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PI-11 Scalability PoC update

October 2020

Milestones

1st - Prove scalability according to guiding principles

2nd - Introduce Event-Sourcing and CQRS

3rd - Report out document

Overview

Re-designed transfers and participants interactions using a distributed transaction

Built a distributed event-based transaction system based on the single responsibility principle - split transfers and participants

Implemented Event-Sourcing and CQRS

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Where we are since PI-10?

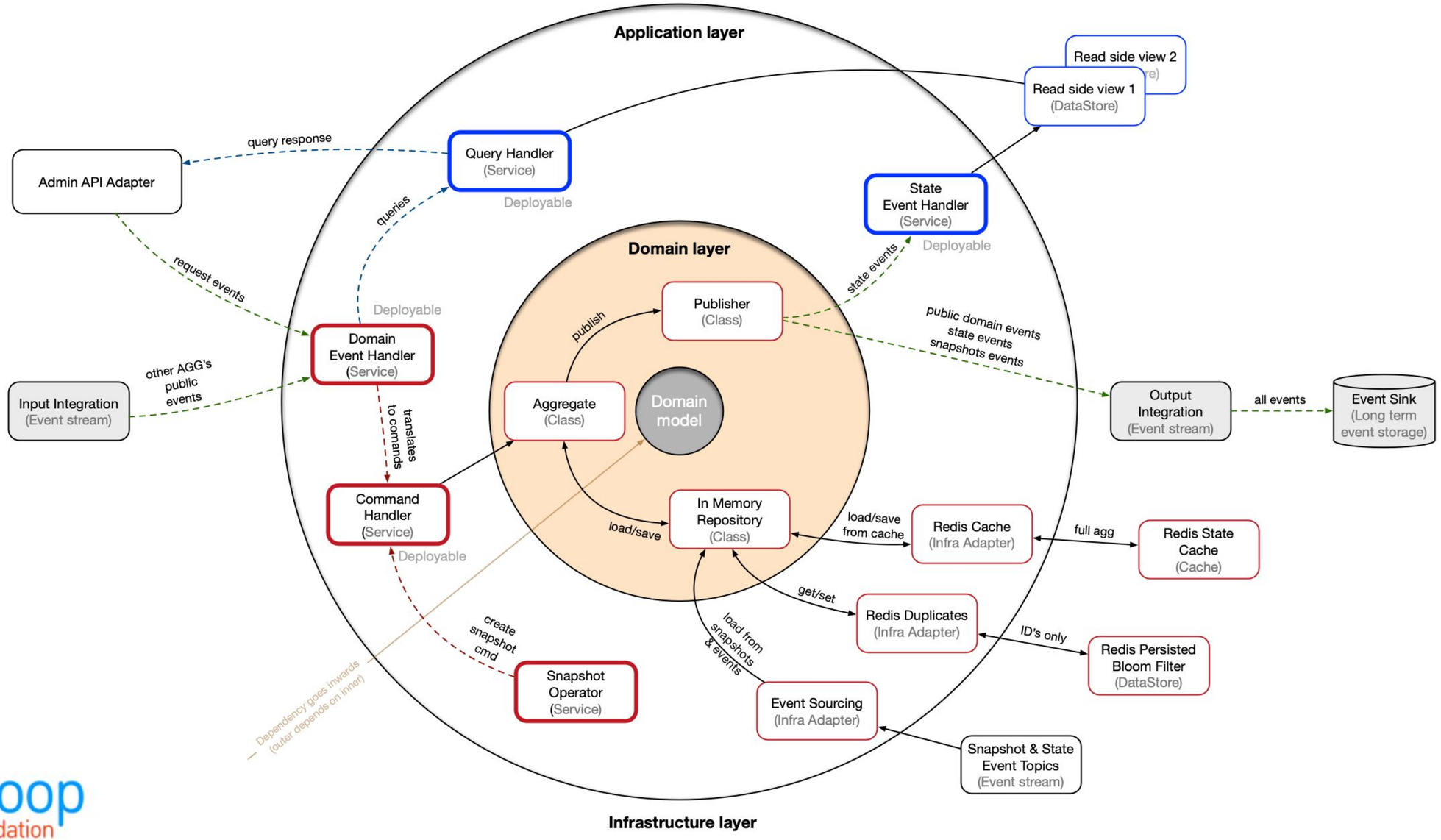
~~Properly test CQRS and Event Sourcing and execute load tests~~

~~Write a CQRS handler to keep necessary DB Data up to date~~

~~Test scaling to 32 or more FSPs (or up to 5000 FTPS)~~

~~“Performance Scalability PoC Report”~~

Architecture Overview (Participants)



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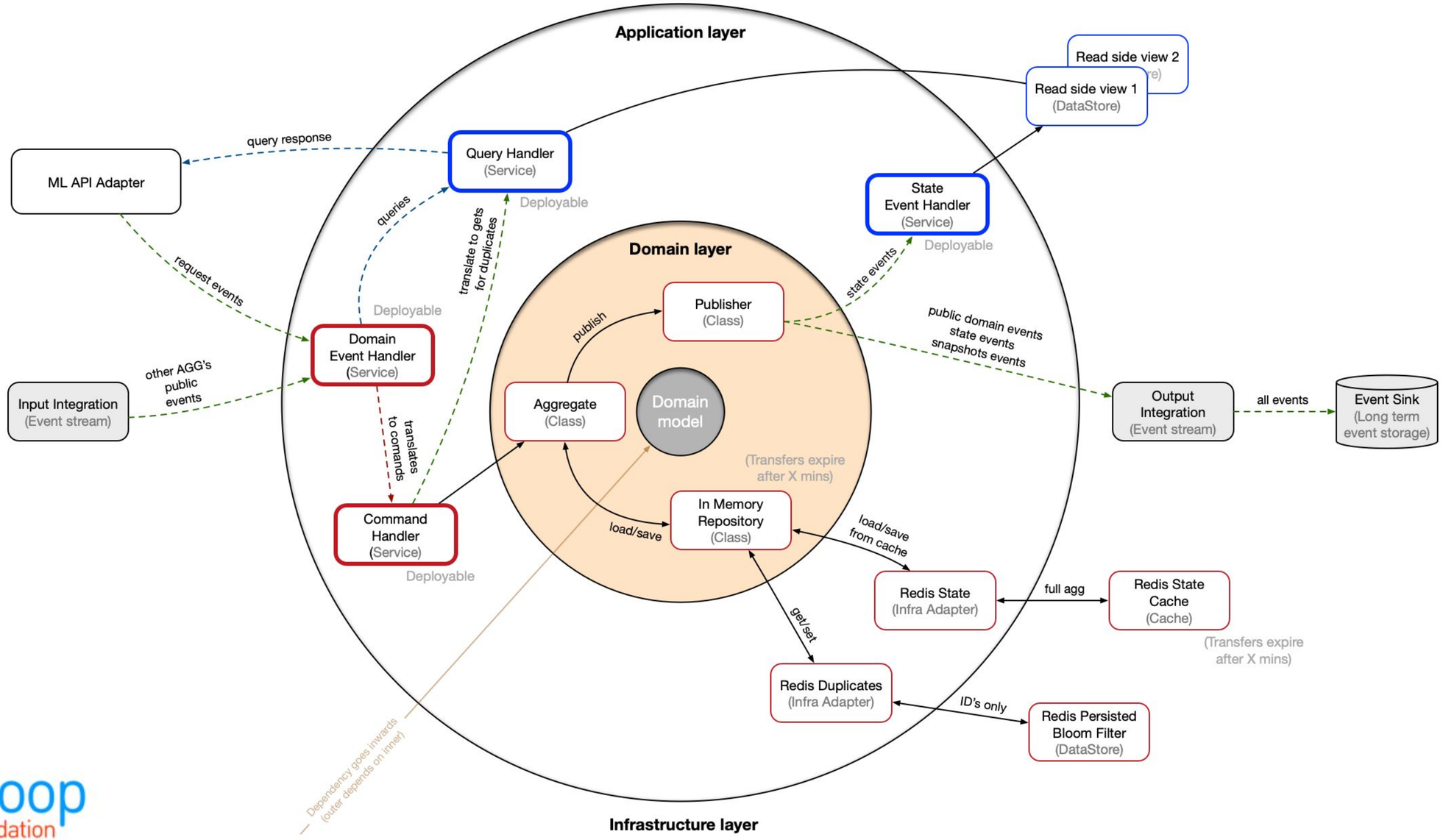
Architecture Overview (Transfers)



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How it flows (recap)

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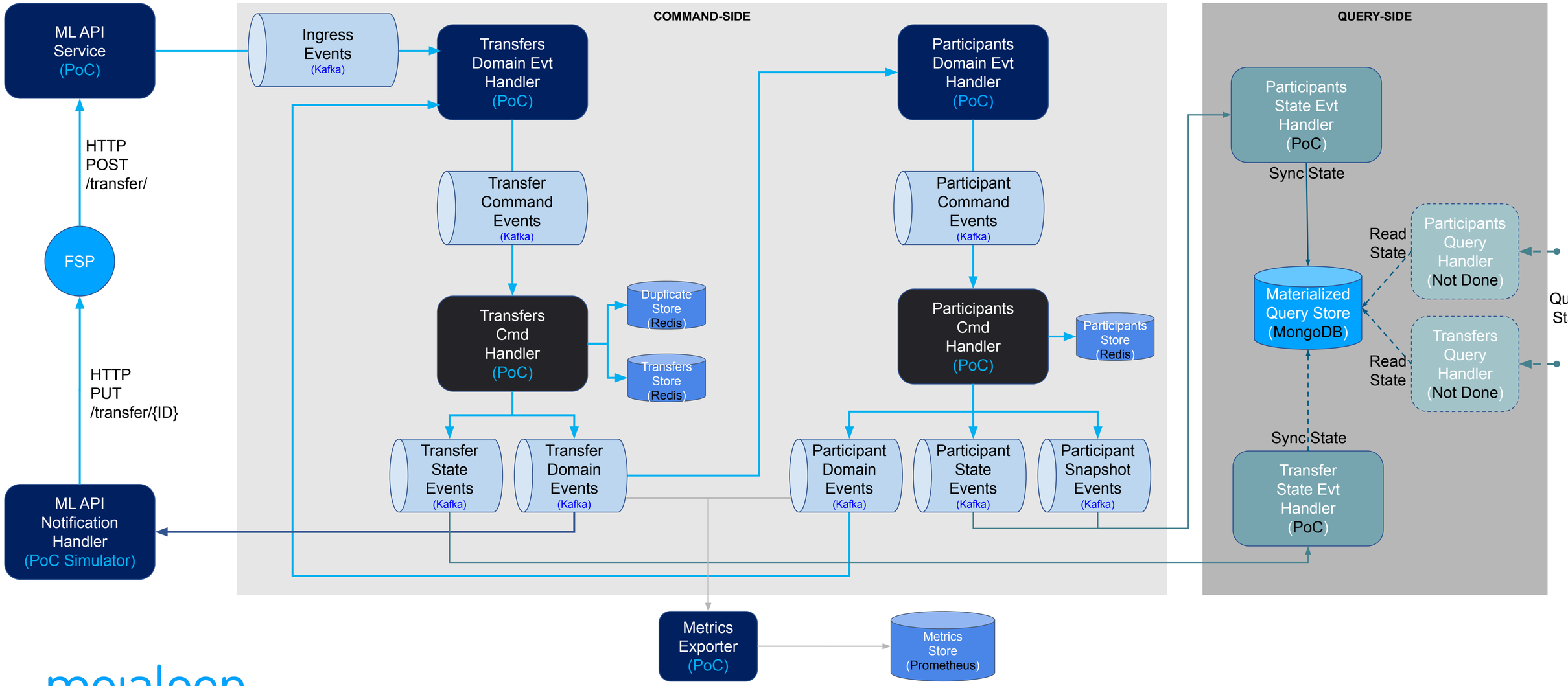
Deployment Architecture

Available deployable Artifacts - Helm, Docker & Github



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Performance Summary

T#	Indicator	Cost Scale Unit (CSU)	8 FSP (ECache)	16 FSP (ECache)	32 FSP (ECache)
T3.1.1	Financial **Transactions Per Second** (FP/s) - **1000/5000 FP/s**	**1.001 FP/s**	**1.602k FP/s**	**3.002k FP/s** (+87%)	**5.12k FP/s** (+71%)
T3.1.2	**Time** for Run - **1H**	**1H 20M**	**1H 20M**	**1H 20M**	**1H 20M**
T3.1.3	**% of Transactions** that took **longer than a second - 1%**	**0.03%**	**0%**	**0%**	**0.22%**

Table 3.1.a. Performance Targets Summary

M#	Metric	Cost Scale Unit (CSU)	8 FSP	16 FSP	32 FSP
M3.1.1	Financial Transactions **Average** Response Time	**79 ms**	**63 ms**	**72 ms**	**43 ms**
M3.1.2	Financial Transactions **Minimum** Response Time	**56 ms**	**50 ms**	**57 ms**	**33 ms**
M3.1.3	Financial Transactions **Maximum** Response Time	**135 ms**	**98 ms**	**102 ms**	**81 ms**
M3.1.4	**Total** Financial Transactions	**3.662 mill**	**5.81 mill**	**11.05 mill**	**18.51 mill**

Table 3.1.b. Non-Indicator Performance Metrics Summary

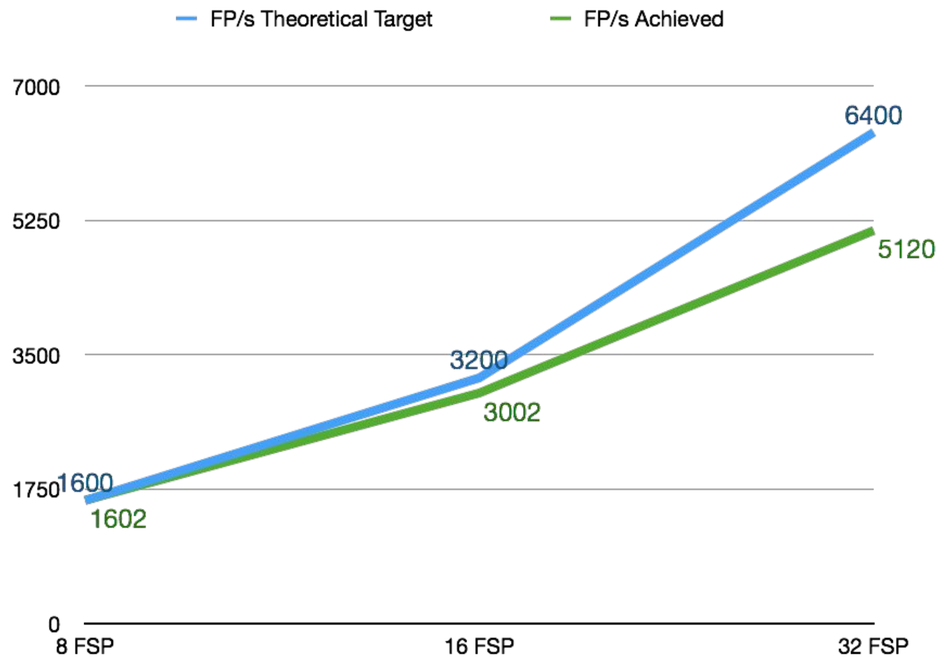


Figure 3.1.a. Scalability Comparison of Achieved Results against S# Targets using AWS Managed ElasticCache (ECache)

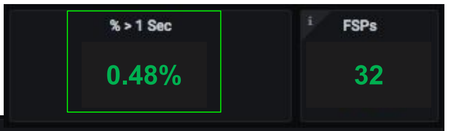
Performance Run: 32 FSPs (**self-hosted)

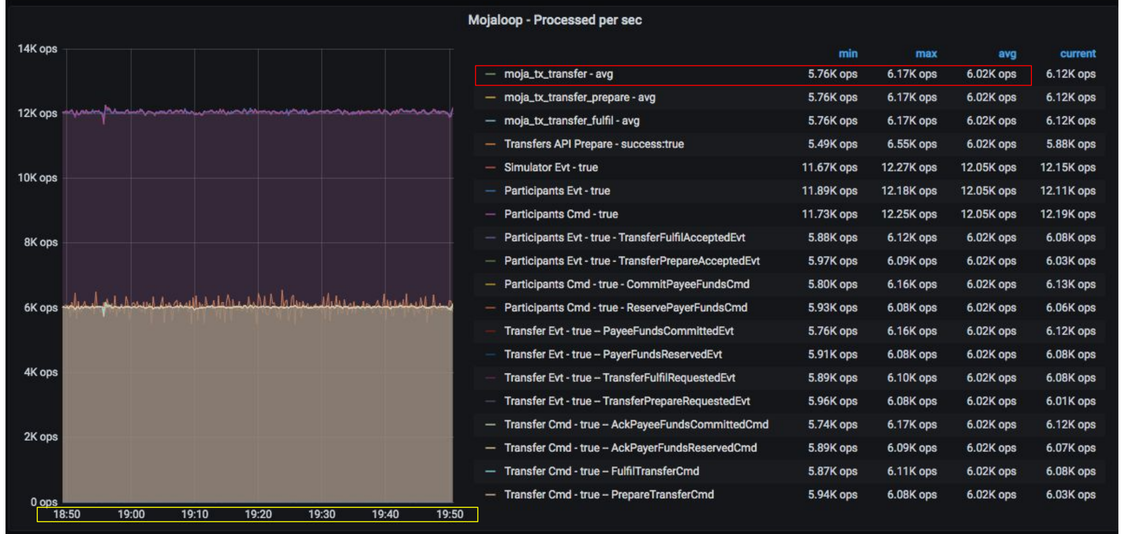
#	Indicators	Target	Actuals
T1	Financial Transactions Per Second (FTP/s)	>= 5000 FTP/s	6.02k FTP/s
T2	Time for performance run	>= 1 Hour sustained run	1 Hour
T3	% of transactions that took longer than a second	< 1%	0.48%

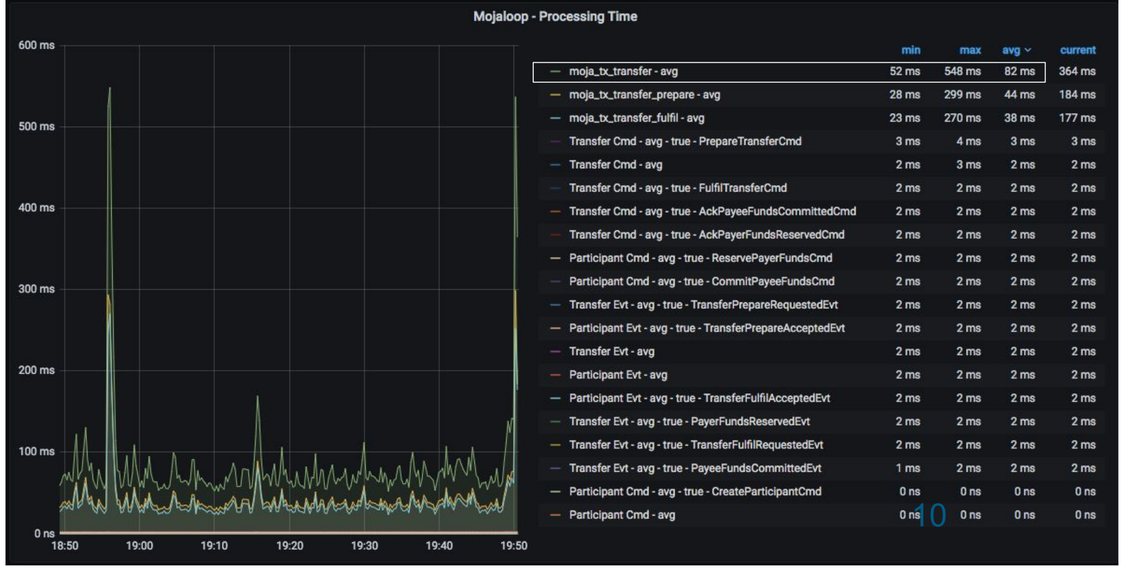
Component	Instance Scale	Infrastructure Type	Infrastructure Scale
Transfers Evt Handler	80	c5.2xlarge	28
Transfers Cmd Handler	80		
Participants Evt Handler	32		
Participants Cmd Handler	32		
ML-API-Adapter Service	24	c5.2xlarge	2

Component	Instance Scale	Infrastructure Type	Infrastructure Scale
Kafka	9	c5.9xlarge	9
Zookeeper	3		
Redis (Clustered - Self-hosted - Master only - No replication - Evenly Distributed Key space)	5 (cache) 1 (persistence)	i3.xlarge	6

Component	Instance Scale	Infrastructure Type	Infrastructure Scale
PoC Simulator - Payee	32	c5.2xlarge	2
PoC Simulator - Metrics Exporter	24	c5.2xlarge	2







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Notes:
* Results achieved without hardware optimization
** Fully Self-hosted (Redis, Kafka)

Scalability

We are close to linear.

Theoretical limit is the participants -> we can do ~*400 **OP/s per participant -> 200 ***FTP/s per Participant

Participant Cmd Handler Scale (1-to-1 to FSP)	Total OP/s (Aggregated Handlers)	Total FP/s (End-to-end Financial Transfer)
5 (CSU)	2000	**1000**
8	3200	**1,600**
16	6400	**3,200**
32	12,800	**6,400**
48	192,000	**9,600**
96	38,400	**19,200**
192	76,800	**36,400**

Table 4.2.1.a. Scaling Factor for ParticipantCmdHandler

Notes:
* Based on c5.2xlarge
** OP/s - Operations per Second
*** FP/s - Financial Transactions per Second

To achieve even more performance per participant:

1. Kafka Message Encoding-Parsing ← Reduce encoding/parsing overhead
2. Separation of Participant Metadata, Account and End-point Information ← Optimize data persistence, & message sizes
3. Virtual positions (sharding the position through different participant handlers) ← Partition FSP position for Parallelism
4. Bloom Filters for Duplicate Checks ← Reduce space requirements for duplicates
5. Batching by FSP (workloads are already in an appropriate FSP bucket - i.e. partitions) ← Optimize processing throughput
6. Provision hardware with faster CPUs (scaling up to achieve a higher throughput) ← Increase processing muscle
7. Tiger Beetle ← Optimize data store

What we achieved against objectives

1. Min Deploy: 1,000 FTP/s, 99% < 1 sec, 1 hour durability, on minimum hardware footprint (required minimum HW footprint to be defined by the PoC) - **Achieved: 8x FSPs for 1x CSU fully self-hosted (Kafka & Redis)**

2. Sub-linear cost to scale for each single unit increment of capacity - i.e. **cost scale unit (CSU)**. The hardware cost of one increment is significantly less than the minimum deployment footprint. The architecture isolates the high-load components to scale separately from the low load ones. - **Achieved: Near-linear performance & cost scalability**

3. Demonstrated Scaled Perf: nearly 5,000 FTP/s, 99% < 1 sec, 1 hour durability for 5 CSU, plus min deploy unit. Proving point (2) - **Achieved: 6020 FTP/s - 6x Performance @ ~8 CSU using self-hosted**

4. Understand how much the PoC design scales, max scaling before 99% < 1 sec fails or error rate increases (optional) - **This is a moving target, we keep getting more: hitting 6k FTP/s**

PI-11 Learnings

1. Limit Event-Sourcing Usage to Participants only
2. Command-Side Caching of Transfers
3. GZIP Compression
4. Redis-Cluster (Sharding) to overcome Network & IOPs limitation

Cost Scale Unit (CSU) - AWS Cost

Central Ledger
- Participants + Transfers - 7x c5.xlarge
- ML-API-Adapter - 1x c5.2xlarge

Infrastructure
- Kafka cluster - 5x r5.xlarge
- Redis - 3x i3.xlarge

Others
- Simulators - 1x c5.2xlarge

7	c5.xlarge
5	r5.xlarge
3	i3.xlarge
2	c5.2xlarge
17	**Total**

2,323 USD / month

8 DFSPs handling 1000 financial transactions per sec

Ireland - 1yr reservation / no upfront - https://calculator.aws/#/estimate?id=279063344e3d2e6372a00c36d469f91f11d4e303

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Conclusion

1. Better horizontal scaling by segregating the different functions across different services and datastores
2. Separate transfers and participants lead to easier partition of datastores
3. Better maintainability / extensibility
4. This design shifts the burden from a shared DB to distributed streaming (kafka), separate (mongodb) read stores and (redis) caches - which are horizontally scalable by design
5. Reduced latency and faster response times
6. Retrofitting is simple and a migration/bootstrapping of data is feasible

Performance Scalability Report

Table of Contents - v0.1-draft - pending community review

Team:

Crosslake
- Pedro Sousa Barreto <pedrob@crosslaketech.com>

ModusBox
- Miguel de Barros <miguel.debarros@modusbox.com>
- Roman Pietrzak <roman.pietrzak@modusbox.com>

Coil
- Donovan Changfoot <donovan.changfoot@coil.com>

Next Steps

1. Community & Design-Authority to provide comments to the report document
2. Design-Authority to provide recommendation
3. Final decision:

    1. Productionize PoC
        - Roadmap, Delivery & Resource Plan for Productionization
        - Production-grade Designs
        - Some productionization work (not dependant on Final Production Designs)

    2. Integrate learnings into existing code-base
        - Select Key Learnings to implement based on available time & resources

How can you help?

We need help reviewing the

“Performance Scalability PoC Report”

Team work

Amar Ramachandran *(Modusbox)*

Donovan Changfoot *(Coil)*

Miguel de Barros *(Modusbox)*

Pedro Barreto *(Crosslake)*

Roman Pietrzak *(Modusbox)*

Sam Kummary *(Modusbox)*

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Q&A

Code at
https://github.com/mojaloop/poc-architecture

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