KAFKA + NETAPP ^AI

Building a Connector Better than Market

🍺🐿️ 🆚 🦀

Guang Zhao

DATA

🍺 NetApp Ontap/StorageGrid

🐿️ Kafka pipeline

❓ How to connect the two

INTERFACE

🍺 Simple (object) storage service (S3)

🐿️ Kafka Connect

🦀 Aiven/Confluent/... Connectors

END OF STORY?

Just a simple config away?

PROBLEM

✅ Parquet, CSV, JSON

❓ 1GB ~ 1TB per object

LIMITS 🍺🦀

🍺 ONTAP/STORAGEGRID

Read: fail `GetObject*` >10GB

Write: both StorageGrid and AWS recommend

- 5GB for single `PutObject`
- 5TB max

🦀 MARKET CONNECTORS

Confluent	Aiven	Lenses
<2GB[a]	<min(Instance,10GB)[a,c,d]	<10GB[d]
Closed	-	-
-	Utf-8 only[b]	-
-	Inefficient conversion	-

- a. Parquet
- b. Text
- c. "Download first" (Anti-Stream)
- d. "Single stream" (S3 limit)

PROBLEM = SCALE 🏋️

LET'S SOLVE IT

Just ask Customer to split their data

End of story?

NO, LET'S REALLY SOLVE IT

Simple I/O abstraction ➡️ data formats

Scalable I/O implementation ➡️ external storage

WHAT AFFECTS SCALABILITY

DATA FORMATS ➡️ ACCESS PATTERNS

CSV, (ND)JSON	Parquet
Line	Columnar
Sequential	Semi Random

PARQUET: SEMI RANDOM ACCESS

```
+----------------+
| Chunk 1, Col 1 <-------+-------+
| Chunk 1, Col 2 |       | Row 1 |
| C...           |       | Row 2 |
| Chunk 1, Col N |       | ...   |
+----------------+       | Row M |
| Chunk 2, Col 1 |       +-------+
| C...           |
| Chunk 2, Col N |
+----------------+
...
| Chunk N        |
+----------------+
| File Metadata  |  Imagine cutting a tofu
+ ---------------+
```

1. jump to the end to read Metadata
2. jump back to chunk, read row in multiple offsets

KAFKA CONNECT(OR)

- Poll external records by batches
- Convert types
- Publishes records to Kafka topic

External systems and data formats, are what?

#0: ALL ARE ... BYTE STREAMS

```
abstract class java.io.InputStream {
    ...
    // Only forward
    long skip(long n) throws IOException;

    // Let's not get into mark() and reset()...
}
```

Can't support Parquet

Can't handle large S3 object

BREAK THE ABSTRACTION

#1: WITH RANDOM ACCESS

```
class RandomAccessInputStream extends j.i.FilterInputStream {
    ...
    // Forward and backward
    void seek(long offset) throws IOException;
}
```

~~Can't support Parquet~~

Can't handle large S3 object

#2: BROKEN INTO EXTENTS

```
class ExtentInputStream extends RandomAccessInputStream {
    long extentSize;
    long extentOffset;
    ...
}
```

DIAGRAM

```
+-------------------------------------------------------+
| byte[0], byte[1], ...                        byte[N]  |
+================+================+=====+================+
| ext[0]         | ext[1]         | ... | ext[M]         |
+----------------+----------------+-----+----------------+
| S3.GetRange[0] | S3.GetRange[1] | ... | S3.GetRange[M] |
+----------------+----------------+-----+----------------+
```

- $byte[i] = ext[i/size][i \mod size]$
- multiple smaller reads on a large object

POWER OF ABSTRACTION

```
                 +--------------+
                 |  Connector   |
                 +-------+------+
                         |
     +------------------+-----------------+-----+
     | Parquet Decoder  | Unicode Decoder | ... |
     +------------------+-----------------+-----+
                         |
+-----------------------+-------------------------------+
| byte[0], byte[1], ...                          byte[N]  |
+================+================+=====+================+
| ext[0]         | ext[1]         | ... | ext[M]         |
+----------------+------+---------+-----+----------------+
                         |
        +---------------+-------------+--------+
        | Object Store  | File System |        |
```

- Bytes 🔄 data formats
- Extents 🔄 external systems

EXTENSIBLE

```
        Data Formats
            ^
            |
    Parquet |
            |
    Text    |
            |   🍺 Ontap  StorageGrid  😄 Aws
            +-----------------------------------> Systems
    Extent-Stream
```

OPTIMIZATION

Extent 🔊 access pattern ➡️ storage

Storage may optimize, such as caching or prefetching

OPTIMAL EXTENT SIZE ❓

Too small: consume resources

Too big: waste unread bytes; S3 limit

🤖 🆚 🤷

How to find out? For each system, each format...

(AUTO-)TUNE OUR CONNECTOR

MACHINE LEARNING PROBLEM

$$\arg\max_{param} P(connector|param, sys, work)$$

- parameters: extent size
- System: S3, Ontap, StorageGrid, Local
- Representative workload?
- P, model: throughput, or latency

🤖 AI ATTEMPT #1

CODE-ONLY AI

👦: Hey 🤖, given my code, what's the optimal parameter?

$$\arg\max_{params} P(connector|param)$$

AI CORRECT?

🤖: "Disk block sizes commonly are 512B or 4KB. Set 1KB."

🤖: "S3 recommends PutObject limit 5GB, max 5TB, Set 5GB."

BENCHMARK

Let's do the hard work

TPC-H DATASET

	Parquet Small	Parquet Large	CSV Small
Table	Customer	Lineitem	Customer
Scale	10	30	10
Rows	1.5M	37.23B	1.5M
Compress	1:2	1:2	1:1
Size(B)	118M	6.3G[a,b]	237M

- a. Beyond Confluent limit
- b. Aiven min instance disk space

WORKLOAD

```
num_polls = 10
batch_size = 128
for i in range(num_polls):
    poll(batch_size)
```

🍺 STORAGEGRID, TIME (MS)

Extent(B)	Csv Small	Parquet Small	Parquet Large
1K	480,501	>1min	>1min
4K	470,438	>1min	>1min
1M	4,695	17,134	12,292
4M	2,967	8,630	9,304
1G	2,937	6,782	6,377
4G	2,669	6,242	6,196

- std ~ 5% mean

🍺 STORAGEGRID VS 😃 AWS, TIME (MS)

Extent(B)	StorageGrid[a]	Aws[a]
1K	480,501	573,496
1M	4,695	4,813
1G	2,937	2,895

- a. CSV Small • std ~ 5% mean

TAKEAWAY

- Our Connector scales better than Confluent
- StorageGrid vs Aws comparable
- Optimal extent size != AI suggests
  - depends on formats, maybe systems
  - requires internal knowledge

🤖 AI ATTEMPT #2

STOCHASTIC GRADIENT DESCENT

```
num_polls = 10
batch_size = 128
x = extent_size
for i in range(num_polls):
    cost = model(poll(batch_size), x)
    grad = gradient(model, cost, x)
    x = step(grad, x)
```

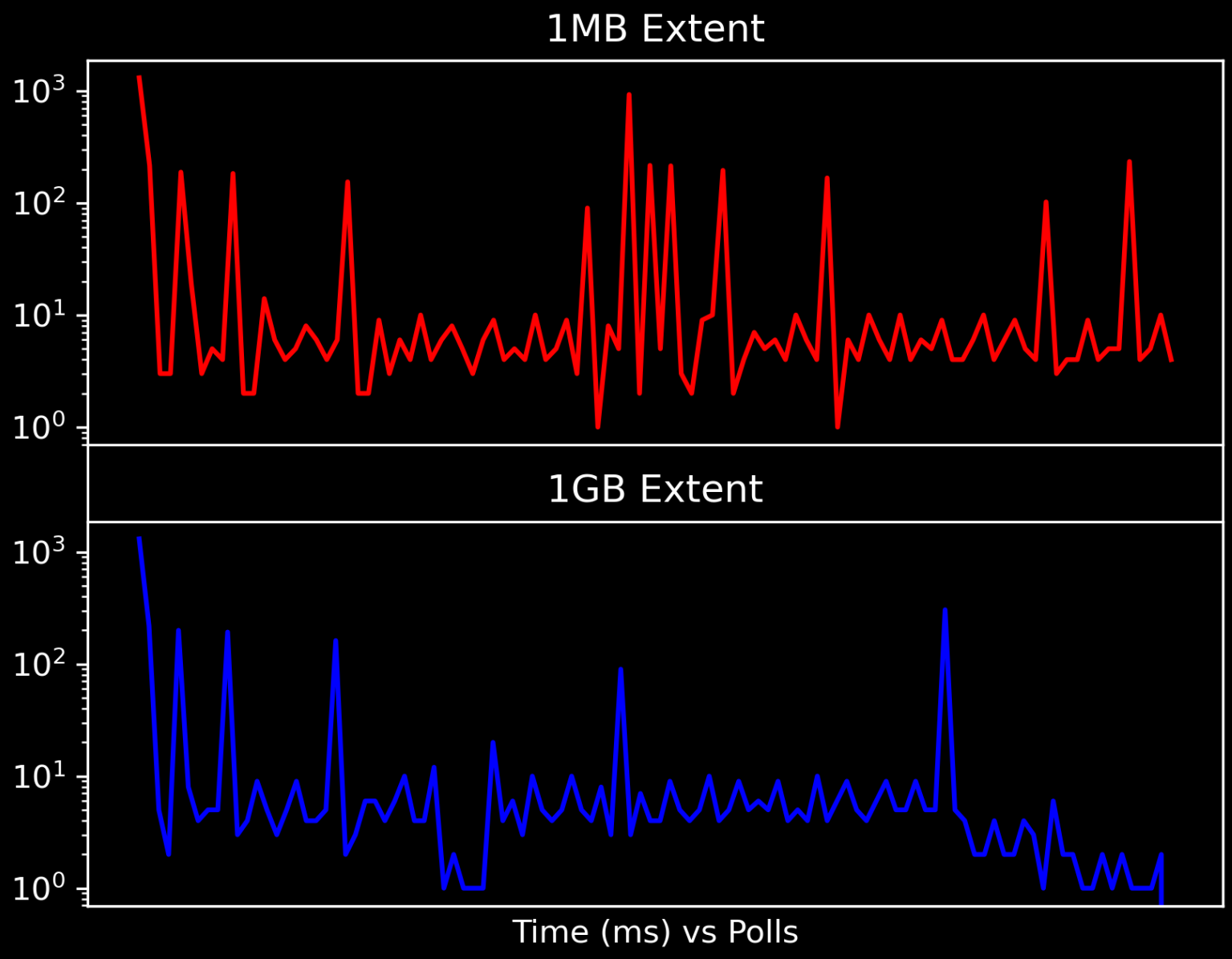
Convergence: found an extent size with fastest poll

PROBLEMS

Model is non-differentiable.

It assumes each poll time is stable given extent.

But there is no bound.


1MB Extent
10^3
10^2
10^1
10^0
1GB Extent
10^3
10^2
10^1
10^0
Time (ms) vs Polls

🤷 NO GUARANTEE

Based on local info, cannot converge to optimal extent

🤖 AI ATTEMPT #3

Combine LLM (#1) and ML (#2)

AGENT FOR BENCHMARK + TUNE

```
while True:
    extent_sizes, num_polls = Llm.generate_response(
        'Propose candidate extent sizes, observation window',
        context)

    costs = []
    for x in extent_sizes:
        costs += repeat(
            num_polls,
            model(poll(batch_size), x))

    better_extent_size = find_min(costs, extent_sizes)

    context.add(better_extent_size)
```

AI gets both general and specific context

RESULT

Experimental... ⏳

FEATURES

- Unlimited size
- Extensible formats
- Extensible endpoints
- (Autotune agent ⏳)
- Unicode
- Aync object discovery
- Nested prefixes
- 1-1 Type conversion

👍 Differentiate from Market {🦀,...}

HEADS UP

- 👁️ Cassandra Parquet/Avro Transformer by Stefan
- Operational to analytical:

```
👁️ Cassandra -- Parquet -- 🐿️ Kafka
                  |
                  |
                  X
```

THANKS

- Anup: Testing
- Amanda: Organizing
- Carlos: Organizing
- Justin: Organizing
- Nilkua: NetApp configs
- Tharindu: Native format
- Varun: Organizing
- Win: Ontap
- Team Kafka: Review PR
- Team Open Source: Discussion
- Team PoC: Customer & Product

🤷 All technical errors are mine.

THOUGHTS?

💻 https://github.com/instaclustr/kafka-connect-connectors

▶ Contribution welcome!

📧 Guang.Zhao@netapp.com

Slack #opensauce

🏢 Melbourne