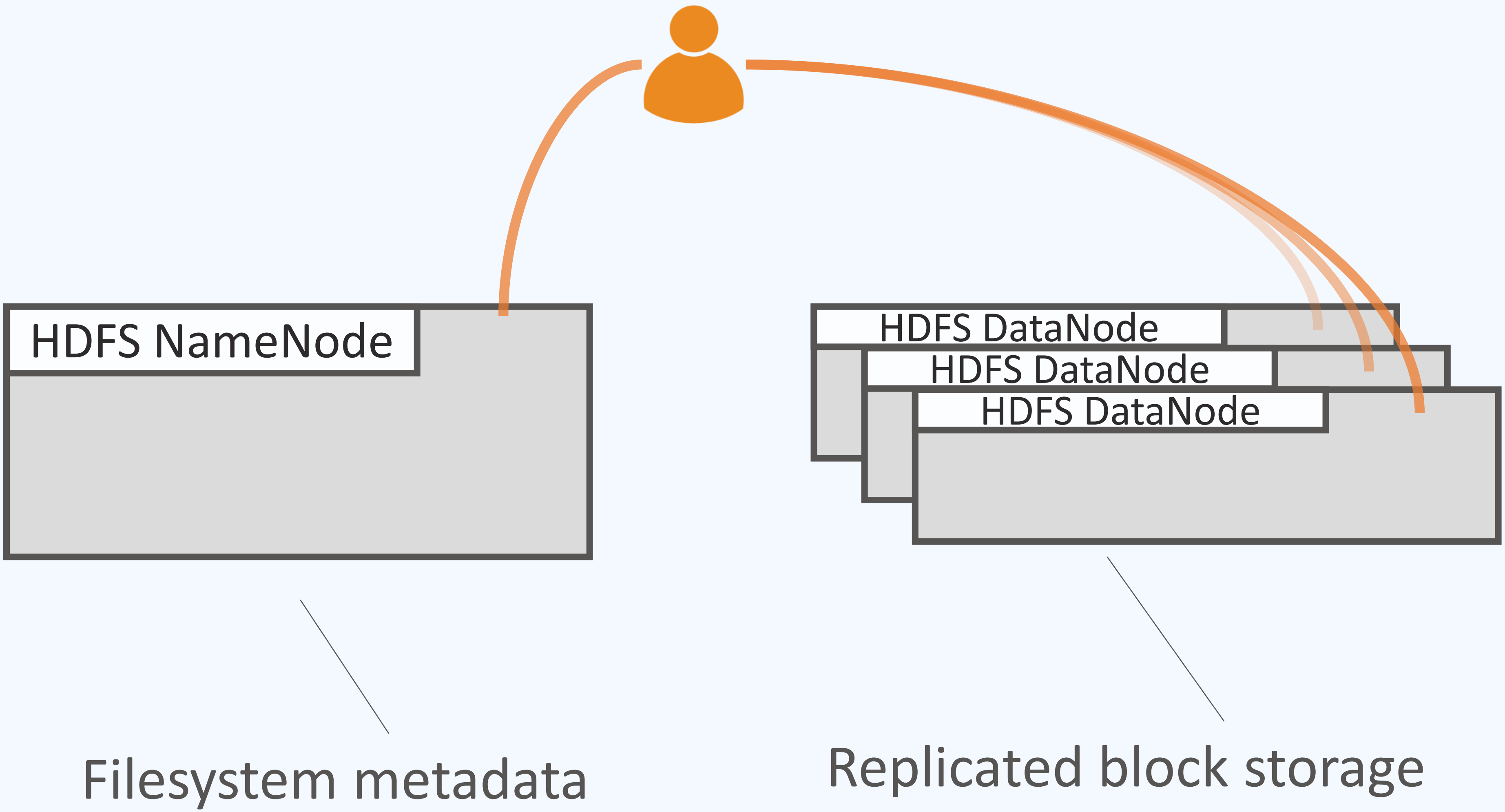
HDFS DataNode

HDFS DataNode

Filesystem metadata

Replicated block storage

Hadoop Distributed File System (HDFS)



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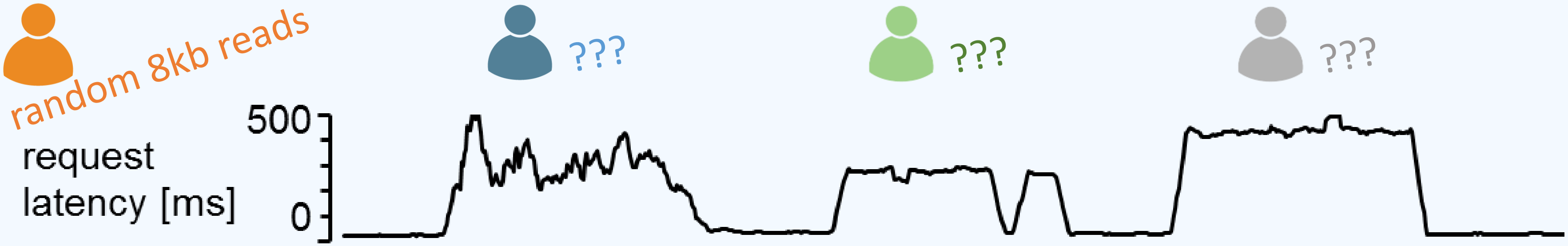
Filesystem metadata

Replicated block storage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???
???
???
request
latency [ms]
500
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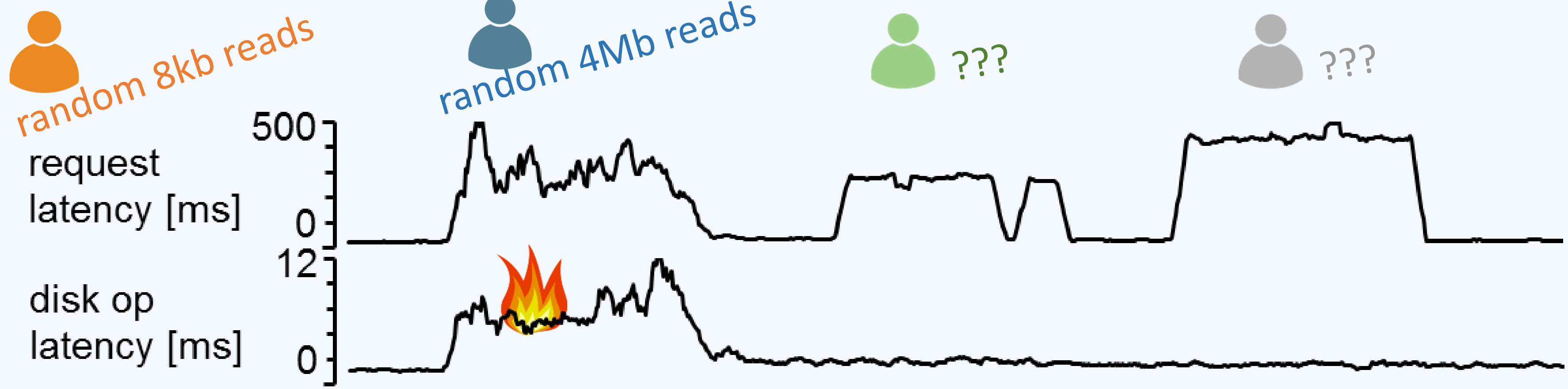
random 8kb reads
random 4Mb reads
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request latency [ms]
500
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disk op latency [ms]
12
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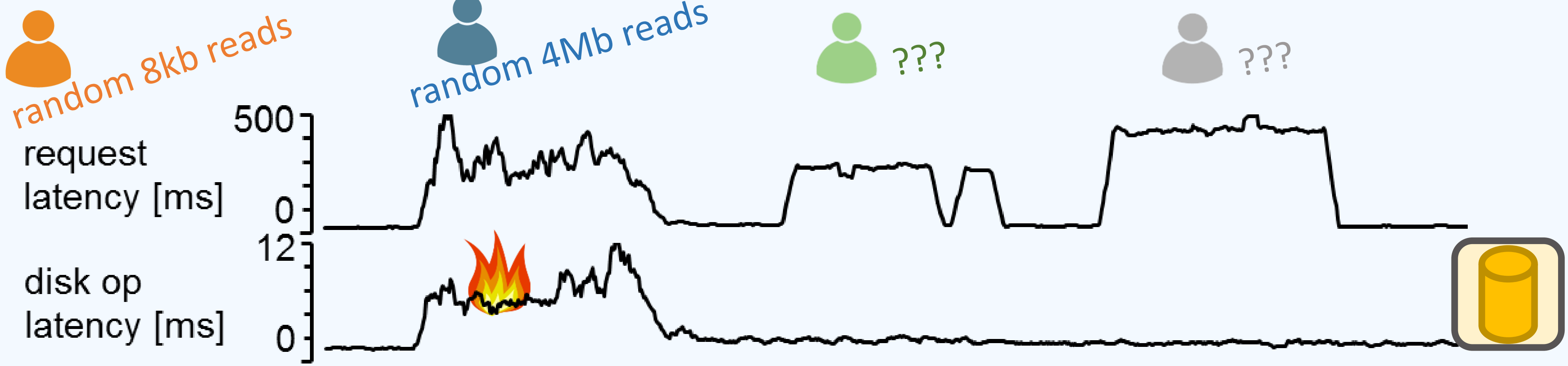
random 8kb reads
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request latency [ms]
500
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disk op latency [ms]
12
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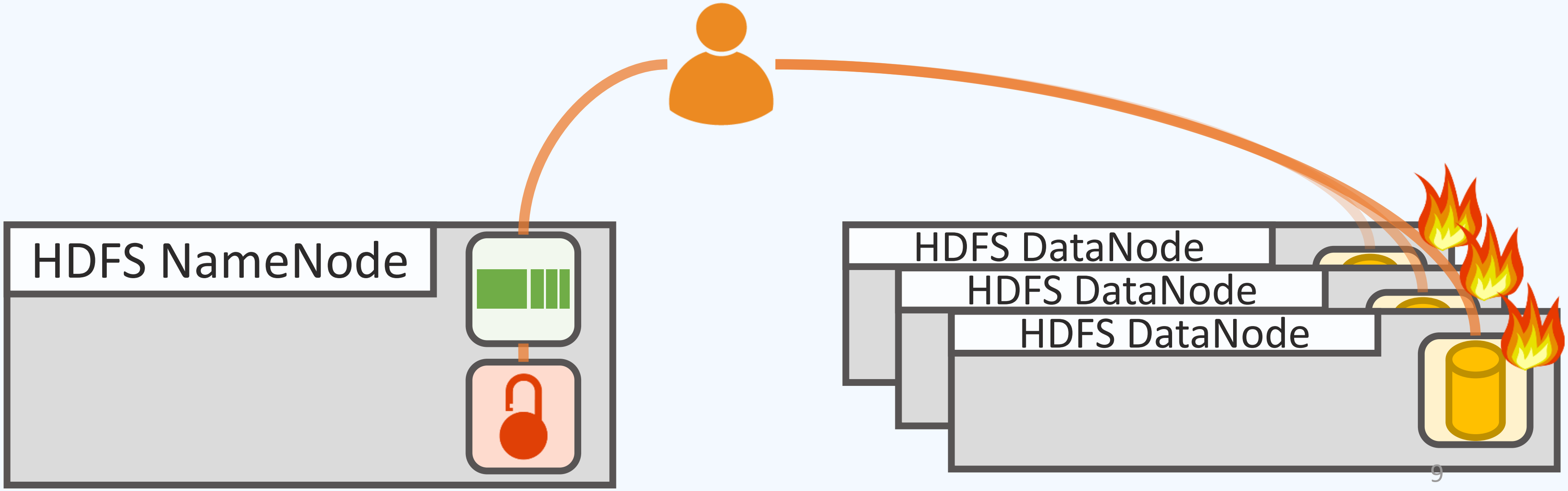
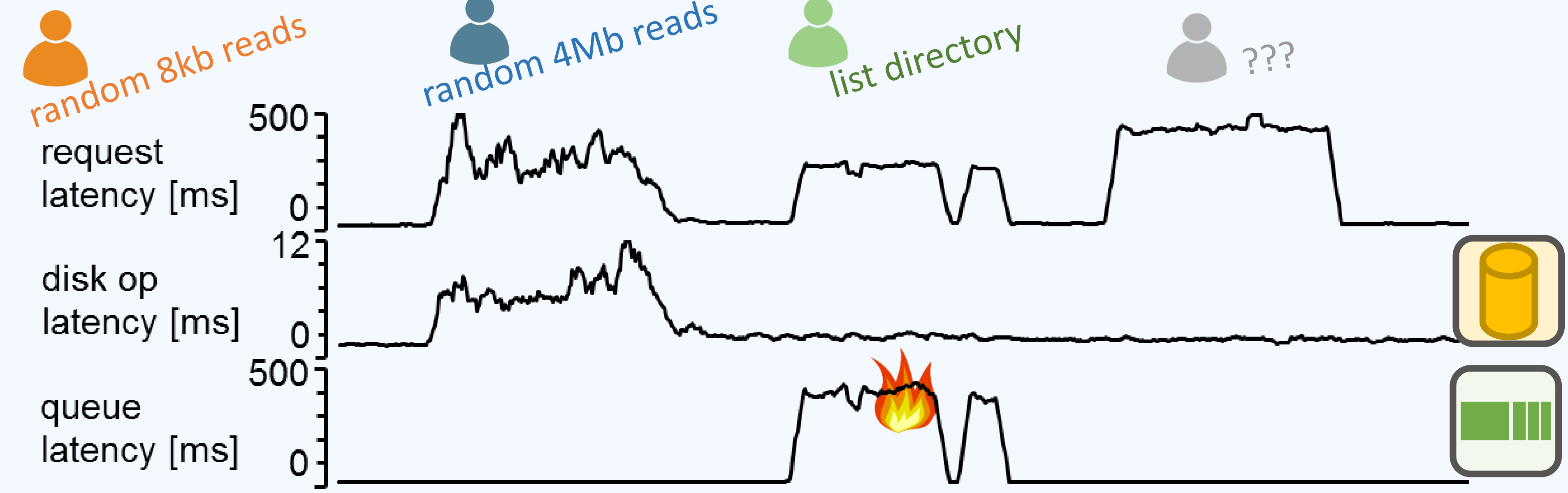

HDFS NameNode
HDFS DataNode
HDFS DataNode
HDFS DataNode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random 4Mb reads
list directory
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request latency [ms]
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disk op latency [ms]
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queue latency [ms]
500
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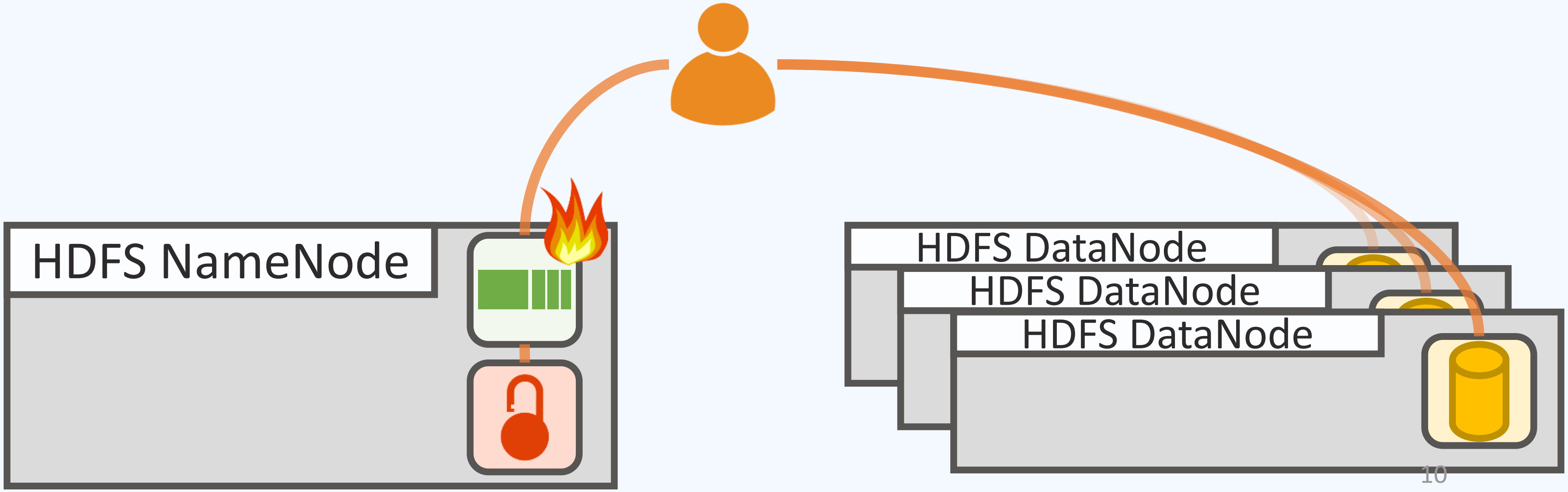
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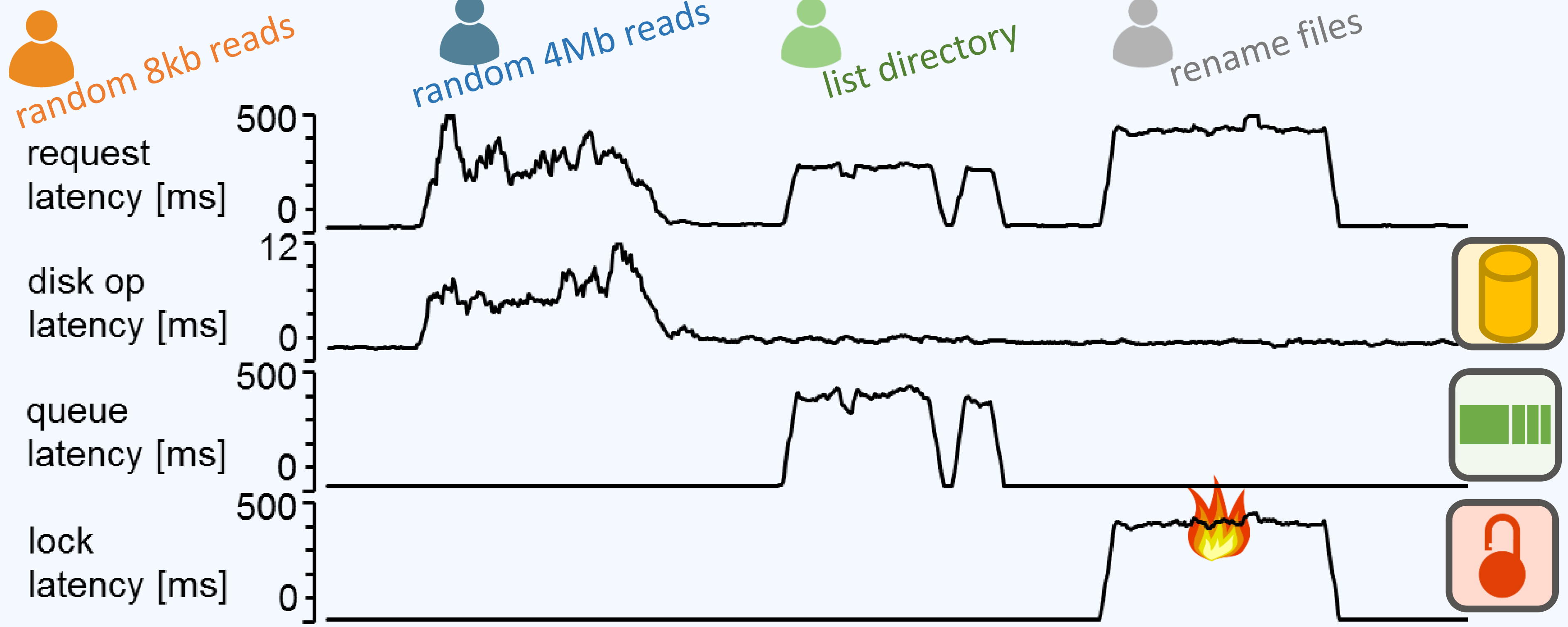
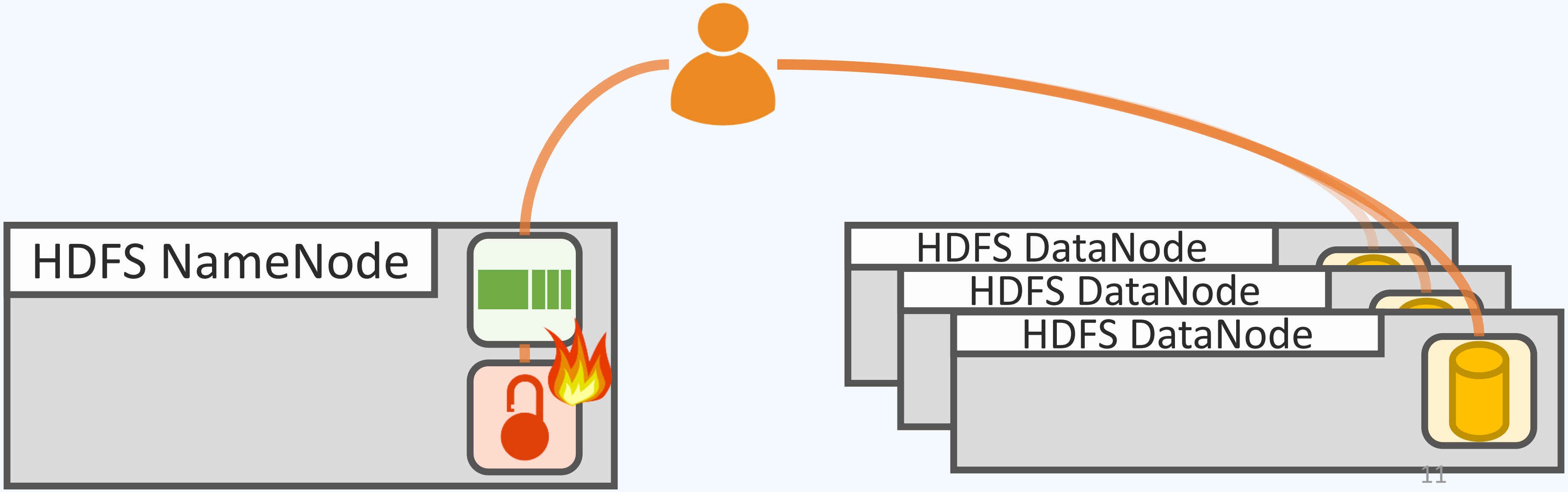



HDFS NameNode

HDFS DataNode

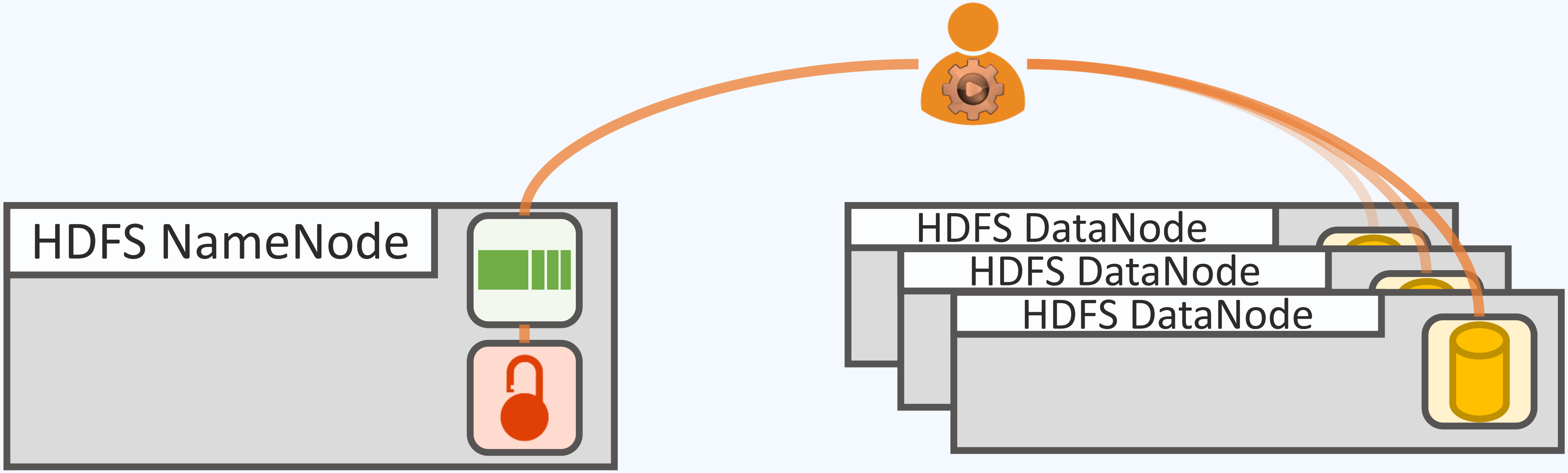
HDFS DataNode

HDFS DataNode

Principle 1: *Consider all resources and request types*

- Fine-grained resources within processes
- Resources shared between processes (disk, network)
- Many different API calls
- Bottlenecks can crop up in many places

  hardware resources: *disk, network, cpu, …*
  software resources*: locks, queues, …*
  data structures: *transaction logs, shared batches, …*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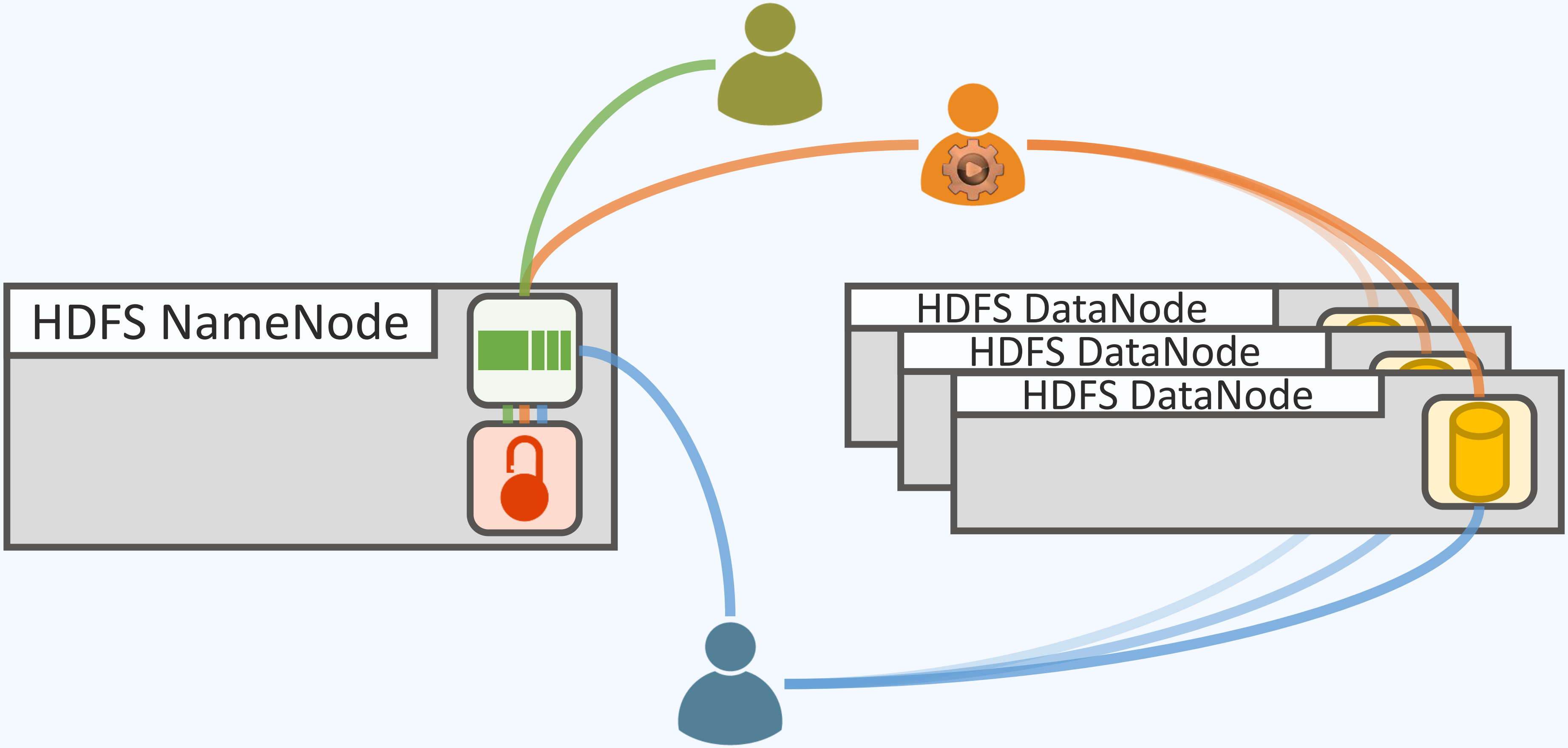
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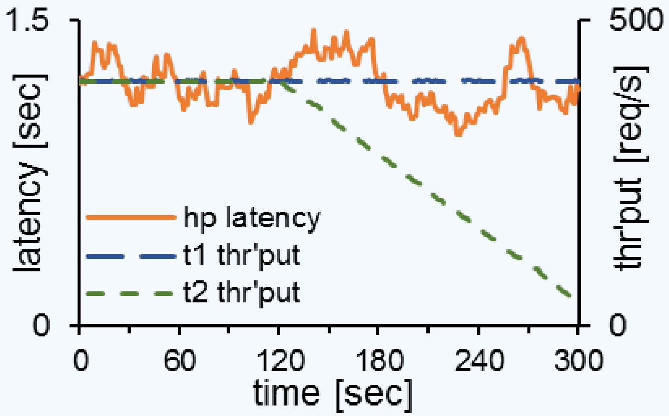
1.5
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500
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latency [sec]
thr'put [req/s]
hp latency
t1 thr'put
t2 thr'put
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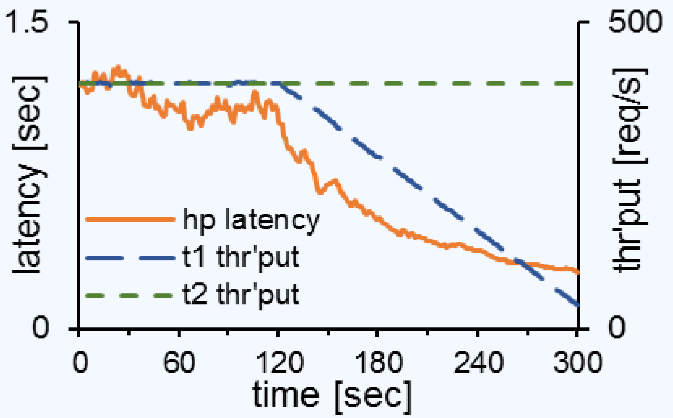
time [sec]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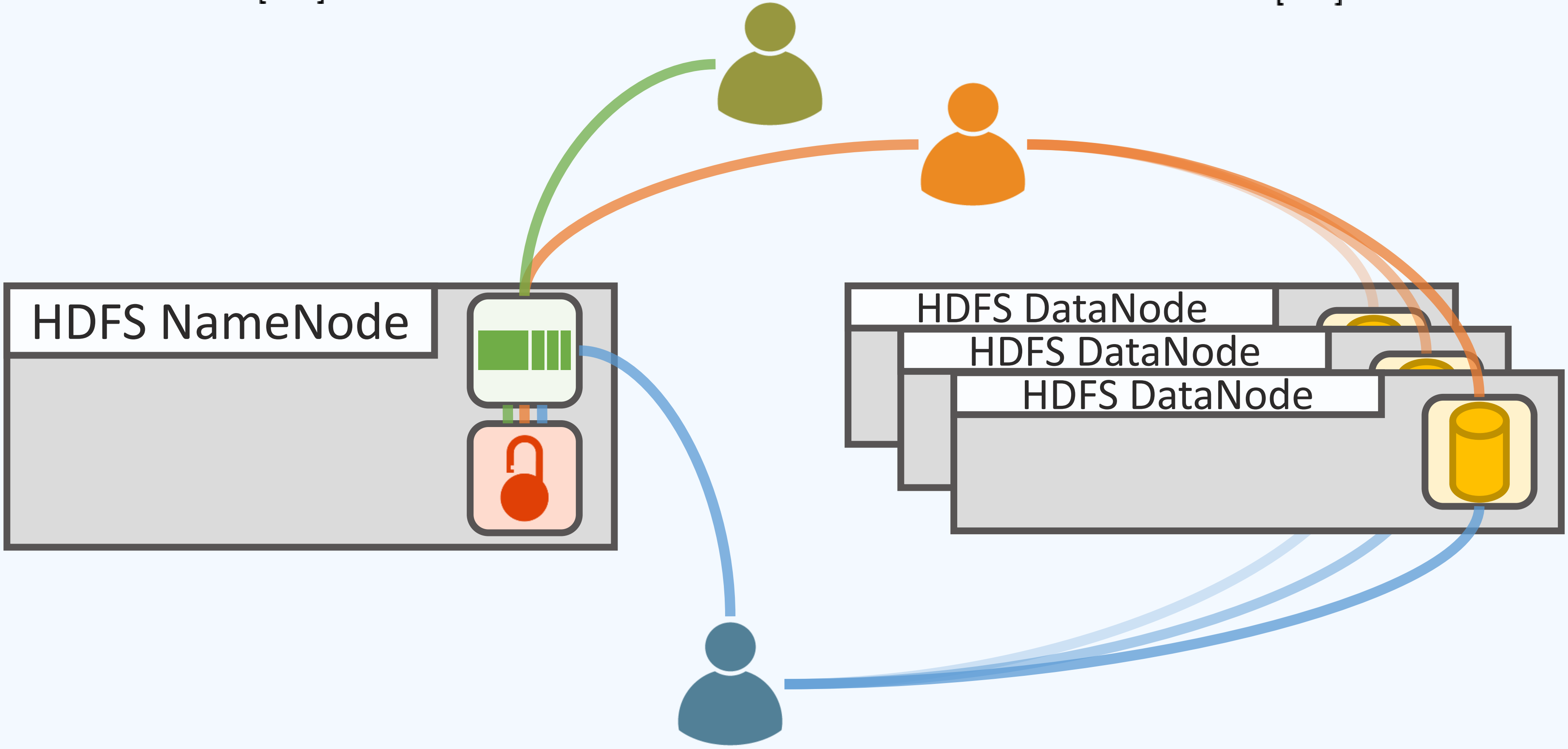
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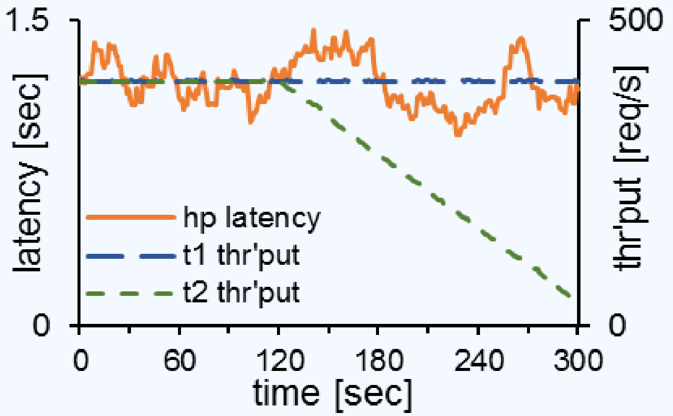
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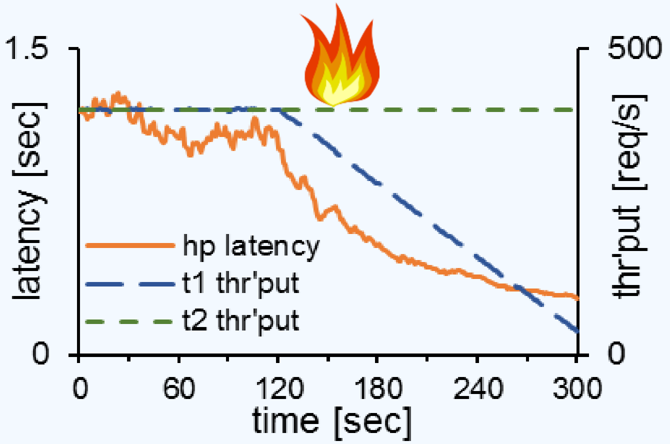
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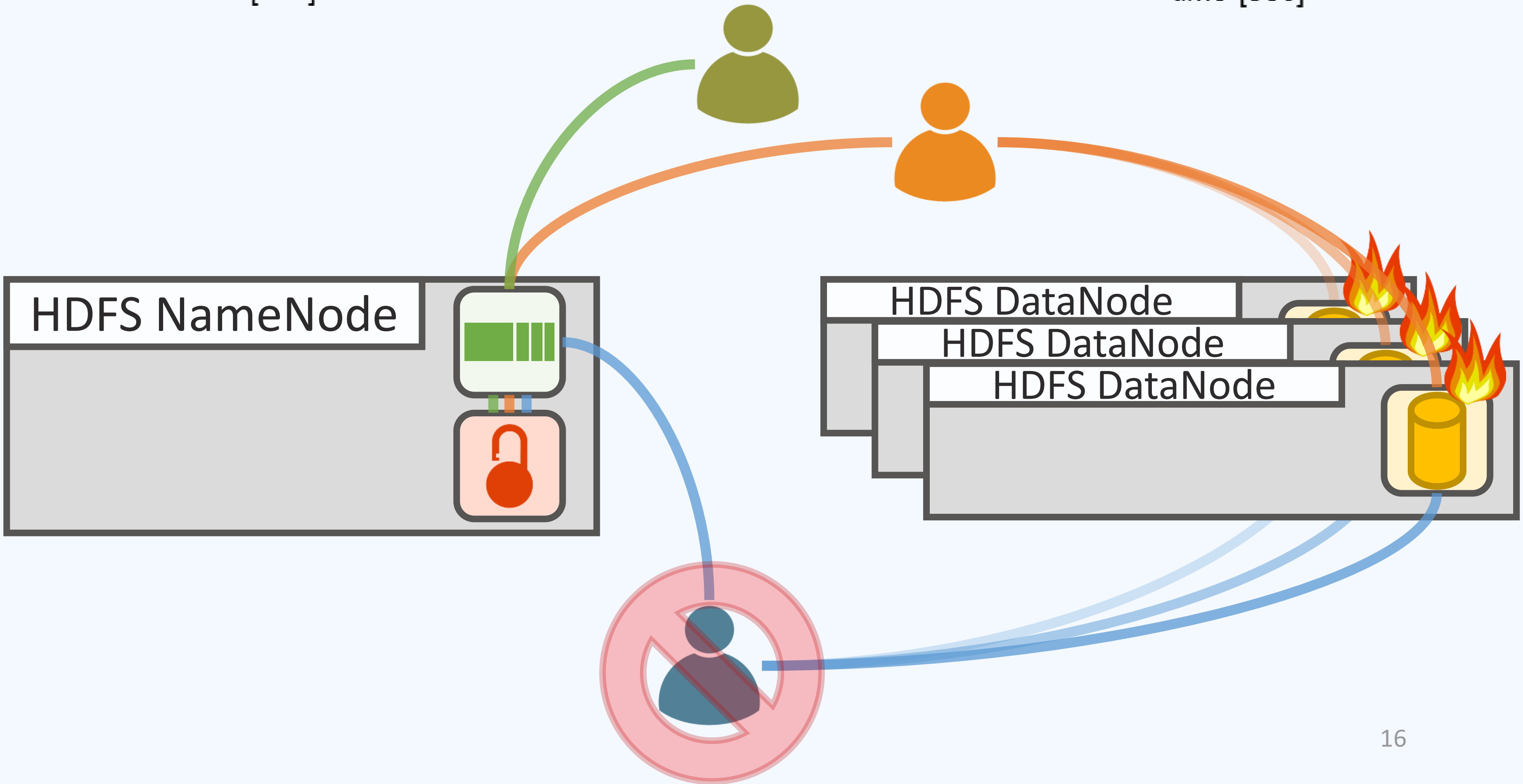
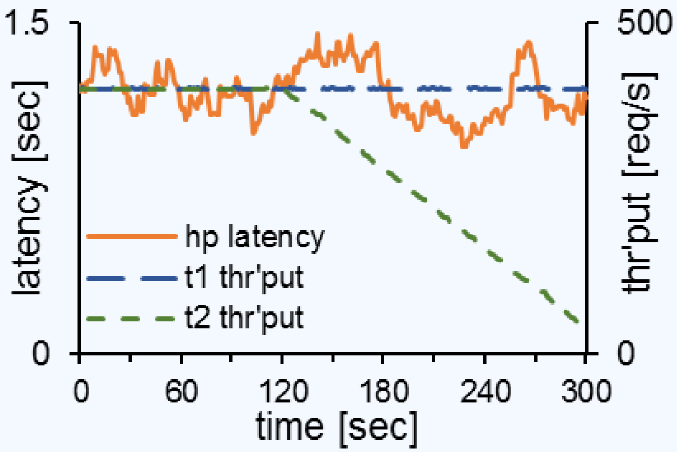

HDFS NameNode
HDFS DataNode
HDFS DataNode
HDFS DataNode

Principle 2: *Distinguish between tenants*

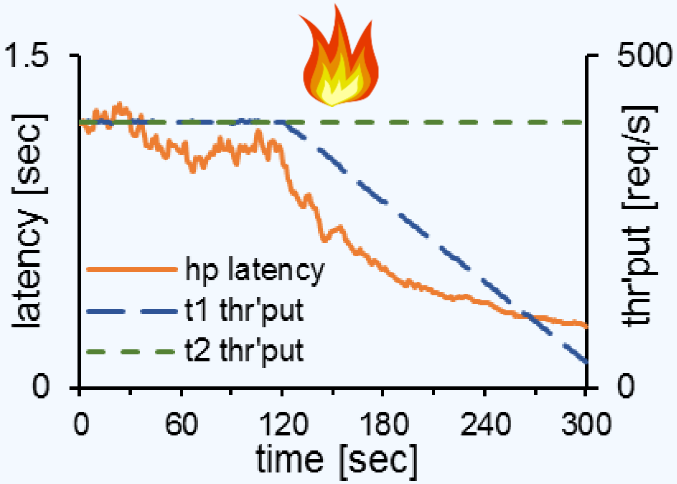
- Tenants might send different types of requests
- Tenants might be utilizing different machines

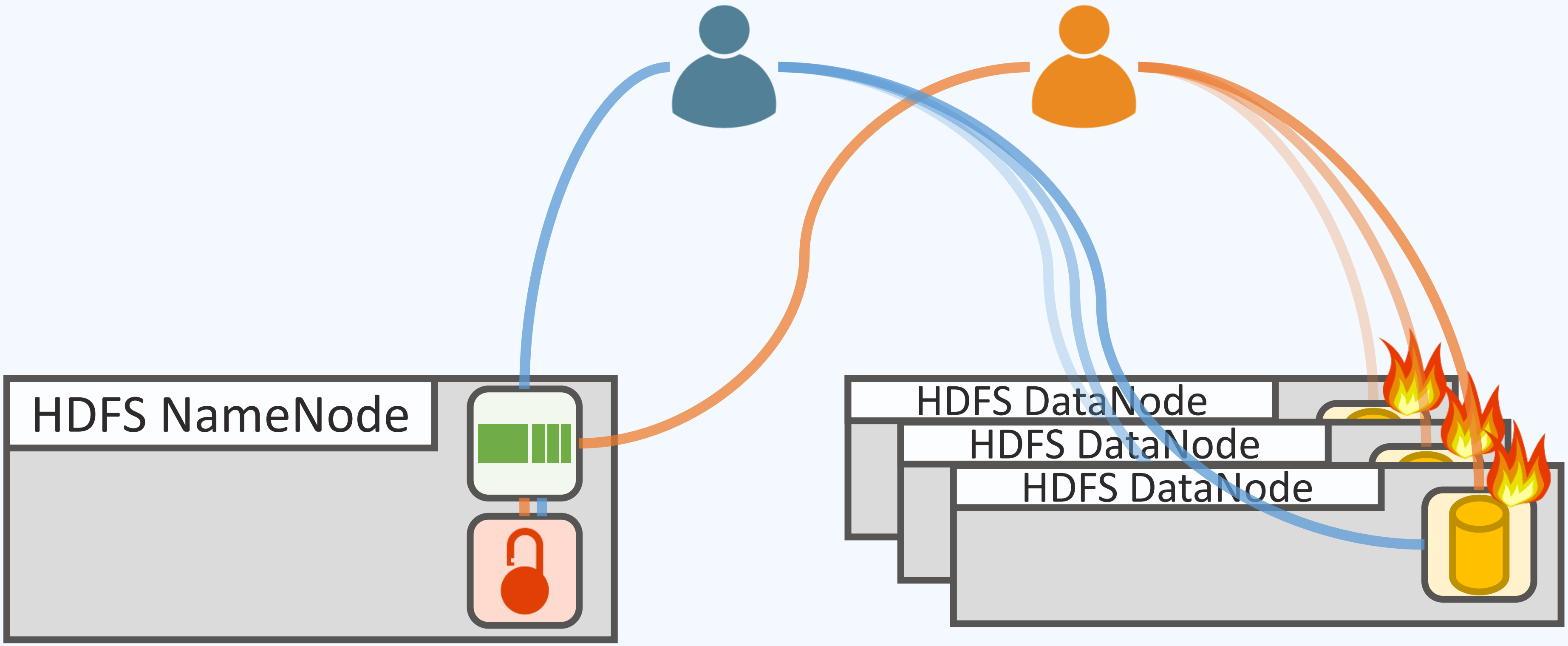


- If a policy is *efficient*, it should be able to *target* the cause of contention

  e.g.,

  if a tenant is causing contention, throttle otherwise leave the tenant alone




HDFS NameNode
HDFS DataNode
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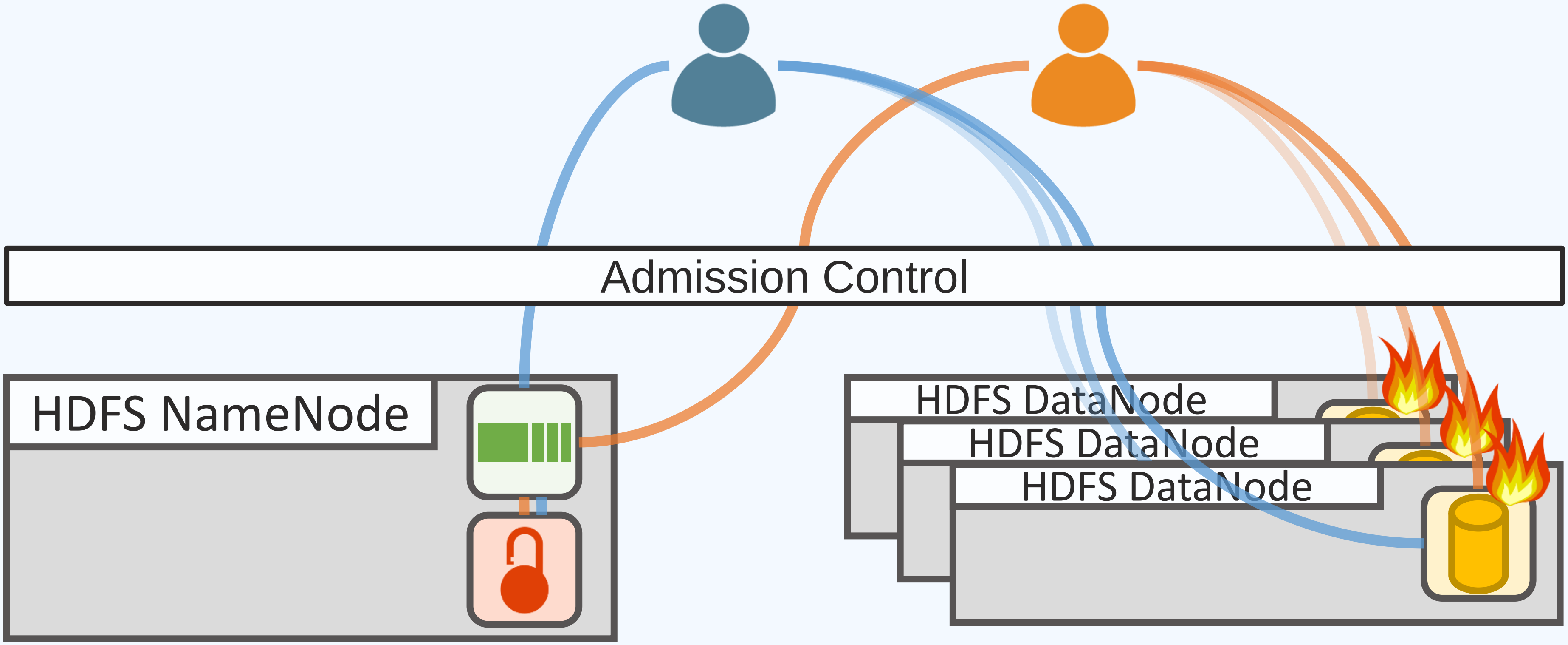
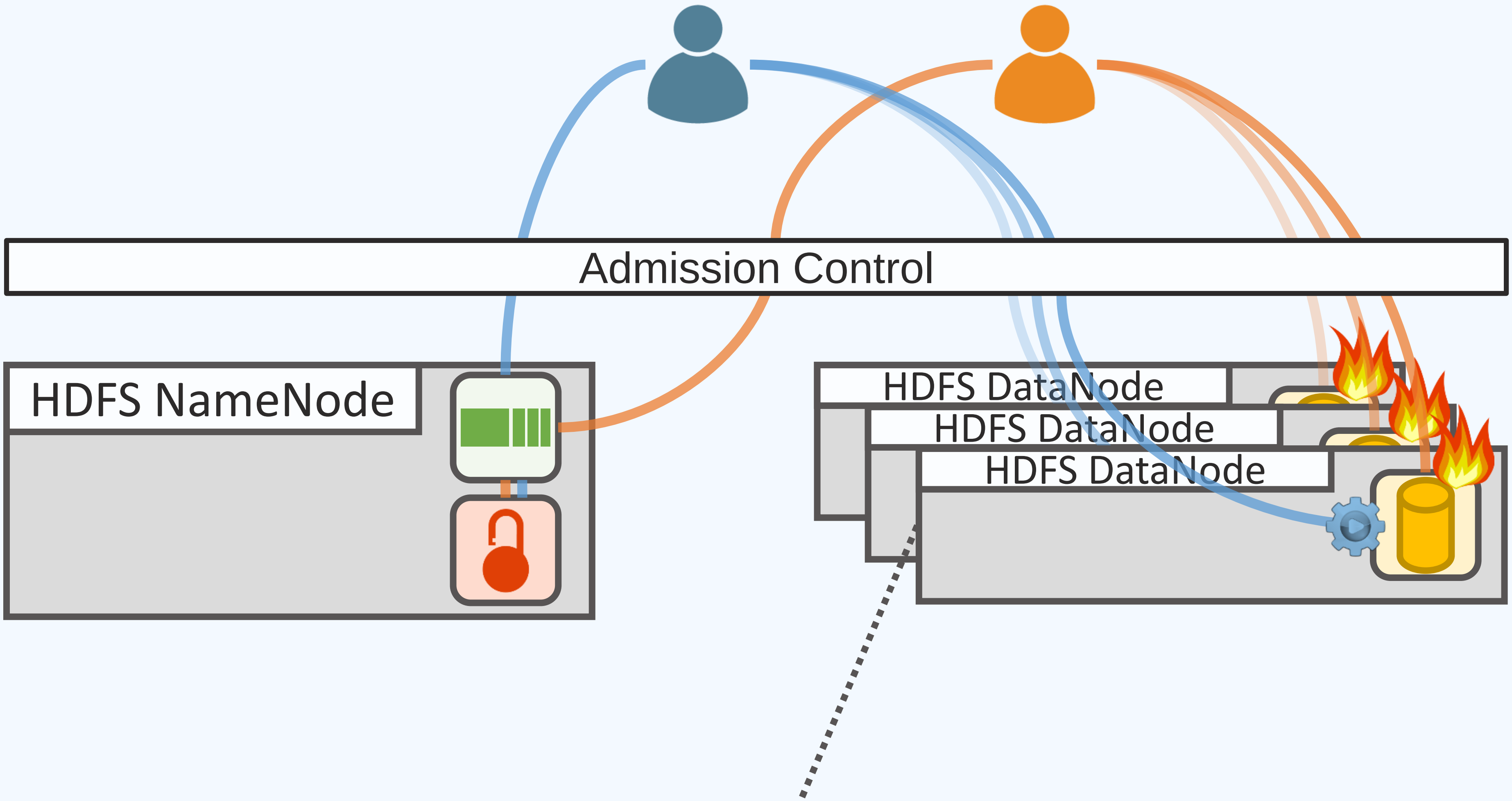
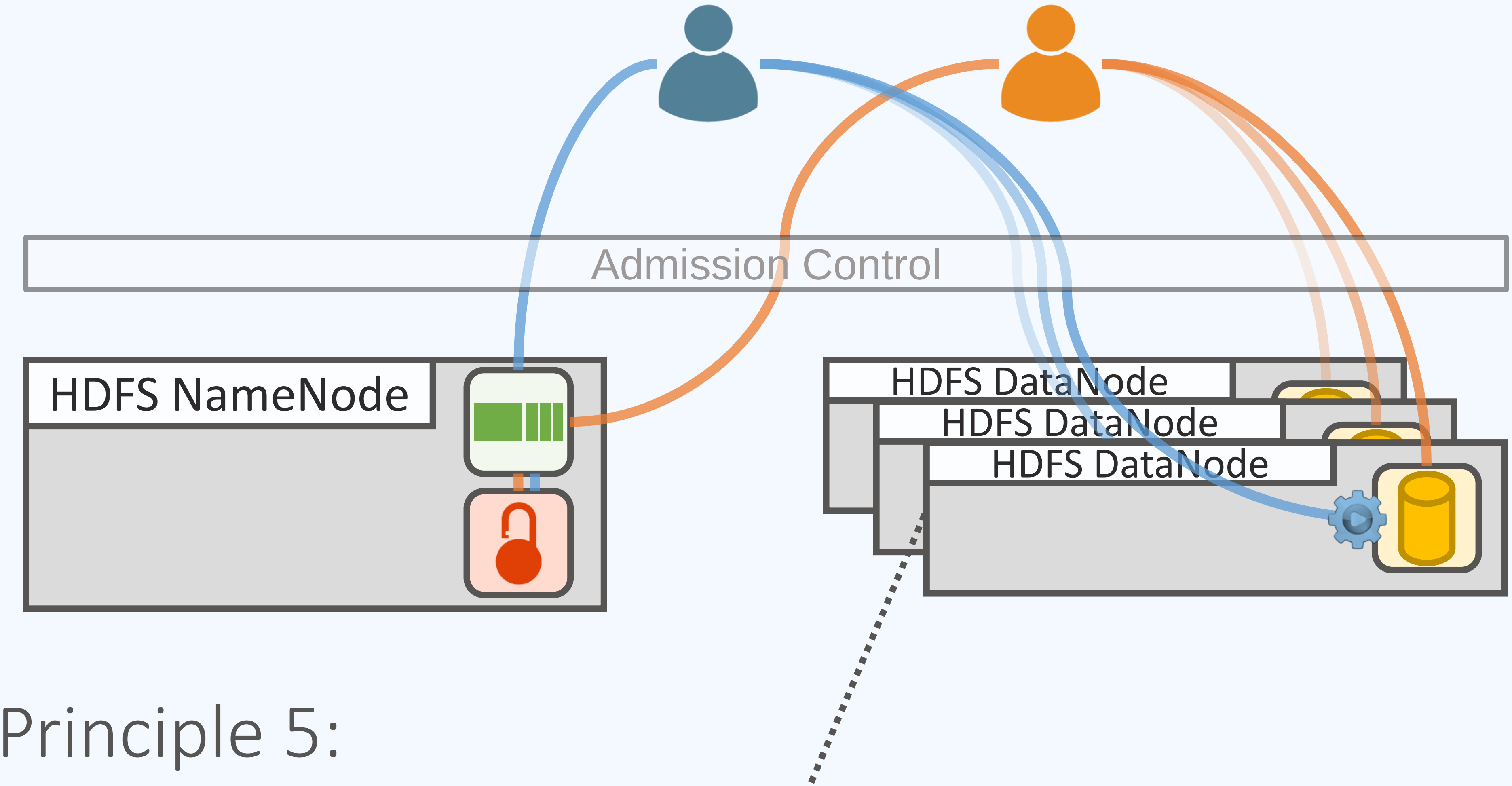

Admission Control
HDFS NameNode
HDFS DataNode
HDFS DataNode
HDFS DataNode



```
while (!Thread.isInterrupted()){
  sendPacket();
}
```



Principle 5:

Schedule early, schedule often

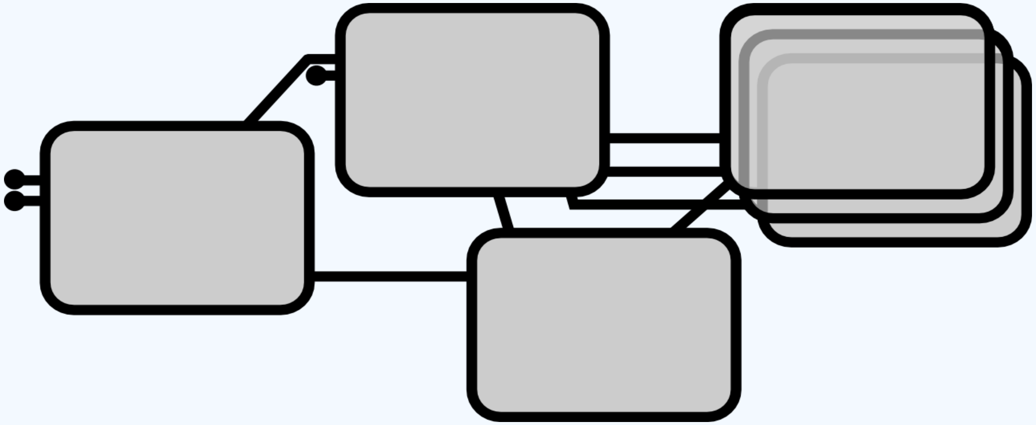
```
while (!Thread.isInterrupted()){
    rate_limit();
    sendPacket();
}
```

Resource Management Design Principles

1. **Consider all request types and all resources**
2. **Distinguish between tenants**
3. Treat foreground and background tasks uniformly
4. Estimate resource usage at runtime
5. **Schedule early, schedule often**

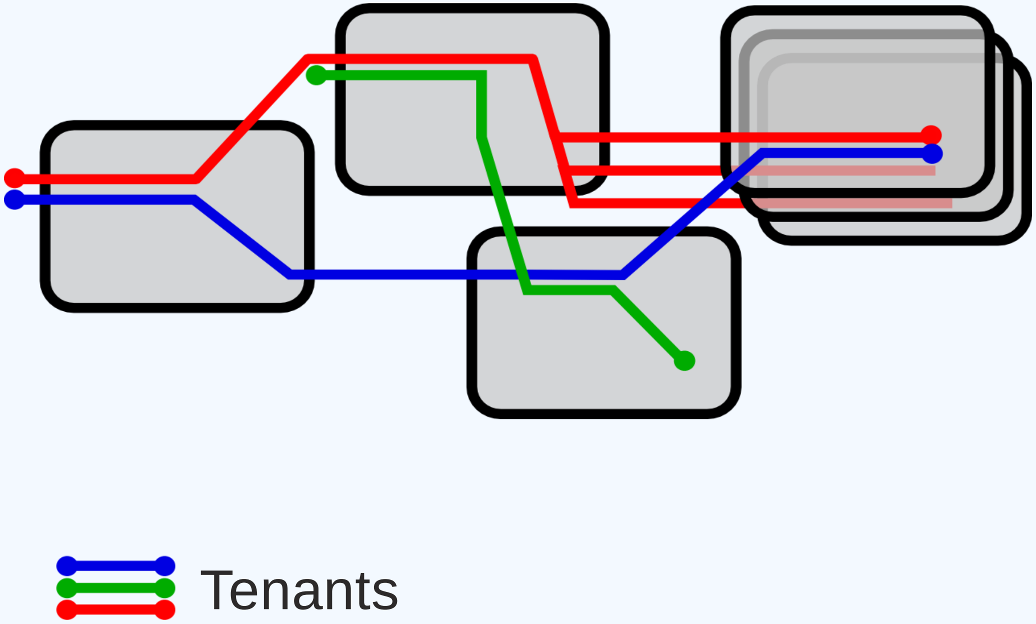
Retro – prototype for **principled** resource management in shared-tenant systems

Retro: end-to-end tracing



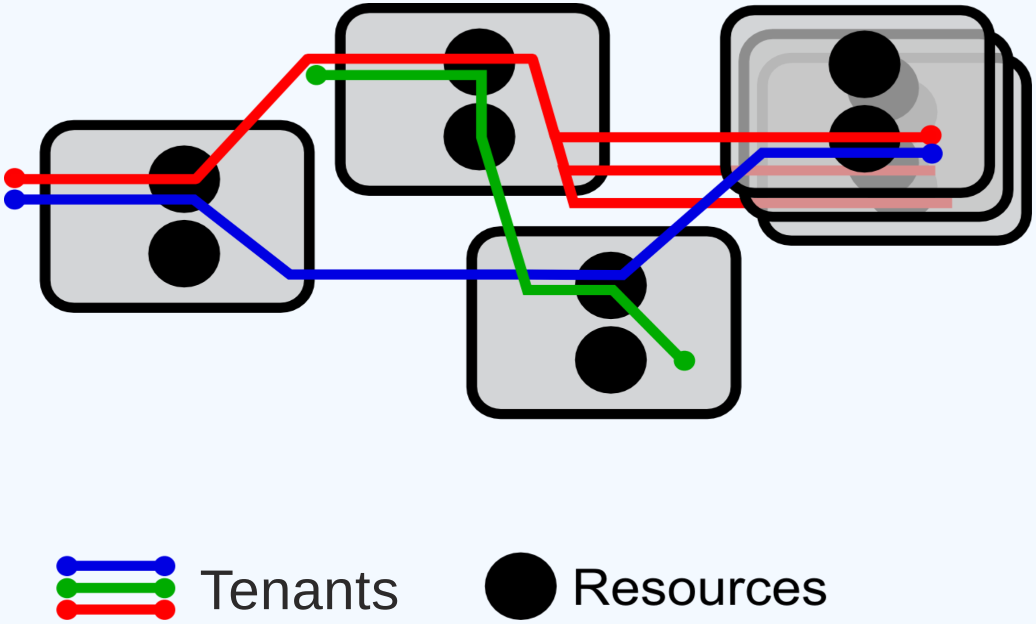
Tenants

Retro: end-to-end tracing

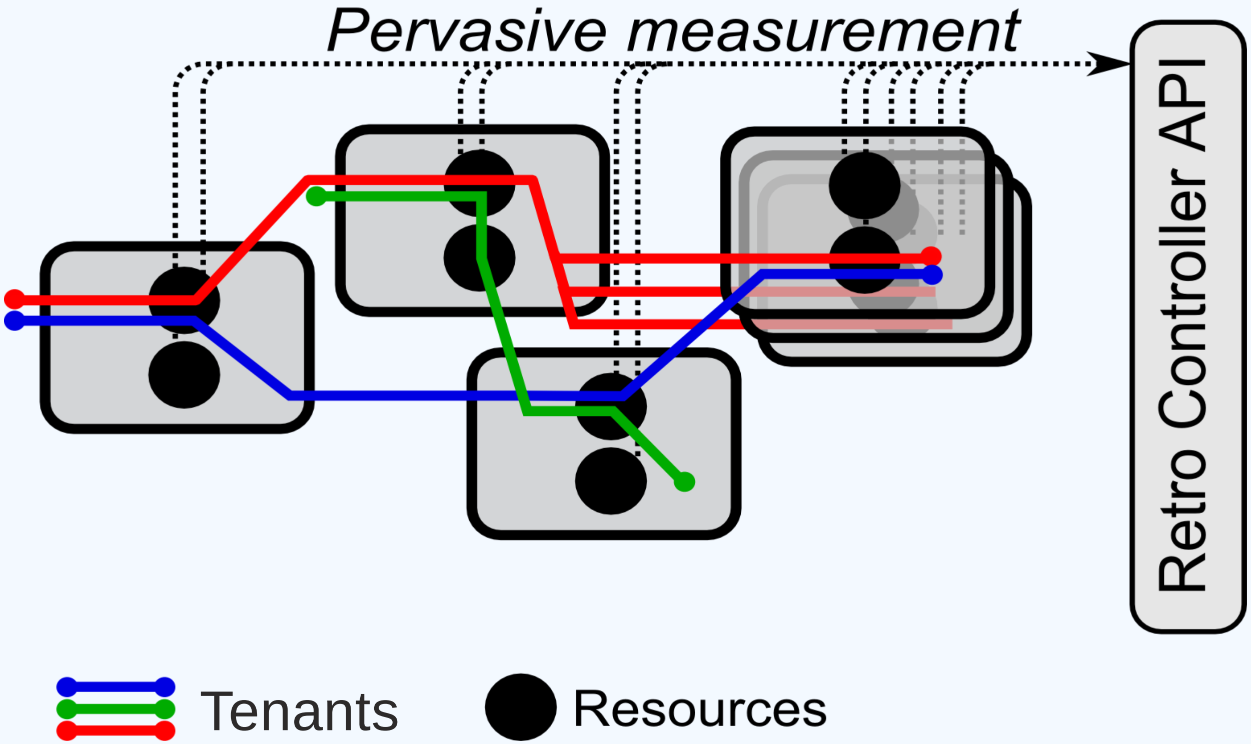


Tenants

Retro: application-level resource interception



Retro: aggregation and centralized reporting



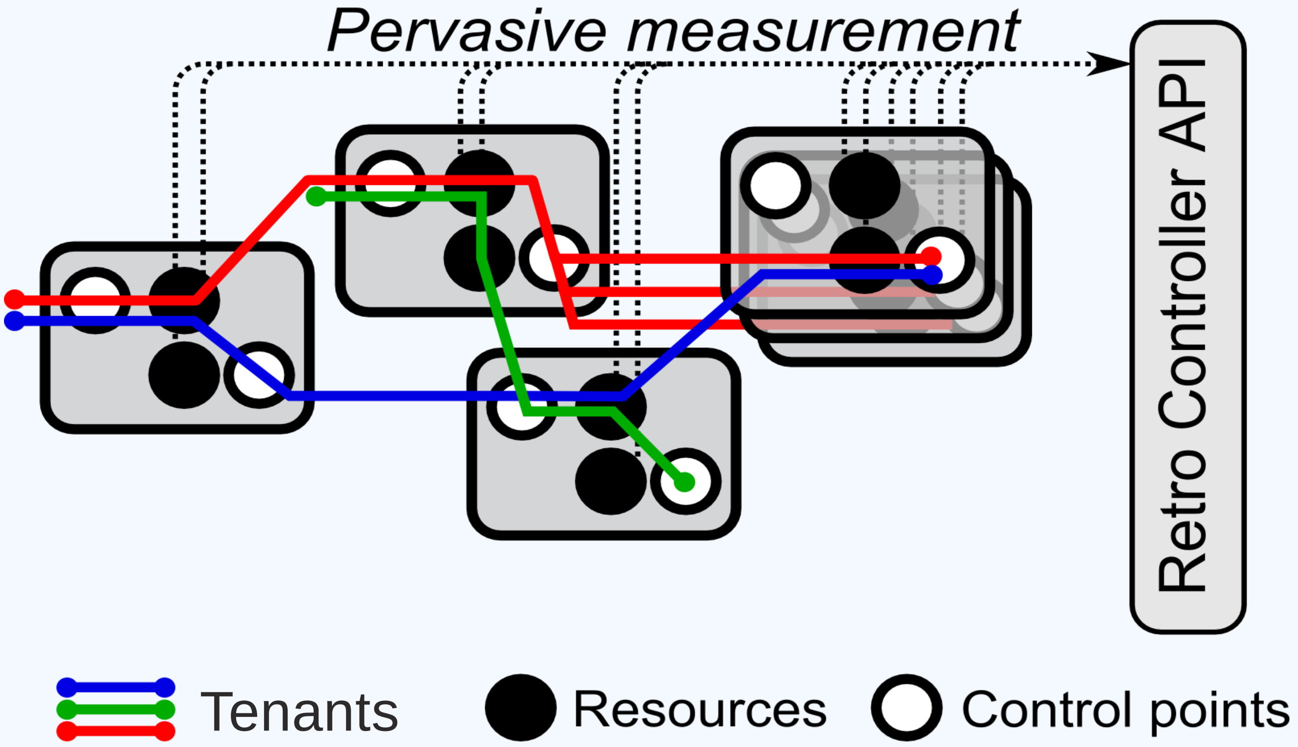
Pervasive measurement

Retro Controller API

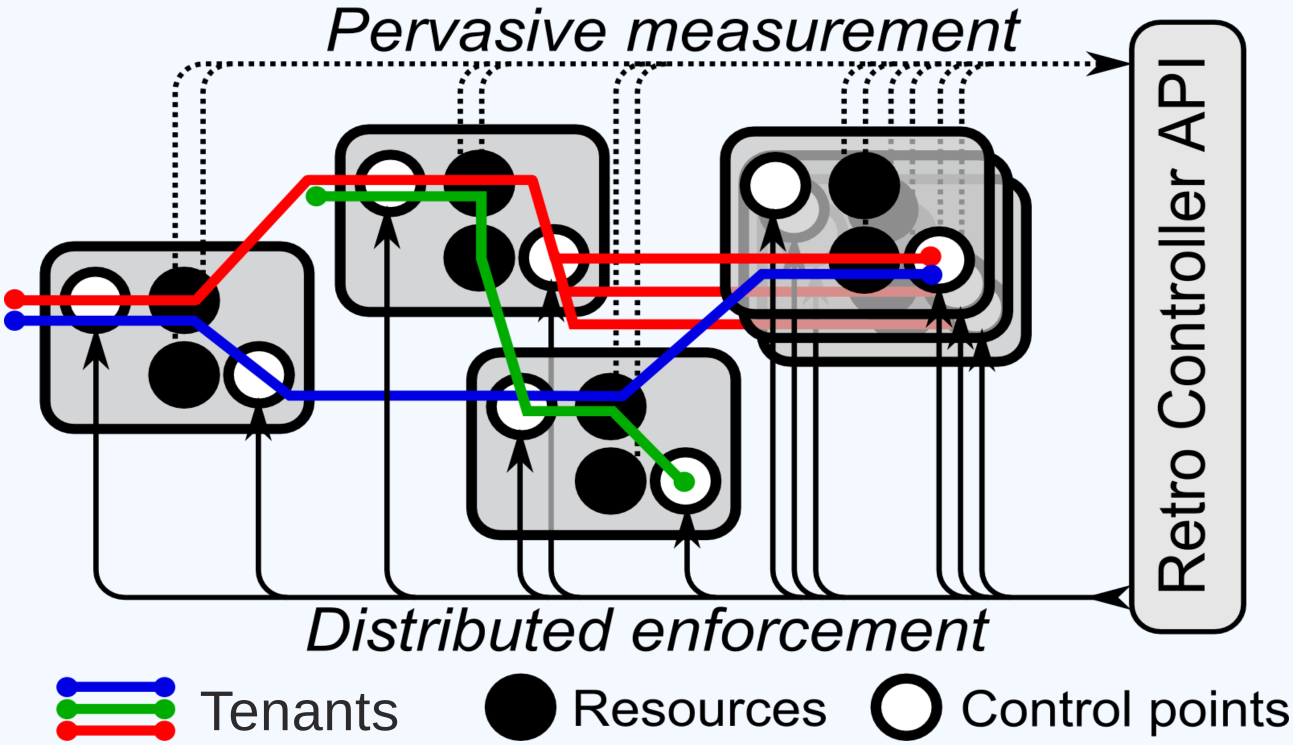
Tenants

Resources

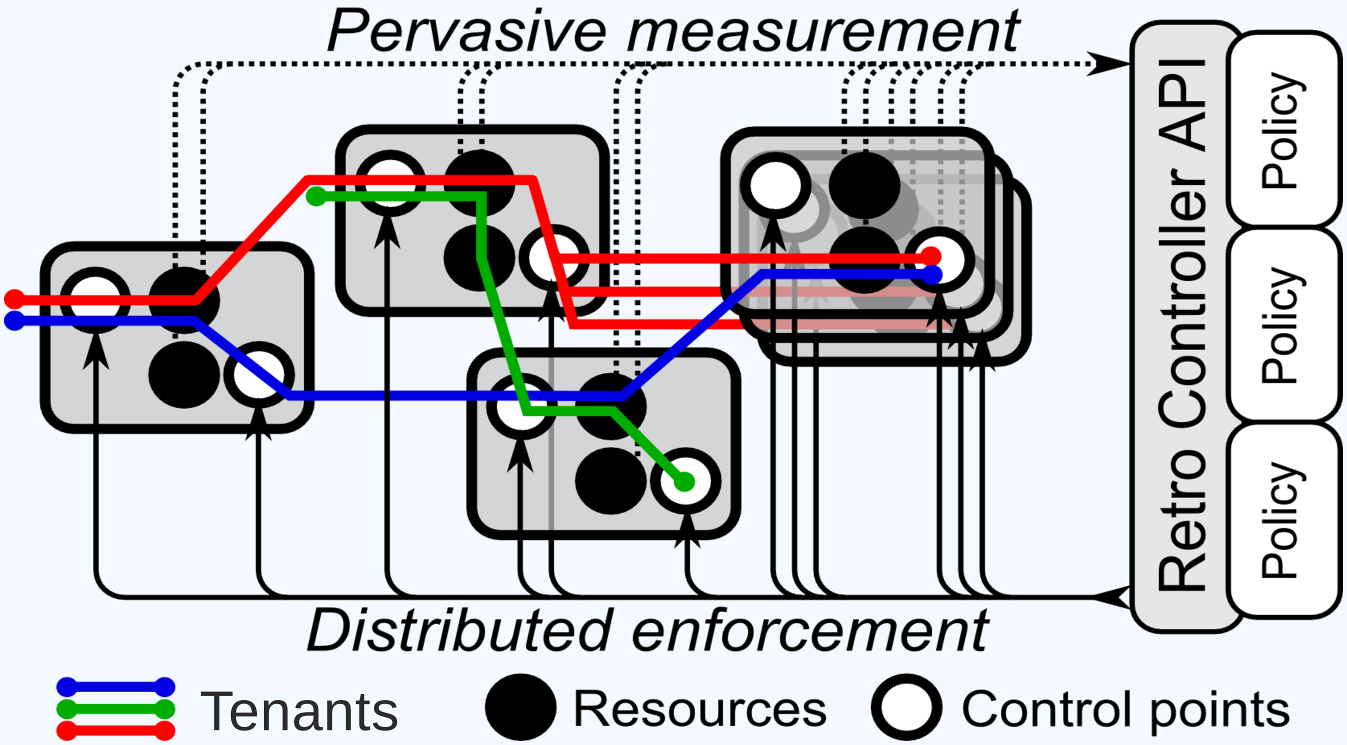
Retro: application-level enforcement



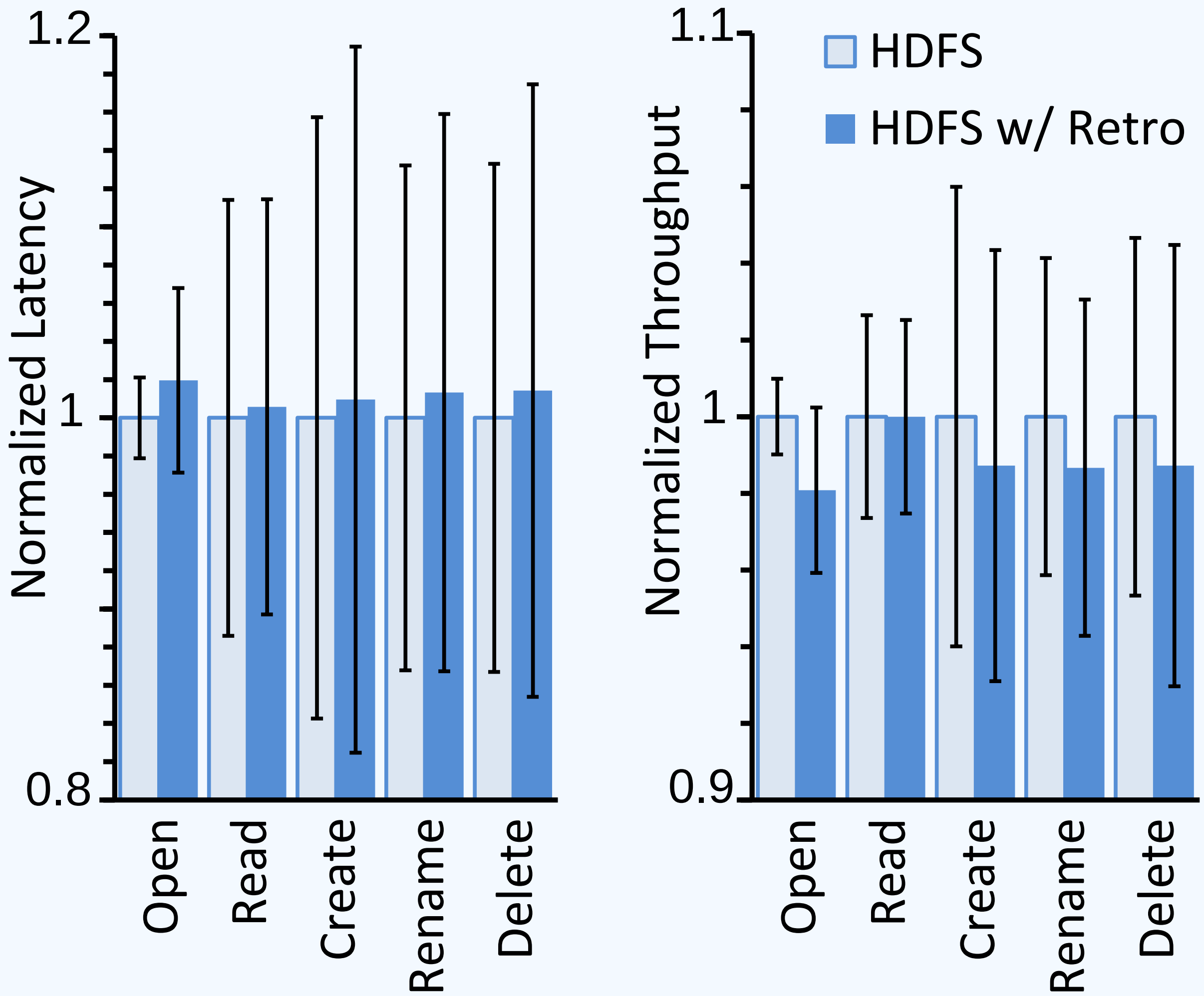
Retro: distributed scheduling



Retro: distributed scheduling

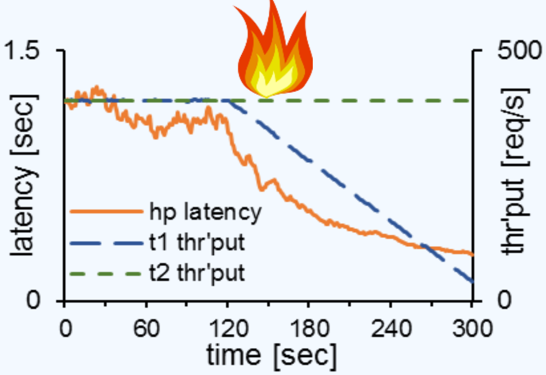


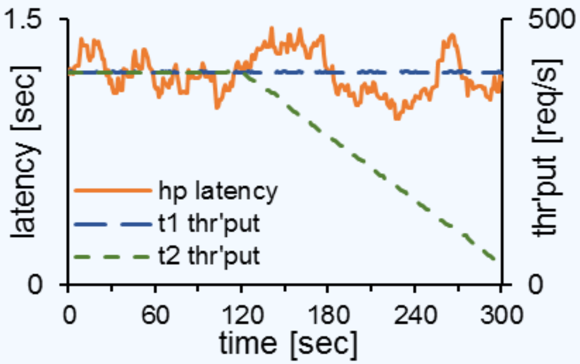
Early Results

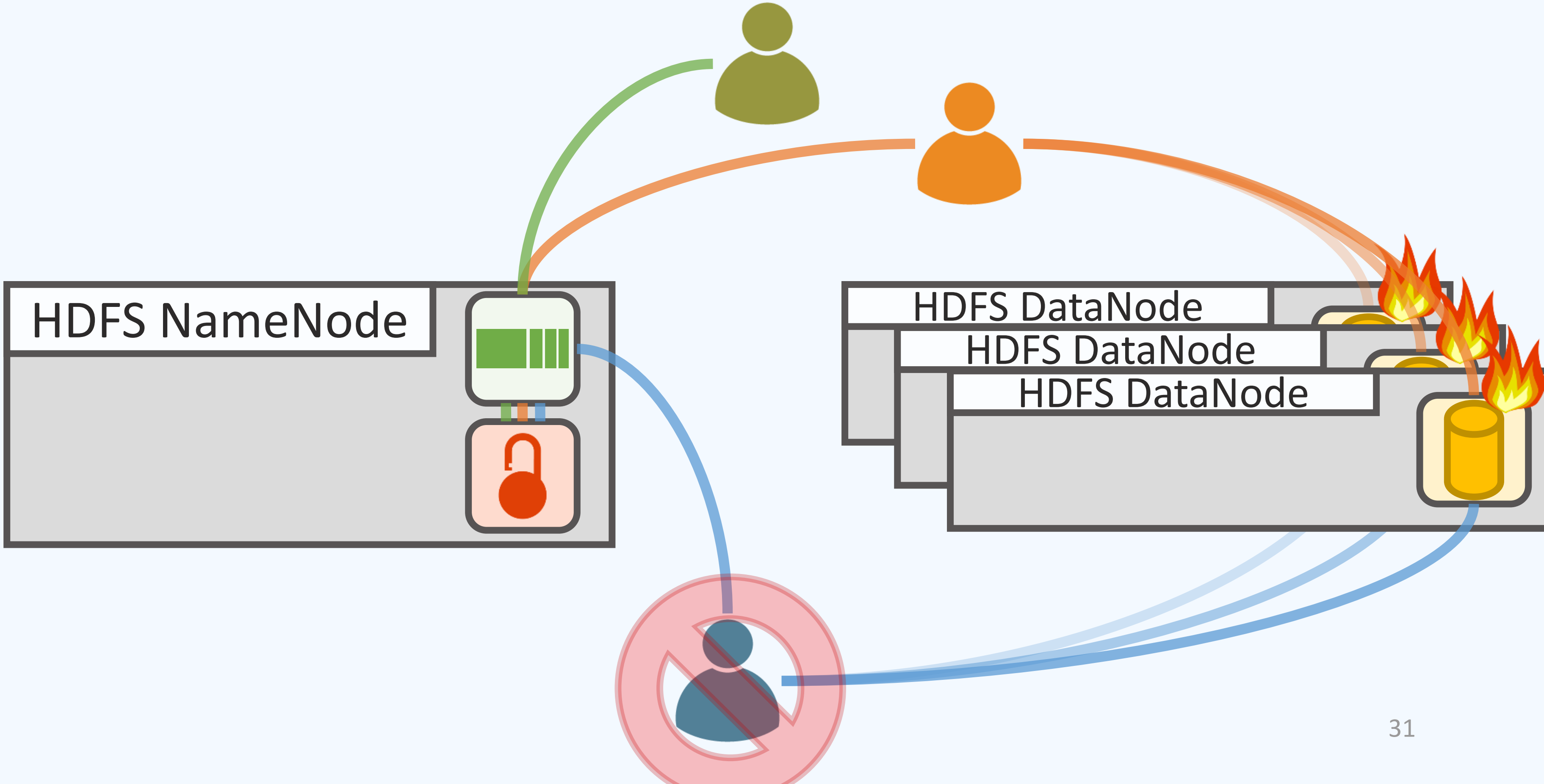


HDFS NNBench benchmark

0.01% to 2% average overhead on end-to-end latency, throughput







HDFS NameNode

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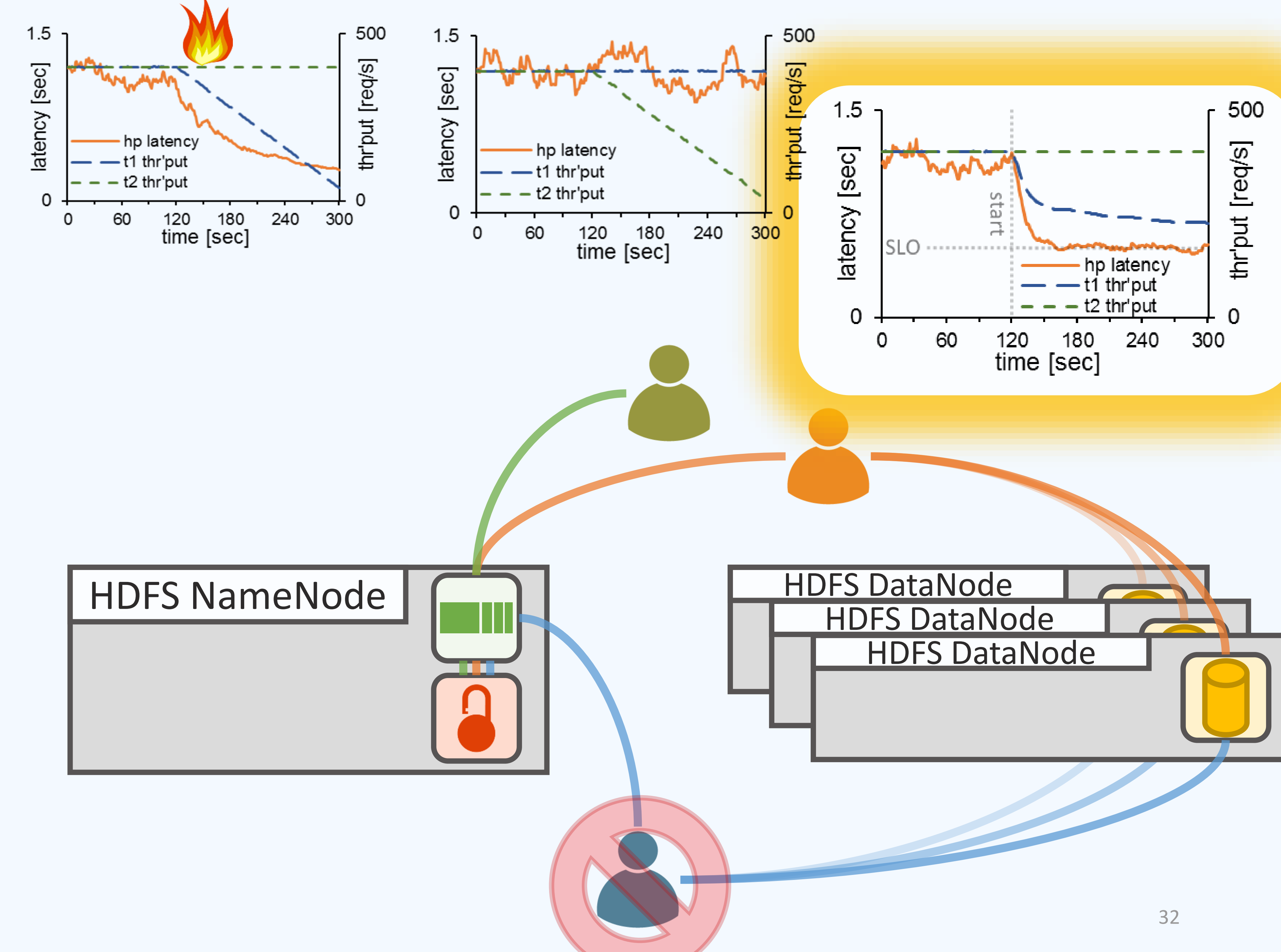
HDFS DataNode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hp latency
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hp latency
t1 thr'put
t2 thr'put
HDFS NameNode
HDFS DataNode
HDFS DataNode
HDFS DataNode

Retrospective

Thus far:

- Per-tenant identification
- Resource measurements
- Schedule enforcement

Next steps:

- Abstractions for writing simplified high-level policies
- Low-level enforcement mechanisms
- Policies to monitor system, find bottlenecks, provide guarantees