Pig

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Introduction

- What is Pig?
  - An open-source high-level dataflow system
  - Provides a simple language for queries and data manipulation, Pig Latin, that is compiled into map-reduce jobs that are run on Hadoop
  - Pig Latin combines the high-level data manipulation constructs of SQL with the procedural programming of map-reduce
- Why is it important?
  - Companies and organizations like Yahoo, Google and Microsoft are collecting enormous data sets in the form of click streams, search logs, and web crawls
  - Some form of ad-hoc processing and analysis of all of this information is required

Existing Solutions

- Parallel database products (ex: Teradata)
  - Expensive at web scale
  - Data analysis programmers find the declarative SQL queries to be unnatural and restrictive
- Raw map-reduce
  - Complex n-stage dataflows are not supported; joins and related tasks require workarounds or custom implementations
  - Resulting code is difficult to reuse and maintain; shifts focus and attention away from data analysis

Language Features

- Several options for user-interaction
  - Interactive mode (console)
  - Batch mode (prepared script files containing Pig Latin commands)
  - Embedded mode (execute Pig Latin commands within a Java program)
- Built primarily for scan-centric workloads and read-only data analysis
  - Easily operates on both structured and schema-less, unstructured data
  - Transactional consistency and index-based lookups not required
  - Data curation and schema management can be overkill
- Flexible, fully nested data model
- Extensive UDF support
  - Currently must be written in Java
  - Can be written for filtering, grouping, per-tuple processing, loading and storing

Pig Latin vs. SQL

- Pig Latin is procedural (dataflow programming model)
  - Step-by-step query style is much cleaner and easier to write and follow than trying to wrap everything into a single block of SQL

```
insert into ValuableClicksPerDMA
select dma, count(*)
from geoinfo join (
                select name, ipaddr
                from users join clicks on (users.name = clicks.user)
                where value > 0;
            ) using ipaddr
group by dma;
```

```
Users               = load 'users' as (name, age, ipaddr);
Clicks              = load 'clicks' as (user, url, value);
ValuableClicks      = filter Clicks by value > 0;
UserClicks          = join Users by name, ValuableClicks by user;
Geoinfo             = load 'geoinfo' as (ipaddr, dma);
UserGeo             = join UserClicks by ipaddr, Geoinfo by ipaddr;
ByDMA               = group UserGeo by dma;
ValuableClicksPerDMA = foreach ByDMA generate group, COUNT(UserGeo);
store ValuableClicksPerDMA into 'ValuableClicksPerDMA';
```

Source: http://developer.yahoo.net/blogs/hadoop/2010/01/comparing_pig_latin_and_sql_fo.html

Pig Latin vs. SQL (continued)

- Lazy evaluation (data not processed prior to STORE command)
- Data can be stored at any point during the pipeline
- An execution plan can be explicitly defined
- – No need to rely on the system to choose the desired plan via optimizer hints
- Pipeline splits are supported
- – SQL requires the join to be run twice or materialized as an intermediate result

```
Users         = load 'users' as (name, age, gender, zip);
Purchases     = load 'purchases' as (user, purchase_price);
UserPurchases = join Users by name, Purchases by user;
GeoGroup      = group UserPurchases by zip;
GeoPurchase   = foreach GeoGroup generate group, SUM(UserPurchases.purchase_price) as sum;
ValuableGeos  = filter GeoPurchase by sum > 1000000;
store ValuableGeos into 'byzip';
DemoGroup     = group UserPurchases by (age, gender);
DemoPurchases = foreach DemoGroup generate group, SUM(UserPurchases.purchase_price) as sum;
ValuableDemos = filter DemoPurchases by sum > 100000000;
store ValuableDemos into 'byagegender';
```

Source: http://developer.yahoo.net/blogs/hadoop/2010/01/comparing_pig_latin_and_sql_fo.html

Data Model

- Supports four basic types
  - Atom: a simple atomic value (*int*, *long*, *double*, *string*)
    - ex: 'Peter'
  - Tuple: a sequence of fields that can be any of the data types
    - ex: ('Peter', 14)
  - Bag: a collection of tuples of potentially varying structures, can contain duplicates
    - ex: {('Peter'), ('Bob', (14, 21))}
  - Map: an associative array, the key must be a *chararray* but the value can be any type

Data Model (continued)

- By default Pig treats undeclared fields as *bytearrays* (collection of uninterpreted bytes)
- Can infer a field's type based on:
  - Use of operators that expect a certain type of field
  - UDFs with a known or explicitly set return type
  - Schema information provided by a LOAD function or explicitly declared using an AS clause
- Type conversion is lazy

Pig Latin

- FOREACH-GENERATE (per-tuple processing)
  - Iterates over every input tuple in the bag, producing one output each, allowing efficient parallel implementation

```
expanded_queries = FOREACH queries GENERATE
                   userId, expandQuery(queryString);
```

- Expressions within the GENERATE clause can take the form of the any of these expressions

t = ('alice', {('lakers', 1) ('iPod', 2)}, ['age' → 20])

Let fields of tuple t be called f1, f2, f3

Expression Type	Example	Value for t
Constant	'bob'	Independent of t
Field by position	$0	'alice'
Field by name	f3	['age' → 20]
Projection	f2.$0	{('lakers') ('iPod')}
Map Lookup	f3#'age'	20
Function Evaluation	SUM(f2.$1)	1 + 2 = 3
Conditional Expression	f3#'age'>18? 'adult':'minor'	'adult'
Flattening	FLATTEN(f2)	'lakers', 1 'iPod', 2

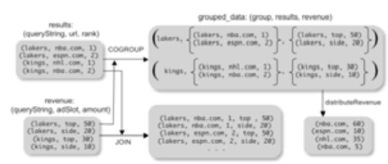
Pig Latin (continued)

- (CO)GROUP vs. JOIN
  - COGROUP takes advantage of nested data structure (combination of GROUP BY and JOIN)
  - User can choose to go through with cross-product for a join or perform aggregation on the nested bags

```
grouped_data = COGROUP results BY queryString,
                       revenue BY queryString;

join_result  = JOIN results BY queryString,
               revenue BY queryString;
```

```
temp_var    = COGROUP results BY queryString,
              revenue BY queryString;
join_result = FOREACH temp_var GENERATE
              FLATTEN(results), FLATTEN(revenue);
```



Pig Latin (continued)

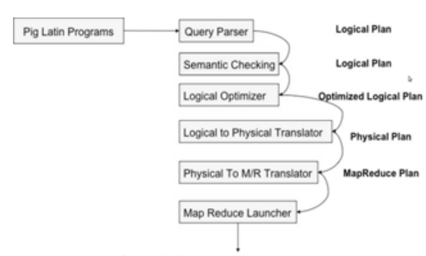
- LOAD / STORE
  - Default implementation expects/outputs to tab-delimited plain text file

```
queries = LOAD 'query_log.txt'
          USING myLoad()
          AS (userId, queryString, timestamp);
```

```
STORE query_revenues INTO 'myoutput'
      USING myStore();
```

- Other commands
  - FILTER, ORDER, DISTINCT, CROSS, UNION
- Nested operations
  - FILTER, ORDER and DISTINCT can be nested within a FOREACH statement to process nested bags within tuples

Compilation



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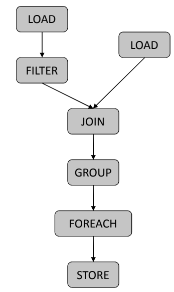
Parsing

- Type checking with schema
- References verifying
- Logic plan generating
  - One-to-one fashion
  - Independent of execution platform
  - Limited optimization

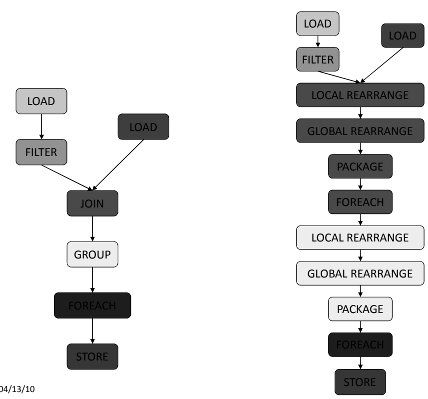
Logic Plan

```
A=LOAD 'file1' AS (x, y, z);
B=LOAD 'file2' AS (t, u, v);
C=FILTER A by y > 0;
D=JOIN C BY x, B BY u;
E=GROUP D BY z;
F=FOREACH E GENERATE
    group, COUNT(D);
STORE F INTO 'output';
```



Physical Plan

- 1:1 correspondence with most logical operators
- Except for:
  - DISTINCT
  - (CO)GROUP
  - JOIN
  - ORDER

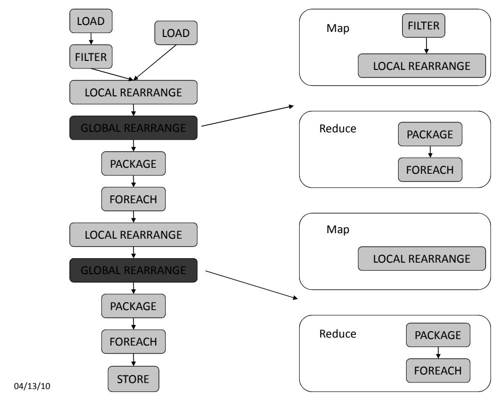


Physical Optimization

- Always use combiner for pre-aggregation
- Insert SPLIT to re-use intermediate result
- Early projection

MapReduce Plan

- Determine MapReduce boundaries
  - GLOBAL REARRANGE
- Some operations are done by MapReduce framework
- Coalesce other operators into Map & Reduce stages
- Generate job jar file



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Branching Plans

- Read the dataset once and process it in multiple ways
- Good
  - Eliminate the cost to read it multiple times
- Bad
  - Reduce the amount of memory for each stream

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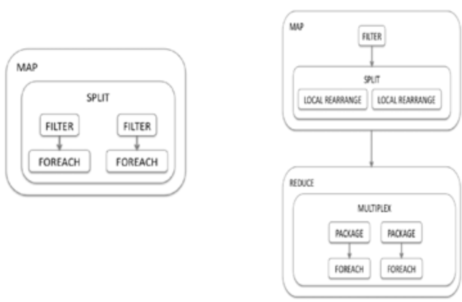
Branching Plans



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Physical plan execution

- Executing the portion of a physical plan within a Map or Reduce stage
- Push vs. Pull (iterator) Model
- Push
  complicated API;
  multiple threads needed

Physical plan execution (contd.)

- Pull
  simple API; single thread
- Two drawbacks
  bag materialization – "push" can control combiner within the operator
  branch point – operators at branch point may face buffering issue

Nested programs example

```
clicks = LOAD ‘clicks’
AS (userid, pageid, linkid, viewedat);
byuser = GROUP clicks BY userid;
result = FOREACH byuser {
uniqPages = DISTINCT clicks.pageid;
uniqLinks = DISTINCT clicks.linkid;
GENERATE group, COUNT(uniqPages),
COUNT(uniqLinks);
};
```

- Tuples grouped by userid
- For each bag of a user, nested program is run
- For each DISTINCT operator, a cursor is initialized

Memory management

- Java memory management
  NO low-level control over allocation and deallocation
- Intermediate results exceed available memory
- Memory manager: a list of Pig bags in a JVM
- Spill old bags and perform Garbage collection:
  when a new bag is added to the list;
  when the memory runs too low

New strategy (from Pig Manual)

- For Pig 0.6.0, the strategy for how Pig decides when to spill bags to disk is changed.
- In the past, Pig tried to figure out when an application was getting close to memory limit and then spill at that time.
- However, because Java does not include an accurate way to determine when to spill, Pig often ran out of memory.

New strategy (from Pig Manual)

- In the current version, allocate a fix amount of memory (10% of available memory by default) to store bags and spill to disk as soon as the memory limit is reached.
- This is very similar to how Hadoop decides when to spill data accumulated by the combiner. (Also with mapper output and reducer input!)

Streaming

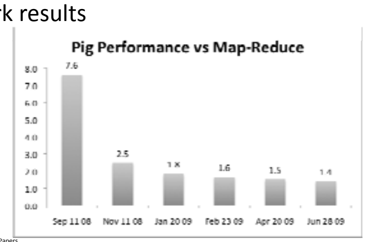
- Allows data to be pushed through external executables
- Example:

```
A = LOAD 'data';
B = STREAM A THROUGH 'stream.pl -n 5';
```

- Due to asynchronous behavior of external executables, each STREAM operator will create two threads for feeding and consuming data from external executables.

Benchmark and Performance

- Pig Mix
  representative of jobs in Yahoo!
- Benchmark results



Images from http://wiki.apache.org/pig/PigTalksPapers

Pig problem

- Fragment-replicate; skewed; merge join
- User has to know when to use which join

- Because… Pig is domestic animal, does whatever you tell it to do.

  - Alan Gates

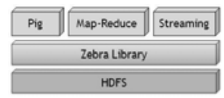
Images from http://wiki.apache.org/pig/PigTalksPapers

Future work

- support more nested operators (current only FILTER, ORDER, DISTINCT)
- Better optimization
  order of execution, non-linear
- Metadata facility (better knowledge of data)
- Parallel job execution (inter-job, currently intra-job)
- Column-storage

Zebra (from Pig project page)

- Zebra is an access path library for reading and writing data in a column-oriented fashion. Zebra functions as an abstraction layer between your client application and data on the Hadoop Distributed File System (HDFS).



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Discussion

- The Good, the Bad, and the Pig
- Compare to LINQ/DryadLINQ? SCOPE?
- Use outside Yahoo!?
- Hybrid system! Local database for physical execution within a Map or Reduce stage.