Data Ingestion and Replication @ Twitter

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Agenda

- Introduction
- Replication and Ingestion Architecture
- Batch Data Replication
- Real Time Log Ingestion
Data Lifecycle Team

- **Ingestion**
  - Offline ingestion to data lakes (HDFS, GCS)
  - Near Real time ingestion to Kafka, Pubsub and BigQuery

- **Replication**
  - Replication of data between data lakes (HDFS, GCS)
  - Replication of data between HDFS/GCS and BigQuery
  - Replicating data between KV Store and BigQuery

- **Metadata Management**
  - Data discovery, segment metadata

- **Storage and Retention**
  - HDFS, GCS
  - BigQuery (Retention only)
Data Ingestion / Replication Challenges

Data scrubbing breaks WORM data model
GDPR Compliance:
- Account deletion must remove all personal information
- User data deletion/modification must remove specified fields or rows associated with a user

Need for Real Time ingestion
Existing pipelines takes hours to ingest data to BigQuery

Engineering Velocity
Building and managing replication pipelines consumes lot of engineering time

Consolidate Replication/Retention Services
8+ different replication mechanisms based on source and destination combination
Data Ingestion / Replication Goals

Dimensions

- **Simple to Use**
  Unified (Batch and Streaming) way to configure replication/ingestion across all analytics stores within few mins

- **Platform Offering**
  Managed Ingestion/Replication offering with production SLOs and multiple tiers of QoS. Automatic schema update handling

- **Platform Integration**
  Metadata driven replication, Scrubbing Aware, Authorization, Authentication, Chargeback, Unified Monitoring

- **Extendable**
  Ability to add new storage systems support easily
Ingestion, Replication & Retention
Data Lifecycle Manager (DLM)
Data Scrubbing -> No more WORM
Need for Metadata Driven Data Lifecycle

- Traditional Batch Polling won’t work and not scalable either
- Similarly TTL based retention also does not work
- Versioning
  - Unit of metadata: **Segment** (Chunk of a dataset that maps to a time interval or version)
  - Increment version on segment rewrite/scrub/creation
  - Listen changes to metadata layer and trigger replication or retention
  - Change replication to version based replication with goal to keep replicate latest version across storage systems
  - Change retention architecture to do version based deletion along TTL
Opportunity to Simplify

Sources:
- Manhattan
- Hadoop HDFS

Destinations:
- Cloud Replicator
- Roneo bird
- Loris, BQ Blaster, BID
- MH Import, Bifrost
- Unsupported

Google BigQuery
Batch Replication Vision

- Managed Replication Service
- Unified Replication config mgmt
- Unified Retention Mgmt
- Scrubbing Replication support
- Self-Serve
- Metadata Store (Versioned Metadata index, Replication Retention Config Mgmt)
- Metadata Tracking
- Log Pipeline
- User Data Processing Jobs or Scrubbing Jobs
- Write to 1 or 2 locations
- Data Replication and Retention Layer (DLM)
- Manhattan
- Hadoop
- Cloud Storage
- Google BigQuery
- Amazon S3
DLM Architecture

Data Life Cycle Manager

- Create Replication Jobs
- Manage life cycle of job scheduling
- Schedules job to executors based on job type
- QoS Mgmt

Analytics data could present in 1 or more locations. DLM’s responsibility to ensure latest data replicated across the systems.
Beam Replicator

Dynamically deploy Beam Job

- Validate replica version
- Copy Replica
  - Load schema
  - Deserialize thrift data
  - Apply UDF (wip)
  - Convert to Avro
  - Write to BigQuery
    - BigQueryIO
    - BigQuery Load
- Commit replica Version
Data Formats

- Supported Data Formats
  - Thrift LZO, Thrift Parquet, Thrift Data Record, Key-Value data, CSV/TSV
- KV data
  - Annotation based deserialization spec embedded in schema

```c
struct ManhattanDatasetPkey {
    1: required i64 userId;
}(persisted = "true", hasPersonalData = "true")

struct ManhattanDatasetValue {
    1: required embedding.TopSimClustersWithScore topSimClustersWithScore;
}(persisted = "true", hasPersonalData = "true")

struct ManhattanDatasetSchema {
    1: required ManhattanDatasetPkey manhattanPkey(MHPkeyCodec = "Injection.long2BigEndian");
    3: required ManhattanDatasetValue manhattanValue(MHValueCodec = "T_COMPACT");
}(persisted = "true", hasPersonalData = "true")
```
### Self-Serve

<table>
<thead>
<tr>
<th>Dataset Name:</th>
<th>Unhydrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role:</td>
<td>Tweetsource</td>
</tr>
<tr>
<td>Owner:</td>
<td>Core Data</td>
</tr>
<tr>
<td>Storage Types:</td>
<td>HDFS, GCS</td>
</tr>
</tbody>
</table>

#### Replication Locations

Select two locations for replication, including at least one that has data.

- **HDFS: proc-atla**
  - Backfill Window in Days: 3
  - Active: ✔

- **GCS**
  - Backfill Window in Days: 3

- **BigQuery**
  - Backfill Window in Days: 3
  - BigQuery Project Name: twtr-bq-tweetsource-prod
  - BigQuery Dataset Name: user
  - BigQuery Table Name: Unhydrated
<table>
<thead>
<tr>
<th><strong>Adoption</strong></th>
<th>1200+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data pipelines</td>
<td></td>
</tr>
<tr>
<td>Data Volume processed per day</td>
<td>4PB+</td>
</tr>
<tr>
<td>Number of Teams/Projects</td>
<td>158</td>
</tr>
<tr>
<td>RecordsProcessedPer day</td>
<td>4Tri+</td>
</tr>
<tr>
<td>Jobs Per day</td>
<td>22k+</td>
</tr>
</tbody>
</table>
What’s Next

- UDF support with SQL like expression for simple filtering
- Migrate existing pipelines to DLM
  - 600+ jobs maintained by 60+ teams
  - Migrate from older services and deprecate them
- Simplify replication between Manhattan KV store and BigQuery
- Cost/Perf Improvements
  - Migrating reflection based schema library to AST based schema library
  - Improve dataflow jobs to read from HDFS and write to BigQuery
Log Ingestion: Sparrow
What is Log Ingestion?

- User interactions & Internal service generate events
  - E.g. ads click, KV store write info
- Events are grouped as Datasets
- Datasets for Data processing & Analytics
History & Challenges at Twitter

- **Scalability**
  - 3~5 billion events per minute, 10~22 TB traffic per minute
  - Huge datasets could have 10~18 GB throughput and 35~43 millions per second
  - >1 million internal clients publishing data to the log ingestion systems

- **Historical Batch Solution**
  - It takes hours to deliver data to the user specified destination
  - Major components is on-premise, no support for data generated on cloud
  - Build on top of old tech such as HDFS, Tez, Mesos
Evolve Log Pipeline - Goals

➔ **Scalability**
  ◆ 3~5 billion events per minute with 50% traffic YoY growth target
  ◆ 10~12GB/s in the largest dataset also with 50% traffic YoY growth target

➔ **Streaming ability**
  ◆ Provide streaming ability to deliver data in near real time

➔ **Cloud native**
  ◆ Running on cloud environment
  ◆ Adopt the cloud technologies

➔ **Compatibility with existing pipeline and Migration Friendness**
  ◆ Produce compatibility - (near) transparent migration for existing consumers
  ◆ Consumer compatibility - Scaldings, MR, etc
  ◆ Data management compatibility - Data protocols/Layout

➔ **User Defined Function Support**
  ◆ Compatible with on-prem UDF.
  ◆ Empowers user to do light transformation light ETL serverlessly
What is Sparrow?

- **Sparrow: enable real-time analytics**
  - Ingest on-prem/GCP data to Pubsub/BigQuery/GCS in realtime.
  - Managed solution - no maintenance needed from users.
  - Cloud native
  - Transparent migration for existing customers
  - Transformation supported before ingestion via UDF(user defined function)
  - PDP(Private data protection) Compliance
  - Chargeback support, cost estimator etc
Sparrow & Historical Pipeline

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**LogPipeline**

- Services emit events (nDC)
- Flume Aggregates
- Tez Process
- Replication
- Load to BQ/GCS

Time:
- Time T
- T + 1hr
- T + 1.5hr
- T + 2hr
- T + 2-3hr

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**Sparrow**

- Services emit events (nDC)
- Sparrow Ingest to PubSub
- Sparrow Processor (Dataflow)
- Streaming insert to BQ/GCS

Time:
- Time T
- T + 1min
- T + 1-3mins
- T + 1-13mins

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Architecture

Events

Clients
K8S, Mesos, Compute engine

Streaming Aggregation
Flume, Kafka, Google PubSub

Streaming Processors
Apache Beam, Google Dataflow

Real time insertion
BigQuery, GCS

Datasets
Sparrow Ingestion & Aggregation

- Transparent support to existing on-prem traffic
- Unified client lib to provide consistent API independent of environment.
- A metadata management system to make pub/sub pluggable
- On the wire data compression before publish to PubSub
Sparrow Processors

- Metadata management
- One beam job+subscription per dataset for transformation
- User Defined Function Support

- Schema conversion & dynamic load schema for transformation
- Airflow based orchestration
- Up to 20GB/s single beam jobs
Sparrow Processors & Orchestration

Cloud SQL DB  Airflow on GKE  Airflow DAGS  DataFlow Jobs

State Tables

master DAG

Child Jobs DAG

Child Jobs

Apache Airflow

Google Dataflow
Sparrow UDF(User defined Function)

Why?
● Users want to do light transformation before ingestion. E.g. filtering, enrich fields
● Writing a dataflow job/MR job is complex for simple ETL
● Maintain the ETL job is tedious and might be time consuming.

Goal
● Provide function based service and help user to focus on their core logic without worrying about schema transformation quota, PDP compliance, etc
● Provide a managed solution to make it maintenance free for users.
● SQL support
Sparrow UDF (User defined function)

- How to use it?
  - Implement in the interface and check in source.

- How it works?
  - Serverless to users
  - Managed solution
  - Every record will be feeded once
  - Zero or multiple output records support

- How to update user defined function?
  - As same as normal review process
  - Automatic update via version.

```java
@LPContext(Dataset="DmEvents")
class AppEventToDirectMessageEventUf extends TBaseRecordUserFunction
    <AppEvent, DmEvent> {
    @Override
    public Record<DmEvent> processRecord(AppEvent appEvent) {
        if (appEvent.type != DirectMessage) {
            return Record.empty();
        }
        DmEvent event = extractDmField(appEvent);
        return enrichEvent(event);
    }
}
```
Beam Job Optimization

- Decreased the beam job resource by 80%~86% via removing shuffle in BigQuery IO connector
  - Collaborate with dataflow eng team and remove shuffle before ingestion
- Data compression on PubSub before processed by beam job
  - Reduce beam worker usage by ~20%
- Optimize schema conversion logic
  - Improve thrift=>avro=>TableRow schema conversion logic with nested schema
Future work for Log Ingestion

● Continuous Job optimization
  ○ Schema conversion optimization

● Performance enhancement
  ○ Long tail problem fix.
  ○ Better compression

● UDF enhancement

● User experience enhancement
  ○ UI support and improvement
  ○ Percentile metrics

● More destinations support
  ○ Druid, BigTable, etc
Recap

Log Ingestion to start the data analytics journey

Data replication bridges different analytics systems and online server databases.

Beam’s Unified model helped us solve both streaming and Batch needs

Managed solution to make it effortless for users & UDF to make easy to do customized ETL

Metadata management system to take care of metadata management & data discovery
Questions?

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Analytics Data @ Twitter

**KV Store**
- 4k+ import / exports

**Data Lakes**
- 14k+ datasets
- 50k+ jobs
- 200PB+ data

**Data Warehouse**
- 25k+ datasets
- 40k jobs/day
- 149PB+ data

**Ingestion + Replication Volume**: 100PB+ day

**Events Processed**: 7+ Trillion
Data Lifecycle Team

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Data Volume processed: 100+PB

Data across storage systems: 1+EB

Events processed: 7+Tri