Shared abstraction: multi-dimensional geo-temporal

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- Stateful processing. E.g.,

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State

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State per key

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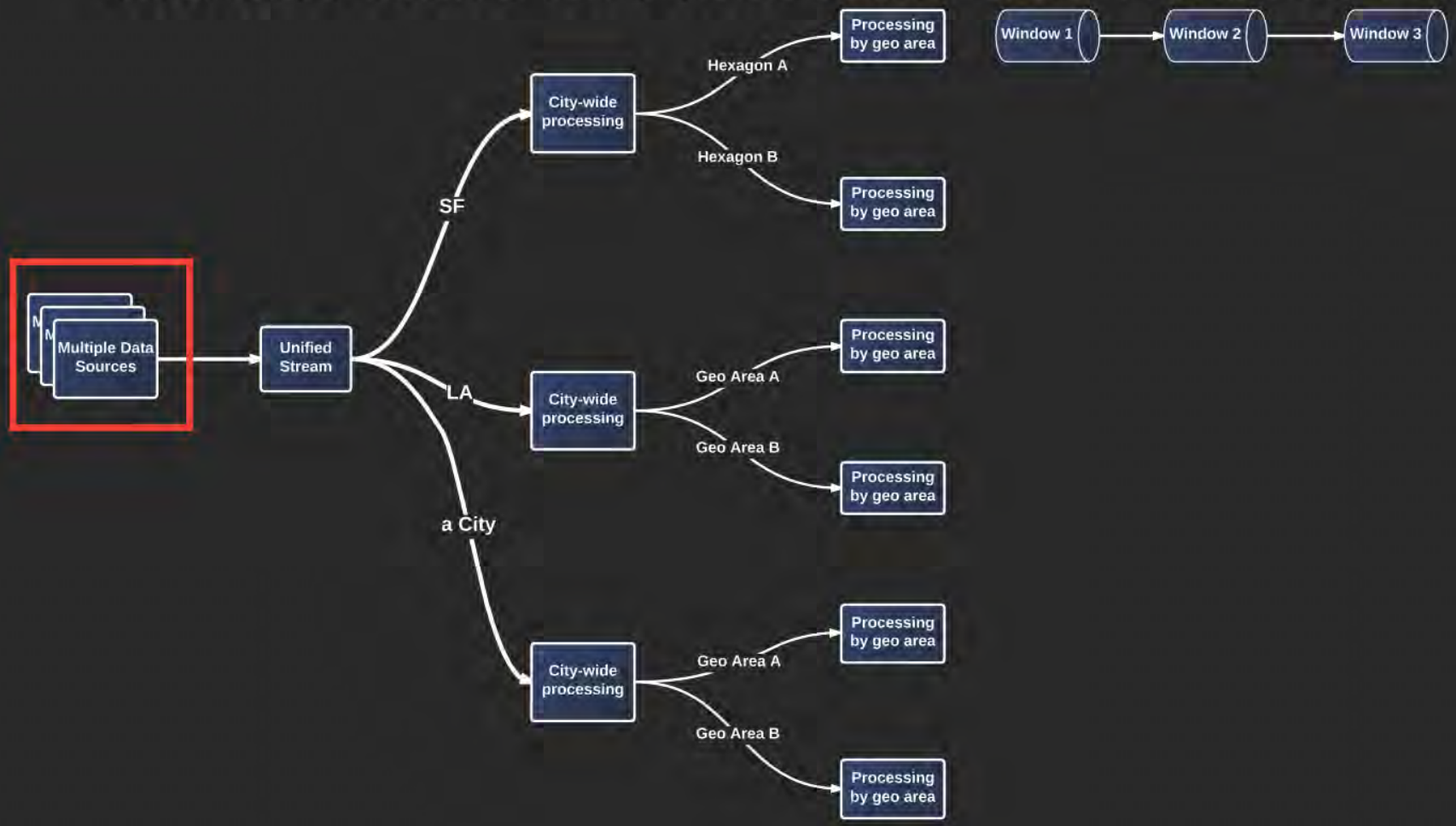
Apache Flink

- Ordering by event time
- Flexible windowing with watermark and triggers
- Exactly-once semantics
- Built-in state management and checkpointing
- Nice data flow APIs

Mental Picture for Processing Geo-temporal Data



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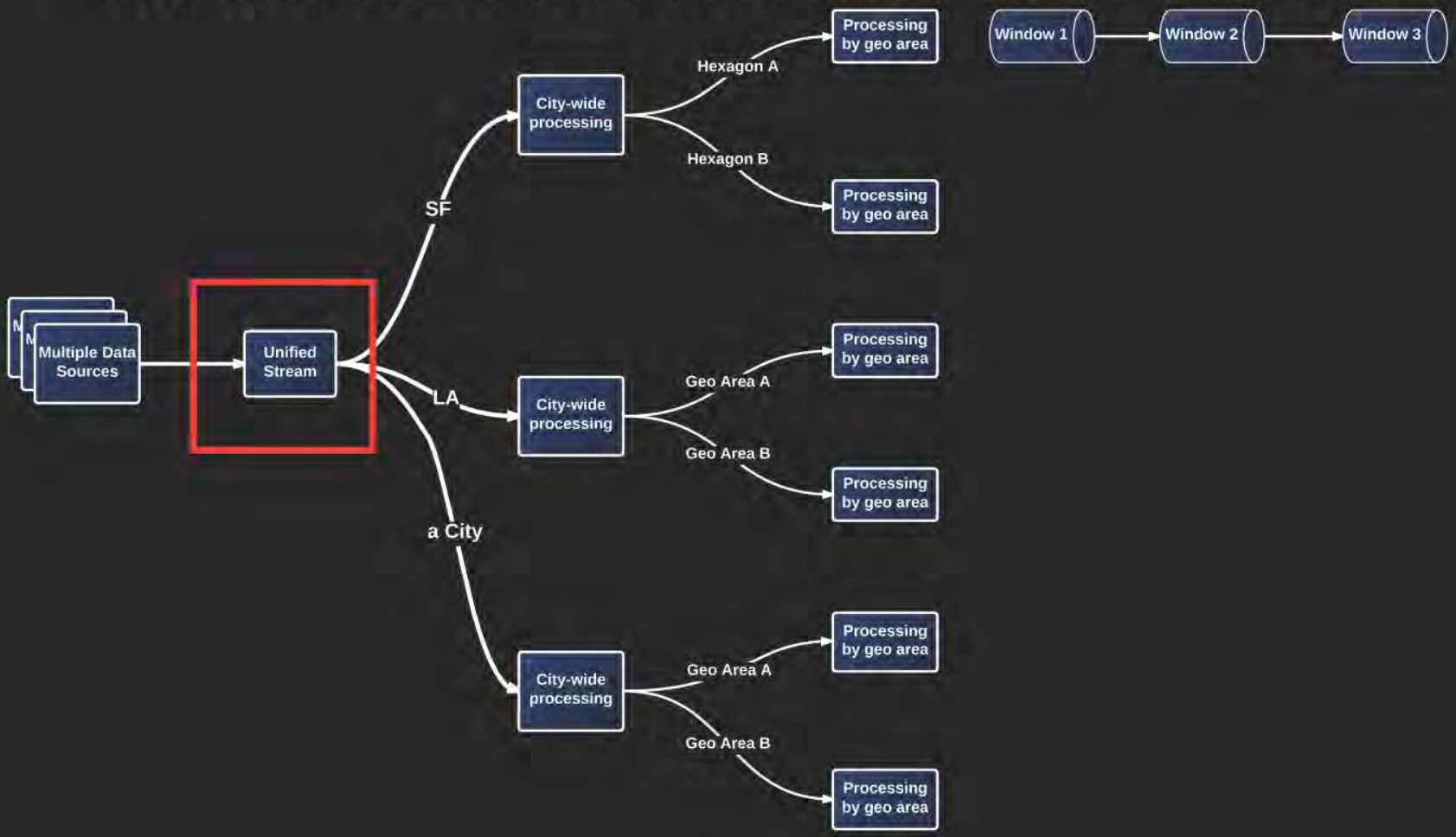

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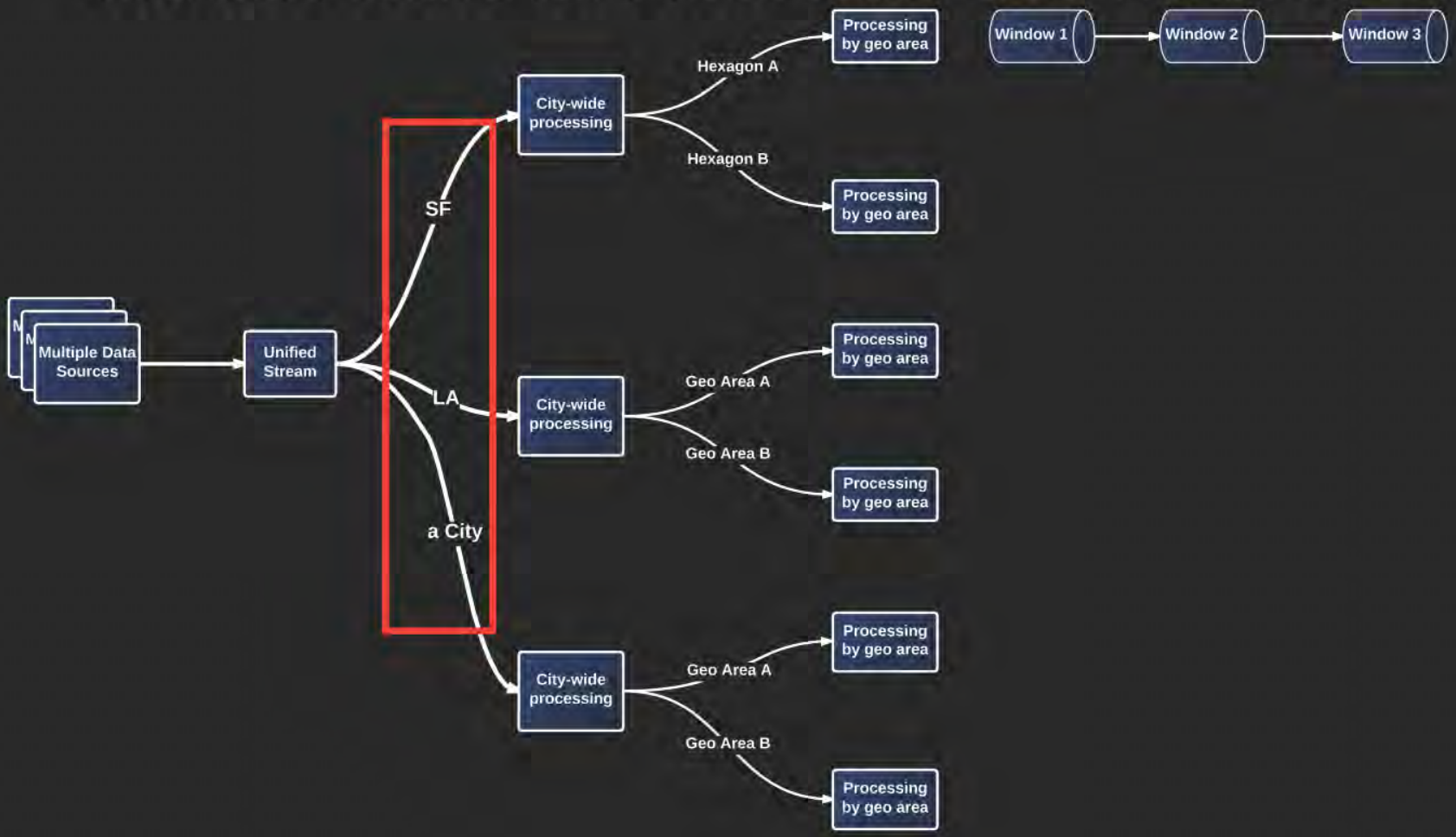
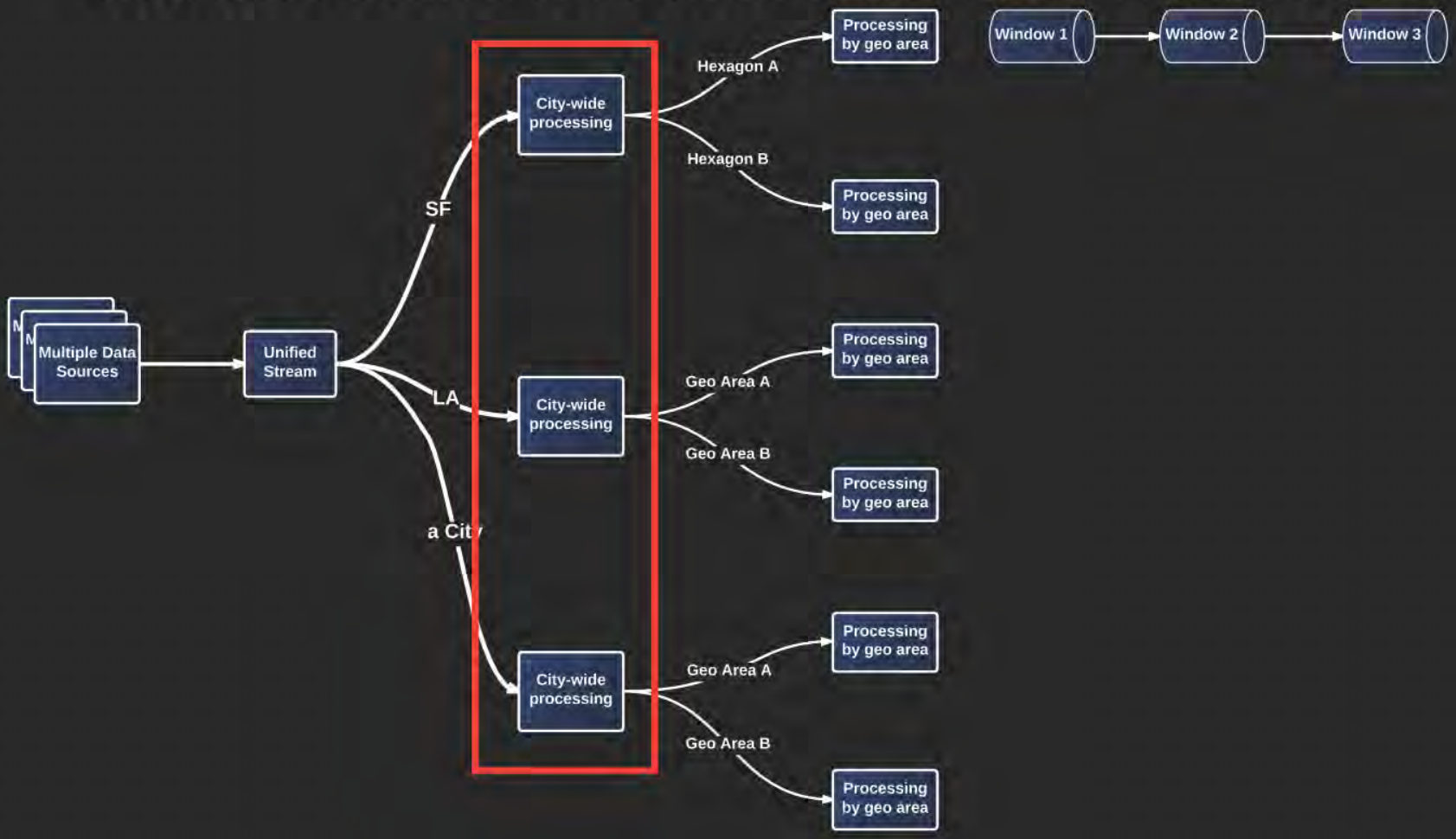
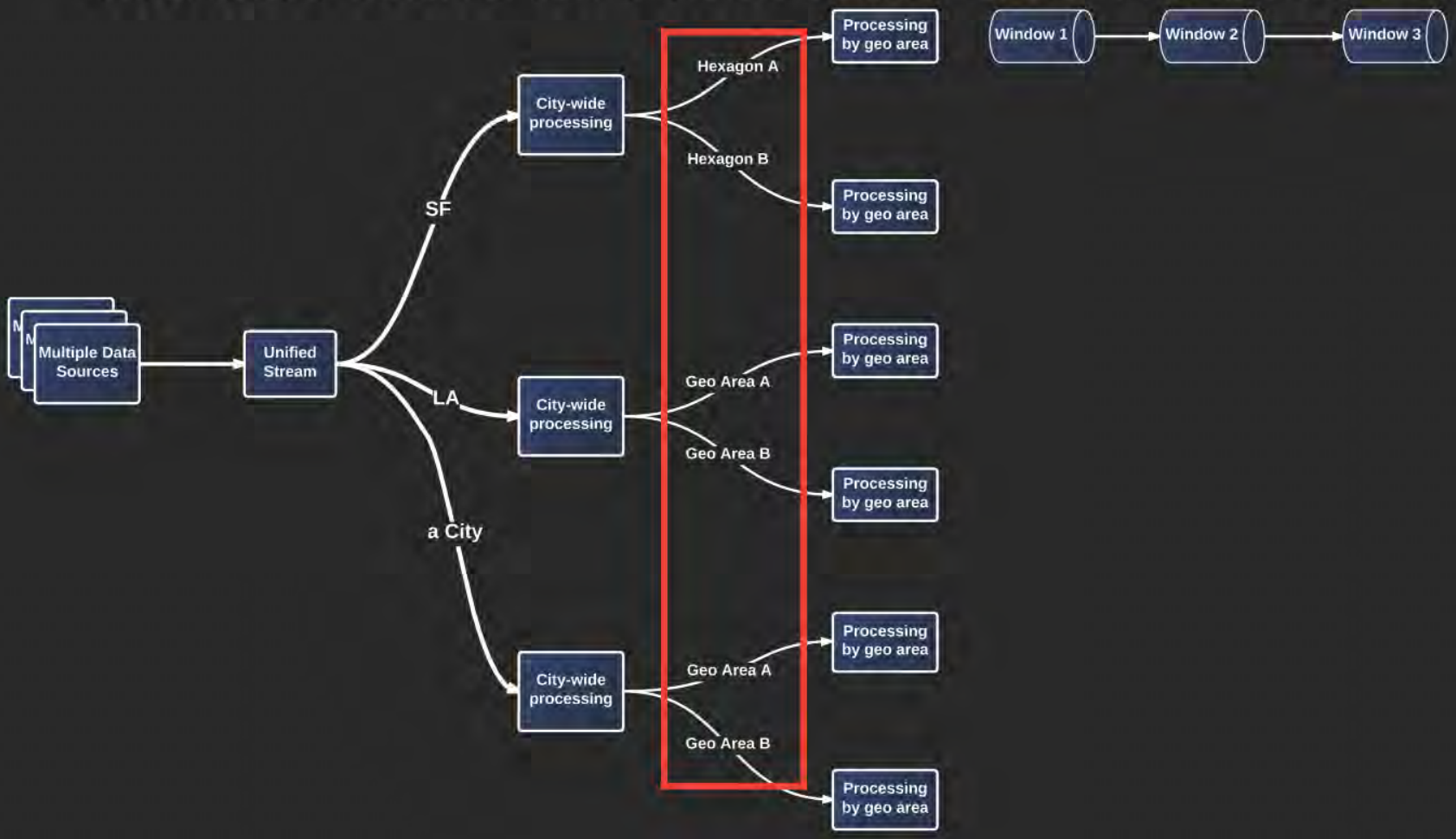


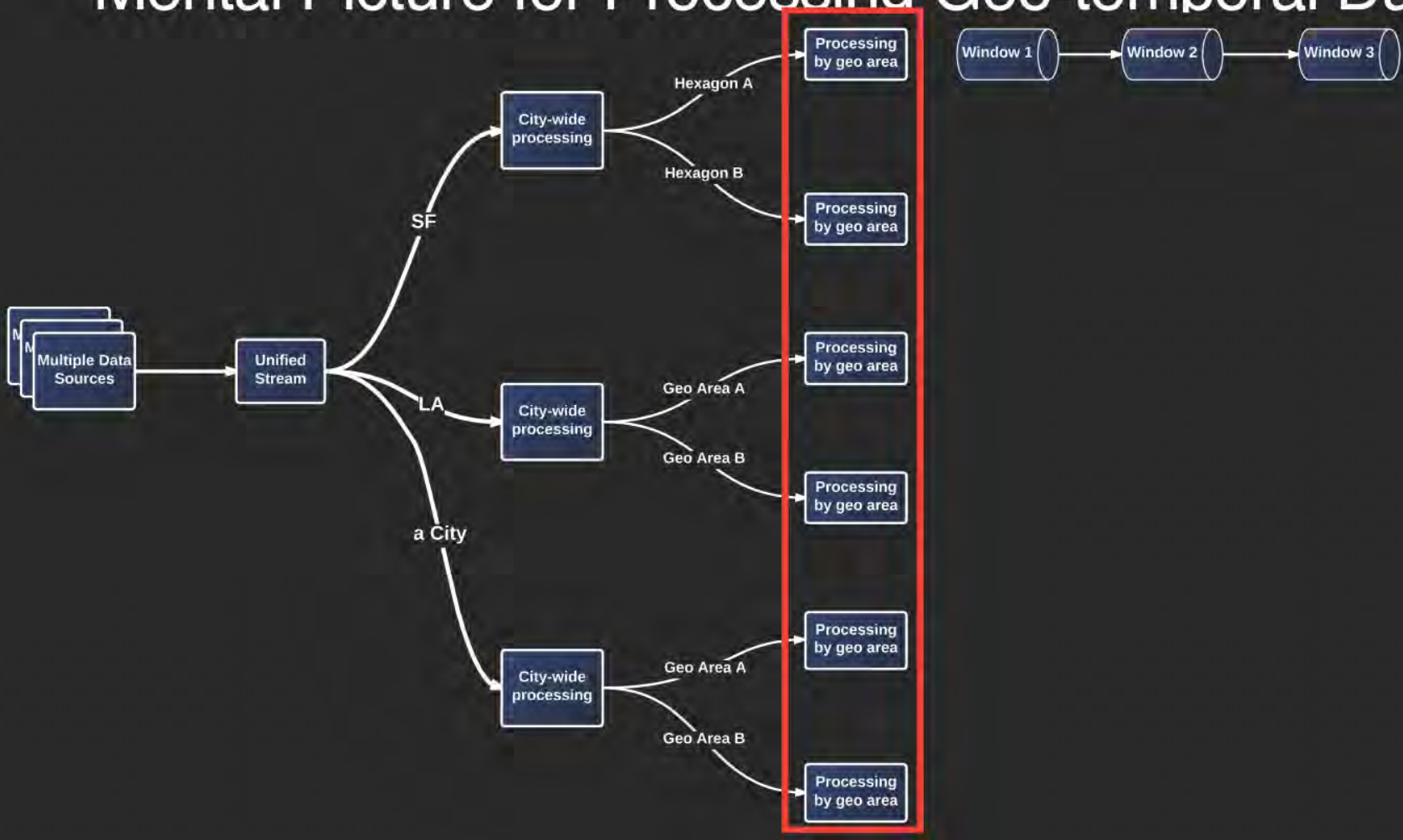
Mental Picture for Processing Geo-temporal Data



Mental Picture for Processing Geo-temporal Data



Mental Picture for Processing Geo-temporal Data



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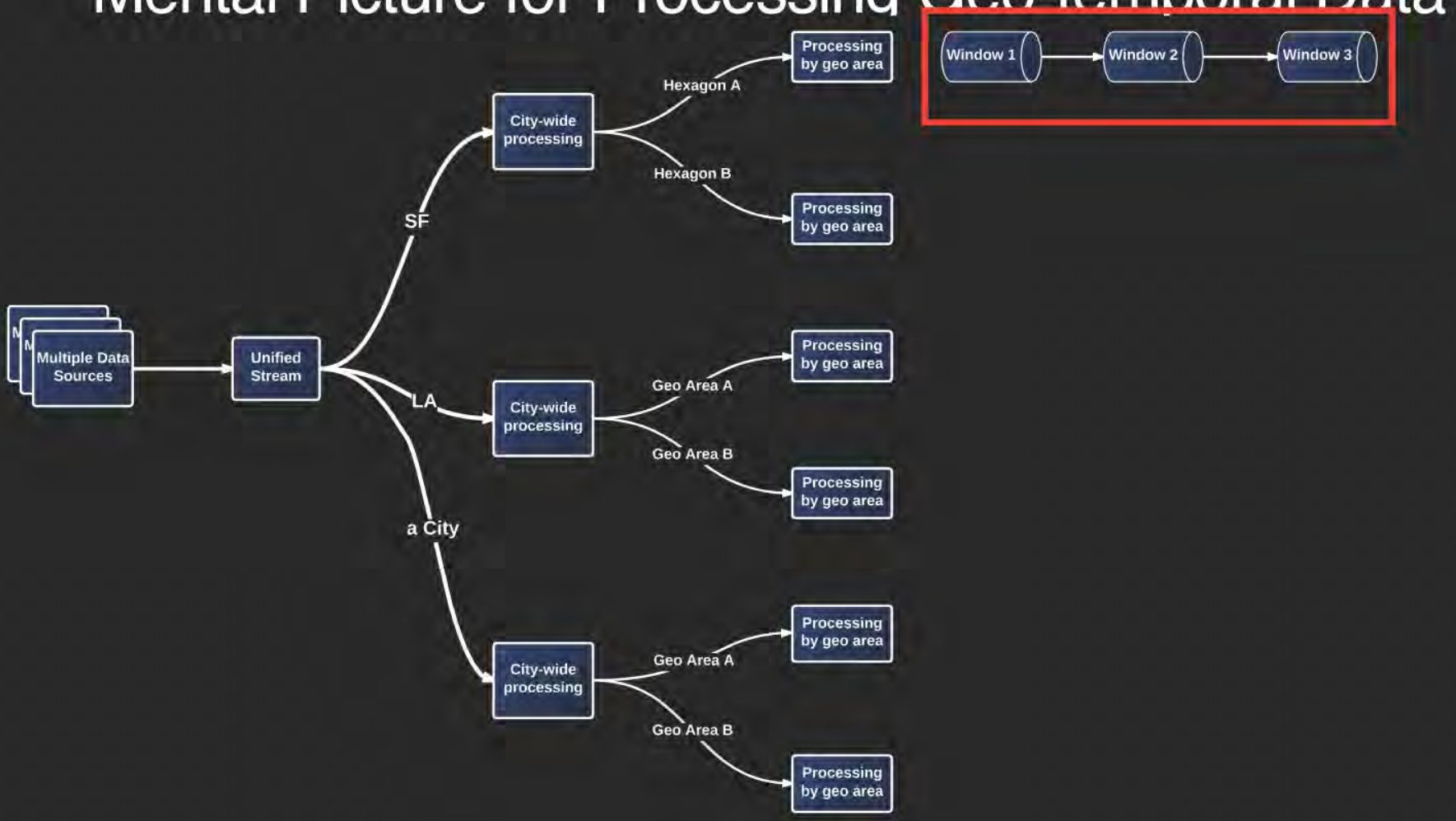
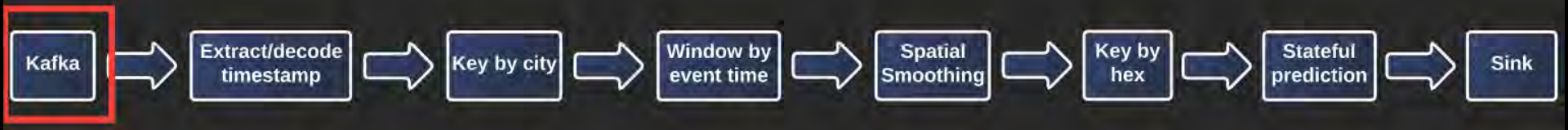


A Simple Example: simple prediction



Sources

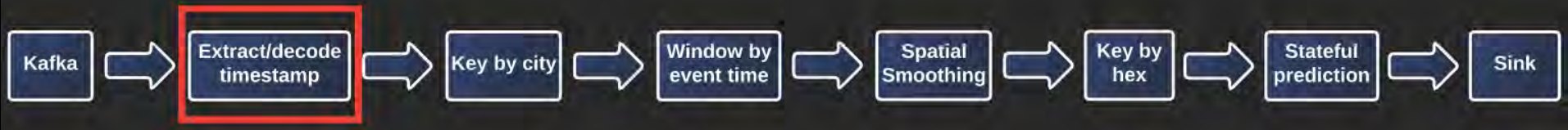
.fromKafka()

.config(config)

.cluster(aCluster)

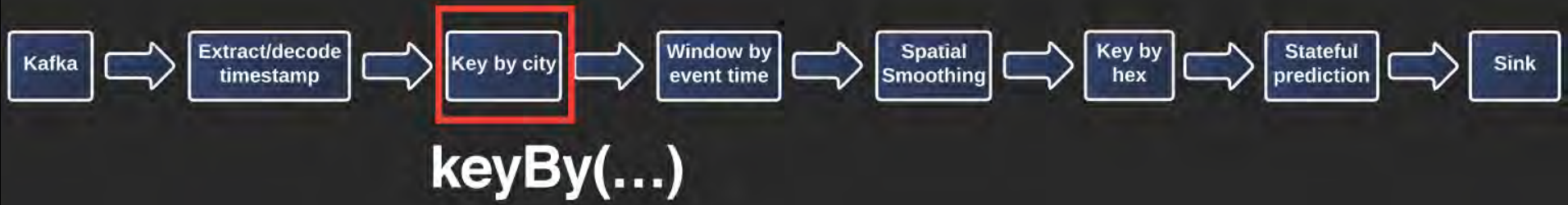
.topics(topicList)

A Simple Example



assignTimestampsAndWatermarks

A Simple Example



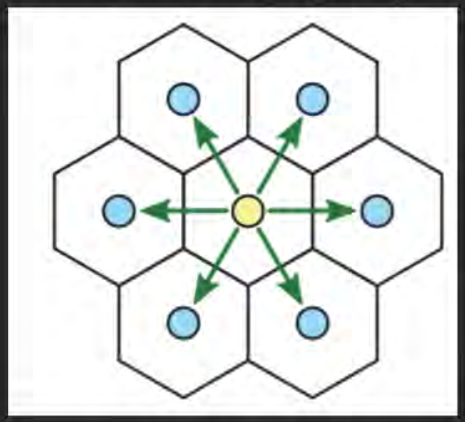
keyBy(…)

A Simple Example

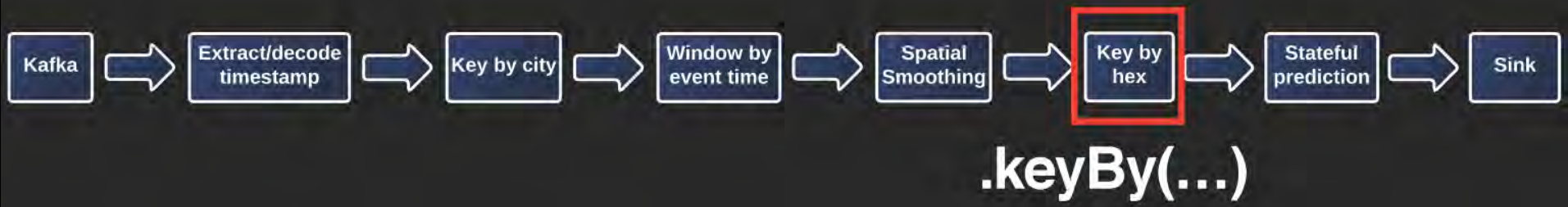
.timeWindow(…)

A Simple Example

.flatMap(…)

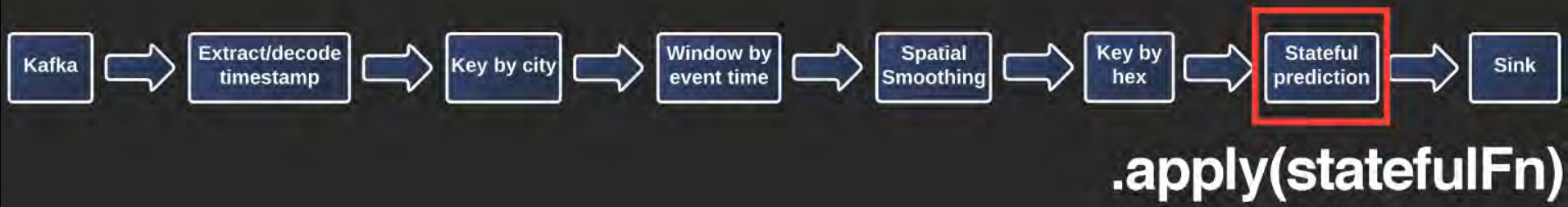


A Simple Example



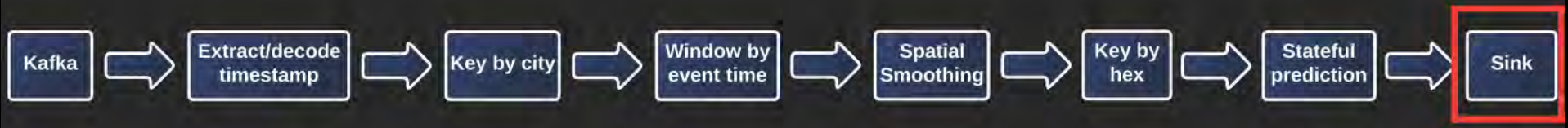
.keyBy(…)

A Simple Example



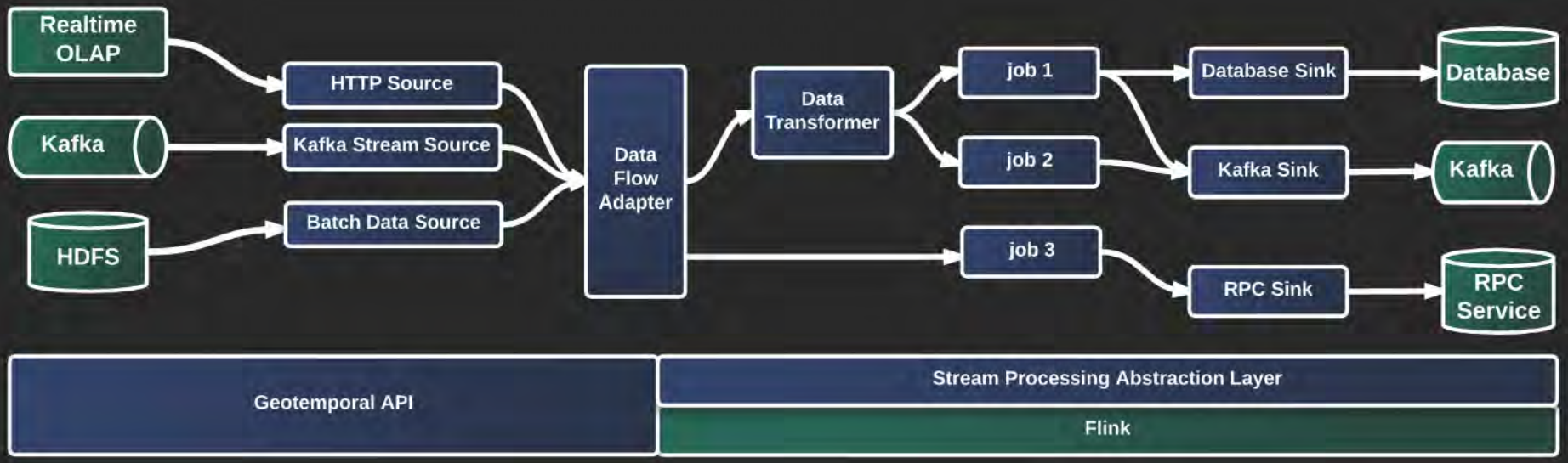
.apply(statefulFn)

A Simple Example



.addSink(.

High Level Data Flow



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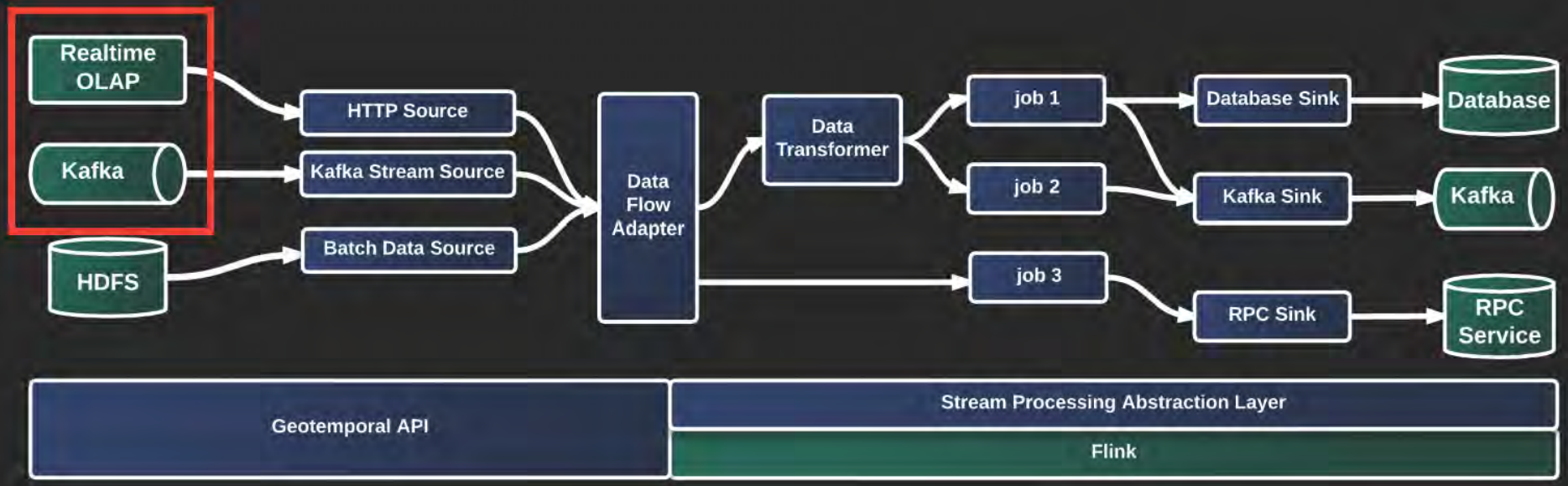

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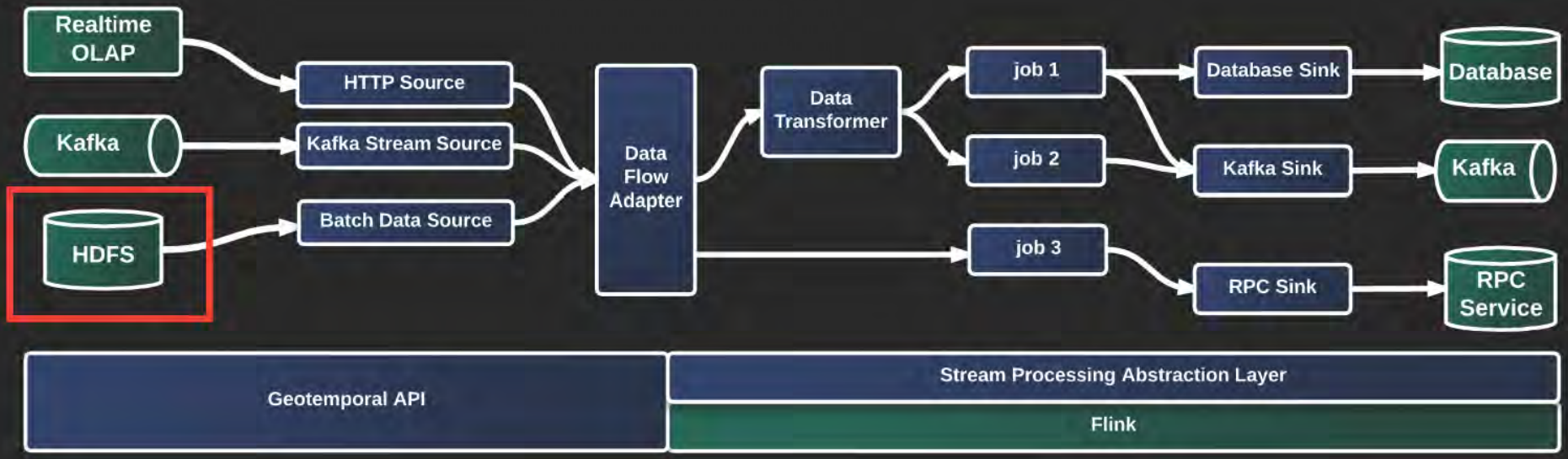

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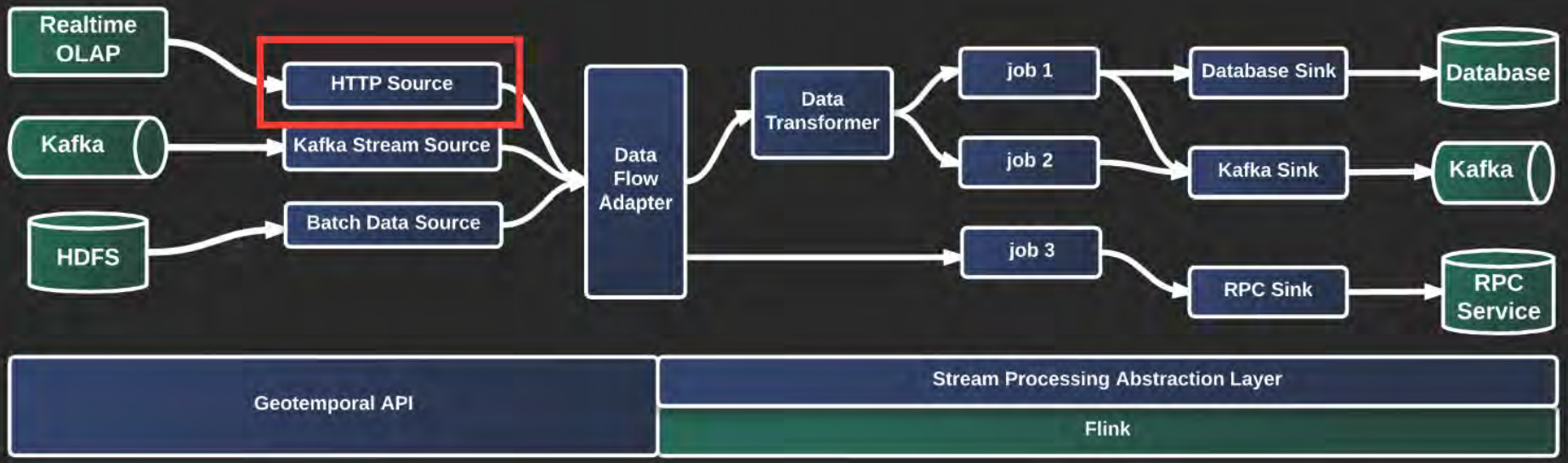

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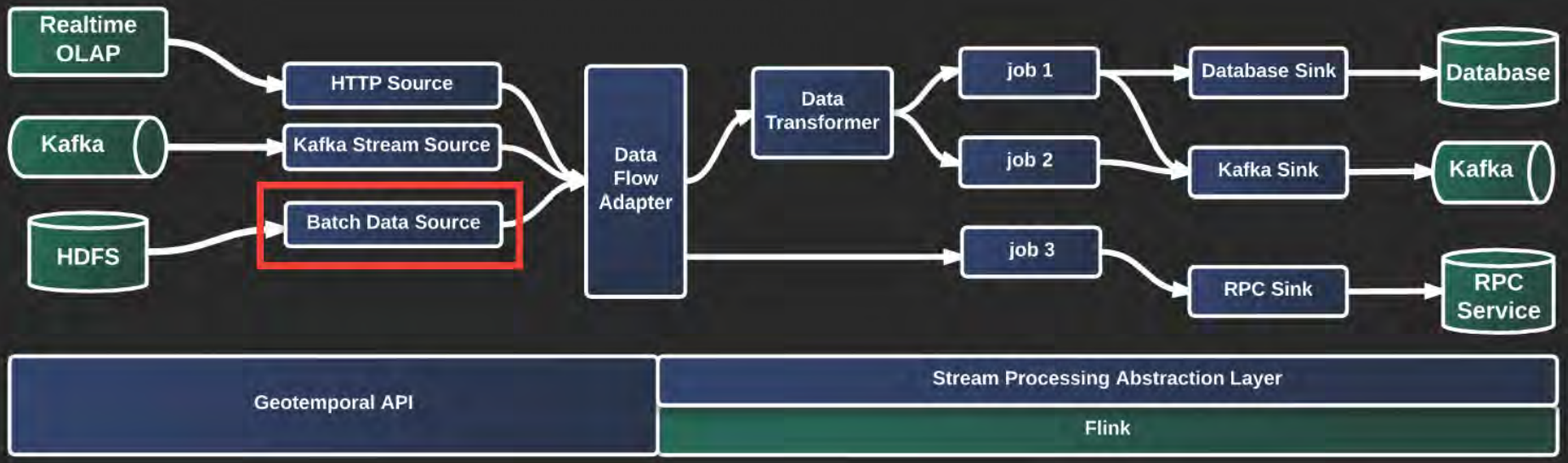

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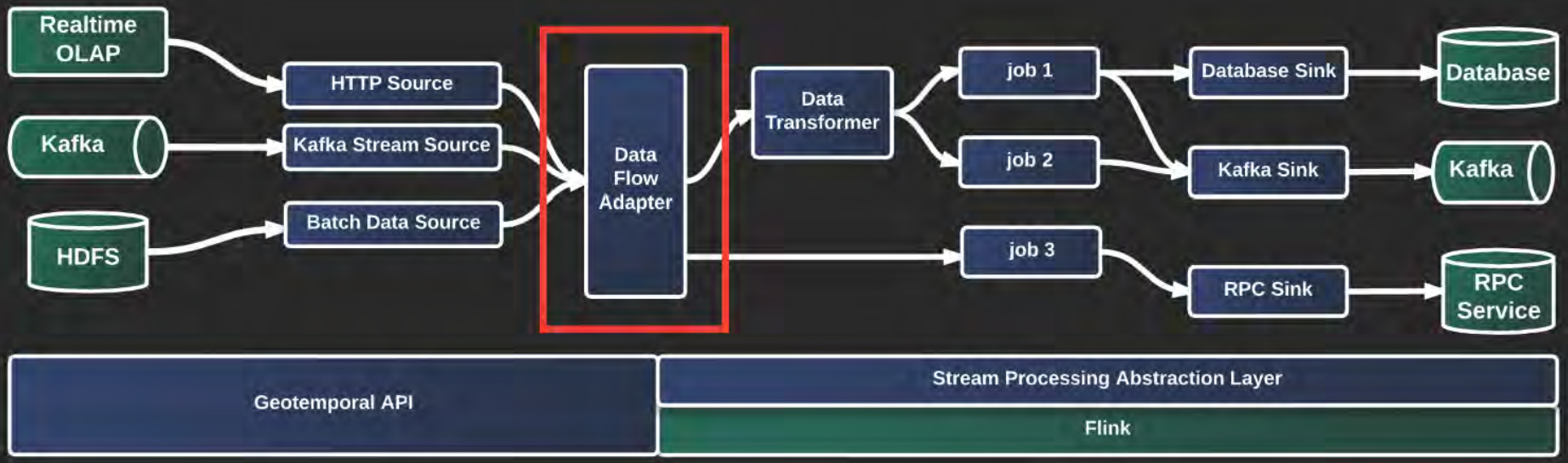
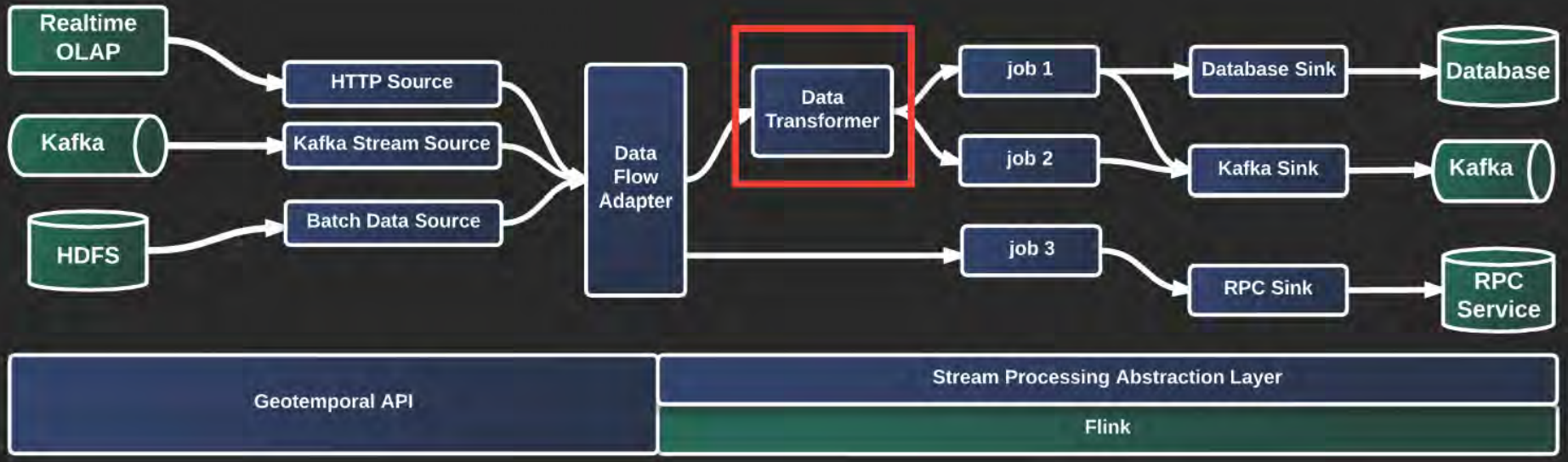


High Level Data Flow



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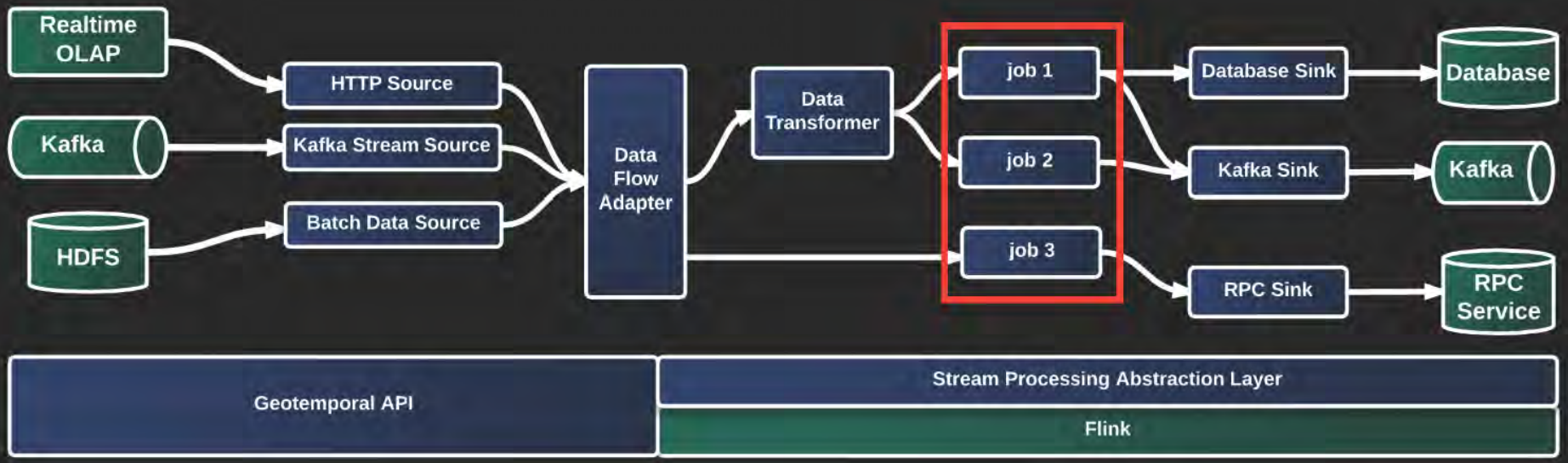
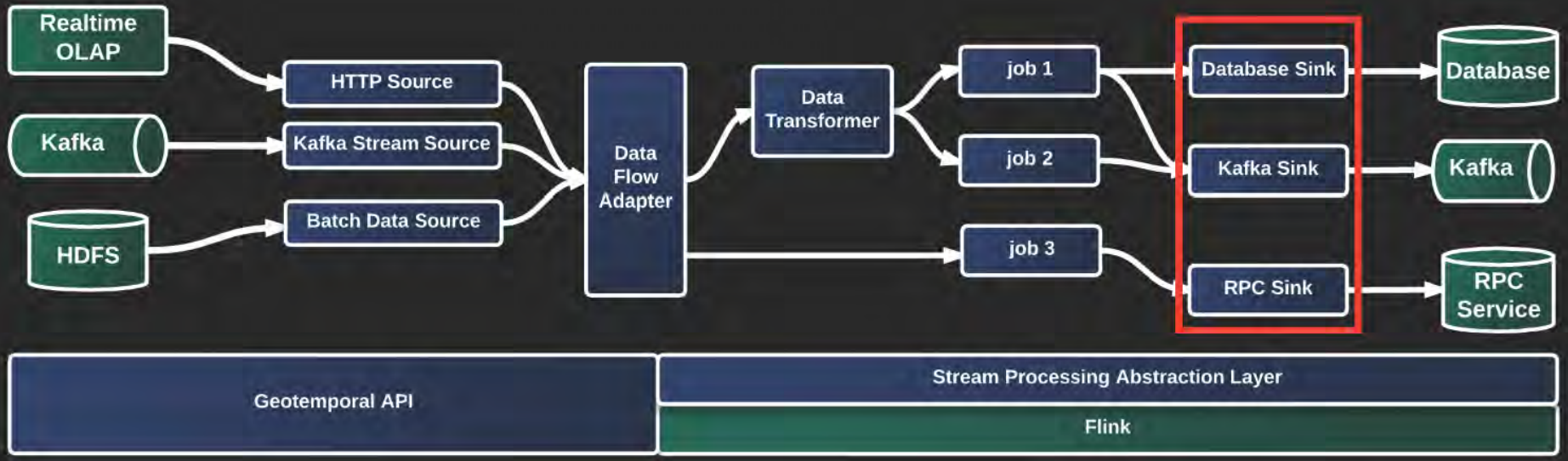


High Level Data Flow



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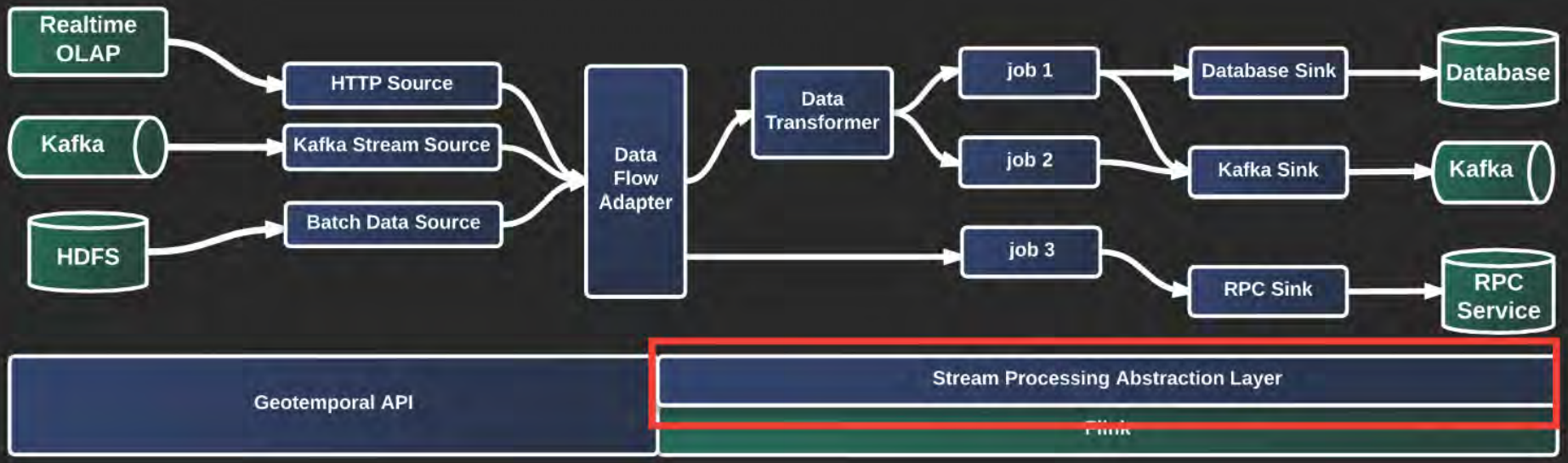

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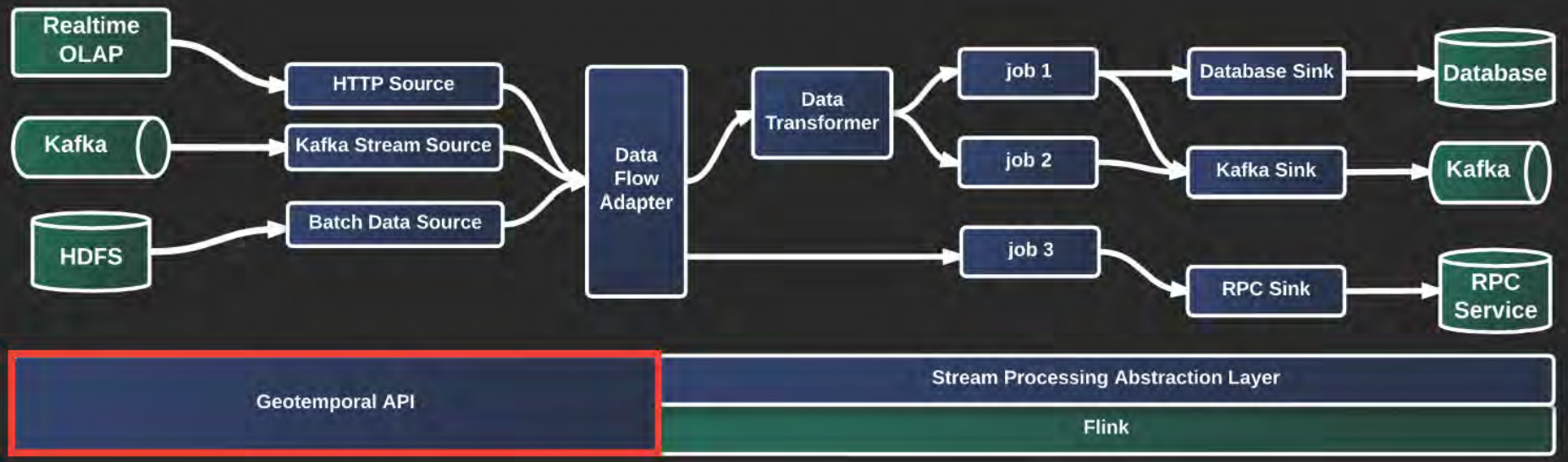
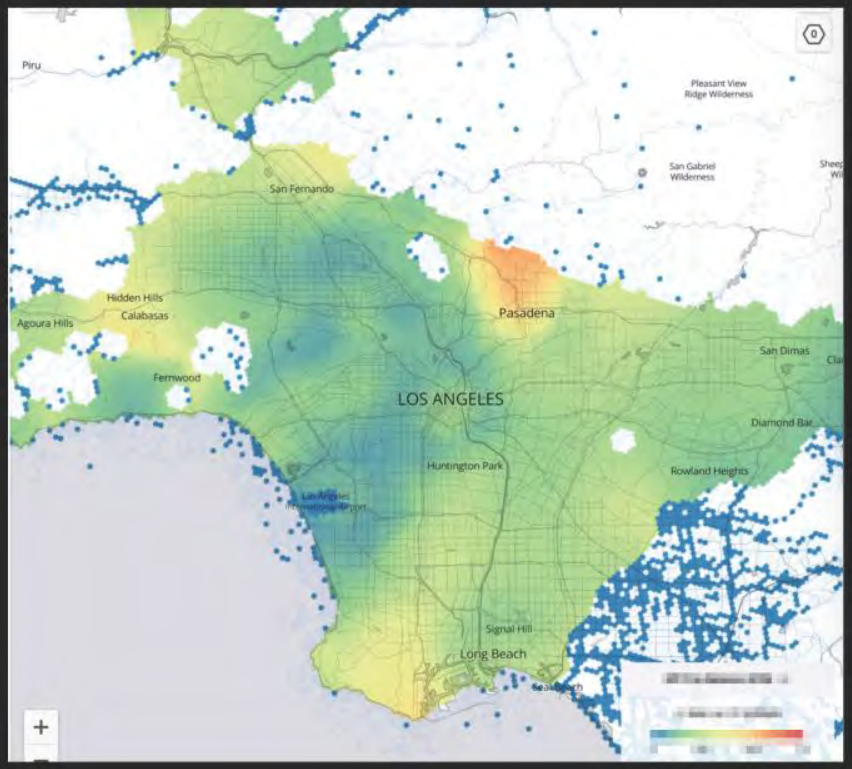


Geotemporal API for efficiency



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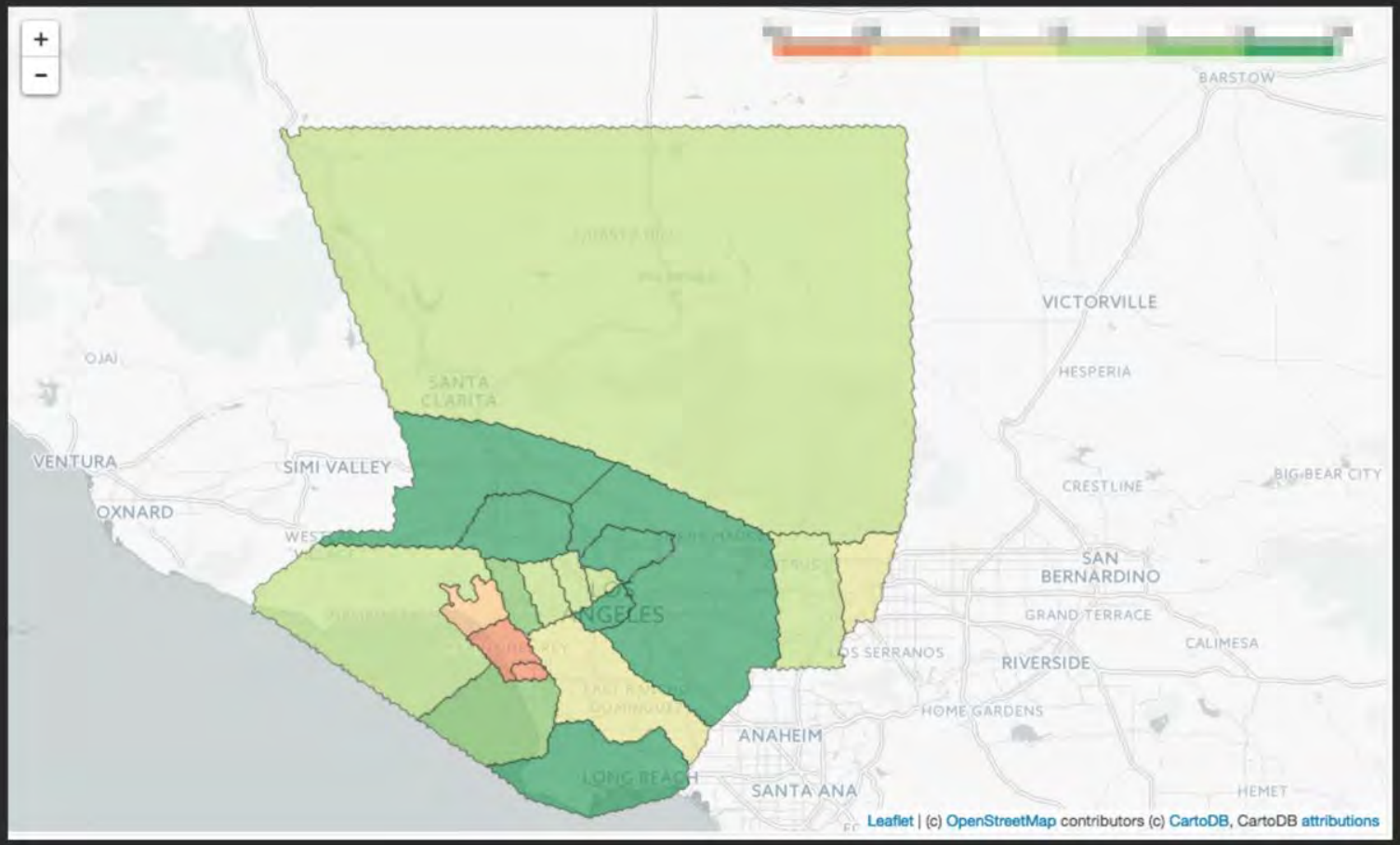
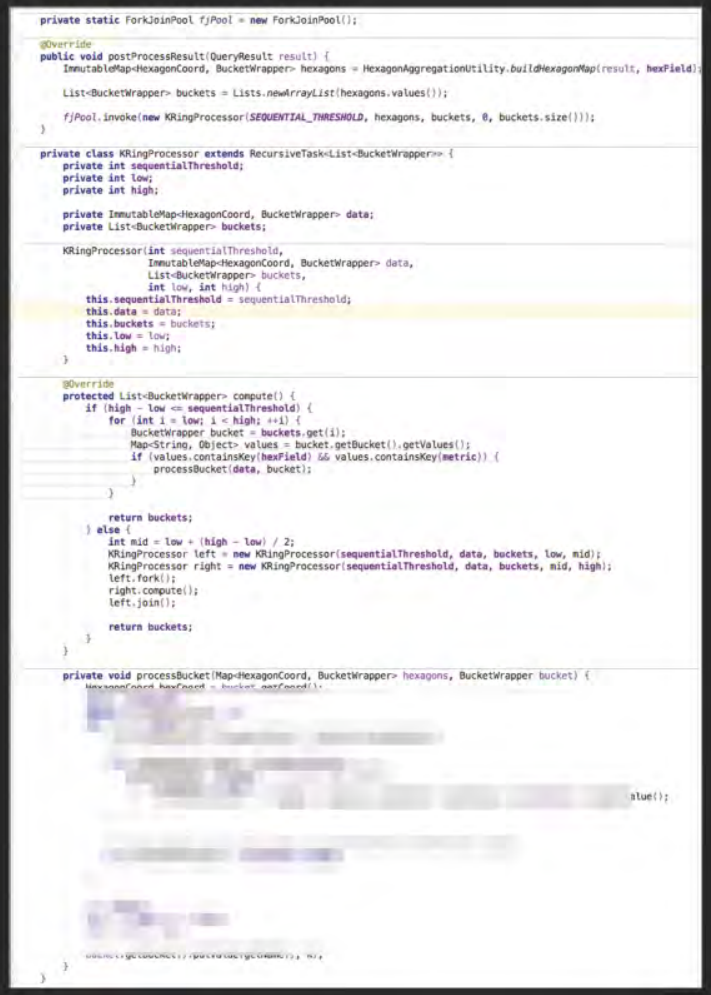


Geotemporal API for productivity



```
private static ForkJoinPool fjPool = new ForkJoinPool();

@Override
public void postProcessResult(QueryResult result) {
    ImmutableMap<HexagonCoord, BucketWrapper> hexagons = HexagonAggregationUtility.buildHexagonMap(result, hexField);

    List<BucketWrapper> buckets = Lists.newArrayList(hexagons.values());

    fjPool.invoke(new KRingProcessor(SEQUENTIAL_THRESHOLD, hexagons, buckets, 0, buckets.size()));
}

private class KRingProcessor extends RecursiveTask<List<BucketWrapper>> {
    private int sequentialThreshold;
    private int low;
    private int high;

    private ImmutableMap<HexagonCoord, BucketWrapper> data;
    private List<BucketWrapper> buckets;

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        this.sequentialThreshold = sequentialThreshold;
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    @Override
    protected List<BucketWrapper> compute() {
        if (high - low <= sequentialThreshold) {
            for (int i = low; i < high; ++i) {
                BucketWrapper bucket = buckets.get(i);
                Map<String, Object> values = bucket.getBucket().getValues();
                if (values.containsKey(hexField) && values.containsKey(metric)) {
                    processBucket(data, bucket);
                }
            }

            return buckets;
        } else {
            int mid = low + (high - low) / 2;
            KRingProcessor left = new KRingProcessor(sequentialThreshold, data, buckets, low, mid);
            KRingProcessor right = new KRingProcessor(sequentialThreshold, data, buckets, mid, high);
            left.fork();
            right.compute();
            left.join();

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        [redacted]
                                                                                    alue();
        [redacted]
    }
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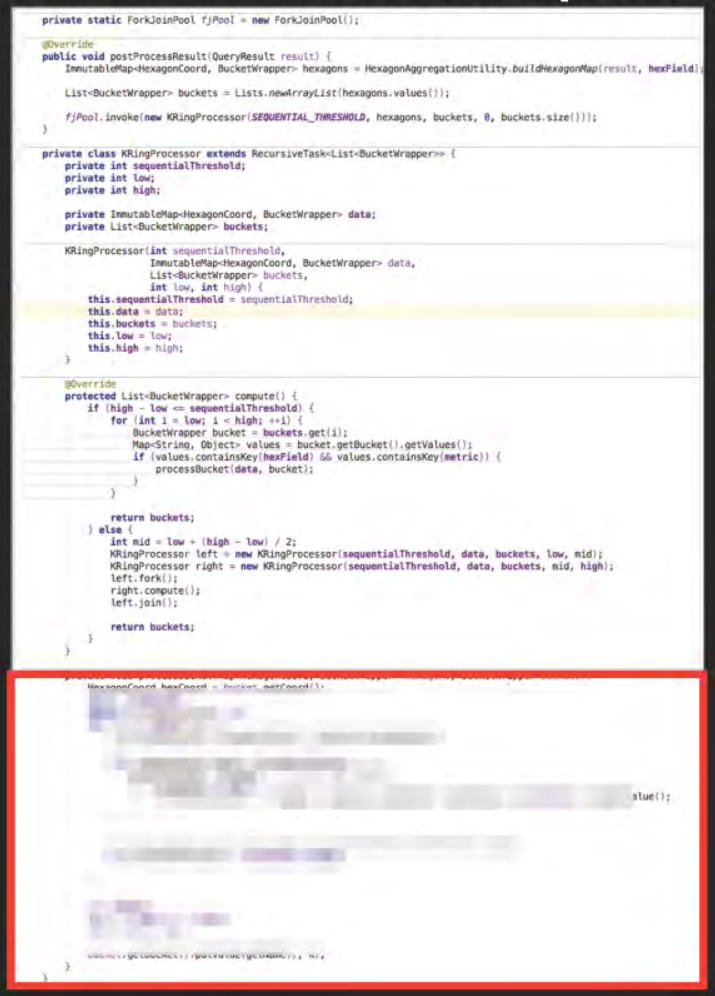
Geotemporal API for productivity



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    }

    [redacted]
}
```

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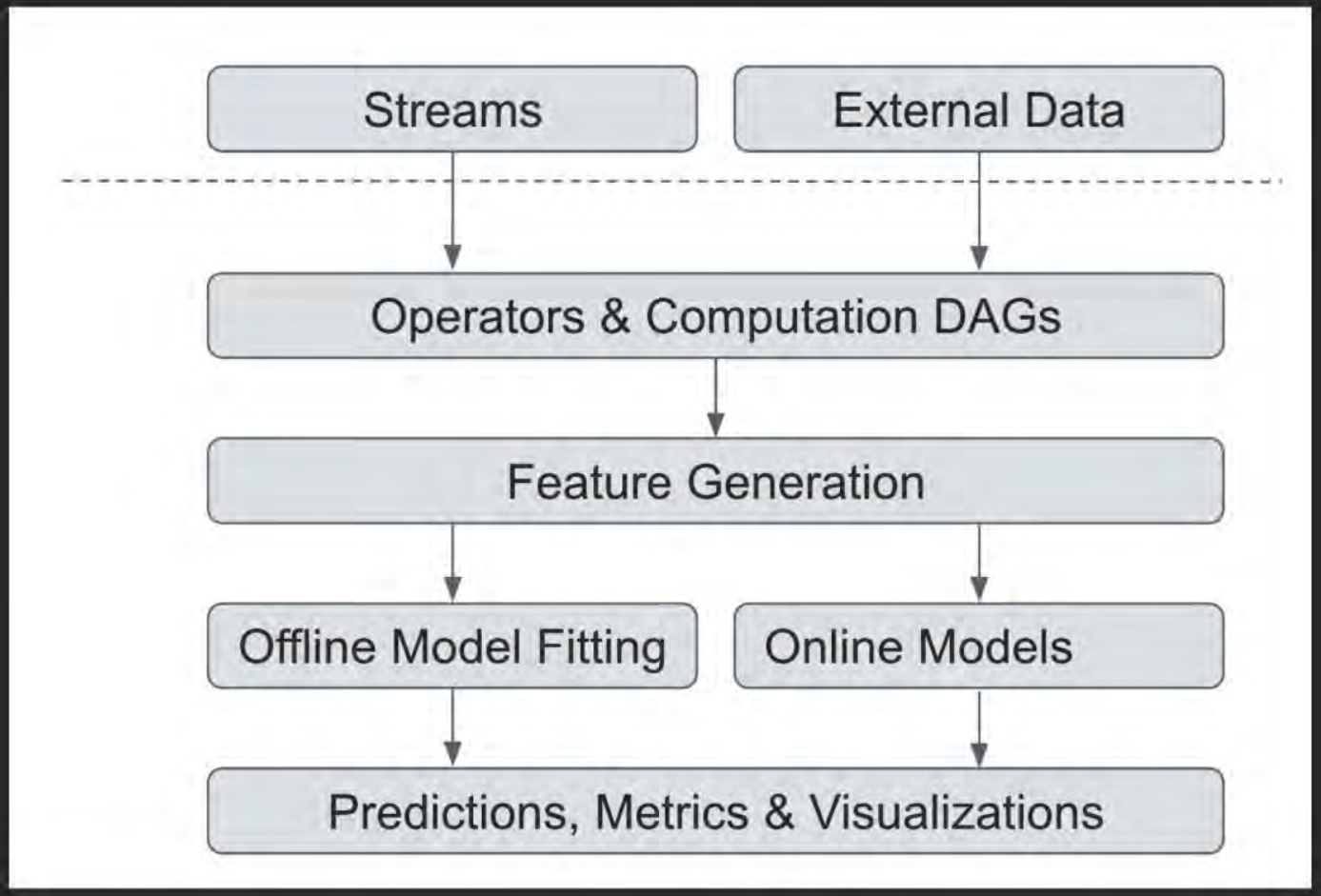
        [redacted]
        alue();
        [redacted]
    }
}
```

```
return hexagonContext.mapGeoArea(
    (context, area) -> {
        double incrementalValue = 0;
        [redacted]
    }
);
```

Forecasting as an example



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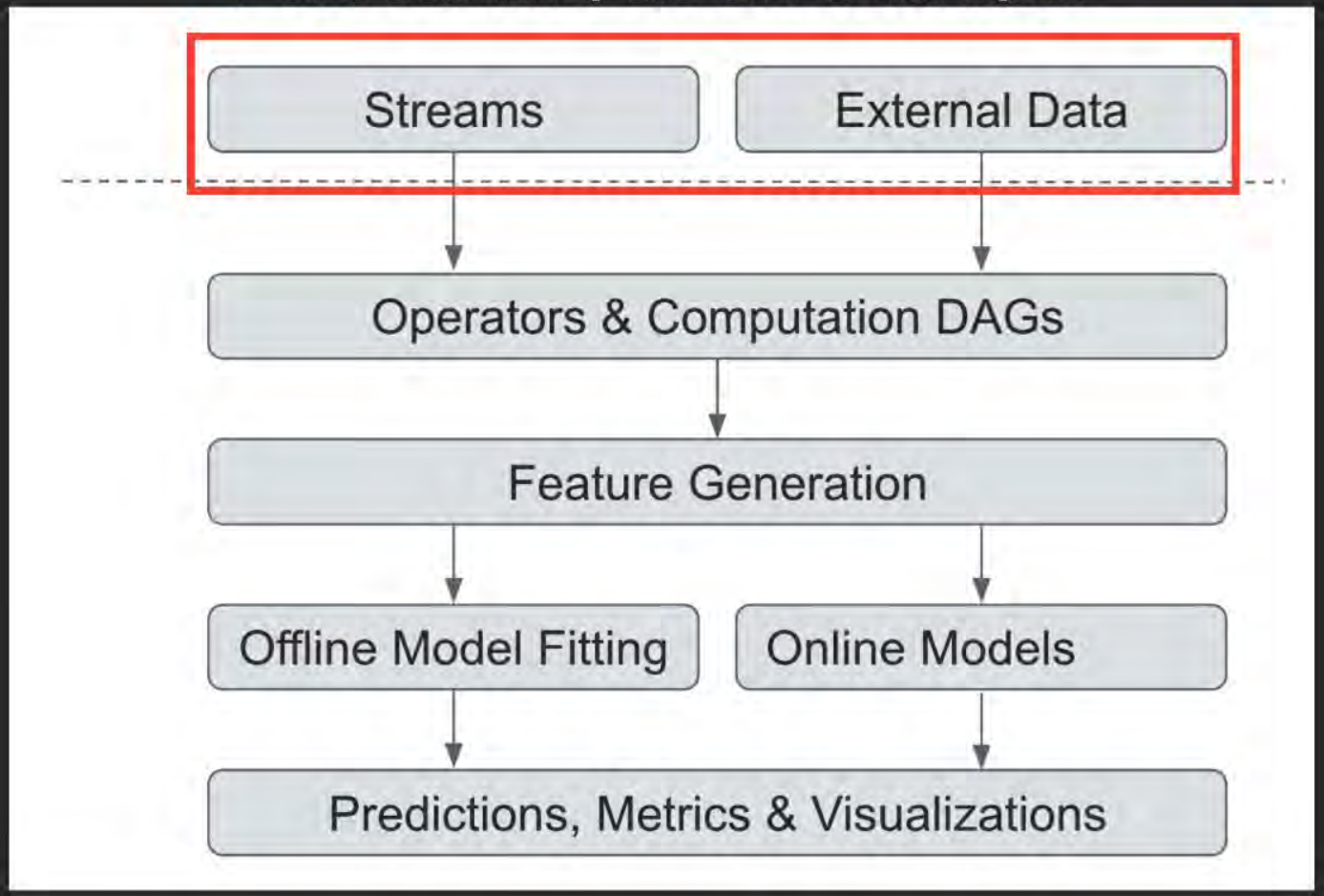

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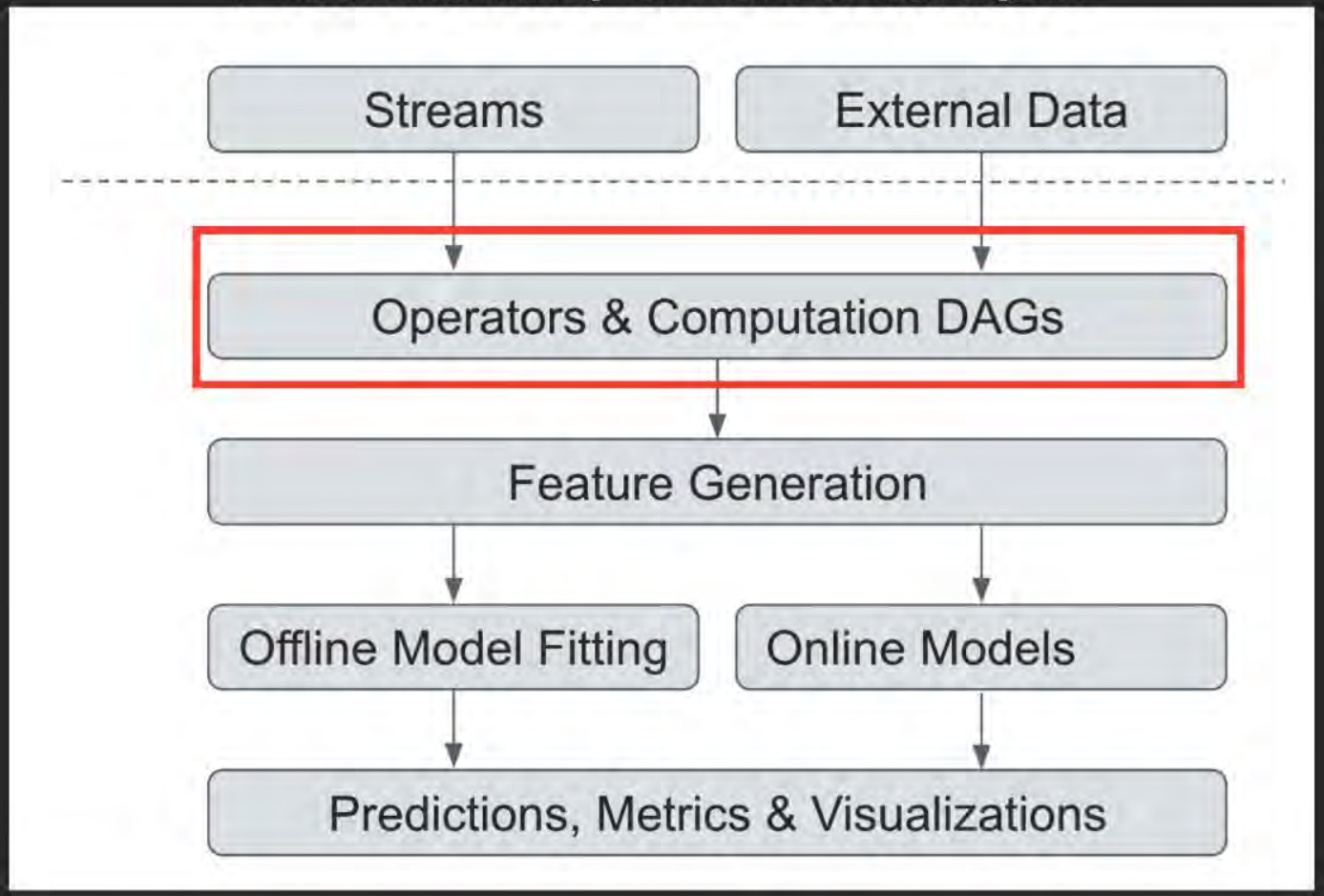

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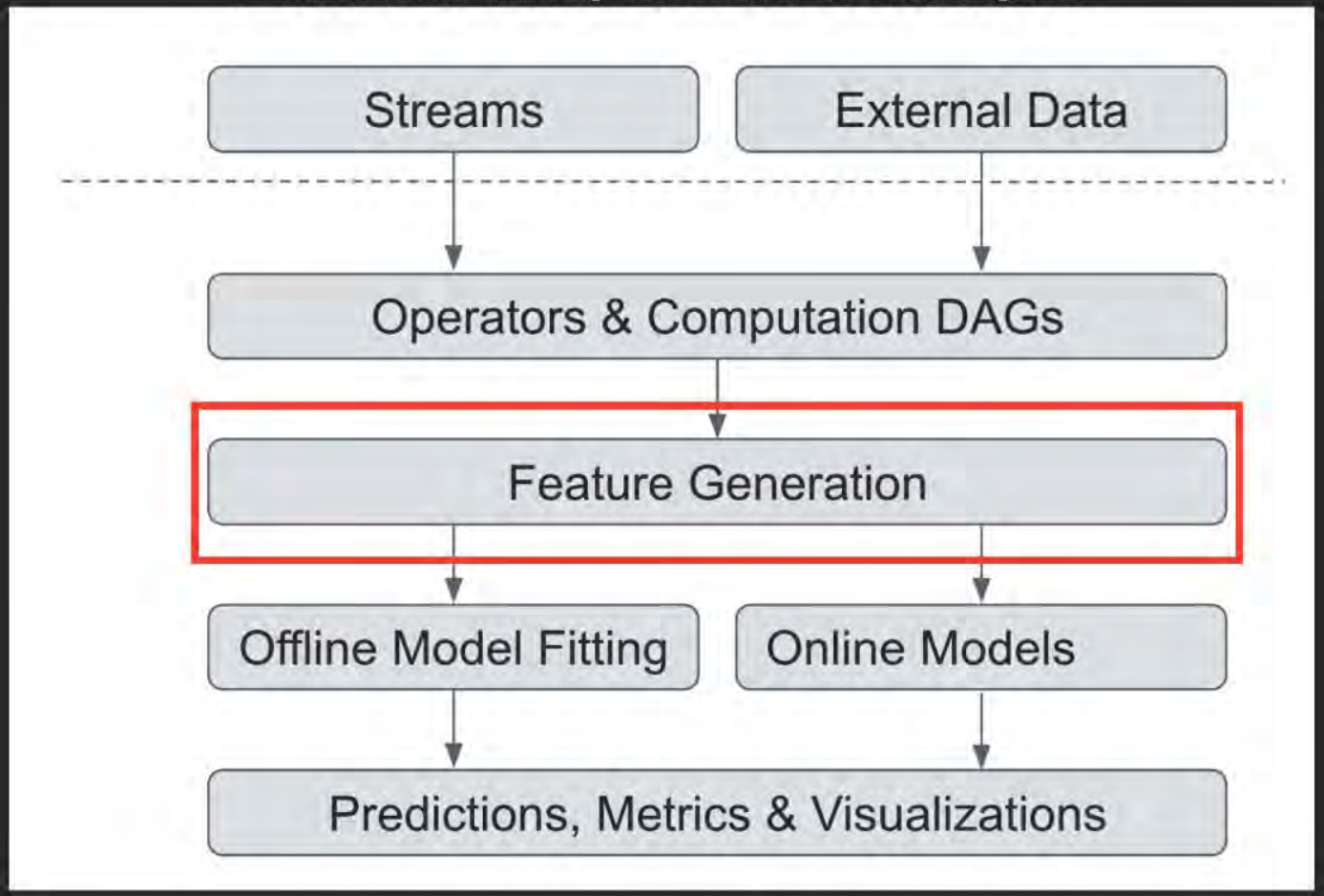

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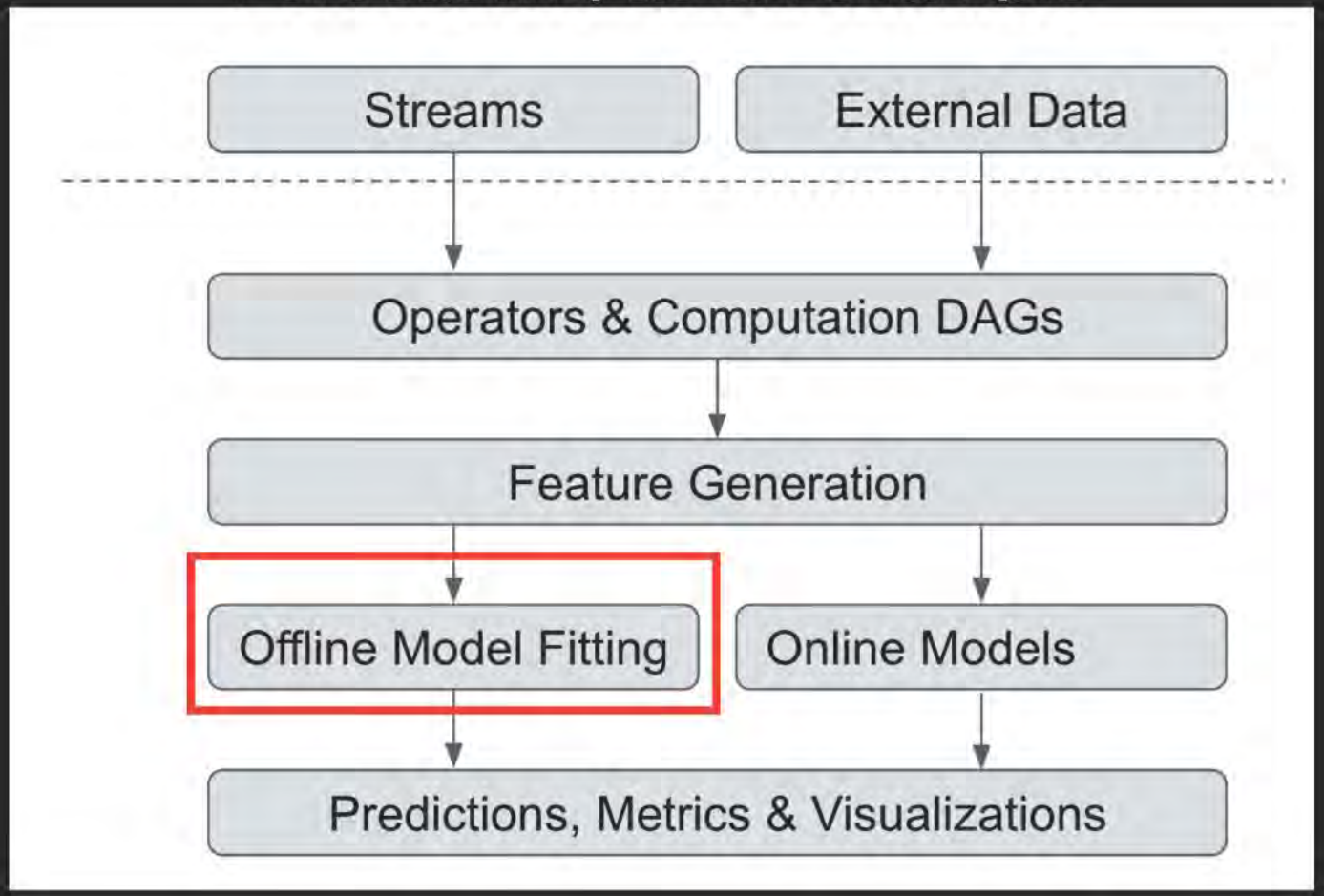
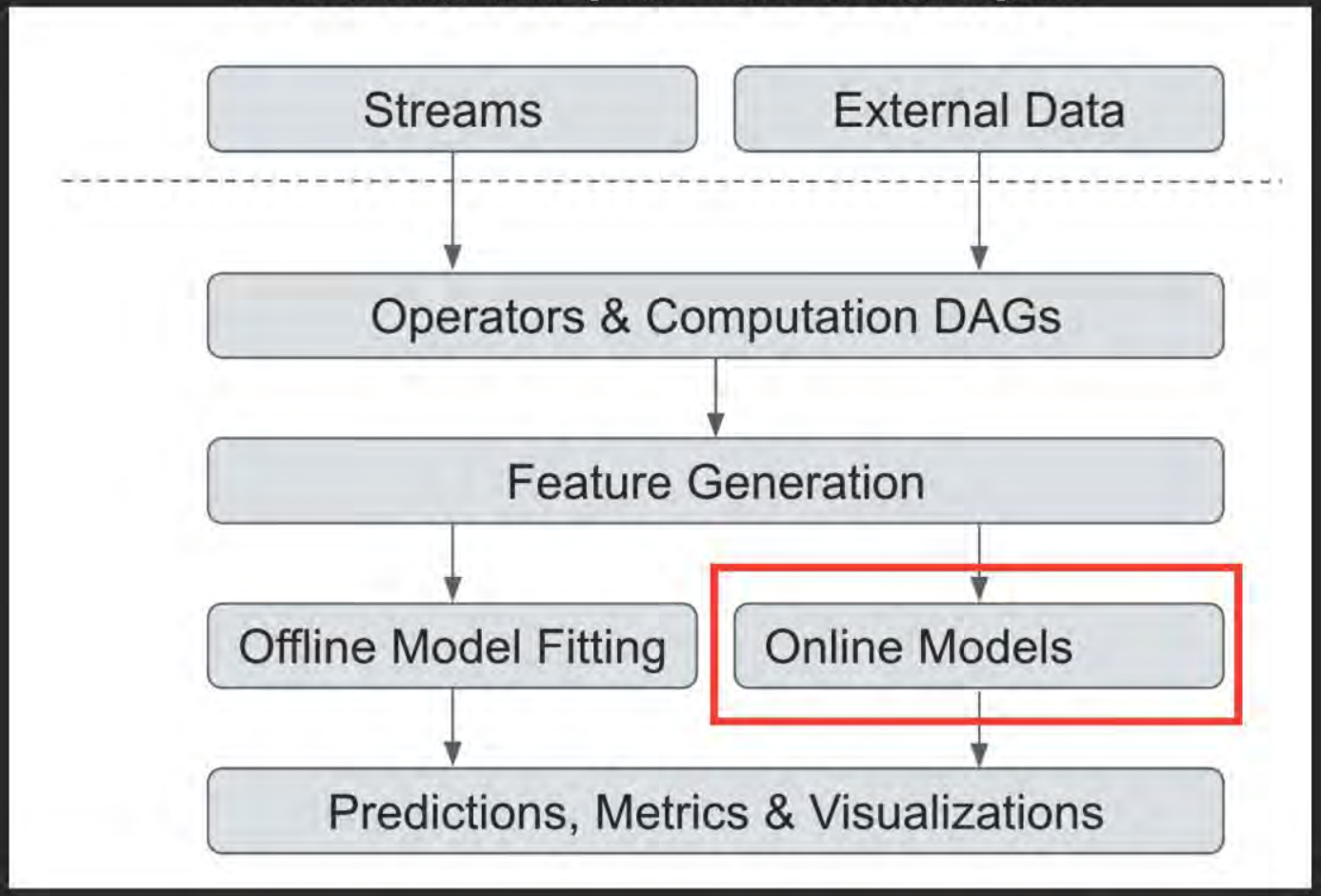
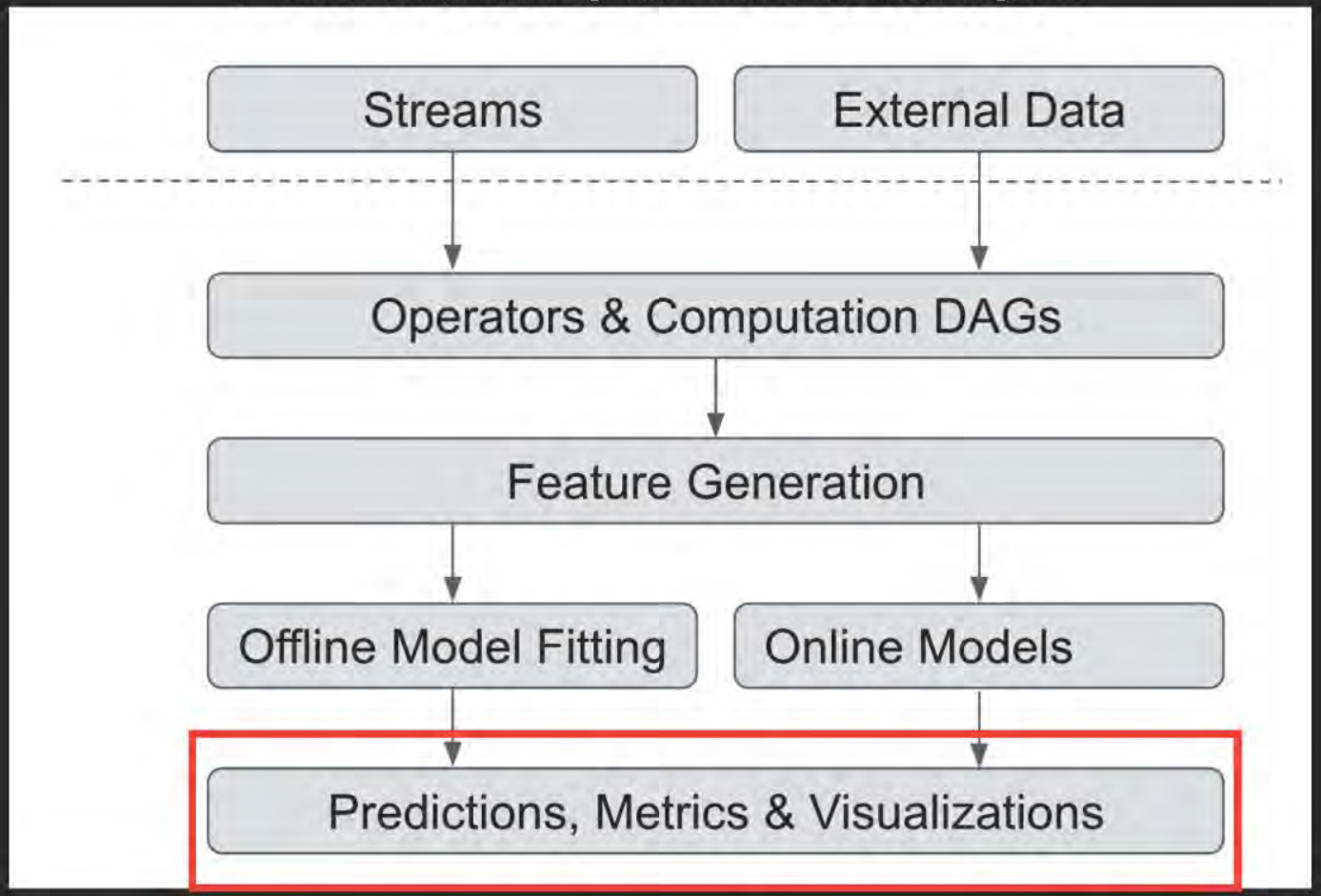


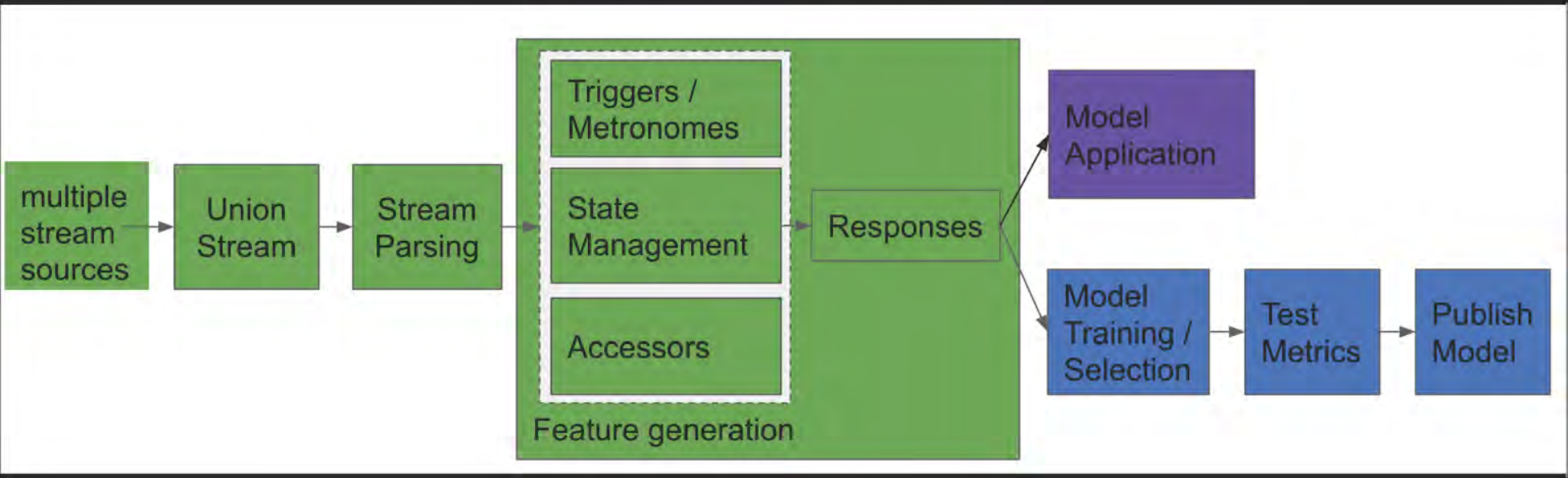
Forecasting as an example



Forecasting as an example



Forecasting as an example



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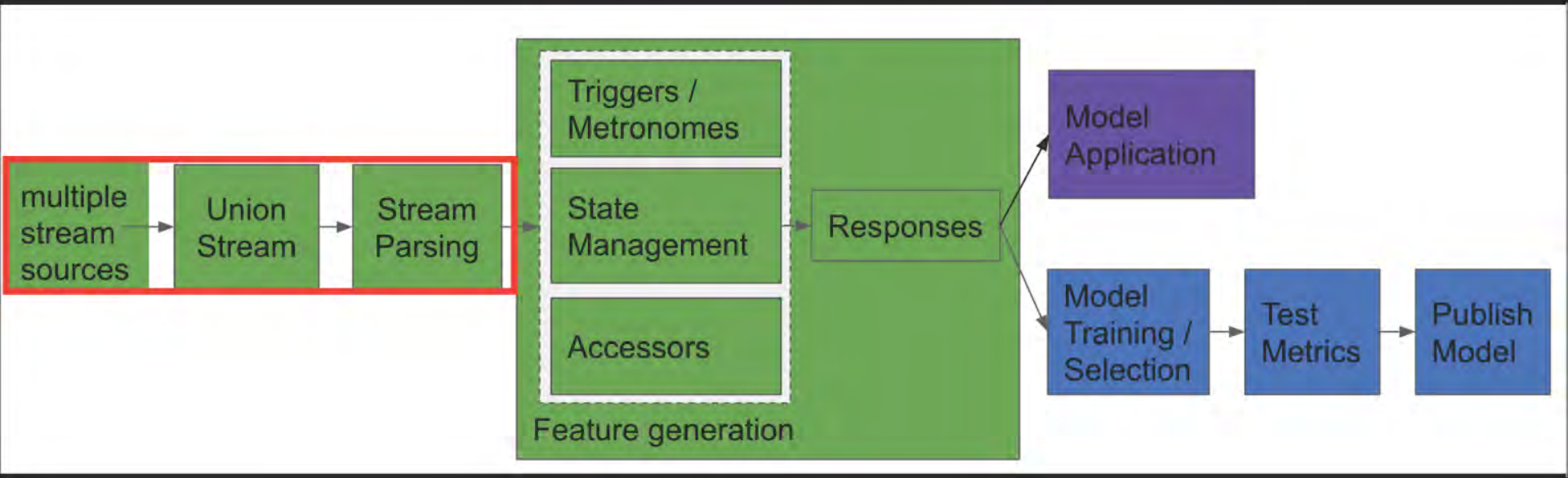

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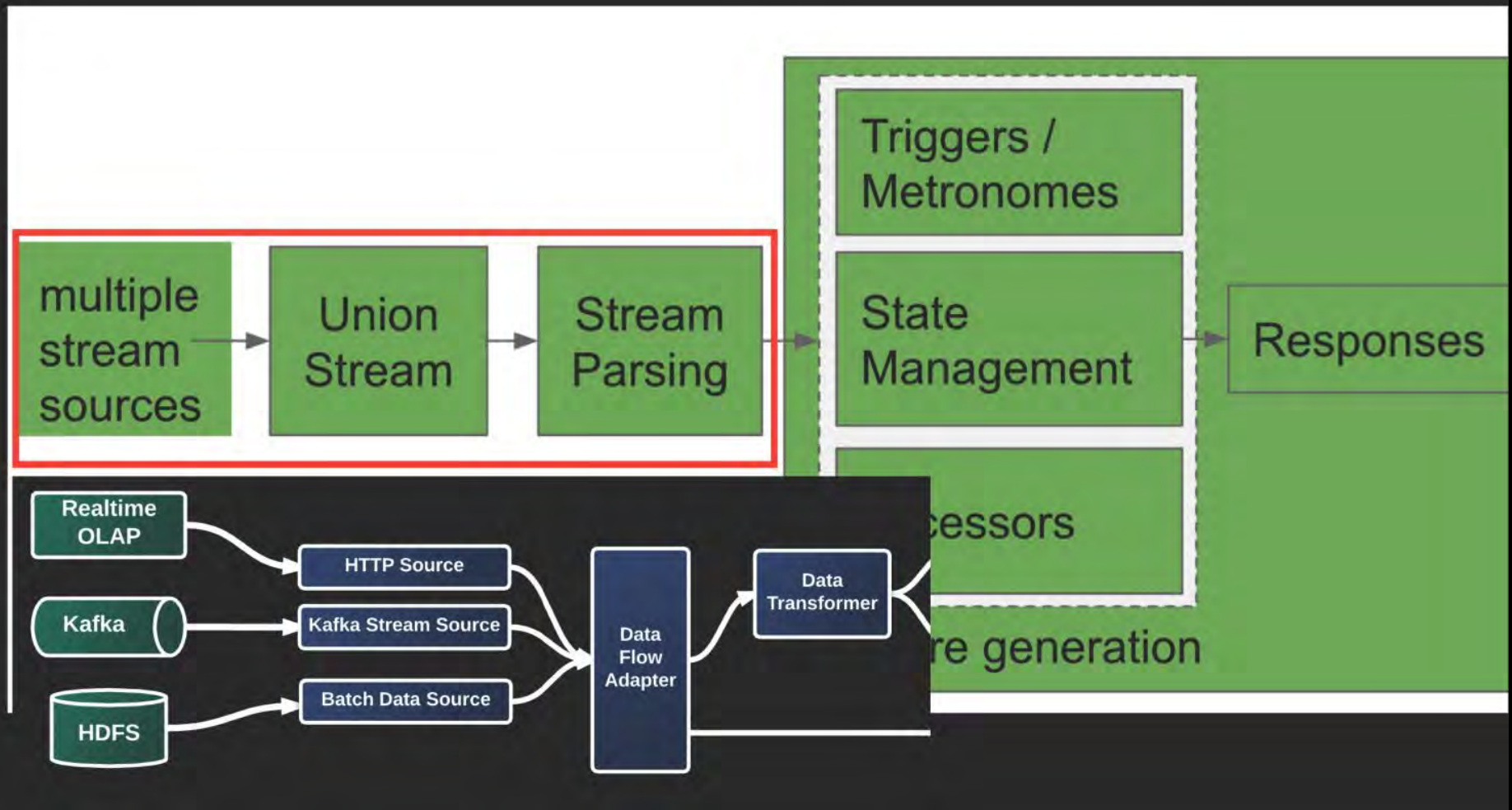

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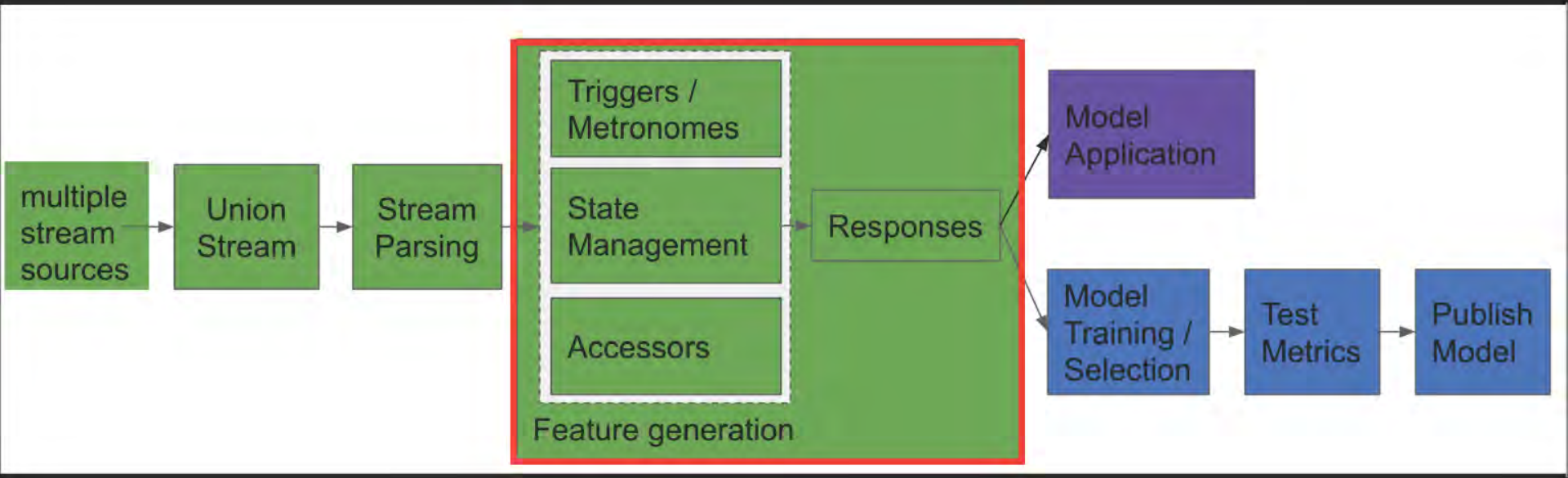
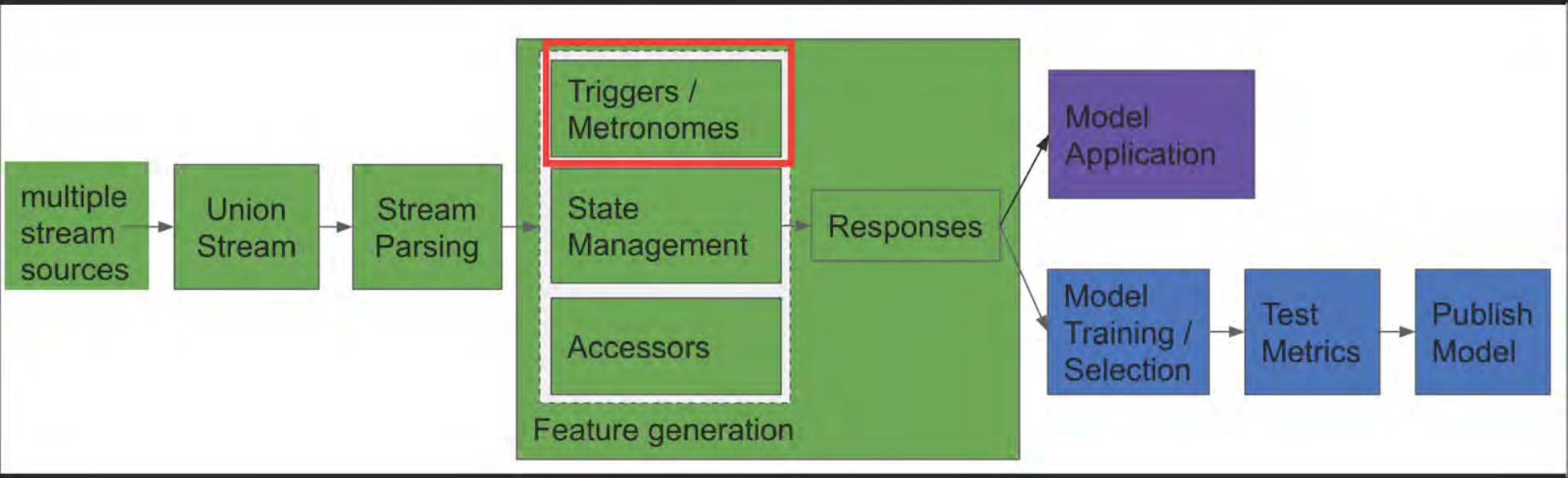
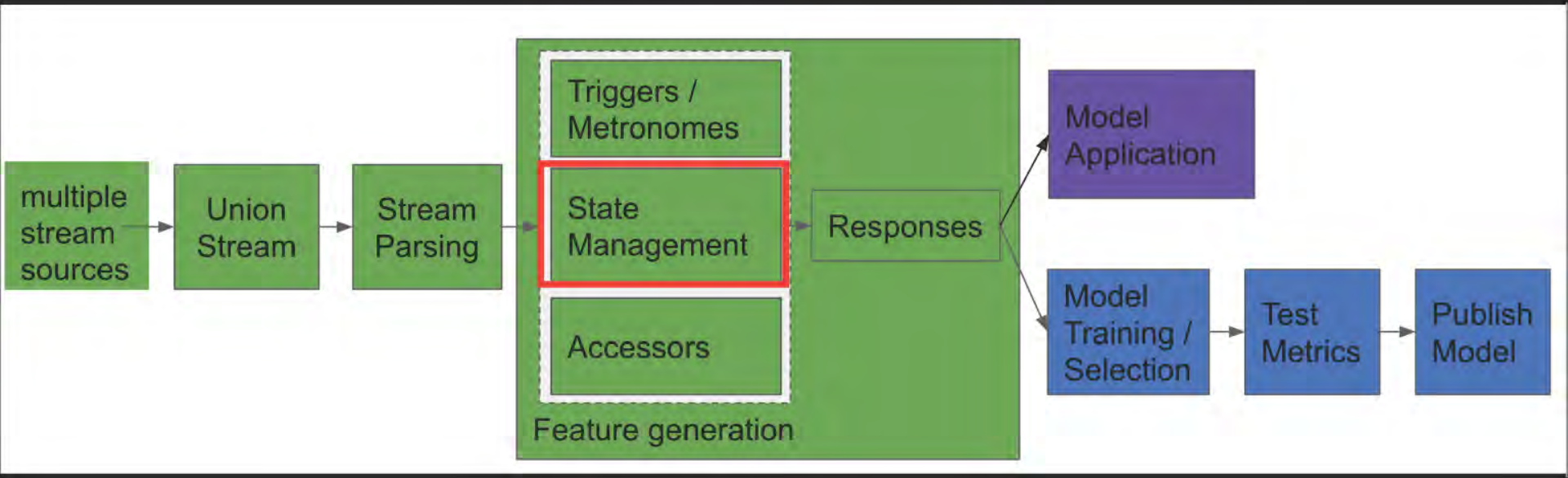


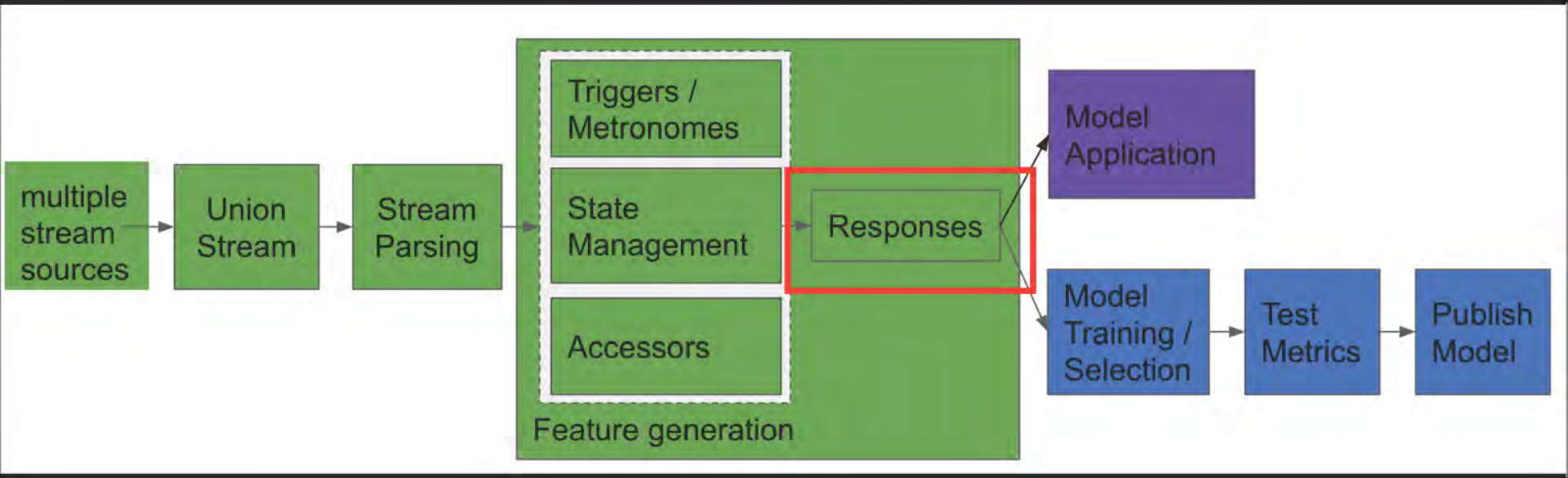
Forecasting as an example



Forecasting as an example



Forecasting as an example



Forecasting as an example