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Apache Drill Implementation Deep Dive

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Berlin Buzzwords 2013-06-03

Which workloads do **you** encounter in **your** environment?

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Batch processing

… for recurring tasks such as large-scale data mining, ETL offloading/data-warehousing ␣ *for the batch layer in Lambda architecture*

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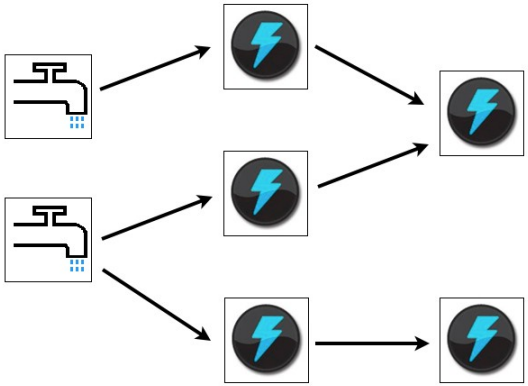
OLTP

… user-facing eCommerce transactions, real-time messaging at scale (FB), time-series processing, etc. ␣ *for the serving layer in Lambda architecture*

Stream processing

Storm

Distributed and fault-tolerant realtime computation



S4 *distributed stream computing platform*

… in order to handle stream sources such as social media feeds or sensor data (mobile phones, RFID, weather stations, etc.) ⇨ *for the speed layer in Lambda architecture*

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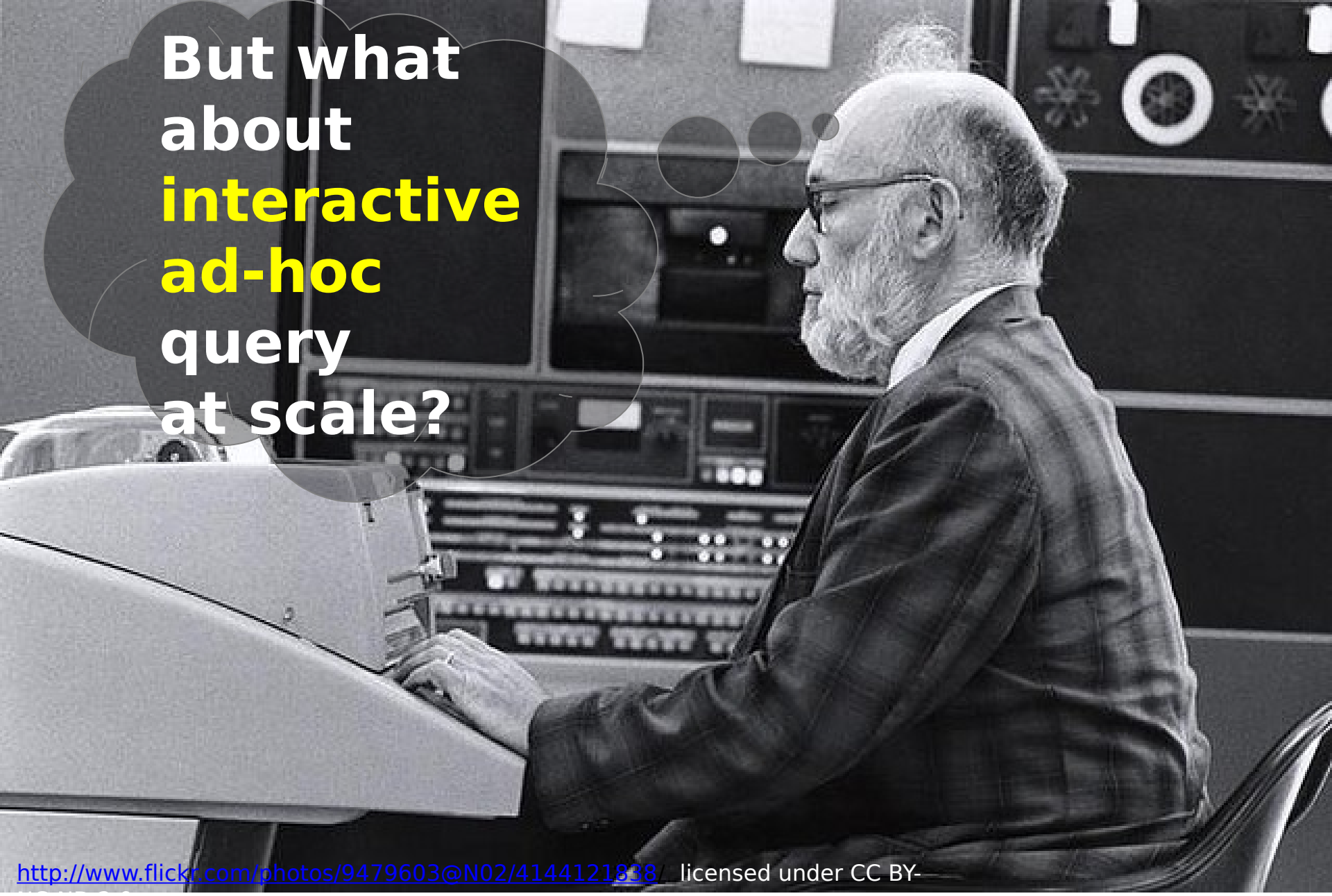
Search/Information Retrieval

… retrieval of items from unstructured documents (plain text, etc.), semi-structured data formats (JSON, etc.), as well as data stores (MongoDB, CouchDB, etc.)



Interactive Query (?)

Use Case: Logistics

- Supplier tracking and performance
- Queries
  - Shipments from supplier ‘ACM’ in last 24h
  - Shipments in region

SUPPLIER_ID	NAME	REGION
ACM	ACME Corp	US
GAL	GotALot Inc	US
BAP	Bits and Pieces Ltd	Europe
ZUP	Zu Pli	Asia

```
{
 "shipment": 100123,
 "supplier": "ACM",
 “timestamp": "2013-02-01",
 "description": ”first delivery today”
},
{
 "shipment": 100124,
 "supplier": "BAP",
 "timestamp": "2013-02-02",
 "description": "hope you enjoy it”
}
…
```

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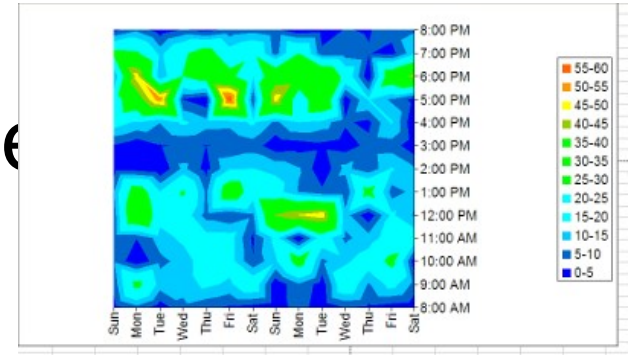
Use Case: Crime Detection

- Online purchases
- Fraud, bilking, etc.
- Batch-generated overvie
- Modes
  - Explorative
  - Alerts



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Requirements

- Support for different data sources
- Support for different query interfaces
- Low-latency/real-time
- Ad-hoc queries
- Scalable, reliable

d now for something completely different ...

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Google’s Dremel

> “Dremel is a scalable, interactive ad-hoc query system for analysis of read-only nested data. By combining multi-level execution trees and columnar data layout, it is capable of running aggregation queries over trillion-row tables in seconds. The system scales to thousands of CPUs and petabytes of data, and has thousands of users at Google.
> …”

http://research.google.com/pubs/pub36632.html

Sergey Melnik, Andrey Gubarev, Jing Jing Long, Geoffrey Romer, Shiva Shivakumar, Matt Tolton, Theo Vassilakis, Proc. of the 36th Int'l Conf on Very Large Data Bases (2010), pp. 330-339

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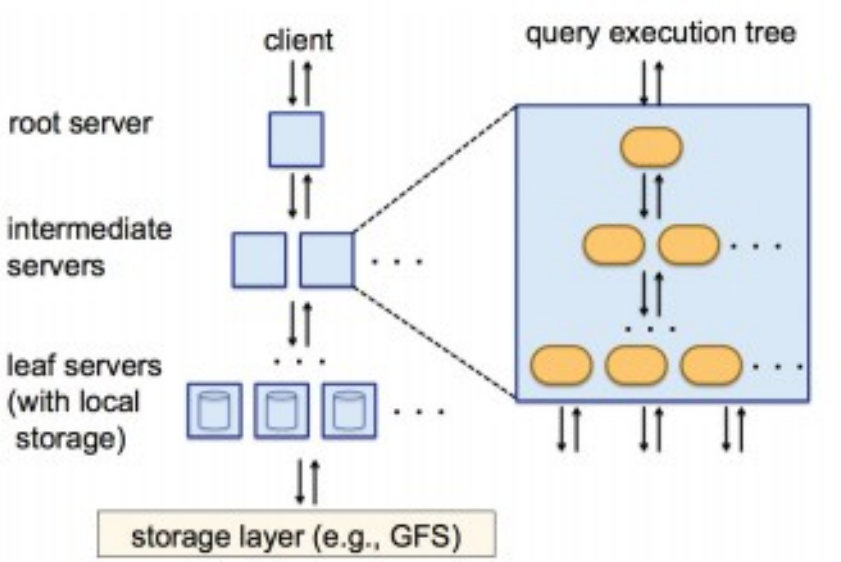
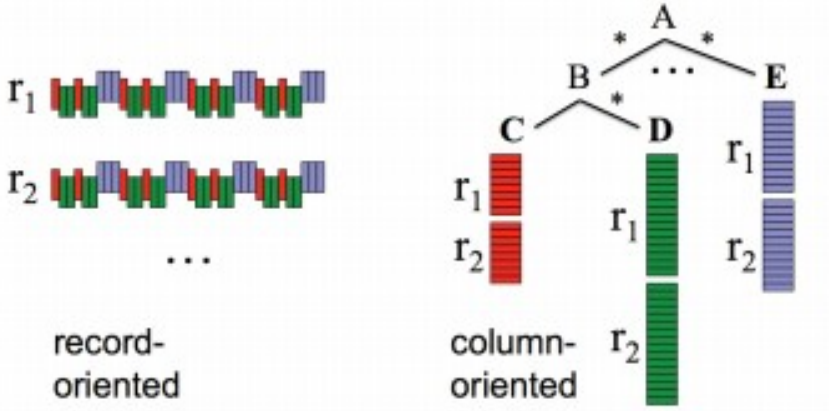
Google's Dremel



multi-level execution trees

columnar data layout



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Google's Dremel

```
DocId: 10                    r1
Links
  Forward: 20
  Forward: 40
  Forward: 60
Name
  Language
    Code: 'en-us'
    Country: 'us'
  Language
    Code: 'en'
  Url: 'http://A'
Name
  Url: 'http://B'
Name
  Language
    Code: 'en-gb'
    Country: 'gb'
```

```
message Document {
  required int64 DocId;
  optional group Links {
    repeated int64 Backward;
    repeated int64 Forward; }
  repeated group Name {
    repeated group Language {
      required string Code;
      optional string Country; }
    optional string Url; }}
```

```
DocId: 20                    r2
Links
  Backward: 10
  Backward: 30
  Forward:  80
Name
  Url: 'http://C'
```

DocId

value	r	d
10	0	0
20	0	0

Name.Url

value	r	d
http://A	0	2
http://B	1	2
NULL	1	1
http://C	0	2

Links.Forward

value	r	d
20	0	2
40	1	2
60	1	2
80	0	2

Links.Backward

value	r	d
NULL	0	1
10	0	2
30	1	2

Name.Language.Code

value	r	d
en-us	0	2
en	2	2
NULL	1	1
en-gb	1	2
NULL	0	1

Name.Language.Country

value	r	d
us	0	3
NULL	2	2
NULL	1	1
gb	1	3
NULL	0	1

nested data + schema

column-striped representation

map nested data to tables

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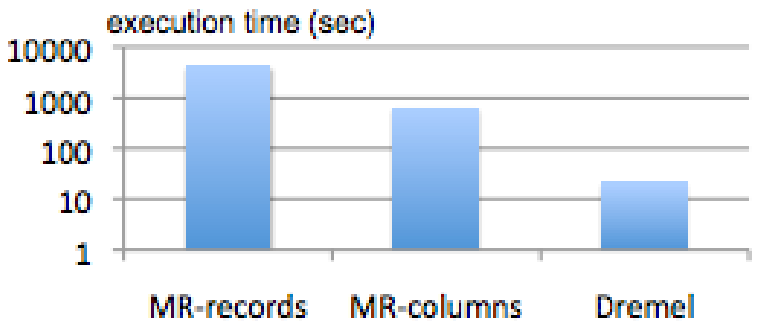
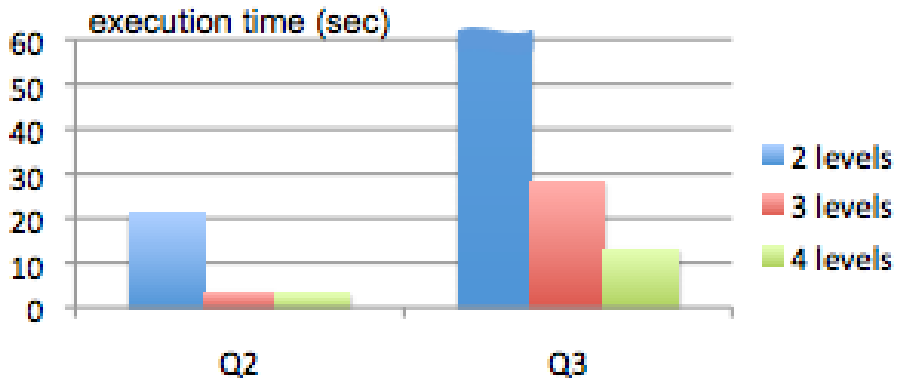
Google's Dremel

Table name	Number of records	Size (unrepl., compressed)	Number of fields	Data center	Repl. factor
T1	85 billion	87 TB	270	A	3×
T2	24 billion	13 TB	530	A	3×
T3	4 billion	70 TB	1200	A	3×
T4	1+ trillion	105 TB	50	B	3×
T5	1+ trillion	20 TB	30	B	2×

experiments:
datasets & query performance





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Back to Apache Drill ...

Apache Drill–key facts

- Inspired by Google's **Dremel**
- Standard **SQL 2003** support
- Plug-able **data sources**
- **Nested data** is a first-class citizen
- **Schema** is **optional**
- **Community** driven, **open**, 100's involved

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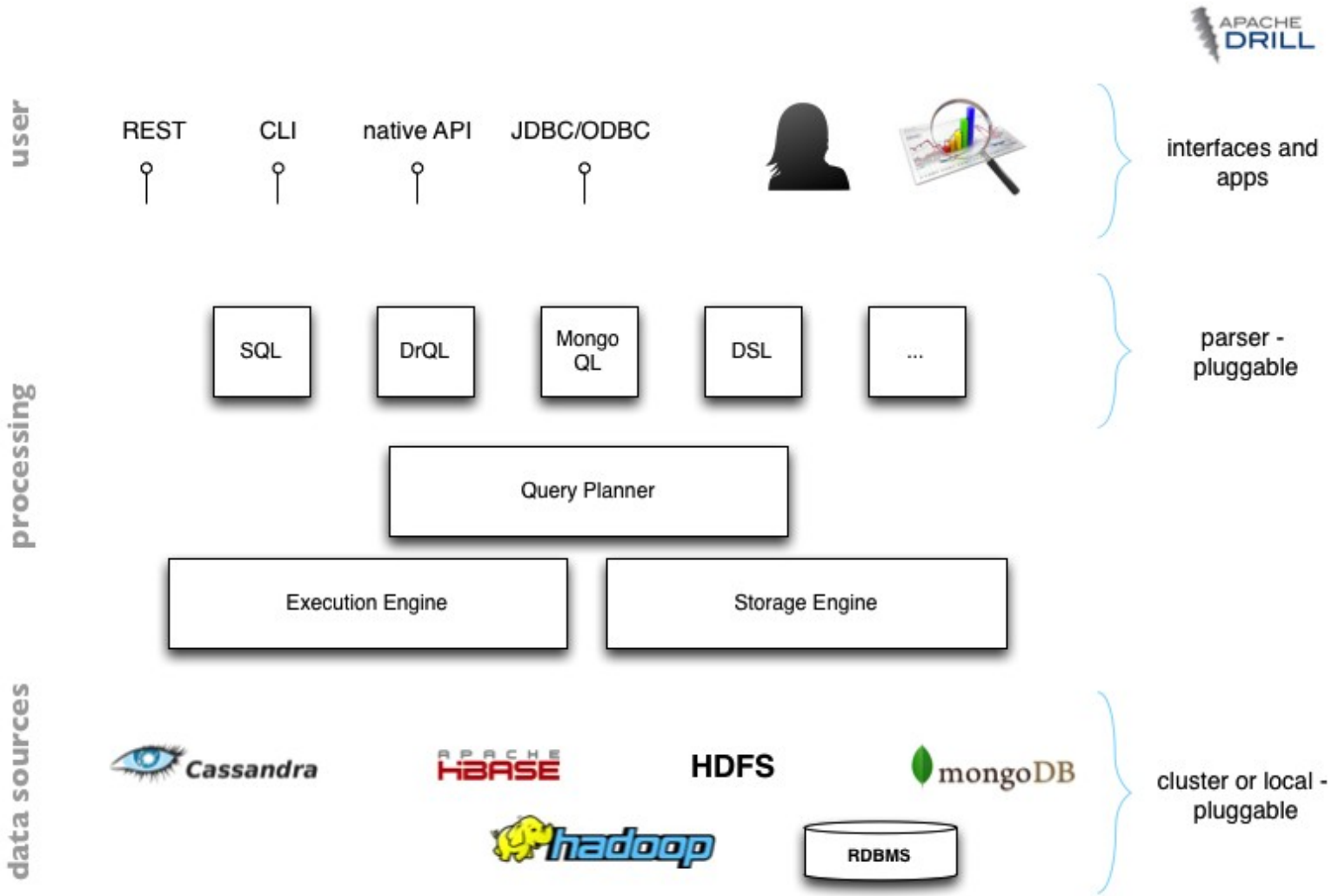
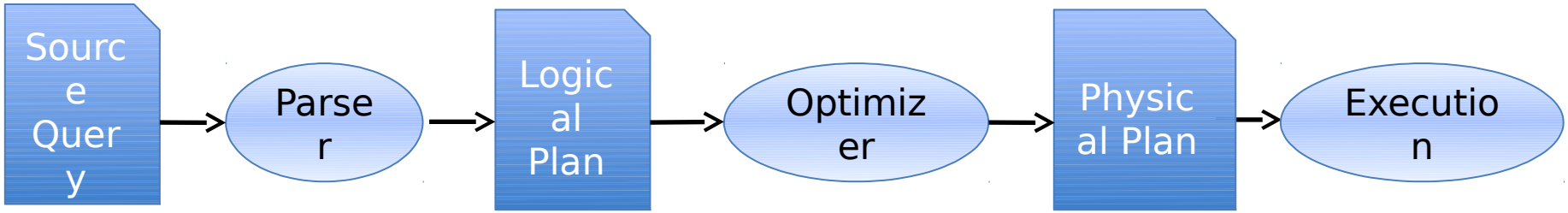
High-level Architecture



Principled Query Execution

- **Source query**—what we want to do (analyst friendly)
- **Logical Plan**— what we want to do (language agnostic, computer friendly)
- **Physical Plan**—how we want to do it (the best way we can tell)
- **Execution Plan**—where we want to do it

Principled Query Execution



SQL 2003
DrQL
MongoQL
DSL

parser API

```
query: [
 {
  @id: "log",
  op: "sequence",
  do: [
   {
    op: "scan",
    source: “logs”
   },
   {
    op: "filter",
    condition:
      "x > 3”
   },
```

Topology
CF
etc.

scanner API

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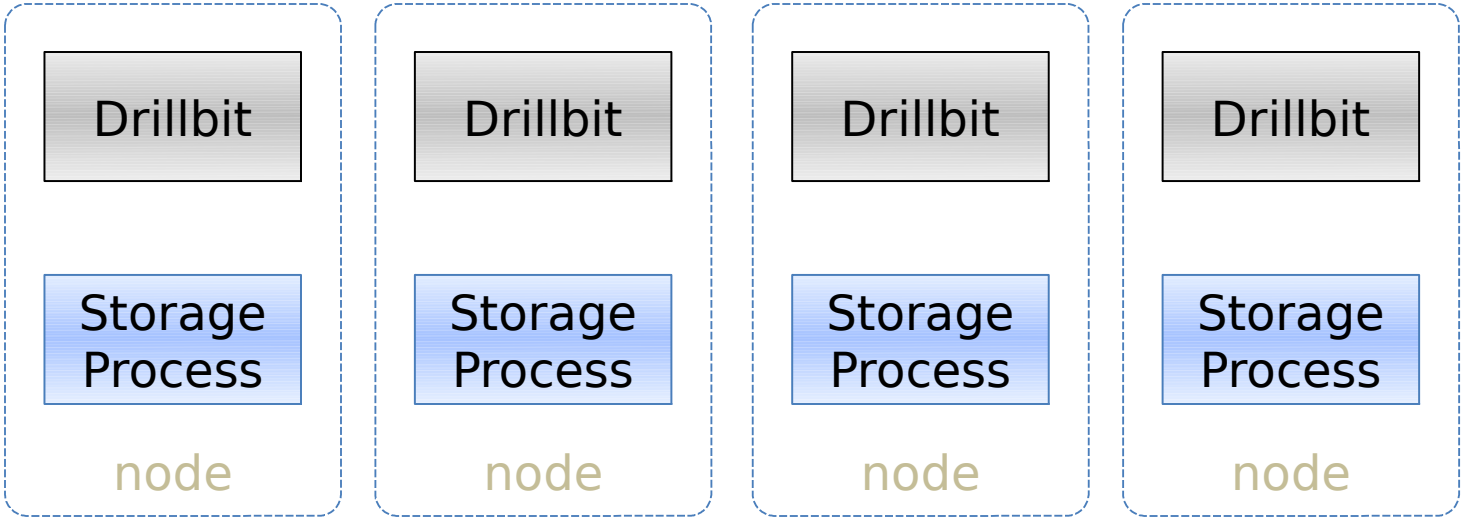
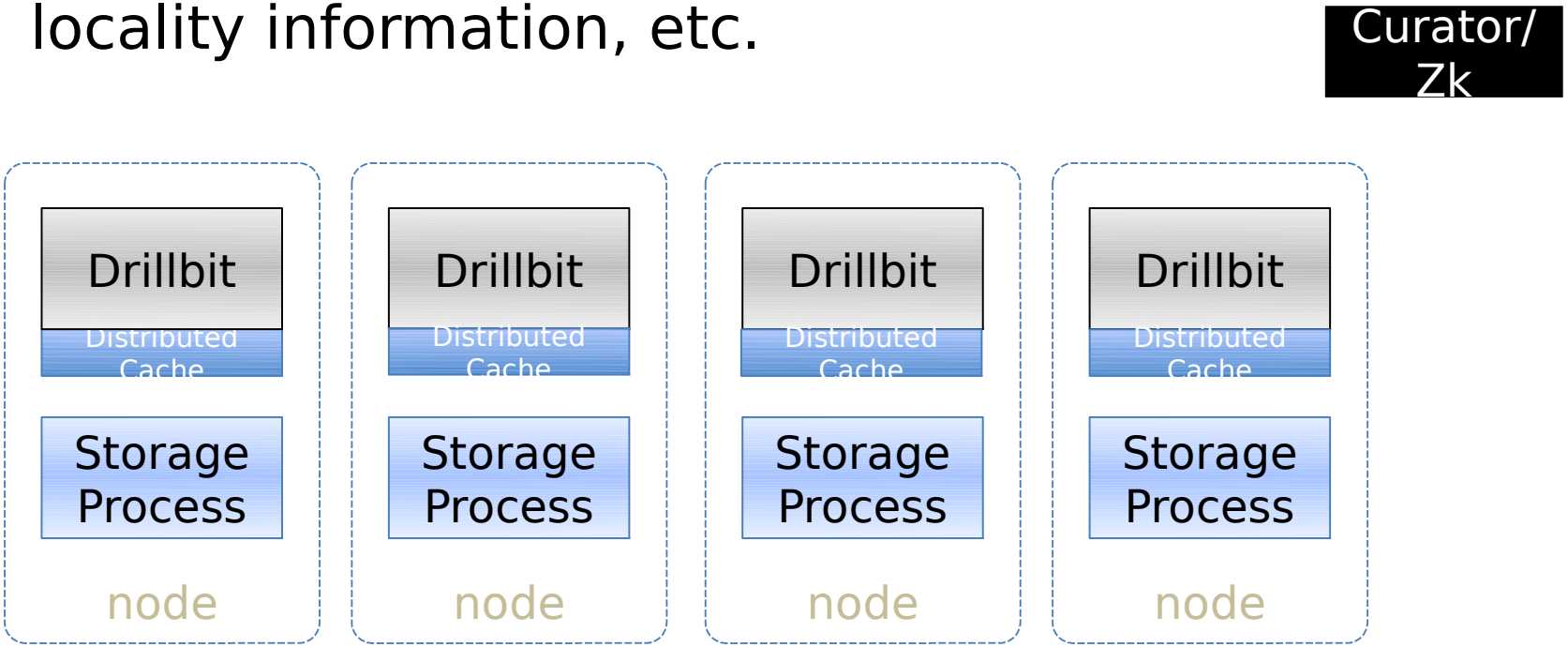
Wire-level Architecture

- Each node: **Drillbit** - maximize data locality
- Co-ordination, query planning, execution, etc, are **distributed**
- Any node can act as endpoint for a query—**foreman**



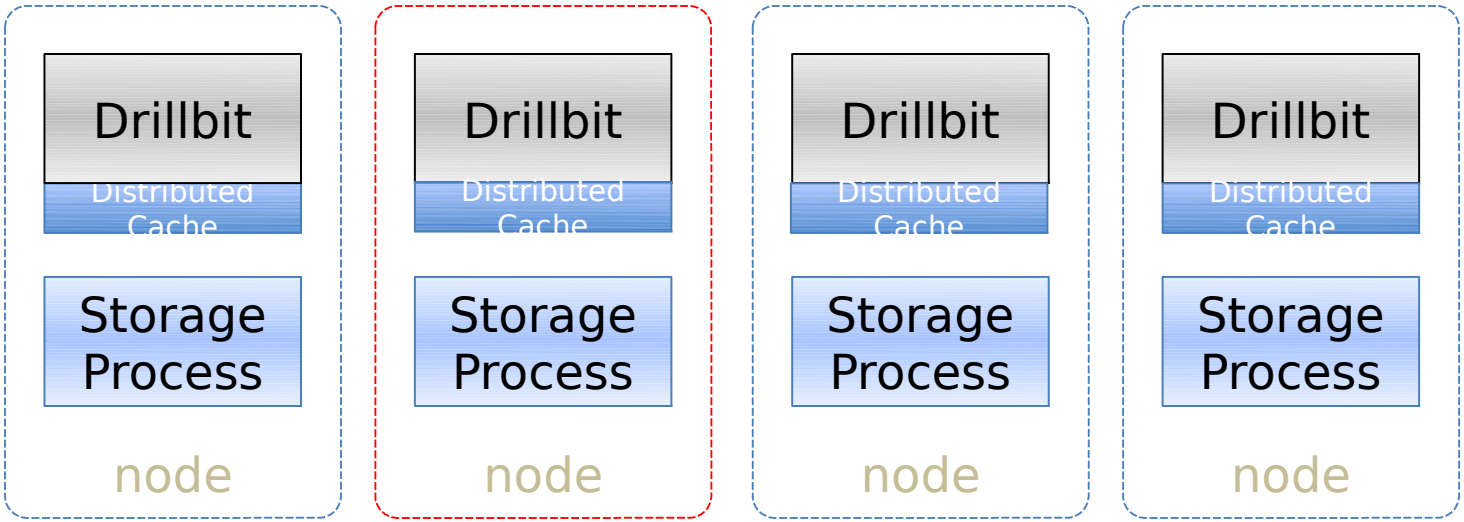
Wire-level Architecture

- **Curator/Zookeeper** for ephemeral cluster membership info
- **Distributed cache** (Hazelcast) for metadata, locality information, etc.



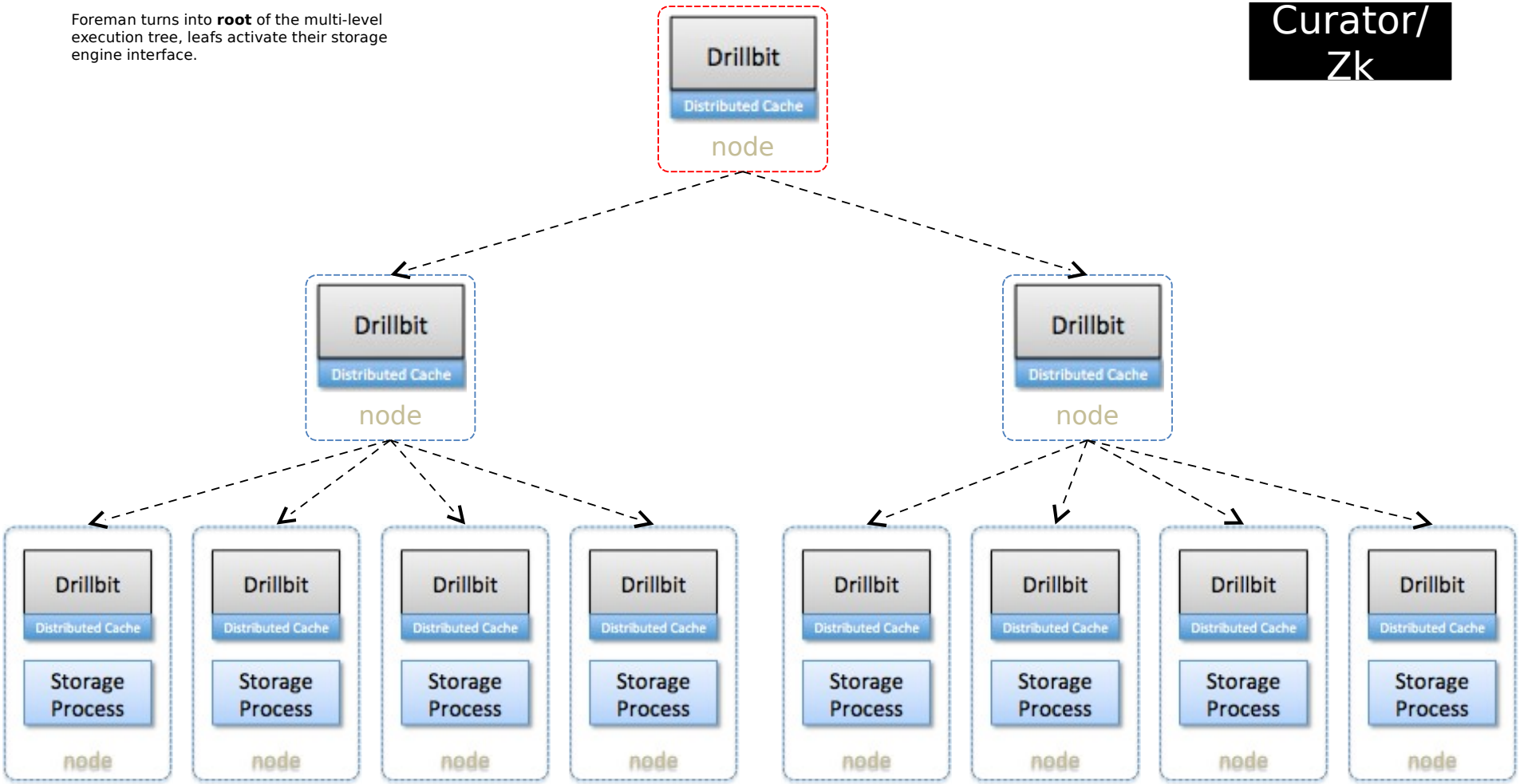
Wire-level Architecture

- Originating Drillbit acts as **foreman**: manages query execution, scheduling, locality information, etc.
- Streaming data **communication** avoiding Curator/ Zk



Wire-level Architecture

Foreman turns into **root** of the multi-level execution tree, leafs activate their storage engine interface.



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On the shoulders of giants ...

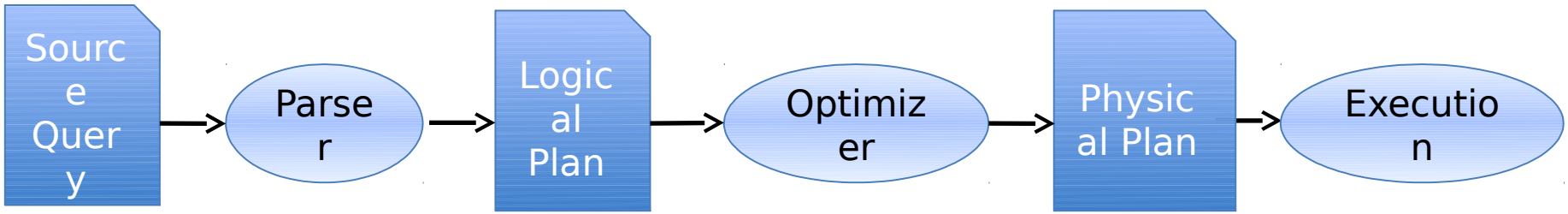
- **Jackson** for JSON SerDe for metadata
- **Typesafe HOCON** for configuration and module management
- **Netty4** as core RPC engine, protobuf for communication
- Vanilla Java, **Larray** and **Netty ByteBuf** for off-heap large data structures
- **Hazelcast** for distributed cache
- Netflix **Curator** on top of Zookeeper for service registry
- **Optiq** for SQL parsing and cost optimization
- **Parquet** (http://parquet.io) as native columnar format
- **Janino** for expression compilation
- **ASM** for ByteCode manipulation
- **Yammer Metrics** for metrics
- **Guava** extensively
- **Carrot HPC** for primitive collections

Key features

- Full SQL – ANSI SQL 2003
- Nested Data as first class citizen
- Optional Schema
- Extensibility Points ...

Extensibility Points

- Source query ▭ parser API
- Custom operators, UDF ▭ logical plan
- Serving tree, CF, topology ▭ physical plan/optimizer
- Data sources &formats ▭ scanner API



User Interfaces

- **API**—DrillClient
  - Encapsulates endpoint discovery
  - Supports logical and physical plan submission, query cancellation, query status
  - Supports streaming return results
- **JDBC** driver, converting JDBC into DrillClient communication.
- **REST** proxy for DrillClient

… and Hadoop?

- How is it different to Hive, Cascading, etc.?
- Complementary use cases*
- … use Apache Drill
  - Find record with specified condition
  - Aggregation under dynamic conditions
- … use MapReduce
  - Data mining with multiple iterations
  - ETL


An Inside Look at Google BigQuery

Table of Contents

Google

*) https://cloud.google.com/files/BigQueryTechnicalWP.pdf

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Let’s get our hands dirty…

Basic Demo

```
{
 "id": "0001",
 "type": "donut",
 ”ppu": 0.55,
 "batters":
 {
  "batter”:
  [
      { "id": "1001", "type": "Regular" },
      { "id": "1002", "type": "Chocolate" },
…
```

data source: **donuts.json**

```
 query:[ {
      op:"sequence",
      do:[
          {
            op: "scan",
            ref: "donuts",
            source: "local-logs",
            selection: {data: "activity"}
          },
          {
            op: "filter",
            expr: "donuts.ppu < 2.00"
          },
…
```

ogical plan: **simple_plan.json**


```
{
  "sales" : 700.0,
  "typeCount" : 1,
  "quantity" : 700,
  "ppu" : 1.0
}
 {
  "sales" : 109.71,
  "typeCount" : 2,
  "quantity" : 159,
  "ppu" : 0.69
}
 {
  "sales" : 184.25,
  "typeCount" : 2,
  "quantity" : 335,
  "ppu" : 0.55
}
```

result: **out.json**

https://cwiki.apache.org/confluence/display/DRILL/Demo+HowTo

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```
SELECT
   t.cf1.name as name,
   SUM(t.cf1.sales) as total_sales
FROM m7://cluster1/sales t
GROUP BY name
ORDER BY by total_sales desc
LIMIT 10;
```


```
sequence: [
  { op: scan, storageengine: m7,
    selection: {table: sales}}
  { op: project, projections: [
   {ref: name, expr: cf1.name},
   {ref: sales, expr: cf1.sales}]}
  { op: segment, ref: by_name, exprs: [name]}
  { op: collapsingaggregate, target: by_name,
    carryovers: [name],
    aggregations: [{ref: total_sales, expr:
    sum(name)}]}
  { op: order, ordering: [{order: desc, expr:
    total_sales}]}
  { op: store, storageengine: screen}
]
```

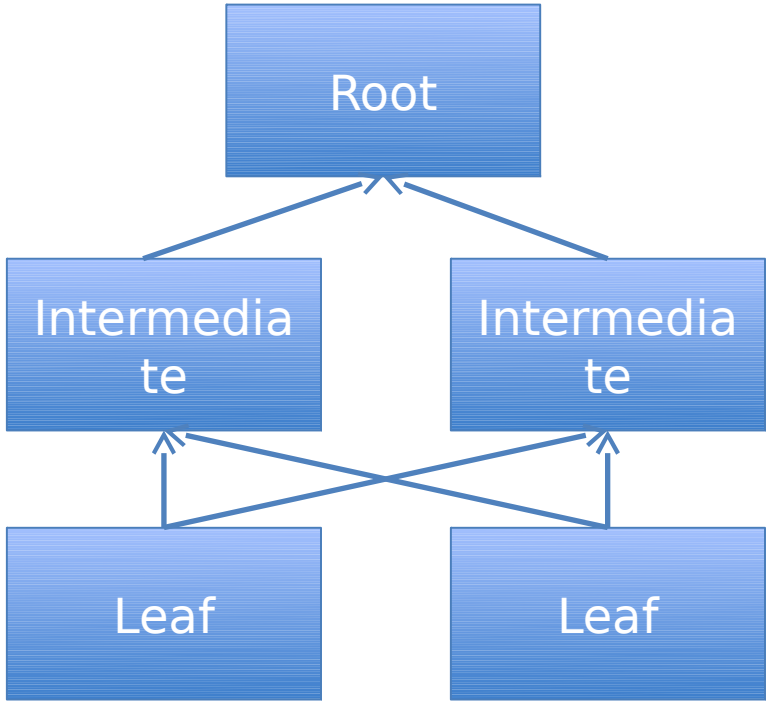

```
{
@id: 1, pop: m7scan, cluster: def,
table: sales, cols: [cf1.name, cf2.name]
}
{
@id: 2, op: hash-random-exchange,
input: 1, expr: 1
}
{
@id: 3, op: sorting-hash-aggregate, input: 2,
grouping: 1, aggr:[sum(2)], carry: [1], sort:
~agrr[0]
}
{
@id: 4, op: screen, input: 4
}
```

Execution Plan

- Break physical plan into fragments
- Determine quantity of parallelization for each task based on estimated costs
- Assign particular nodes based on affinity, load and topology

Execution Plan

- One root fragment (runs on driving node)
- Leaf fragments (first tasks to run)
- Intermediate fragments (won't start until they receive data from their children)
- In the case where the query output is routed to storage, the root operator will often receive metadata to present rather than data



Example Fragments

Root Fragment

```
{
  pop : "screen",
  @id : 1,
  child : {
    pop : "random-receiver",
    @id : 2,
    providingEndpoints :
[ "Cglsb2NhbGhvc3QY0gk=" ]
  }
}
```

Intermediate Fragment

```
{
  pop : "single-sender",
  @id : 1,
  child : {
    pop : "mock-store",
    @id : 2,
    child : {
      pop : "filter",
      @id : 3,
      child : {
        pop : "random-receiver",
        @id : 4,
        providingEndpoints :
[ "Cglsb2NhbGhvc3QYqRI=",
"Cglsb2NhbGhvc3QY0gk=" ]
      },
      expr : " ('b')  > (5) "
    }
  },
  destinations : [ "Cglsb2NhbGhvc3QYqRI=" ]
}
```

Leaf Fragment 1

```
{
  pop : "hash-partition-sender",
  @id : 1,
  child : {
    pop : "mock-scan",
    @id : 2,
    url : "http://apache.org",
    entries : [ {
      id : 1,
      records : 4000}]
  },
  destinations : [ "Cglsb2NhbGhvc3QY0gk=" ]
```

Leaf Fragment 2

```
{
  pop : "hash-partition-sender",
  @id : 1,
  child : {
    pop : "mock-scan",
    @id : 2,
    url : "http://apache.org",
    entries : [ {
      id : 1,
      records : 4000
    }, {
      id : 2,
      records : 4000
    } ]
  },
  destinations : [ "Cglsb2NhbGhvc3QY0gk=" ]
}
```

Optimizer

- Convert Logical to Physical
- Very much TBD
- Likely leverage Optiq
- Hardest problem in system, especially given lack of statistics
- Probably not parallel

Execution Engine

- Single JVM per Drillbit
- Small heap space for object management
- Small set of network event threads to manage socket operations
- Callbacks for each message sent
- Messages contain header and collection of native byte buffers
- Designed to minimize copies and ser/de costs
- Query setup and fragment runners managed via processing queues & thread pools

Data

- Records are broken into batches
- Batches contain a schema and a collection of fields
- Each field has a particular type (e.g. smallint)
- Fields (a.k.a. columns) are stored in ValueVectors
- ValueVectors are façades to byte buffers.
- The in-memory structure of each ValueVector is well defined and language agnostic
- ValueVectors defined based on the width and nature of the underlying data
- There are three sub value vector types

Execution Paradigm

- We will have a large amount of operators
- Each operator works on a batch of records at a time
- A loose goal is batches are roughly a single core's L2 cache in size
- Each batch of records carries a schema
- An operator is responsible for reconfiguring itself if a new schema arrives (or rejecting the record batch if the schema is disallowed)
- Most operators are the combination of a set of static operations along with the evaluation of query specific expressions
- Runtime compiled operators are the combination of a pre-compiled template and a runtime compiled set of expressions
- Exchange operators are converted into Senders and Receiver when execution plan is materialized
- Each operator must support consumption of a SelectionVector, a partial materialization of a filter

Storage Engine

- Input and output is done through storage engines
- Responsible for providing metadata & statistics about the data
- Exposes a set of optimizer (plan rewrite) rules to support things such as predicate pushdown
- Provides one or more storage engine specific scan operators that can support affinity exposure and task splitting
- Primary interfaces are **RecordReader** and **RecordWriter**
- RecordReaders are responsible for
  - Converting stored data into canonical ValueVector format
  - Providing schema for each record batch
- Our initial storage engines will be for DFS and HBase

Be a part of it!

Status

- Heavy development by multiple organizations

- Available
  - Logical plan (ADSP)
  - Reference interpreter
  - Basic SQL parser
  - Basic demo

Status

May 2013

- Full SQL support (+JDBC)
- Physical plan
- In-memory compressed data interfaces
- Distributed execution

Status

May 2013

- HBase and MySQL storage engine
- WebUI client

Contributing

Contributions appreciated (not only code drops) …

- Test data & test queries
- Use case scenarios (textual/SQL queries)
- Documentation
- Further schedule
  - Alpha Q2
  - Beta Q3

Kudos to ...

- Julian Hyde, Pentaho
- Lisen Mu, XingCloud
- Tim Chen, Microsoft
- Chris Merrick, RJMetrics
- David Alves, UT Austin
- Sree Vaadi, SSS
- Jacques Nadeau, MapR

Engage!

- Follow @ApacheDrill on Twitter

- Sign up at mailing lists (user | dev)
  http://incubator.apache.org/drill/mailing-lists.html

- Standing G+ hangouts every Tuesday at 5pm IT
  http://j.mp/apache-drill-hangouts

- Keep an eye on http://drill-user.org/