Spark Streaming At Bing Scale

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Scale

- Billions of search queries per month
- Hundreds of services power Bing stack
- Thousands of machines – several Data Centers
- Tens of TBs of events per hour
- Several data processing frameworks

Data Curation

- Events of individual services - little value
- Need correlation of events & curated datasets
  - at scale, on time, high fidelity
  - contributes directly to improving quality of services & monetization

Data Pipelines

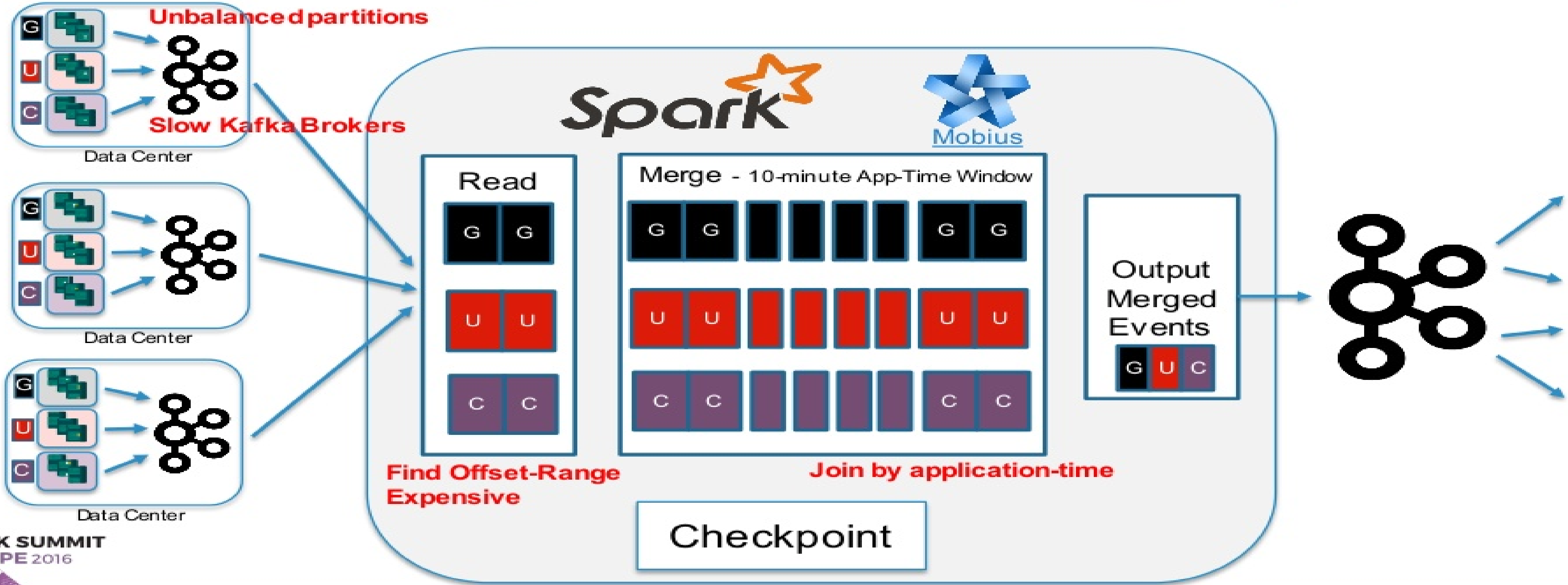
- Traditionally implemented entirely using Batch processing in COSMOS infrastructure
  - Storage – DFS (similar to HDFS)
  - Execution – Dryad (general purpose, more expressive than map-reduce)
  - Query – SCOPE (SQL 'style' scripting language that supports inline C#)
- Data pipelines are adopting near real-time processing – <u>new issues to address</u>

NRT Data Pipelines

Key issues to address in stream processing applications:

- Events generated in different DCs and at a rapid rate
- Events arrive out of order
- Events are delayed or get lost
- Managing state can be very expensive and hard to get right

NRT Processing Scenario – Event Merge Pipeline



Unbalanced Kafka Partitions

- Direct API - Kafka partition maps to RDD partition
- Largest partition is the long pole in processing
- Solution
  - Repartition data from one Kafka partition into multiple RDDs w/o extra shuffling cost of *DStream.Repartition()*
  - Repartition threshold is configurable per topic
  - *DynamicPartitionKafkaRDD.scala* at github.com/Microsoft/Mobius

Slow Kafka Brokers

- Slow Kafka brokers increase batch time
- Delay in starting the next batch accumulates
- Solution
  - Submit Kafka data-fetch job on-time (defined by batch interval) in a separate thread, even when previous batch delayed
  - *CSharpDStream.scala* at github.com/Microsoft/Mobius

Find Offset-Range Expensive

- Finding Offset-range for {DC X Topic X Partition} is expensive
  - Several DCs – 3 topics each – average of 170 partitions per topic
  - {Get metadata + get offset range} took 10 mins for 2 min batch window
- {Metadata refresh + Find Offset} and data processing not parallel
- Solution
  - Move find offset-range to a separate thread
  - Materialize and cache Kafka RDD in that thread
  - *DynamicPartitionKafkaInputDStream.scala* at github.com/Microsoft/Mobius

Join By Application-Time

- Application-time based join not available in Spark 1.*
- Solution
  - Use custom join function in *DStream.UpdateStateByKey()*
  - Custom join function enforces time window based on application time
  - *UpdateStateByKey* maintains partially joined events as the state
  - *PairDStreamFunctions.cs* at github.com/Microsoft/Mobius

THANK YOU.

ADDITIONAL SLIDES

Dynamic Repartition

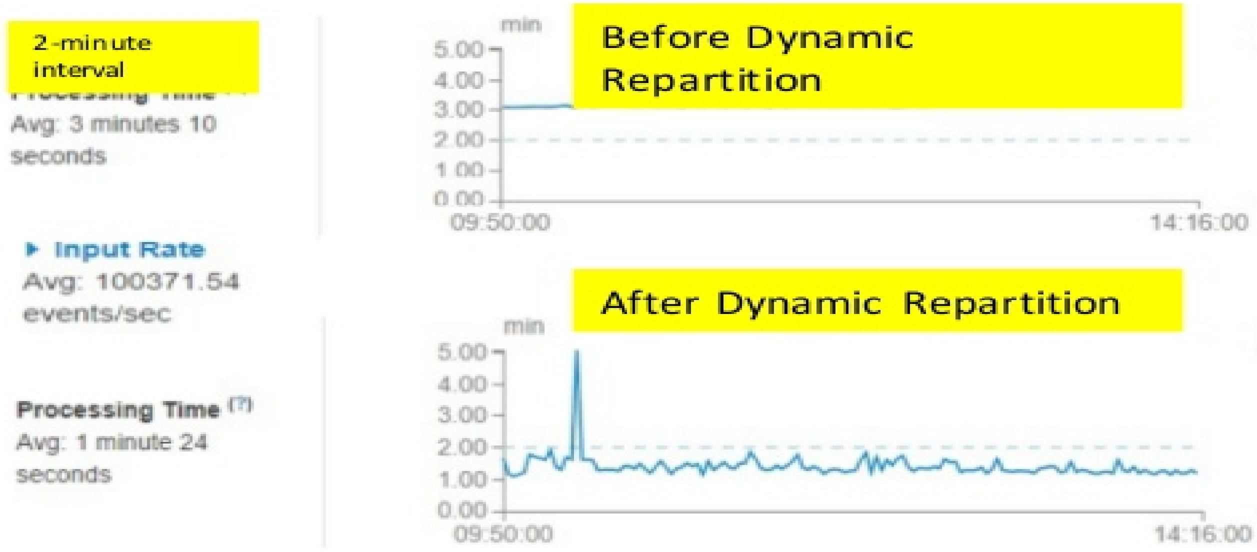
Pseudo Code

```
class DynamicPartitionKafkaRDD(kafkaPartitionOffsetRanges)
  override def getPartitions {
    // repartition threshold per topic loaded from config
    val maxRddPartitionSize = Map<topic, partitionSize>

    // apply max repartition threshold
    kafkaPartitionOffsetRanges.flatMap { case o =>
      val rddPartitionSize = maxRddPartitionSize(o.topic)
      (o.fromOffset until o.untilOffset by rddPartitionSize).map(
        s => (o.topic, o.partition, s, (o.untilOffset, s + rddPartitionSize)))
    }
  }
```

Source Code

DynamicPartitionKafkaRDD.scala - https://github.com/Microsoft/Mobius



On-time Kafka fetch job submission

Pseudo Code

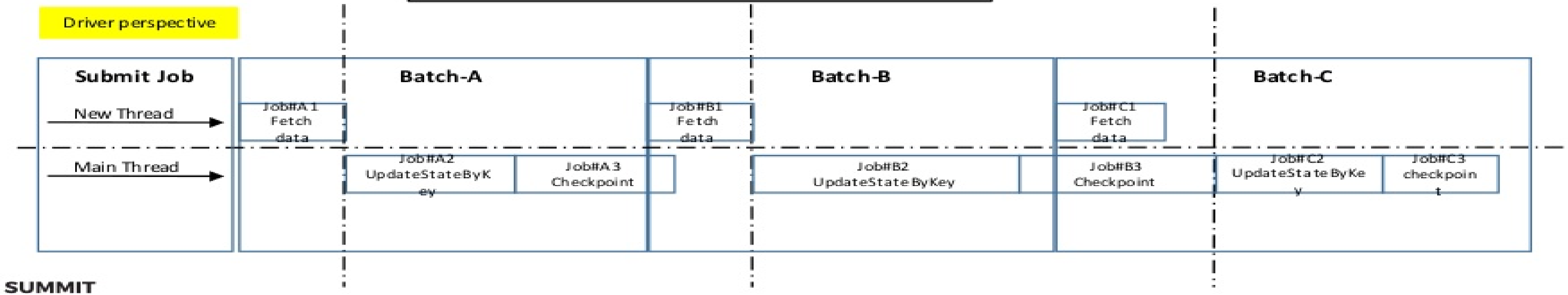
```
class CSharpStateDStream
  override def compute {
    val lastState = getOrCompute (validTime - batchInterval)

    val rdd = parent.getOrCompute(validTime)
    if (!lastBatchCompleted) {
      // if last batch not complete yet
      // run Fetch data job to materialize rdd in a separate thread
      rdd.cache()
      ThreadPool.execute(sc.runJob(rdd))
      // wait for job to complete
    }

    <compute UpdateStateByKey Dstream>
  }
```

Source Code

CSharpDStream.scala - https://github.com/Microsoft/Mobius



Parallel Kafka metadata refresh + RDD materialization

Pseudo Code

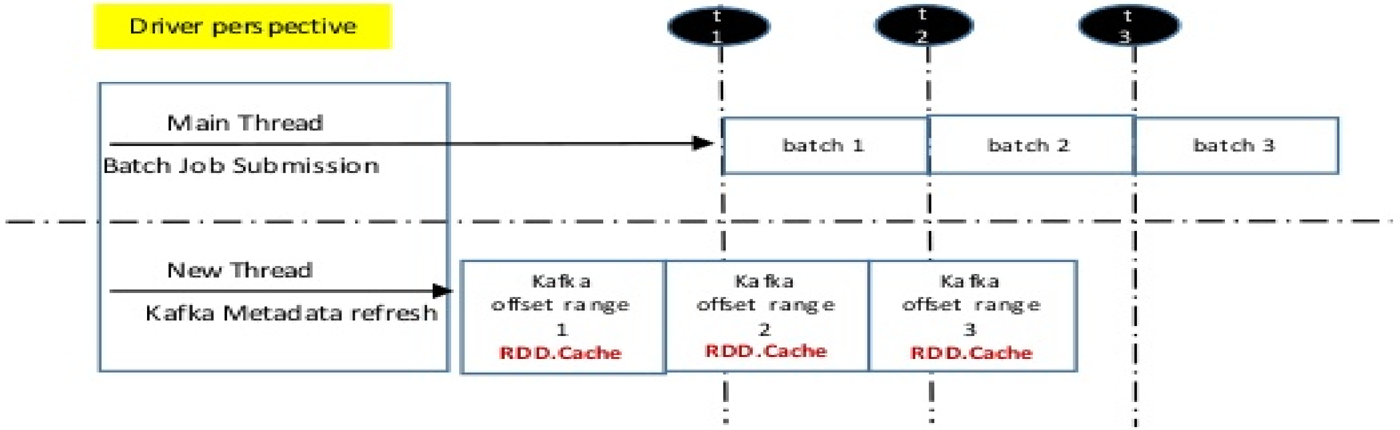
```
class DynamicPartitionKafkaInputDStream

  // starts a separate schedule thread at refreshOffsetsInterval
  refreshOffsetsScheduler.scheduleAtFixedRate(
     <get offset ranges>
     <generate kafka RDD>
     // materialize and cache
     sc.runJob(kafkaRdd.cache)
     <enqueue kafka RDD>
  )

  override def compute {
     <dequeue kafka RDD nonblockingly>
  }
```

Source Code

DynamicPartitionKafkaInputDStream.scala - https://github.com/Microsoft/Mobius



Use *UpdateStateByKey* to join DStreams

Pseudo Code

```
Iterator[(K, S)] JoinFunction(
    int pid, Iterator[(K:key, Iterator[V]:newEvents, S:oldState)] events)
{

    val currentTime = events.newEvents.max(e => e.eventTime);

    foreach (var e in events) {
        val newState = <oldState join newEvents>
        if (oldState.min(s => s.eventTime) + TimeWindow < currentTime) // TimeWindow 10minutes
            <output to external storage>
        else
            return (key, newState)
    }
}
```

***UpdateStateByKey* C# API**

PairDStreamFunctions.cs, https://github.com/Microsoft/Mobius