Mastering Kafka workload balancing with Strimzi's Cruise Control integration

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  - Messaging & data streaming
- CNCF Ambassador
- Strimzi maintainer
- Running, swimming, Formula 1 & MotoGP addicted

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Apache Kafka & Strimzi

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In a nutshell ...

- Apache Kafka
  - Distributed event streaming platform
  - A cluster is made by brokers
  - Clients exchange data/events/messages through topics split in replicated partitions
- Strimzi
  - Running Apache Kafka on Kubernetes
  - From day-1 to deploy your cluster to day-2 for managing the cluster
  - Operator pattern and Kubernetes-oriented approach

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What if your load is unbalanced?

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The cluster is balanced at the start

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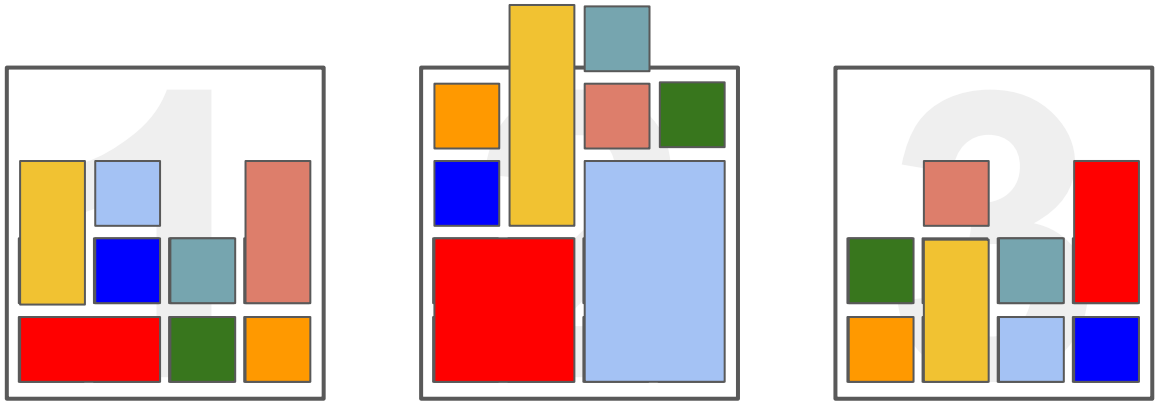
Brokers get different load overtime



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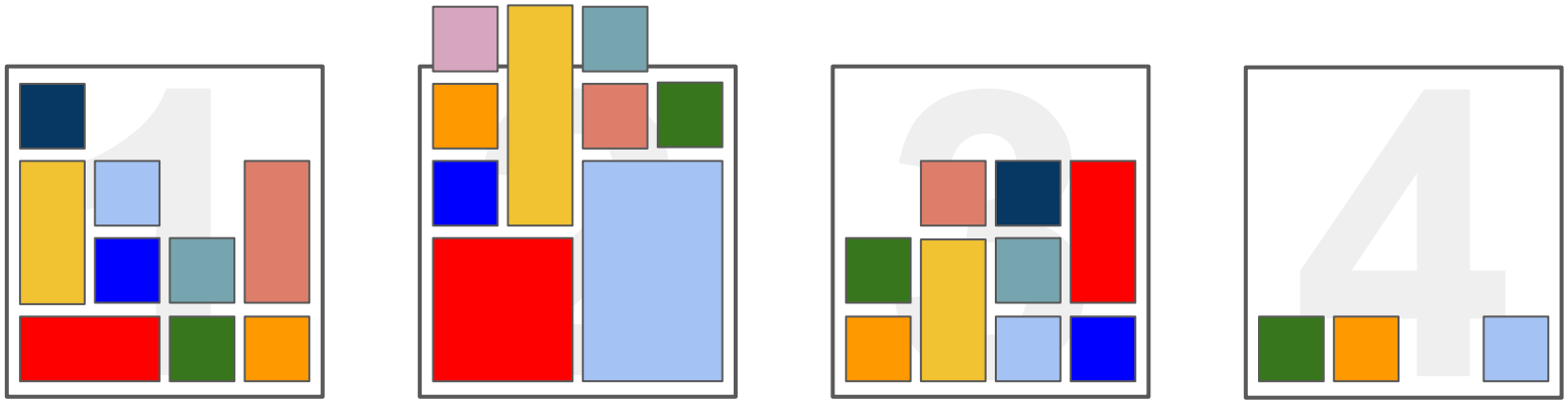
Scaling doesn't help



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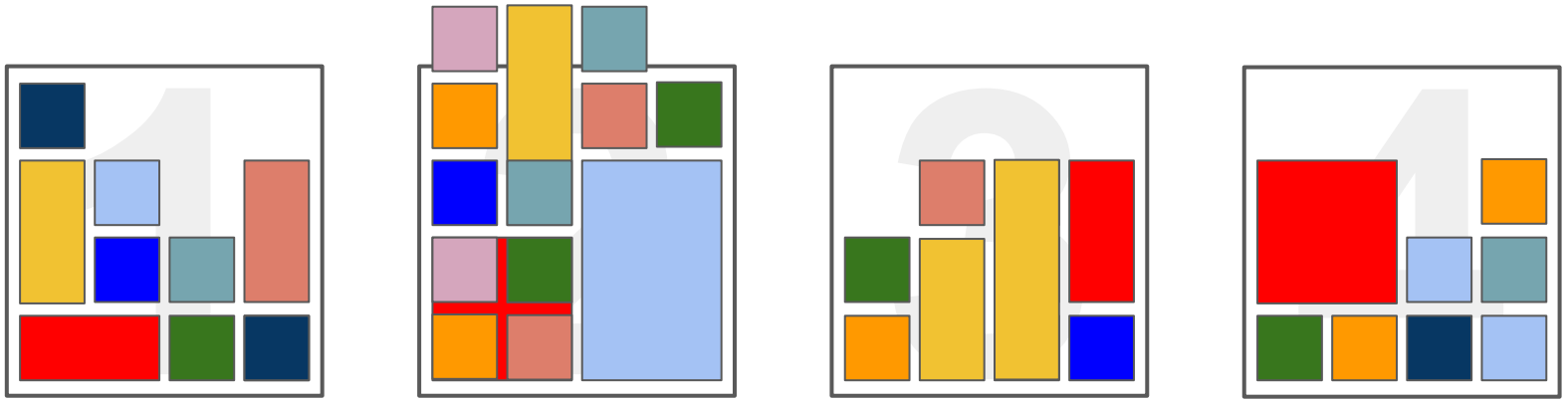
Rebalance



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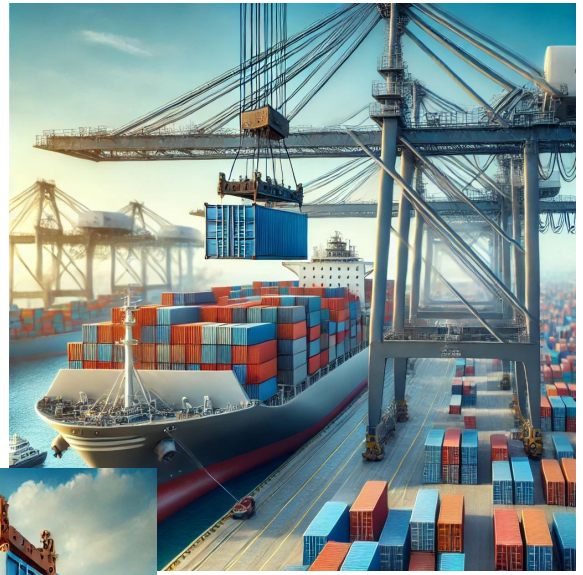
How to rebalance your load?



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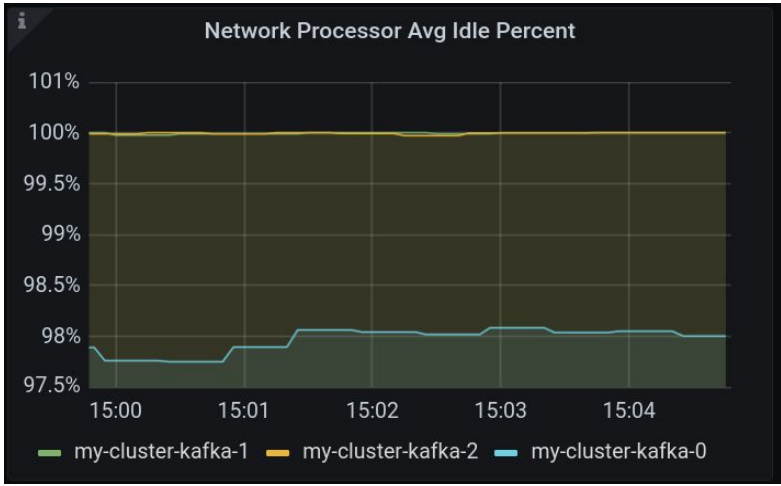
Cruise Control

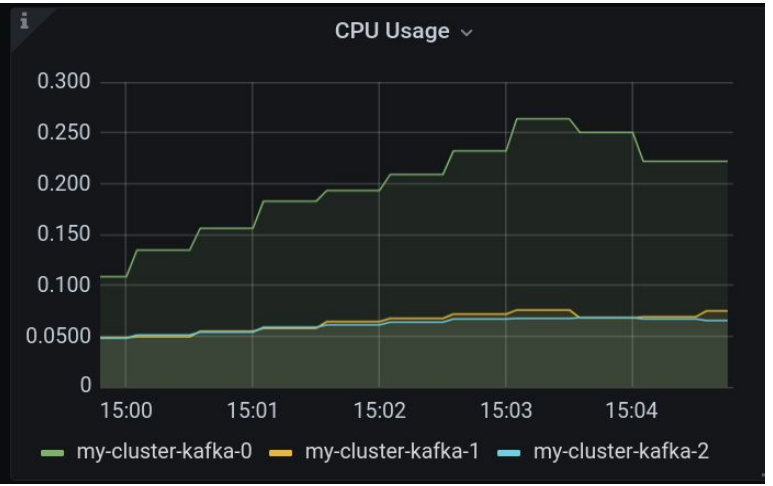
- Open Source project developed by LinkedIn
- Apache Kafka cluster re-balancing by ...
  - Monitoring CPU, disk, network throughput, and partition leadership
  - Processing an optimization proposal
  - Moving topics' partitions across brokers

Cruise Control

- Goal-based approach
  - Hard (must be satisfied) & Soft (best effort)
- Users can define constraints:
  - Disk usage
  - Optimal network load, CPU and memory utilization
  - Distribution of leader replicas
  - Rack awareness

Unbalanced workload





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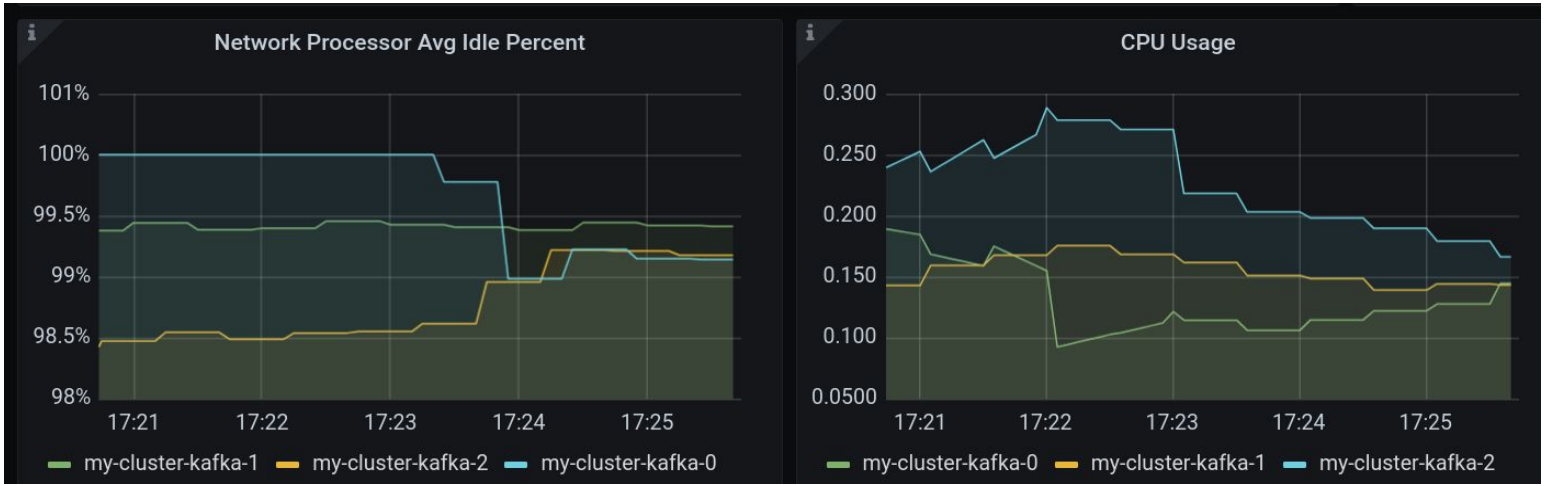
Balanced workload



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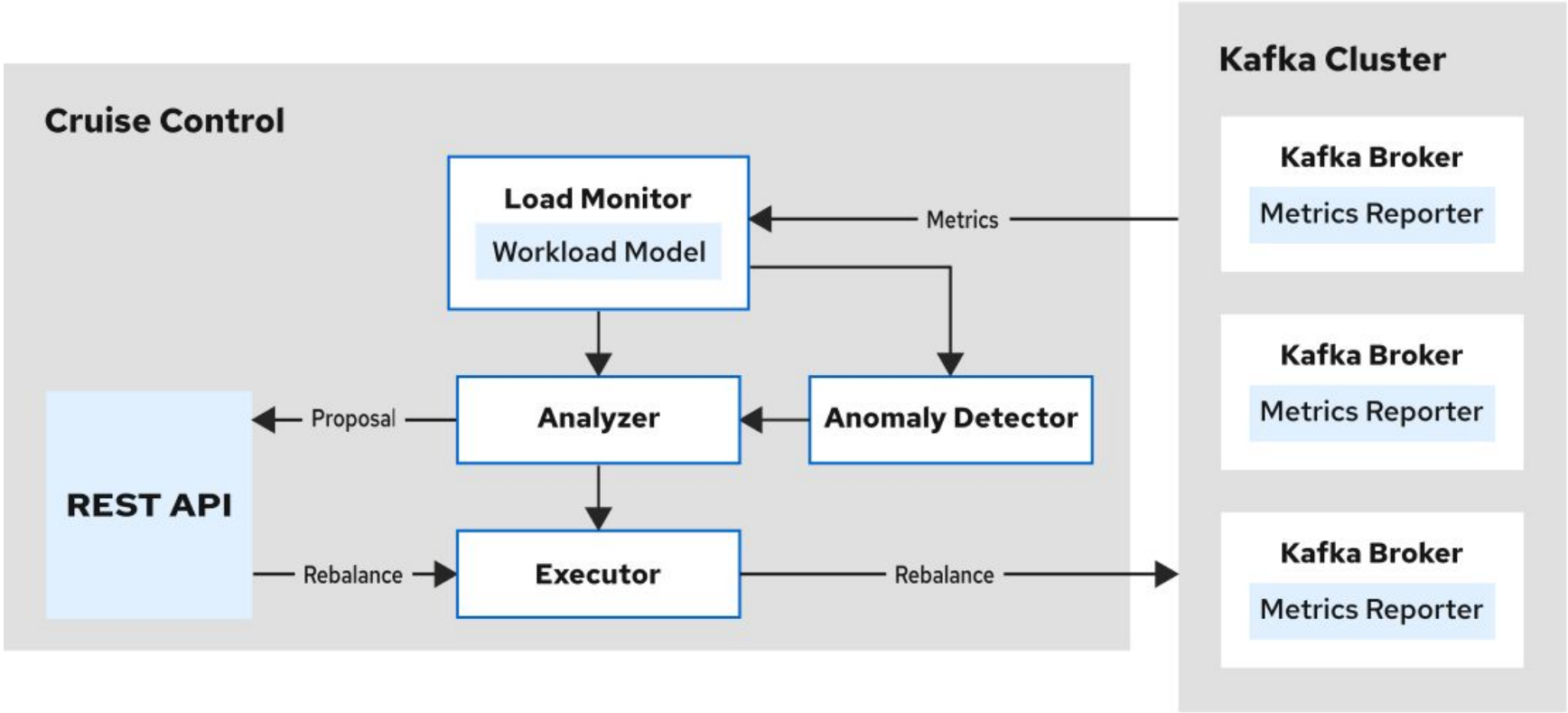
Cruise Control
Load Monitor
Workload Model
Metrics
Analyzer
Anomaly Detector
Proposal
REST API
Rebalance
Executor
Rebalance
Kafka Cluster
Kafka Broker
Metrics Reporter
Kafka Broker
Metrics Reporter
Kafka Broker
Metrics Reporter

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Strimzi's Cruise Control Integration

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Configuration & Deployment

- Cruise Control enabled within the `Kafka` custom resource
- Configured via the `spec.cruiseControl` field
  - Default goals configuration
  - Broker capacity (e.g. network, CPU, storage)
  - Logging, resources, ...
- Run as a separated Deployment
- Brokers configured to use metrics reporter

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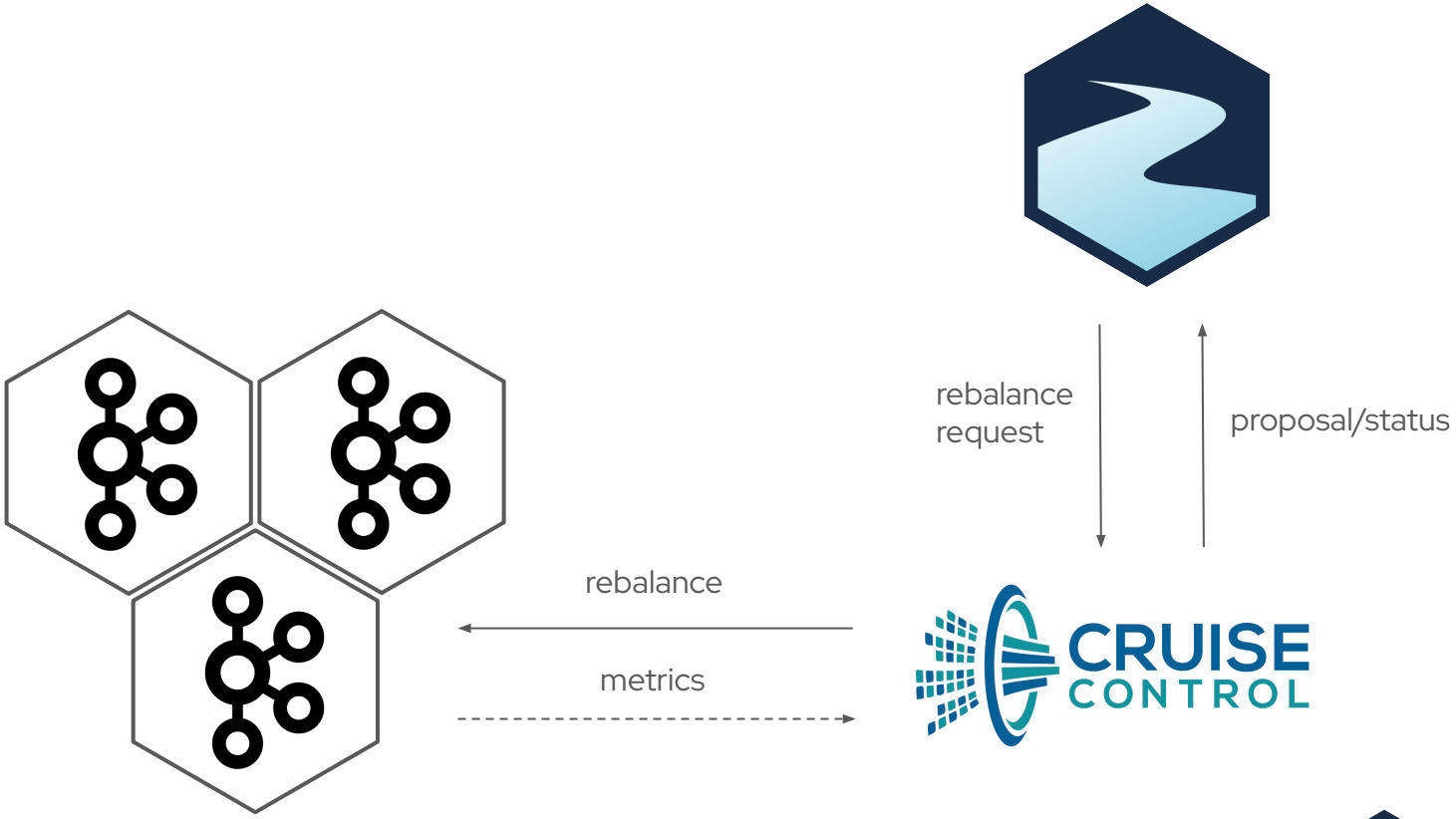
rebalance
request
proposal/status
rebalance
metrics
CRUISE
CONTROL

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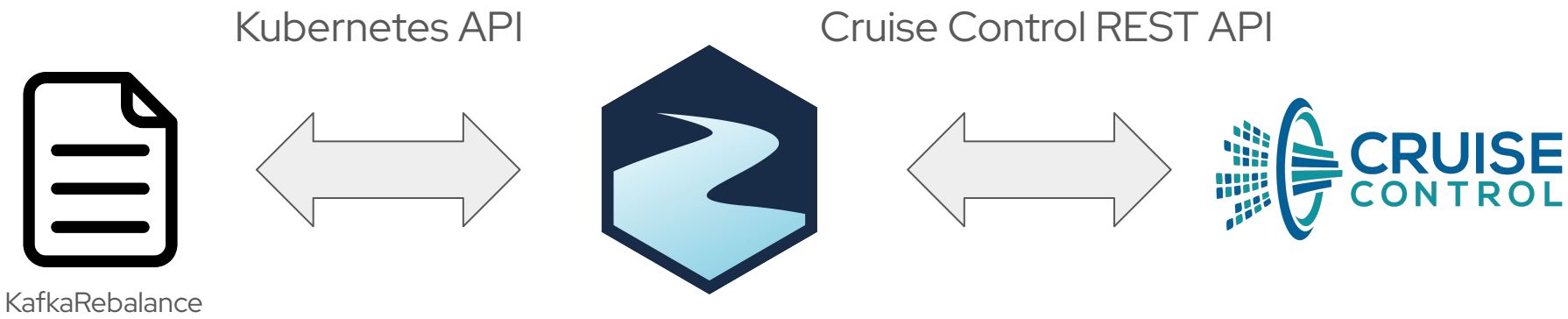
Kube-native rebalancing experience



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User creates a `KafkaRebalance`

```yaml
apiVersion: kafka.strimzi.io/v1beta2
Kind: KafkaRebalance
metadata:
 Name: my-rebalance
 labels:
   strimzi.io/cluster: my-cluster
spec:
 goals:
   - CpuCapacityGoal
   - NetworkInboundCapacityGoal
   - DiskCapacityGoal
   - RackAwareGoal
 mode: full
 replicationThrottle: 100
 # ... and more
```


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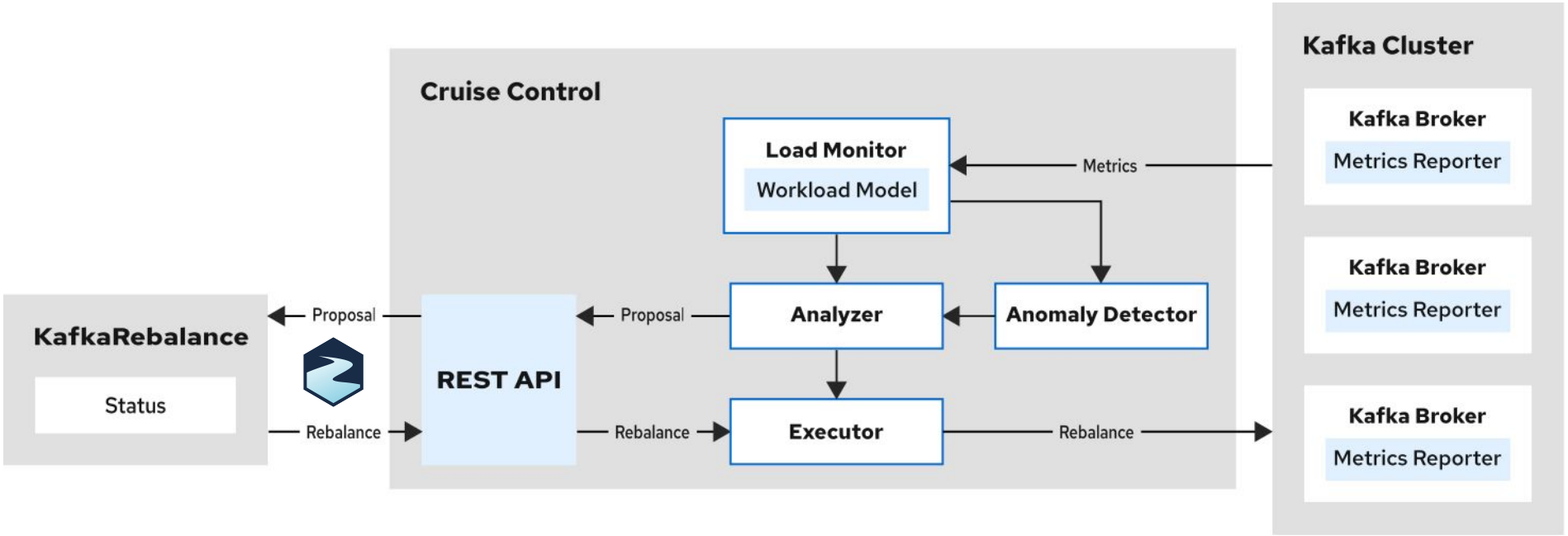
Kafka Cluster
Kafka Broker
Metrics Reporter
Kafka Broker
Metrics Reporter
Kafka Broker
Metrics Reporter
Cruise Control
Load Monitor
Workload Model
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REST API
Executor
Proposal
Proposal
Rebalance
Rebalance
Rebalance
KafkaRebalance
Status

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Cruise Control returns a proposal

```
status:
  conditions:
  - lastTransitionTime: "2025-03-24T03:45:16.824326Z"
    status: "True"
    type: ProposalReady
  optimizationResult:
    dataToMoveMB: 5643
    excludedBrokersForLeadership: []
    excludedBrokersForReplicaMove: []
    excludedTopics: []
    intraBrokerDataToMoveMB: 0
    monitoredPartitionsPercentage: 100
    numIntraBrokerReplicaMovements: 0
    numLeaderMovements: 4
    numReplicaMovements: 67
    onDemandBalancednessScoreAfter: 98
    onDemandBalancednessScoreBefore: 85
    # …
```

Annotation-driven approach

- Use `strimzi.io/rebalance` annotation to:
  - `approve` a proposal
  - `stop` the current proposal generation or ongoing rebalancing
  - `refresh` a proposal
- Use auto-approval mechanism via `strimzi.io/rebalance-auto-approval=true`

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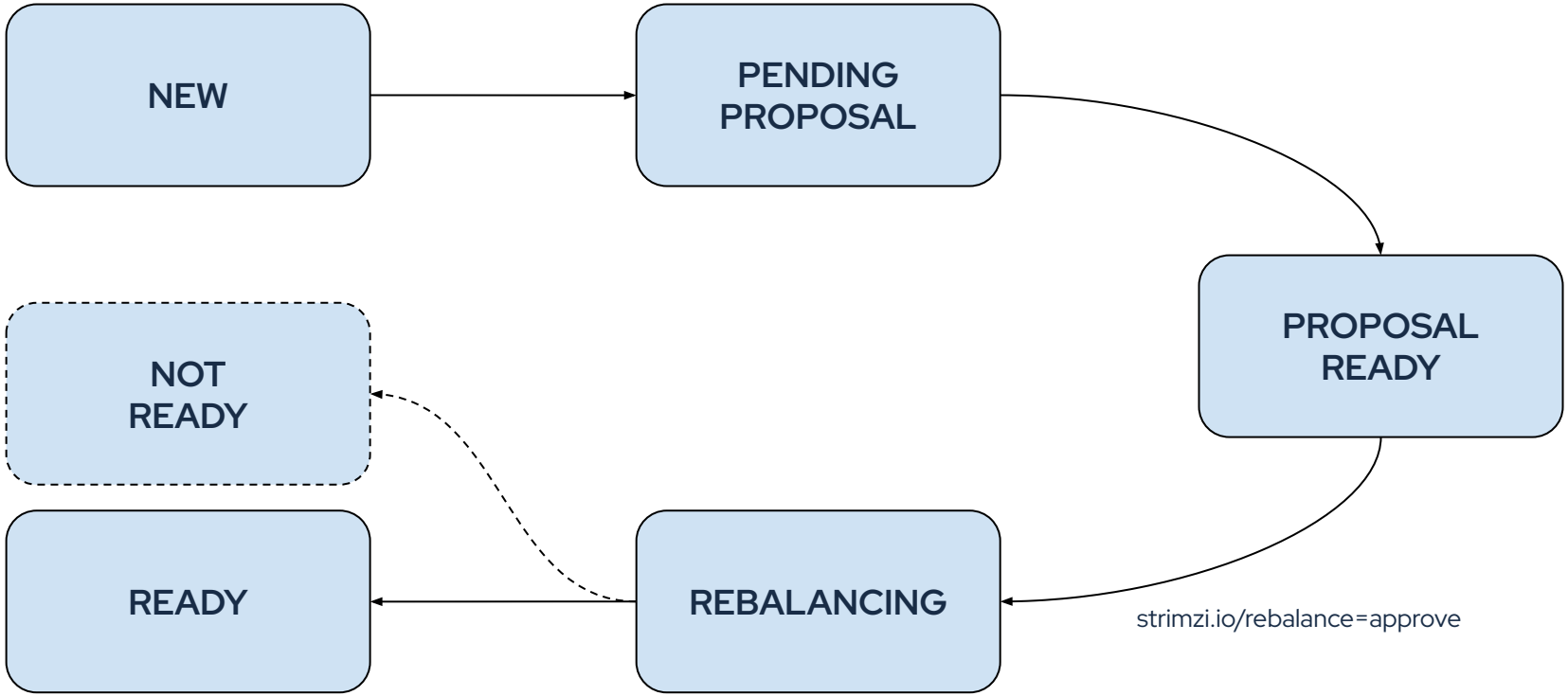
NEW
PENDING PROPOSAL
PROPOSAL READY
NOT READY
READY
REBALANCING
strimzi.io/rebalance=approve

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Rebalancing `mode`(s)

- **`full`** (default)
  - To run a full rebalance across all the brokers in the cluster
- **`add-brokers`**
  - To move replicas across newly created `brokers` after a scaling up
- **`remove-brokers`**
  - To move replicas out of the `brokers` to be removed before doing a scaling down
- **`remove-disks`**
  - To move replicas between JBOD disks used for storage on the same broker

Auto-rebalancing on cluster scaling

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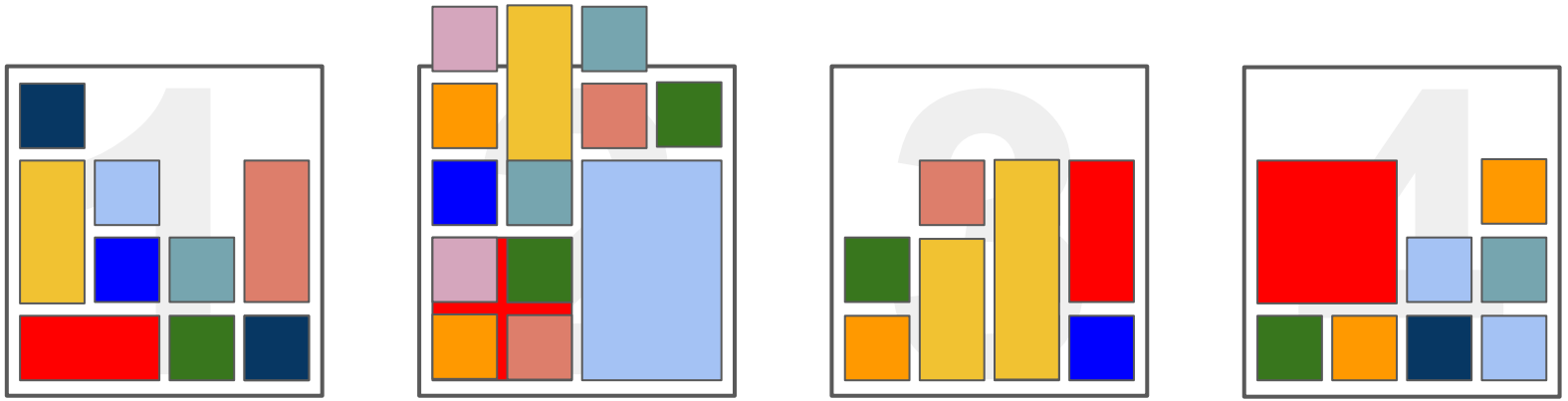
Auto-rebalancing

- Automatically triggers a rebalance when brokers are added or removed
  - Makes it easier to scale the Kafka cluster up or down
  - Moves partition replicas to new brokers after they were added
  - Moves partition replicas from brokers before they are removed
- Rebalancing via a `KafkaRebalance` template

Scale-up



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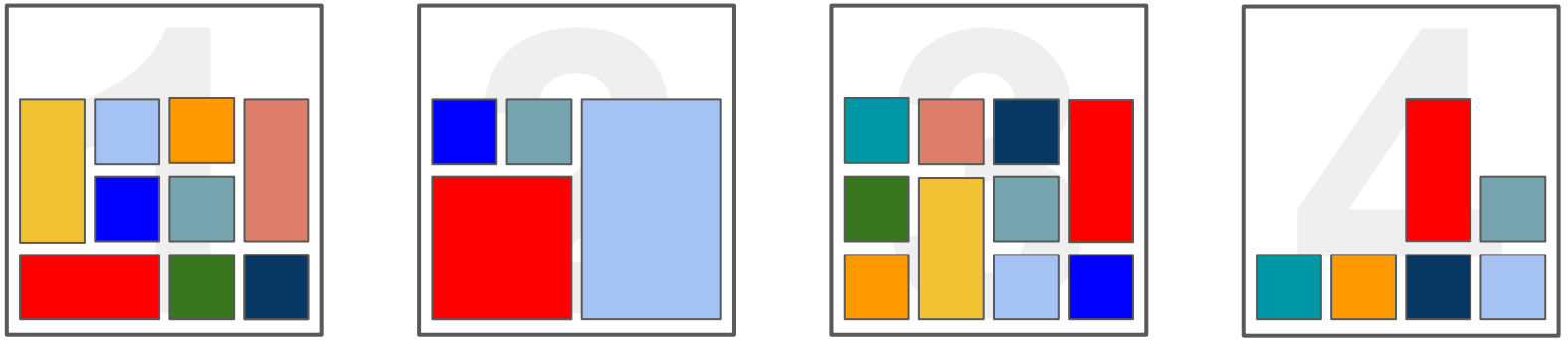
Scale-down



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What's next?

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Kafka cluster self-healing

- Strimzi leverages Cruise Control for cluster rebalancing
  - Manual rebalancing involves the usage of a **`KafkaRebalance`** custom resource
  - Auto-rebalancing helps only on scaling the cluster up or down
- Plan to integrate the Cruise Control self-healing feature
  - Anomaly detectors to detect broker or disk failures, goal violation, topic anomalies and more
  - Anomalies being notified and fixed where possible

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https://strimzi.io/join-us/

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Do you want more about Strimzi?

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Other talks

- Strimzi: What's New and What's Next
  - Project lightning talks, Wed 1st April 15:46 BST
- Simplifying Apache Kafka on Kubernetes with Strimzi
  - Maintainer Track, Wed 2nd April 15:15 BST

Thank you

 Website: https://strimzi.io

 GitHub: https://github.com/strimzi

 Twitter: @strimziio

 YouTube: https://youtube.com/c/Strimzi

 LinkedIn: https://www.linkedin.com/company/strimzi

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