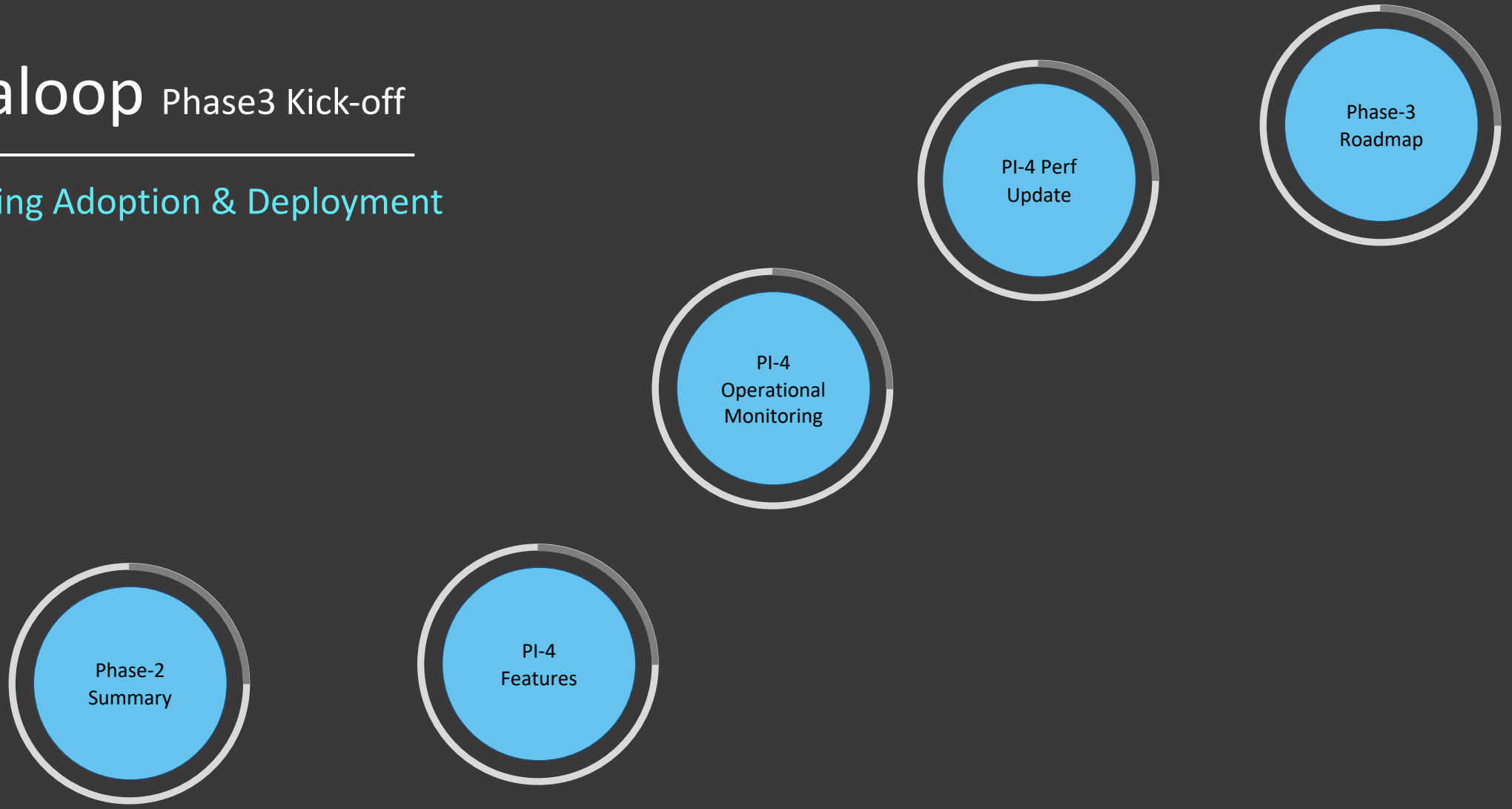
mojaloop

# Mojaloop Phase3

## Supporting Adoption & Deployment

# Mojaloop Phase3 Kick-off

## Supporting Adoption & Deployment




29th -31st January 2019

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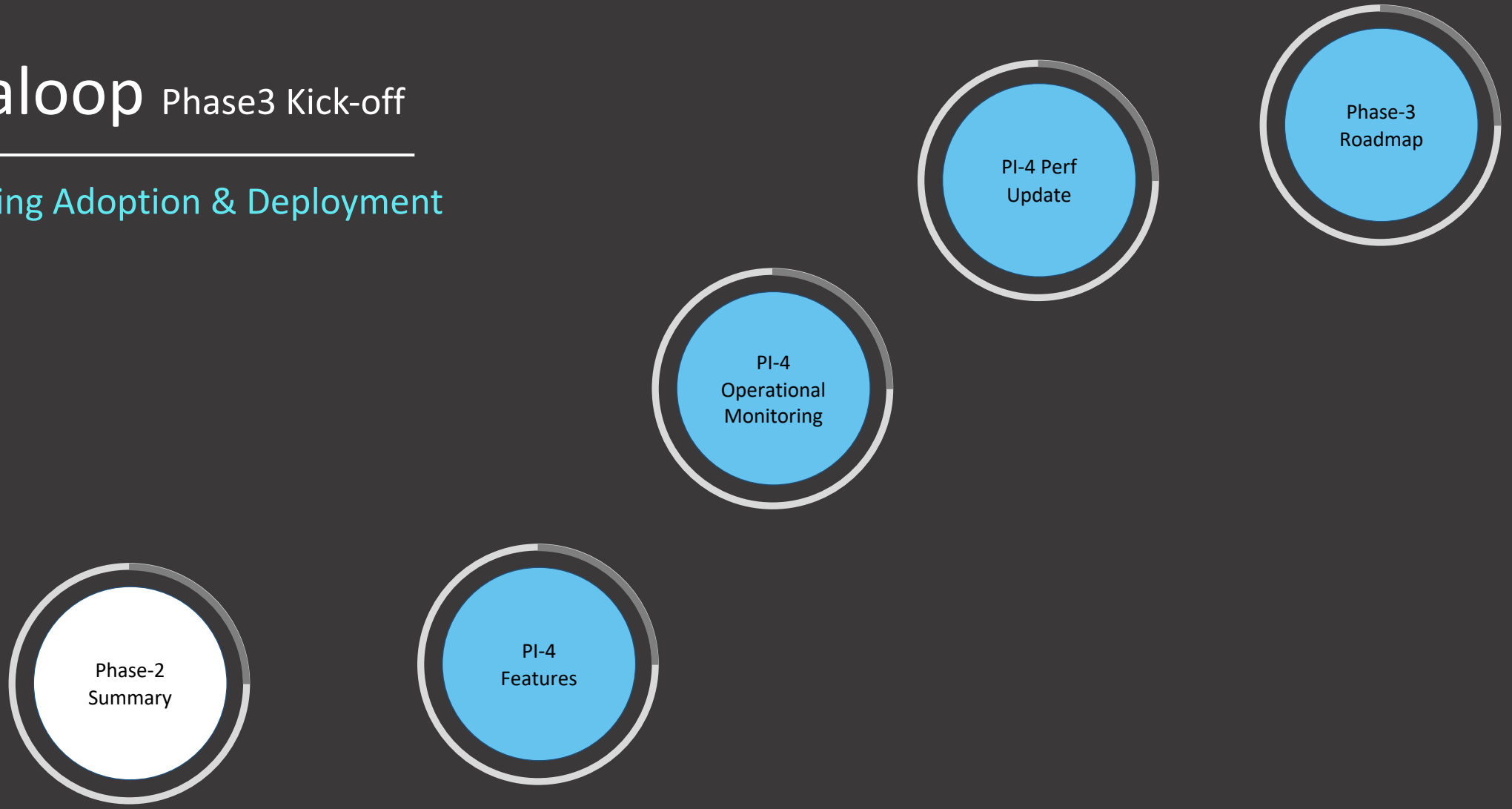
# Phase-3 Kick-off Agenda

1. Phase-2 Summary (focus on PI-4)
2. PI-4 Features
    a. Settlements
    b. QA Regression testing framework
    c. CEP, email-notifier
3. PI-4 Operational Monitoring Capability
4. Performance
5. Phase-3 RoadMap

# Mojaloop Phase3 Kick-off

## Supporting Adoption & Deployment

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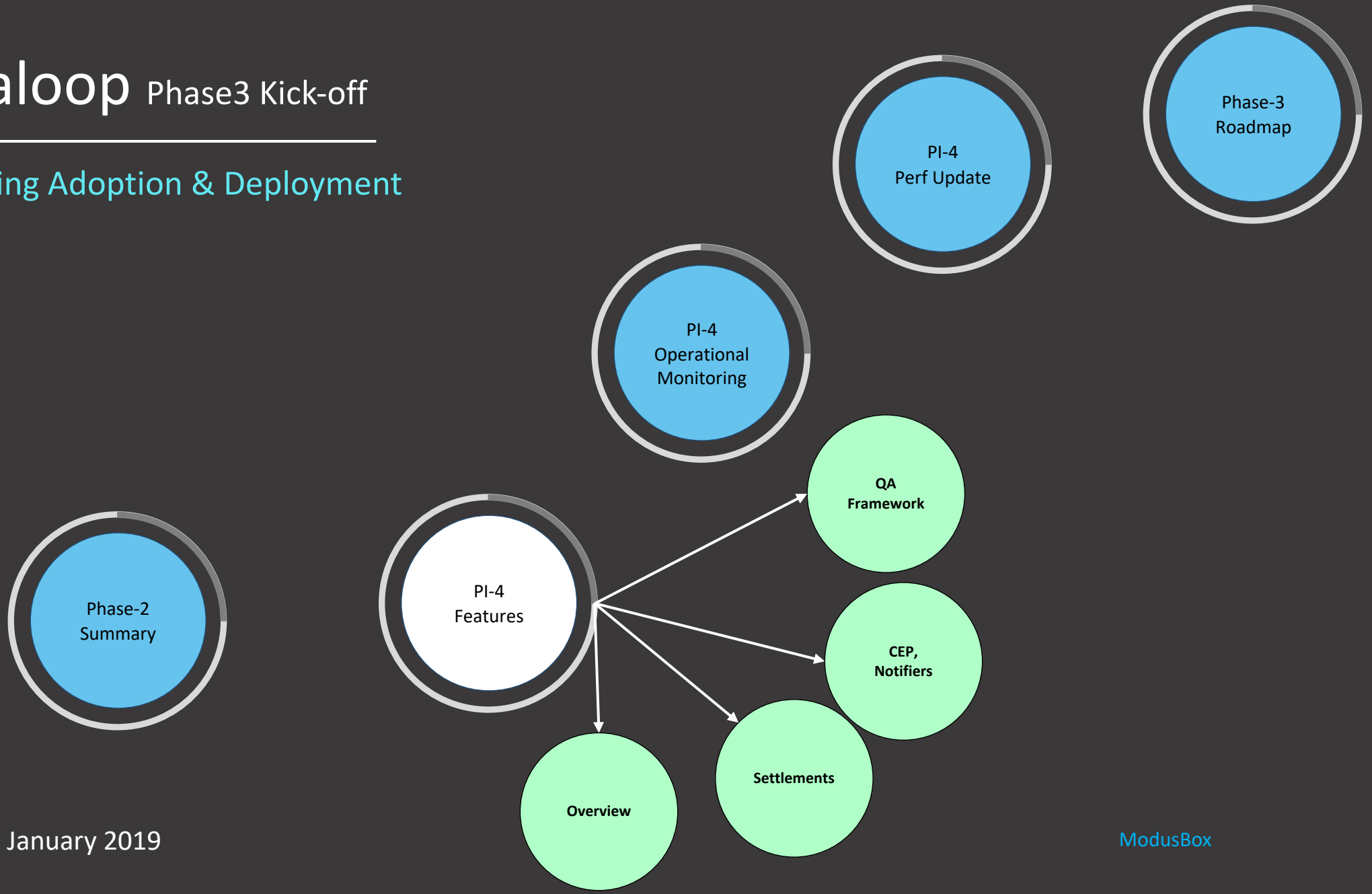
# Timeline Overview

| Timeline | Summary |
|---|---|
| Phase-1 | Level One Project<br>• Reference Implementation<br>• 6 Program Increments (PIs) (2016 - 17) |
| Phase-2 | Road To Productionization: Phase-2 (2018)<br>• PI – 1 (Feb - April)<br>• PI - 2 (April - June)<br>• PI - 3 (June - August)<br>• PI – 3.5 (September)<br>• PI – 4 (November-December 2018): Performance, Settlements, CEP, QA Framework, Operational Monitoring, Managed backlog for Phase-3 |
| Phase-3 | Supporting Adoption & Deployment – (2019 Jan - June)<br>• PI-5: Merchant Payments, Account lookup, PoC for automated DFSP handler provisioning.<br>• PI-6: Error, Event handling frameworks, PoC for Bulk payments, Comprehensive QA Framework, streamlined CI/CD process |

# Mojaloop Phase3 Kick-off

## Supporting Adoption & Deployment

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# Phase-2 Summary: PI-4

| PI | Topic | Summary |
|---|---|---|
| **PI-4** | **1. Performance Improvements** | 1. Performance issues investigated, several high priority issues addressed to improve performance. |
| | **3. QA Regression testing framework** | 2. A Regression testing framework is developed that can be run on a given Mojaloop Switch deployment for the features covered. Currently this is run daily against the dev AWS envt. and result reported. |
| | **3. Settlements support** | 3. Settlements Functionality evolved to support more key features |
| | **4. Operational Monitoring Capability** | 4. Instrumentation for metrics, Grafana dashboards developed. Support for ELK added |
| | **5. Managed backlog for phase-3** | 5. Backlog for Phase-3 using storiesonboard provided for discussion |
| | **6. Bug Fixes, Community support** | 6. High priority bugs fixed based on QA support by partners, internal QA, performance testing and other sources. Support for community questions provided. |

# PI-4 Features Overview

# PI-4 Features: Overview

| PI | Topic | Summary |
|---|---|---|
| **PI-4** | **1. QA Regression testing framework** | A functional /regression testing framework is available that can be run periodically on a given deployment and send reports. |
| | **2. Settlements support** | Support for commercial Settlements activity provided; Functionality for integration of accounts with Banks added. Features to activate, de-activate FSPs, accounts provided. Reconciliation of positions and handling of aborted settlements provided. |
| | **3. Central Event Processor (CEP), Notifier** | A central event processing framework developed to monitor, respond to events based on Rules and send alarms/notifications as configured |

# Switch Operations [Resources] - Overview of changes

**Participants**
[●] POST - Create
[●] GET - Query
[●] *PUT - Update*

**Participants Limits**
[●] POST - Set initial Position
[●] *Manage Limits*
 [●] POST - Set Limits
 [●] *PUT - Update Limits & Thresholds*
 [●] GET - Query Limits

**Positions**
[●] GET - Query by FSP

**Participants Callback**
[●] POST - Set Callback URIs
[●] PUT - Update Callback URIs
[●] GET - Query Callback URIs

**Settlement Windows**
[●] POST - Open new window, and close previous
[●] GET - Query

**Settlements**
[●] POST – Create/trigger new Settlement with associated Windows
[●] *PUT - Receive Acknowledgments from Settlement Providers*
 [●] Process successful Settlement acknowledgements
 [●] *Reconcile Positions based on successful Settlements*
[●] GET – Query

**Accounts to support Bank integrations**
[●] *Funds In (Collateral deposited into an a/c, e.g.: FSP)*
[●] *Funds Out*

Key
[●] Fully implemented
[●] Legacy Code
[●] Partially implemented
[●] Not implemented
[○] Out of Scope



**Note**: Changes from PI3 to PI4 Italicized

# Switch Operations [Use Cases]: Overview of changes

## Participants

[●] *Manage Participants*
- [●] Create Initial Value
- [●] Query
- [●] *Update*

[●] *Manage Participant Limits*
- [●] Create Initial Value
- [●] Query
- [●] *Update*

[●] Manage Callback URLs
- [●] Create Initial Value
- [●] Query
- [●] Update

[●] *Manage Thresholds for Limits*
- [●] *Create Initial Value*
- [●] *Query*
- [●] *Update*

## Onboarding, Auditing, Security

[○] To be defined/prioritized

## Settlements

[●] Open, close Settlement Windows
[●] Query Settlement Windows
[●] Query Settlement Report
[●] Create/Trigger Settlement with Windows
[●] *Process successful Settlement Acknowledgements*
[●] *Reconcile Positions based on successful Settlements*
[●] *Process failed Settlement Acknowledgements*
[●] *Sending notification for Position Adjustment*
[○] Link Funds In/Out to Limits

## Positions

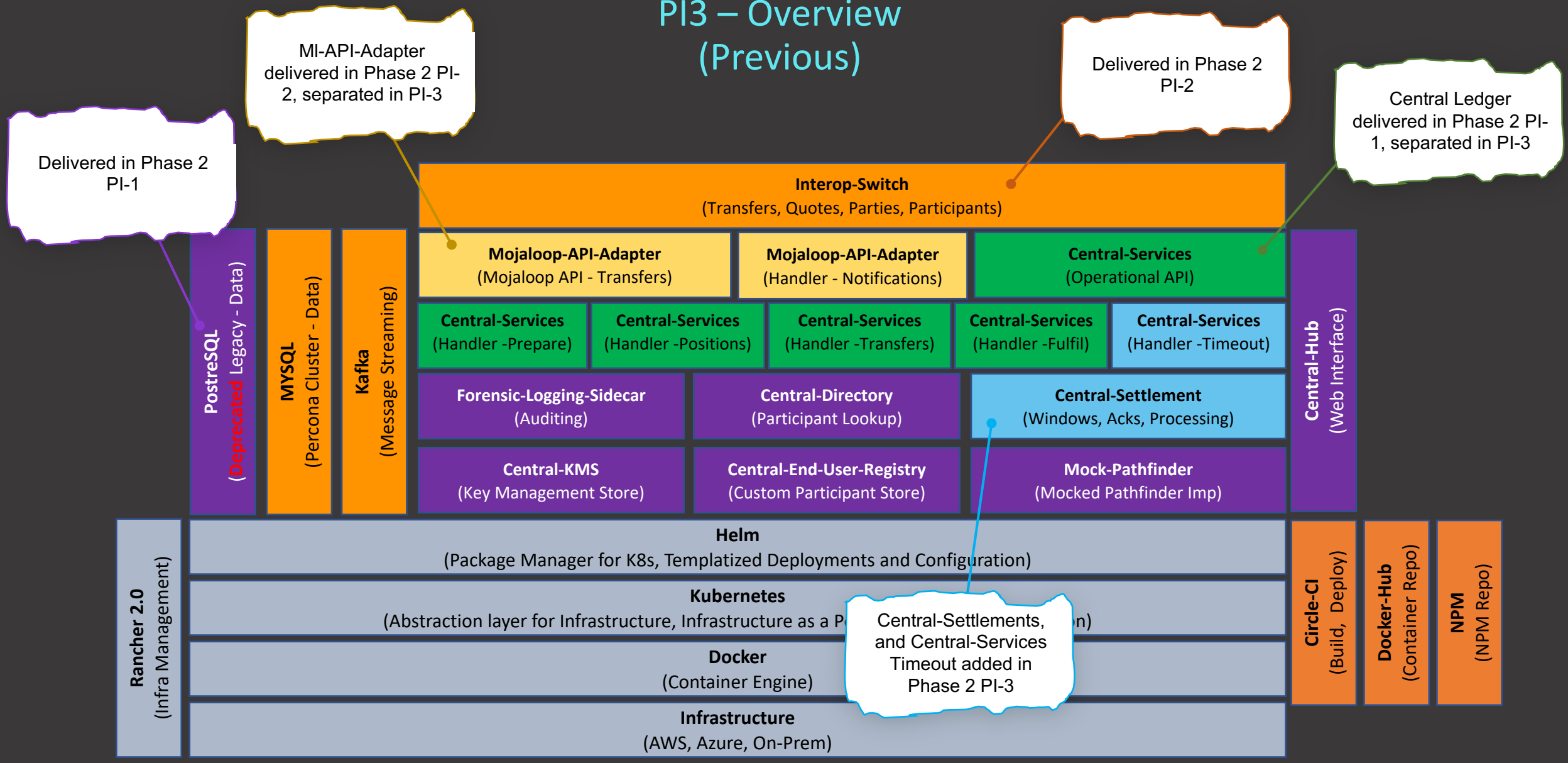
[●] Query Positions
[●] Manage Positions
- [●] Create Initial Value

## Monitoring

[●] *Instrumentation for metrics*
[●] *Real-time Metric Monitoring via Promfana*
[●] *Log Monitoring via EFK (ELK)* (Dashboards pending)
[●] *Instrumentation for metrics* (only done for Golden Path Process)
[○] *ZipKin*

Key
[●] Fully implemented
[●] Legacy Code
[●] Partially implemented
[●] Not implemented
[○] Out of Scope

# PI3 – Overview (Previous)



# PI4 – Overview (Current)

Added OpenVPN for Security

Operational Monitoring of Metric Instrumentation and Logging

Persistent store for CEP (JSON Store)

Alternate settling mechanisms. Funds In/Out. Alerts

**Get Transfers** – Async Get Transfers
**Admin** – Support Settlement Process

CEP sends email notifications based on set rules

FSP Simulator for Functional & Performance Testing support

OpenVPN/VPC

**Zipkin** (Future - Distributed Tracing)

**EFK** - ElasticSearch / Fluentd / Kabana (Log Search / Collection / Monitoring)

**Promfana** - Prometheus / Grafana (Real-time Metric Collection / Monitoring)

**Interop-Switch** (To be Retired - Transfers, Quotes, Parties, Participants)

**PostreSQL** (Deprecated Legacy - Data)

**MongoDB** (CEP - Data)

**MYSQL** (Percona Cluster - Data)

**Kafka** (Message Streaming)

**Mojaloop-API-Adapter** (Mojaloop API - Transfers)

**Mojaloop-API-Adapter** (Handler - Notifications)

**Central-Services** (Operational API)

**Simulator** (QA Simulator)

**Central-Services** (Handler - Prepare)

**Central-Services** (Handler - Positions)

**Central-Services** (Handler - Fulfil)

**Central-Services** (Handler - Timeout)

**Central-Services** (Handler - Get Transfers)

**Central-Event-Processor** (CEP)

**Forensic-Logging-Sidecar** (Auditing)

**Central-Directory** (Participant Lookup)

**Central-Settlement** (Windows, Processing, Funds In/Out, Alerts)

**Central-Services** (Handler - Admin)

**Email-Notifier** (Handler - Email)

**Central-KMS** (Key Management Store)

**Central-End-User-Registry** (Custom Participant Store)

**Mock-Pathfinder** (Mocked Pathfinder Imp)

**Central-Hub** (Retired - Web Interface)

**Rancher 2.0** (Infra Management)

**Helm** (Package Manager for K8s, Templatized Deployments and Configuration)

**Kubernetes** (Abstraction layer for Infrastructure, Infrastructure as a Policy, Container Orchestration)

**Docker** (Container Engine)

**Infrastructure** (AWS, Azure, On-Prem)

Removed from Helm Charts v4.4.x as we are no longer deploying the Central-Hub

Real-time End-to-end tracing of Transactions to be looked at in PI5

Key
[ 👥 ] Community Contributions

NPM Repo publishing fixed as part of CI/CD Process

**NPM** (NPM Repo)

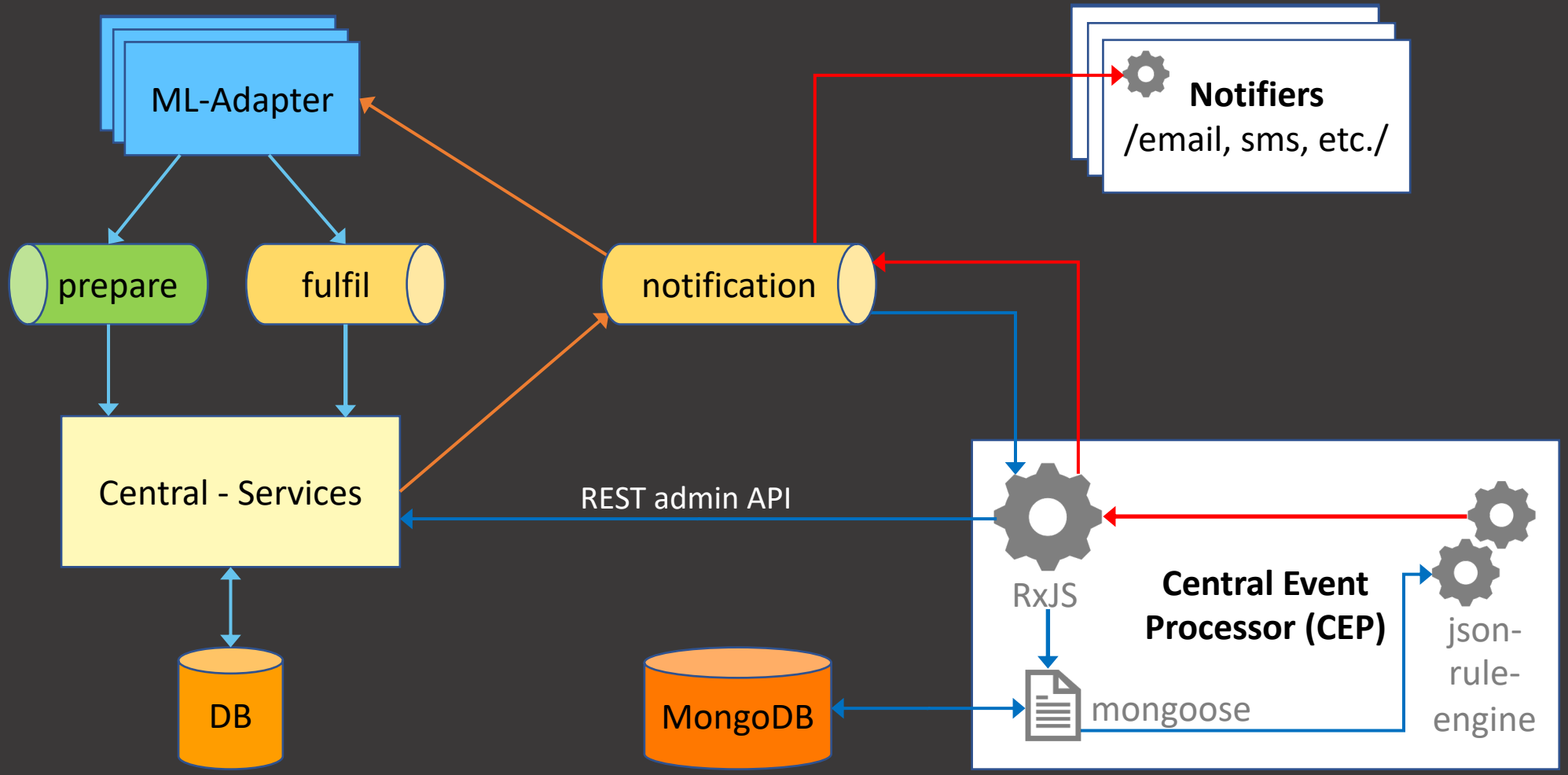
**Circle-CI** (Build, Deploy)

**Docker-Hub** (Container Repo)

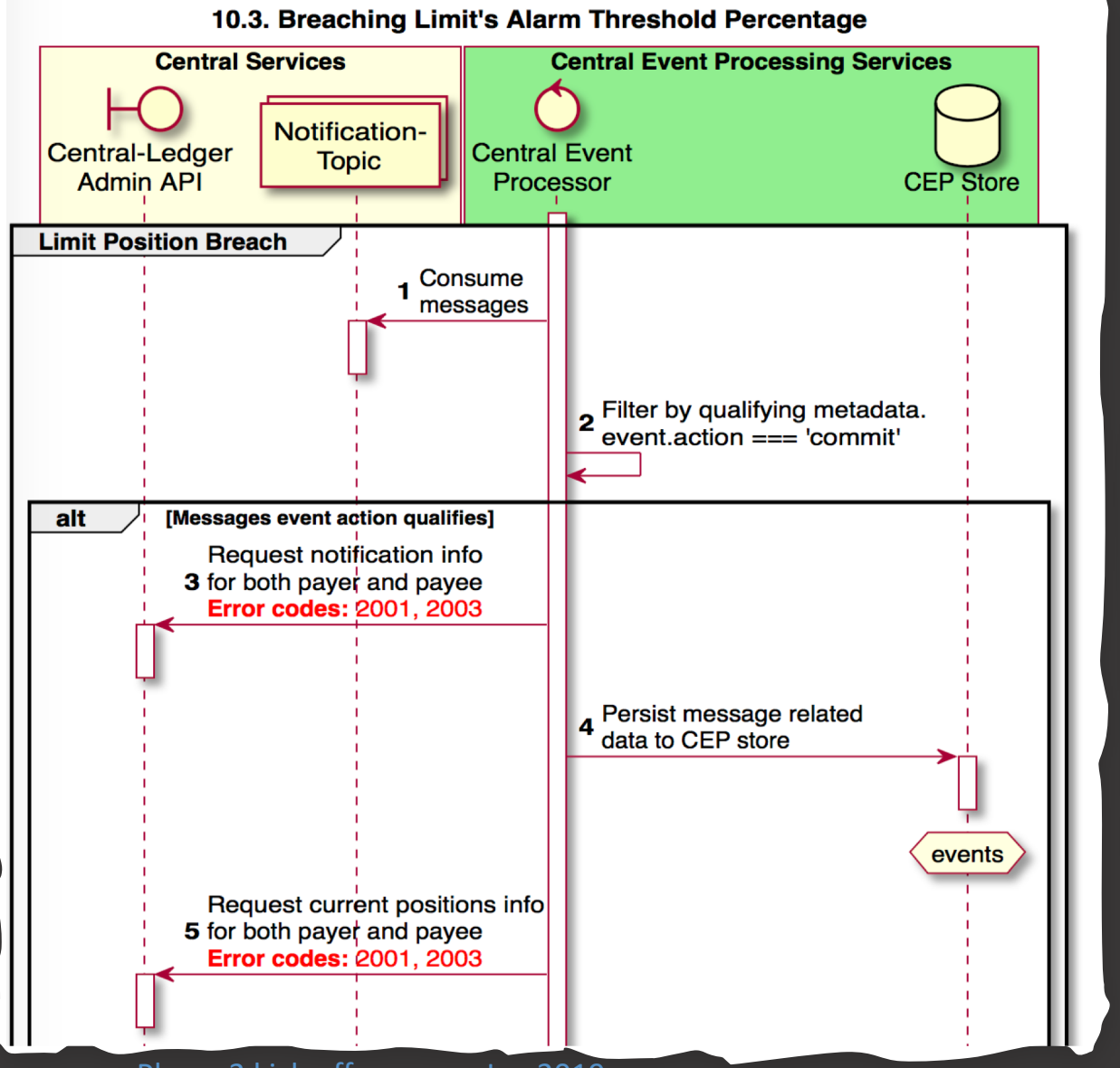
# PI-4 Features

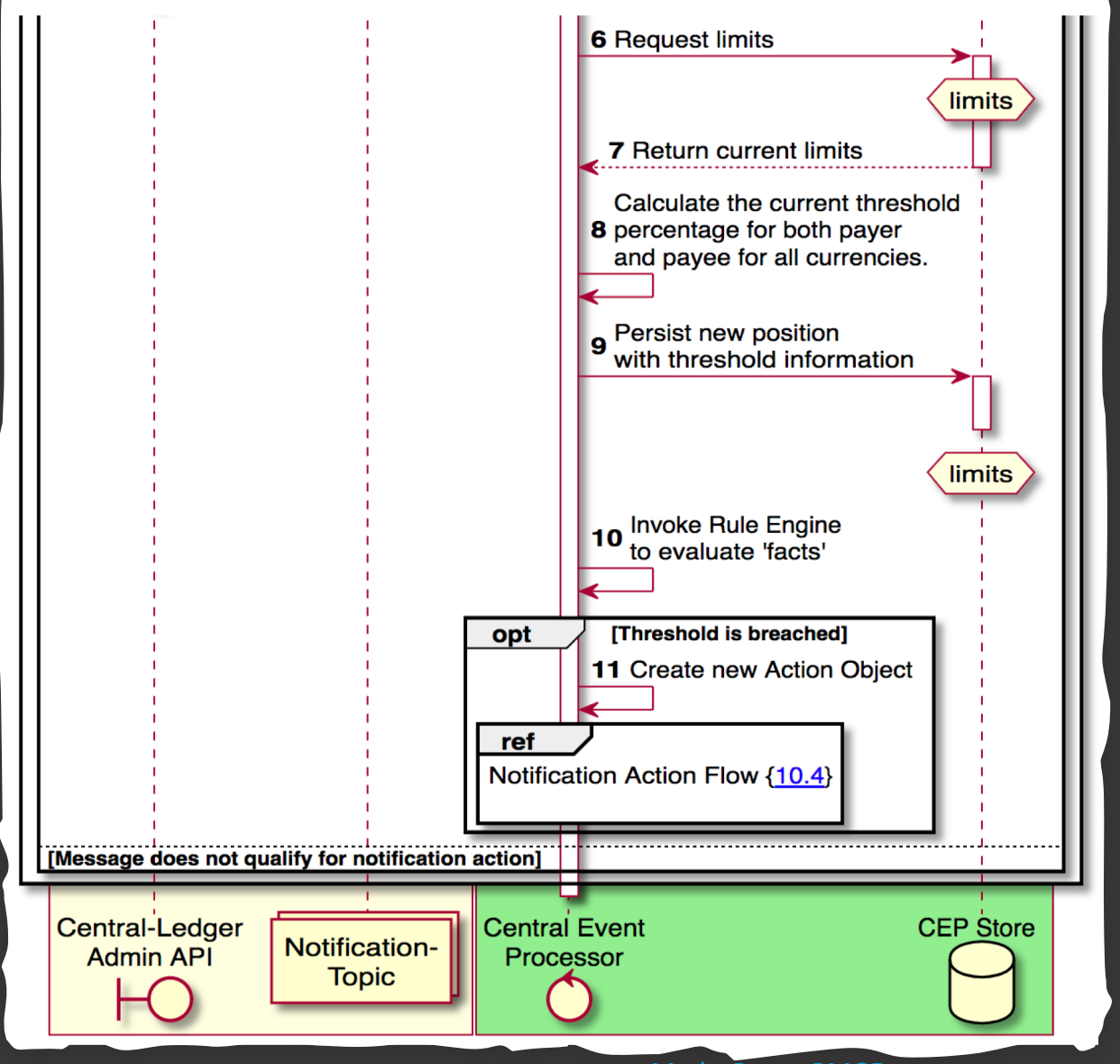
# Event Processing, Notifications

# CEP Architecture and Technologies Overview



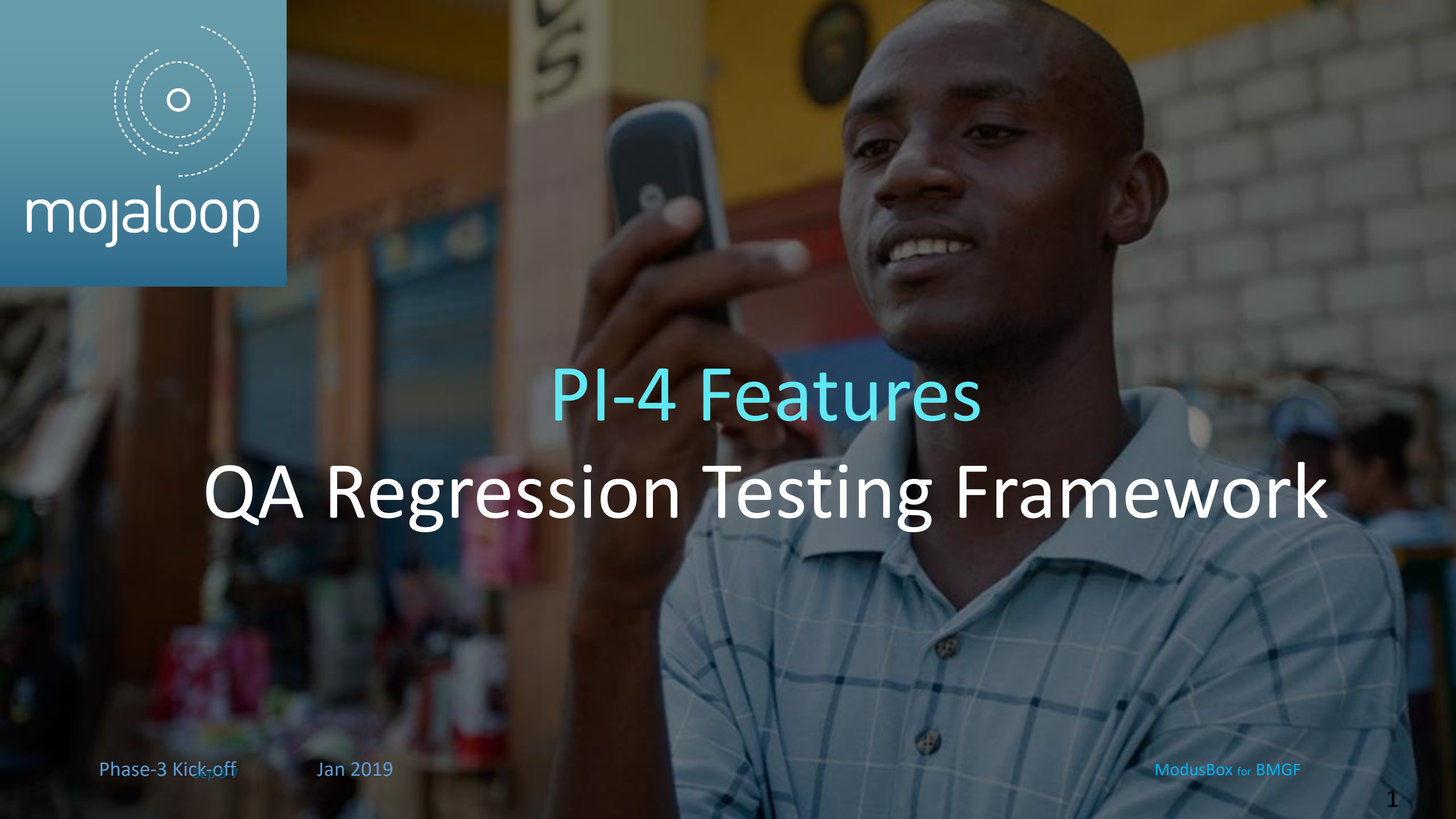
# Example Central Event Processor Action



# CEP & Email Notifier - Demo Index

1. Net Debit Cap (NDC) Threshold Percentage Breach Alarm
    a. Set participant (dfsp1) NDC limit
    b. Set notification email endpoints for Hub and dfsp1
    c. Execute a transfer – *prepare* & *fulfil (to achieve the result)*
2. Net Debit Cap Change Notification
    a. Set notification email endpoints
    b. Adjust participant limit



# PI-4 Features
# QA Regression Testing Framework

# Regression Testing

## is typically characterized by

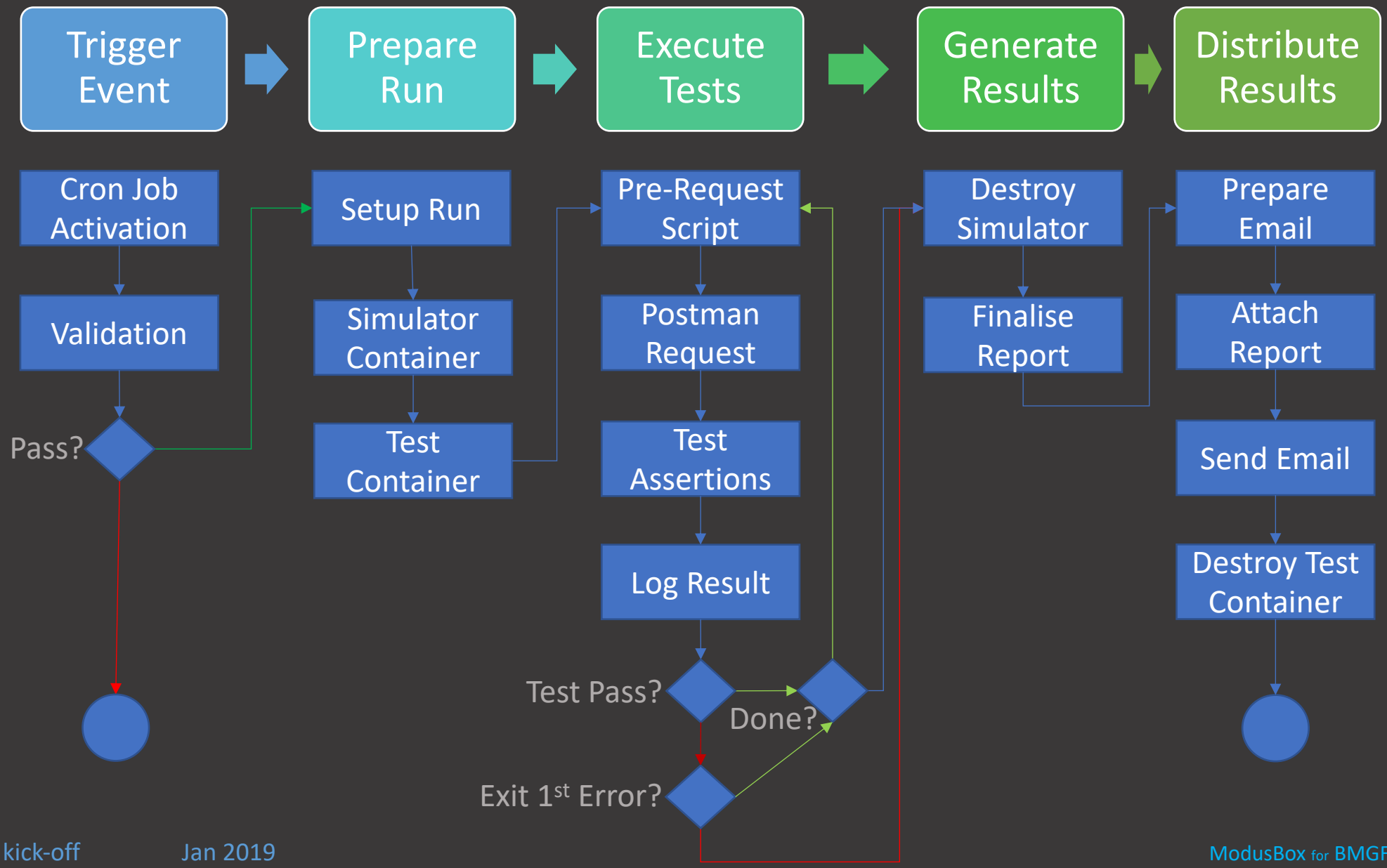
- Ensuring a specified deployed environment performs and produces consistent results
- Can be triggered manually or automatically by linking it with an event
- Ideally could be executed many as many times as required - idempotent
- Automatically sends out alerts in case of any failure or unexpected result
- Communicated results can be used to pinpoint anomalies
- Executes the entire range of functionality of the system under test (FR / NFR)

# Regression Testing

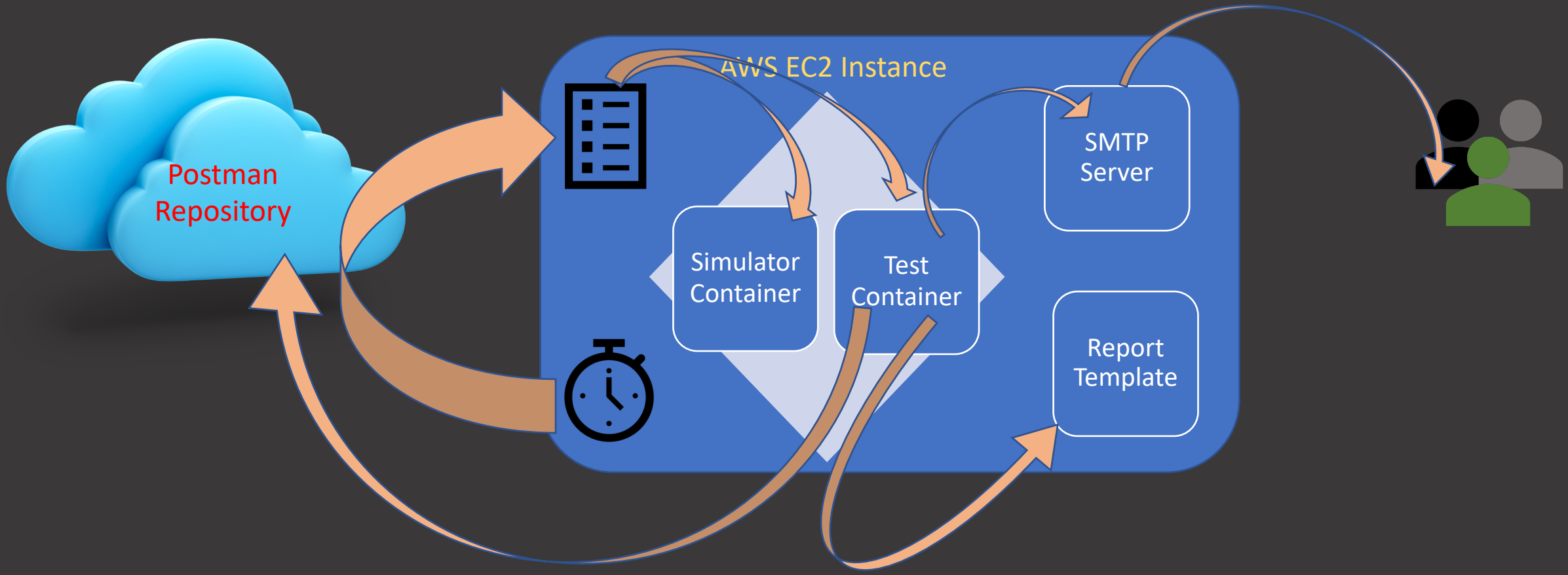
is not

- Unit testing
- Coverage testing
- Integration testing
- Specific functionality (use case) testing
- Testing or checking the health of a deployed environment

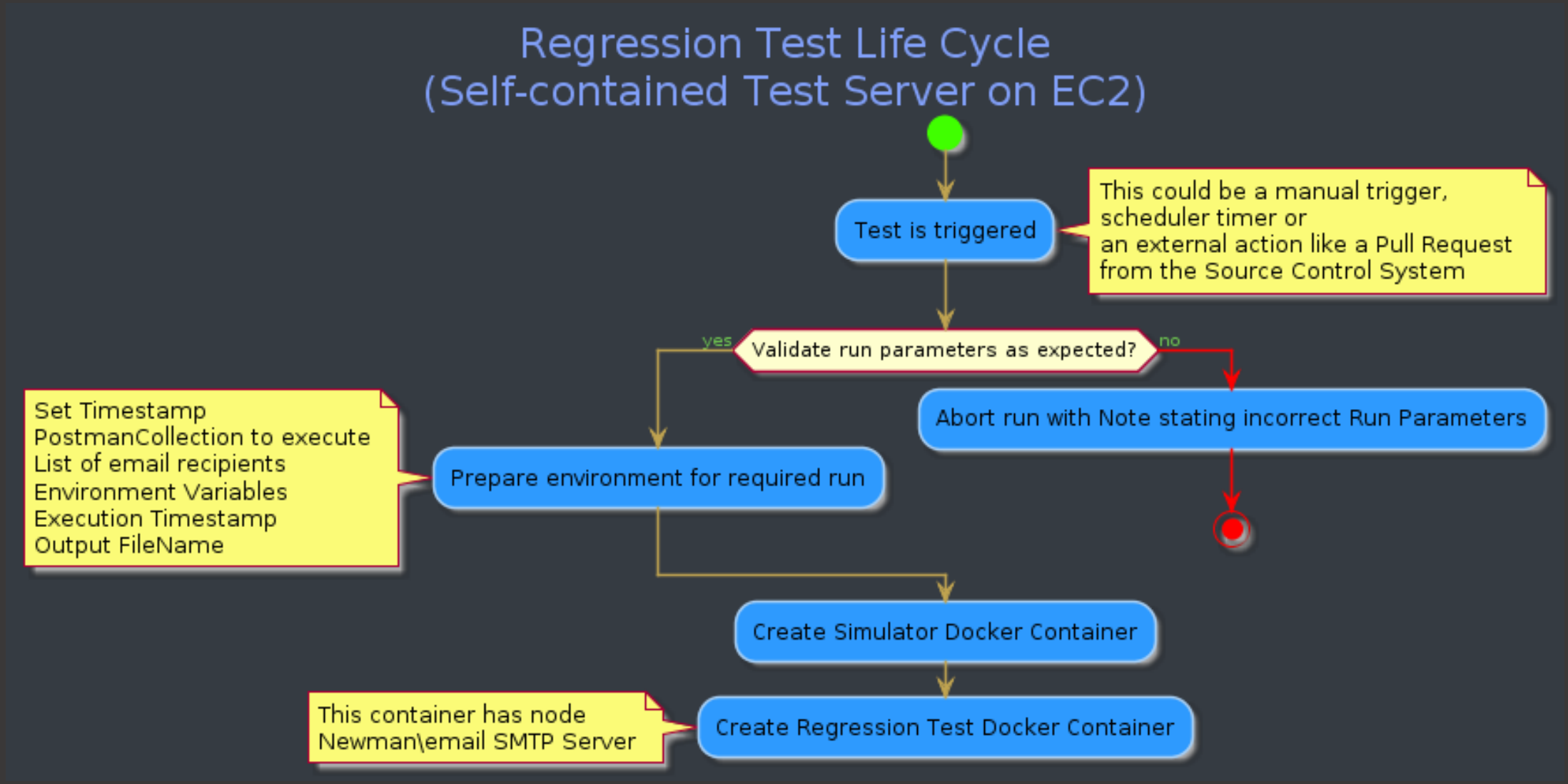
# Regression Testing – Instance Life-Cycle



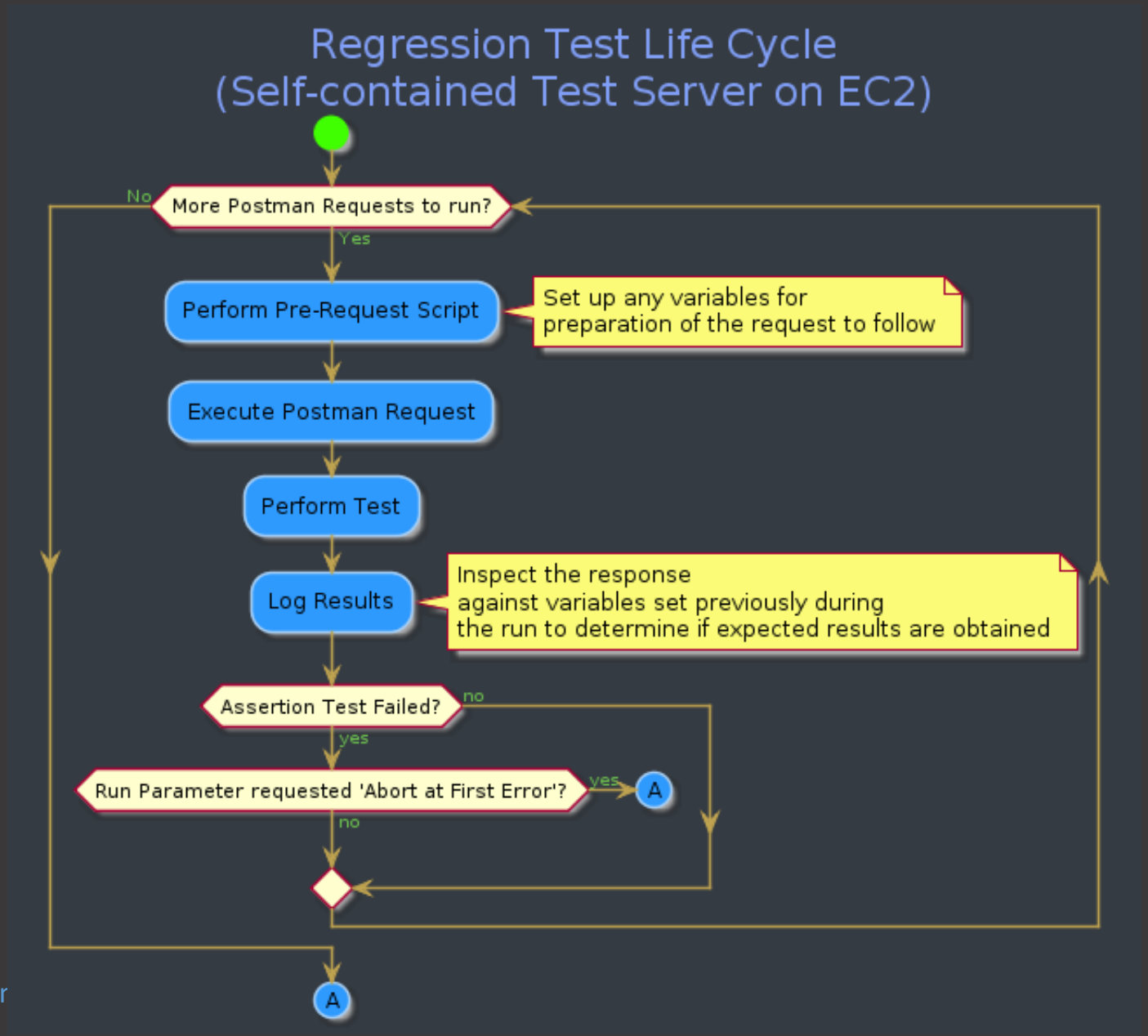
# Regression Testing Info-graphic



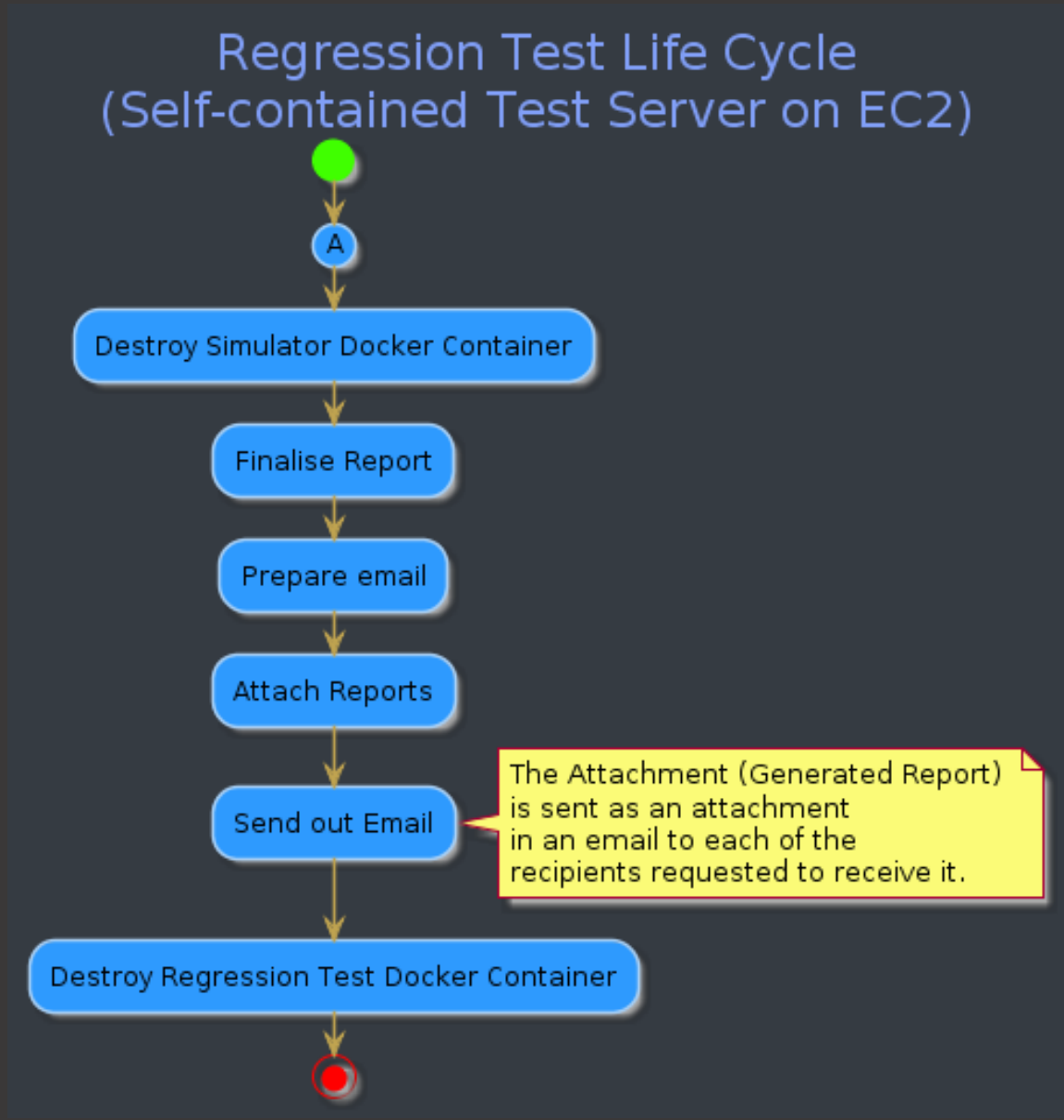
# Regression Testing Process Flow – Part 1



# Regression Testing Process Flow – Part 2

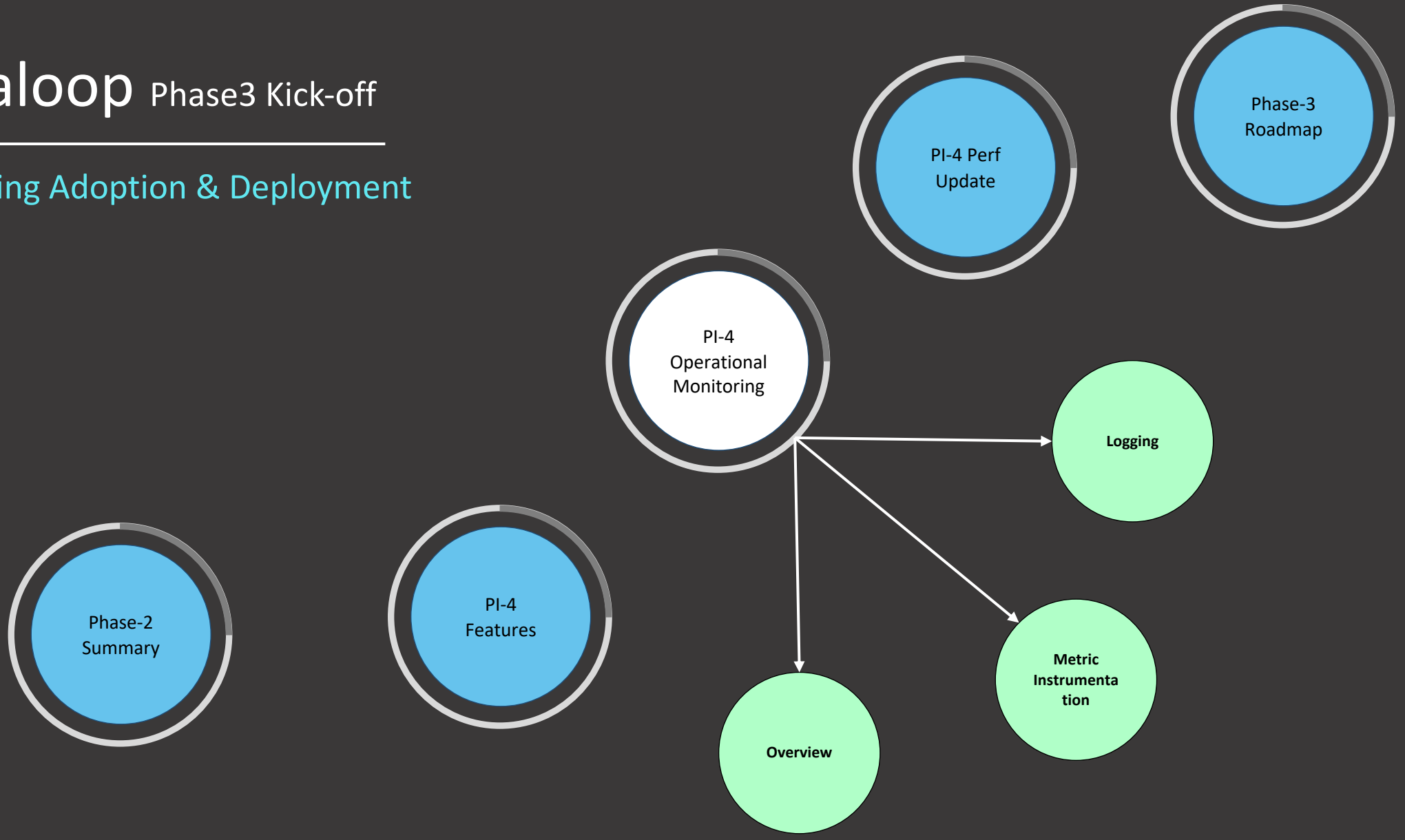


# Regression Testing Process Flow – Part 3



# Mojaloop Phase3 Kick-off

## Supporting Adoption & Deployment



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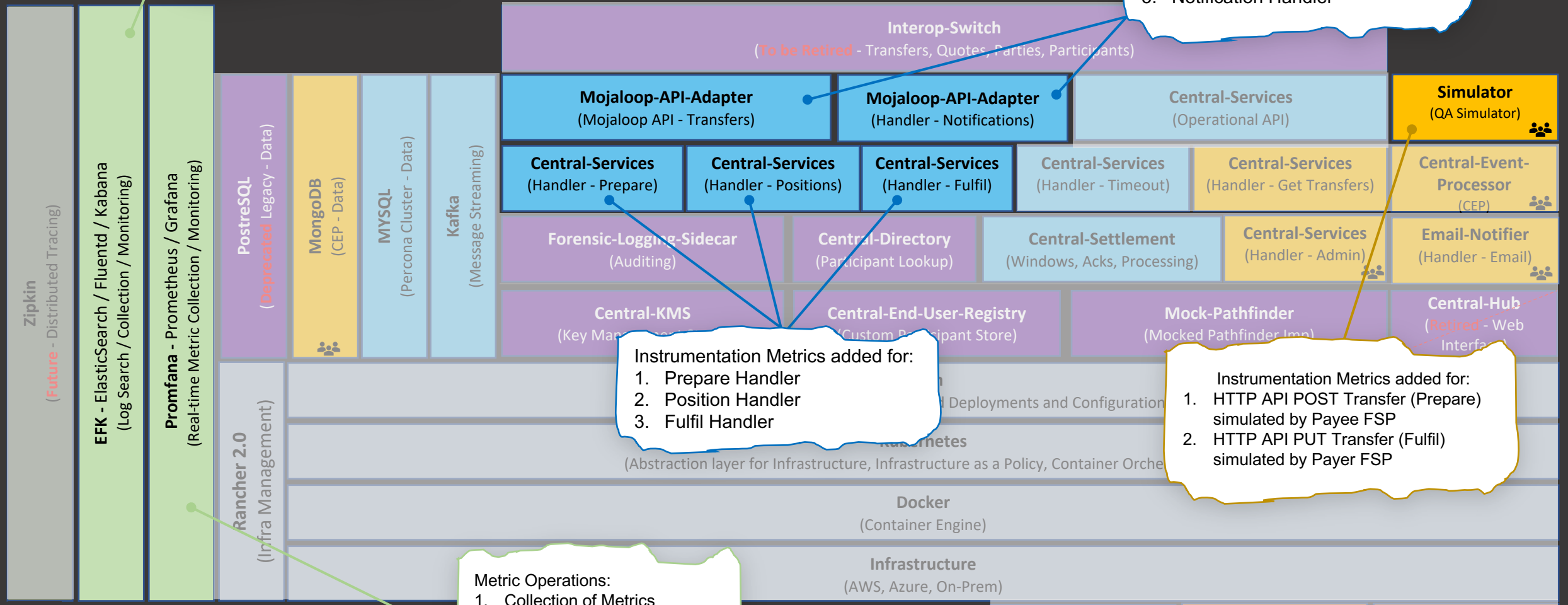
# Operational Monitoring
# Overview

# Operational Monitoring - Overview

Logging Operations:
1. Collection of logs
2. Querying logs
3. Monitoring of of logs via Dashboards
4. Alerts based on log events

Instrumentation Metrics added for:
1. HTTP API POST Transfer (Prepare)
2. HTTP API PUT Transfer (Fulfil)
3. Notification Handler

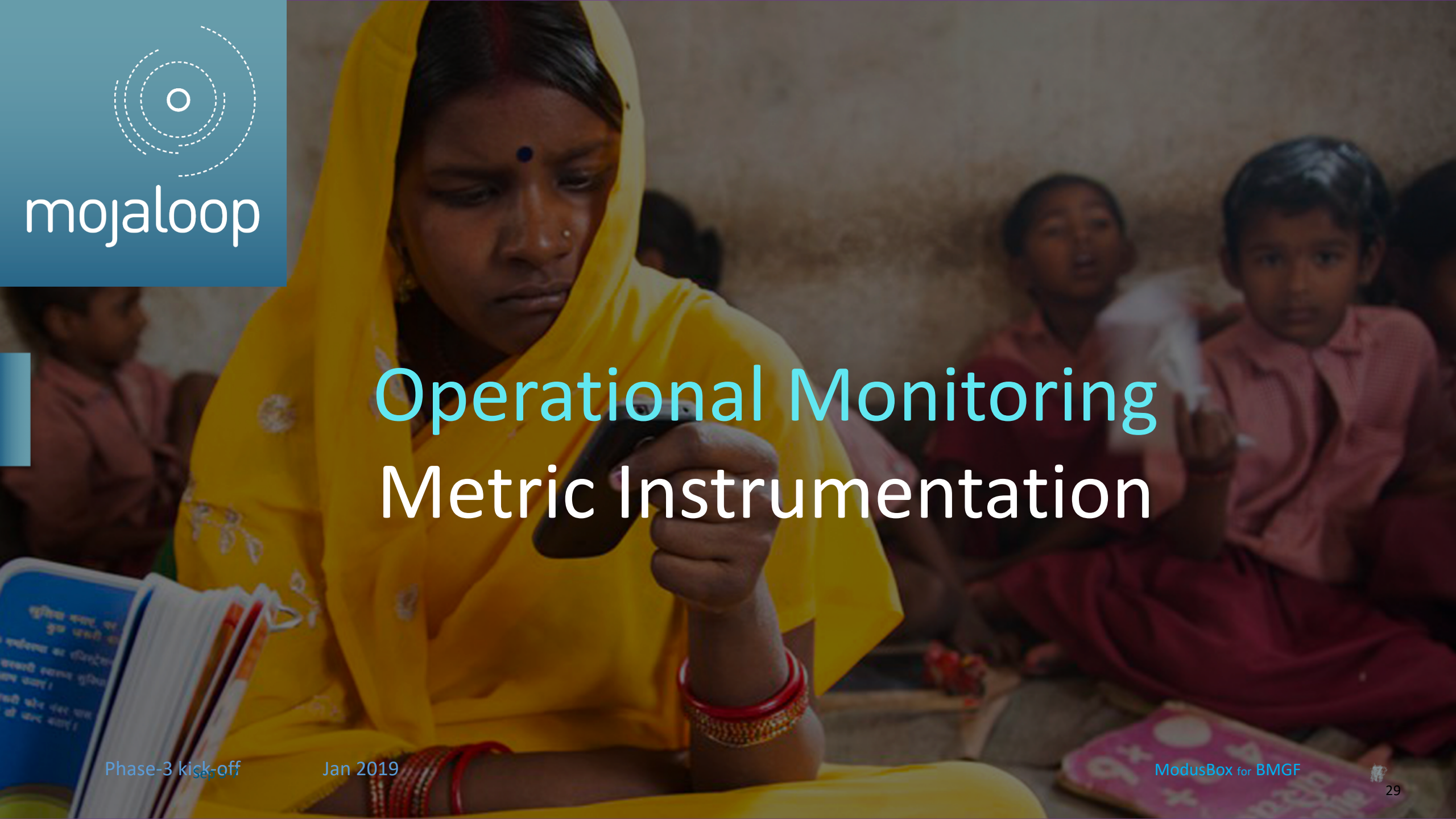



Instrumentation Metrics added for:
1. Prepare Handler
2. Position Handler
3. Fulfil Handler

Instrumentation Metrics added for:
1. HTTP API POST Transfer (Prepare) simulated by Payee FSP
2. HTTP API PUT Transfer (Fulfil) simulated by Payer FSP

Metric Operations:
1. Collection of Metrics
2. Querying of Metrics
3. Monitoring of Metrics via Dashboards
4. Alerts based on Metric events

Key
[ ] Community Contributions



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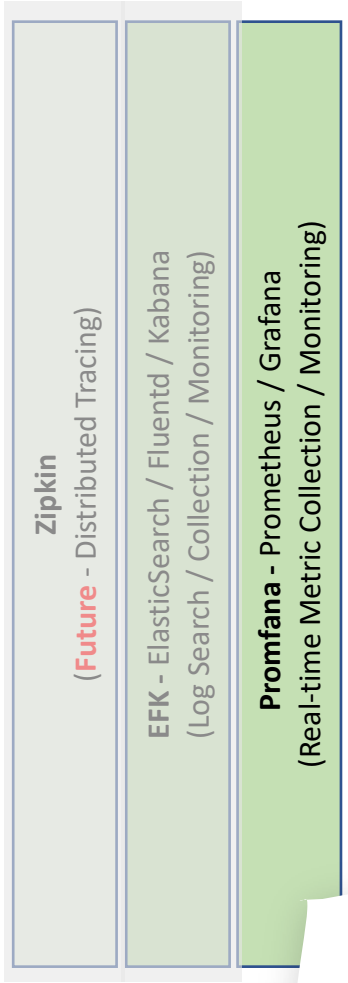
# Operational Monitoring
# Metric Instrumentation

# Operational Monitoring - Metric Instrumentation

1. Overview
    a. Motivation
    b. Technologies
2. Architecture
3. Dashboards

# Ops Metric Instrumentation - Overview




## What is Metric Instrumentation?

Real-time operational visibility for:

- Performance
- Health
- Alerts

*Ref:* *http://prometheus.io*, *http://Grafana.com*

## What is Promfana?

**Prometheus**

Leading open-source instrumentation solution for monitoring

**Grafana**

The open platform for beautiful analytics and monitoring

## Why Promfana?

- Metric Instrumentation for Mojaloop
- Low overhead on nodejs (histograms + pull metric end-point)
- Real-time metric visualization for Performance and Health monitoring of the Mojaloop Stack

### Dimensional data

Prometheus implements a highly dimensional data model. Time series are identified by a metric name and a set of key-value pairs.

### Powerful queries

PromQL allows slicing and dicing of collected time series data in order to generate ad-hoc graphs, tables, and alerts.

### Great visualization

Prometheus has multiple modes for visualizing data: a built-in expression browser, Grafana integration, and a console template language.

### Efficient storage

Prometheus stores time series in memory and on local disk in an efficient custom format. Scaling is achieved by functional sharding and federation.

### Simple operation

Each server is independent for reliability, relying only on local storage. Written in Go, all binaries are statically linked and easy to deploy.

### Precise alerting

Alerts are defined based on Prometheus's flexible PromQL and maintain dimensional information. An alertmanager handles notifications and silencing.

### Many client libraries

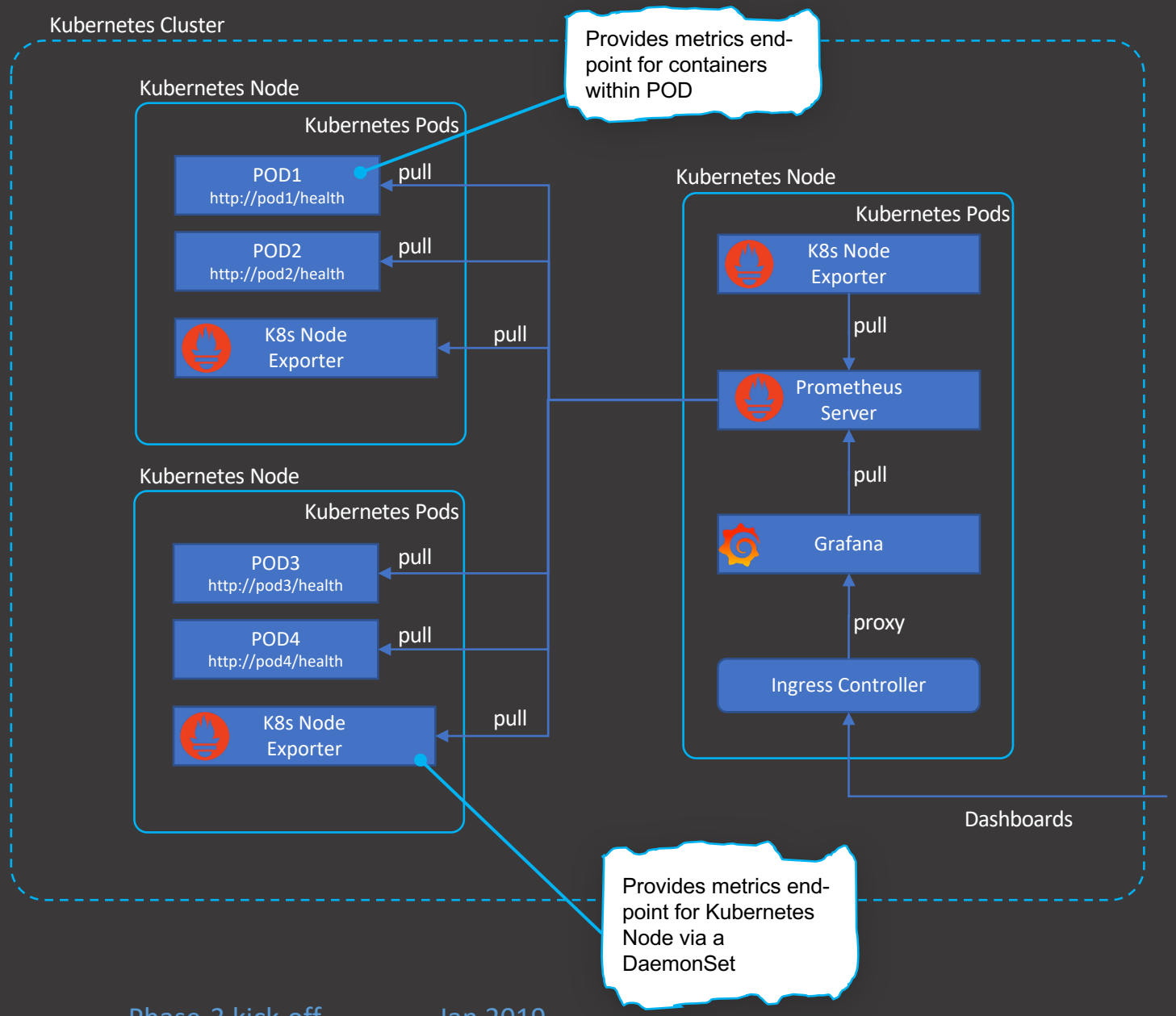
Client libraries allow easy instrumentation of services. Over ten languages are supported already and custom libraries are easy to implement.

### Many integrations

Existing exporters allow bridging of third-party data into Prometheus. Examples: system statistics, as well as Docker, HAProxy, StatsD, and JMX metrics.

CoreOS docker DigitalOcean SOUNDCLOUD PERCONA ERICSSON weaveworks

# Ops Metric Instrumentation – Architecture




## Requirements:

- Each pod to expose a HTTP API for /metrics operation to provide the instrumentation

## Enabling Collection of Metrics for a Pod

- Add annotation to Pod during deployment

```
annotations:
    prometheus.io/port: "8080      <-- Specifies Port for /metrics collection
    prometheus.io/scrape: "true"   <-- Informs Prom Server that Pod is a target for collection
```

- This can be configured in each Helm chart by enabling Metrics

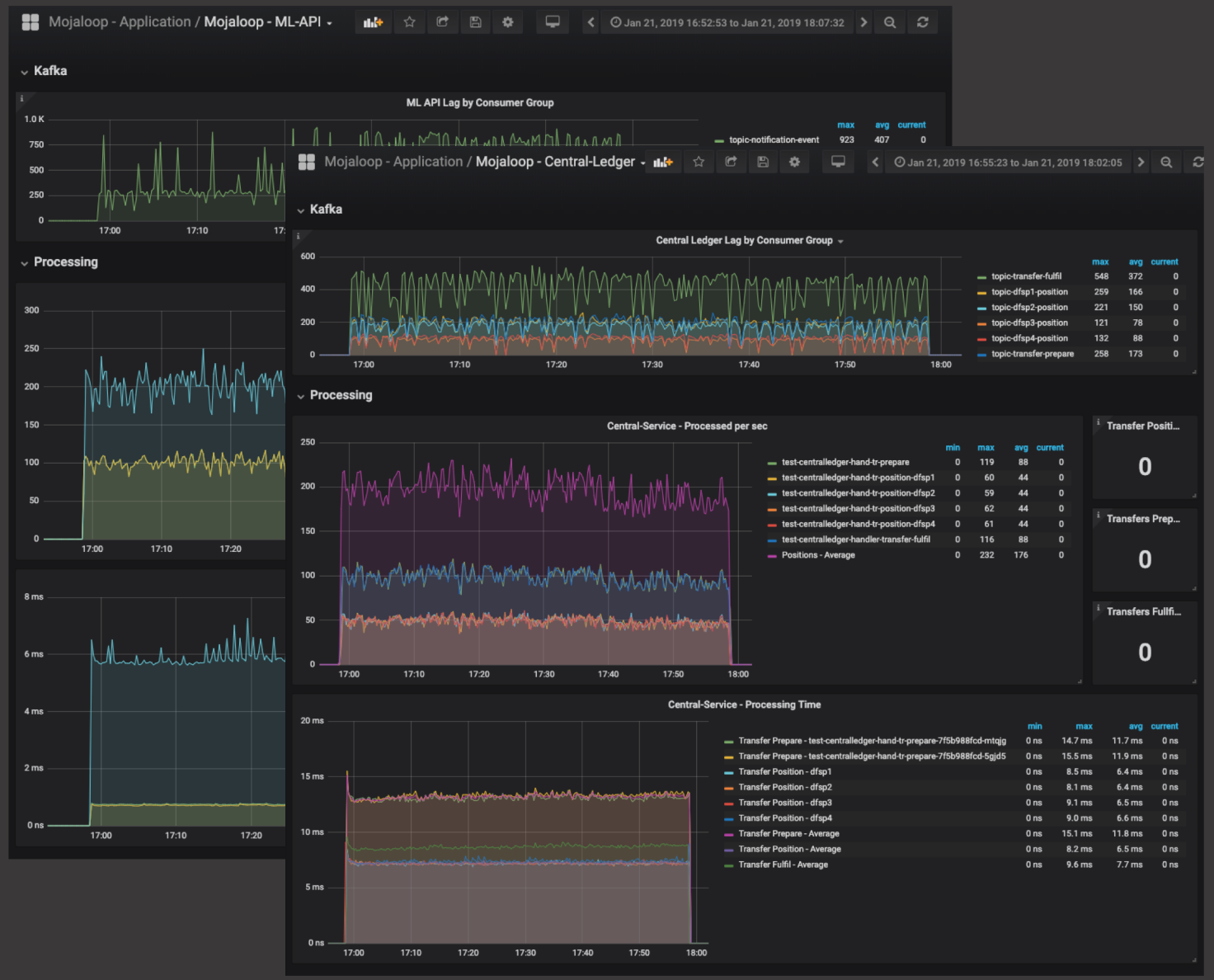
```
metrics:
    enabled: true      <-- By default this has been 'disabled'
```

## Metrics Supported Components:


| | | |
|---|---|---|
| **Mojaloop-API-Adapter** (Transfer Prepare & Fulfil) | **Mojaloop-API-Adapter** (Handler - Notifications) | |
| **Central-Services** (Handler - Prepare) | **Central-Services** (Handler - Positions) | **Central-Services** (Handler - Fulfil) |
| **Simulator** (QA Simulator) | | |

Phase-3 kick-off Jan 2019

# Ops Metric Instrumentation – Dashboards




## Documentation

http://mojaloop.io/helm/monitoring/

## Mojaloop Application

- ML-API-Adapter -- nodejs + application
- Central-Ledger -- nodejs + application
- Simulators -- nodejs + application

## Data Store

- MySQL Overview
- PXC Galera Overview
- PXC Galera Graphs

## Messaging

- Kafka Cluster Overview
- Kafka Topic Overview

## Kubernetes

- Clusters
- Deployments

**DEMO**

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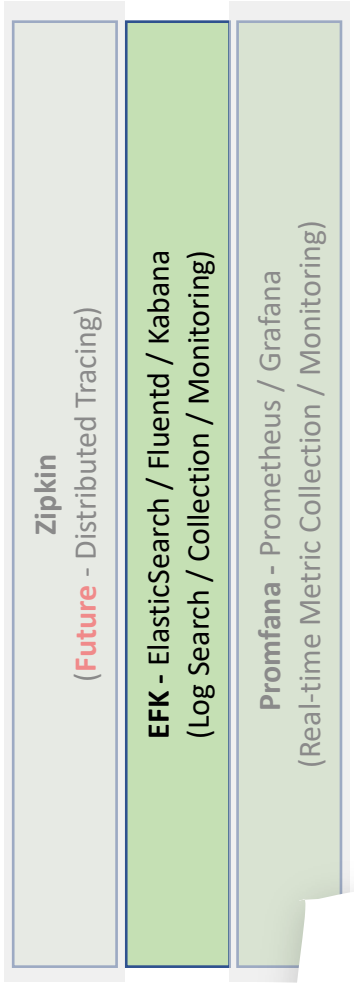
# Operational Monitoring
# Logging

# Operational Monitoring - Logging

1. Overview
2. Architecture

# Ops Logging – Overview




*Ref:* *http://prometheus.io*, *http://Grafana.com*

## What is EFK (aka ELK)?

elasticsearch

Elasticsearch is a distributed, RESTful search and analytics engine.

fluentd

Open source data collector for unified logging layer, with ingestions into Elasticsearch.

kibana

Kibana lets you visualize your Elasticsearch data and navigate the Elastic Stack.

## Why EFK?

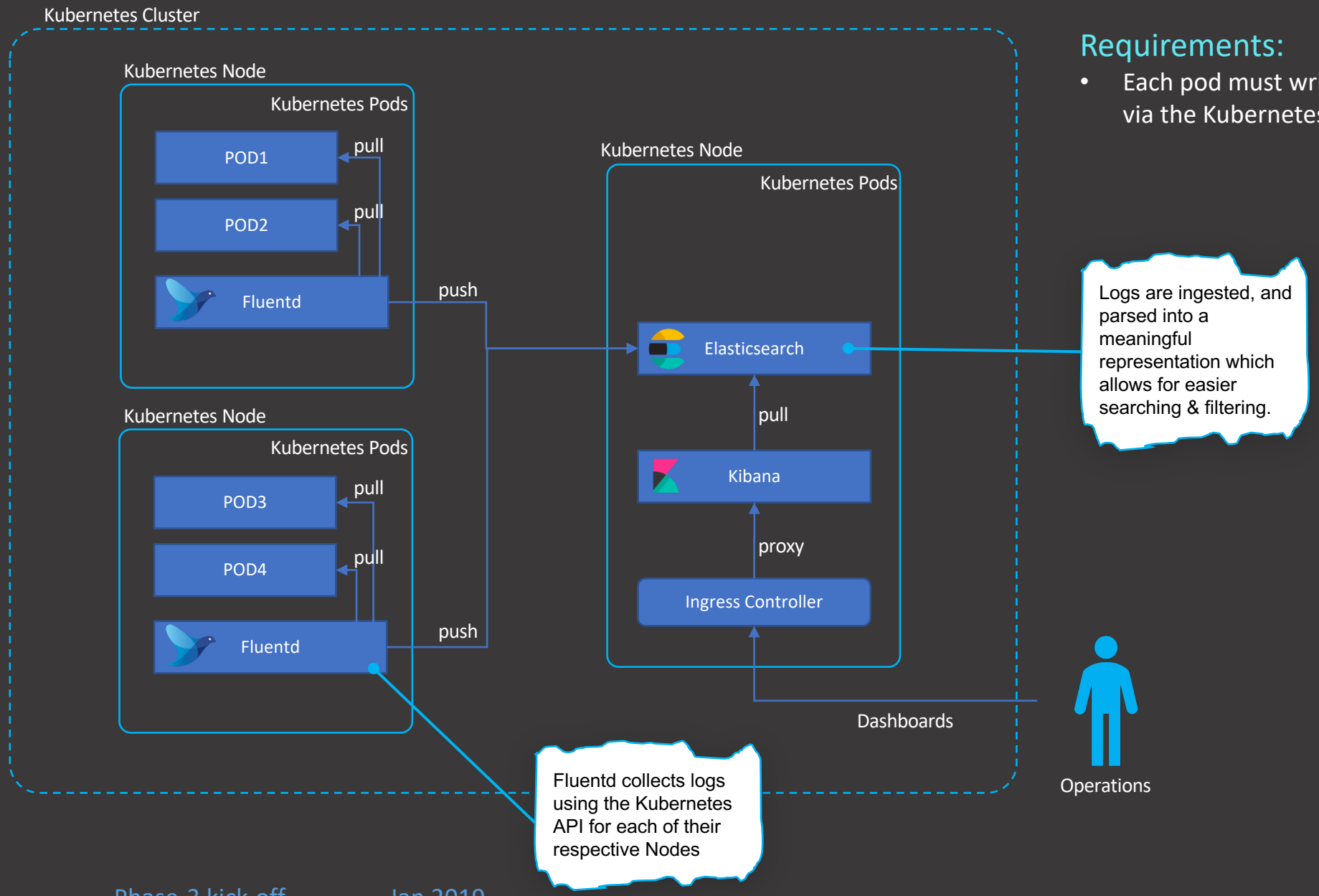
- Central location and storage of all Mojaloop log files
- Management of log data (persistence, long-term storage, etc)
- Management of alert/events based on log data
- Assist with tracing & trouble shooting Mojaloop's distributed micro-service logs
- Produces real-time metrics or alerts to Prometheus

## Why E-F-K and not E-L-K?

- Fluentd is used instead of Logstash due to its support & seemless integration for Kubernetes (k8s).
- K8s Pods/Containers are easily collected by Fluentd and ingested into ElasticSearch using the underlying K8s logging architecture.

Sprint Rabobank AIRBUS ebay vimeo Fermilab

# Ops Logging – Architecture

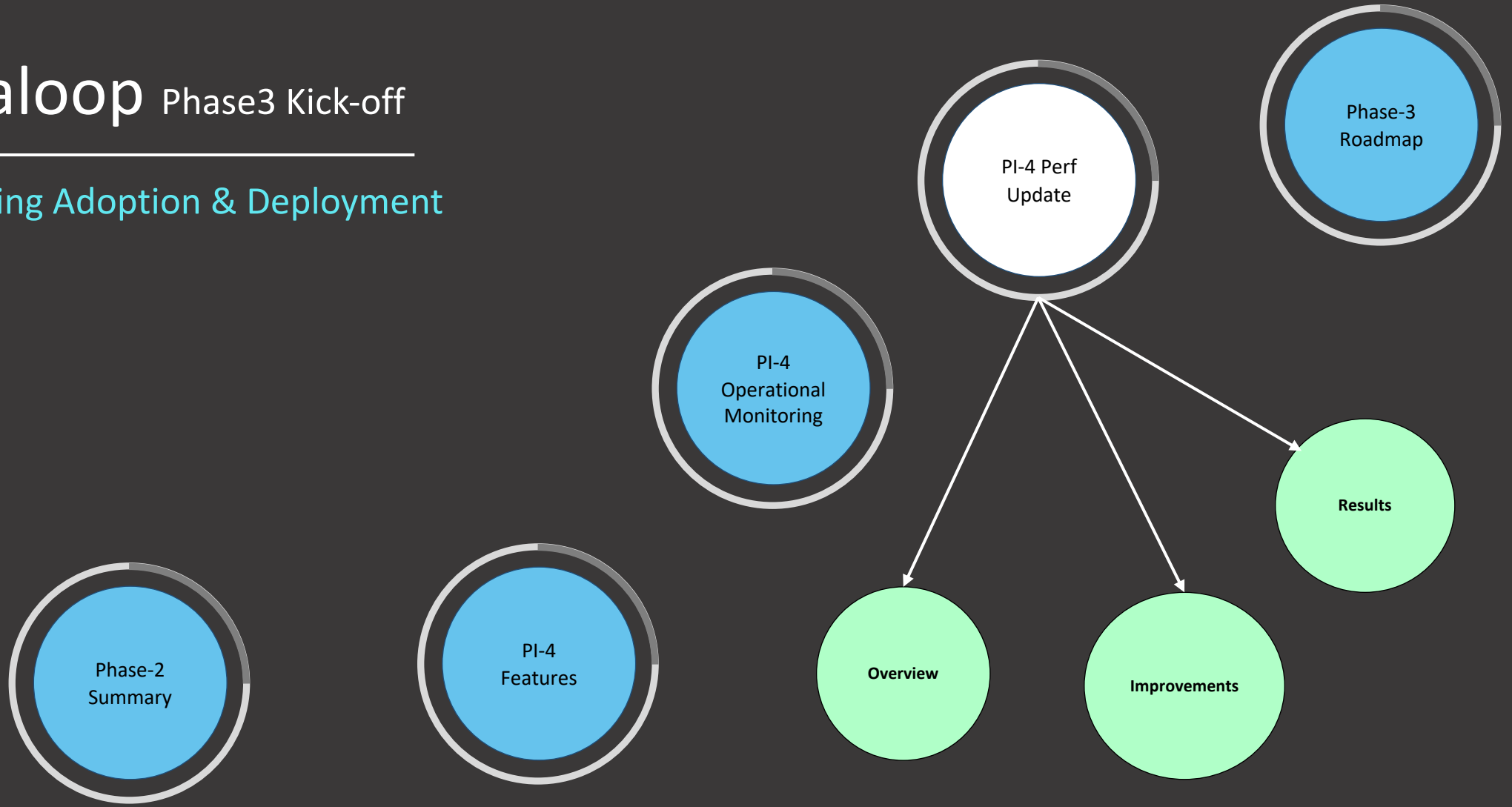



## Requirements:

- Each pod must write logs to stdout so that it is accessible via the Kubernetes Log API

# Mojaloop Phase3 Kick-off

## Supporting Adoption & Deployment



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# Performance Update
# Overview

# Performance Improvements

1. PI3 Performance Summary
2. PI4 Performance Summary
3. Infrastructure Setup

# PI4 Performance Summary

Key
[●] Completed in PI-4
[●] Partially completed in PI-4
[●] To be considered in Future

## Approach:

[●] Set a base-line on PI-3 Code-base
[●] Configure Environment for Production-like setup
[●] Identified & fix stability issues due to failure on load
[●] Optimized Kafka Client (Producers, Consumers) for Performance
[●] Scenarios with Multiple FSPs
[●] Increase multi-threaded processing of non-[1]EOS Kafka Consumers (Prepare, Transfer, Fulfil, Notification)
[●] Optimized Handlers with reduced CPU Usage
[●] Optimized Handlers with reduced IO
[●] Tested against an alternative hosted Kafka service[2]
[●] Increase scalability of solution
[●] Optimized Handlers with PRISM

## Comparison of Selected Results (in seconds):

| Metric | PI2 | PI3 | PI4 Switch |
|---|---|---|---|
| Number of Messages | 100 | 100 | **358 201** |
| Prepare Process | ✓ | ✓ | ✓ |
| Fulfil Process | ✗ | ✗ | ✓ |
| Transactions Per Second | 6.51 | 22.18 | **207** |
| Average Transaction Time | 8.21 | 1.65 | **0.101** |
| Shortest Response Time | 2.594 | 0.942 | **0.32** |
| Longest Response Time | 19.746 | 2.589 | **3.047** |
| Standard Deviation | n/a | n/a | **0.119** |
| % of requests taking longer than 1 second | n/a | n/a | **0.002%** |
| Duration | 15 seconds | 4.5 seconds | **1 hour** |

***[1] EOS – Exactly Once Semantic,***
***[2] Mojaloop Kafka deployment on Rancher K8s-Phoenix Environment was comparable and better at times,***
***[3] Average over 3 runs – individual results in the appendix***

# PI4 Performance Next Steps

Key
[●] Completed in PI-4
[●] Partially completed in PI-4
[●] To be considered in Future

## Next Steps:

[●] Test Different Kafka Consumer Modes & Libraries (Producers, Consumers) for Performance (only tested end-to-end in recursive mode)
[●] Optimize Kafka Producers for Local Queue Issue
[●] Optimize Handlers with PRISM[1] (or similar approaches)
[●] Test/Optimize scalability of solution
[●] Implement full Batch Processing of Kafka Consumers
[●] Re-factor Kafka Consumers once EOS is natively supported
[●] Automate Performance Tests into CI/CD pipeline

## On-going:

[●] Configure Kafka Client (Producers, Consumers) for Performance
[●] Optimize Kafka Server performance

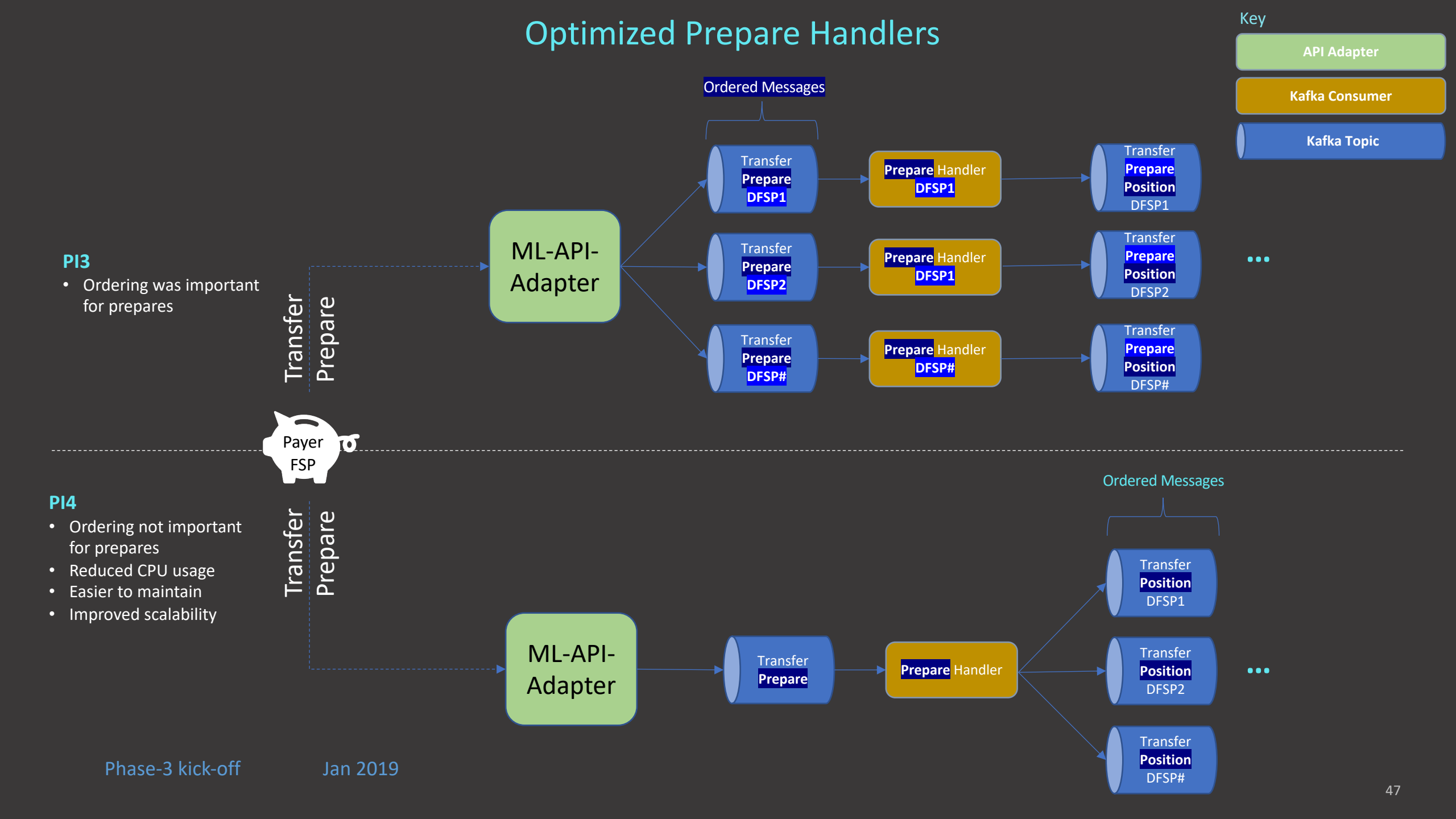
[1] ***PRISM –*** Persisted Replicated Internal State Messaging

# Performance Update
# Improvements

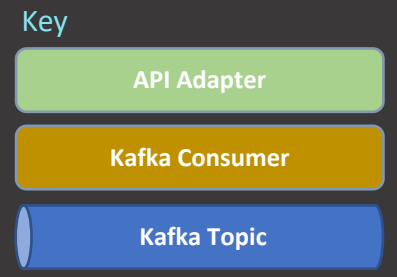
# Performance Improvements

1. Optimized Prepare Handlers
2. Optimized Position Handlers
3. Optimized IO
4. Optimized CPU Usage on Handlers
5. PRISM Optimization

# Optimized Prepare Handlers

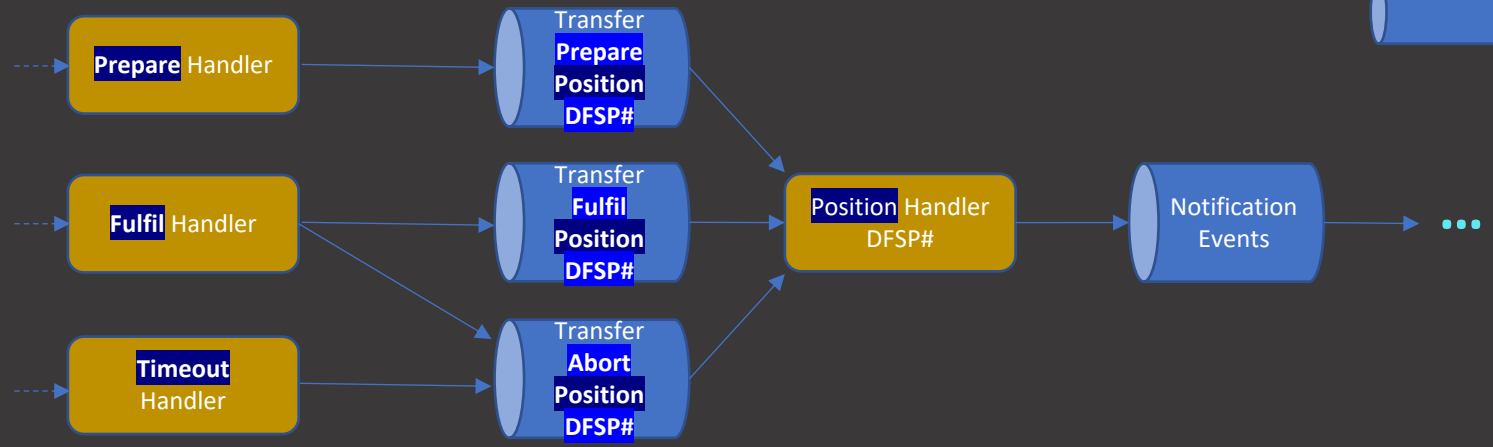


# Optimized Position Handlers



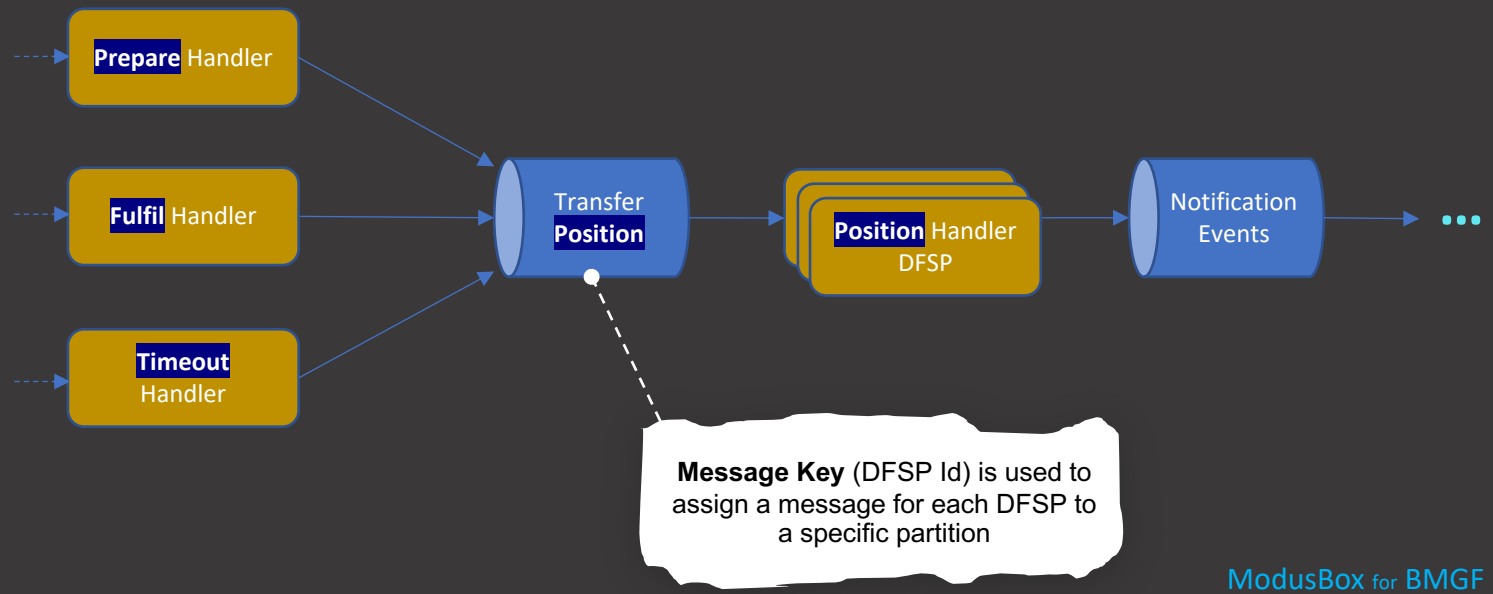

## PI3

- Messages for each DFSP and Action (Prepare, Fulfil, Abort) is routed to a specific Topic
- Each Position Handler internally uses 3 Consumers for each DFSP Topic within the same thread Pool = 3x CPU Usage




## PI4

- Message keys are used to route each message to a specific Partition ← This guarantees ordering and the integrity of the FSPs transfer process
- CPU usage reduced by three-fold
- Easier to maintain
- Improved scalability
- *Possible issue/limitation*:
  - Increasing partitions on Kafka can only be done when there no active consumers or the ordering will be an issue.
  - Mitigation:
    - Create more than required Partitions up-front for future DFSP growth
    - Create versioned topics



# Optimized IO

## Description:

- Slow response times observed on Handlers due to high IO

## Resolution:

- Handlers:
  - Manual Commits were causing excessive high IO thread contention which was drastically reduced by enabling auto-commits
  - Optimized Kafka configurations to reduce unnecessary IO
  - Loggers were moved into an async process

(20% improvement)

## Considerations:

- Additional logic will need to be added in Handlers as the auto-commits allows for re-processing of messages. The handlers will not re-apply any business logic as the “state” of the transactions will have moved on, however it is possible that there will be unwanted notifications sent to the FSPs. Thus we will have to store the Kafka index for each message to validate if the message is a re-request from FSP or a re-processing of a previous message.

## PoC Producer - Commit = Manual

**Number** of unique matched entries: **10000**
Total difference of all requests in milliseconds: 1308
Shortest response time in millisecond: 0
Longest response time in millisecond: 3
**Mean**/The average time a transaction takes in millisecond: **0.1122**
Standard **deviation** in milliseconds: **0.3206**
Number of entries that took longer than a second: 0
% of entries that took longer than a second: 0.00%
Average **transactions per second**: **7645.26**

## PoC Producer - Commit = Auto

**Number** of unique matched entries: **10000**
Total difference of all requests in milliseconds: 1234
Shortest response time in millisecond: 0
Longest response time in millisecond: 3
**Mean**/The average time a transaction takes in millisecond: **0.1023**
Standard **deviation** in milliseconds: **0.3080**
Number of entries that took longer than a second: 0
% of entries that took longer than a second: 0.00%
Average **transactions per second**: **8103.73**

## PoC Consumer - Commit = Manual

**Number** of unique matched entries: **10000**
Total difference of all requests in milliseconds: 16154
Shortest response time in millisecond: 0
Longest response time in millisecond: 3
**Mean**/The average time a transaction takes in millisecond: **0.1116**
Standard **deviation** in milliseconds: **0.3187**
Number of entries that took longer than a second: 0
% of entries that took longer than a second: 0.00%
Average **transactions per second**: **619.04**

## PoC Consumer - Commit = Auto

**Number** of unique matched entries: **10000**
Total difference of all requests in milliseconds: 8852
Shortest response time in millisecond: 0
Longest response time in millisecond: 3
**Mean**/The average time a transaction takes in millisecond: **0.1018**
Standard **deviation** in milliseconds: **0.3063**
Number of entries that took longer than a second: 0
% of entries that took longer than a second: 0.00%
Average **transactions per second**: **1129.69**

# Optimized CPU Usage on Handlers

## Description:

- Excessive CPU usage on handlers, specifically the position handlers was observed consistently

## Resolution:

- All nodejs processors
  - Async logging (Max CPU ~40% -> ~20%)

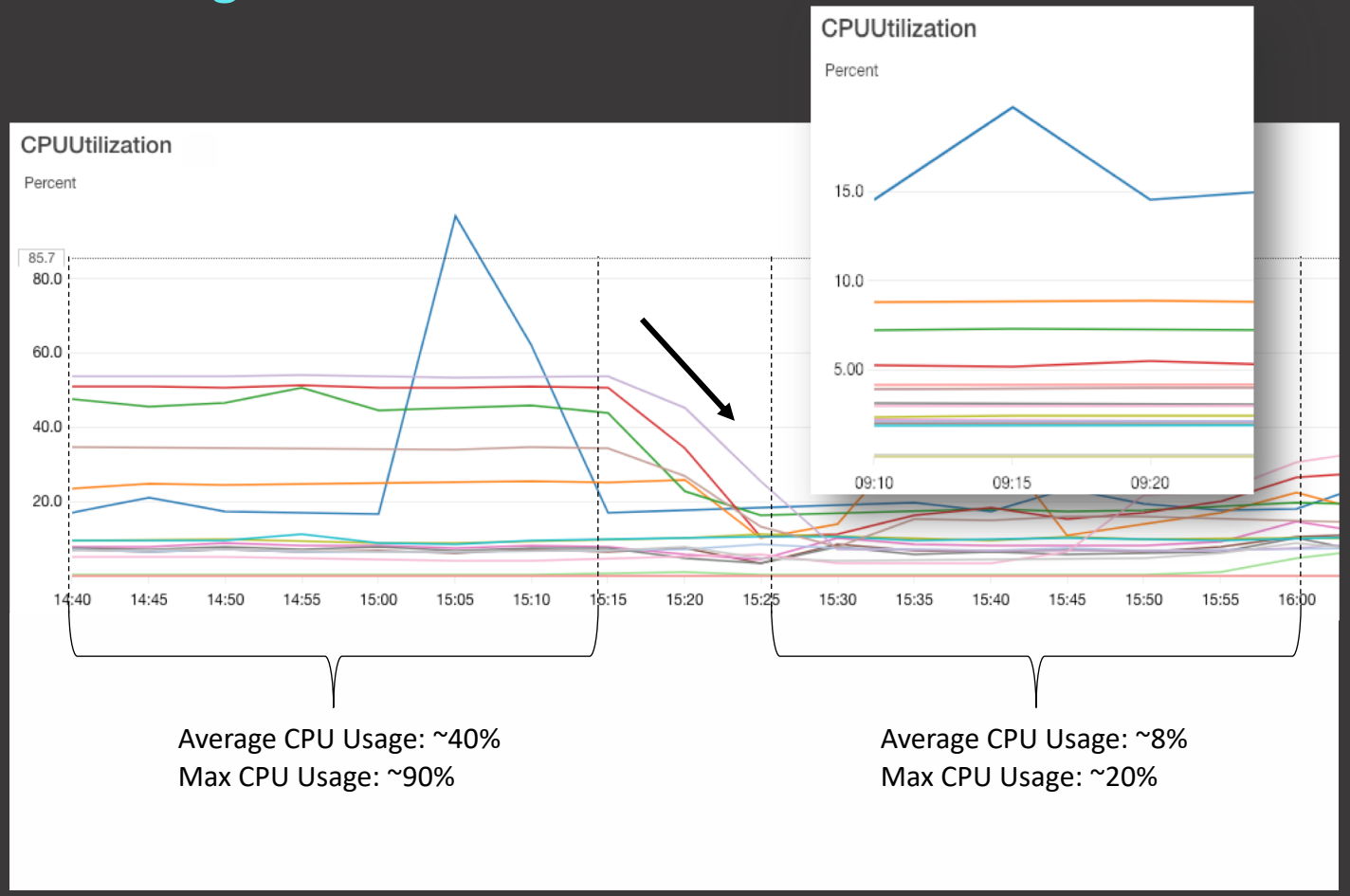
- Position Handlers
  - Single Topic – Combined topics Abort, Prepare and Fulfil topics
  - Applied optimized config for Producers
  - Applied optimized config for Consumers

- Prepare Handlers
  - Combined separate Topics for each DFSP into a single topic to allow for multiple partitions
  - Applied optimized config for Producers
  - Applied optimized config for Consumers

- Fulfil Handlers
  - Applied optimized config for Producers
  - Applied optimized config for Consumers

- Notification Handlers
  - Applied optimized config for Producers
  - Applied optimized config for Consumers

Phase-3 kick-off Jan 2019




Key

[●] Completed in PI-4

[●] Partially completed in PI-4

[●] To be considered in Future

# PRISM Optimization

## Meaning:

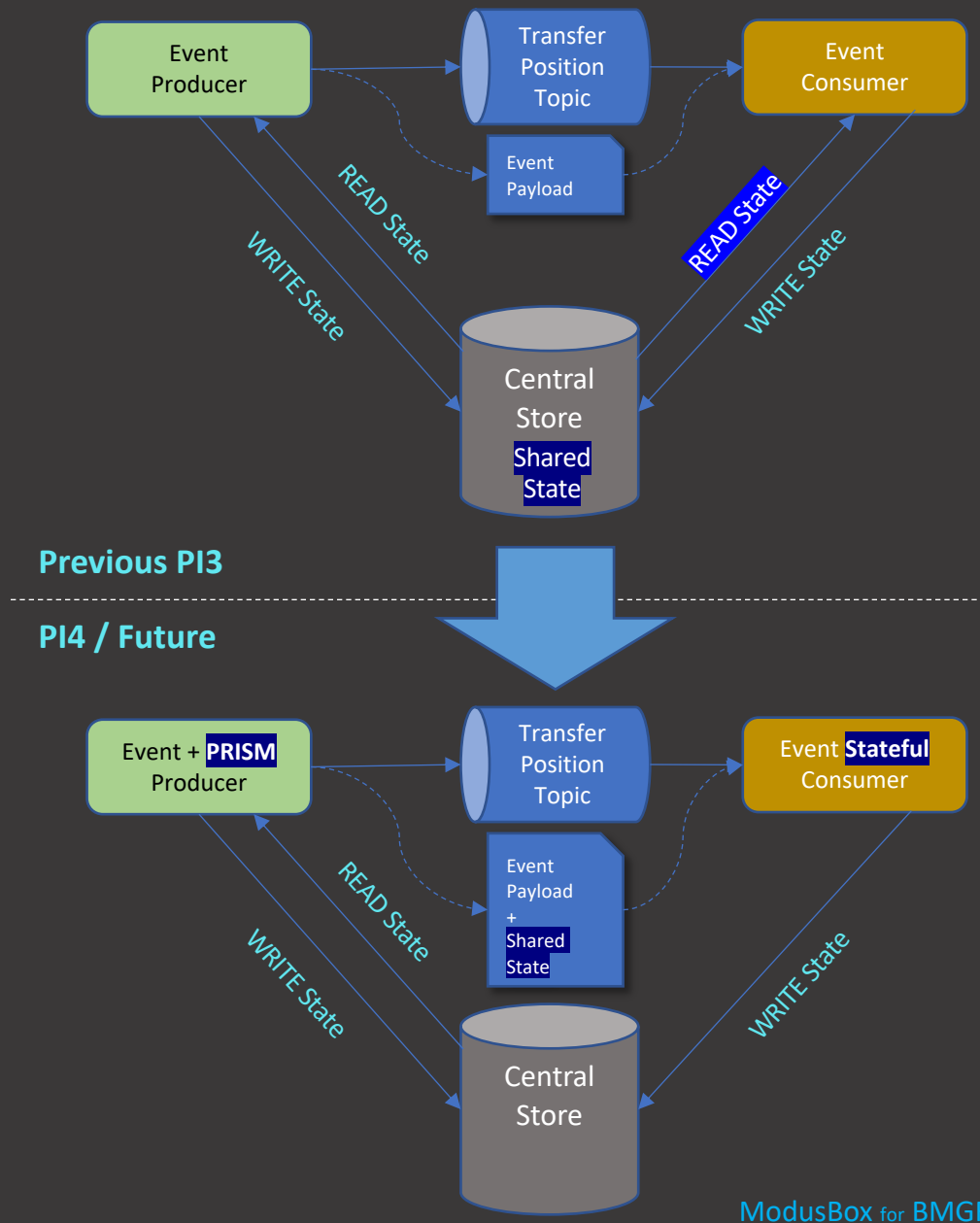
- PRISM - Persisted Replicated Internal State Messaging

## Description:

- Kafka messaging system is used for stateful enrichment of messages to down-stream handlers

## Considerations:

- We can minimize unnecessary locks between the Prepare, Position, Fulfil and Timeout Handlers by using PRISM to pass the necessary information to the down-stream handlers
- Timeout handler logic will need to be moved to the Position Handler ← "Position Handler" should perhaps be renamed to the "Transfer Handler" as it handled events for position change, rejection core-logic, etc

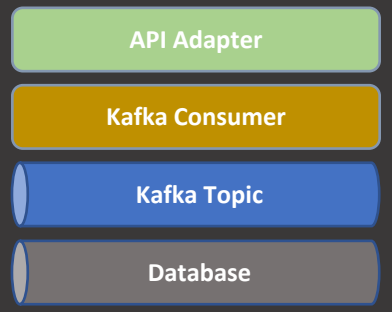



Key

[●] Completed in PI-4

[●] Partially completed in PI-4

[●] To be considered in Future




ModusBox for BMGF

# PI-4 Features
# Settlements Update

# Settlement Business Challenges

1. Movement within the Switch
2. Understanding Accounting Principles
3. Managing the risk in the system
4. Changes Undertaken
5. Checking NDC for a sender
6. Delayed Settlement Risk
7. Key Learnings

# Movement within the Switch

- Funds need to be moved in the various accounts within the switch – safe in the knowledge that funds are available to support the transfer
- The following Controls are in place
  - Net Debit Cap
  - Position – how much a DFSP may owe or be owed
    - An increase in the position reflects the increase in the Liability of the Payer
    - A decrease in the position reflects the decrease in the Liability of the Payee

# Accounting Principles

- The Mojaloop platform accounts for the financial position of the switch and therefore any movements are recorded from that perspective

- We also need to be careful with the language we use when talking about accounts. An Increase and a Decrease depends on the type of account that is being reviewed. An increase is not synonymous with more positive (Dr) or negative (Cr) transactions.

- The DFSP sees an increase in their liability when recording the transaction in their systems, whilst the Switch records the transaction as an increase in their Asset. For the switch the transaction should be immediately balanced with an increase in the liability to the receiving DFSP once the transfer is committed.

# Depending on an Account – Increase means…

- The mnemonic **DEADCLIC** is used to help remember the effect of debit or credit transactions on the relevant accounts. **DEAD**: **D**ebit to increase **E**xpense, **A**sset and **D**rawing accounts and **CLIC**: **C**redit to increase **L**iability, **I**ncome and **C**apital accounts.
- The account types are related as follows:

current equity = sum of equity changes across time (increases on the left side are debits, and increases on the right side are credits, and vice versa for decreases)

current equity = Assets - Liabilities

- sum of equity changes across time = owner's investment (Capital above) + Revenues - Expenses

- *From <https://en.wikipedia.org/wiki/Double-entry_bookkeeping_system>*

| | Debit | Credit |
|---|---|---|
| Asset | Increase | Decrease |
| Liability | Decrease | Increase |
| Income (revenue) | Decrease | Increase |
| Expense | Increase | Decrease |
| Capital | Decrease | Increase |

# Understanding Accounting Principles

- Standard Process in accounting Software
  - Debits (Drs) are Positive
  - Credits (Crs) are Negatives.
- When adding up
  - if the net position is positive (More Drs) they are treated as an asset
  - if the net position is negative (More Crs) they are treated as a liability.
- The Switch has a different perspective to the DFSPs but follows the same rules:
  - Funds in - the cash (asset) increases, is a debit;
  - The change in the customer's account balance (liability) is a credit.
  - When a transfer takes place, the Dr is applied to the sender - it will lead to a reduction in the amount that is owed back to the DFSP (reduced liability).

# New Accounts in the System

- The purpose of the new accounts is as follows
  - Position Account – Facilitates the Debtors book per currency per DFSP
  - Hub Multi-Lateral Net Settlement (HMLNS) Account – Used to balance Debtors settlements
  - DFSP Settlement account – Reconciliation account for external movements of funds
  - Hub Reconciliation Account – Control account – Net Position across all DFSP settlement accounts
- Certain types of transfers allowed in each account
  - P2P Transfers – Position account Only
  - Settlement Transfers – Position Account and HMLNS
  - Fund Transfers (in and Out) - DFSP Settlement account and Hub Reconciliation Account

# Managing the risk in the system

- Dr reduces the switches liability, so it will always be applied in the Reservation ring fenced first. Applying this to the System Treatment of a P2P Transfer
  - Reserve state - the Position of the Payer DFSP is Debited (Dr)
  - Commit state - the Position of the Payee DFSP is Credited (Cr) – failure in receiving the funds leads to liability issues.
- Standard approach - confirmation expected before funds are released also lead to consistency in reporting, reconciliation or roll back.
- This principle is applied to all transfers, potential loss of funds due to change reviewed as part of the flow – assessing if transactions that may occur whilst the process is underway do not expose the switch to a financial risk.

# Changes Undertaken

- We have introduced options on the relationship with real money flows
  - Real time settlement
  - Delayed settlement

  - Which required the addition of 3 more account types
    - DFSP Settlement Ledgers – to mirror funds in the real bank account
    - Hub Multilateral Settlement Ledger
    - Hub Reconciliation Ledger

  - Each have their own risk which has been factored in Design

# Checking NDC for a Sender

| | Activity | | DFSP1 Transfer Ledger | | | | DFSP1 Settlement Ledger | |
|---|---|---|---|---|---|---|---|---|
| | | | Transfer | Position | NDC | | Transaction | Balance |
| 1 | **Settlement Window** Closed | | | +350 | +800 | | | -1000 |
| 2 | DFSP1 Settlement Processed | DR | | +350 | +**800** | | | -1000 |
| 5 | DFSP1 Position Reset | CR | -350 | 0 | +800 | | | -1000 |
| 6 | Funds Transfer For Settlement - DFSP 1 | | | 0 | +800 | | +350 | -650 |

Step 1 is the closure of the Window
Steps 2-5 are the steps to settle
Steps 6 and 7 are the real movement of funds.

However when the money flows the NDC is now higher than the Settlement Ledger balances – Automation of these steps requires a change in the NDC

The NDC adjustment needs to be applied before any processing of the settlement window – to ensure the control is in place before any positions are reset. This could lead to a temporary block on transfers, but eliminates the risk that transfers are allowed before the settlement is processed

*Note that the balance of transfers is done in the Hub Multilateral Settlement Ledger to ensure reconciliation, but it also allows for the settlement amounts to be handled differently*

# In delayed settlement a new risk is introduced
# Net Receiver becomes Net Sender

| | Activity | | | DFSP2 Transfer Ledger | | | | DFSP2 Settlement Ledger | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Transfer | Position | NDC | | Transaction | Balance |
| 1 | Settlement Window Closed | | | | -350 | +800 | | | -1000 |
| 2 | DFSP2 → DFSP1 $600 | Allowed | | 900 | 550 | +800 | | | -1000 |
| 5 | DFSP2 Position Reset | DR | | +350 | 900 | +800 | | | -1000 |
| 6 | DFSP2 Settlement Processed | CR | | | 900 | +800 | | -350 | -1350 |

If the time between Step 1 and Step 6 is large, the likelihood of this impact is increased.

- Envisioned scenario is a Natural disaster over the weekend that reverses the normal flows before the settlement can be processed
- The settlement Windows is closed on Friday Evening, and the settlement and resetting of the Position does not happen until the following Monday or Tuesday (in the case of a Bank Holiday weekend)

- Before the position is reset, the DFSP had sufficient funds, but the reset would immediately block their ability to continue sending

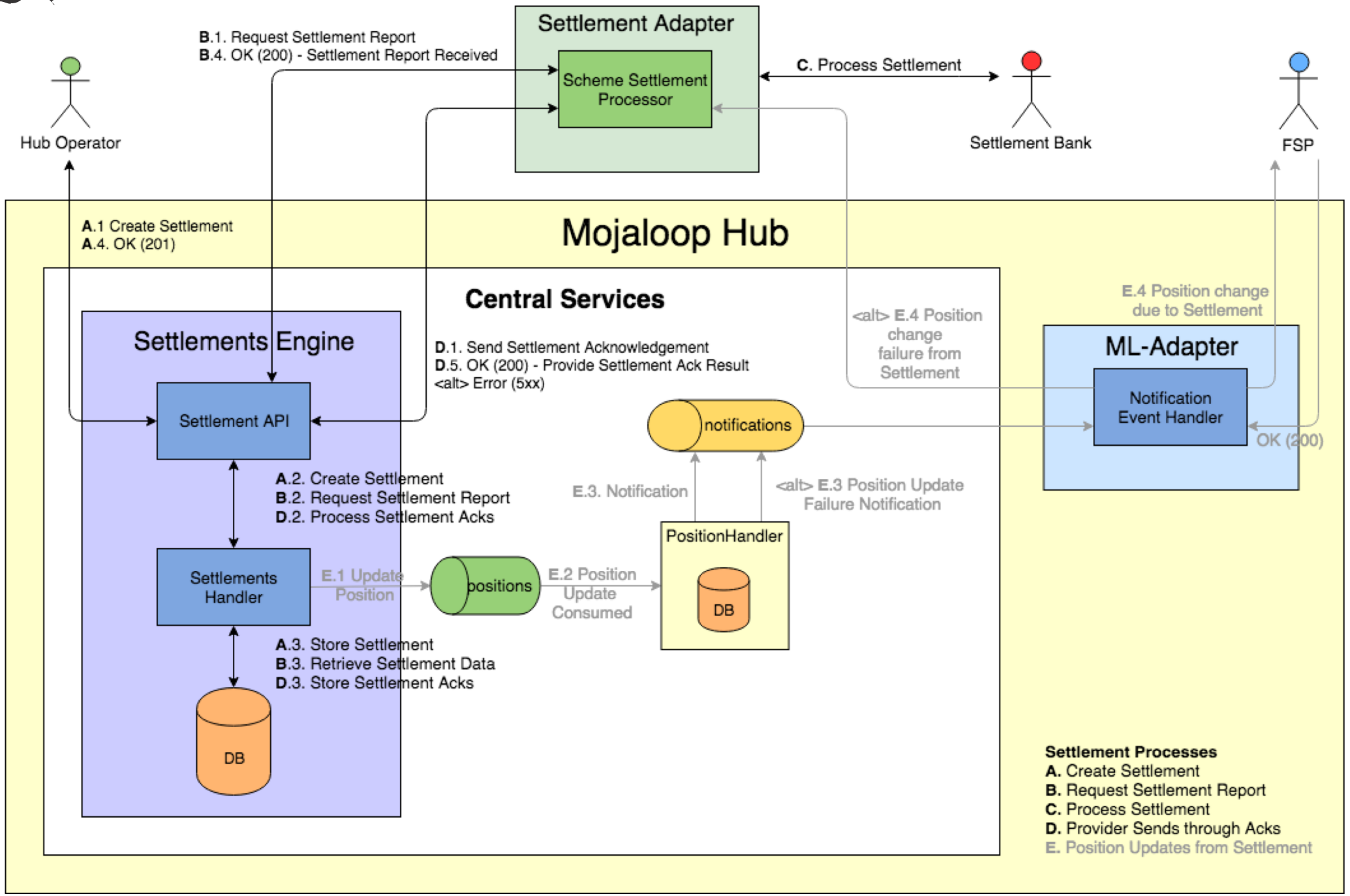
# Key Learning

- Get a good basic understanding of Double Entry book keeping
- Model any transfers or movements via T accounts first
- Then extend the model to a spreadsheet
- Work through the transfers and put in some rogue transactions to ensure you have adequate

# Settlements Functionality

1. Phase-2 Overview
    a. Settlement Windows
    b. Settlements API
2. PI-4 Update
3. Settlements Demo Index

# Settlements Solution Design




Phase-3

# Settlement Windows

Usage benefits:

1. Continuity
2. Isolation
3. Manageability

**Note**: No changes were made to the settlement windows states flow.

# Settlements API

1. POST */settlementWindows/{ID}* –current window closure
2. POST */settlements* – trigger a settlement for **CLOSED / ABORTED** windows
3. PUT */settlements/{id}* – update settlement accounts
    a. PUT */settlements/{id}/participants/{id}/accounts/{id}*
    b. PUT */settlements/{id}/participants/{id}*
4. GET endpoints provide information about settlements and windows

# Settlements Redesign

1. Database Schema Changes: One new column

   **settlementParticipantCurrency.settlementTransferId** added

2. Enumeration Additions:

   a. *ledgerAccountType*: **HUB_MULTILATERAL_SETTLEMENT, HUB_RECONCILIATION, SETTLEMENT**

   b. *settlementState*: **PS_TRANSFERS_RECORDED, PS_TRANSFERS_RESERVED, PS_TRANSFERS_COMMITTED, SETTLING**

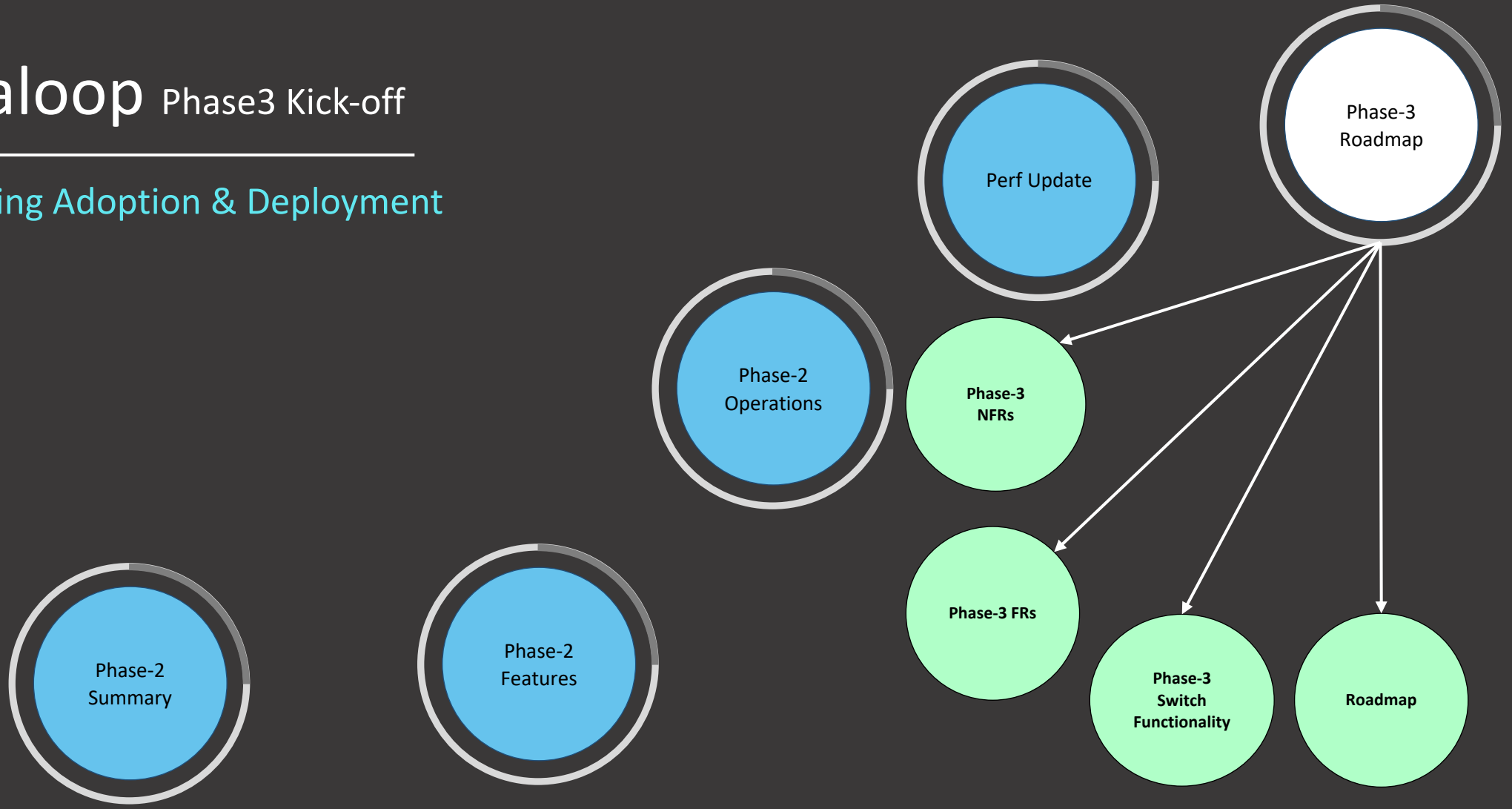
3. Settlement Process & Settlement Transfer

# Settlements Demo Index

1. 10 transfers ($100 ea.) between 3 participants
2. dfsp1 → dfsp2: **2** transfers, dfsp2 → dfsp3: **5**, dfsp3 → dfsp1: **3**
3. Balance: dfsp1 **-100** (recipient), dfsp2 **+300** (sender), dfsp3 **-200** (recipient)
4. Golden path for end-to-end settlement
5. Notes:
    a. Same-state Account Updates and Settlement Abort
    b. Observables: API GET endpoints and DB queries

# Mojaloop Phase3 Kick-off

## Supporting Adoption & Deployment



# Phase-3 Roadmap: NFRs

| PI | Summary |
|---|---|
| Phase - 3 | 1. DFSP Handler Provisioning |
| | 2. API Gateway |
| | 3. Implementing Topology Guidelines |
| | 4. Automated Testing: Integrated Functional tests |
| | 5. Event Logging Framework |
| | 6. Error Handling Framework |
| | 7. DevOps |

# Phase-3 Roadmap: FRs

| PI | Summary |
|---|---|
| Phase - 3 | 1. Settlement Management |
| | 3. Central Directory |
| | 5. Forensic Logging |
| | 4. Merchant “Request To Pay” |
| | 5. Bulk Payments |

# Switch Functionality – Mojaloop End-points (Current)

## Mojaloop v1.0 – API Specification

### Transfers:
[●] POST - Prepare
[●] PUT - Response
[●] PUT – Error
  [●] Outgoing
  [●] Incoming
[●] GET - Query

### Parties:
[●] GET - Request
[●] PUT - Response
[o] PUT - Error

### Quotes:
[●] POST - Request
[●] PUT - Response
[●] PUT - Error
[o] GET - Query

### Participants:
[●] POST - Create
[●] PUT - Response
[o] POST - Bulk Create
[o] PUT - Error
[o] DEL - Delete

### Transactions:
[o] PUT - Response
[o] GET - Query

### TransactionRequests:
[o] POST - Request
[o] PUT - Response
[o] PUT - Error
[o] GET - Query

### Authorizations:
[o] GET - Request
[o] PUT - Response
[o] PUT - Error

### BulkTransfers:
[o] POST - Request
[o] PUT - Response
[o] PUT - Error
[o] GET - Query

### BulkQuotes:
[o] POST - Request
[o] PUT - Response
[o] PUT - Error
[o] GET - Query

Key
[●] Fully implemented
[●] Legacy Code
[●] Partially implemented
[●] Not implemented
[o] Out of Scope for Phase2

# Switch Functionality – Mojaloop End-points (Phase-3)

## Mojaloop v1.0 – API Specification

### Transfers:
[●] POST - Prepare
[●] PUT - Response
[●] PUT – Error
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  [●] Incoming
[●] GET - Query

### Parties:
[●] GET - Request
[●] PUT - Response
[●] PUT - Error

### Quotes:
[●] POST - Request
[●] PUT - Response
[●] PUT - Error
[●] GET - Query

### Participants:
[●] POST - Create
[●] PUT - Response
[○] POST - Bulk Create
[●] PUT - Error
[○] DEL - Delete

### Transactions:
[○] PUT - Response
[●] GET - Query

### TransactionRequests:
[●] POST - Request
[●] PUT - Response
[●] PUT - Error
[●] GET - Query

### Authorizations:
[○] GET - Request
[○] PUT - Response
[○] PUT - Error

### BulkTransfers:
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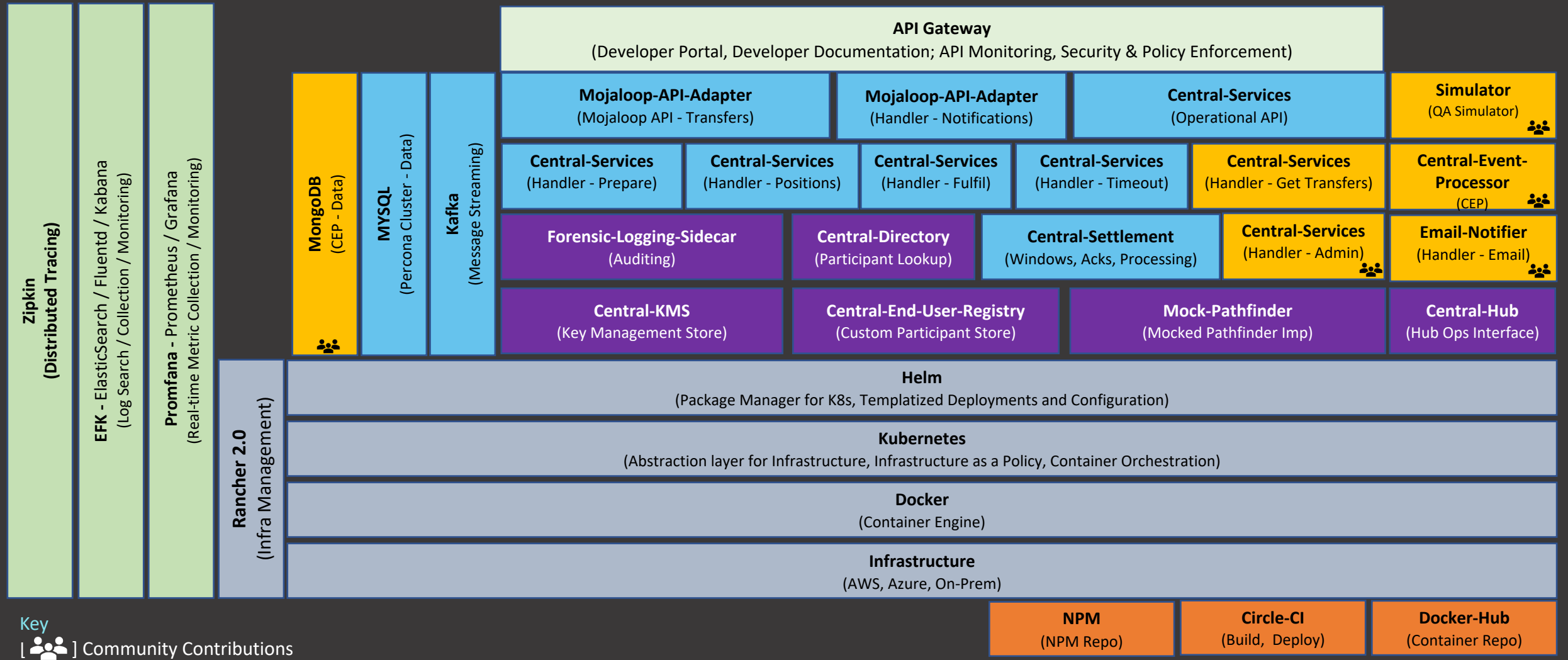
[○] GET - Query

Key
[●] Fully implemented
[●] Legacy Code
[●] Partially implemented
[●] Not implemented
[○] Out of Scope for Phase2

# APPENDIX

# Appendix - Contents

# Component Architecture – End-state

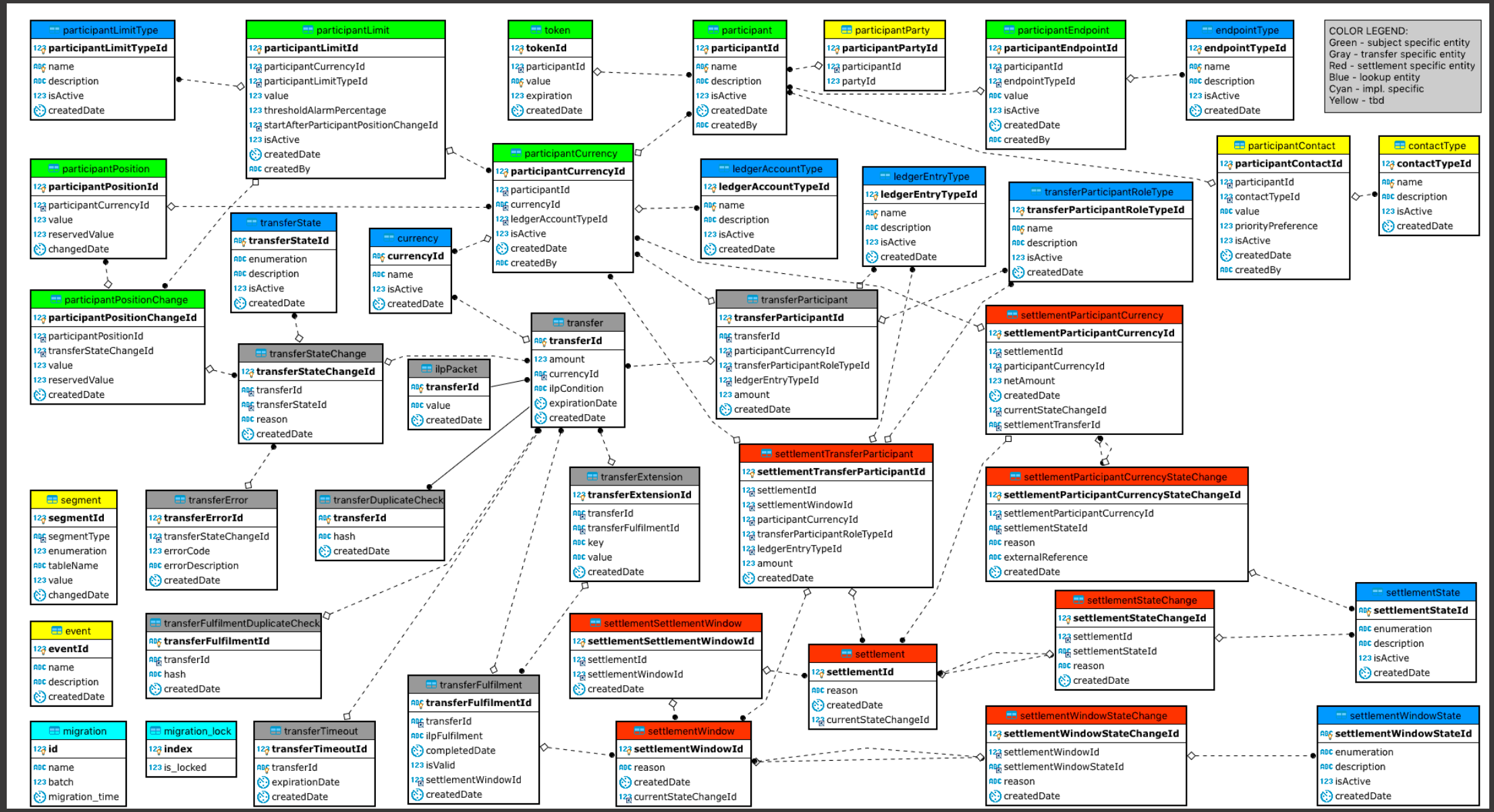



Key
[ ] Community Contributions

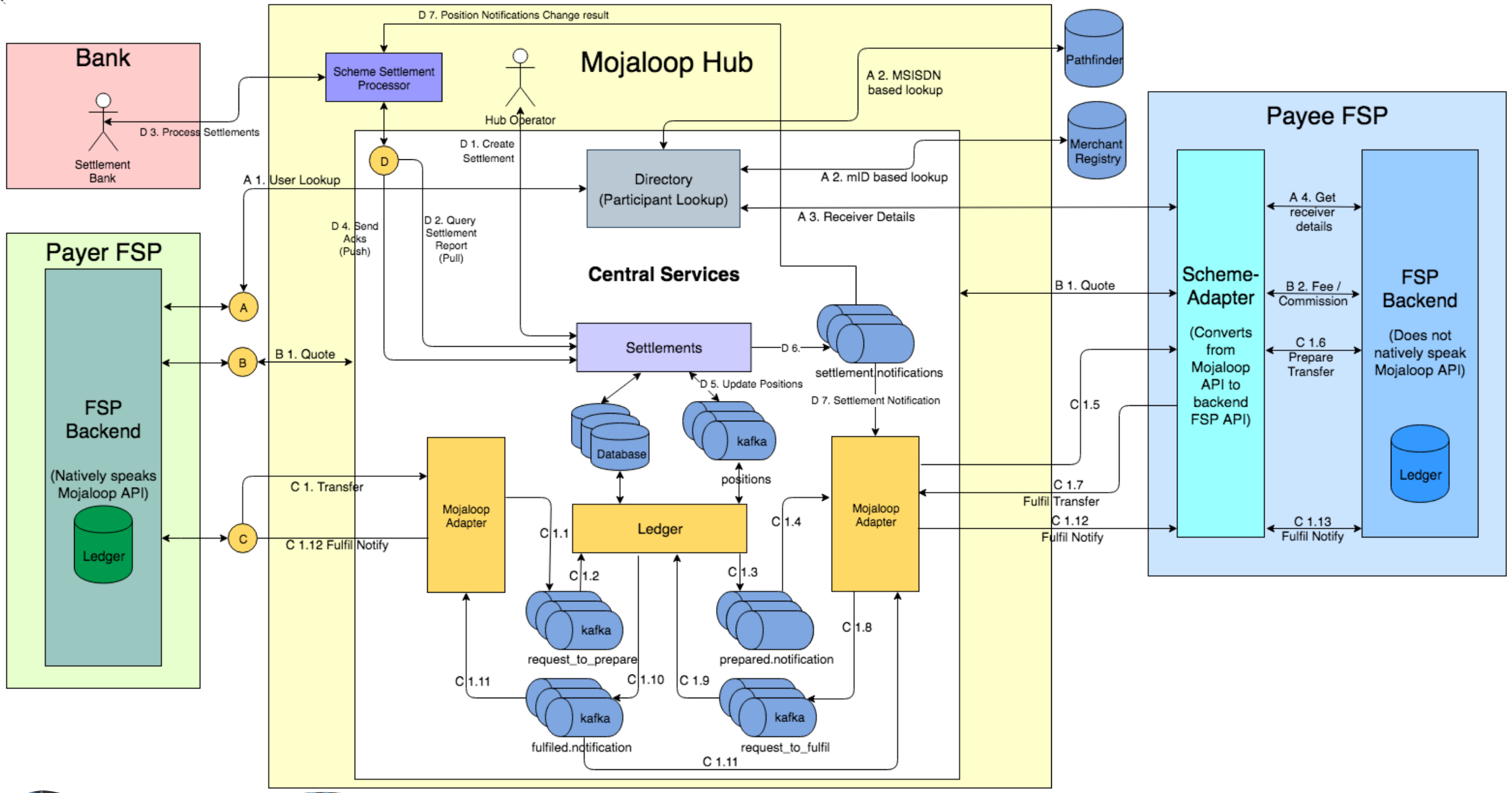
Phase-3 kick-off Jan 2019

ModusBox for BMGF

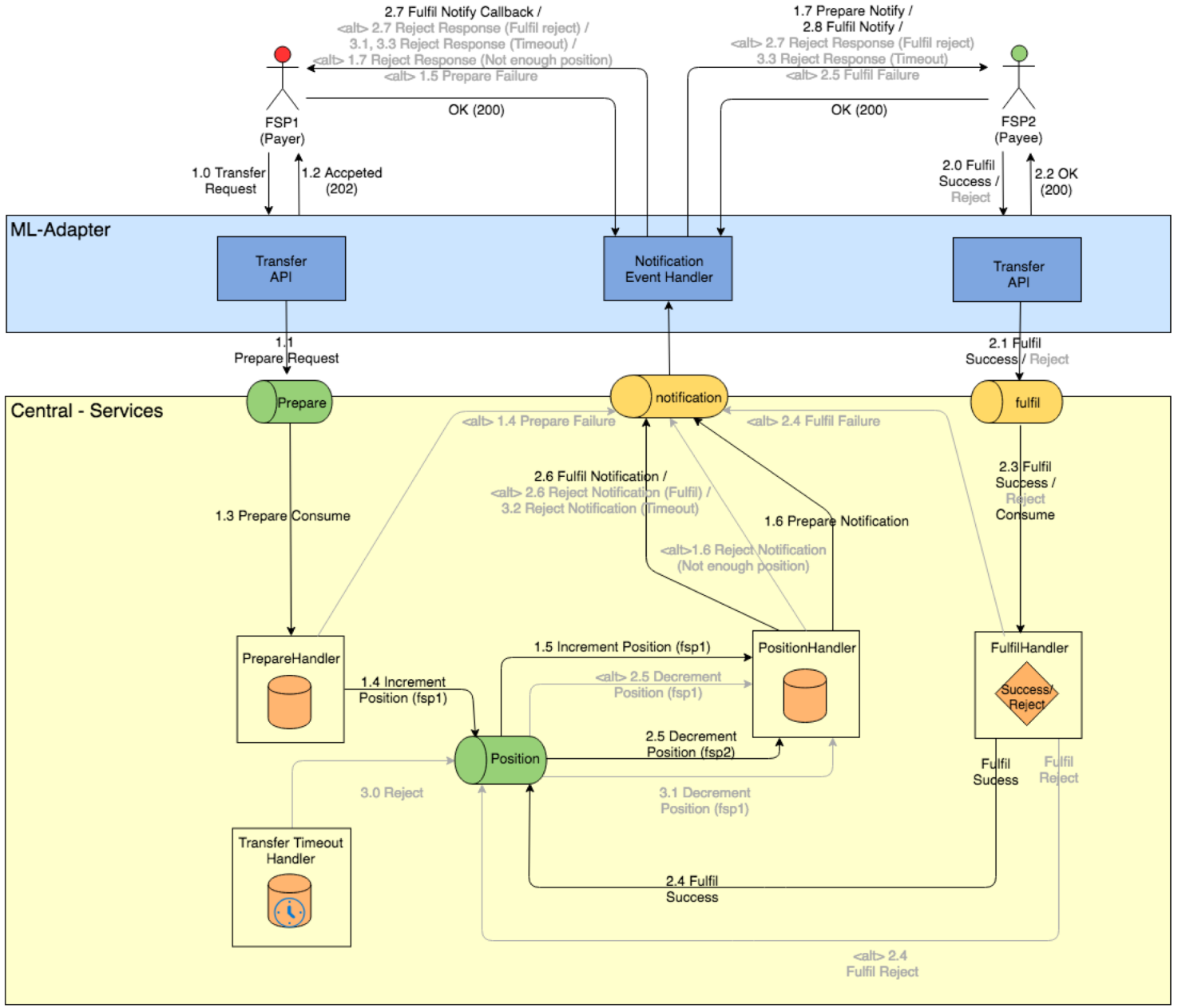
# Database Design – PI4



# End-to-end Flow



# Transfers Solution Design



# Deployment Architecture – Helm Overview

*Ref: http://helm.sh*

## What is Helm?

Open Source Package Manager for Kubernetes through the use of Charts.

Charts help you define, install and upgrade releases for Kubernetes deployment via templates and configuration.

## Why Helm?

### Manage Complexity

Charts describe even the most complex apps; provide repeatable application installation, and serve as a single point of authority.

### Easy Updates

Take the pain out of updates with in-place upgrades and custom hooks.

### Simple Sharing

Charts are easy to version, share, and host on public or private servers.

### Rollbacks

Use `helm rollback` to roll back to an older version of a release with ease.


Microsoft Google codefresh bitnami ticketmaster codecentric

# Deployment Architecture – Kubernetes Overview

**What is Kubernetes?**
Open-source system for automating deployment, scaling, and management of containerized applications.

kubernetes

## Why Kubernetes?

**Deploy your applications quickly and predictably**
- Infrastructure as a Policy
- Abstraction of Infrastructure (Cloud, On-Prem)

**Scale your applications on the fly**
- Policy rule based scaling
- Limit hardware & resources by scaling horizontally up/down

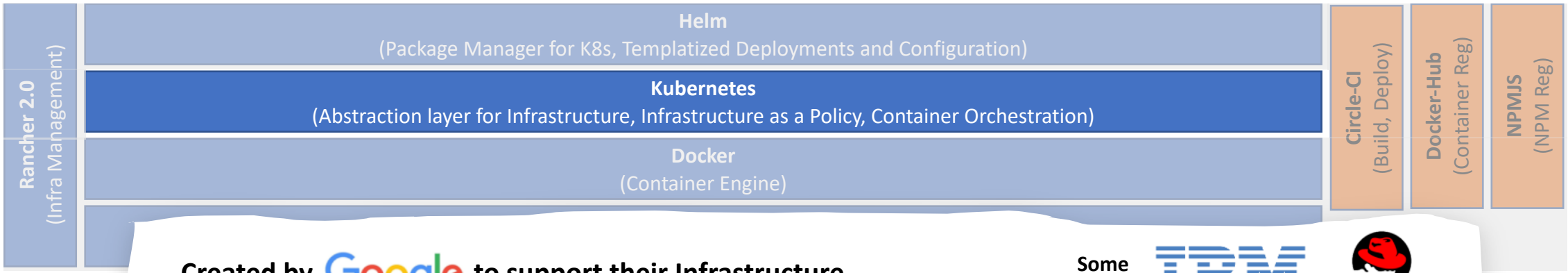
**Roll out new features seamlessly**
- Rolling updates

**Discoverability**
- Dynamic service resolution via DNS

**Durability**
- Self-healing
- Auto-[placement, restart, replication, scaling] based on Policies
- Load Balancing

**Security**
- Isolation through Containers, Network and Namespaces

**Operations**
- App config & secrets stored in distributed key-value store (etcd)
- Monitoring of containers




**Created by Google to support their Infrastructure.**

**Some contributors:** IBM redhat

# Deployment Architecture – Rancher Overview

*Ref: http://rancher.com*

## What is Rancher?

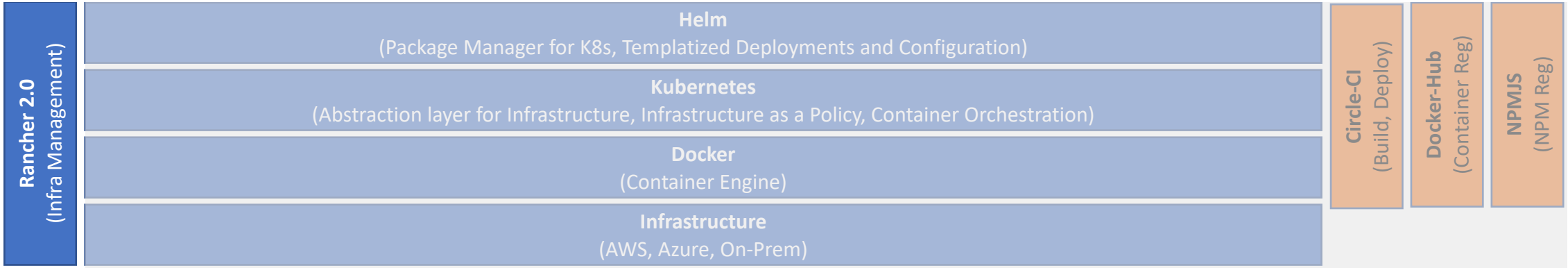
Rancher is enterprise management for Kubernetes.

Every distro. Every cluster. Every cloud.

## Why Rancher?

- Kubernetes Management (v1.8 to *v1.9)
- Container Management
- *Access Management (RBAC)
- *Helm Repository Management
- Multi-environment Management (multi k8s clusters, On-prem, Azure, Google, AWS, etc)
- Multi-Provider provisioning (On-prem, Azure, Google, AWS, vSphere)
- Easily scale up/down Kubernetes clusters

** New in Rancher v2.x*



# Deployment Architecture – CircleCI Overview

circleci

## What is CircleCI? Cloud based Continuous Integration & Deployment Platform

*Ref: http://circleci.com*

**VCS Integration**
CircleCI integrates with GitHub, GitHub Enterprise, and Bitbucket. Every time you commit code, CircleCI creates a build.

**Automated Testing**
CircleCI automatically tests your build in a clean container or virtual machine.

**Automated Deployment**
Passing builds are deployed to various environments so your product goes to market faster.

**Notifications**
Your team is notified if a build fails so issues can be fixed quickly.

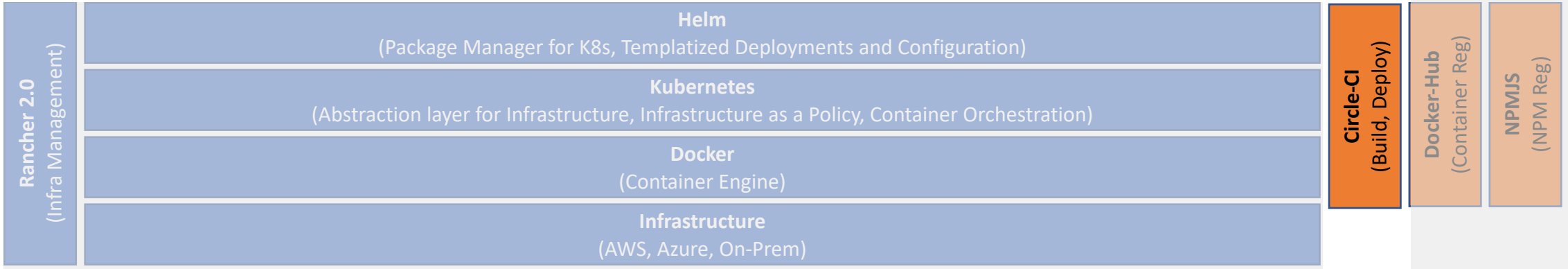
## Why CircleCI?

**Workflows for Job Orchestration**
Orchestrate customizable job execution (such as build, test, deploy), giving complete control over your development process.

**Language-Agnostic Support**
Supports any language that builds on Linux or macOS, including C++, Javascript, .NET, PHP, Python, and Ruby.

**First-Class Docker Support**
Run any image from Docker's public/private registry or other common registries. Build Docker images, access Docker layer caching, Compose.

**Powerful Caching**
Speed up builds with expanded caching options, including images, source code, dependencies, and custom caches. Full control over cache save and restore points for optimal performance.




** Forrester names CircleCI a leader (https://www2.circleci.com/circleci-forrester-wave-leader-2017.html)*

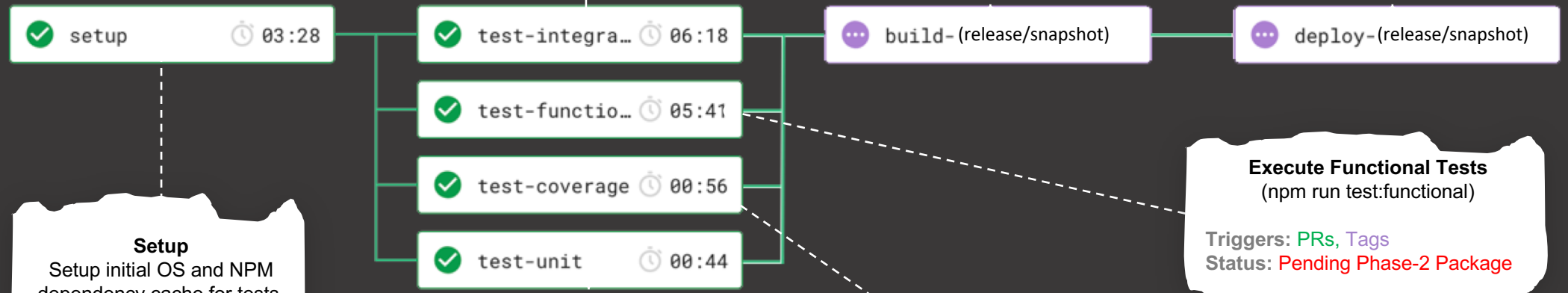
# Deployment Architecture – CI/CD Pipeline

circleci

Triggers:

- [●] Pull-Requests (inc. from external Forks)
- [●] Publishing tagged Releases
- [●] Publishing tagged Snapshots

Ref: https://circleci.com/projects/gh/mojaloop




**Execute Integration Tests**
(npm run test:integration)

**Triggers:** PRs, Tags
**Status:** Working

**Build & Publish Artifact**
Docker or NPM build and publish to repository

**Triggers:** Tags
**Status:** Pending Phase-2 Package

**Deploy Artifact**
Execute either helm install or upgrade (if existing deployment) with latest Artifacts

**Triggers:** Tags
**Status:** Pending Phase-2 Package

**Setup**
Setup initial OS and NPM dependency cache for tests, builds, and deployments.

**Triggers:** PRs, Tags
**Status:** Working

**Unit Tests**
(npm run test:unit)

**Triggers:** PRs, Tags
**Status:** Working

**Execute Functional Tests**
(npm run test:functional)

**Triggers:** PRs, Tags
**Status:** Pending Phase-2 Package

**Coverage Check**
Executes Code Coverage checks. The results will be published to SonarQube if the branch is "Master".
(npm run test:coverage)

**Triggers:** PRs, Tags
**Status:** Working

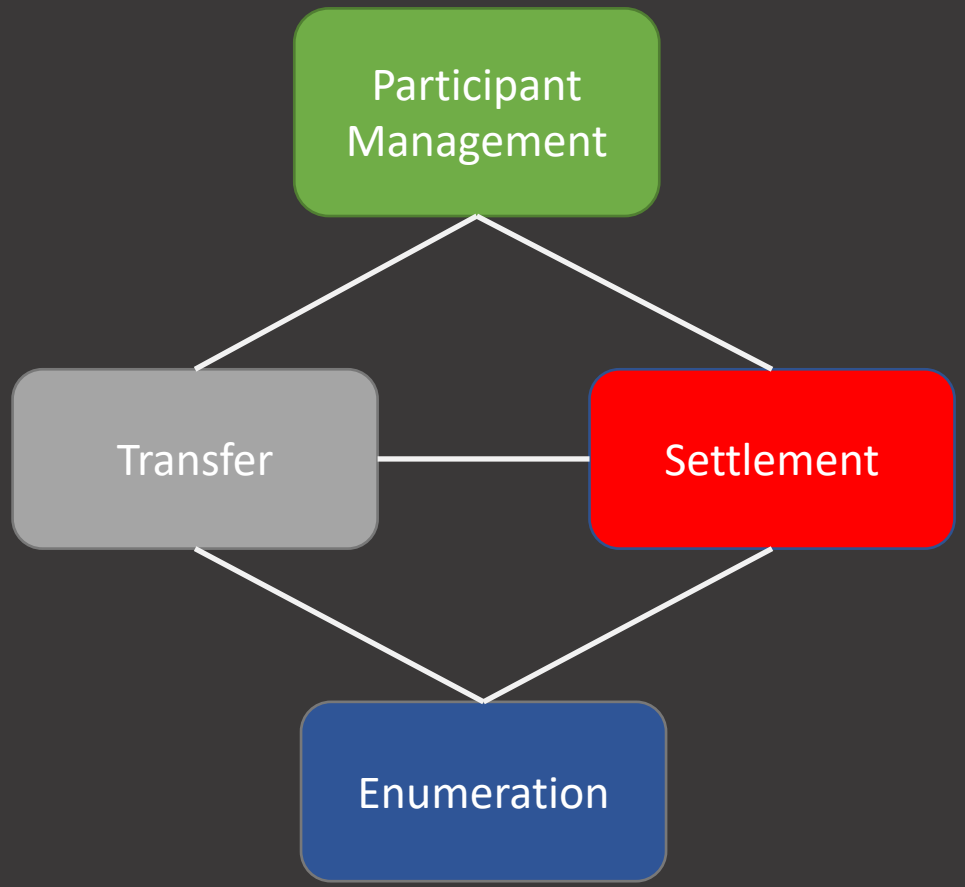
# Database Design

## Database Design Objectives

1. Align the data model to support to the Mojaloop specification
2. Design for efficiency and reduce locking
3. Data integrity maintained through a idempotency pattern

## How was this achieved?

1. Redesign scheme to reflect the Mojaloop API and support the state transitions.
2. Inserts are used instead of updates to ensure reduced locking, and increased speed of data “updates”
3. Inserts are used to ensure an idempotent pattern for data “updates” is maintained. The result being that all “updates” have a history.
4. Support for batch processing of DFSP position, maintain repeatable and deterministic outcomes of rule processing and “running balance” for positions.



# Switch Functionality – Mojaloop

## Mojaloop v1.0 – P2P Use-case

### Payer-Initiated Transaction

[●] P2P Transfers – Golden Path
- [●] Prepares, Fulfils
- [●] Rejections, Timeouts
- [●] Error Endpoints

## Mojaloop v1.0 – End Points for P2P

### Transfers

[●] POST - Prepare
[●] PUT - Response
[●] PUT – Error
- [●] Outgoing
- [●] Incoming

[●] GET - Query

### Quotes

[●] POST - Request
[●] PUT - Response
[●] PUT - Error
[○] GET - Query

### Parties

[●] GET - Request
[●] PUT - Response
[○] PUT - Error

### Participants

[●] POST - Create
[●] PUT - Response

Key
- [●] Fully implemented
- [●] Legacy Code
- [●] Partially implemented
- [●] Not implemented
- [○] Out of Scope

# Switch Functionality – Mojaloop Use Cases (Phase-2)

## Mojaloop v1.0 – Use-cases

### Payer-Initiated Transaction

[●] P2P Transfers – Golden Path
- [●] Prepares, Fulfils
- [●] Rejections, Timeouts
- [●] Error Endpoints

[●] Customer-Initiated Merchant Payment
[●] Customer-Initiated Cash-out - Receive Amount
[●] Customer-Initiated Cash-out - Send Amount
[○] ATM-Initiated Cash-out
[●] Refund

### Bulk Transactions

[○] Bulk Payments

### Payee-Initiated Transaction

[○] Merchant-Initiated Merchant Payment
[○] Agent-Initiated Cash-out
[○] Agent-Initiated Cash-In – Send Amount
[○] Agent-Initiated Cash-In – Receive Amount

### Payee-Initiated Transaction using OTP

[○] Merchant-Initiated Merchant Payment Authorized on POS
[○] Agent-Initiated Cash-out Authorized on POS

Key
[●] Fully implemented
[●] Supported, not tested
[●] Partially implemented
[●] Not implemented
[○] Out of Scope

# PI4 Performance Summary

Key
[●] Completed in PI-4
[●] Partially completed in PI-4
[●] To be considered in Future

## Approach:

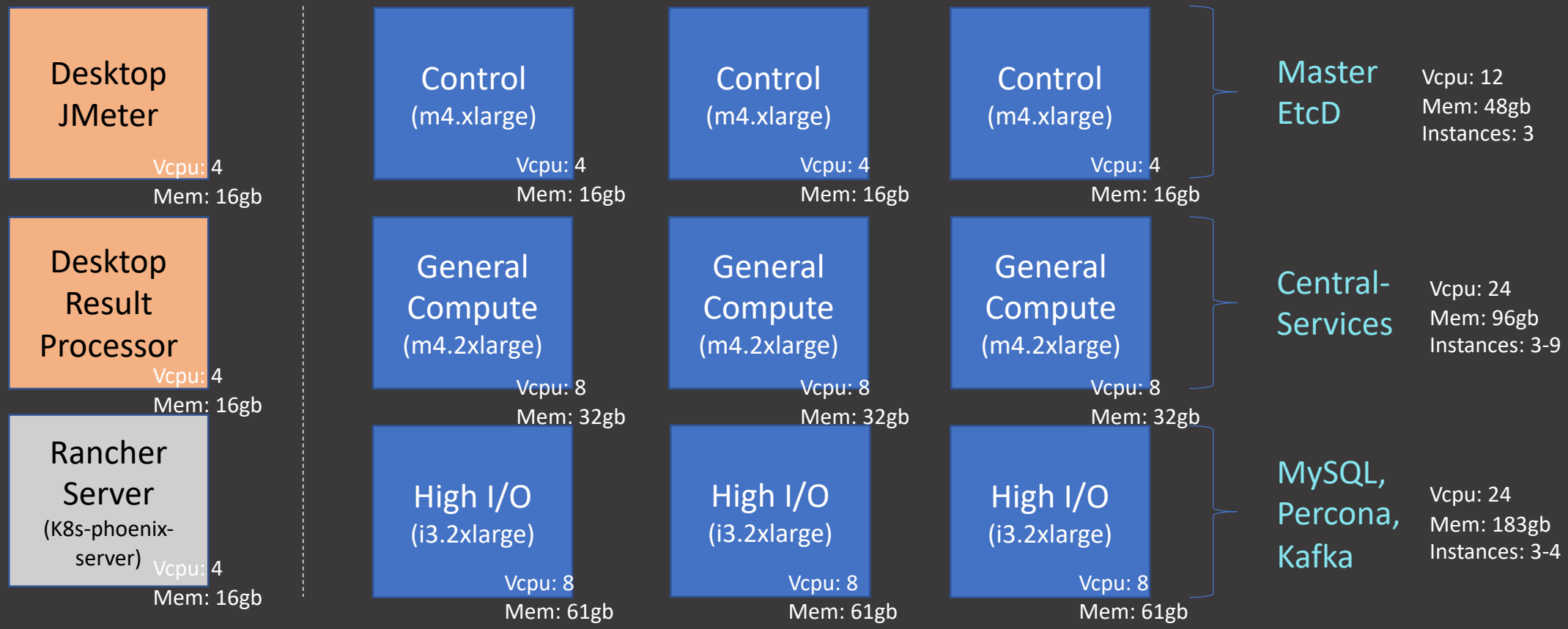
[●] Set a base-line on PI-3 Code-base
[●] Configure Environment for Production-like setup
[●] Identified & fix stability issues due to failure on load
[●] Optimized Kafka Client (Producers, Consumers) for Performance
[●] Scenarios with Multiple FSPs
[●] Increase multi-threaded processing of non-[1]EOS Kafka Consumers (Prepare, Transfer, Fulfil, Notification)
[●] Optimized Handlers with reduced CPU Usage
[●] Optimized Handlers with reduced IO
[●] Tested against an alternative hosted Kafka service[2]
[●] Increase scalability of solution
[●] Optimized Handlers with PRISM

## Comparison of Selected Results (in seconds):

| Metric | PI2 | PI3 | PI4[3] | |
|---|---|---|---|---|
| Number of Messages | 100 | 100 | **358 201** | |
| Prepare Process | ✓ | ✓ | ✓ | ✓ |
| Fulfil Process | ✗ | ✗ | ✓ | ✓ |
| Included Mock FSP Simulator Times | ✗ | ✗ | ✓ | ✗ |
| Transactions Per Second | 6.51 | 22.18 | 99 | **207** |
| Average Transaction Time | 8.21 | 1.65 | 0.111 | **0.101** |
| Shortest Response Time | 2.594 | 0.942 | 0.47 | **0.32** |
| Longest Response Time | 19.746 | 2.589 | 3.057 | **3.047** |
| Standard Deviation | n/a | n/a | 0.120 | **0.119** |
| % of requests taking longer than 1 second | n/a | n/a | 0.17% | **0.002%** |
| Duration | 15 seconds | 4.5 seconds | 1 hour | **1 hour** |

***[1] EOS – Exactly Once Semantic,***
***[2] Mojaloop Kafka deployment on Rancher K8s-Phoenix Environment was comparable and better at times,***
***[3] Average over 3 runs – individual results in the appendix***

# Performance Update –
# Environment: Infrastructure Setup



# Results[1] - KafkaPoC

KafkaPoC - Producer

| | Recursive Mode | PoC Flow Mode | PoC Stream Mode |
|---|---|---|---|
| Date | 2018-12-21 @ 15h49 | 2018-12-21 @ 15h49 | 2018-12-21 @ 15h49 |
| # No. Request | 10 000 | 10 000 | 10 000 |
| Time | 1.2 Seconds | 1.2 Seconds | 1.2 Seconds |
| Min Response | 0 ms | 0 ms | 0 ms |
| Max Response | 3 ms | 2 ms | 3 ms |
| Mean/Avg | 0.10 ms | 0.10 ms | 0.10 ms |
| Std. Deviation | 0.31 ms | 0.31 ms | 0.09 ms |
| % > 1 Second | 0.00% | 0.00% | 0.00% |
| Trans / per Sec | 7861 | 7874 | 7993 |

KafkaPoC - Consumer

| | Recursive Mode | PoC Flow Mode | PoC Stream Mode |
|---|---|---|---|
| Date | 2018-12-21 @ 15h49 | 2018-12-21 @ 15h49 | 2018-12-21 @ 15h49 |
| # No. Request | 10 000 | 10 000 | 10 000 |
| Time | 2.6 Seconds | 1.6 Seconds | 2.1 |
| Min Response | 0 ms | 0 ms | 0 ms |
| Max Response | 1 ms | 2 ms | 1 ms |
| Mean/Avg | 0.08 ms | 0.06 ms | 0.06 ms |
| Std. Deviation | 0.27 ms | 0.25 ms | 0.24 ms |
| % > 1 Second | 0.00% | 0.00% | 0.00% |
| Trans / per Sec | 3796 | 5938 | 4725 |



[1] *All results are available on demand. Only selected results shown here*

# Results[1] -Mojaloop End-to-end Transfer Process

Calculations including Simulators (With Mock FSP)

| | |
|---|---|
| Date | 2018-12-14 @ 20h50 |
| # No. Request | 359 508 |
| Time | 1 Hour |
| Min Response | 48 ms |
| Max Response | 1492 ms |
| Mean/Avg | 111 ms |
| Std. Deviation | 114 ms |
| % > 1 Second | 0.25% |
| Trans / per Sec | 100 |

Recursive Mode

| | |
|---|---|
| Date | 2019-01-18 @ 20h35 |
| # No. Request | 359 839 |
| Time | 1 Hour |
| Min Response | 44 ms |
| Max Response | 6913 ms |
| Mean/Avg | 118 ms |
| Std. Deviation | 205 ms |
| % > 1 Second | 0.25% |
| Trans / per Sec | 100 |

Recursive Mode

| | |
|---|---|
| Date | 2019-01-25 @ 10h48 |
| # No. Request | 355 258 |
| Time | 1 Hour |
| Min Response | 51 ms |
| Max Response | 768 ms |
| Mean/Avg | 106 ms |
| Std. Deviation | 41 ms |
| % > 1 Second | 0.00% |
| Trans / per Sec | 98 |

Recursive Mode

Calculations excluding Simulators (Without Mock FSP)

| | |
|---|---|
| Date | 2018-12-14 @ 20h50 |
| # No. Request | 359 508 |
| Time | 1 Hour |
| Min Response | 33 ms |
| Max Response | 1482 ms |
| Mean/Avg | 101 ms |
| Std. Deviation | 112 ms |
| % > 1 Second | 0.25% |
| Trans / per Sec | 197 |

| | |
|---|---|
| Date | 2019-01-18 @ 20h35 |
| # No. Request | 359 839 |
| Time | 1 Hour |
| Min Response | 23 ms |
| Max Response | 6903 ms |
| Mean/Avg | 107 ms |
| Std. Deviation | 205 ms |
| % > 1 Second | 0.24% |
| Trans / per Sec | 216 |

| | |
|---|---|
| Date | 2019-01-25 @ 10h48 |
| # No. Request | 355 258 |
| Time | 1 Hour |
| Min Response | 41 ms |
| Max Response | 758 ms |
| Mean/Avg | 95 ms |
| Std. Deviation | 41 ms |
| % > 1 Second | 0.00% |
| Trans / per Sec | 210 |



[1] *All results are available on demand. Only selected results shown here*

# System Treatment of a P2P Transfer

- From a system perspective, any P2P transfer is managed with three separate stages:
  - Prepare
  - Reserve
  - Commit or Abort
- During the prepare stage, the entries are recorded in the database, without affecting the balance of the relevant ledger.
- When moving to the reserve state, the Position of the Payer DFSP is increased to reserve the funds. This ensures the principal that funds are ring-fenced - so cannot be used for another transfer until they are released.
- When moving to the commit state, the Position of the Payee DFSP is decreased allowing them to send more funds to other DFSPs if desired.
- After receiving a quote, the payer DFSP can initiate a transfer. That initial request results in the transfer being prepared, and then the Position increased to reserve the funds. This is referred to as the Prepare leg of the transfer process within Mojaloop. When the Payee DFSP sends a confirmation of the transfer, the transfer is committed, and the Payee DFSPs Position is reduced and since they are now able to use those funds - the commited state means the transfer is irrevocable at this point. This portion is referred to as the Fulfil leg of the transfer process within Mojaloop.
- NEEDS REWORK

# Movement within the Switch

- To ensure the safe movement of funds, it is important that any transfers from one account to another are done in an orderly manner. This approach should ensure that funds are ring-fenced, and the switch does not enter a situation where funds are released, before they are confirmed to be available.
- The principle role of the switch is to facilitate transfers between the DFSPs.
  - This is within an agreed limit known as the Net Debit Cap, which from a DFSP perspective is the maximum Debt (Dr balance) THEY - the DFSP - can have with the Switch.
  - Within the Switch, this is the amount that the DFSP owes to other DFSPs - this value is known as the Position.
  - Within the switch, the Position of a DFSP increases the more they owe. From the perspective of the Payer/Sending DFSP it is an increase in their liability, from the Payee/Receiving DFSP it is a reduction in their liability (or increase in their assets if sufficient). So therefore the Payer DFSP sees their position increase, and the Payee sees their position decrease

# Understanding Accounting Principles

- Standard practice in accounting software is to treat Debits (Drs) as positives and Credits (Crs) as negatives. That way when you add up the items in a ledger, if the net position is positive (More Drs) they are treated as an asset, and if the net position is negative (More Crs) they are seen as a liability. Debits and Credits can occur in any account. – this has been adopted in MojaLoop
- It is worth noting that the Switch has a different perspective to the DFSPs but follows the same rules: when funds are input the cash (asset) increases, which is a debit; the increase in the customer's account balance (liability from the Switch's perspective) is a credit. The reporting of the switch, follows this process. When a transfer takes place, the Dr is applied to the sender - because when the movement is applied back to the account balance, it would lead to a reduction in the amount that is owed back to the DFSP (reduced liability).

# Managing the risk in the system

- As we outlined above in Understanding a Double Entry, a Dr reduces the switches liability, so it will always be applied in the Reservation stage so any impact to the switch is based on ensuring funds have been ring fenced first. Applying this to the System Treatment of a P2P Transfer
  - When moving to the reserve state, the Position of the Payer DFSP is Debited (Dr) to reserve the funds.
  - When moving to the commit state, the Position of the Payee DFSP is Credited (CR) allowing them to send more funds to other DFSPs if desired – but failure in receiving those funds would lead to liability issues.
- Adopting a standard approach where confirmations are expected to take place before funds are realeased also lead to consistency in reporting, reconciliation or roll back.
- This principle must be applied in all transfers, and the potential loss of funds due to any change reviewed as part of the flow – ensuring that transactions that may occur whilst the process is underway do not expose the switch to a financial risk.

# Changes Undertaken

- We have introduced options on the relationship with real money flows
  - Real time settlement
  - Delayed settlement

  - Which required the addition of 3 more account types
    - DFSP Settlement Ledgers – to mirror funds in the real bank account
    - Hub Multilateral Settlement Ledger
    - Hub Reconciliation Ledger

  - Each have their own risk which has been factored in Design

# Checking NDC for a Sender

| | Activity | | DFSP1 Transfer Ledger | | | DFSP2 Transfer Ledger | | | DFSP1 Settlement Ledger | | DFSP2 Settlement Ledger | | Multi Lateral Settlement Ledger | | Hub Reconciliation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Transfer | Position | NDC | Transfer | Position | NDC | Transaction | Balance | Transaction | Balance | Transaction | Balance | Transaction | Balance |
| 1 | **Settlement Window** Closed | | | +350 | +800 | | -350 | +800 | | -1000 | | -1000 | | 0 | | +2000 |
| 2 | DFSP1 Settlement Processed | DR | | +350 | **+800** | | -350 | +800 | | -1000 | | -1000 | +350 | +350 | | +2000 |
| 3 | DFSP2 Position Reset | DR | | +350 | **+800** | +350 | 0 | +800 | | -1000 | | -1000 | | +350 | | +2000 |
| 4 | DFSP2 Settlement Processed | CR | | +350 | +800 | | 0 | +800 | | -1000 | | -1000 | -350 | 0 | | +2000 |
| 5 | DFSP1 Position Reset | CR | -350 | 0 | +800 | | 0 | +800 | | -1000 | | -1000 | | | | +2000 |
| 6 | Funds Transfer For Settlement - DFSP 1 | | | 0 | +800 | | 0 | +800 | +350 | -650 | | -1000 | | 0 | -350 | +1650 |
| 7 | Funds Transfer For Settlement - DFSP 2 | | | 0 | +800 | | 0 | +800 | | -650 | -350 | -1350 | | 0 | +350 | +2000 |

Step 1 is the closure of the Window
Steps 2-5 are the steps to settle
Steps 6 and 7 are the real movement of funds.

However when the money flows the NDC is now higher than the Settlement Ledger balances – Automation of these steps requires a change in the NDC

The NDC adjustment needs to be applied before any processing of the settlement window – to ensure the control is in place before any positions are reset. This could lead to a temporary block on transfers, but eliminates the risk that transfers are allowed before the settlement is processed

*Note that the balance of transfers is done in the Hub Multilateral Settlement Ledger to ensure reconciliation, but it also allows for the settlement amounts to be handled differently*

# In delayed settlement a new risk is introduced Net Receiver becomes Net Sender

| | Activity | | DFSP1 Transfer Ledger | | | | DFSP2 Transfer Ledger | | | | DFSP1 Settlement Ledger | | | DFSP2 Settlement Ledger | | | Hub Reconciliation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Transfer | Position | NDC | | Transfer | Position | NDC | | Transaction | Balance | | Transaction | Balance | | Transaction | Balance |
| 1 | Settlement Window Closed | | | +350 | +800 | | | -350 | +800 | | | -1000 | | | -1000 | | | +2000 |
| 2 | DFSP2 → DFSP1 $600 | Allowed | -900 | -550 | +800 | | 900 | 550 | +800 | | | -1000 | | | -1000 | | | +2000 |
| 3 | Net Debit Cap Adjusted - lower Balance | | | -550 | **+650** | | | 550 | +800 | | | -1000 | | | -1000 | | | +2000 |
| 4 | DFSP1 Settlement Processed | DR | | -550 | +650 | | | 550 | +800 | | +350 | **-650** | | | -1000 | | | +2000 |
| 5 | DFSP2 Position Reset | DR | | -550 | +650 | | +350 | **900** | **+800** | | | -650 | | | -1000 | | | +2000 |
| 6 | DFSP2 Settlement Processed | CR | | -900 | +650 | | | 900 | +800 | | | -650 | | -350 | **-1350** | | | +2000 |
| 7 | DFSP1 Position Reset | CR | -350 | -900 | +650 | | | 900 | +800 | | | -650 | | | -1000 | | | +2000 |

If the time between Step 1 and Step 6 is large, the likelihood of this impact is large.

- Envisioned scenario is a Natural disaster over the weekend that reverses the normal flows before the settlement can be processed
- The settlement Windows is closed on Friday Evening, and the settlement and resetting of the Position does not happen until the following Monday or Tuesday (in the case of a Bank Holiday weekend)

- Before the position is reset, the DFSP had sufficient funds, but the reset would immediately block their ability to continue sending