Tracing the Latencies of Ares: A DSM Case Study

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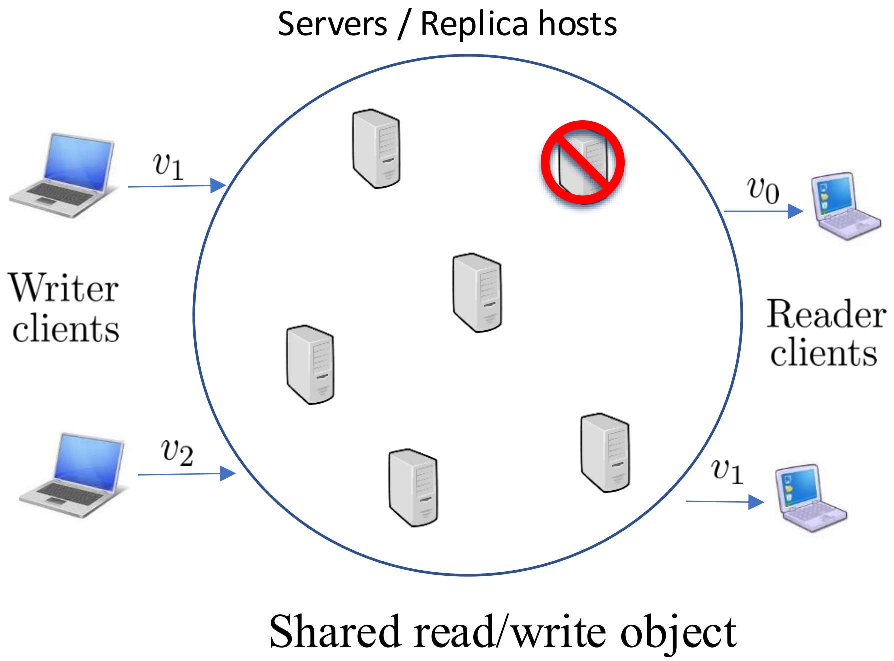
Distributed Shared Memory Emulations (DSMs)



- A set of servers (configuration) maintain replicas of the same data object.
- Clients (readers/writers) access the object by sending messages to these servers.
- Read/Write operations are structured in terms of phases.
- Each phase consists of two communication exchanges (broadcast & convergecast).
- Fixed Configuration -> Static environment, Reconfiguration -> Dynamic environment
- Consistency guarantees
  - Safety, Regularity, **Atomicity** (Atomic DSMs) [Lamport 1986]

L. Lamport,"On Interprocess Communication," Distributed Computing, vol. 1, no. 2, pp. 77–101, 1986.

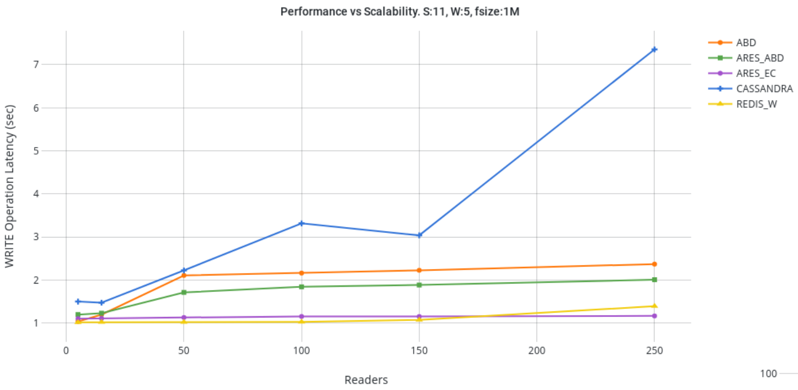
Performance Analysis Challenges in DSMs

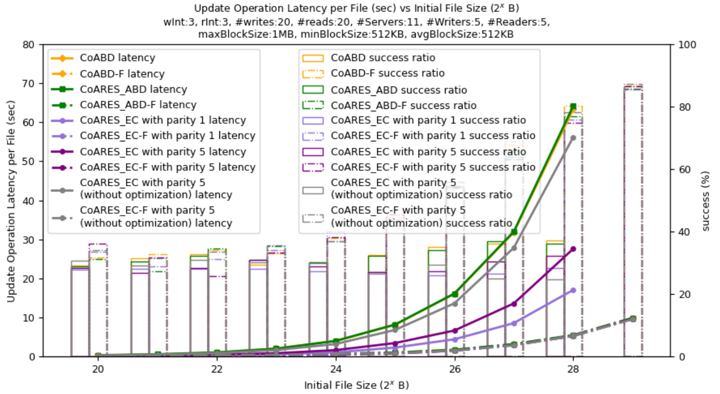
- Identifying performance bottlenecks in complex DSMs can be challenging
- Traditional logging techniques may not provide sufficient insight

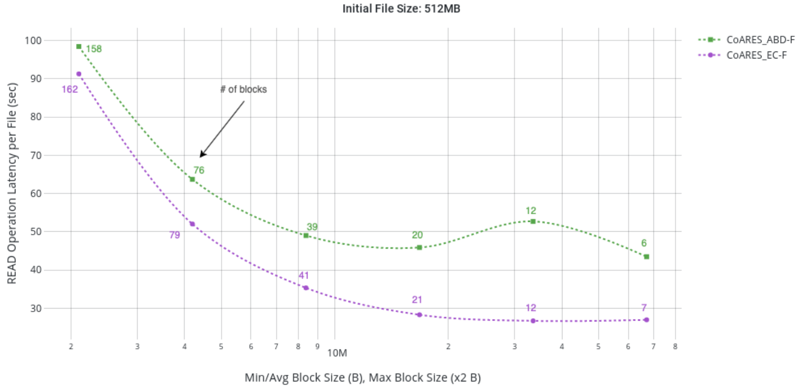
```
import os
import logging
from sys import platform
from pythonjsonlogger import jsonlogger

atrigeorgi
class SetupLogger:

    atrigeorgi
    def setup_logger(self, logfile, level=logging.DEBUG):
        # Due to race conditions, we sometimes get error.
        # OSError: [Errno 17] File exists: 'log'
```








```
self.logger.debug('READ-COMPLETE-DSMM',
                  extra={"clientID": self.uid, "objectID": file_id, "tag": maxTag, "value": value})
```

“**Distributing Tracing** is a monitoring technique used to track individual requests as they move across multiple components within a distributed system. It helps to pinpoint where failures occur and what causes poor performance.”

Distributed Tracing – Terminology

- A **trace** represents the entire journey of a request.
- A **span** represents a unit of work within a trace (e.g., procedures, sections of code).
- Tracings tools: Opentemetry, Zipkin, Jaeger.

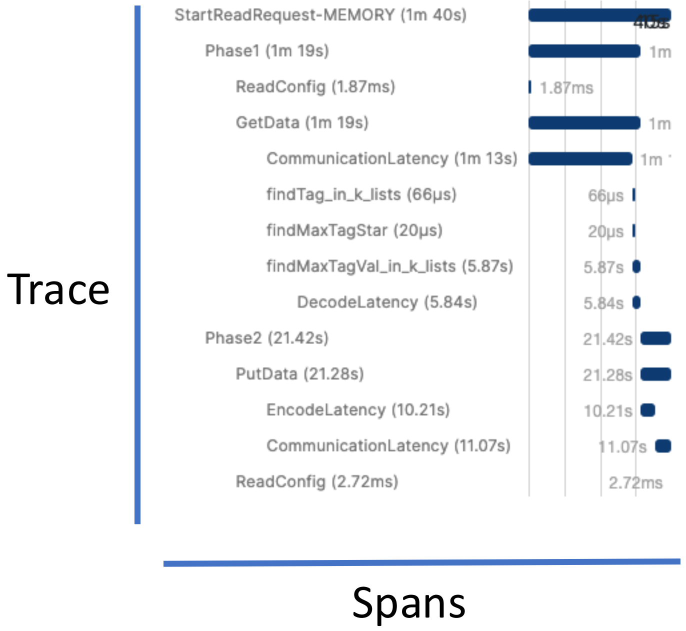
```
with self.tracer.start_as_current_span("StartWriteRequest-MEMORY"+self.phase) as parent_span:
    with self.tracer.start_as_current_span("Phase1"):
        with self.tracer.start_as_current_span("GetTag"):

            # increase msg counter for next op
            self.msg_id += 1

            # Creating 'READ' message with the following fields
            # [type, msgID, clientID, objectID]
            message = {'type': 'READ-TAG', 'msgID': self.msg_id, 'clientID': self.uid, 'objectID': file_id}

            with self.tracer.start_as_current_span("CommunicationLatency"):
                # Broadcast it
                self.broadcastMessage(message)

                # Wait for READ-TAG-ACK messages to come from a majority
                msgs_list = self.waitReply(self.majority, "READ-TAG-ACK")
```



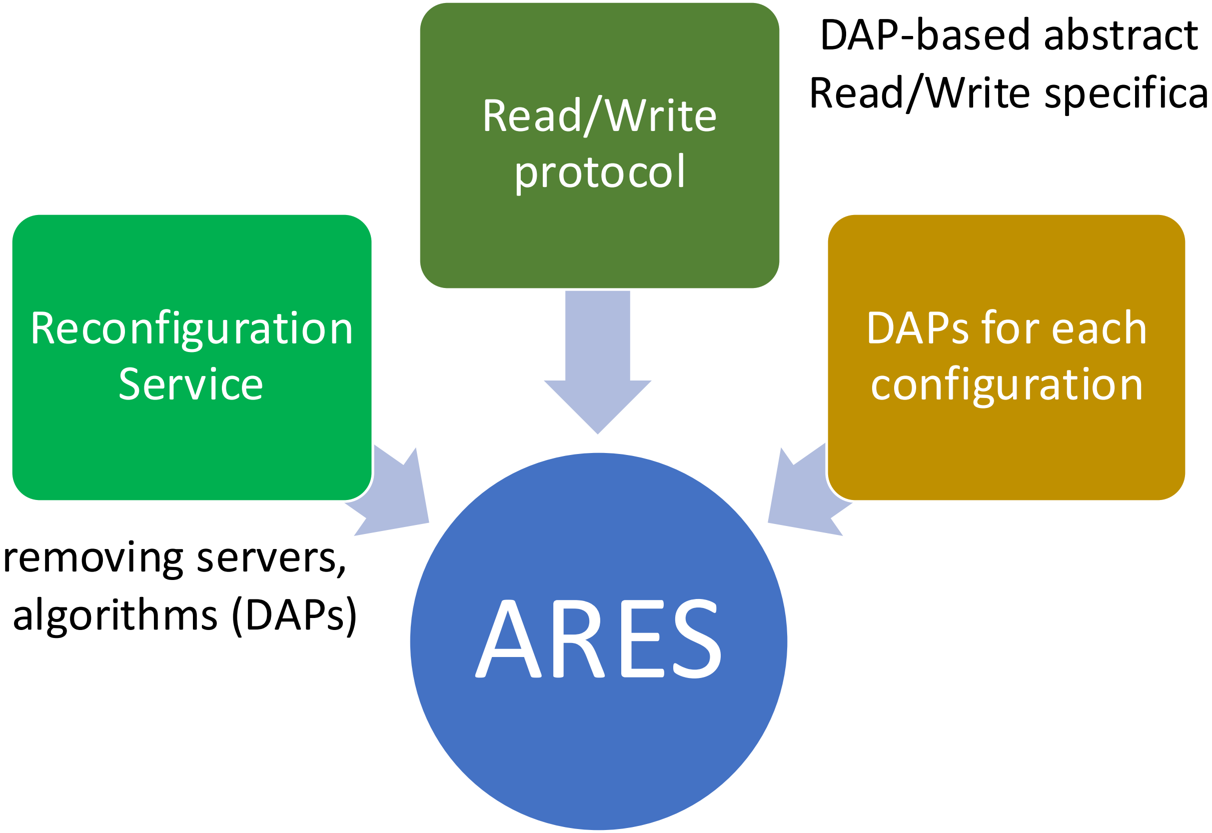
Main Objective

Our main objective is to bring Distributed Tracing into DSMs.

We will achive this through the ***ARES*** DSM.

ARES - Adaptive, Reconfigurable, Erasure Code, Atomic Storage

DAP-based abstract Read/Write specifications



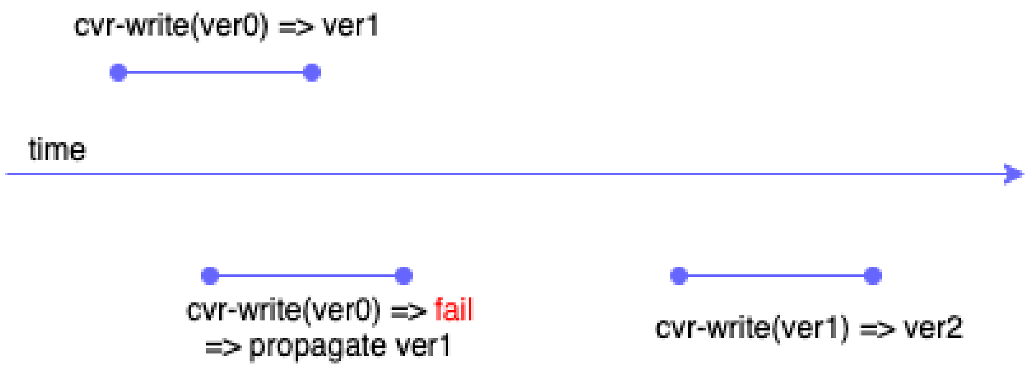
define the exact methodology to access the object
ABD-DAP, EC-DAP

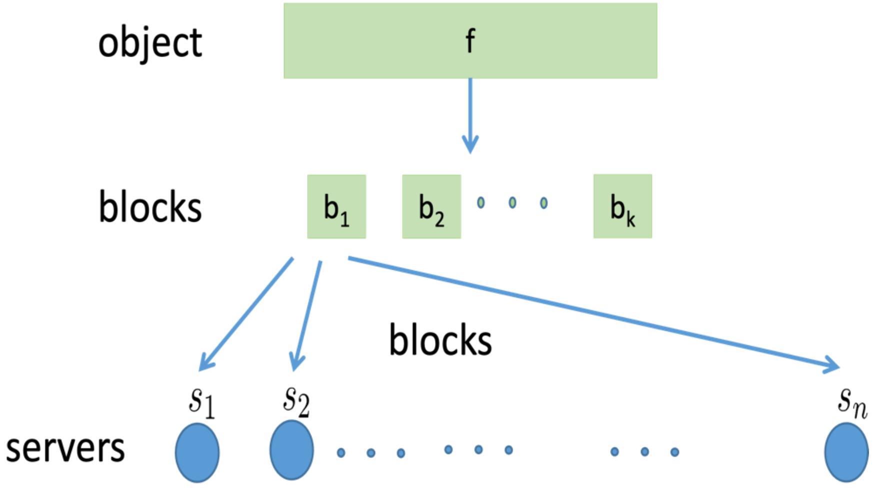
masks host failures by adding/removing servers, and switches between storage algorithms (DAPs)

N. Nicolaou, V. Cadambe, N. Prakash, A. Trigeorgi, K. M. Konwar, M. Medard, and N. Lynch, "Ares: Adaptive, reconfigurable, erasure coded, atomic storage," ACM Trans. Storage, jan 2022. Just Accepted.

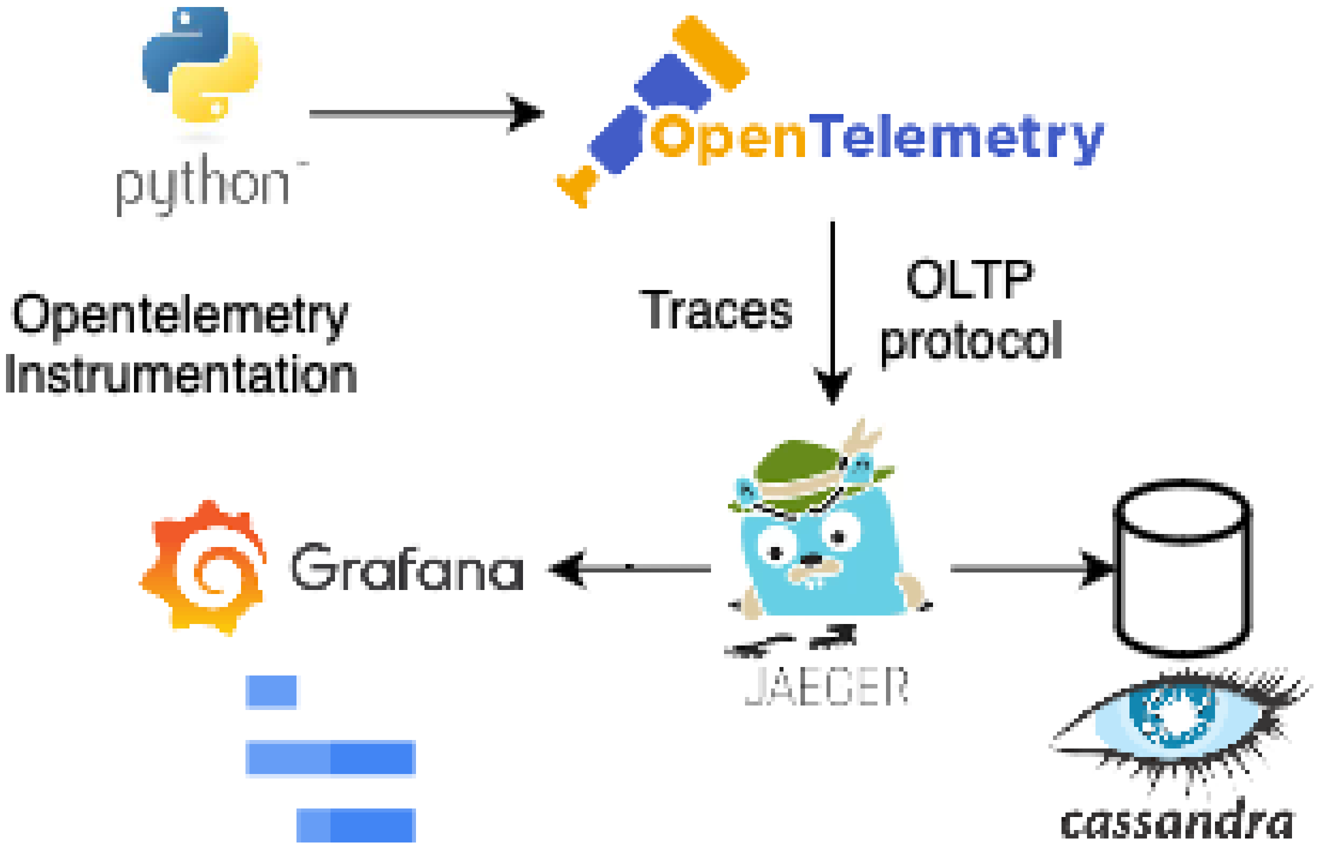
Evaluated Algorithms

ARESABD	This is Ares that uses the ABD-DAP implementation.
CoARESABD	The coverable version of *ARESABD.*
CoARESABDF	The fragmented version of *CoARESABD*.
ARESEC	This is *ARES* that uses the EC-DAP implementation.
CoARESEC	The coverable version of *ARESEC.*
CoARESECF	This is the two-level data striping algorithm obtained when *CoARESF* is used with the EC-DAP implementation; i.e., it is the fragmented version of *CoARESEC*.

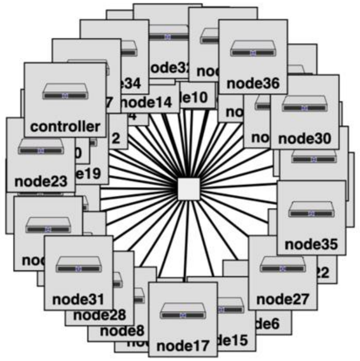


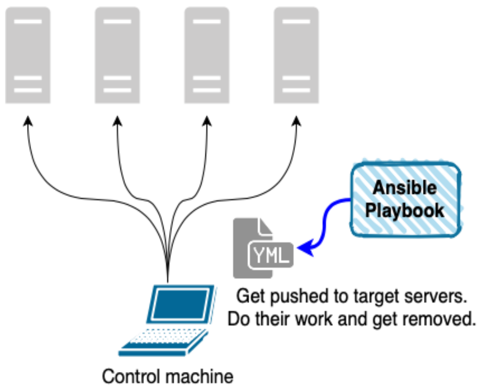


Methodology: ARES Distributed Tracing



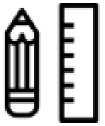
Experimental Setup





We used two main tools to run the experiments:

- **Emulab:** an emulated WAN environment testbed.
  - 39 machines with 100 Mb/s bandwidth
  - Each server is deployed on a different machine.
  - Clients are all deployed in the remaining machines in a round robin fashion.
- **Ansible:** a tool to automate different IT tasks.

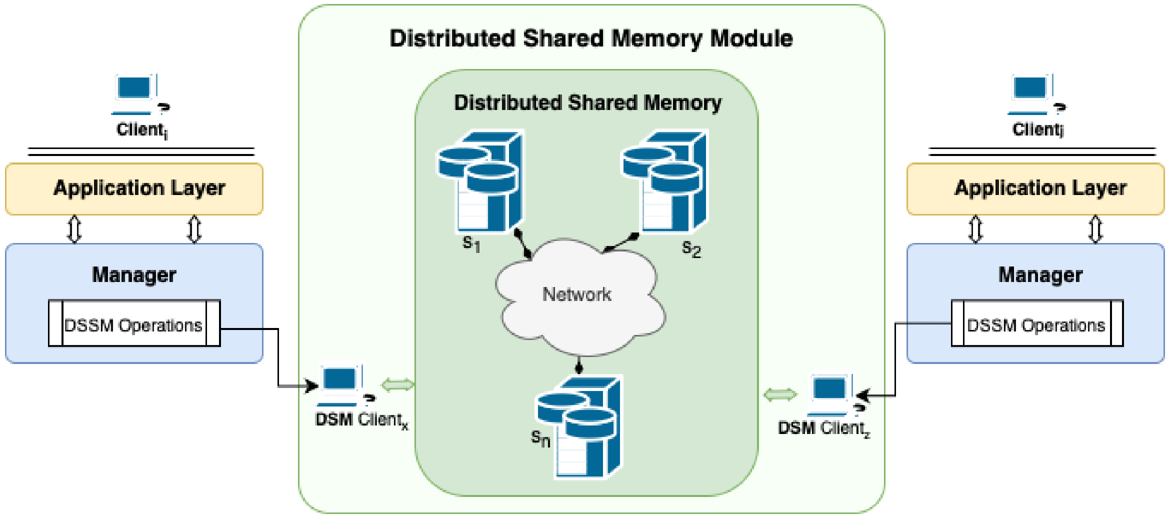


- **Performance Metric**
  - Operation latency of clients (Communication + Computation Overhead).
  - Sample traces near the average duration for each scenario.
  - Three executions.

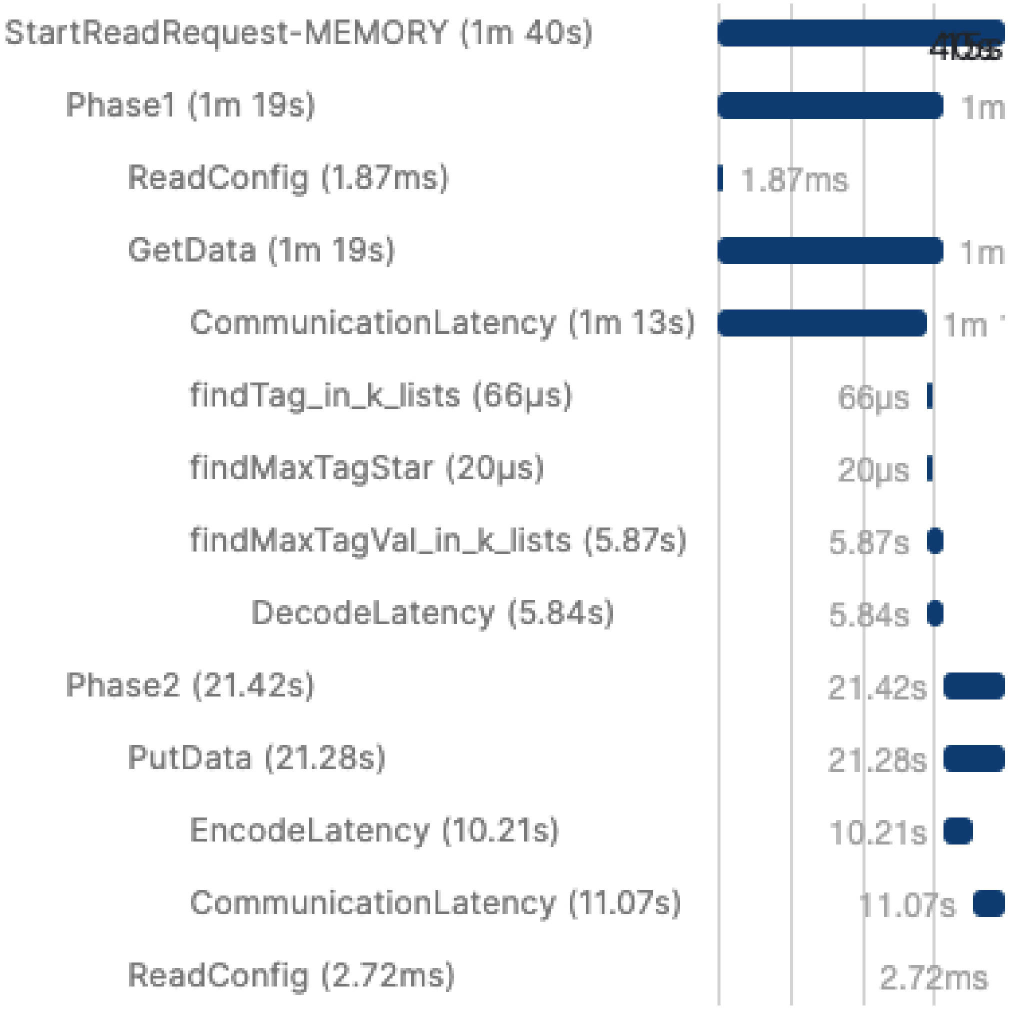
Debug Levels

Monitor read, write, and reconfig operations at two debug levels:

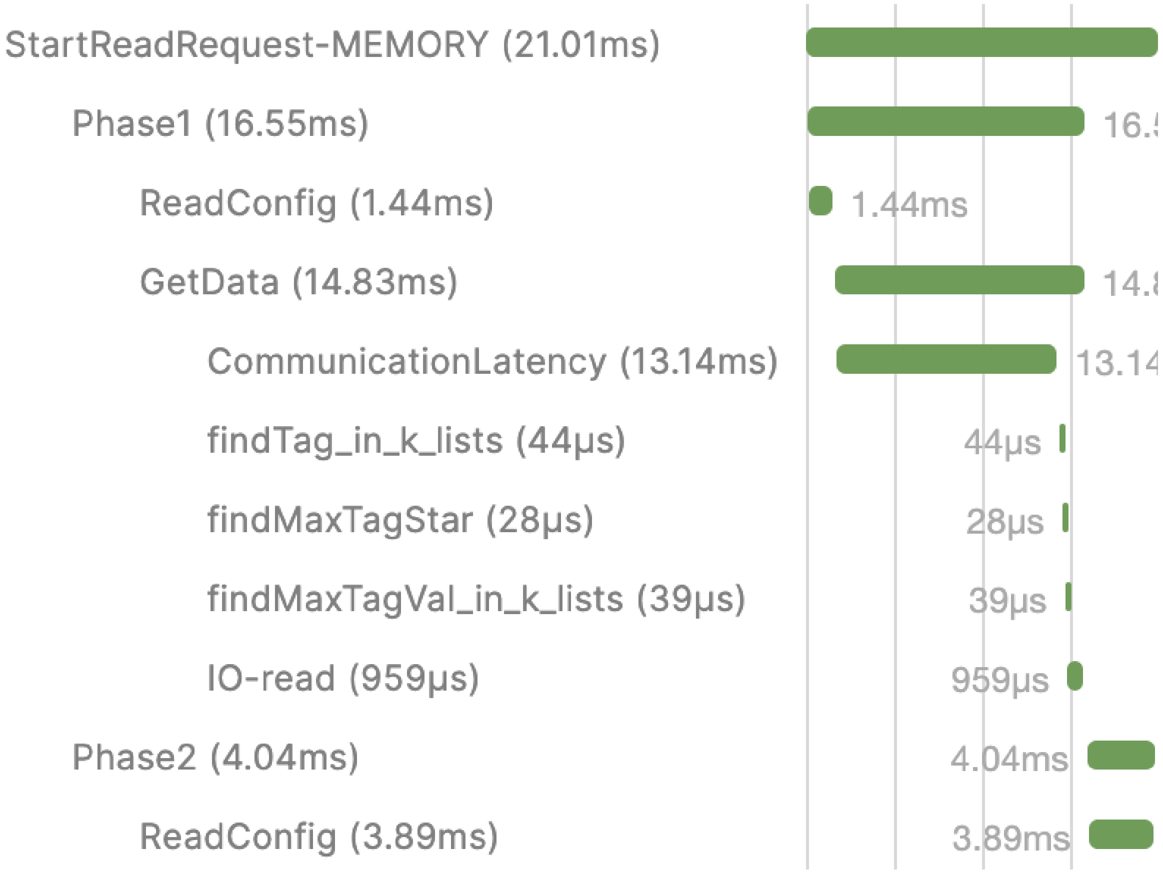
- **User:** This level includes the computation latency and the latencies for exchaning requests with the DSMM.
- **Memory:** This level includes communication and computation latencies within the DSMM.



File Size

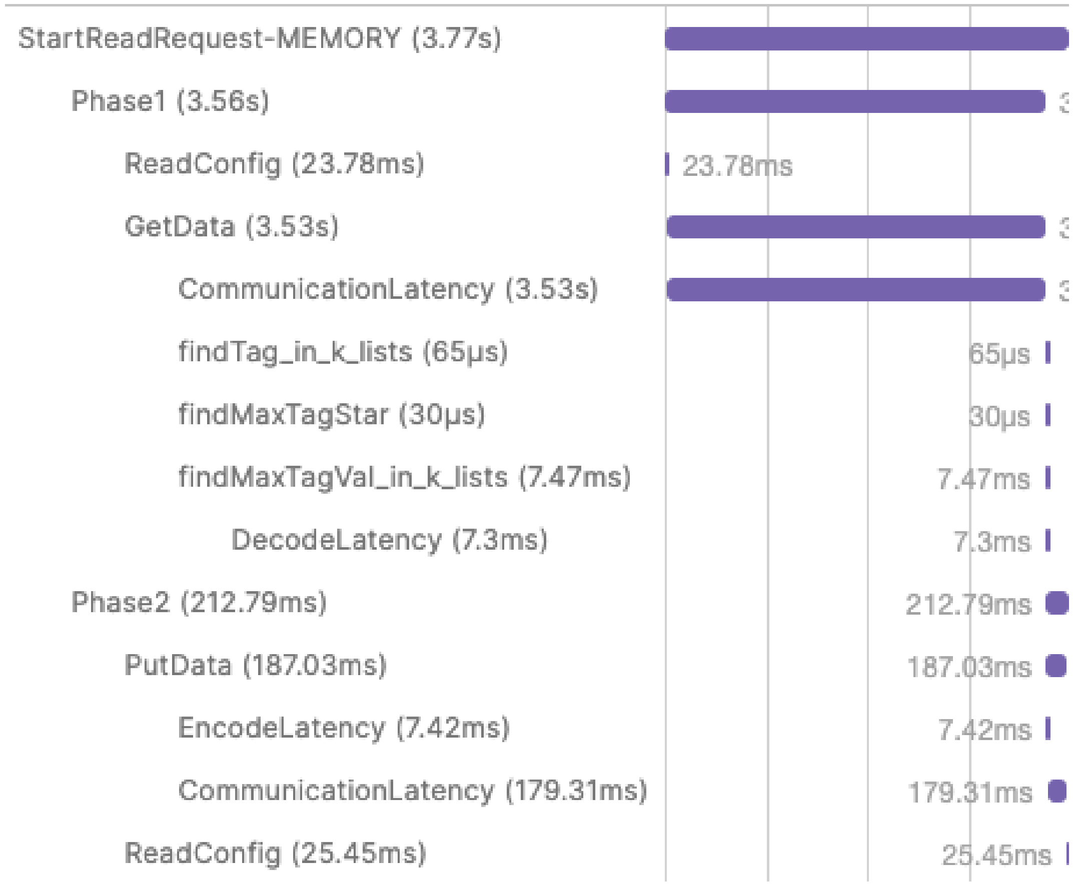


ARESEC, S:11, W:5, R:5, fsize:512MB, Debug Level:DSMM

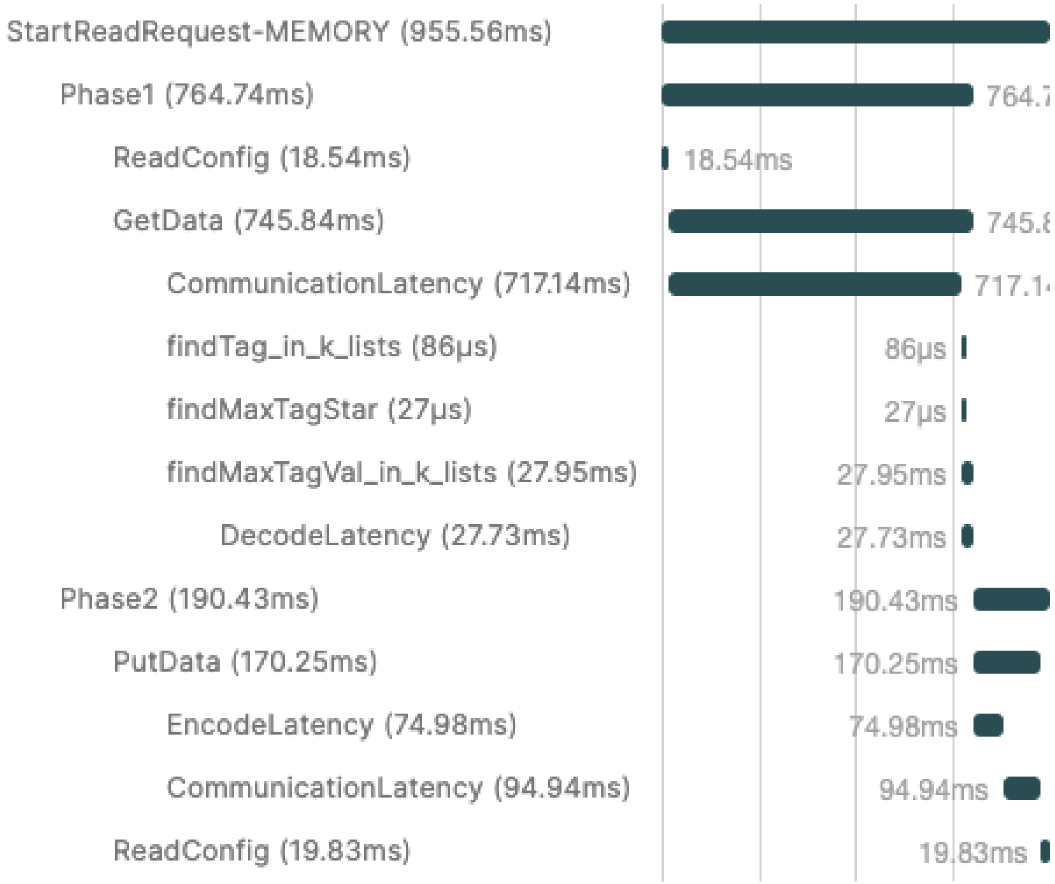


CoARESECF, S:11, W:5, R:5, init fsize:512MB, Debug Level:DSMM

Participation Scalability

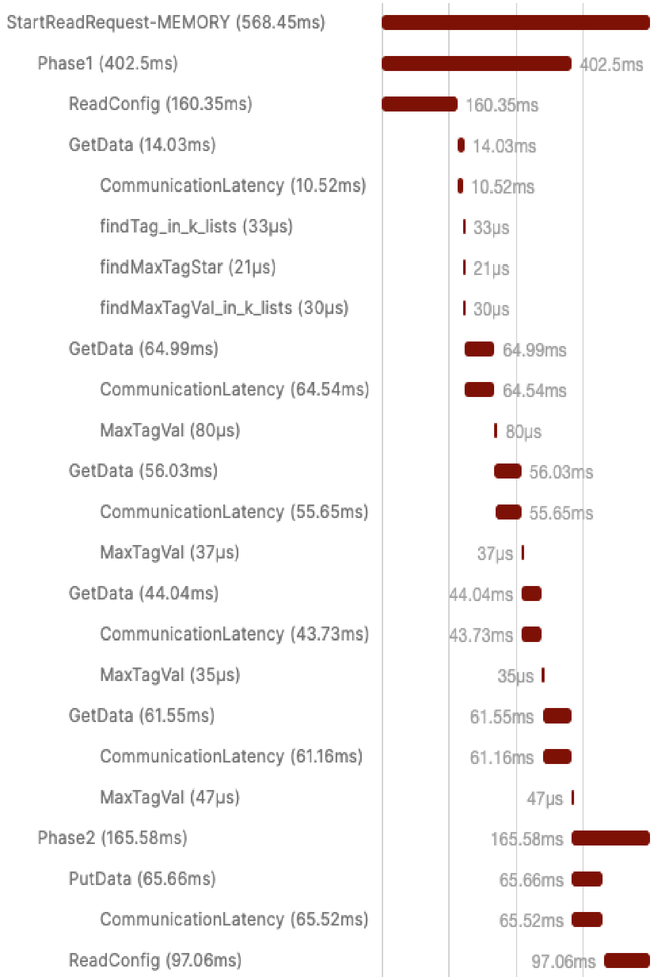


ARESEC, S:3, W:5, R:50, fsize:4MB, Debug Level:DSMM

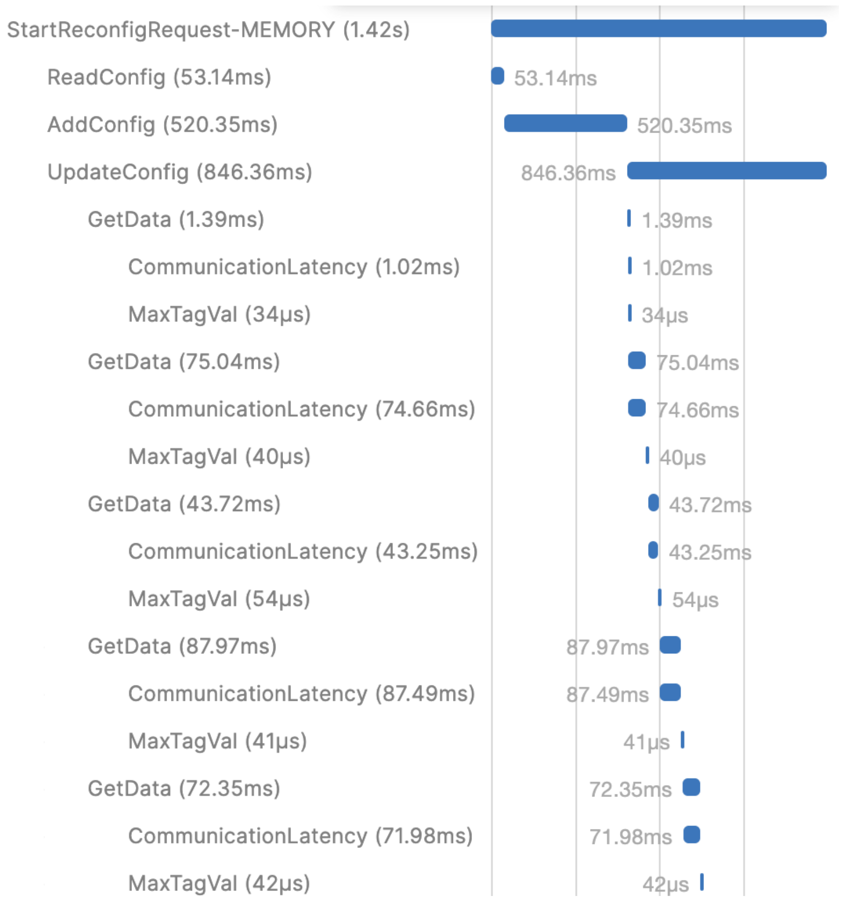


ARESEC, S:11, W:5, R:50, fsize:4MB, Debug Level:DSMM

Longevity

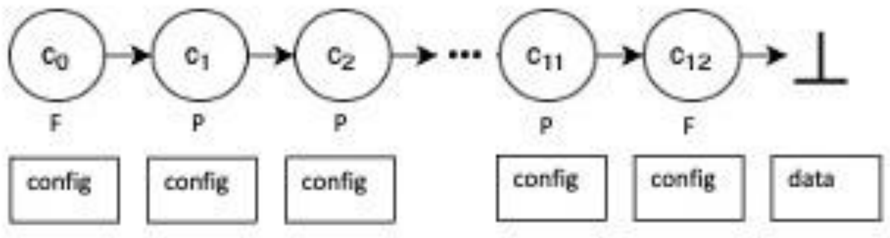


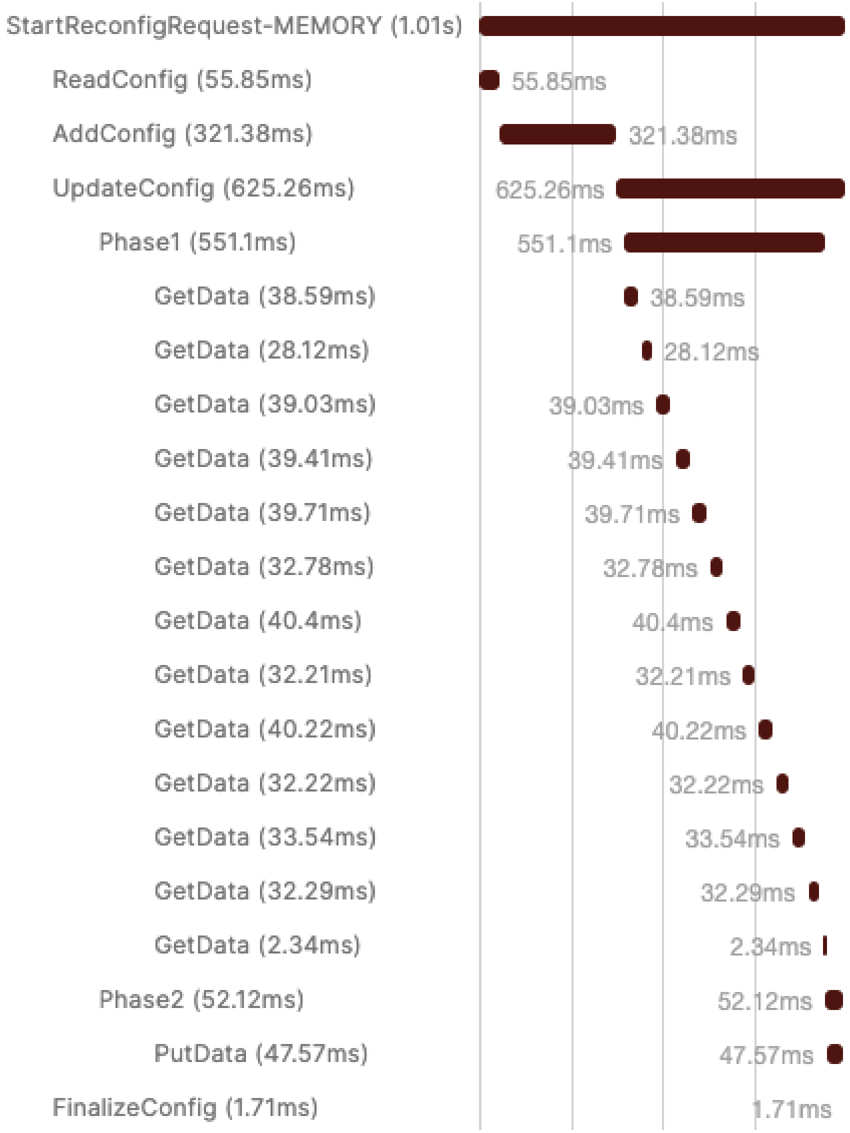
CoAresF, S:11, W:5, R:15, G=5, fsize:4MB, Debug Level:DSMM



CoAresF, S:11, W:5, R:15, G=5, fsize:4MB, Debug Level:DSMM

The Latencies of **read-config** and **get-data**.





Conclusions

Distributed tracing is crucial for diagnosing and resolving performance issues in DSM algorithms.

Optimization Strategies

- **Piggy-backing**: Integrating configurations with read/write messages to expedite configuration discovery.
- **Garbage Collection**: Eliminating obsolete configurations for quicker access to the latest data.
- **Data Batching**: A single reconfiguration across multiple objects to enhance efficiency.

Thank you!

For more information you can see the websites of our related projects: