Druid for real-time analysis

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Druid the Sales Pitch

Intro

Experience

- Real Time Social Media Analytics

Real Time?

- Ingestion Latency: seconds
- Query Latency: seconds

Demand

- Twitter: `20k msg/s`, `1msg = 10ko` during 24h
- Facebook public: 1000 to 2000 msg/s continuously
- Low Latency

Reality

- Twitter: 400 msg/s continuously, burst to 1500
- Facebook: 1000 to 2000 msg/s

Origin (PHP)

1st Refactoring (Node.js)

Return of Experience

Return of Experience

2nd Refactoring

2nd Refactoring (FTW!)

2nd Refactoring return of experience

Demo

Pre Considerations

Discovered vs Invented

Try to conceptualize a s.t.

- Ingest Events
- Real-Time Queries
- Scalable
- Highly Available

Analytics: timeseries, alerting system, top N, etc...

In the End

Druid concepts are always emerging naturally

Druid

Who?

Metamarkets

Powered by Druid

- Alibaba, Cisco, Criteo, eBay, Hulu, Netflix, Paypal...

Goal

Druid is an open source store designed for real-time exploratory analytics on large data sets.

hosted dashboard that would allow users to arbitrarily explore and visualize event streams.

Concepts

- Column-oriented storage layout
- distributed, shared-nothing architecture
- advanced indexing structure

Key Features

- Sub-second OLAP Queries
- Real-time Streaming Ingestion
- Power Analytic Applications
- Cost Effective
- High Available
- Scalable

Right for me?

- require fast aggregations
- exploratory analytics
- analysis in real-time
- lots of data (trillions of events, petabytes of data)
- no single point of failure

High Level Architecture

Inspiration

- Google's BigQuery/Dremel
- Google's PowerDrill

Index / Immutability

Druid indexes data to create mostly immutable views.

Storage

Store data in custom column format highly optimized for aggregation & filter.

Specialized Nodes

- A Druid cluster is composed of various type of nodes
- Each designed to do a small set of things very well
- Nodes don't need to be deployed on individual hardware
- Many node types can be colocated in production

Druid vs X

Elasticsearch

- resource requirement much higher for ingestion & aggregation
- No data summarization (100x in real world data)

Key/Value Stores (HBase/Cassandra/OpenTSDB)

- Must Pre-compute Result
  - Exponential storage
  - Hours of pre-processing time
- Use the dimensions as key (like in OpenTSDB)
  - No filter index other than range
  - Hard for complex predicates

Spark

- Druid can be used to accelerate OLAP queries in Spark
- Druid focuses on the latencies to ingest and serve queries
- Too long for end user to arbitrarily explore data

SQL-on-Hadoop (Impala/Drill/Spark SQL/Presto)

- Queries: more data transfer between nodes
- Data Ingestion: bottleneck by backing store
- Query Flexibility: more flexible (full joins)

Data

Concepts

- **Timestamp column**: query centered on time axis
- **Dimension columns**: strings (used to filter or to group)
- **Metric columns**: used for aggregations (count, sum, mean, etc...)

Roll-up

Example

timestamp	page	...	added	deleted
2011-01-01T00:01:35Z	Justin Bieber		10	65
2011-01-01T00:03:63Z	Justin Bieber		15	62
2011-01-01T01:04:51Z	Justin Bieber		32	45
2011-01-01T01:01:00Z	Ke$ha		17	87
2011-01-01T01:02:00Z	Ke$ha		43	99
2011-01-01T02:03:00Z	Ke$ha		12	53

timestamp	page	...	nb	added	delet
2011-01-01T00:00:00Z	Justin Bieber		2	25	1
2011-01-01T01:00:00Z	Justin Bieber		1	32	4
2011-01-01T01:00:00Z	Ke$ha		2	60	186
2011-01-01T02:00:00Z	Ke$ha		1	12	53

as SQL

```
GROUP BY timestamp, page, nb, added, deleted
   :: nb = COUNT(1)
   ,  added = SUM(added)
   ,  deleted = SUM(deleted)
```

In practice can dramatically reduce the size (up to x100)

Sharding

Segments

```
sampleData_2011-01-01T01:00:00:00Z_2011-01-01T

2011-01-01T01:00:00Z  Justin Bieber    1 20   4
2011-01-01T01:00:00Z  Ke$ha            1 30   106

sampleData_2011-01-01T01:00:00:00Z_2011-01-01T

2011-01-01T01:00:00Z  Justin Bieber    1 12   4
2011-01-01T01:00:00Z  Ke$ha            2 30   80
```

Core Data Structure

Timestamp | Dimensions | Metrics

Timestamp	Page	Username	Gender	City	Characters Added	Characters Removed
2011-01-01T01:00:00Z	Justin Bieber	Boxer	Male	San Francisco	1800	25
2011-01-01T01:00:00Z	Justin Bieber	Reach	Male	Waterloo	2912	42
2011-01-01T02:00:00Z	Ke$ha	Helz	Male	Calgary	1953	17
2011-01-01T02:00:00Z	Ke$ha	Xeno	Male	Taiyuan	3194	170

- dictionary
- a bitmap for each value
- a list of the columns values encoded using the dictionary

Dictionary

```
{ "Justin Bieber": 0
, "Ke$ha": 1
}
```

Columnn Data

```
[ 0
, 0
, 1
, 1
]
```

Bitmaps

one for each value of the column

```
value="Justin Bieber": [1,1,0,0]
value="Ke$ha": [0,0,1,1]
```

Data

Indexing Data

- Immutable snapshots of data
- data structure highly optimized for analytic queries
- Each column is stored separately
- Indexes data on a per shard (segment) level

Loading data

- Real-Time
- Batch

Querying the data

- JSON over HTTP
- Single Table Operations, no joins.

Columnar Storage

Index

- Values are dictionary encoded

```
{"USA" 1, "Canada" 2, "Mexico" 3, ...}
```

- Bitmap for every dimension value (used by filters)

```
"USA" -> [0 1 0 0 1 1 0 0 0]
```

- Column values (used by aggergation queries)

```
[2,1,3,15,1,1,2,8,7]
```

Data Segments

- Per time interval
  - skip segments when querying
- Immutable
  - Cache friendly
  - No locking
- Versioned
  - No locking
  - Read-write concurrency

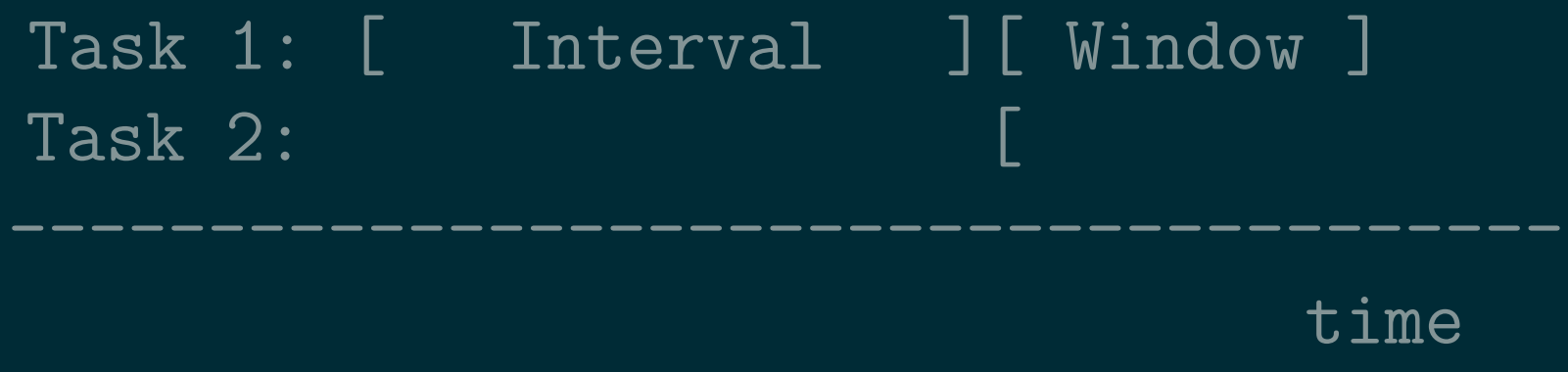
Real-time ingestion

- Via Real-Time Node and Firehose
  - No redundancy or HA, thus not recommended
- Via Indexing Service and Tranquility API
  - Core API
  - Integration with Streaming Frameworks
  - HTTP Server
  - **Kafka Consumer**

Batch Ingestion

- File based (HDFS, S3, ...)

Real-time Ingestion



Minimum indexing slots =
Data Sources $\times$ Partitions $\times$ Replicas $\times$ 2

Querying

Query types

- Group by: group by multiple dimensions
- Top N: like grouping by a single dimension
- Timeseries: without grouping over dimensions
- Search: Dimensions lookup
- Time Boundary: Find available data timeframe
- Metadata queries

Tip

- Prefer `topN` over `groupBy`
- Prefer `timeseries` over `topN`
- Use limits (and priorities)

Query Spec

- Data source
- Dimensions
- Interval
- Filters
- Aggergations
- Post Aggregations
- Granularity
- Context (query configuration)
- Limit

Example(s)

TODO

Caching

- Historical node level
  - By segment
- Broker Level
  - By segment and query
  - `groupBy` is disabled on purpose!
- By default - local caching

Load Rules

- Can be defined
- What can be set

Components

Druid Components

- Real-time Nodes
- Historical Nodes
- Broker Nodes
- Coordinator
- For indexing:
  - Overlord
  - Middle Manager
- Deep Storage
- Metadata Storage
- Load Balancer
- Cache

Coordinator

Manage Segments

Real-time Nodes

- Pulling data in real-time
- Indexing it

Historical Nodes

- Keep historical segments

Overlord

- Accepts tasks and distributes them to middle manager

Middle Manager

- Execute submitted tasks via Peons

Broker Nodes

- Route query to Real-time and Historical nodes
- Merge results

Deep Storage

- Segments backup (HDFS, S3, ...)

Considerations & Tools

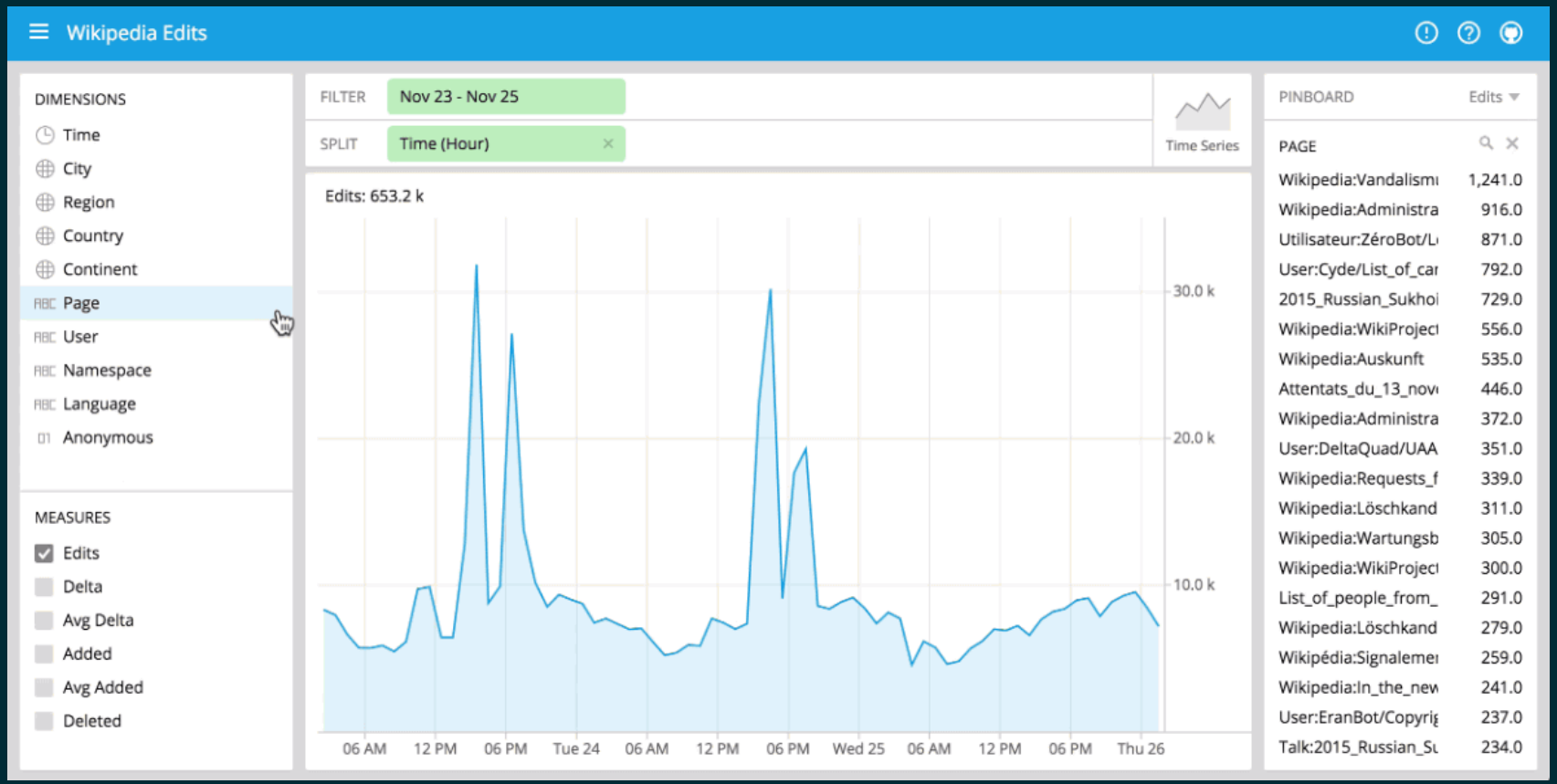
When *not* to choose Druid

- Data is not time-series
- Cardinality is *very* high
- Number of dimensions is high
- Setup cost must be avoided

Graphite (metrics)

Graphite

Pivot (exploring data)



Pivot

Caravel (exploring data)