KAFKA SUMMIT
LONDON 2023

Dataflows for machine learning operations

Andrei Paleyes and Alex Rakowski

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Part I – Dataflow and Streams

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What is ML@CL group?

Machine
Learning
@
Computer
Lab

ML@CL

UNIVERSITY OF CAMBRIDGE

Dataflow research at ML@CL

Towards better data discovery and collection with flow-based programming

Christian Cabrera

RESEARCH-ARTICLE OPEN ACCESS

Causal fault localisation in dataflow systems

Authors: Andrei Paleyes, Neil David Lawrence Authors Info & Claims

EuroMLSys '23: Proceedings of the 3rd Workshop on Machine Learning and Sy

140–147 • https://doi.org/10.1145/3578356.3592593

RESEARCH-ARTICLE OPEN ACCESS

An empirical evaluation of flow based programming in the machine learning deployment context

Authors: Andrei Paleyes, Christian Cabrera, Neil D. Lawrence Authors Info & Claims

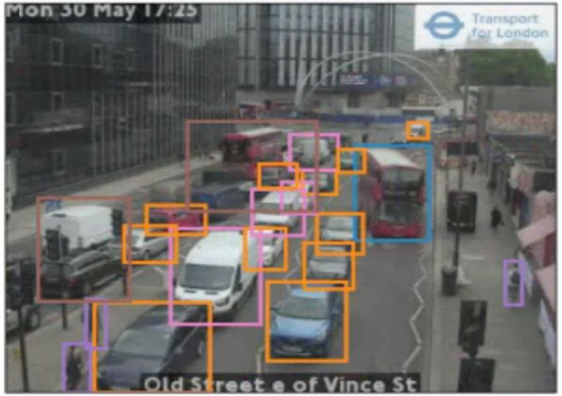
CAIN '22: Proceedings of the 1st International Conference on AI Engineering: Software Engineering for AI • May 2022 • Pages

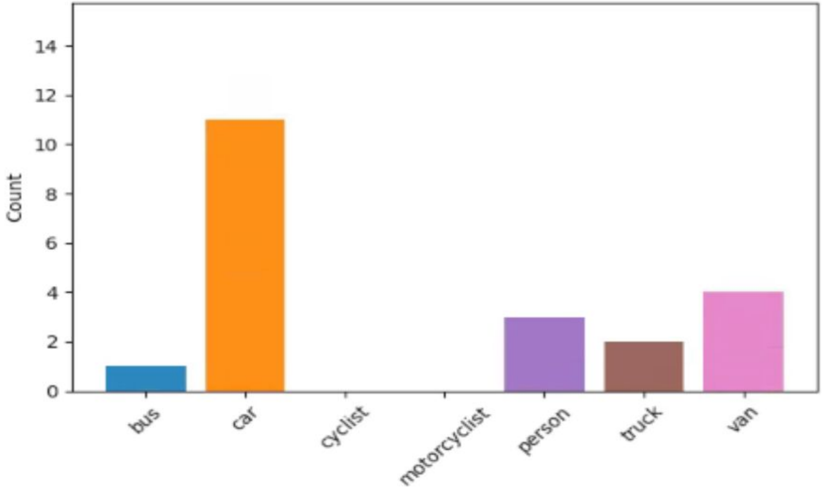
Dataflow graphs as complete causal graphs

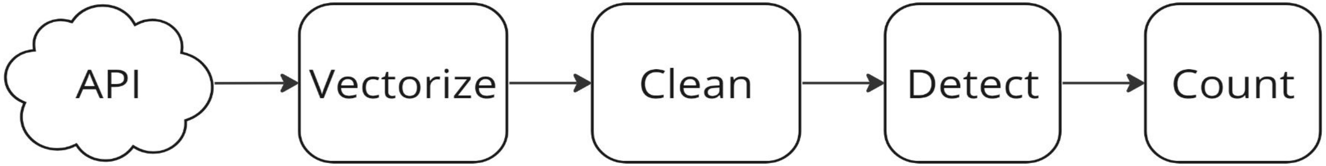
Andrei Paleyes*[1], Siyuan Guo*[12], Bernhard Schölkopf[2], Neil D. Lawrence[1]
[1]Department of Computer Science and Technology, University of Cambridge
[2]Max Planck Institute for Intelligent Systems

Open Source: Seldon Core

Inference graph

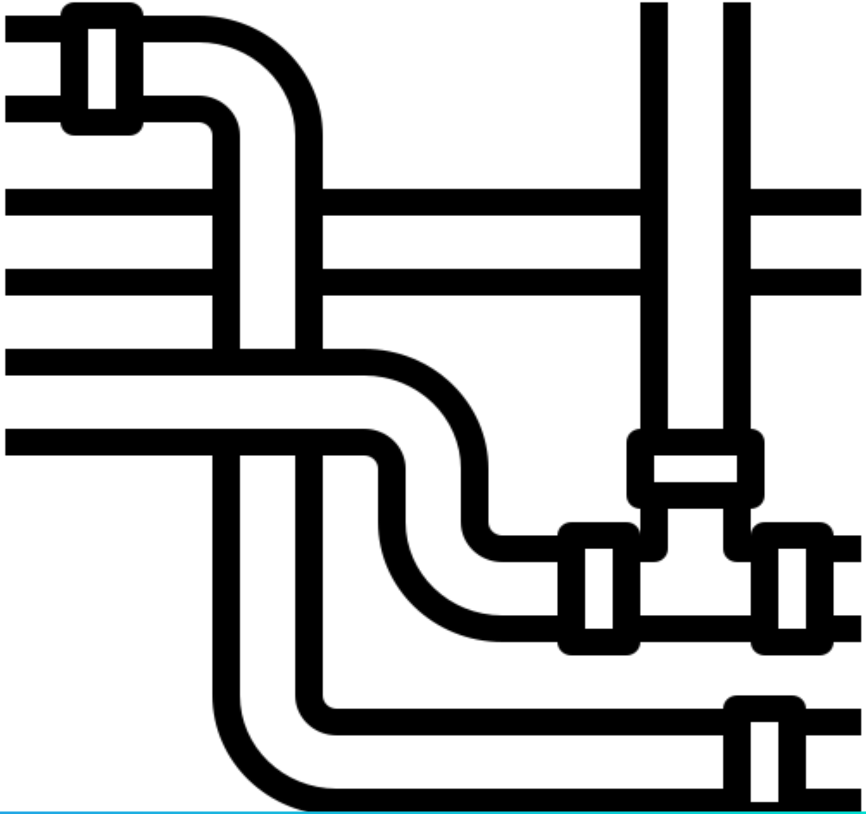




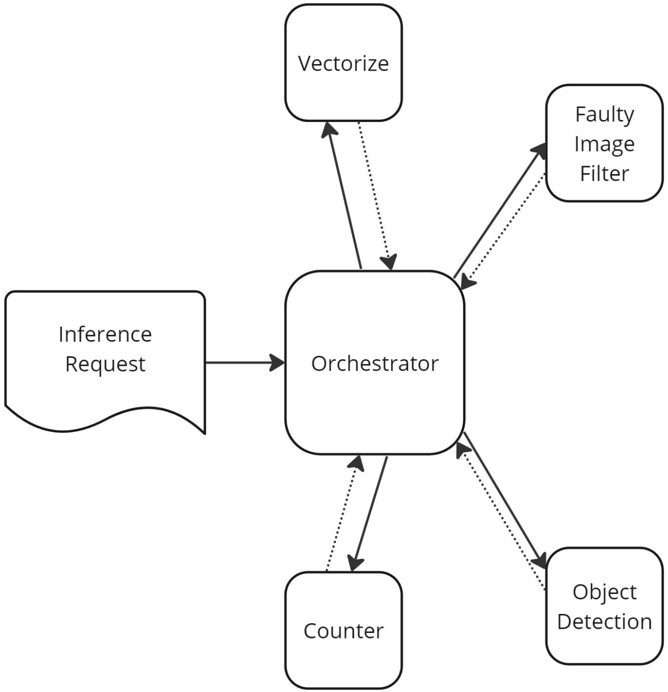


Pipelines

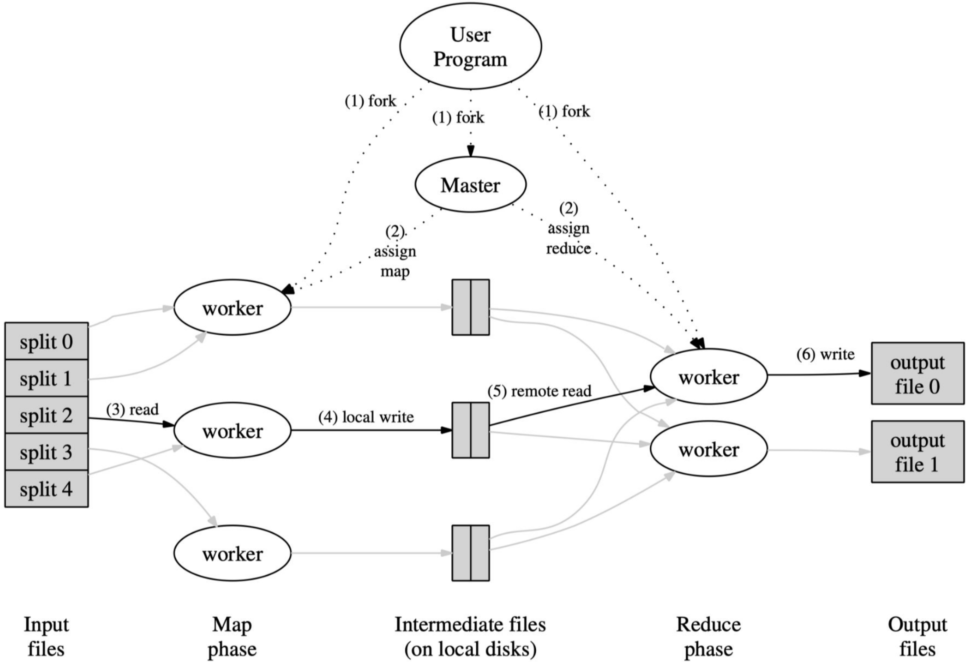
```
apiVersion: mlops.seldon.io/v1alpha1
kind: Pipeline
metadata:
 name: road-counter
spec:
 steps:
   - name: vectorize
   - name: faulty_image_filter
     inputs:
     - vectorize.outputs
   - name: object_detection
     inputs:
     - vectorize.outputs
     - faulty_image_filter.outputs
. . . . .
 output:
   steps:
   - counter
```



Core V1 - Central orchestration



Dataflow architecture

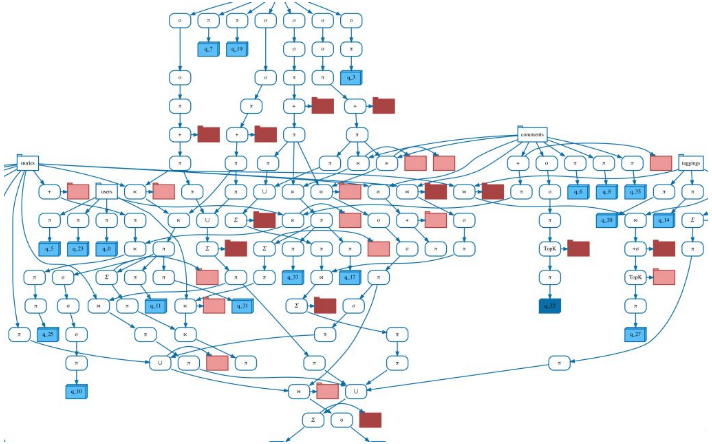


Dean, J. & Ghemawat, S. (2008). MapReduce: simplified data processing on large clusters. Communications of the ACM, 51(1), 107-113.

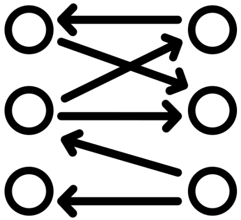
Dataflow vs control flow

“In control flow, the processor follows explicit order, executing instructions one after another. In **dataflow**, by contrast, an instruction is ready to execute as soon as all its inputs are available.”

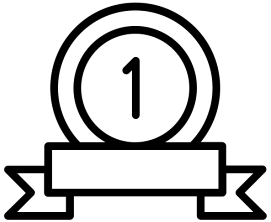
M. Schwarzkopf, *The Remarkable Utility of Dataflow Computing*



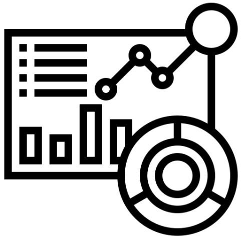
Dataflow features



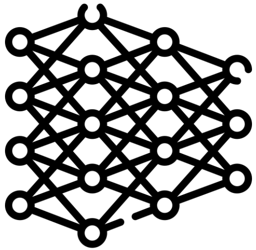
Separation of data and operations



Data as a first class citizen

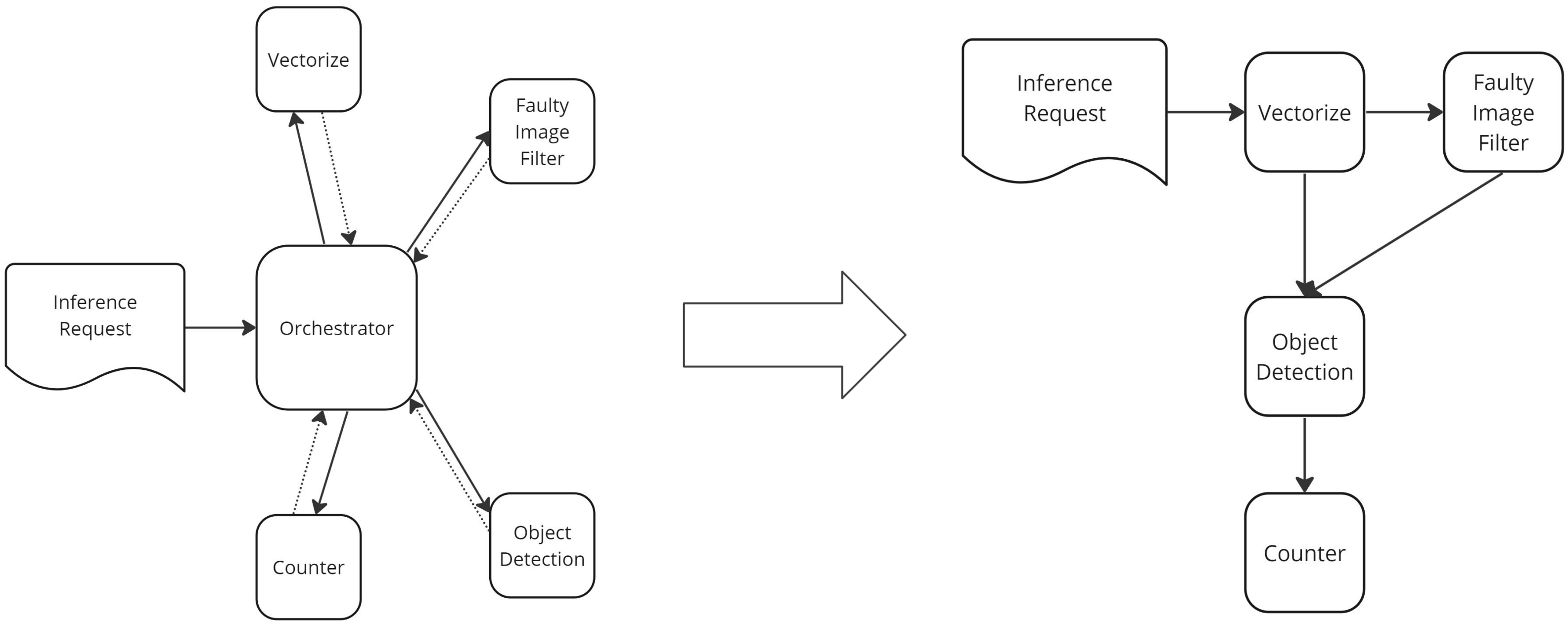


Dataflow graph of the entire system

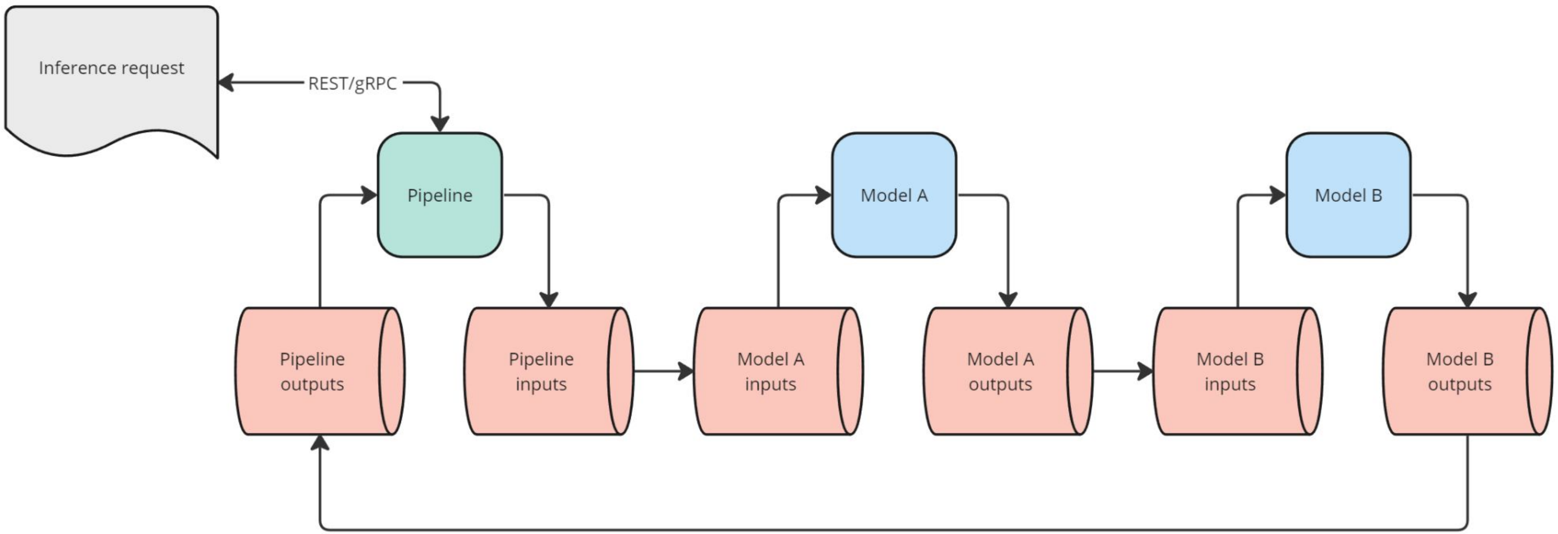


Decentralisation

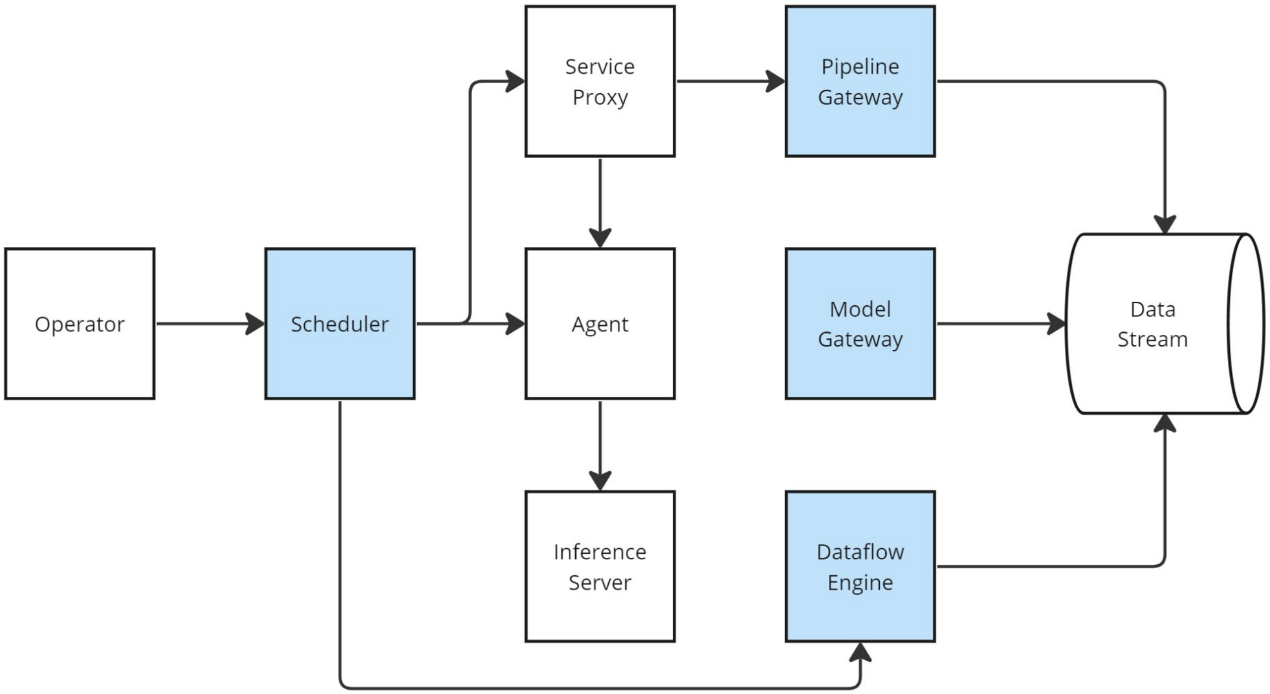
Dataflow and inference graph



Role of streaming in dataflow



Control plane



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Part II – Implementation

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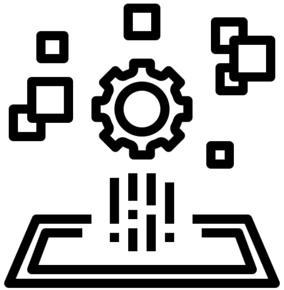
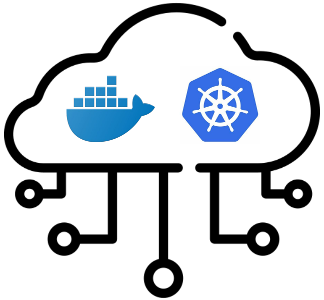
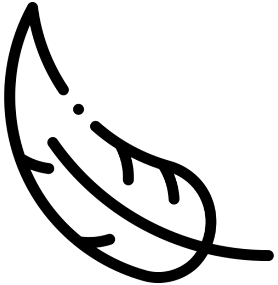
Tech Stack — Constraints



OSS



Platform agnostic



Lightweight

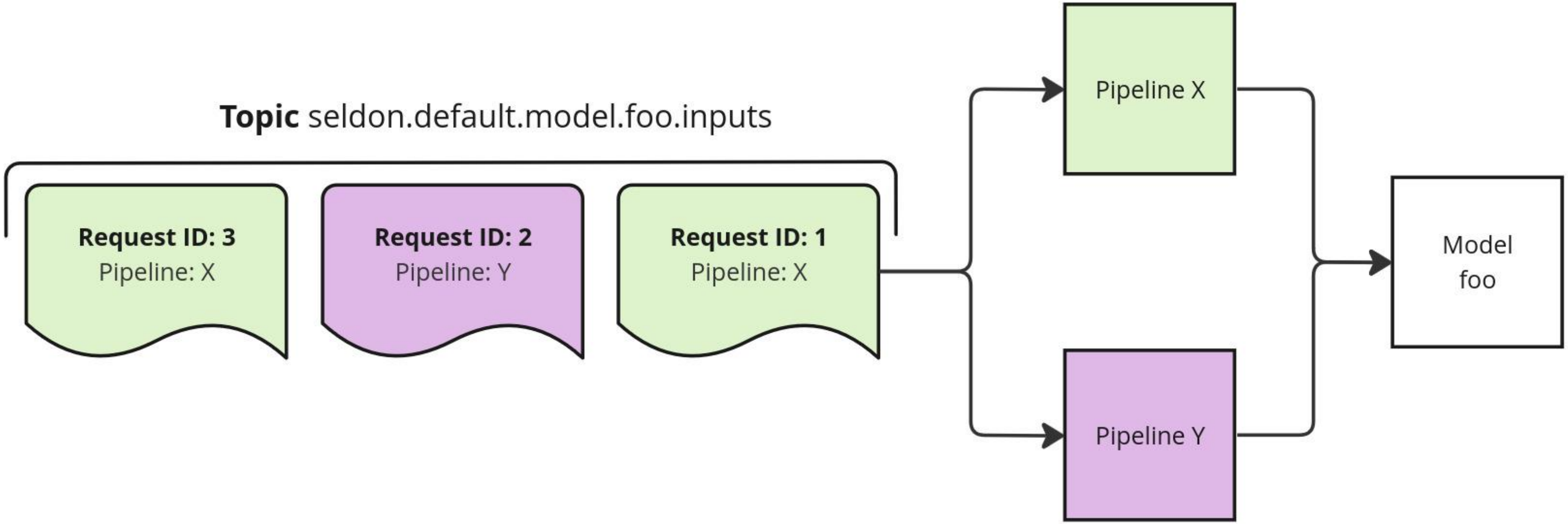
Tech Stack — Contenders

kafka

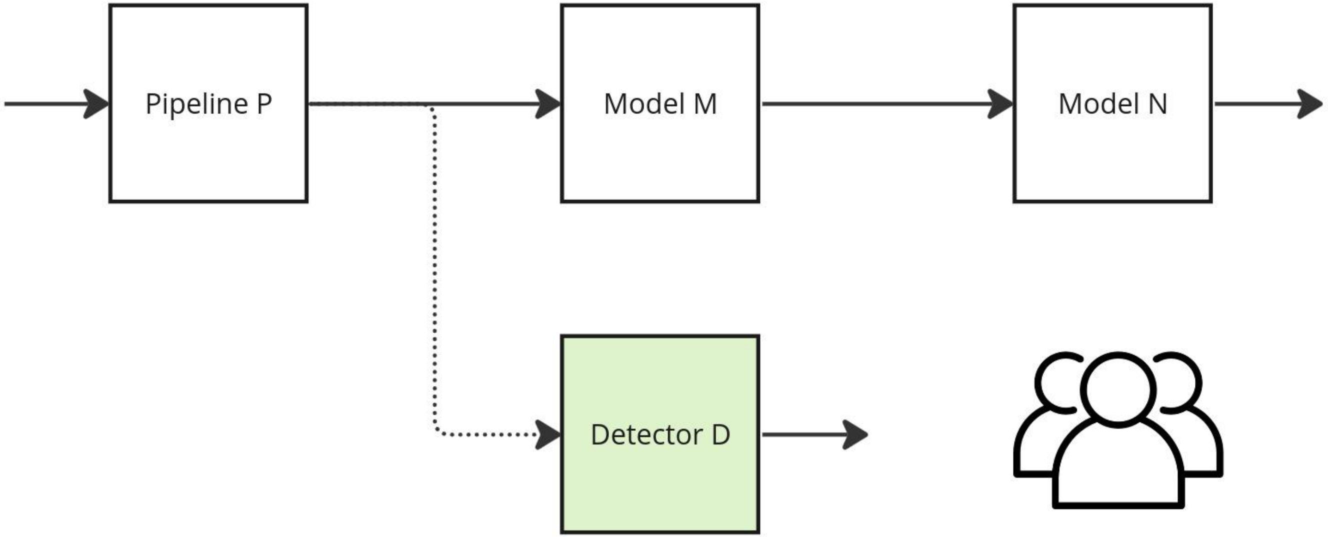
RabbitMQ

Flink

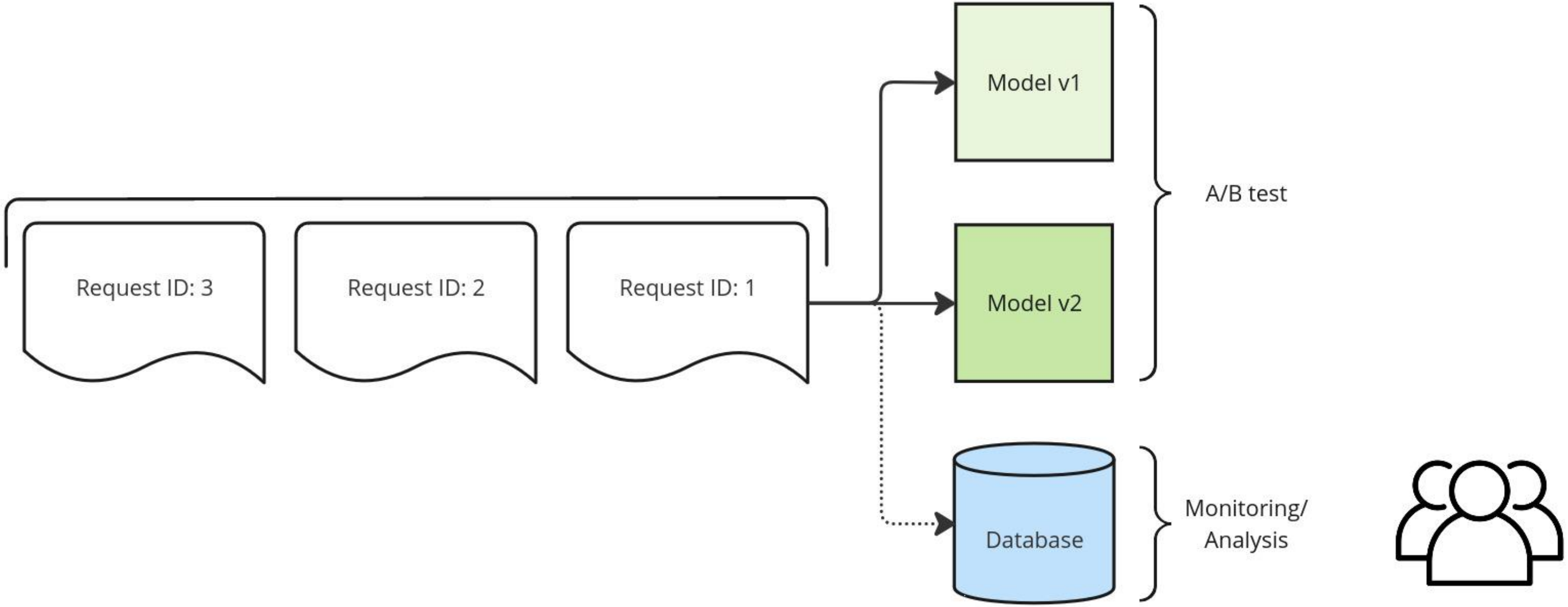
Pub/Sub – Multiplexing Pipelines



Pub/Sub – Extending Pipelines



Pub/Sub – Repeatable Streams



Tech Stack — Choices

```
fun <T> KStream<T, TRecord>.filterForPipeline(pipelineName: String): KStream<T, TRecord> {
    return this
        .transformValues(ValueTransformerSupplier { PipelineNameFilter(pipelineName) })
        .filterNot { _, value -> value == null }
}
```

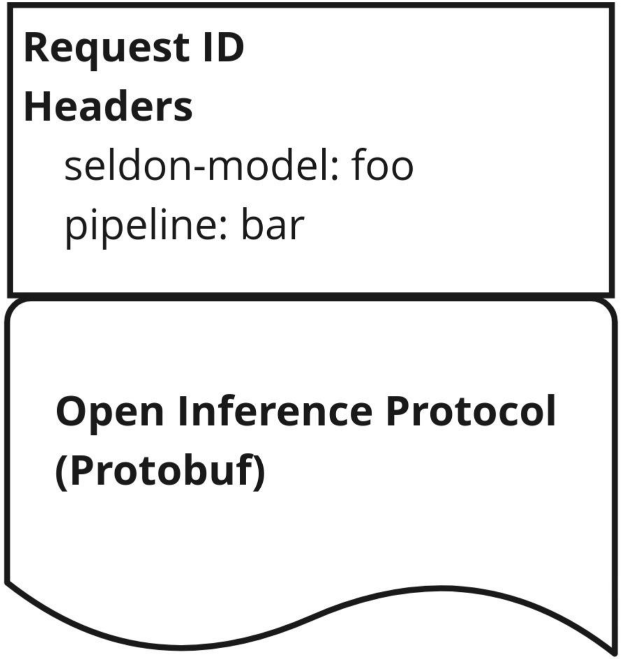
```
private fun buildInputInputStream(builder: StreamsBuilder) {
    val s1 = builder
        .stream(inputTopic.topicName, consumerSerde)
        .filterForPipeline(inputTopic.pipelineName)
        .unmarshallInferenceV2Request()
        .filterRequests(inputTopic.pipelineName, inputTopic.topicName, tensors, tensorRenaming)
        // handle cases where there are no tensors we want
        .filter { _, value -> value.inputsList.size != 0 }
        .batchMessages(batchProperties)
        .marshallInferenceV2Request()
```

Anatomy of a Topic Name

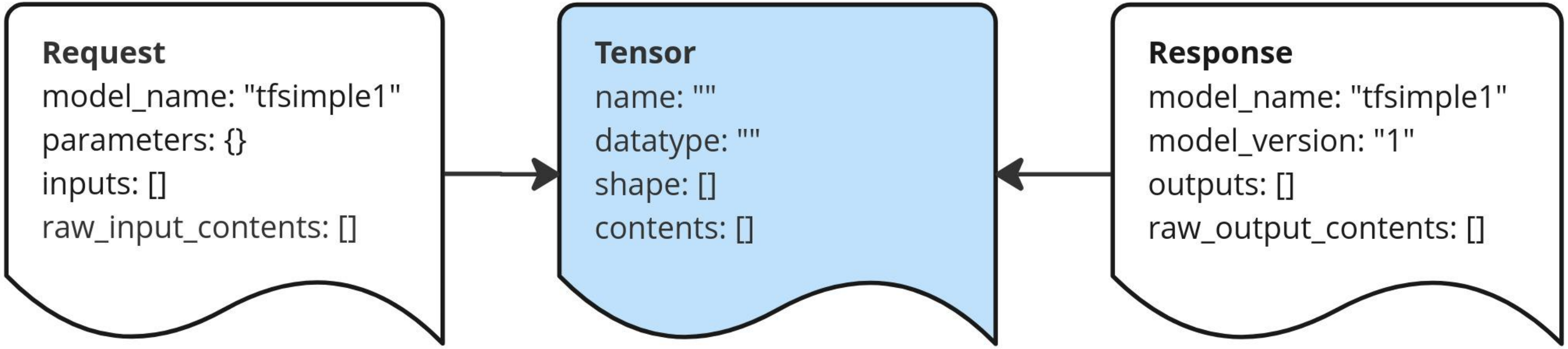
```
<prefix>.<namespace>.<pipeline|model>.<name>.<inputs|outputs>
    seldon.default.pipeline.foo.inputs
    seldon.recommendations.model.bar.outputs

<prefix>.<namespace>.errors.errors
    ml.default.errors.errors
```

Anatomy of an Inference Message



Open Inference Protocol



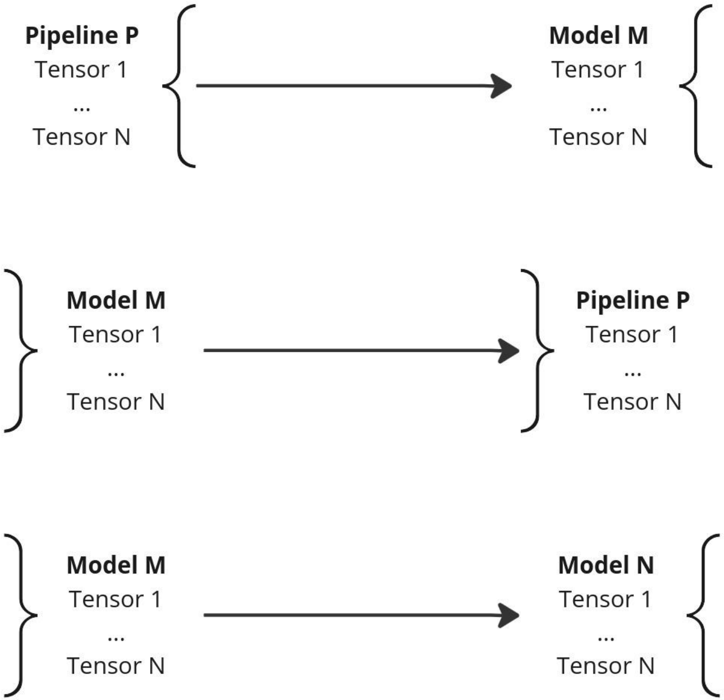
Open Inference Protocol – Batching

Tensor

shape: [BATCH_SIZE, ...]

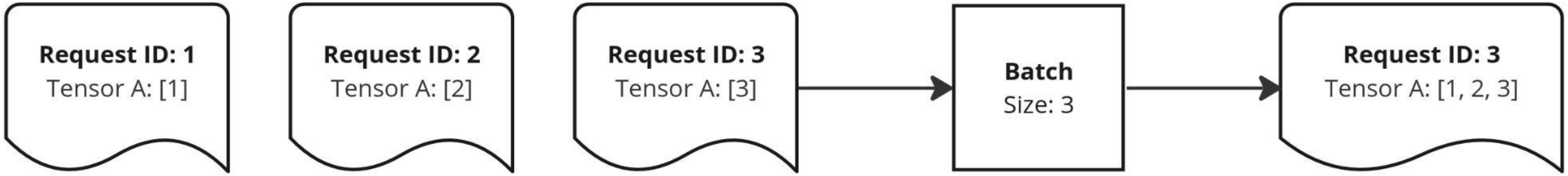
...

Dataflow Operations – Topic Chaining

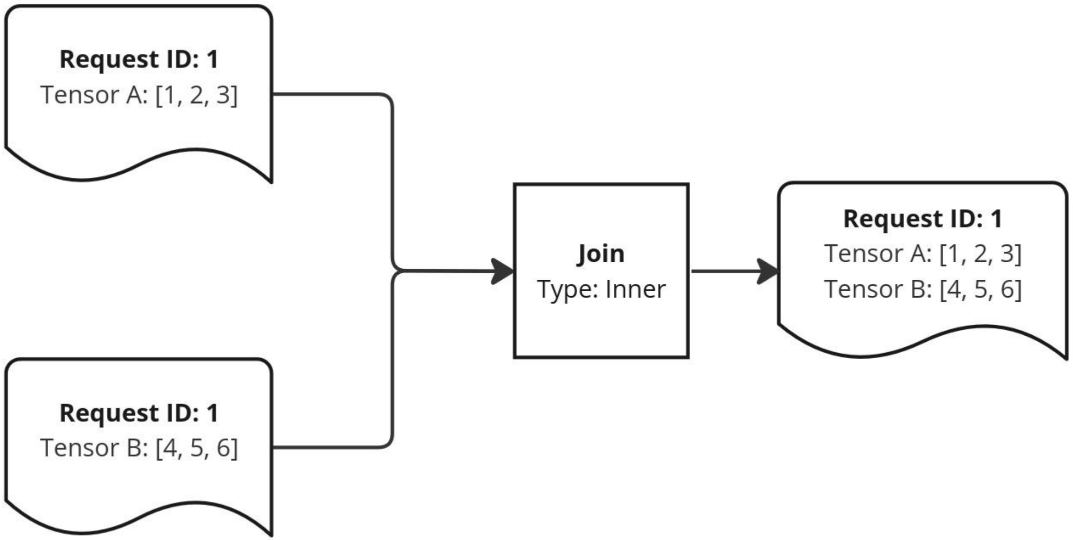


Dataflow Operations – Tensor Projection

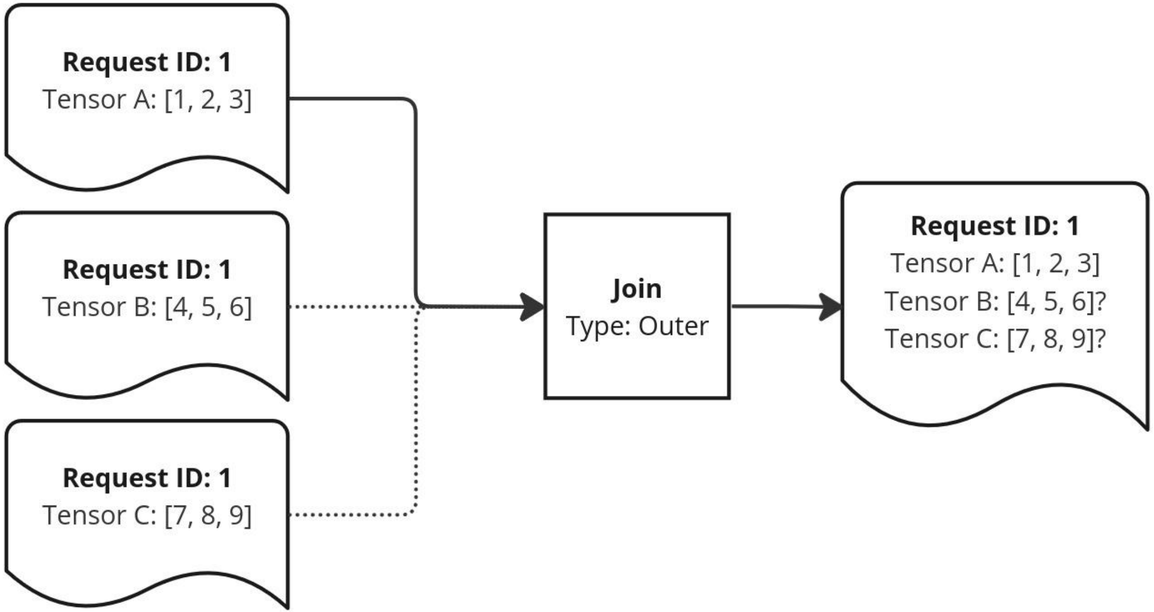
Dataflow Operations – Batching



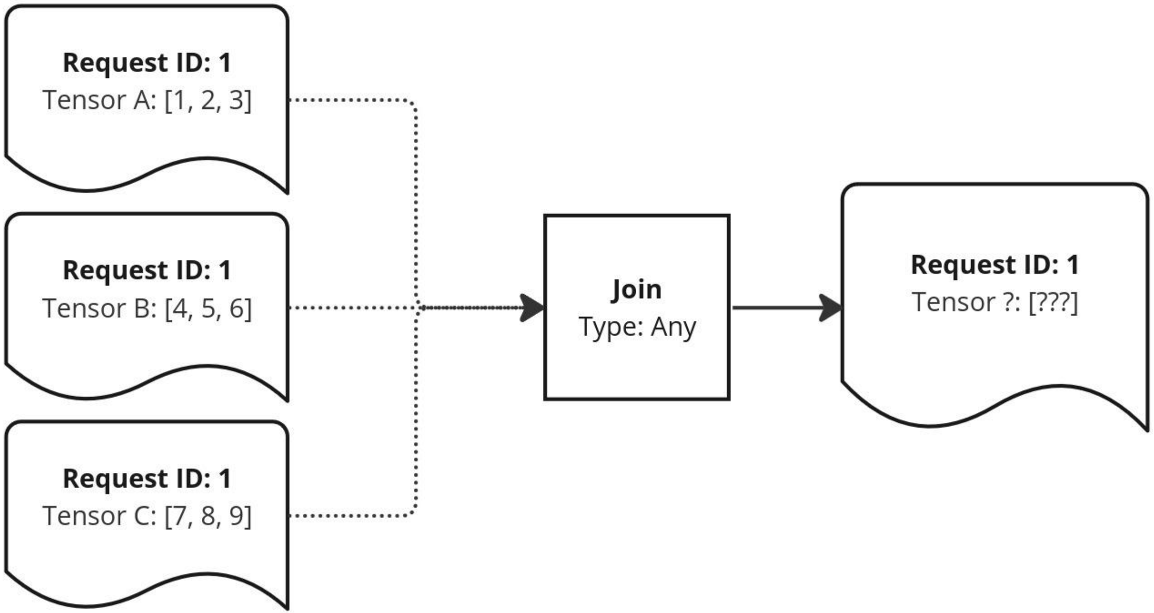
Dataflow Operations – Inner Join



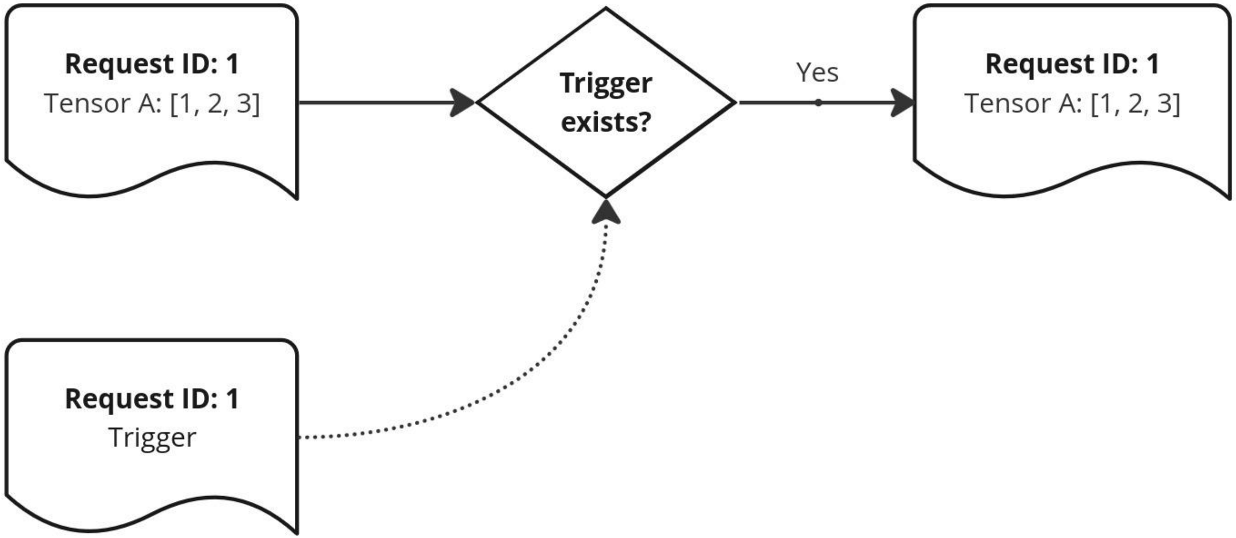
Dataflow Operations – Outer Join



Dataflow Operations – Any Join



Dataflow Operations – Triggers



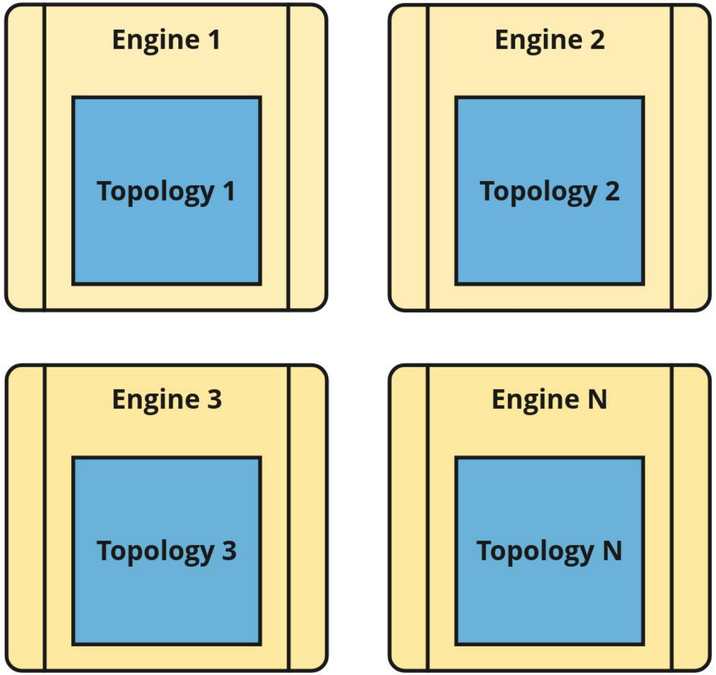
Topologies

Core v2 Pipeline = KStream Topology

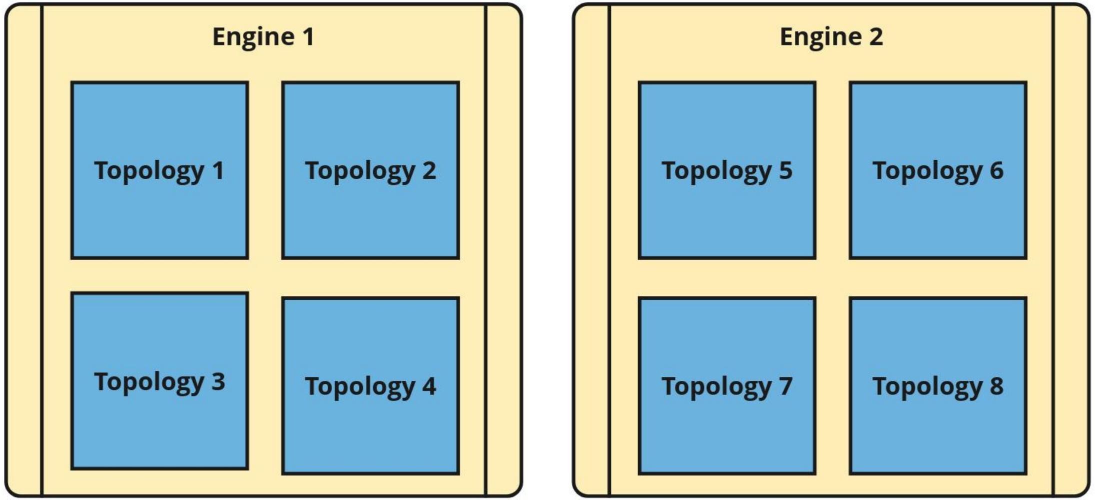
```yaml
apiVersion: mlops.seldon.io/v1alpha1
kind: Pipeline
metadata:
 name: road-counter
spec:
 steps:
   - name: vectorize
   - name: faulty_image_filter
     inputs:
     - vectorize.outputs
   - name: object_detection
     inputs:
     - vectorize.outputs
     - faulty_image_filter.outputs
...
```

```kotlin
val builder = StreamsBuilder()
builder
       .stream(inputTopic.topicName, consumerSerde)
       .filterForPipeline(inputTopic.pipelineName)
...
val topology = builder.build()
```

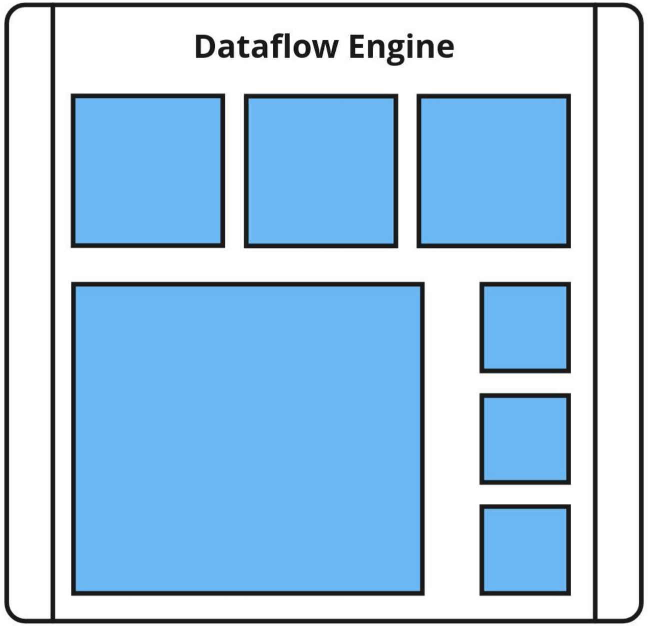
Pipeline Allocation – 1 Topology = 1 Engine



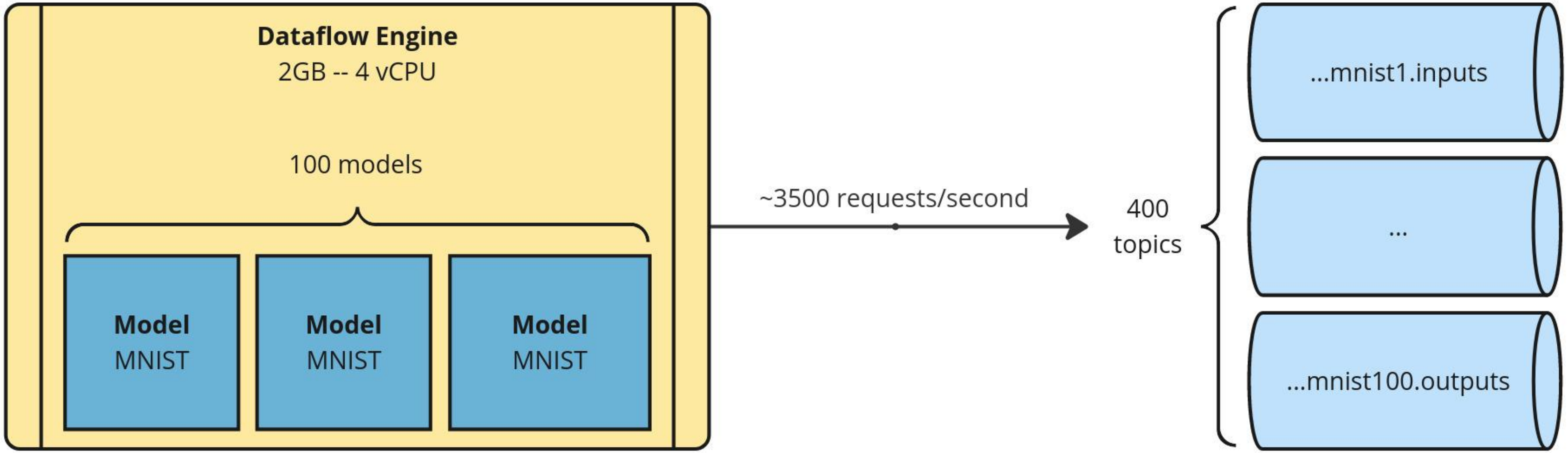
Pipeline Allocation – Shared Engines



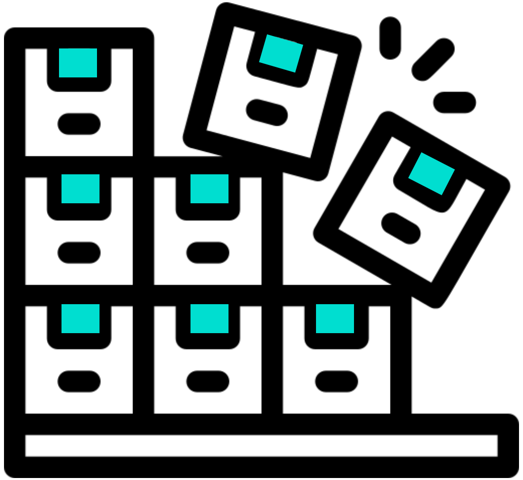
Pipeline Allocation — Threads



How Many Is Too Many?



How Many Is Too Many?

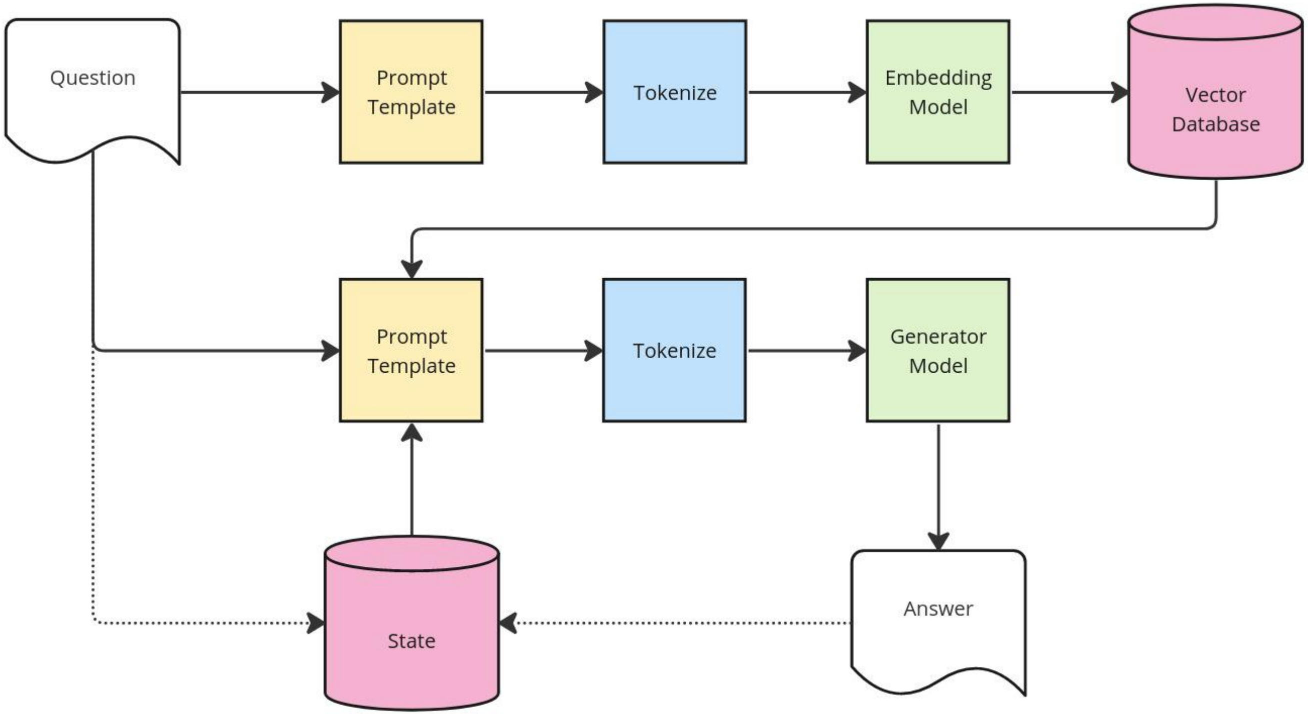


[KSQL Limitations in Confluent Cloud]

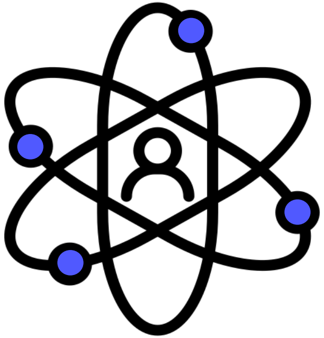
[Kafka Summit 2022 - Modular Topologies]

[KIP-809 (Modular Topologies)]

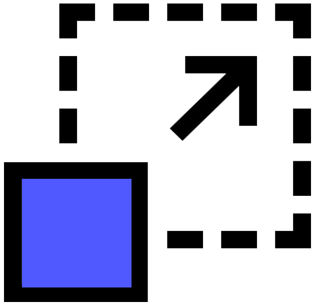
Advanced ML Applications



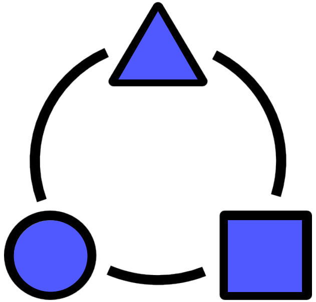
Challenges



Dynamism

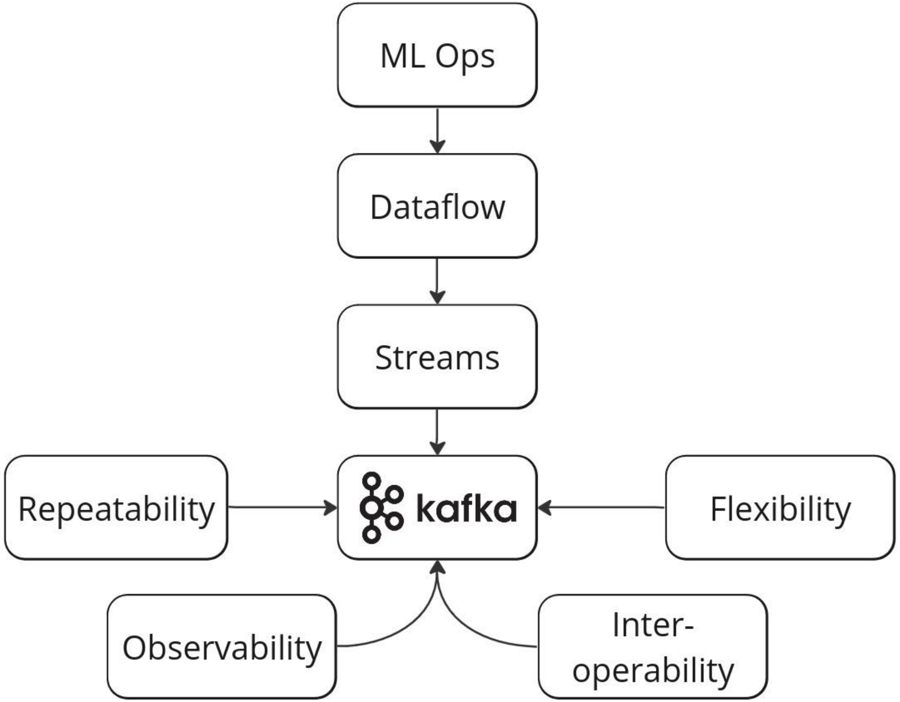


Scalability



Variety

Thanks for listening!



The Seldon Core v2 Team

Core v2 on GitHub

SCAN ME

Team

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CTO

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Machine Learning Engineer

Adrian Gonzalez-Martin
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Alex Rakowski
Software Engineer

Andrei Paleyes
MLOps Researcher

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