Stream processing with R and Amazon Kinesis

Budapest Data Forum 2016

Gergely Daroczi

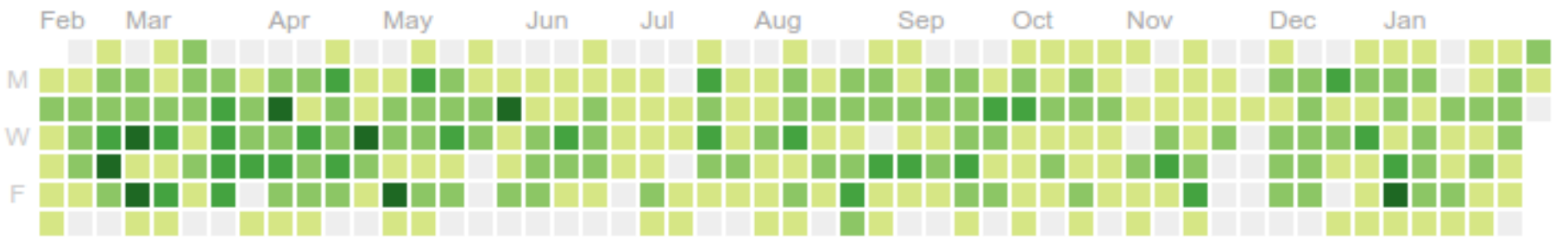
@daroczig

June 16 2016

About me

CARD.COM

Contributions



Summary of pull requests, issues opened, and commits. Learn how we count contributions.

Less More

Contributions in the last year	Longest streak	Current streak
3,477 total	22 days	2 days
Feb 9, 2015 – Feb 9, 2016	December 26 – January 16	February 7 – February 8

CARD.com's View of the World

Gergely Daróczi @daroczig · Apr 11

Just received my "I ♥ R" prepaid debit card from @CARD. Will be fun to use this #rstats designed card at #user2015 :)

RETWEETS 10 FAVORITES 16

CARD.com's View of the World

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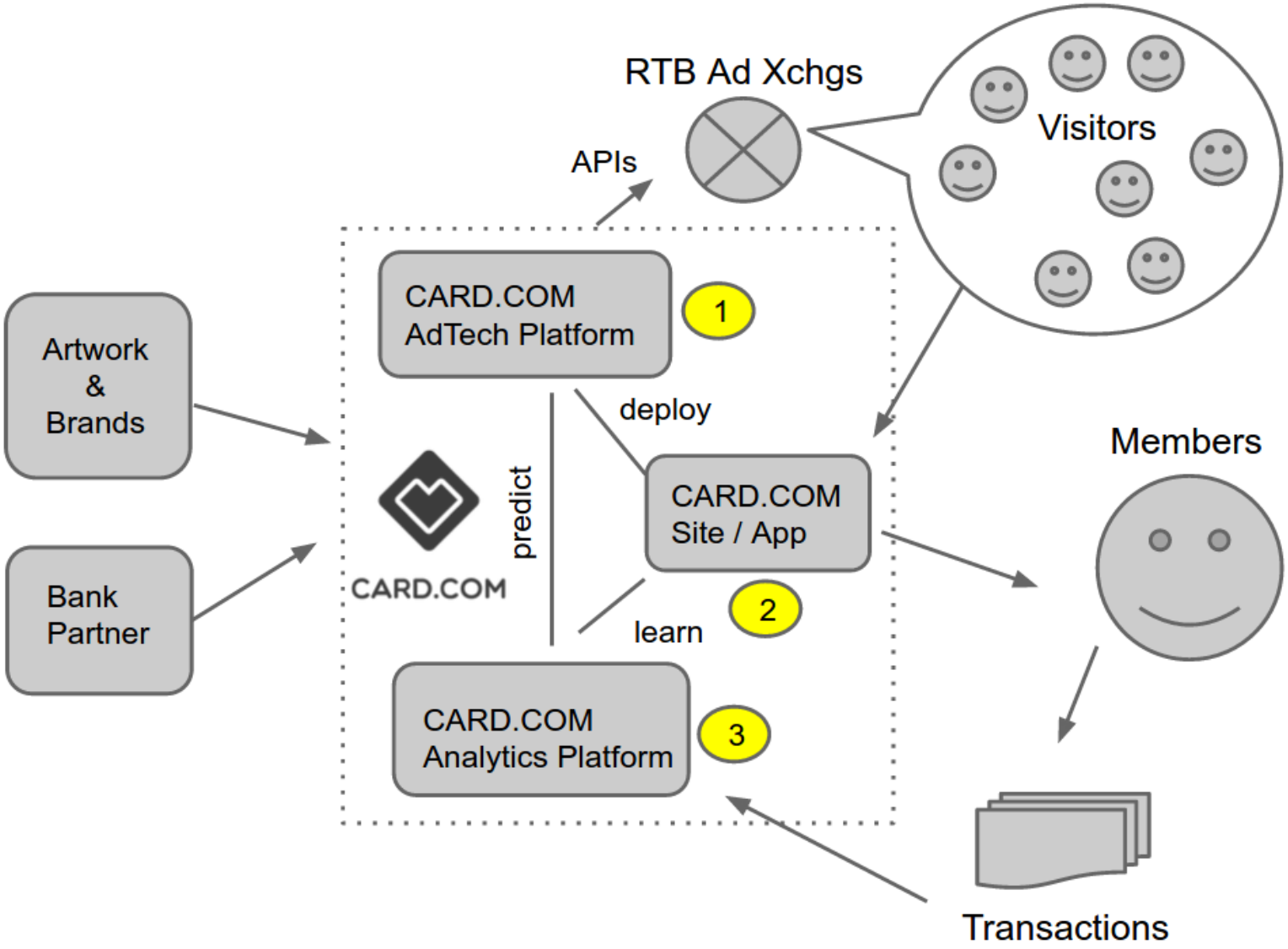
Modern Marketing at CARD.com



Further Data Partners

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- card transaction processors
- card manufacturers
- CIP/KYC service providers
- online ad platforms
- remarketing networks
- licensing partners
- communication engines
- others

Infrastructure

Why R?

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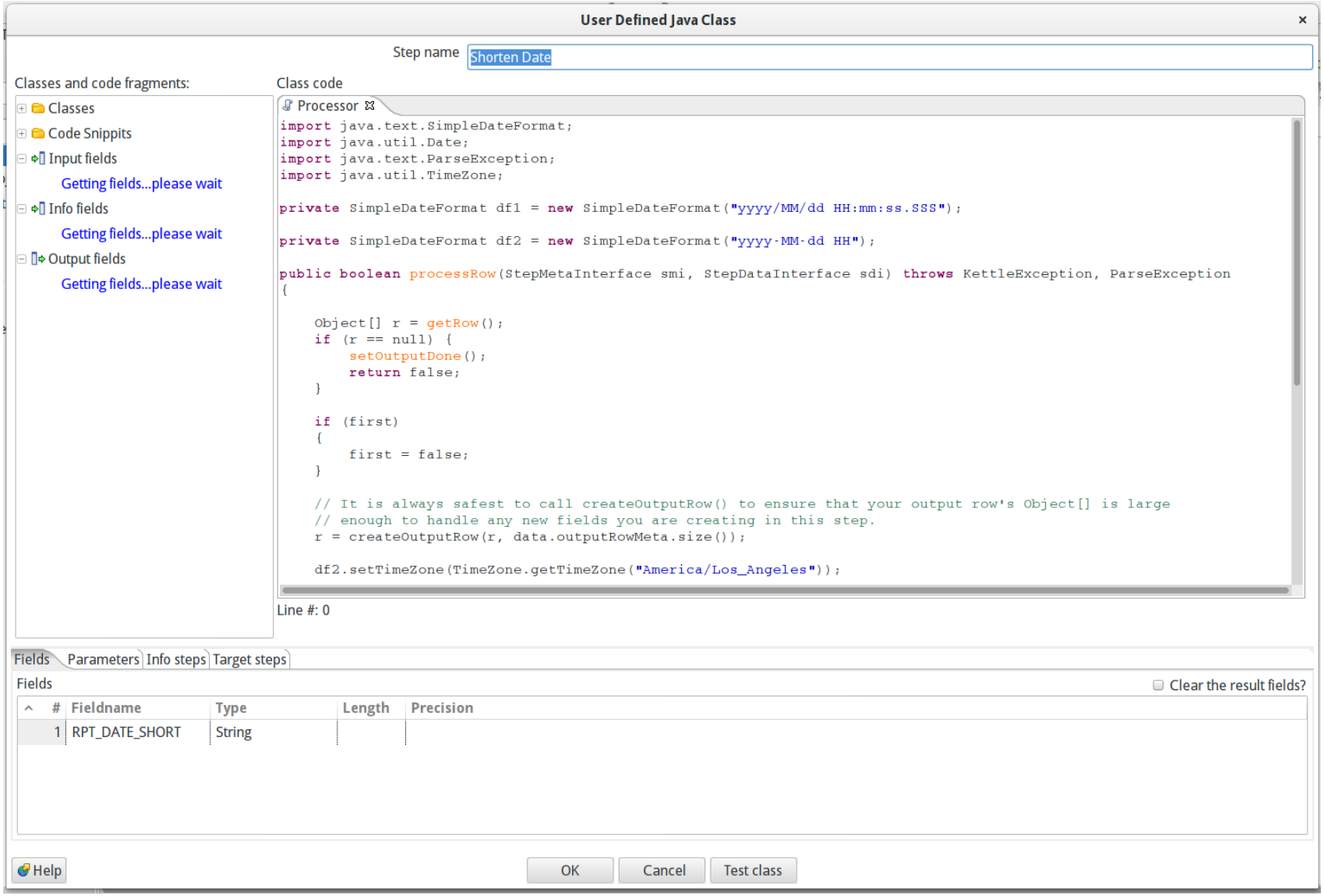


MySQL
hadoop
HDFS
Parquet
Jenkins
cloudera
IMPALA
HIVE
pentaho
Drupal
ubuntu
redis
docker
python
H2O.ai
amazon
web services
PhoneGap
jQuery
mobile
APACHE
CORDOVA
php
R

The Classic Era

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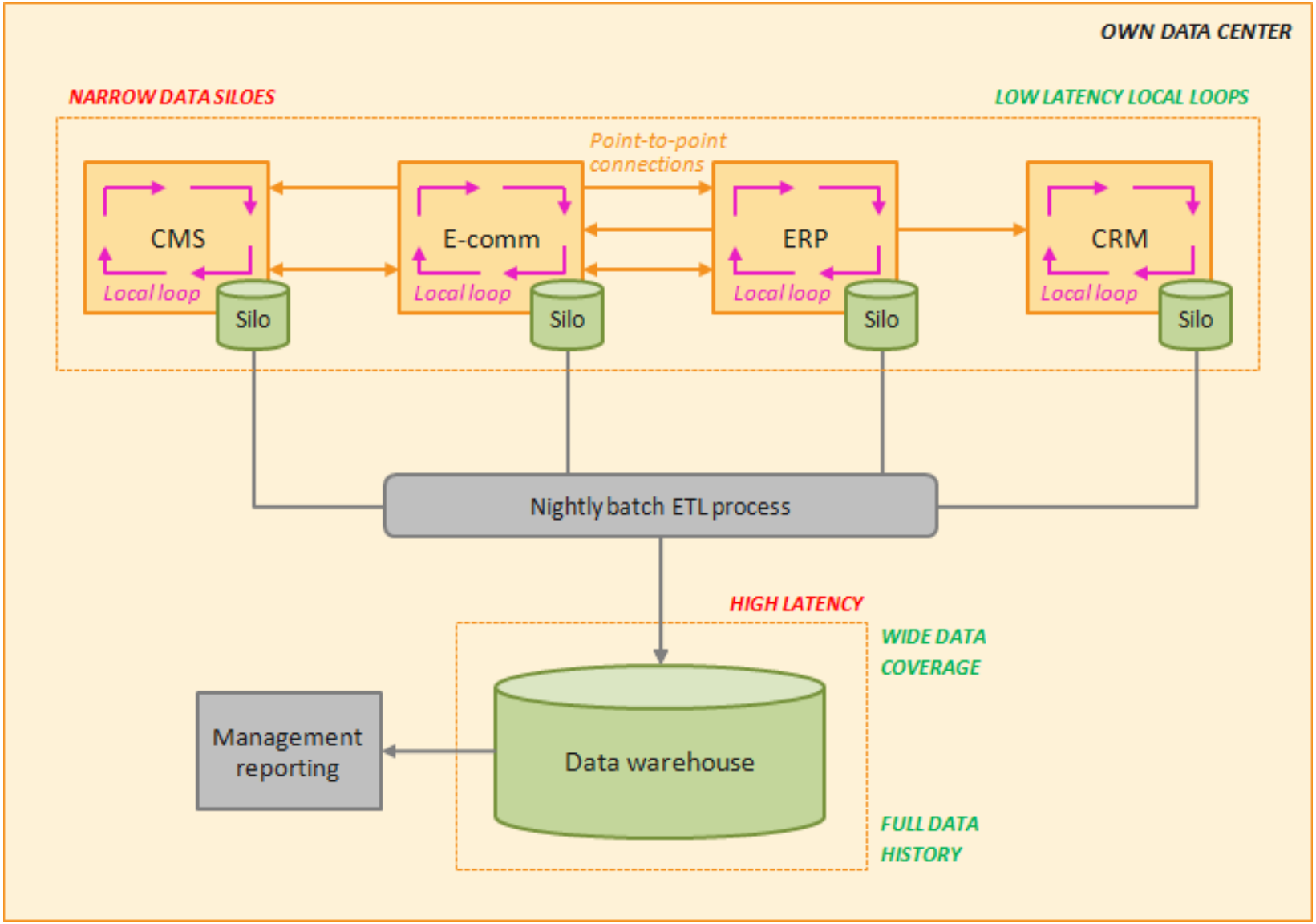

Source: SnowPlow

The Hybrid Era

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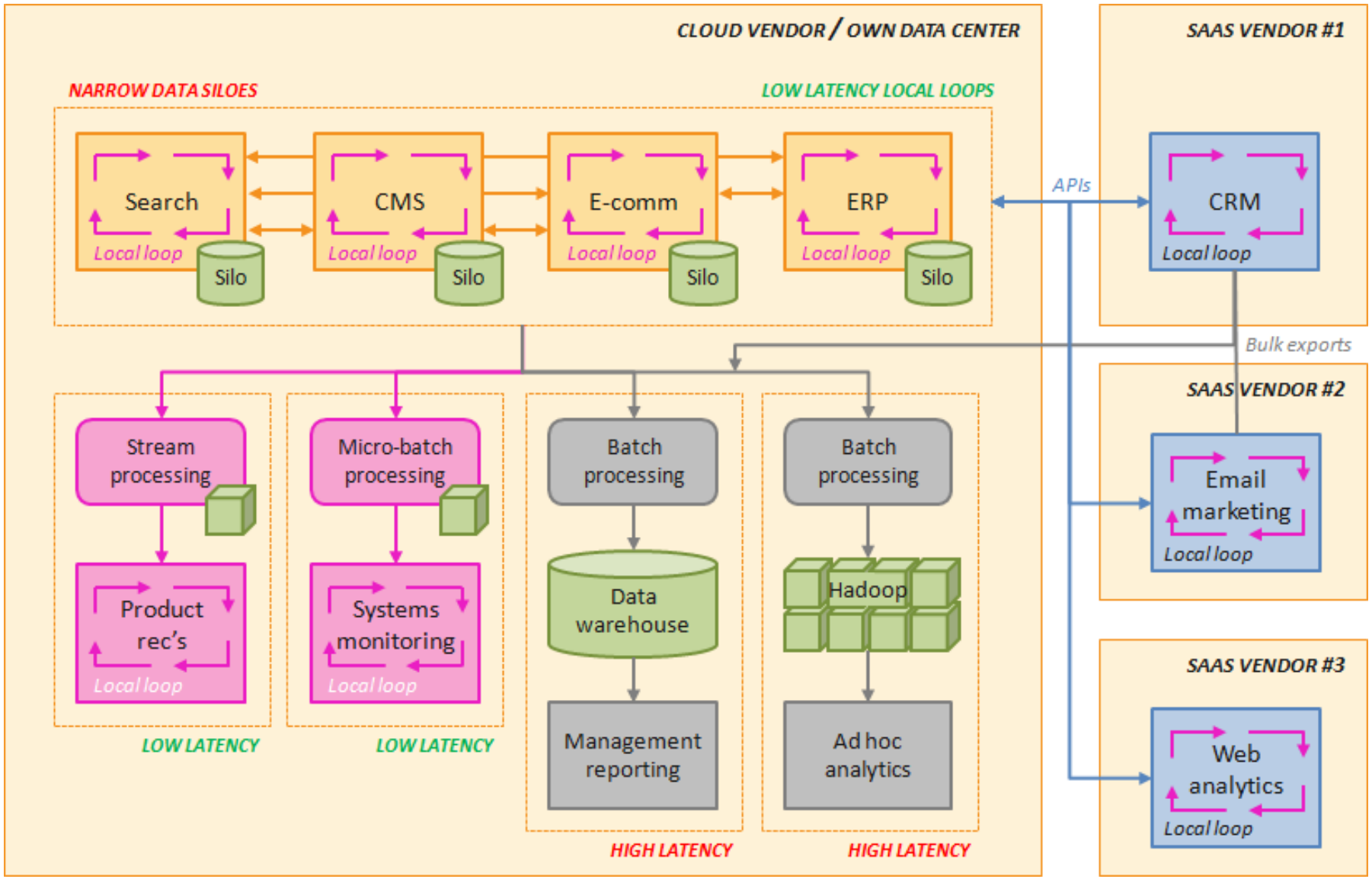
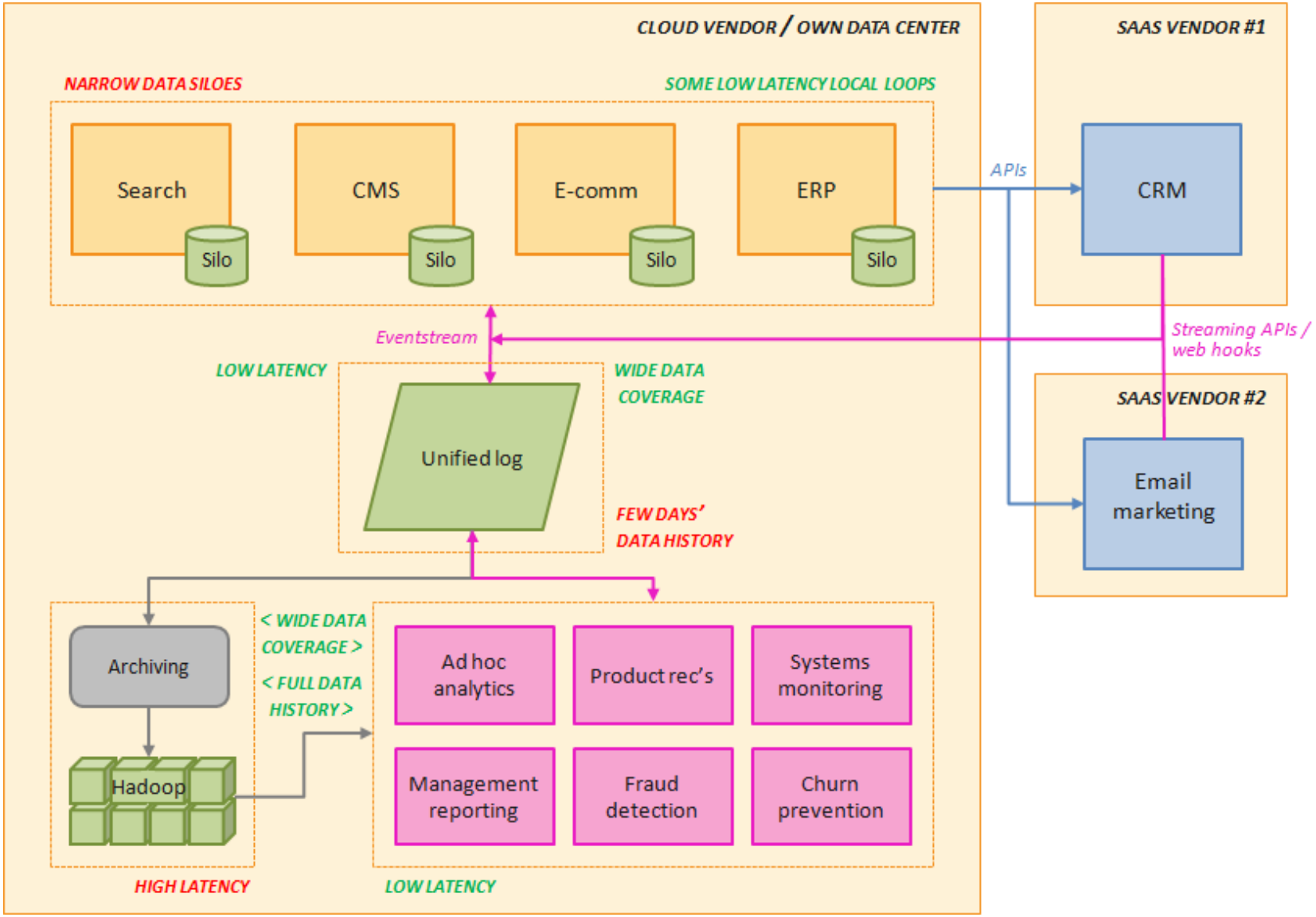


Source: SnowPlow

The Unified Era



Source: SnowPlow

Why Amazon Kinesis & Redshift?

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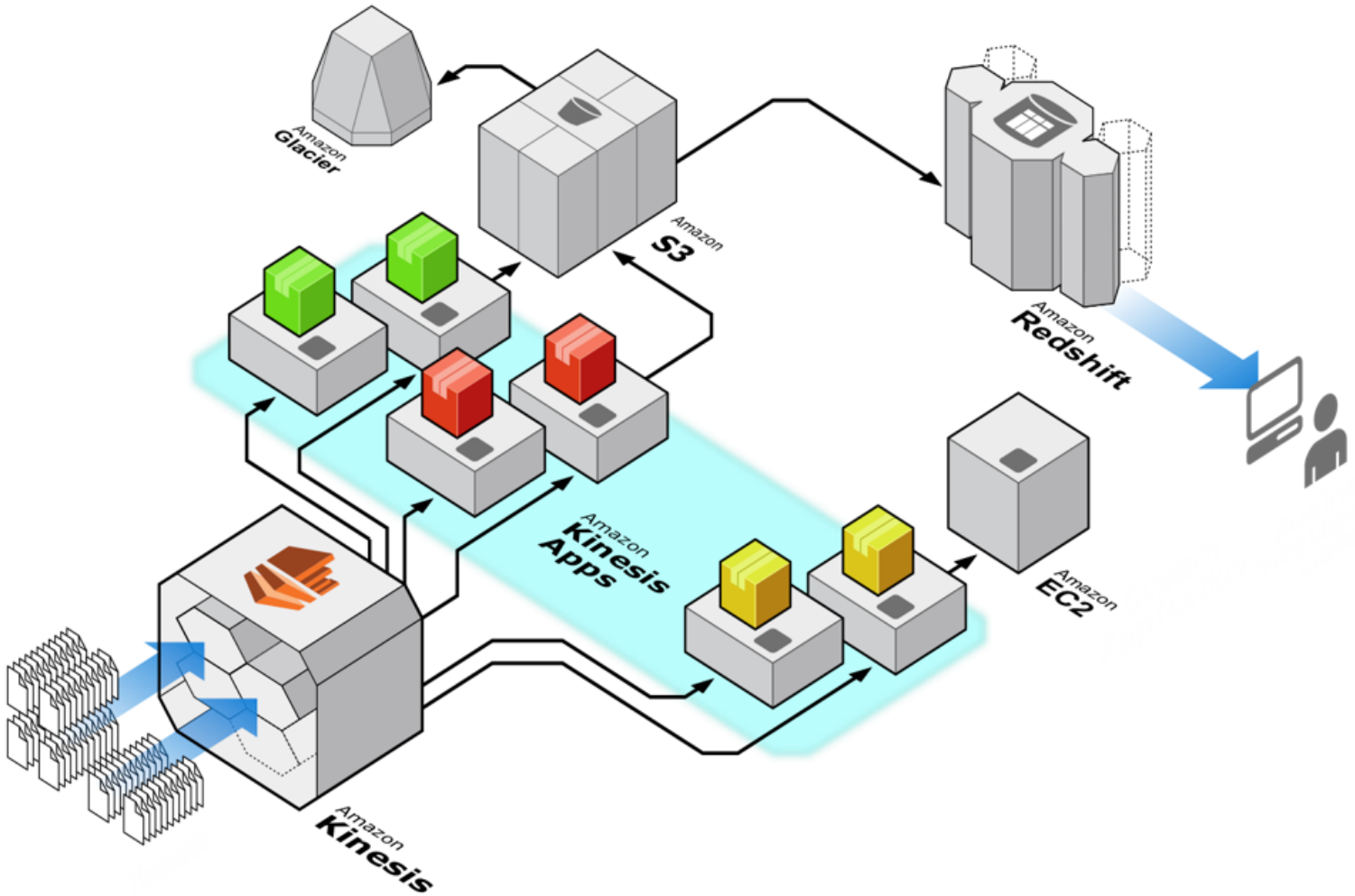

Source: Kinesis Product Details

Intro to Amazon Kinesis Streams

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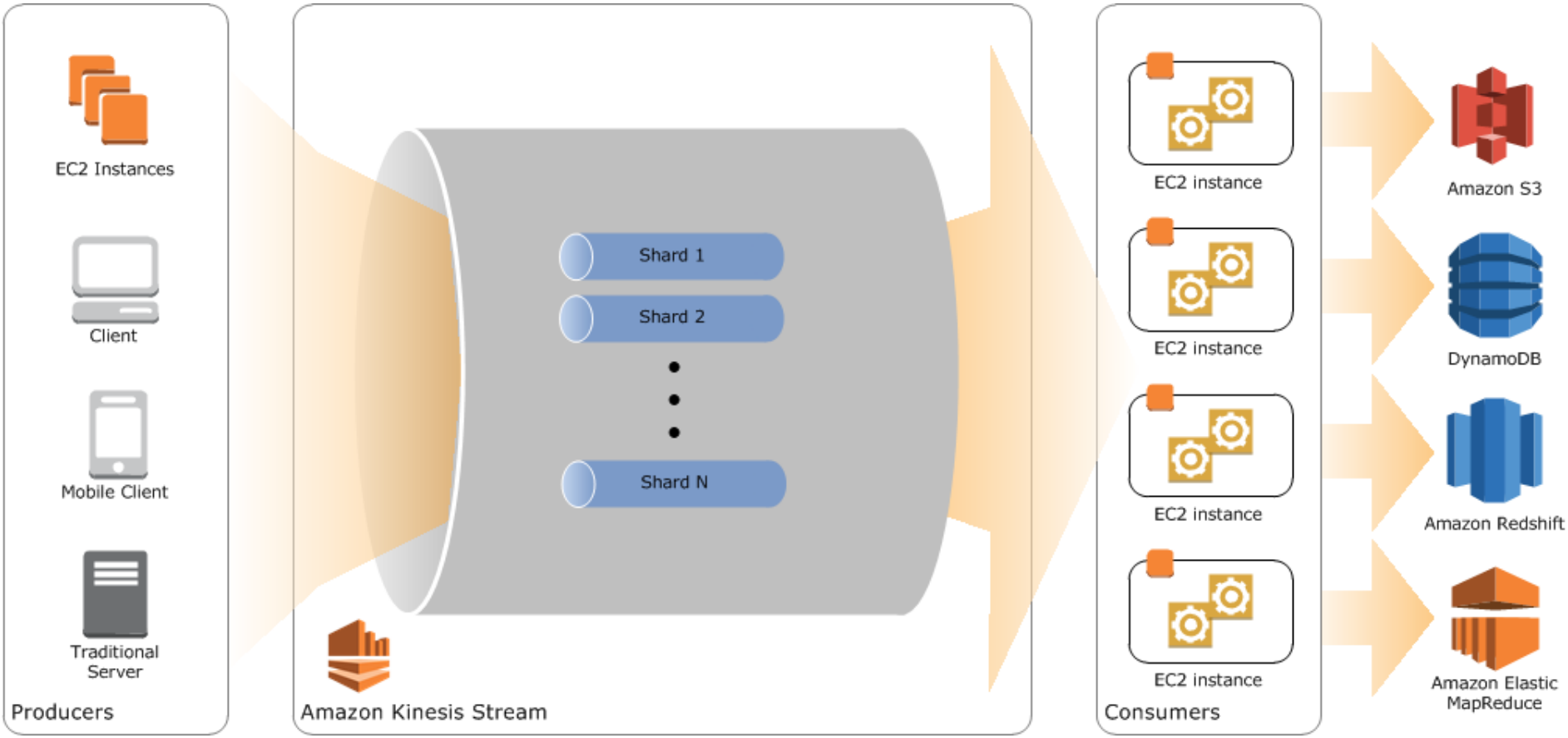
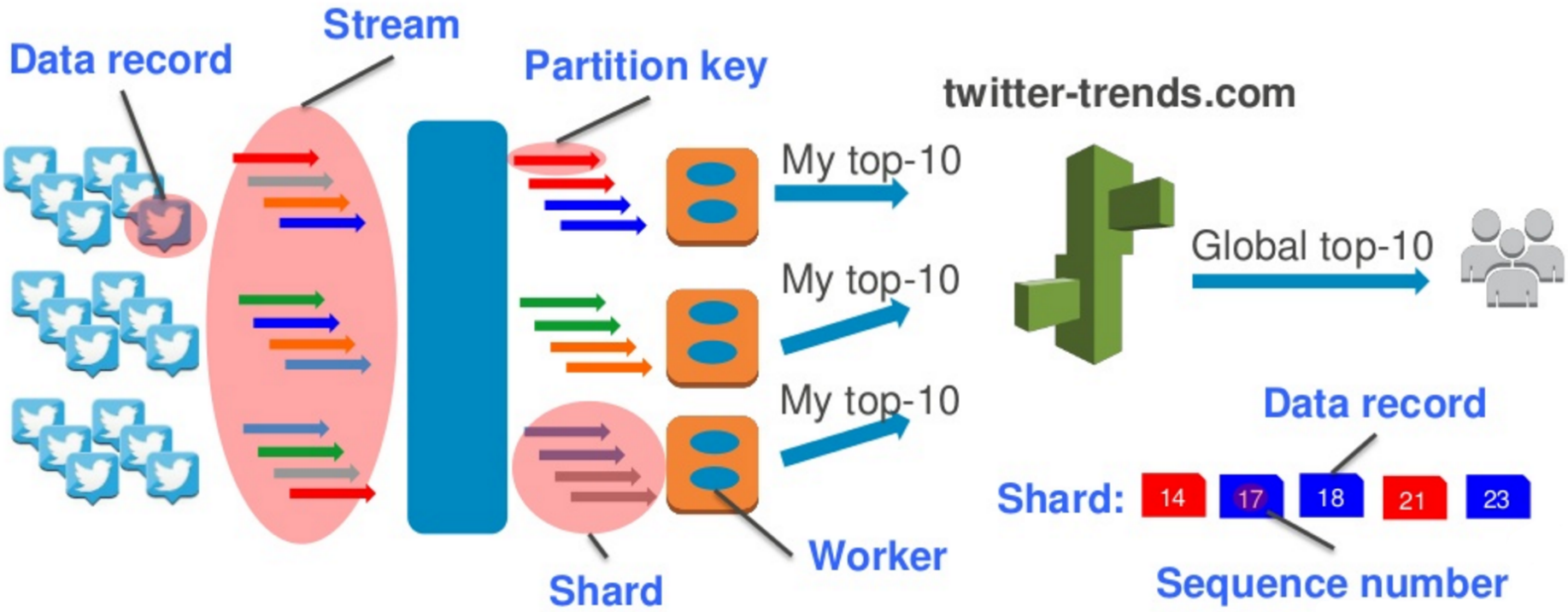


Source: Kinesis Developer Guide

Intro to Amazon Kinesis Shards



Source: AWS re:Invent 2013

How to Communicate with Kinesis

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Writing data to the stream:

- Amazon Kinesis Streams API (!)
- Amazon Kinesis Producer Library (KPL) from Java
- flume-kinesis
- Amazon Kinesis Agent

Reading data from the stream:

- Amazon Kinesis Streams API (!)
- Amazon Kinesis Client Library (KCL) from Java, Node.js, .NET, Python, Ruby

Managing streams:

- Amazon Kinesis Streams API (!)

Now We Need an R Client!

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Initialize connection to the SDK:

```
> library(rJava)
+ .jinit(classpath =
+         list.files(
+             '~/Projects/kineric/inst/java/',
+             full.names = TRUE),
+         parameters = "-Xmx512m")
```

What methods do we have there?

```
> kc <- .jnew('com.amazonaws.services.kinesis.AmazonKinesisClient')
> .jmethods(kc)
[1]  "public void com.amazonaws.services.kinesis.AmazonKinesisClient.splitShard(jav
[2]  "public void com.amazonaws.services.kinesis.AmazonKinesisClient.splitShard(com
[3]  "public void com.amazonaws.services.kinesis.AmazonKinesisClient.removeTagsFrom
[4]  "public com.amazonaws.services.kinesis.model.ListStreamsResult com.amazonaws.s
[5]  "public com.amazonaws.services.kinesis.model.ListStreamsResult com.amazonaws.s
[6]  "public com.amazonaws.services.kinesis.model.ListStreamsResult com.amazonaws.s
[7]  "public com.amazonaws.services.kinesis.model.ListStreamsResult com.amazonaws.s
[8]  "public com.amazonaws.services.kinesis.model.GetShardIteratorResult com.amazon
[9]  "public com.amazonaws.services.kinesis.model.GetShardIteratorResult com.amazon
[10] "public com.amazonaws.services.kinesis.model.GetShardIteratorResult com.amazon
```

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Set API endpoint:

```
> kc$setEndpoint('kinesis.us-west-2.amazonaws.com', 'kinesis', 'us-west-2')
```

What streams do we have access to?

```
> kc$listStreams()
[1] "Java-Object{{StreamNames: [test_kinesis],HasMoreStreams: false}}"
> kc$listStreams()$getStreamNames()
[1] "Java-Object{[test_kinesis]}"
```

Describe this stream:

```
> (kcstream <- kc$describeStream(StreamName = 'test_kinesis')$getStreamDescription()
[1] "Java-Object{{StreamName: test_kinesis,StreamARN: arn:aws:kinesis:us-west-2:595
> kcstream$getStreamName()
[1] "test_kinesis"
> kcstream$getStreamStatus()
[1] "ACTIVE"
> kcstream$getShards()
[1] "Java-Object{[
{ShardId: shardId-000000000000,HashKeyRange: {
StartingHashKey: 0,EndingHashKey: 170141183460469231731687303715884105723 24},Sequen
{ShardId: shardId-000000000001,HashKeyRange: {StartingHashKey: 170141183460469231 73
```

Writing to the Stream

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```
> prr <- .jnew('com.amazonaws.services.kinesis.model.PutRecordRequest')
> prr$setStreamName('test_kinesis')
> prr$setData(J('java.nio.ByteBuffer')$wrap(.jbyte(charToRaw('foobar'))))
> prr$setPartitionKey('42')
> prr
[1] "Java-Object{{StreamName: test_kinesis,
     Data: java.nio.HeapByteBuffer[pos=0 lim=6 cap=6],
     PartitionKey: 42,}}"
> kc$putRecord(prr)
[1] "Java-Object{{ShardId: shardId-000000000001,
    SequenceNumber: 49562894160449444332153346371084313572324361665031176210}}"
```

Get Records from the Stream

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First, we need a shared iterator, which expires in 5 minutes:

```
> sir <- .jnew('com.amazonaws.services.kinesis.model.GetShardIteratorRequest')
> sir$setStreamName('test_kinesis')
> sir$setShardId(.jnew('java/lang/String', '0'))
> sir$setShardIteratorType('TRIM_HORIZON')
> iterator <- kc$getShardIterator(sir)$getShardIterator()
```

Then we can use it to get records:

```
> gir <- .jnew('com.amazonaws.services.kinesis.model.GetRecordsRequest')
> gir$setShardIterator(iterator)
> kc$getRecords(gir)$getRecords()
[1] "Java-Object{[]}"
```

Get Records from the Stream

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> iterator <- kc$getShardIterator(sir)$getShardIterator()
```

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```
> gir <- .jnew('com.amazonaws.services.kinesis.model.GetRecordsRequest')
> gir$setShardIterator(iterator)
> kc$getRecords(gir)$getRecords()
[1] "Java-Object{[]}"
```

The data was pushed to the other shard:

```
> sir$setShardId(.jnew('java/lang/String', '1'))
> iterator <- kc$getShardIterator(sir)$getShardIterator()
> gir$setShardIterator(iterator)
> kc$getRecords(gir)$getRecords()
[1] "Java-Object{[{SequenceNumber: 49562894160449444332153346371084313572324361665
ApproximateArrivalTimestamp: Tue Jun 14 09:40:19 CEST 2016,
Data: java.nio.HeapByteBuffer[pos=0 lim=6 cap=6],
PartitionKey: 42}]}"
```

Get Further Records from the Stream

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```
> sapply(kc$getRecords(gir)$getRecords(),
+        function(x)
+        rawToChar(x$getData()$array()))
[1] "foobar"
> iterator <- kc$getRecords(gir)$getNextShardIterator()
> gir$setShardIterator(iterator)
> kc$getRecords(gir)$getRecords()
[1] "Java-Object{[]}"
```

Get the oldest available data again:

```
> iterator <- kc$getShardIterator(sir)$getShardIterator()
> gir$setShardIterator(iterator)
> kc$getRecords(gir)$getRecords()
[1] "Java-Object{[{SequenceNumber: 49562894160449444332153346371084313572324361665
```

Or we can refer to the last known sequence number as well:

```
> sir$setShardIteratorType('AT_SEQUENCE_NUMBER')
> sir$setStartingSequenceNumber('49562894160449444332153346371084313572324361665031
> iterator <- kc$getShardIterator(sir)$getShardIterator()
> gir$setShardIterator(iterator)
> kc$getRecords(gir)$getRecords()
[1] "Java-Object{[{SequenceNumber: 49562894160449444332153346371084313572324361665
```

Managing Shards

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No need for both shards:

```
> ms <- .jnew('com.amazonaws.services.kinesis.model.MergeShardsRequest')
> ms$setShardToMerge('shardId-000000000000')
> ms$setAdjacentShardToMerge('shardId-000000000001')
> ms$setStreamName('test_kinesis')
> kc$mergeShards(ms)
```

What do we have now?

```
> kc$describeStream(StreamName = 'test_kinesis')$getStreamDescription()$getShards()
[1] "Java-Object{[
{ShardId: shardId-000000000000,HashKeyRange: {StartingHashKey: 0,EndingHashKey: 170
SequenceNumberRange: {
StartingSequenceNumber: 49562894160427143586954815717376297430913467927668719618,
EndingSequenceNumber: 49562894160438293959554081028945856364232263390243848194}},
{ShardId: shardId-000000000001,HashKeyRange: {StartingHashKey: 170141183460469231731
SequenceNumberRange: {
StartingSequenceNumber: 49562894160449444332153346340517833149186116289174700050,
EndingSequenceNumber: 49562894160460594704752611652087392082504911751749828626}},
{ShardId: shardId-000000000002,
ParentShardId: shardId-000000000000,
AdjacentParentShardId: shardId-000000000001,
HashKeyRange: {StartingHashKey: 0,EndingHashKey: 340282366920938463463374607431768
SequenceNumberRange: {StartingSequenceNumber: 49562904991497673099704924344727019521
```

Next Steps

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Ideas:

- R function managing/scaling shards and attaching R processors
- One R processor per shard (parallel threads on a node or cluster)
- Store started/finished sequence number in memory/DB (checkpointing)

Example (Design for a simple MVP on a single node)

mcparallel starts parallel R processes to evaluate the given expression

Next Steps

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Example (Design for a simple MVP on a single node)

mcparallel starts parallel R processes to evaluate the given expression

Problems:

- duplicated records after failure due to in-memory checkpoint
- needs a DB for running on a cluster
- hard to write good unit tests

Next Steps

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Why not use KCL then?

Amazon Kinesis Client Library

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- An easy-to-use programming model for processing data

```
java -cp amazon-kinesis-client-1.6.1.jar \
  com.amazonaws.services.kinesis.multilang.MultiLangDaemon \
  test-kinesis.properties
```

- Scale-out and fault-tolerant processing (checkpointing via DynamoDB)
- Logging and metrics in CloudWatch
- The MultiLangDaemon spawns processes written in any language, communication happens via JSON messages sent over stdin/stdout
- Only a few events/methods to care about in the consumer application:
  1. initialize
  2. processRecords
  3. checkpoint
  4. shutdown

Messages from the KCL

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1. initialize:
   - Perform initialization steps
   - Write "status" message to indicate you are done
   - Begin reading line from STDIN to receive next action
2. processRecords:
   - Perform processing tasks (you may write a checkpoint message at any time)
   - Write "status" message to STDOUT to indicate you are done.
   - Begin reading line from STDIN to receive next action
3. shutdown:
   - Perform shutdown tasks (you may write a checkpoint message at any time)
   - Write "status" message to STDOUT to indicate you are done.
   - Begin reading line from STDIN to receive next action
4. checkpoint:
   - Decide whether to checkpoint again based on whether there is an error or not.

Again: Why R?

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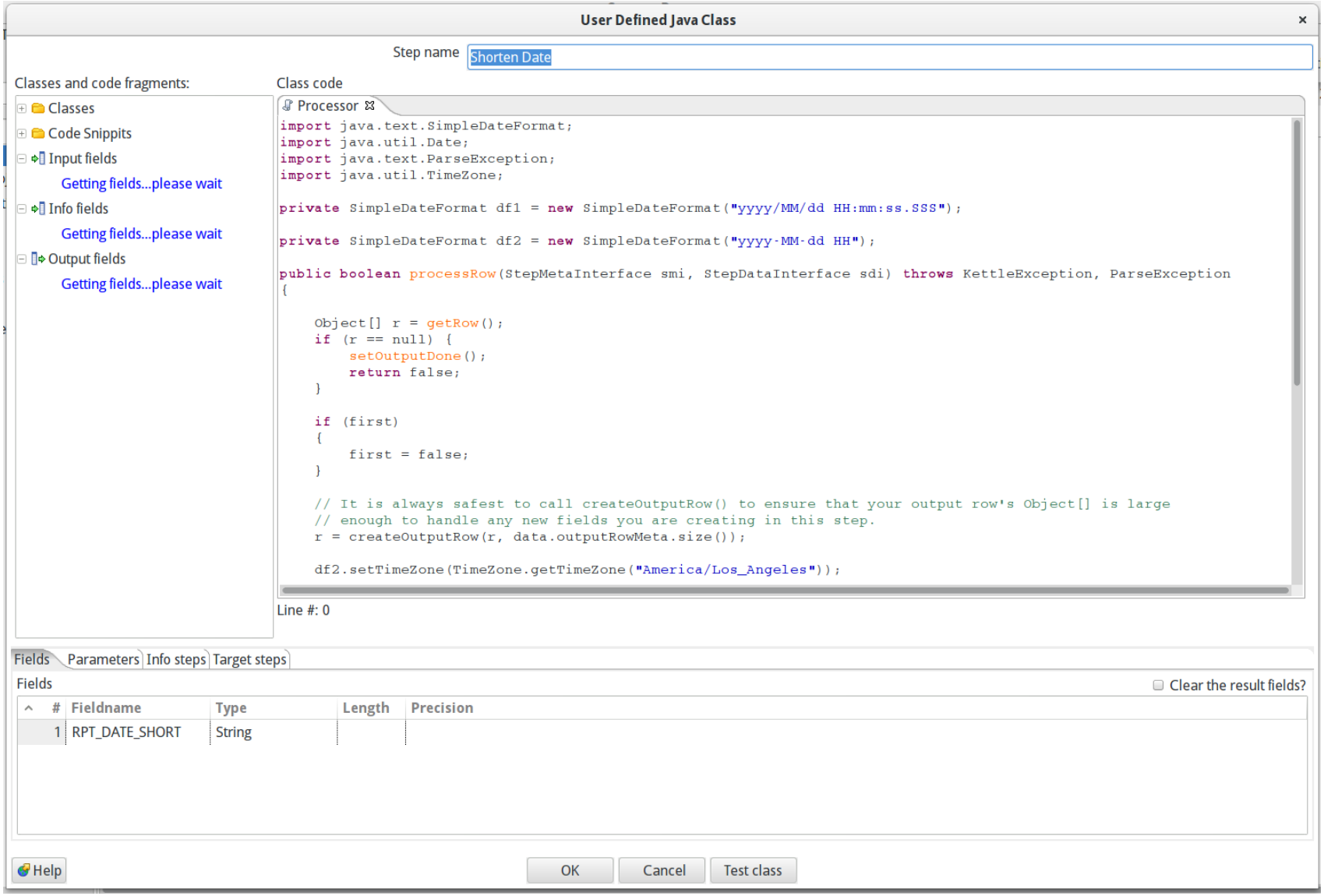

R Script Interacting with KCL

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```
#!/usr/bin/r -i

while (TRUE) {

    ## read and parse messages
    line <- fromJSON(readLines(n = 1))

    ## nothing to do unless we receive a record to process
    if (line$action == 'processRecords') {

        ## process each record
        lapply(line$records, function(r) {

            business_logic(r)
            cat(toJSON(list(action = 'checkpoint', checkpoint = r$sequenceNumber)))

        })
    }

    ## return response in JSON
    cat(toJSON(list(action = 'status', responseFor = line$action)))

}
```

Examples

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