Processing Big Data in Motion

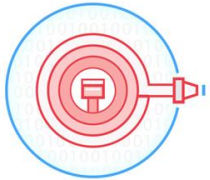
Streaming Data Ingestion and Processing

Roger Barga, General Manager, Kinesis Streaming Services, AWS

April 7, 2016

Riding the Streaming Rapids

Microsoft Research



Streaming Map Reduce
& Machine Learning over Streams

Azure Stream Analytics

Relational Semantics
and Implementation

Complex Event Processing
over Streaming Data

amazon web services

2007 & 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2015 | 2016

Interest in and *demand* for stream data processing is *rapidly increasing** …

* *Understatement of the year…*

Why?

Most data is *produced continuously*

127.0.0.1 user-identifier frank [10/Oct/2000:13:55:36 -0700] "GET /apache_pb.gif HTTP/1.0" 200 2326

Common Log Entry


```
{
  "payerId": "Joe",
  "productCode": "AmazonS3",
  "clientProductCode": "AmazonS3",
  "usageType": "Bandwidth",
  "operation": "PUT",
  "value": "22490",
  "timestamp": "1216674828"
}
```


Metering Record

<R,AMZN,T,G,R1>

NASDAQ OMX Record

“SeattlePublicWater/Kinesis/123/Realtime” – 412309129140

MQTT Record

<165>1 2003-10-11T22:14:15.003Z mymachine.example.com evntslog - ID47 [exampleSDID@32473 iut="3" eventSource="Application" eventID="1011"][examplePriority@32473 class="high"]

Syslog Entry

Why?

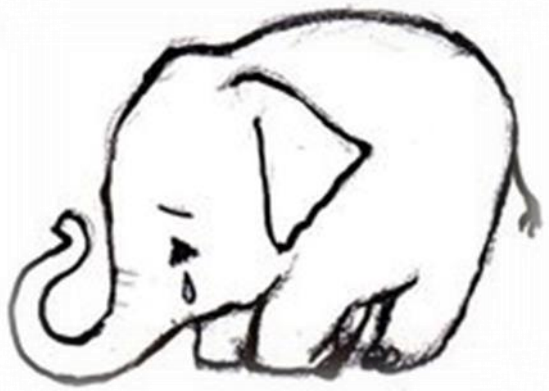
Time is money

- *Perishable Insights (Forrester)*

- Hourly server logs: how your systems were misbehaving an hour ago
- Weekly / Monthly Bill: What you spent this past billing cycle?
- Daily fraud reports: tells you if there was fraud yesterday
- CloudWatch metrics**: what just went wrong *now***
- Real-time spending alerts/caps: **guaranteeing you can't overspend**
- Real-time detection: **blocks fraudulent use *now***

Why?

Time is money



- *Perishable Insights (Forrester)*
- *A more efficient implementation*
- *Most ‘Big Data’ deployments process continuously generated data (batched)*

Why?

Availability

Variety of stream data processing systems, active ecosystem but still early days…

Why?

Disruptive

Foundational for business critical workflows

Enable new class of applications & services that process data continuously.

You

Need to begin thinking about applications & services in terms of streams of data and continuous processing.

A change in perspective is worth 80 IQ points… – *Alan Kay*

Agenda

- Scalable & Durable Data Ingest
  - A quick word on our motivation
  - Kinesis Streams, through a simple example
- Continuous Stream Data Processing
  - Kinesis Client Library (KCL)
  - One select design challenge: dynamic resharding
  - How customers are using Kinesis Streams today
- Building on Kinesis Streams
  - Kinesis Firehose
  - AWS Event Driven Computing

Our Motivation for Continuous Processing

AWS Metering service

- 100s of millions of billing records per second
- Terabytes^{++} per hour
- Hundreds of thousands of sources
- For each customer: gather all metering records & compute monthly bill
- Auditors guarantee 100% accuracy at months end

Seem perfectly reasonable to run as a batch, but relentless pressure for realtime…

With a Data Warehouse to load

- 1000s extract-transform-load (ETL) jobs every day
- Hundreds of thousands of files per load cycle
- Thousands of daily users, hundreds of queries per hour

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Other Service Teams, Similar Requirements

- CloudWatch Logs and CloudWatch Metrics
- CloudFront API logging
- ‘Snitch’ internal datacenter hardware metrics

Right Tool for the Job

Enable Streaming Data Ingestion and Processing

Real-time Ingest

- Highly Scalable
- Durable
- Replayable Reads

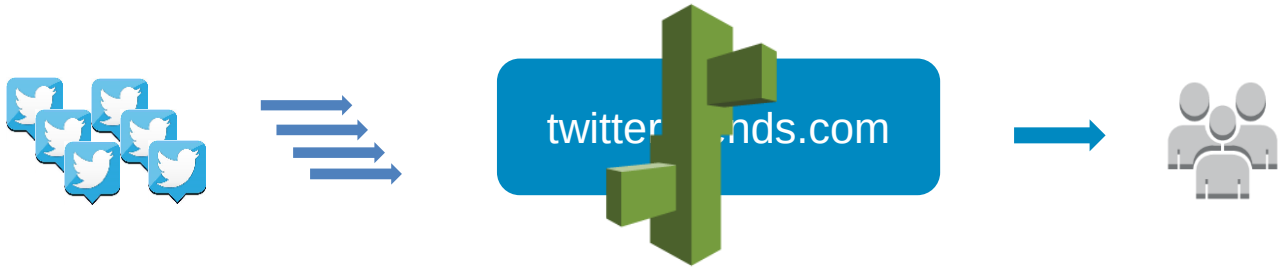
Continuous Processing

- Support multiple simultaneous data processing applications
- Load-balancing incoming streams, scale out processing
- Fault-tolerance, Checkpoint / Replay

Amazon Kinesis

Example application

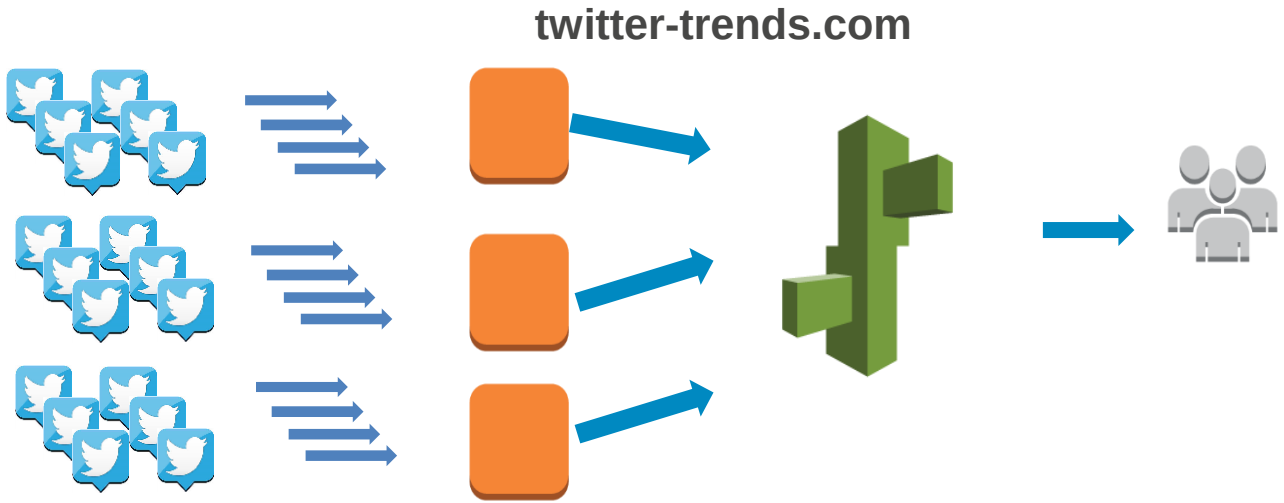
twitter-trends.com website



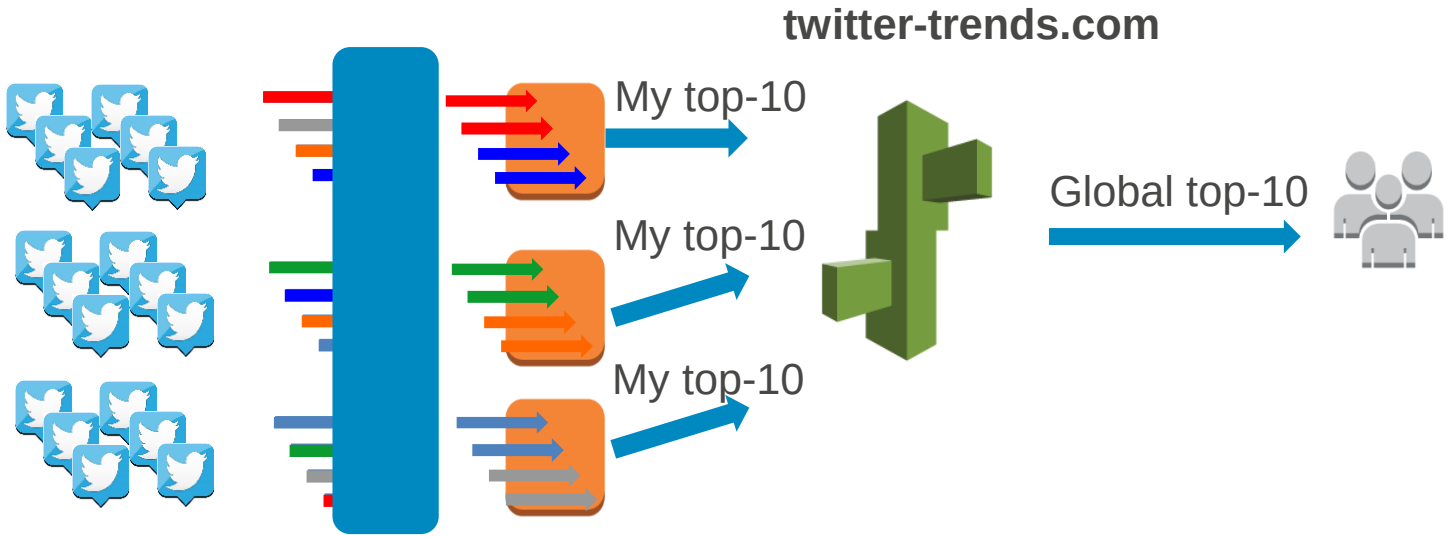
Elastic Beanstalk

twitter-trends.com

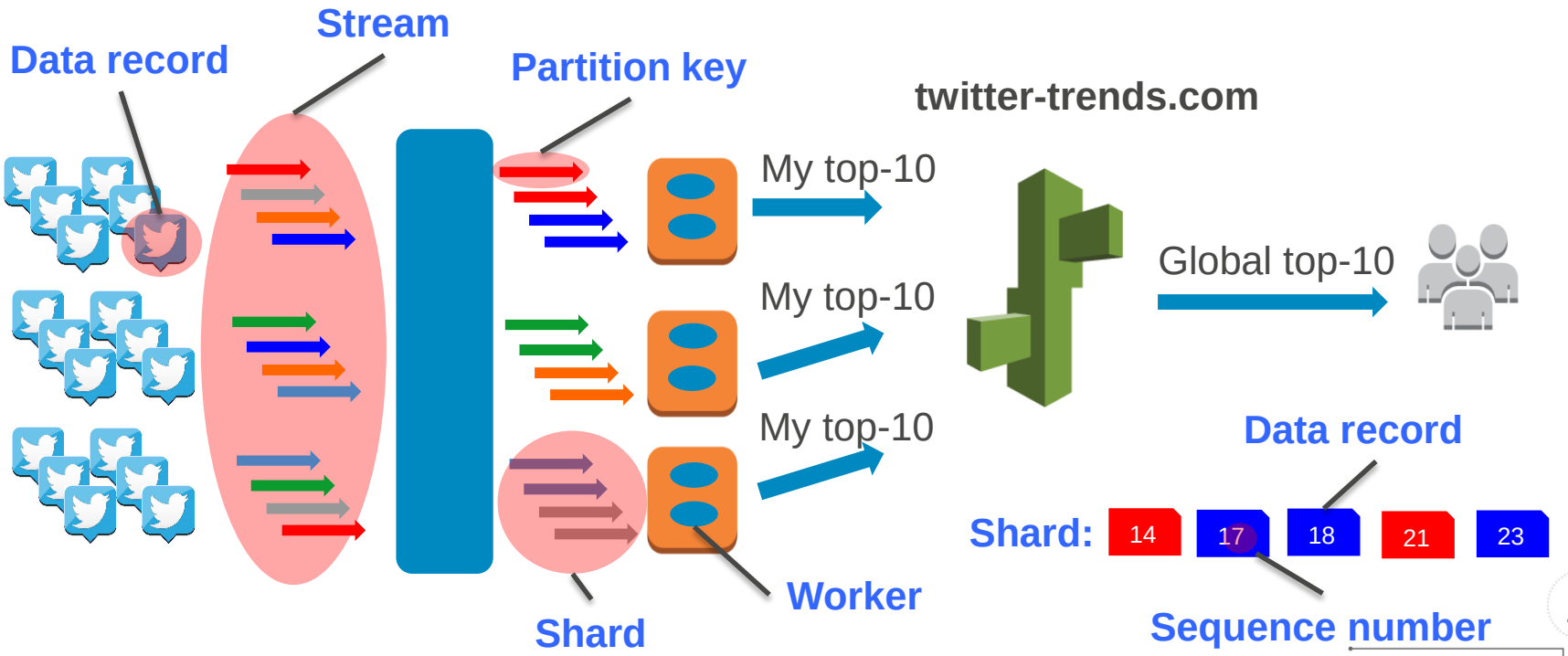
Too big to handle on one box



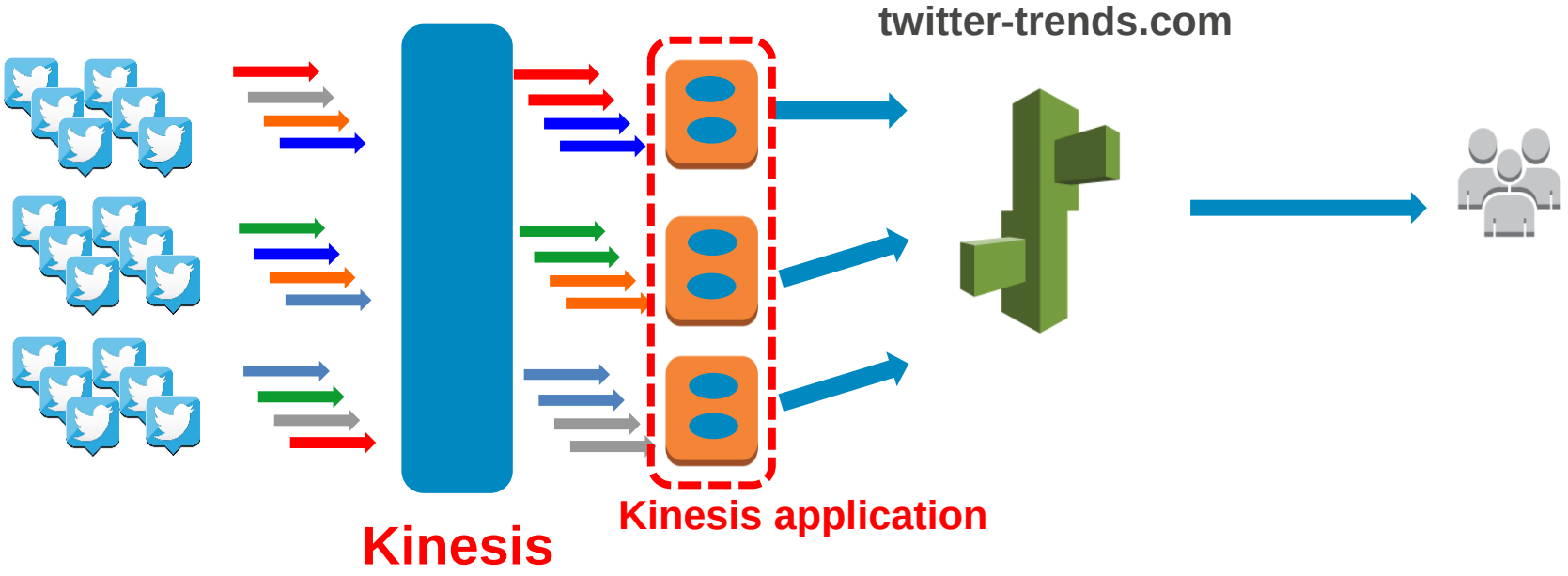
The solution: streaming map/reduce



Core concepts

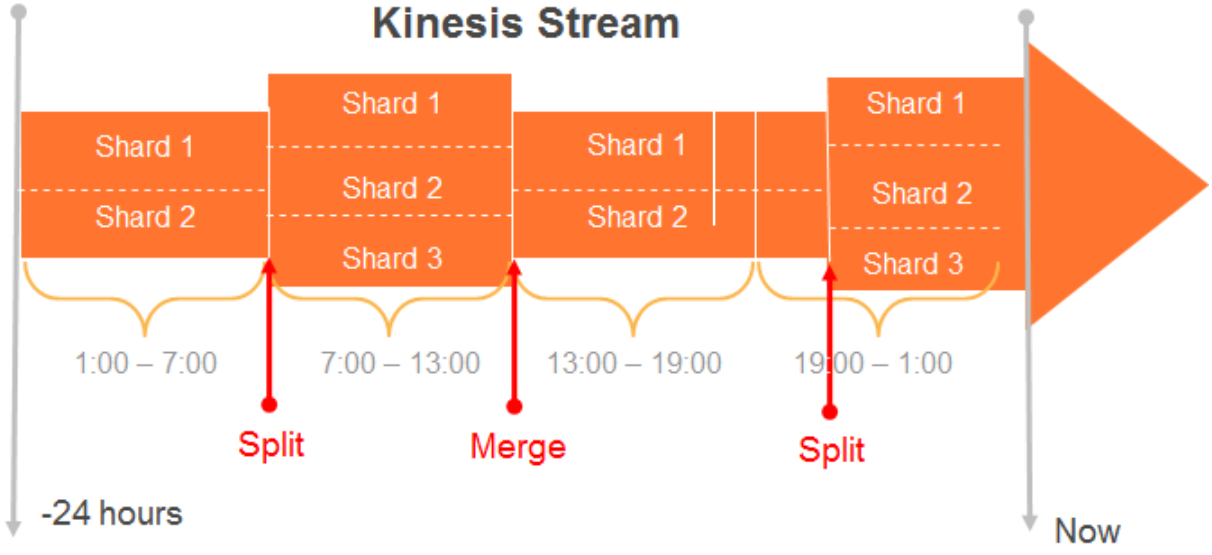


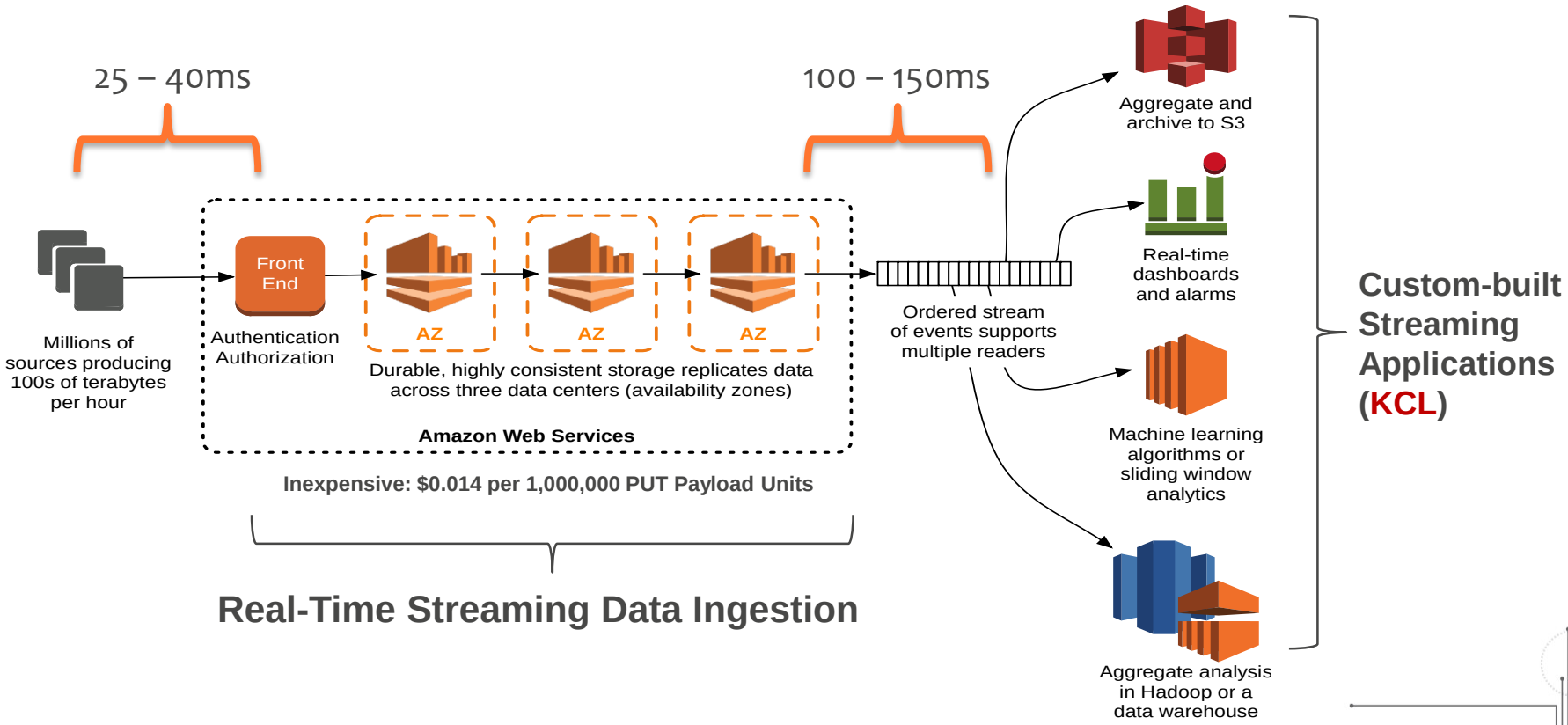
How this relates to Kinesis



Kinesis Streaming Data Ingestion

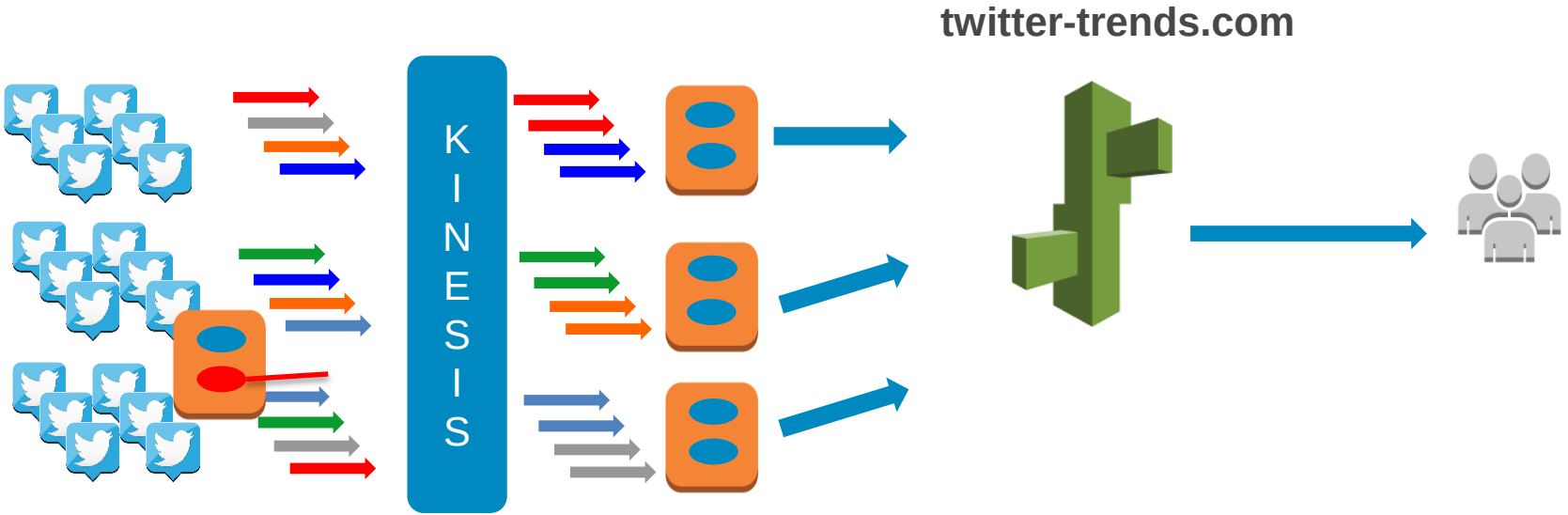
- Streams are made of **Shards**
- Each Shard ingests data up to 1MB/sec, and up to 1000 TPS
- Producers use a PUT call to store data in a Stream: PutRecord {Data, PartitionKey, StreamName}
- Each Shard emits up to 2 MB/sec
- All data is stored for **24 hours**, **7 days** if extended retention is 'ON'
- **Scale** Kinesis streams by adding or removing Shards
- **Replay** data from retention period



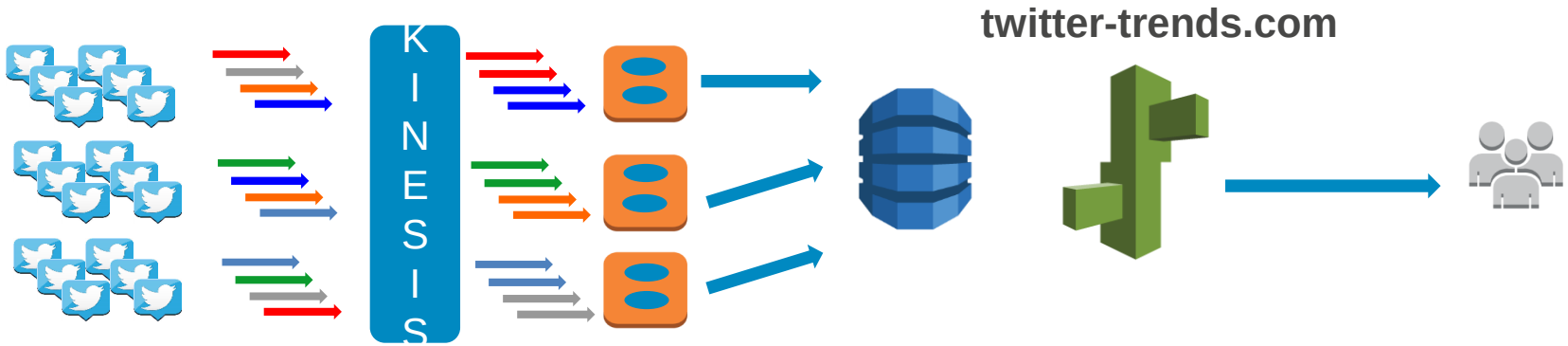

25 – 40ms
100 – 150ms
Millions of sources producing 100s of terabytes per hour
Front End
Authentication Authorization
AZ
AZ
AZ
Durable, highly consistent storage replicates data across three data centers (availability zones)
Amazon Web Services
Ordered stream of events supports multiple readers
Aggregate and archive to S3
Real-time dashboards and alarms
Machine learning algorithms or sliding window analytics
Aggregate analysis in Hadoop or a data warehouse
Custom-built Streaming Applications (KCL)
Inexpensive: $0.014 per 1,000,000 PUT Payload Units
Real-Time Streaming Data Ingestion

Kinesis Client Library

Using the Kinesis API directly



Using the Kinesis API directly

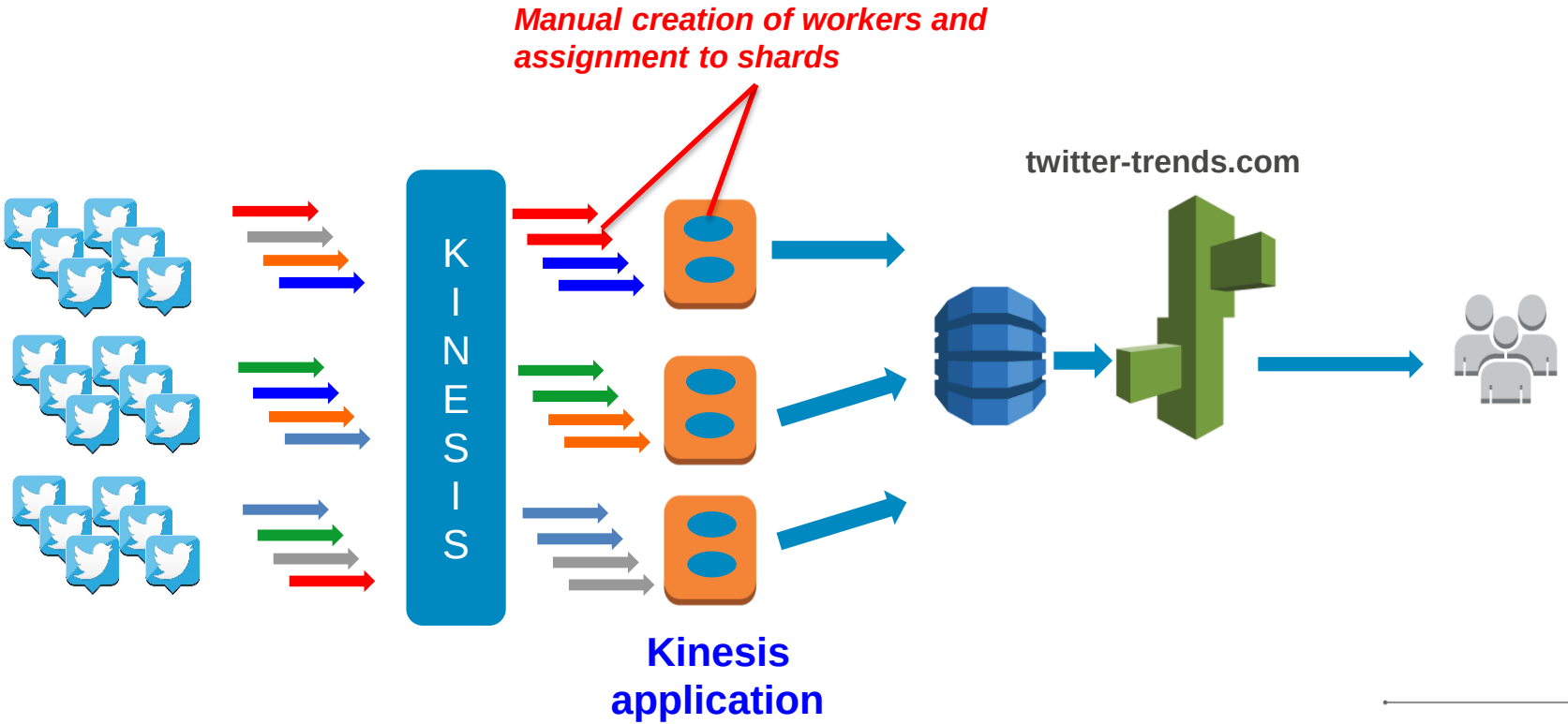



```
iterator = getShardIterator(shardId, LATEST);
while (true) {
   [records, iterator] =
      getNextRecords(iterator, maxRecsToReturn);
   process(records);
}
```

```
process(records): {
   for (record in records) {
      updateLocalTop10(record);
    }
   if (timeToDoOutput()) {
      writeLocalTop10ToDDB();
   }
}
```

```
while (true) {
   localTop10Lists =
         scanDDBTable();
   updateGlobalTop10List(
         localTop10Lists);
   sleep(10);
}
```

Challenges with using the Kinesis API directly



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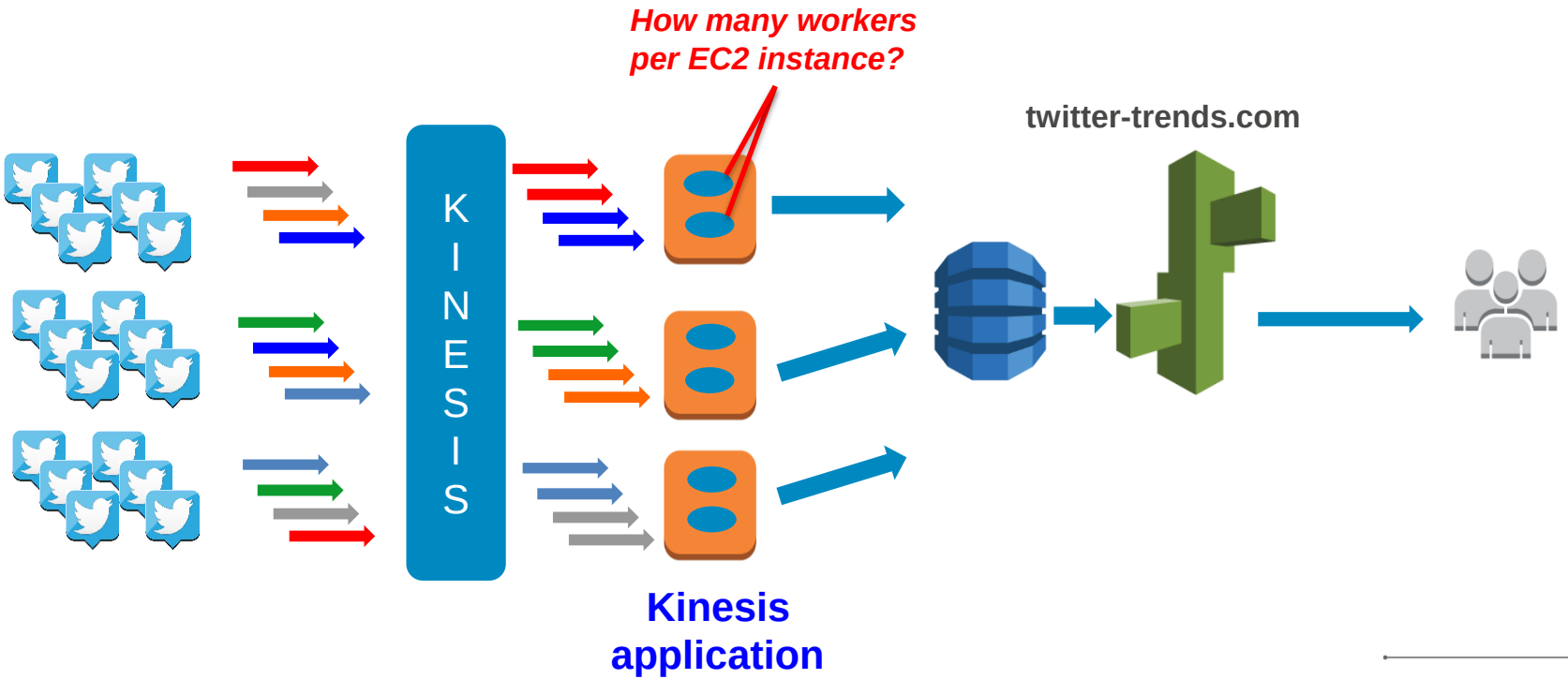

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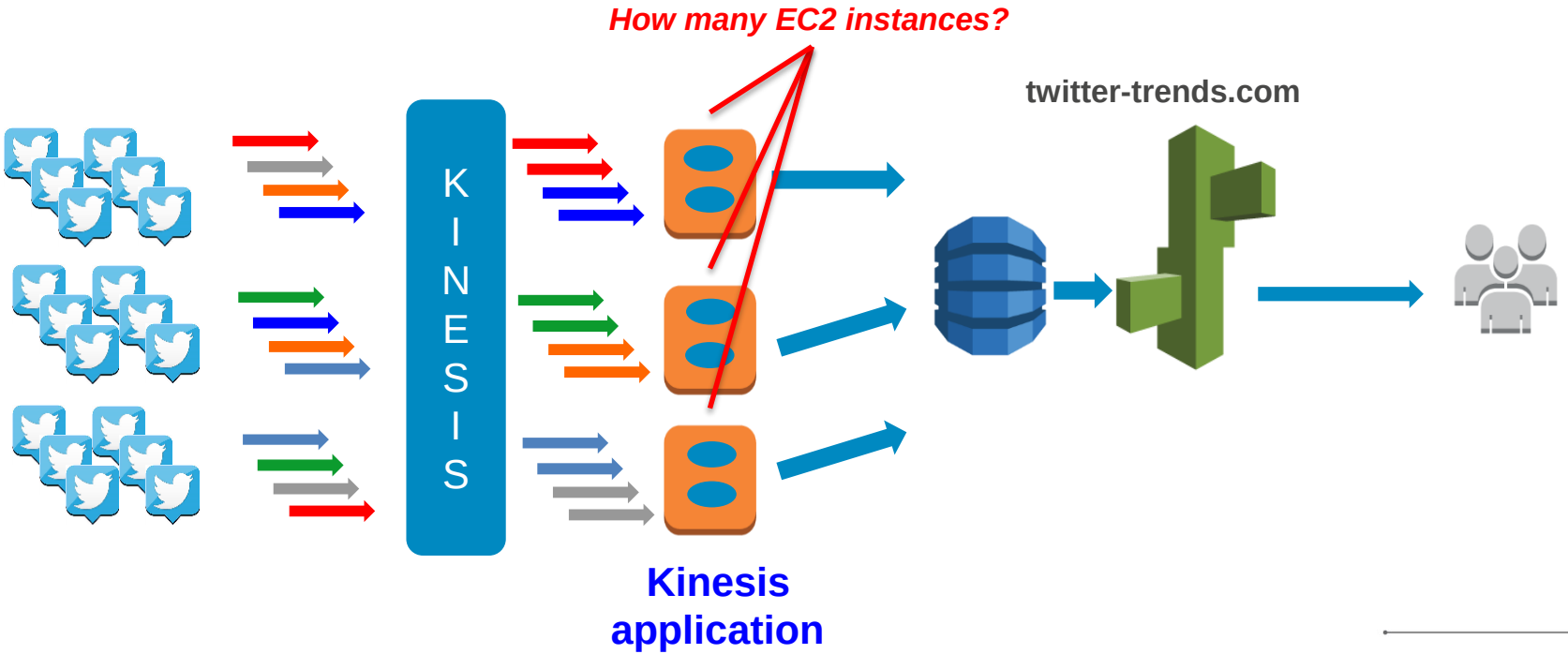
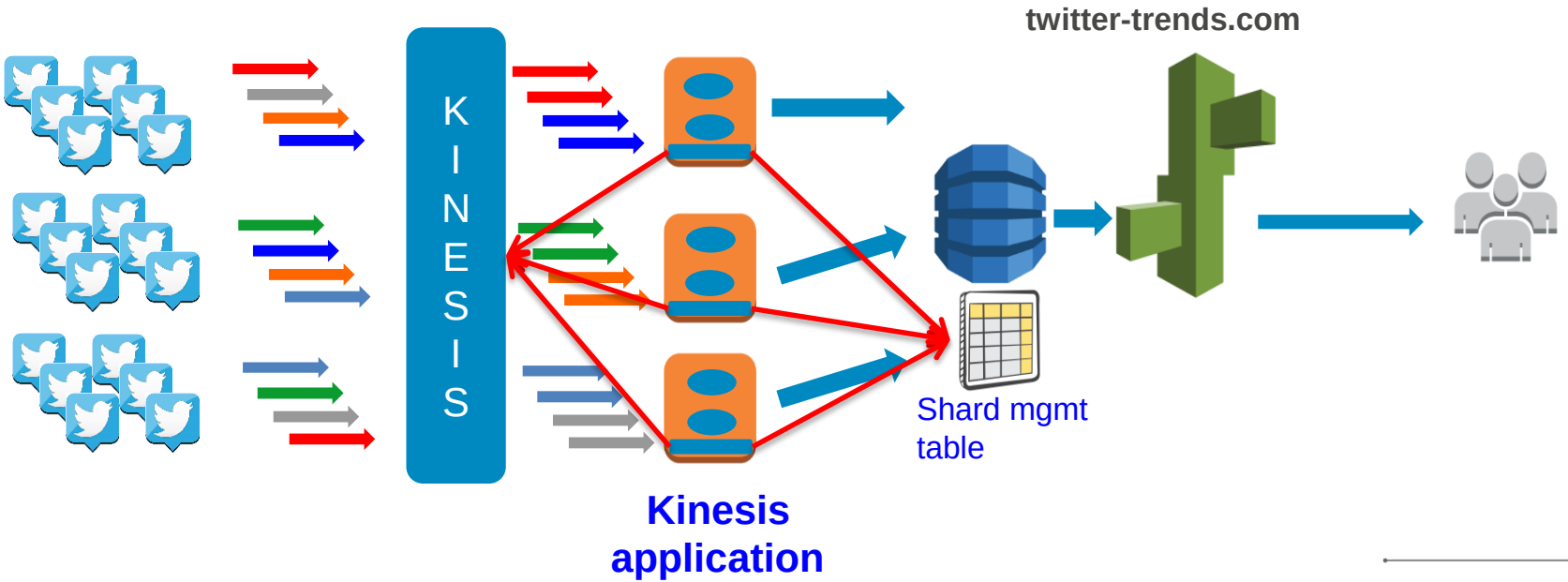
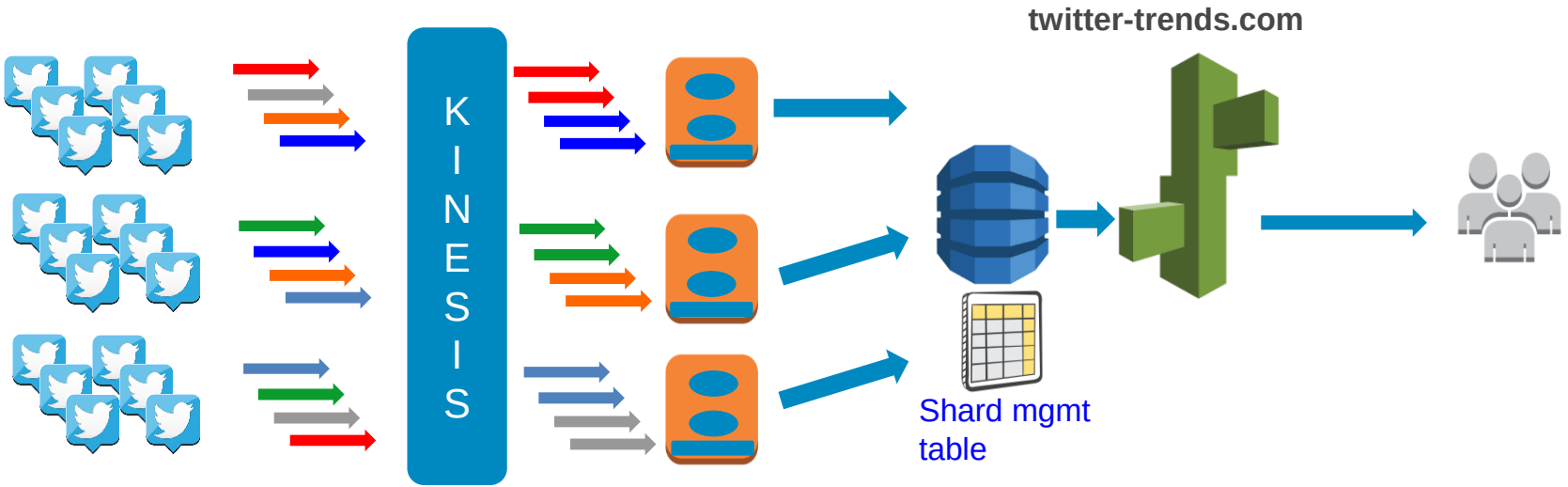


Using the Kinesis Client Library



Elasticity and Load Balancing



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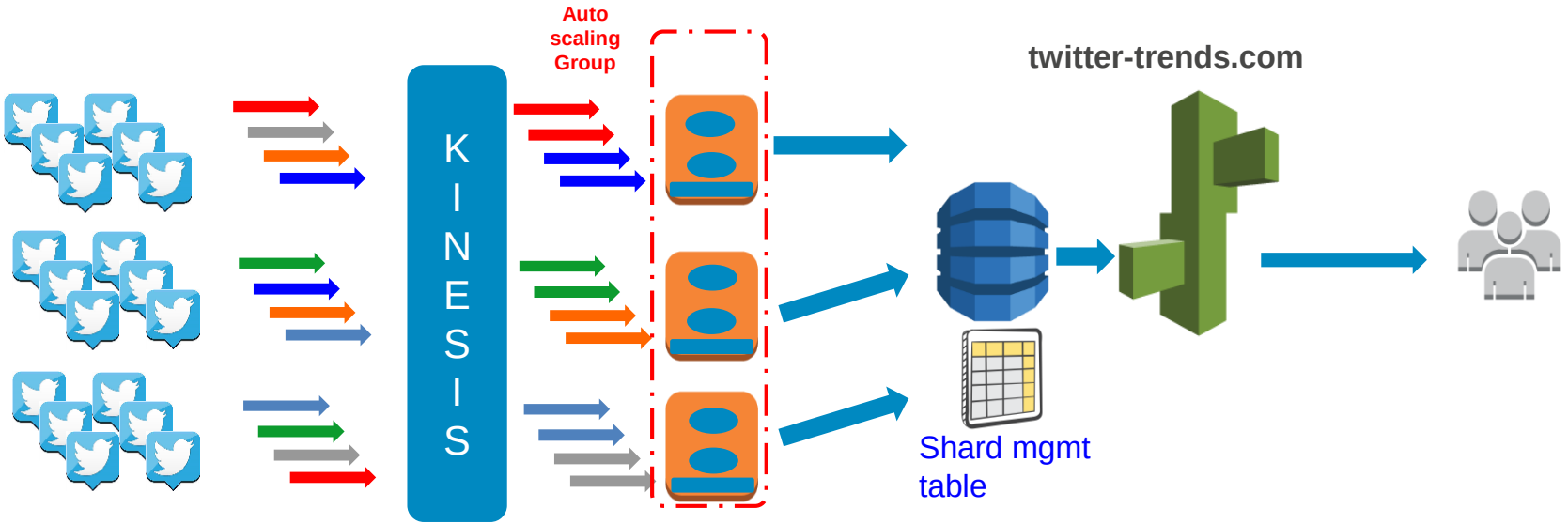

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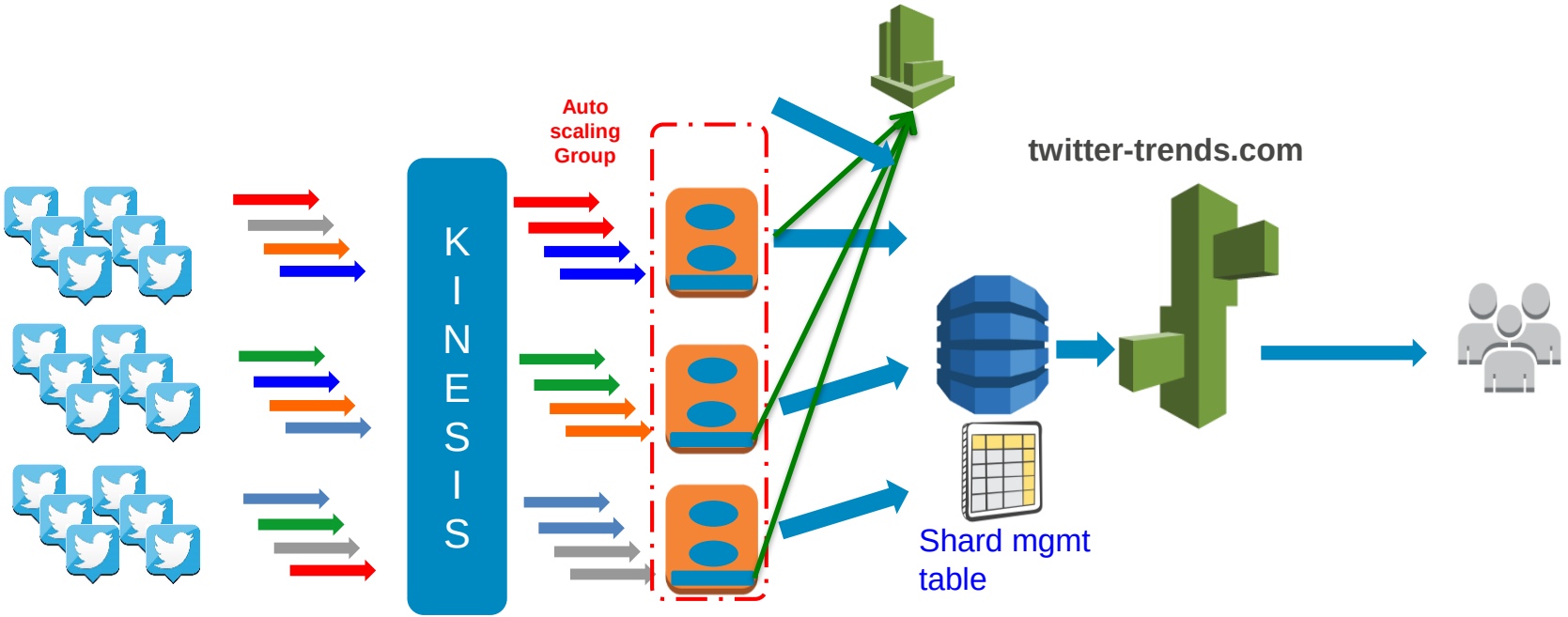

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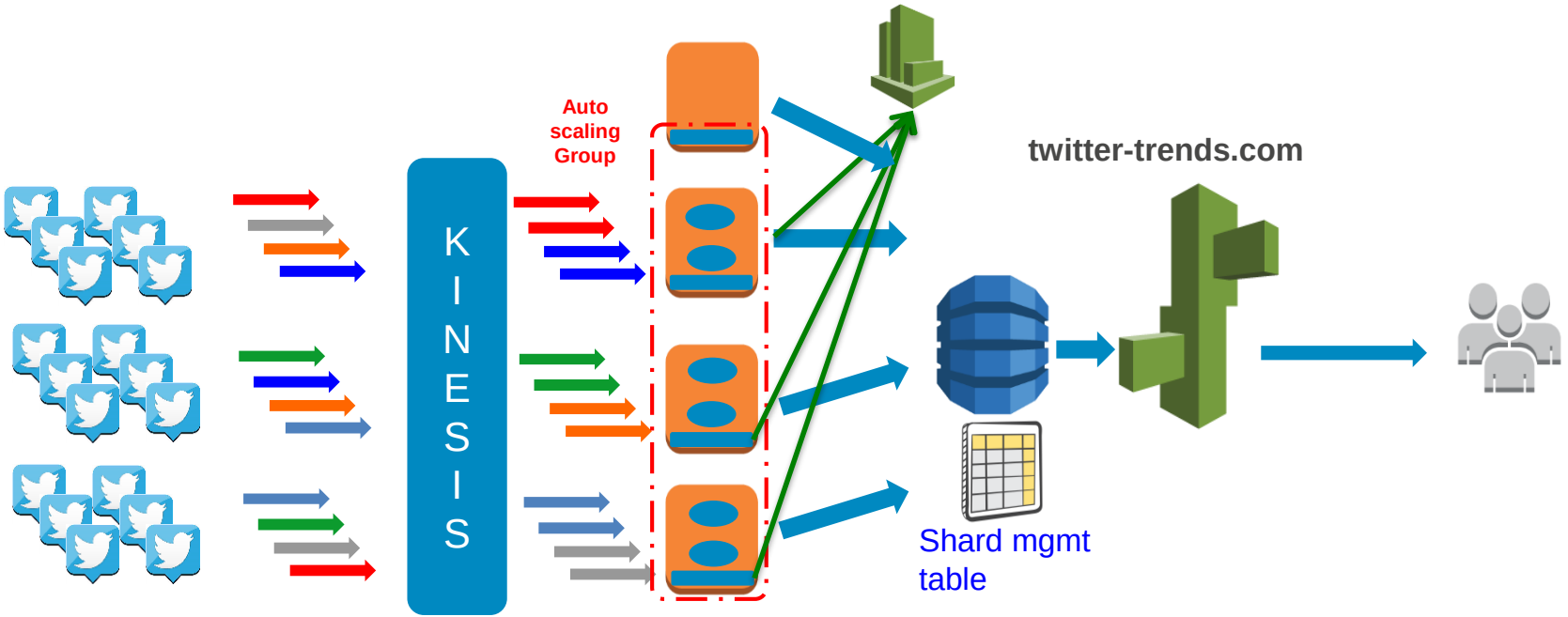

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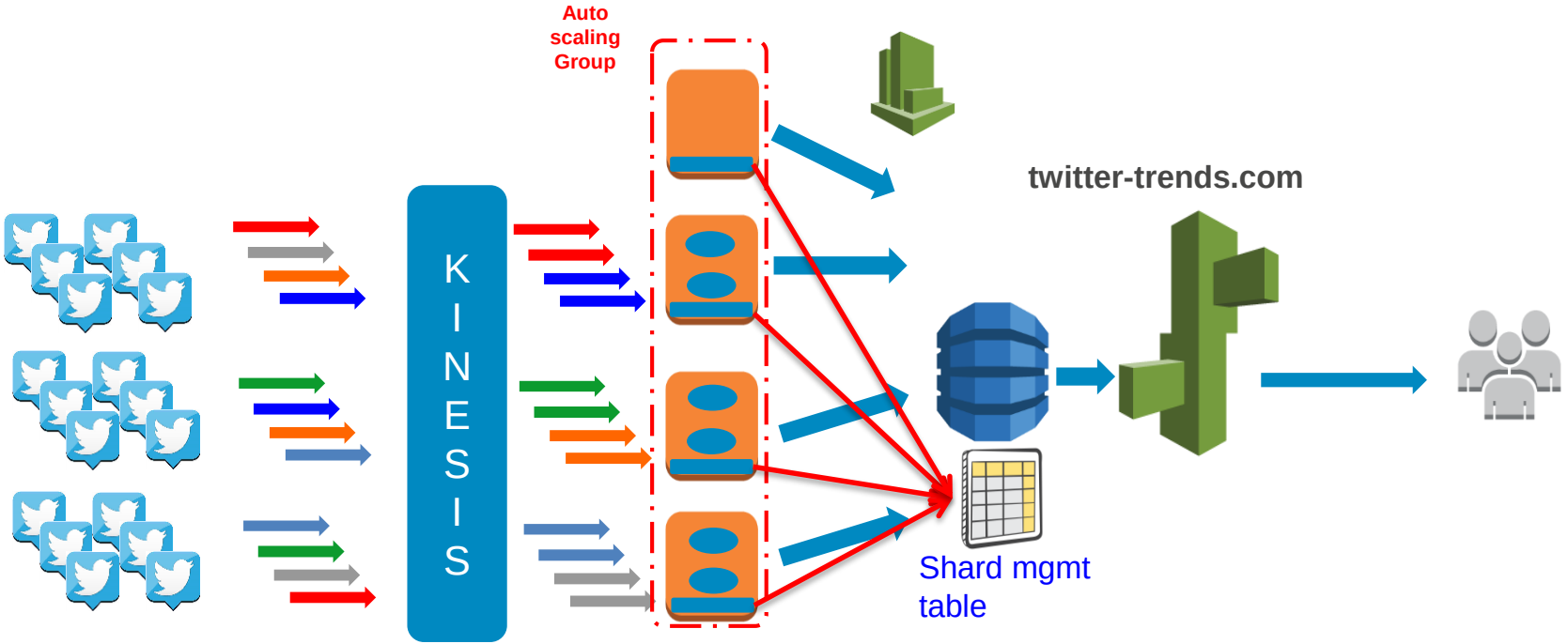
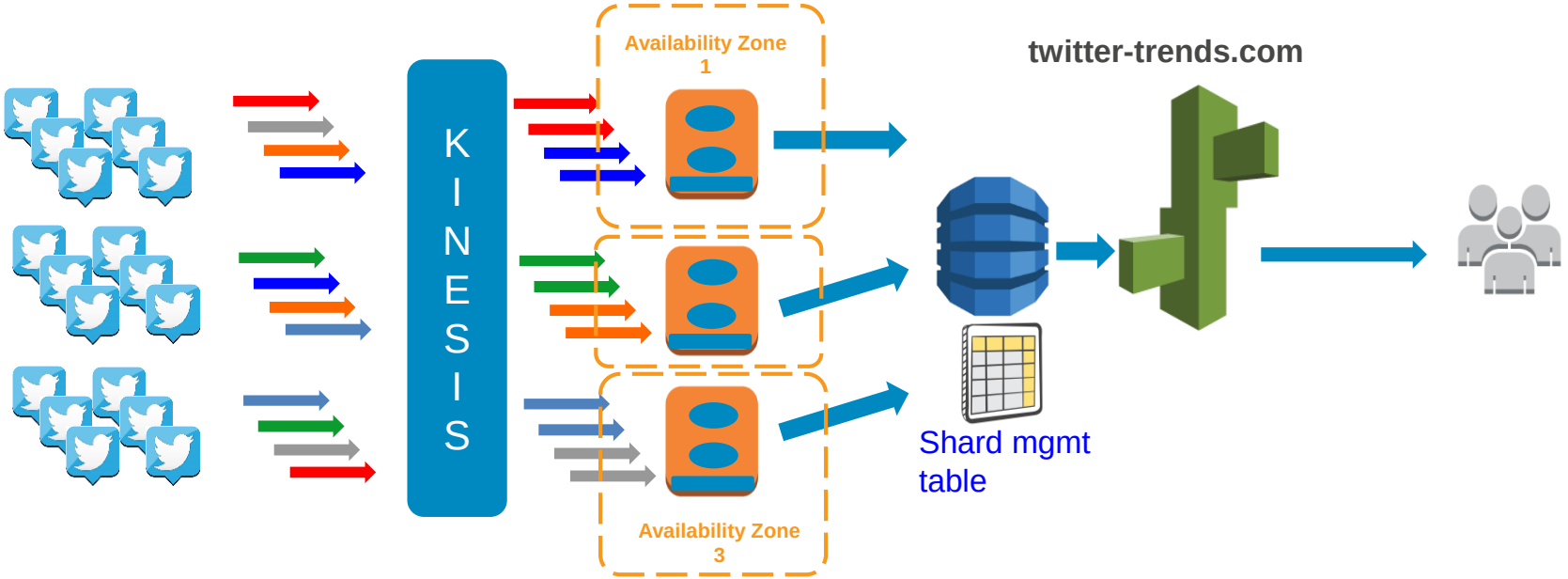


Fault Tolerance Support



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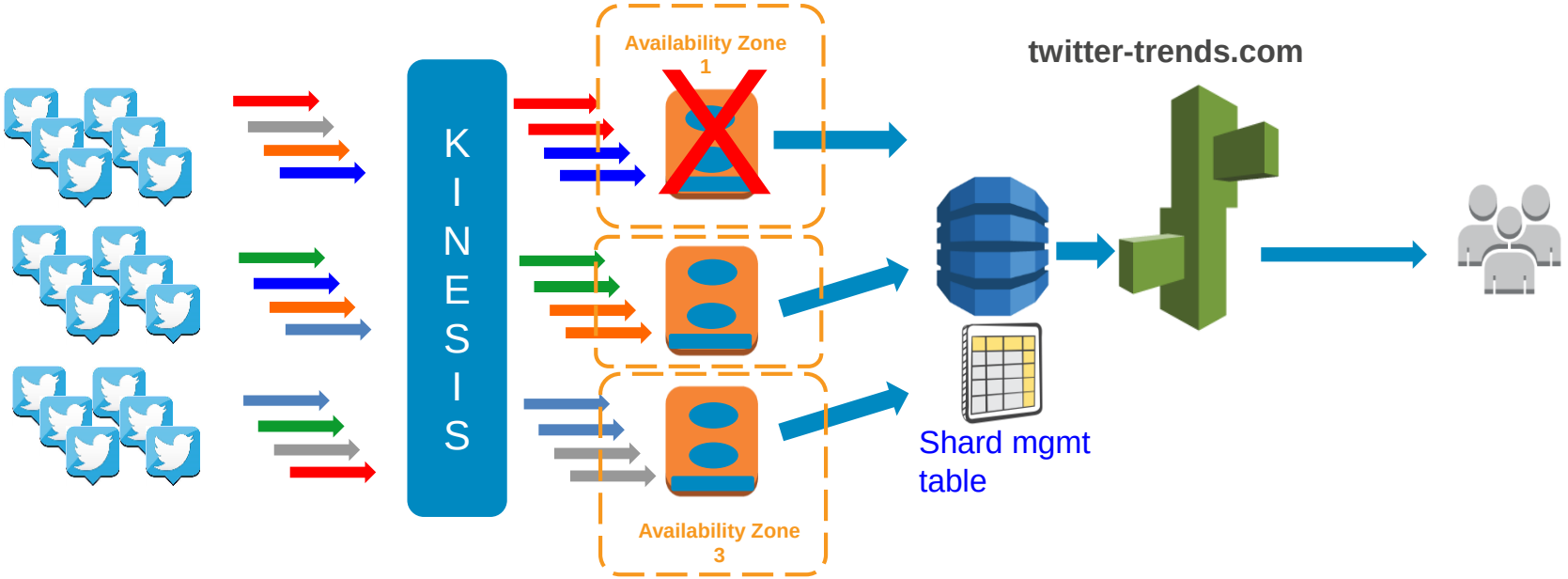

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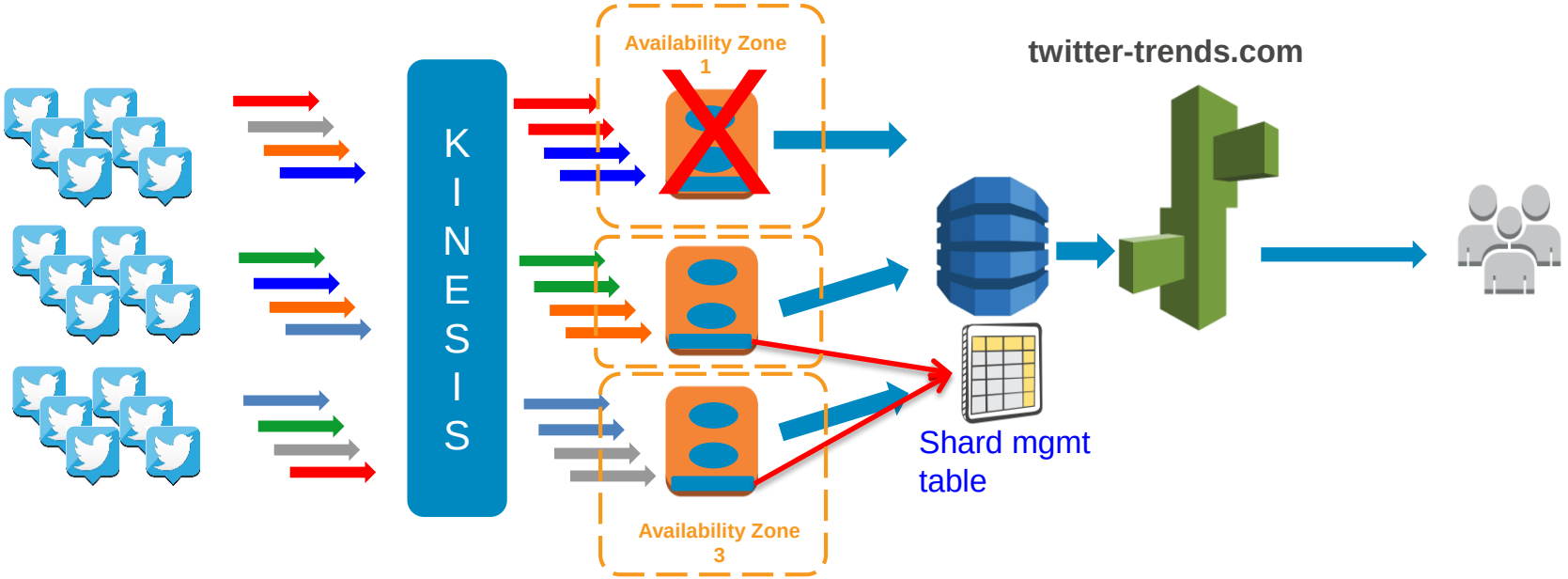

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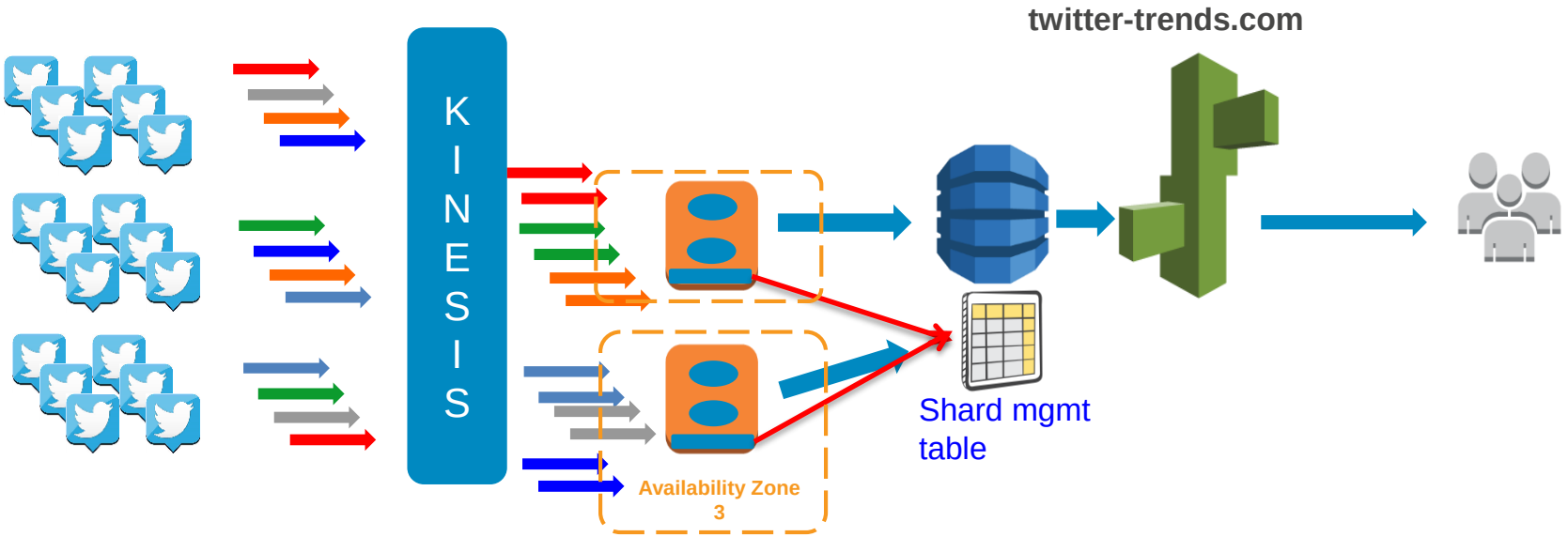
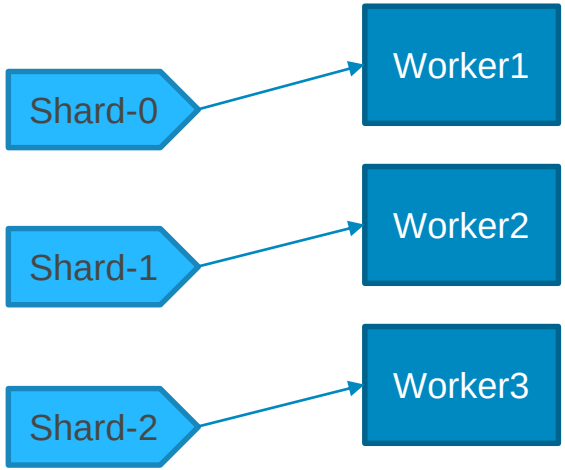
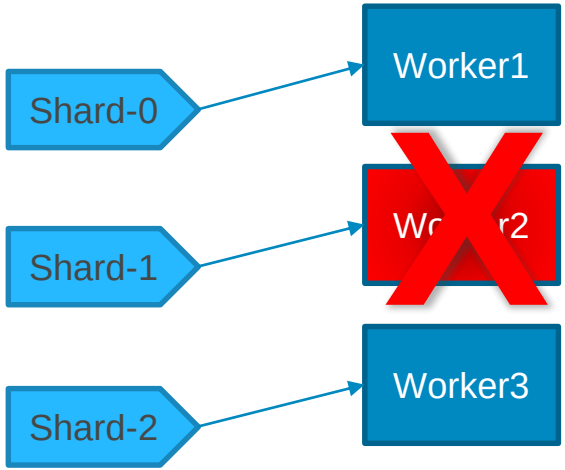


Worker Fail Over



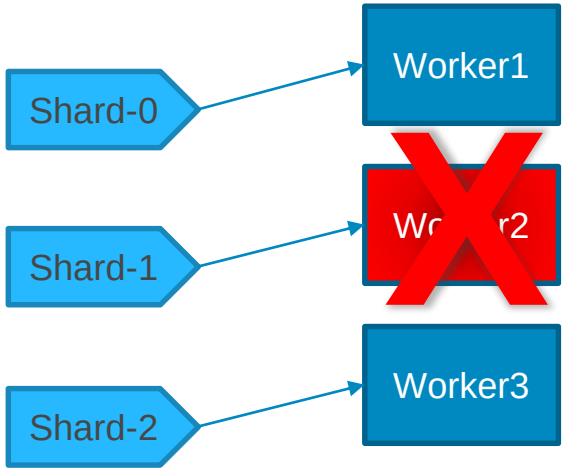
LeaseKey	LeaseOwner	LeaseCounter
Shard-0	Worker1	85
Shard-1	Worker2	94
Shard-2	Worker3	76

Worker Fail Over



LeaseKey	LeaseOwner	LeaseCounter
Shard-0	Worker1	~~85~~ 86
Shard-1	Worker2	94
Shard-2	Worker3	~~76~~ 77

Worker Fail Over



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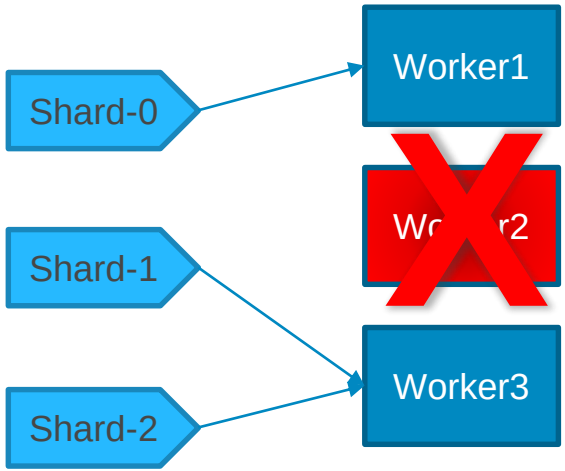
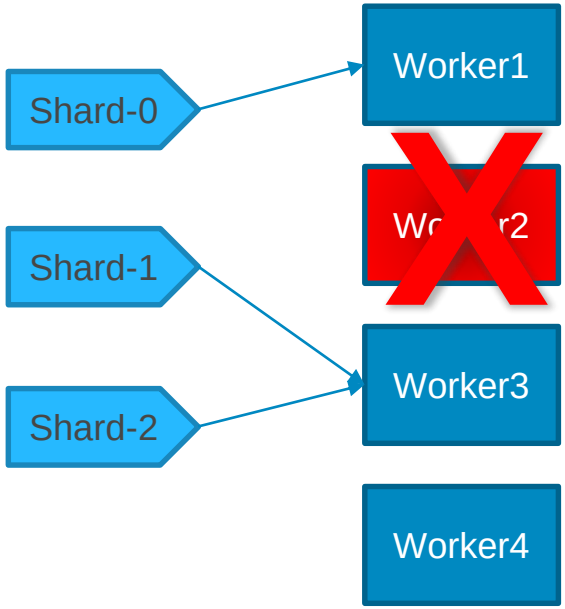


LeaseKey	LeaseOwner	LeaseCounter
Shard-0	Worker1	~~85~~ ~~86~~ ~~87~~ 88
Shard-1	Worker3	~~94~~ 95
Shard-2	Worker3	~~76~~ ~~77~~ ~~78~~ 79

Worker Load Balancing



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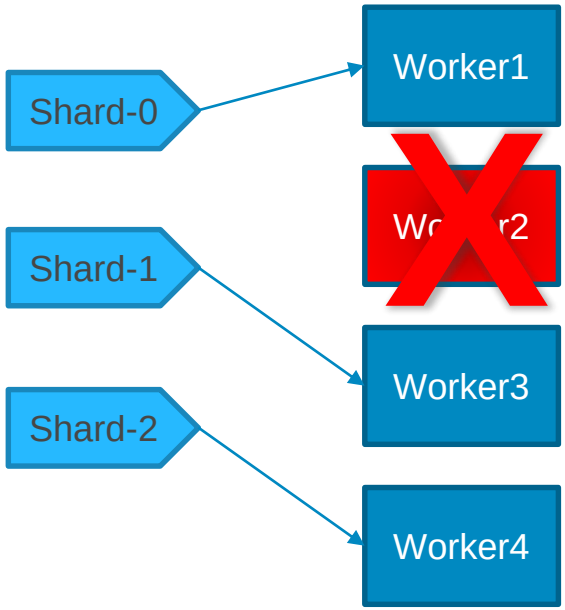
Worker Load Balancing



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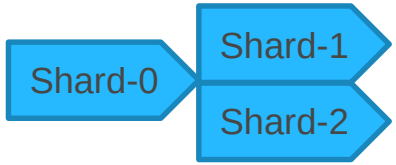
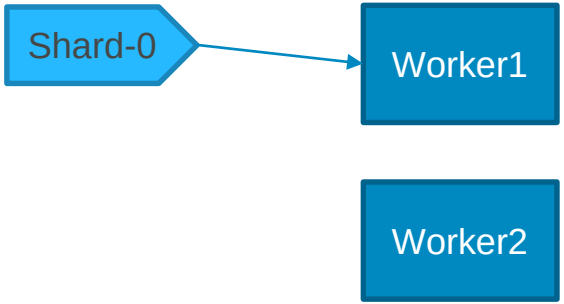
Shard-0	Worker1	88
Shard-1	Worker3	96
Shard-2	Worker4	79

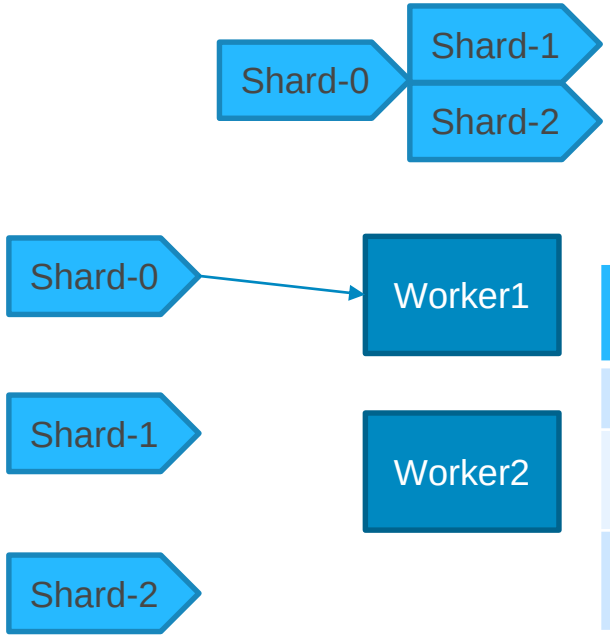
Resharding





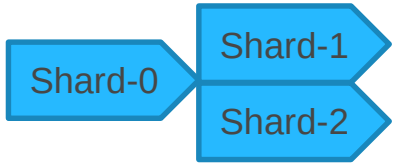
LeaseKey	LeaseOwner	LeaseCounter	checkpoint
Shard-0	Worker1	90	SHARD_END

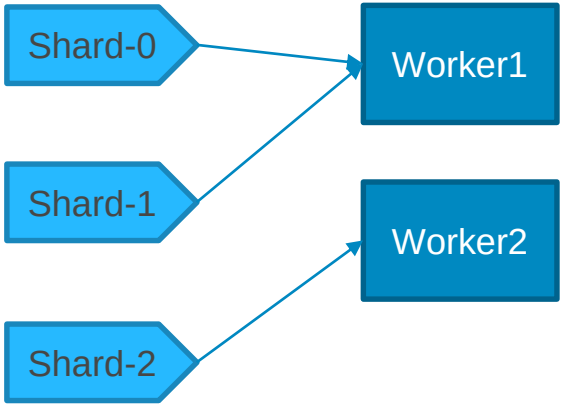
Resharding



LeaseKey	LeaseOwner	LeaseCounter	checkpoint
Shard-0	Worker1	90	SHARD_END
Shard-1		0	TRIM_HORIZON
Shard-2		0	TRIM_HORIZON

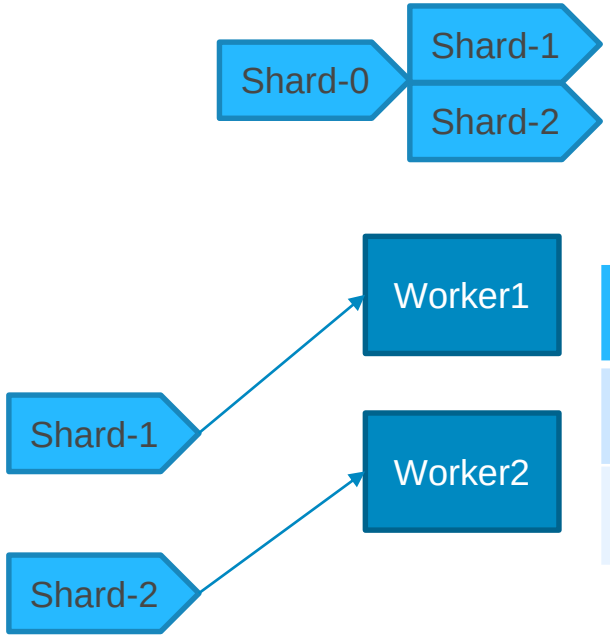
Resharding





LeaseKey	LeaseOwner	LeaseCounter	checkpoint
Shard-0	Worker1	90	SHARD_END
Shard-1	Worker1	2	TRIM_HORIZON
Shard-2	Worker2	3	TRIM_HORIZON

Resharding



LeaseKey	LeaseOwner	LeaseCounter	checkpoint
Shard-1	Worker1	2	TRIM_HORIZON
Shard-2	Worker2	3	TRIM_HORIZON

Putting this into production

Cost & Scale

500MM tweets/day = ~ 5,800 tweets/sec

2k/tweet is ~12MB/sec (~1TB/day)

$0.015/hour per shard, $0.014/million PUTS

Kinesis cost is $0.47/hour

Redshift cost is $0.850/hour (for a 2TB node)

Total: $1.32/hour

Design Challenge(s)

- Dynamic Resharding & Scale Out
- Enforcing Quotas (think proxy fleet with 1Ks servers)
- Distributed Denial of Service Attack (unintentional)
- Dynamic Load Balancing on Storage Servers
- Heterogeneous Workloads (tip of stream vs 7 day)
- Optimizing Fleet Utilization (proxy, control, data planes)
- Avoid Scaling Cliffs
- …

Kinesis Streams: Streaming Data the AWS Way

- Easy to provision, deploy, and manage

- Elastically scalable

- Real-time latencies

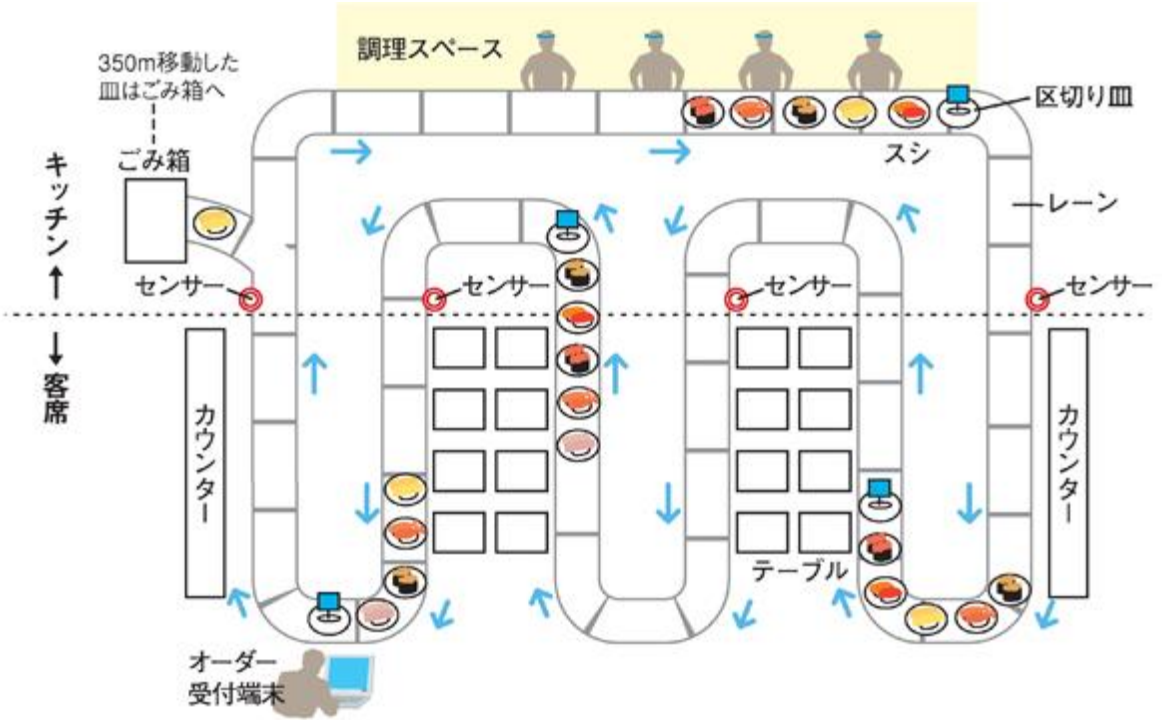
- Choose the service, or combination of services, for your specific use cases.

- Pay as you go, no up front costs

Amazon Kinesis

Sushiro: Kaiten Sushi Restaurants

380 stores stream data from sushi plate sensors and stream to Kinesis



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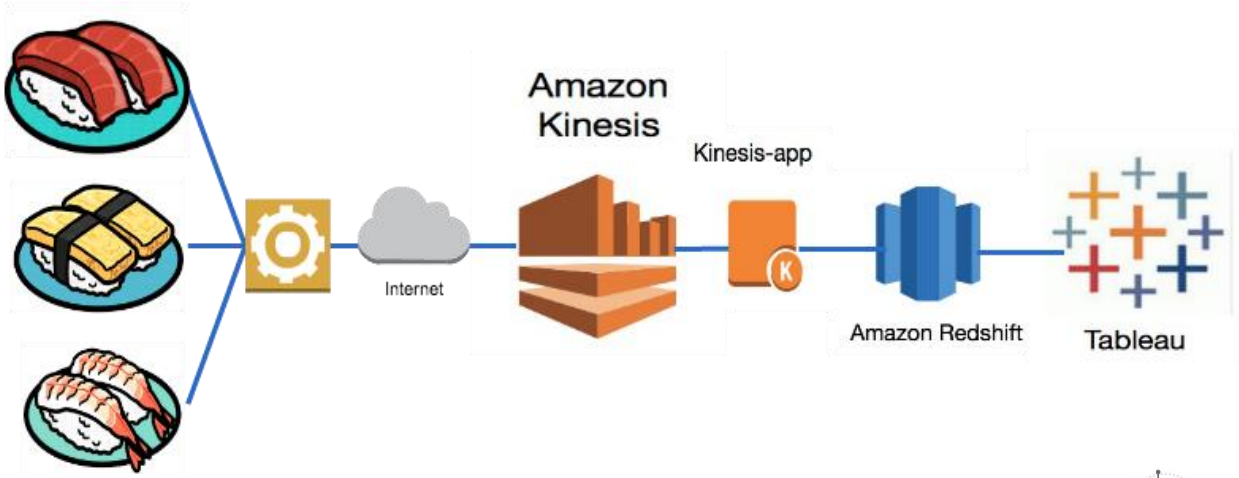


Real-Time Streaming Data with Kinesis Streams

1 TB+/day game data analyzed in real-time | Gaming

5 billion events/wk from connected devices | IoT

17 PB of game data per season | Entertainment

100 billion ad impressions/day, 30 ms response time | Ad Tech

100 GB/day click streams 250+ sites | Enterprise

50 billion ad impressions/day sub-50 ms responses | Ad Tech

17 million events/day | Technology

1 billion transactions per day | Bitcoin

Streams provide a foundational abstraction on which to build higher level services

Amazon Kinesis Firehose

Capture and submit streaming data to Firehose

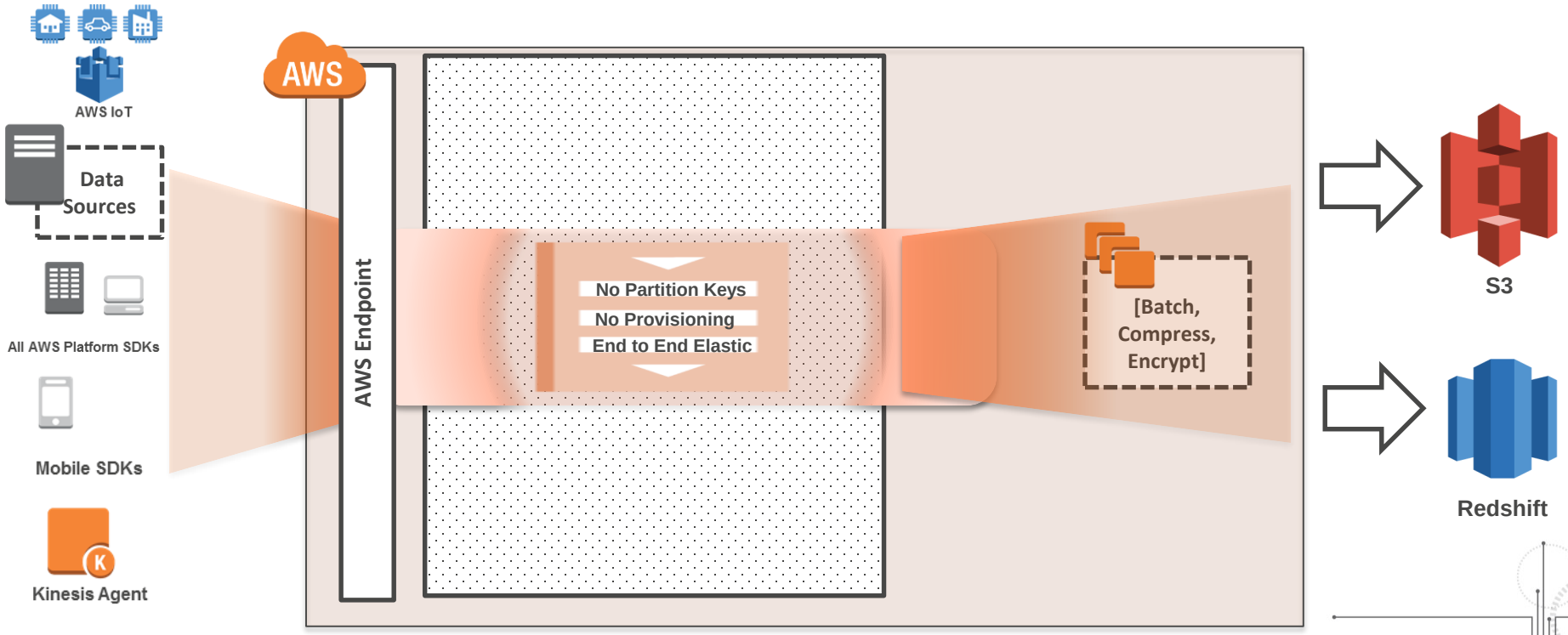
Firehose loads streaming data continuously into S3 and Redshift

Analyze streaming data using your favorite BI tools

- **Zero Admin:** Capture and deliver streaming data into S3, Redshift, and other destinations without writing an application or managing infrastructure
- **Direct-to-data store integration:** Batch, compress, and encrypt streaming data for delivery into S3, and other destinations in as little as 60 secs, set up in minutes
- **Seamless elasticity:** Seamlessly scales to match data throughput

Amazon Kinesis Firehose

Fully Managed Service for Delivering Data Streams into AWS Destinations



AWS Event-Driven Computing

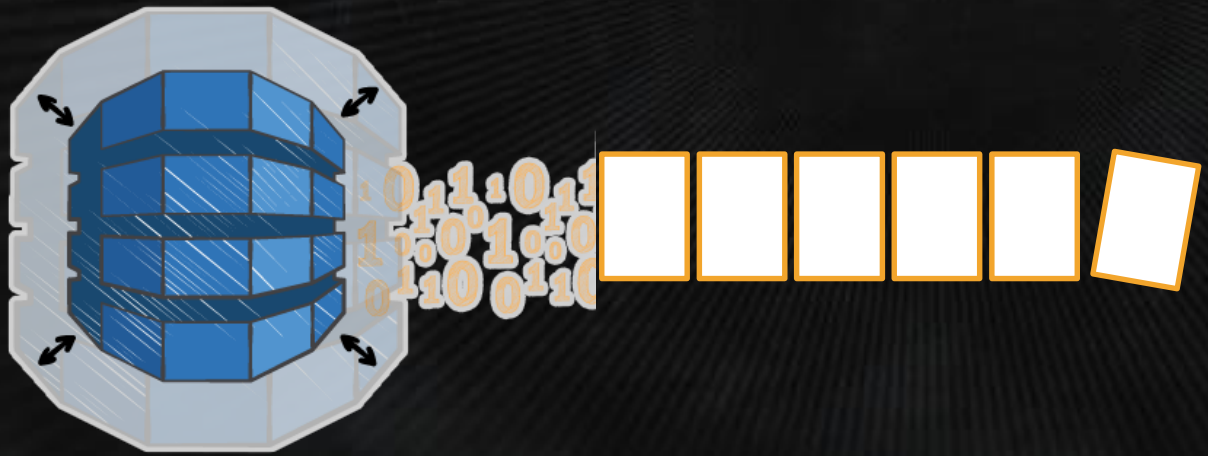
- Compute in response to recently occurring events
- Newly arrived/changed data
  - Example: generate thumbnail for an image uploaded to S3
- Newly occurring system state changes
  - Example: EC2 instance created
  - Example: DynamoDB table deleted
  - Example: Auto-scaling group membership change
  - Example: RDS-HA primary fail-over occurs

Event Driven Computing in AWS Today

S3 event notifications

Event Driven Computing in AWS Today

DynamoDB Update Streams



Event Driven Computing in AWS Today

Cloudtrails event log for API calls

Event Driven Computing in AWS Tomorrow

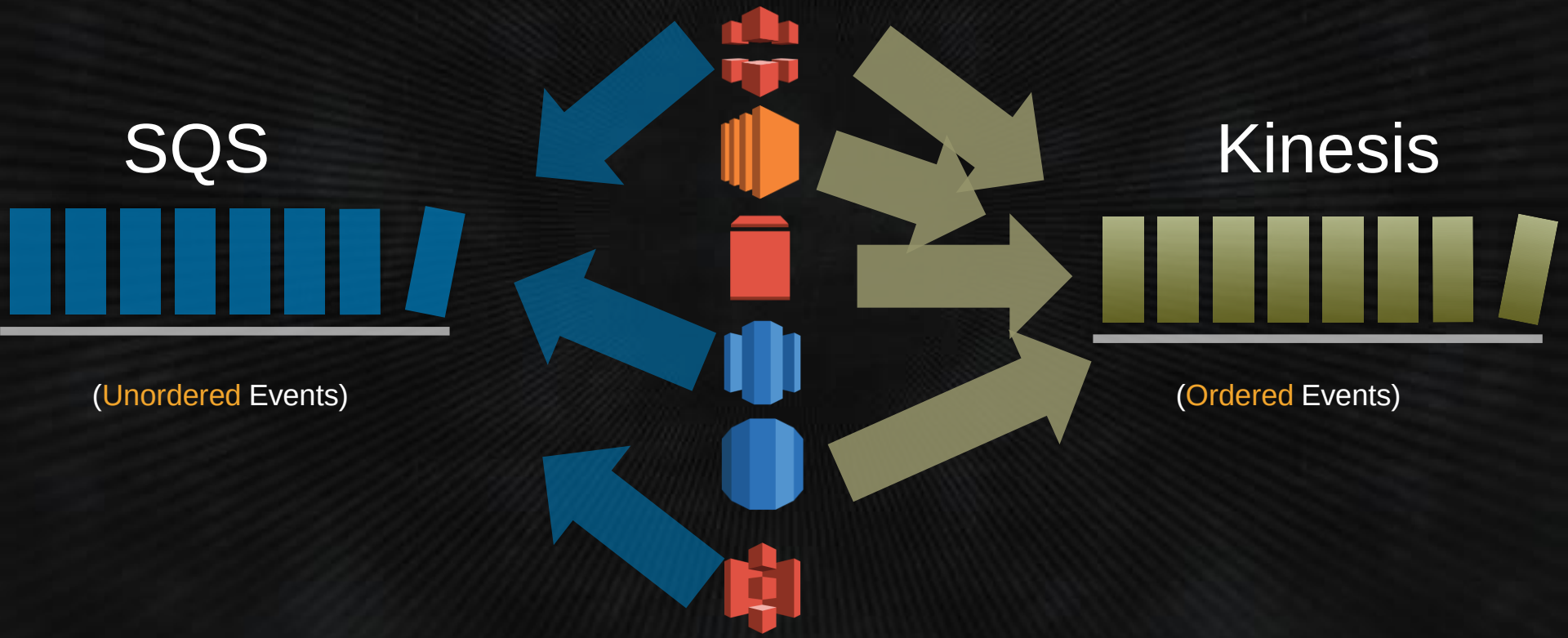
Single Event logs for asynchronous service events

Event Driven Computing in AWS Tomorrow

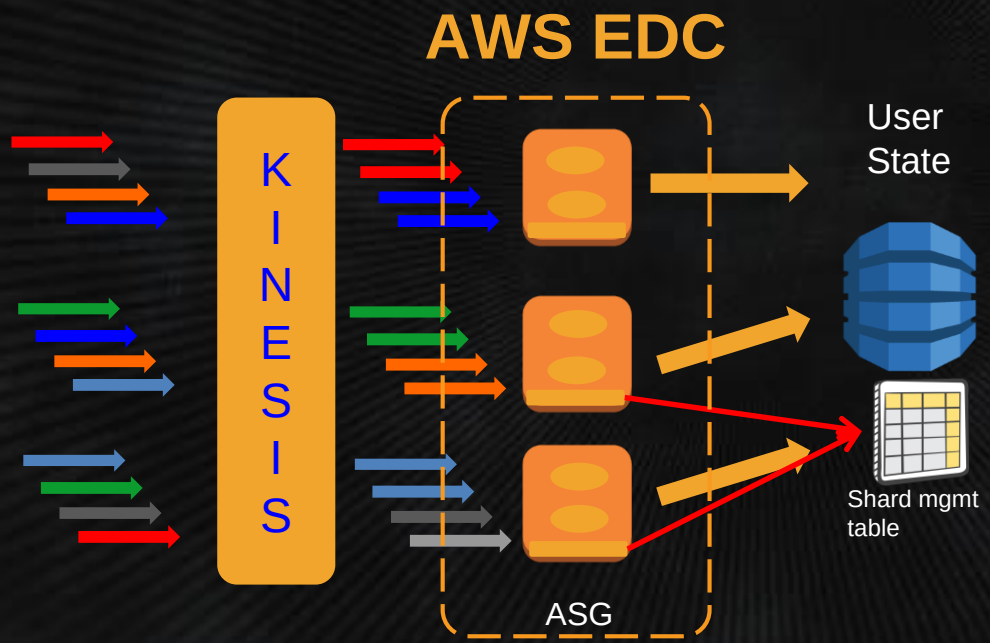
Event logs for asynchronous service events

Event logs from other data storage services

A Unified Event Log Approach



Ordered Event Log Using Kinesis Streams and the Kinesis Client Library



Use of the KCL

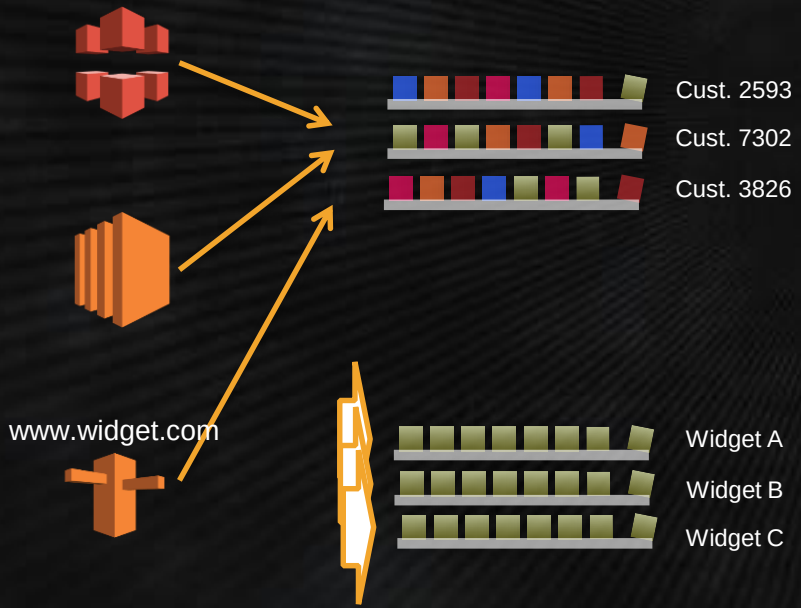
Mostly writing business logic

EDC Rules Language

Simple CloudWatch actions in response to matching rules.

Event Logs for Customers' Services

Vision: customers' services and applications leverage the AWS event log infrastructure



Per-customer control plane events sent to customer's unified control plane log

Per-entity data plane event logs

Closing Thoughts

Streaming data is highly prevalent and relevant;

Stream data processing is on the rise;

A key part of business critical workflows today, a powerful abstraction for building a new class of applications & data intensive services tomorrow.

A rich area for distributed systems, programming model, IoT, and new service(s) research.

Questions