Unlock BDaaS efficiency with storage disaggregation and in-memory acceleration on All Flash systems

Jian Zhang (jian.zhang@intel.com), Senior Software Engineer Manager
Yuan Zhou (yuan.zhou@intel.com), Senior Software Engineer

Intel APAC R&D
Agenda

- Background and Motivations
- Disaggregated Analytics Architecture
- Performance of Disaggregated Analytics Solutions
- In-memory Acceleration for Disaggregated Analytics Architecture
- Summary
Background and Motivation
Discontinuity in big data infrastructure – why?

CONGESTION in busy analytic clusters causing missed SLAs.

MULTIPLE TEAMS COMPETING and sharing the same big data resources.
Causing customers to pick a solution

SINGLE LARGE CLUSTER

Get a bigger cluster for many teams to share.

MULTIPLE SMALL CLUSTERS

Give each team their own dedicated cluster, each with a copy of PBs of data.

ON DEMAND ANALYTIC CLUSTERS

Give teams ability to spin-up/spin-down clusters which can share data sets.
## Benefits of compute and storage disaggregation

<table>
<thead>
<tr>
<th>Independent scale of CPU and storage capacity</th>
<th>Single copy of data</th>
<th>Enable Agile application development</th>
<th>Hybrid cloud deployment</th>
<th>Simple and flexible software management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rightsize HW for each layer</td>
<td>• Multiple compute cluster share common data repo/lake</td>
<td>• In-memory cloning</td>
<td>• Mix and match resources depending on workload nature and life cycle</td>
<td>• Avoid software version management</td>
</tr>
<tr>
<td>• Reduce resource wastage</td>
<td>• Simplified data management</td>
<td>• Snapshot service</td>
<td></td>
<td>• Upgrade compute software only</td>
</tr>
<tr>
<td>• Cost saving</td>
<td>• Reduced provisioning overhead</td>
<td>• Quick &amp; efficient copies</td>
<td></td>
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<tr>
<td></td>
<td>• Improve security</td>
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</table>
Disaggregated Analytics Architecture
Unified Hadoop File System and API for cloud storage

Hadoop Compatable File System abstraction layer: Unified storage API interface Hadoop fs -ls s3a://job/

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Evolution of AI/Analytics Solutions

GENERATION 1
MONOLITHIC HADOOP STACKS

GENERATION 2
DECOUPLED STACK WITH PRIVATE CLOUD INFRASTRUCTURE

**ANALYTICS + INFRASTRUCTURE**

**Provisioned Compute Pool**

**Shared Data Lake**
Performance of Disaggregated Analytics Solutions
Workloads

- **Simple Read/Write**
  - DFSIO: TestDFSIO is the canonical example of a benchmark that attempts to measure the Storage's capacity for reading and writing bulk data.
  - Terasort: a popular benchmark that measures the amount of time to sort one terabyte of randomly distributed data on a given computer system.

- **Batch ingestion**
  - Support collection of data from a variety of data sources in a consistent and repeatable manner designed to reduce data loss, improve traceability, increase availability, and increase timeliness.

- **Data Transformation**
  - ETL: Taking data as it is originally generated and transforming it to a format (Parquet, ORC) that more tuned for analytical workloads.

- **Batch Analytics**
  - To consistently executing analytical process to process large set of data.
  - Leveraging 54 derived from TPC-DS* queries with intensive reads across objects in different buckets.

- **Interactive Query**
  - This is very similar to the batch analytics workload, with the key distinction being required response time.

- **Streaming**
  - Streaming data collection is the landing and aggregation of streaming data from messaging queues.

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5x Compute Node
- Intel® Xeon™ processor E5-2699 v4 @ 2.2GHz, 128GB mem
- 2x10G 82599 10Gb NIC
- 2x SSDs
- 3x Data storage (can be eliminated)

Software:
- Hadoop 2.7.3
- Spark 2.1.1
- Hive 2.2.1
- Presto 0.177
- RHEL7.3

5x Storage Node, 2 RGW nodes, 1 LB nodes
- Intel(R) Xeon(R) CPU E5-2699v4 2.20GHz
- 128GB Memory
- 2x 82599 10Gb NIC
- 1x Intel® P3700 1.0TB SSD as WAL and rocksdb
- 4x 1.6TB Intel® SSD DC S3510 as data drive
- 2x 400G S3700 SSDs
- 1 OSD instances one each S3510 SSD
- RHEI7.3
- RHCS 2.3

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Bigdata on Object Storage Performance Overview
-- batch analytics

- Significant performance improvement from Hadoop 2.7.3/Spark 2.1.1 to Hadoop 2.8.1/Spark 2.2.0 (improvement in s3a)
- Batch analytics performance of 10-node Intel AFA is almost on-par with 60-node HDD cluster
Improve Query Success Ratio
-- Functional Trouble-shooting

1TB Query Success % (54 TPC-DS Queries)

- **hive-parquet**
- **spark-parquet** (untuned)
- **presto-parquet** (tuned)

1TB&10TB Query Success % (54 TPC-DS Queries)

- **spark-parquet**
- **spark-orc**
- **presto-parquet**
- **presto-parquet**

**Count of Issue Type**

- S3a driver issue
- Runtime issue
- Middleware issue
- Improper default configuration
- Deployment issue
- Compatible issue
- Ceph issue

- 100% selected TPC-DS* query passed with tunings
- Improper Default configuration
- small capacity size,
- wrong middleware configuration
- improper Hadoop/Spark configuration for different size and format data issues

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Optimizing HTTP Requests
-- The bottlenecks

2017-07-18 14:53:52.259976 7fddd676c700 1 ===== starting new request req=0x7fddd676710 =====
2017-07-18 14:53:52.271829 7fddd5fbb700 1 ===== starting new request req=0x7fddd5fbb700 =====
2017-07-18 14:53:52.273940 7fddd7fff700 0 ERROR: flush_read_list(): d->client_c->handle_data() returned -5
2017-07-18 14:53:52.274223 7fddd7fff700 0 WARNING: set_req_state Err err_no=5 resorting to 500
2017-07-18 14:53:52.274253 7fddd7fff700 0 ERROR: s->cio->send_content_length() returned err=-5
2017-07-18 14:53:52.274257 7fddd7fff700 0 WARNING: s->cio->print() returned err=-5
2017-07-18 14:53:52.274267 7fddd7fff700 0 ERROR: STREAM_IO(s)->complete_header() returned err=-5

Http 500 errors in RGW log

Comput time take the big part. (compute time = read data + sort)

New connections out every time, Connection not reused
Optimizing HTTP Requests -- S3a input policy

- Enable random read policy hadoop:

  ```
  <property>
    <name>fs.s3a.experimental.input.fadvise</name>
    <value>random</value>
  </property>
  <property>
    <name>fs.s3a.readahead.range</name>
    <value>64K</value>
  </property>
  ```

- By reducing the cost of closing existing HTTP requests, this is highly efficient for file IO accessing a binary file through a series of `PositionedReadable.read()` and `PositionedReadable.readFully()` calls.

- Background
  - The S3A filesystem client supports the notion of input policies, similar to that of the POSIX `fadvise()` API call. This tunes the behavior of the S3A client to optimize HTTP GET requests for various use cases. To optimize HTTP GET requests, you can take advantage of the S3A experimental input policy `fs.s3a.experimental.input.fadvise`.
  - Ticket: https://issues.apache.org/jira/browse/HADOOP-13203
Optimizing HTTP Requests -- Performance

- Readahead feature is supported from Hadoop 2.8.1, but not enabled by default. By applying random read policy, the 500 issue is fixed and performance improved 3x.

- All Flash storage architecture also show great performance benefit and low TCO which compared with HDD storage.
In-memory Acceleration for Disaggregated Analytics Architecture
Acceleration Layer For Disaggregated Architecture

- With disaggregated storage, the networking overhead of I/O will be bigger
  - Network is going to be a bottleneck
- Bigdata I/O stack is still using technology 10+ years ago
  - New technology like SPDK, RDMA has not been used
- We want to implement a new storage layer for intermediate data like cache/shuffle to accelerate the data access
In-memory Accelerator POC with Alluxio*

- The world's first system that unifies disparate storage systems at memory speed
  - HDFS, Blob, S3, GCS, Minio, Ceph, Swift, MapR-FS to name a few
- Accelerates Cloud Deployments for Analytics and Machine Learning
  - Location aware data management; optimized for object storage and every* major CSP; User Space File system enables ML frameworks to access cloud data
- Trusted by the world's leading companies.
  - Alibaba, Baidu, CMU, Google, IBM, Intel, NJU, Red Hat, UC Berkeley and Yahoo, JD.com etc.
POC System Configuration

5x Compute Node

**Hardware:**
- Intel® Xeon™ processor Gold 6140 @ 2.3GHz, 384GB Memory
- 1x 82599 10Gb NIC
- 5x P4500 SSD (2 for spark-shuffle)

**Software:**
- Hadoop 2.8.1
- Spark 2.2.0
- Hive 2.2.1
- RHEL7.3

5x Storage Node

**Hardware:**
- Intel(R) Xeon(R) CPU Gold 6140 @ 2.30GHz, 192GB Memory
- 2x 82599 10Gb NIC
- 7x 1TB HDD for Ceph bluestore or HDFS namenode and datanode

**Software:**
- Hadoop 2.8.1
- Ceph 12.2.7
- RHEL7.3

Alluxio Acceleration Layer

- 200GB Mem for mem mode
- 1TB SSD(P4500) for SSD mode

**Software:**
- Alluxio 1.7.0

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POC Performance with Alluxio*

- Alluxio based in memory acceleration layers provides significant performance boost for analytics workloads with disaggregated storage
  - Up to 3.25x for Terasort
  - Up to 1.8x compared with local HDFS

### Alluxio Acceleration of Disaggregated analytics storage with different workloads (Normalized)

<table>
<thead>
<tr>
<th>Workload</th>
<th>spark(yarn) + Local HDFS (HDD)</th>
<th>spark(yarn) + S3 (HDD)</th>
<th>spark(yarn) + alluxio(SSD) + S3 (HDD)</th>
<th>spark(yarn) + alluxio(MEM) + S3 (HDD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch Query (54 queries)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>IO INTENSIVE (7 queries)</td>
<td>1.0</td>
<td>0.7</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>TERASORT 100G</td>
<td>1.0</td>
<td>0.6</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>KMEANS 76G</td>
<td>1.0</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>TERASORT 1T</td>
<td>1.0</td>
<td>0.4</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>KMEANS 374g</td>
<td>1.0</td>
<td>0.6</td>
<td>1.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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Summary
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- Discontinuity in bigdata infrastructure drives storage disaggregation, Decoupling compute and storage brings cost savings, agility and flexibility and becoming increasing popular in public CSPs
- Cloud based Bigdata and Analytics grows much faster than on-premise solutions, public cloud adoption is No.1 priority for Bigdata investments
- BDA on Cloud performance is much lower compared with on-premise
- In memory acceleration layer helps to deliver higher performance and enables new usage scenario;
  - Little or no interruptions to AI/Analytics processing
  - Memory Locality Optimizations via Compute-Side Caching
  - Optimizes both performance and TCO for AI/Analytical workload
  - Alluxio based POC demonstrates up to 3.25x performance boost for bigdata analytics workloads on s3 cloud storage
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Backup
Architecture involvement

Dedicate LB Deployment & Configuration

DNS + Dedicate RGW Deployment & Configuration

DNS + RGW and OSD co-locality Deployment & Configuration

System configuration

System configuration