Inspector Gadget: A Framework for Custom Monitoring and Debugging of Distributed Dataflows

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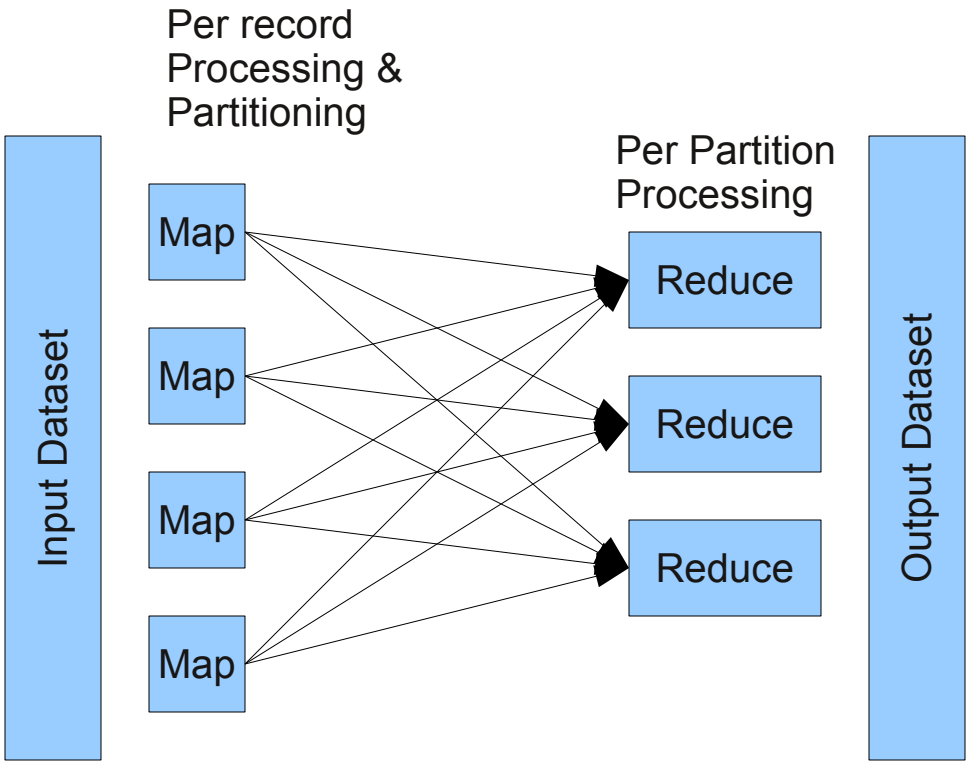
Yahoo! Research

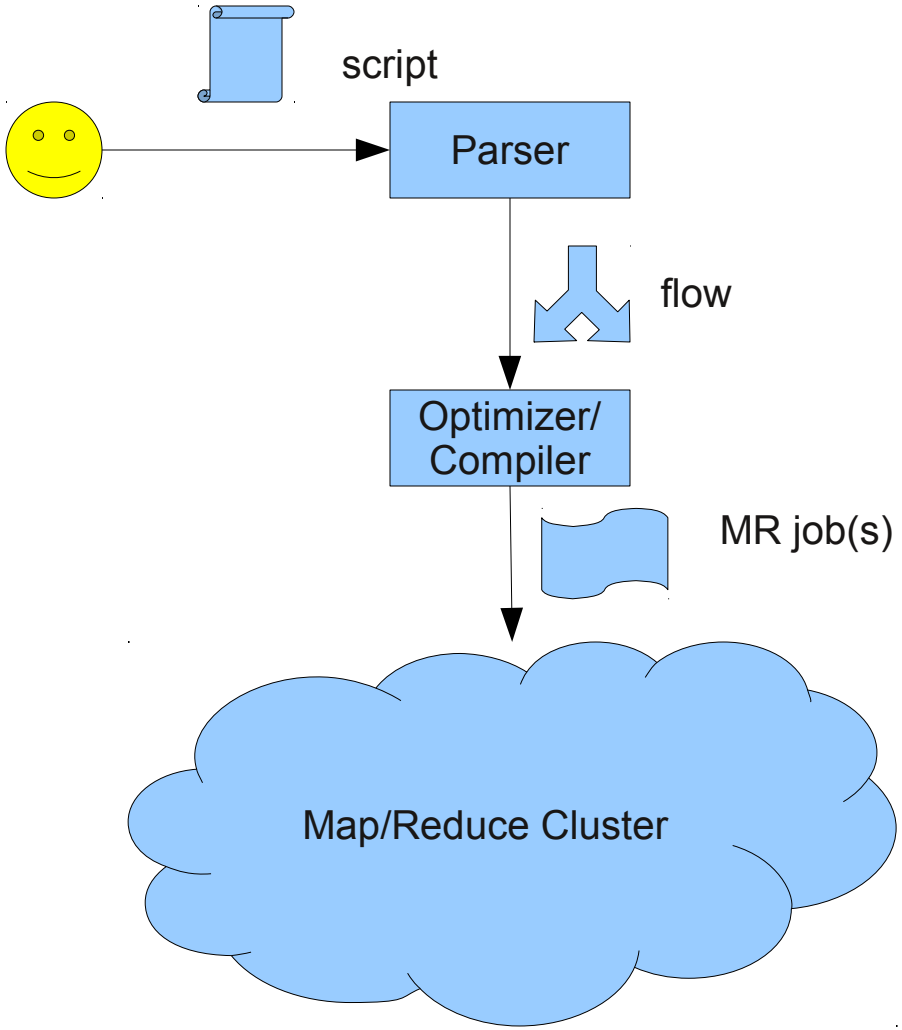
Web Scale problems

- Lots of servers, users, and data
- Fun to have power at your fingertip
- Sucks when things go wrong

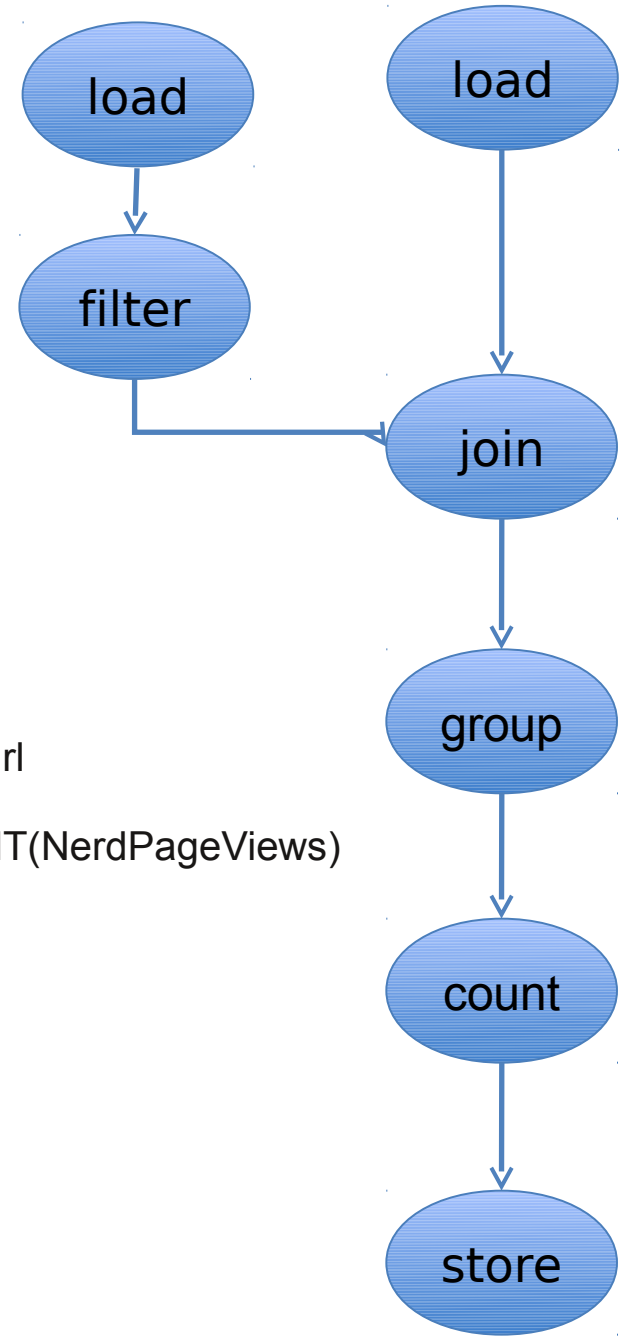
Map/Reduce


Per record
Processing &
Partitioning
Per Partition
Processing
Input Dataset
Map
Map
Map
Map
Reduce
Reduce
Reduce
Output Dataset

Pig on Map/Reduce



Example Pig Workflow




```
Pages = load 'webpages'
UserViews = load 'userclicks'
NerdPages  =filter Pages by NerdFilter(content)
NerdPageViews = join NerdPages, UserViews by url
NerdUsers  = group NerdPageViews by user
Counts = foreach NerdUsers generate user, COUNT(NerdPageViews)
store Counts into 'nerdviewcounts'
```

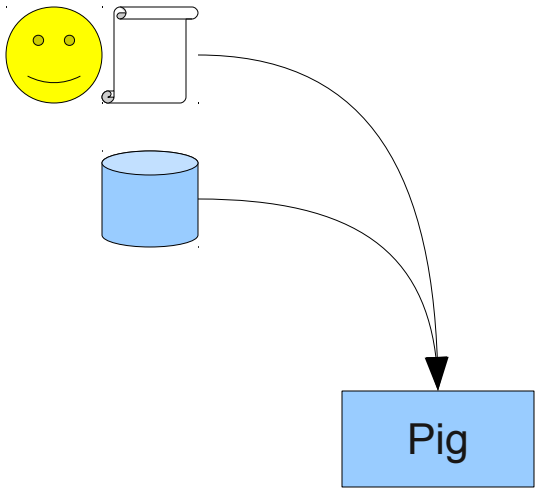
Motivated by User Interviews

Interviewed 10 Yahoo dataflow programmers (mostly Pig users; some users of other dataflow environments)
Asked them how they (wish they could) debug

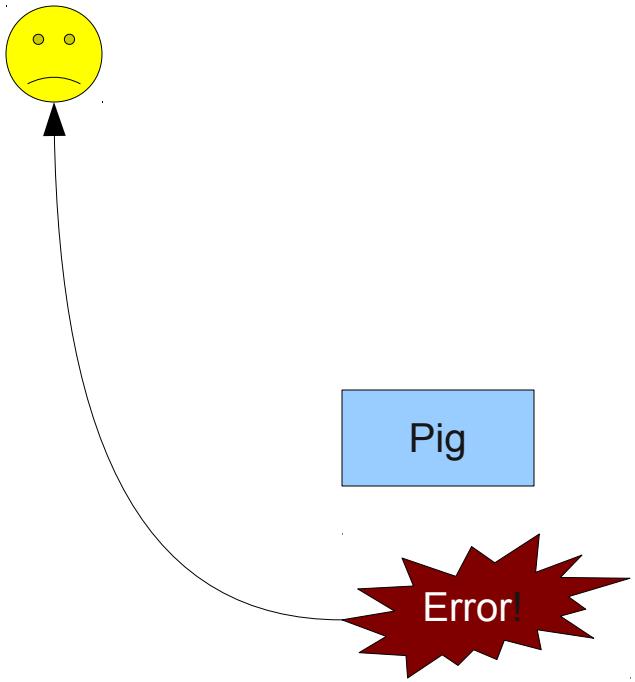
Summary of User Interviews

# of requests	feature
7	**crash culprit determination**
5	**row-level integrity alerts**
4	table-level integrity alerts
4	data samples
3	data summaries
3	memory use monitoring
3	backward tracing (provenance)
2	**forward tracing**
2	golden data/logic testing
2	step-through debugging
2	latency alerts
1	latency profiling
1	overhead profiling
1	trial runs

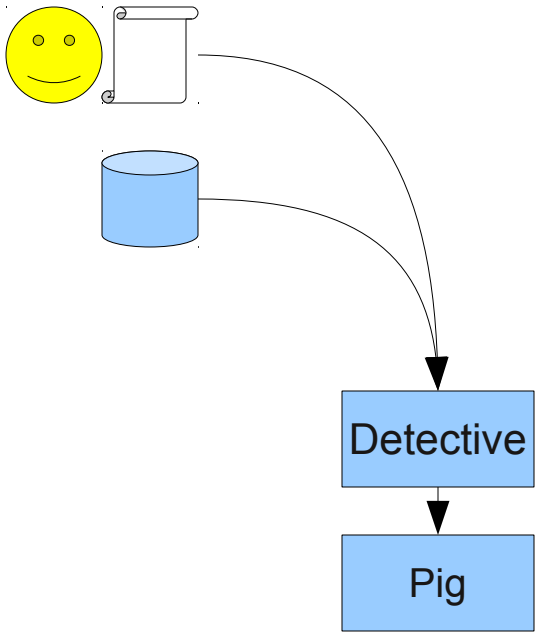
Running Pig



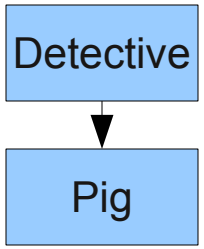
Running Pig



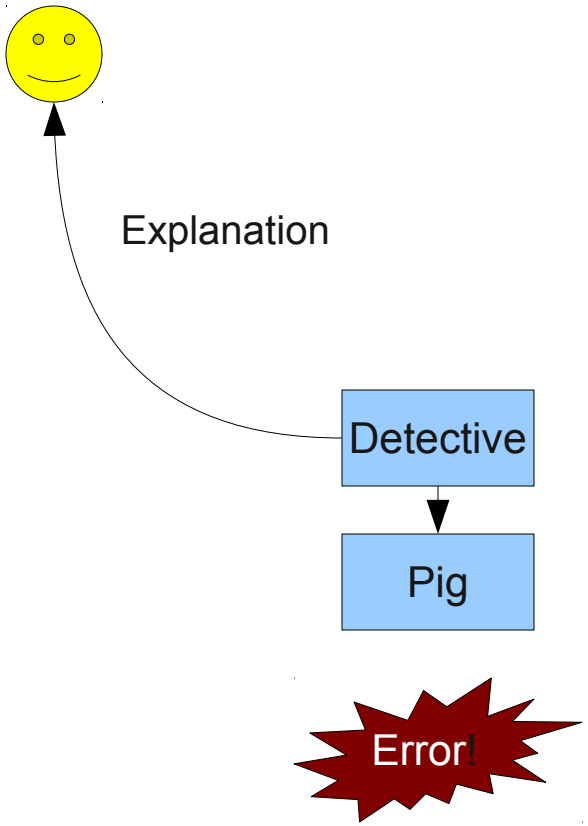
Running Pig



Running Pig



Running Pig



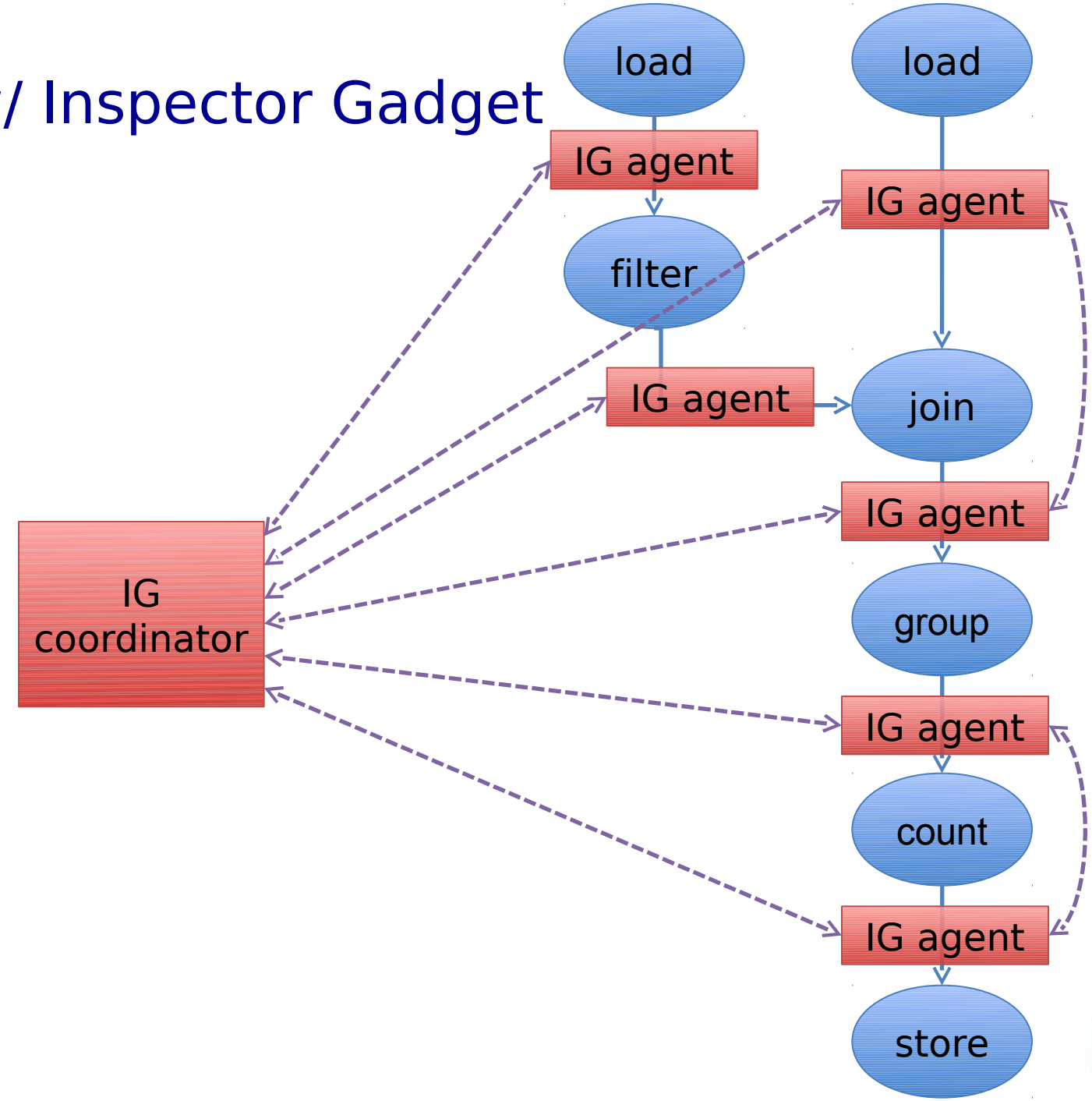
Our Approach

Goal: a programming framework for adding debugging features to Pig

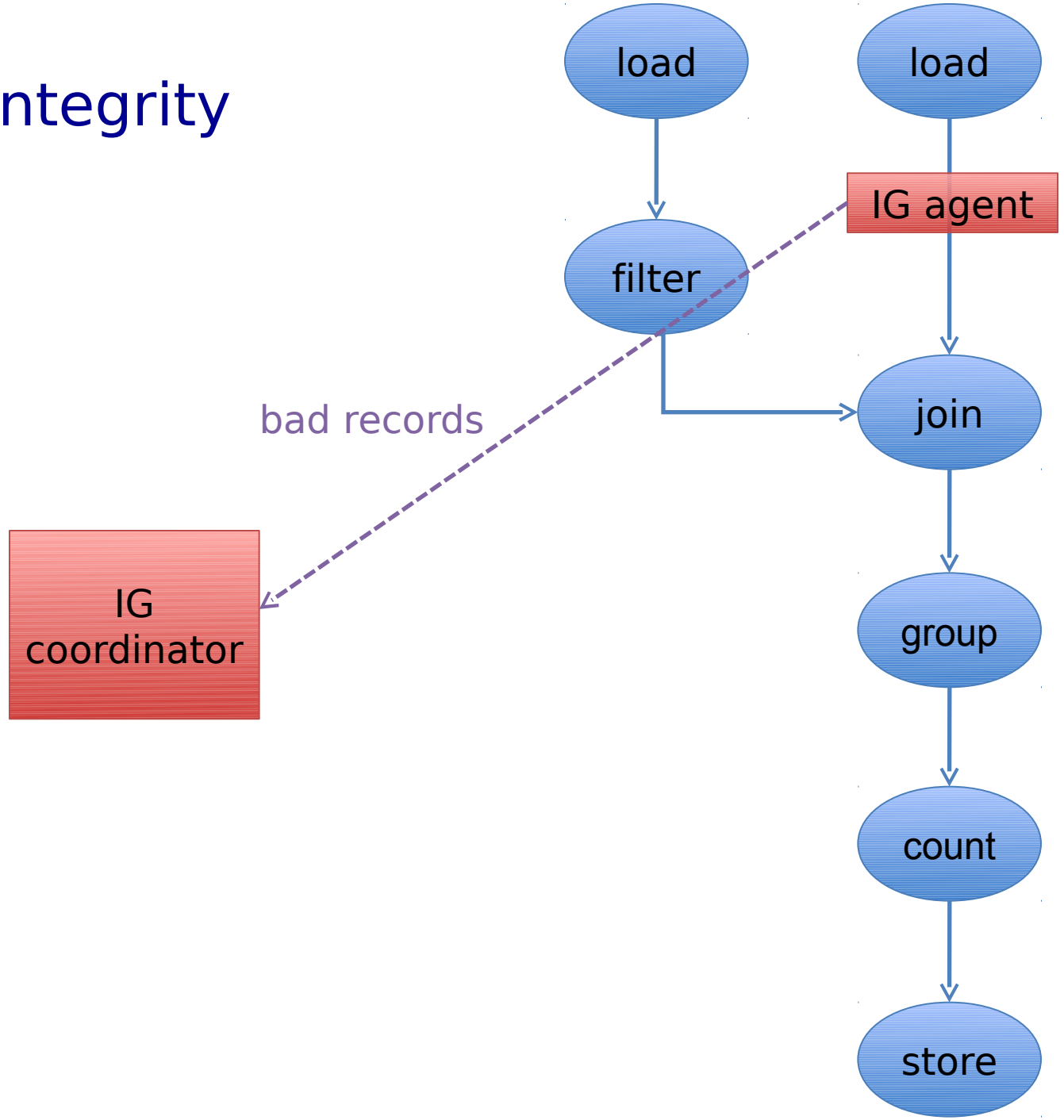
Precept: avoid modifying Pig or tampering with data flowing through Pig

Approach: perform Pig script rewriting – insert special (User Defined Functions) UDFs that look like no-ops to Pig

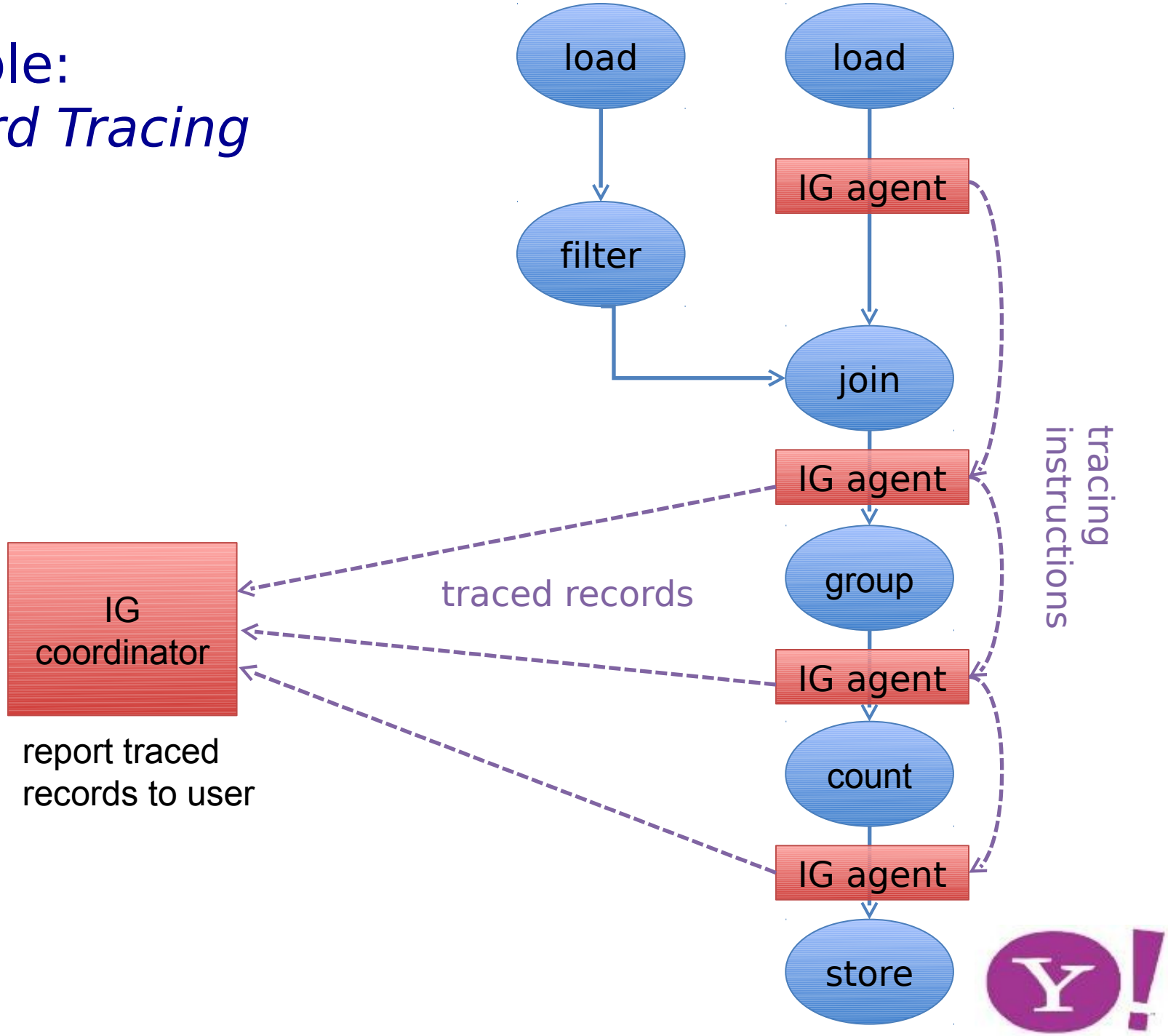
Pig w/ Inspector Gadget



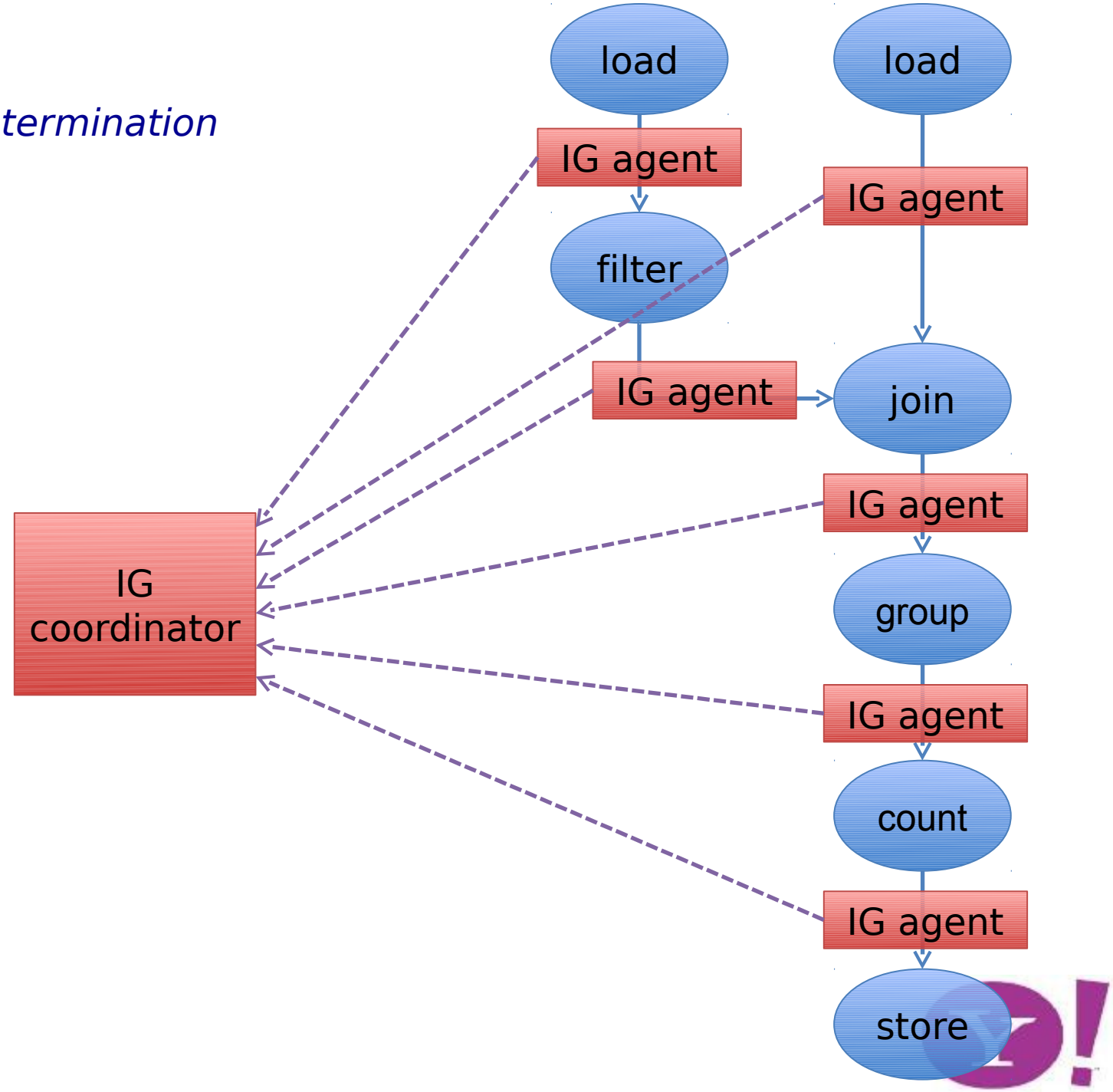
Row Integrity



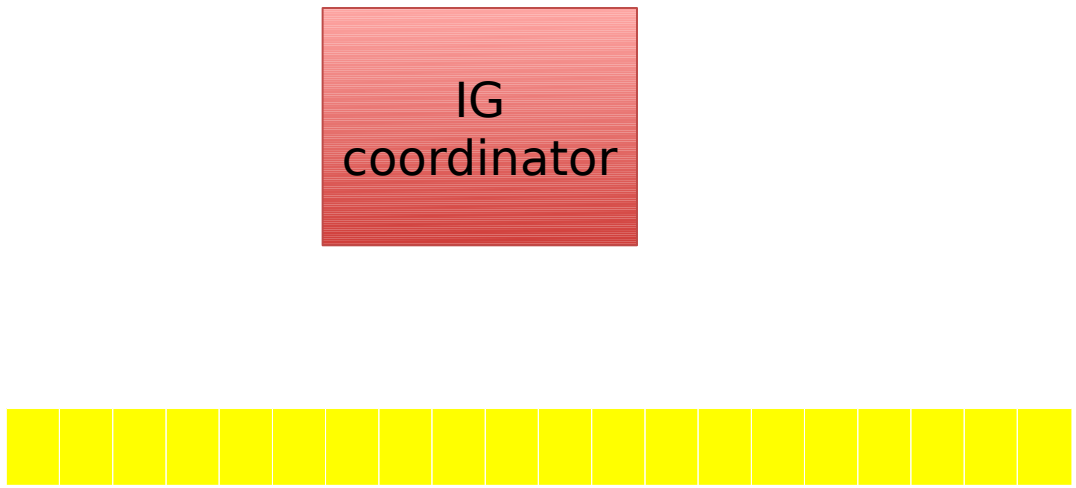
Example:
Forward Tracing



Example:
Crash Culprit Determination



Crash Culprit Sending every 5th



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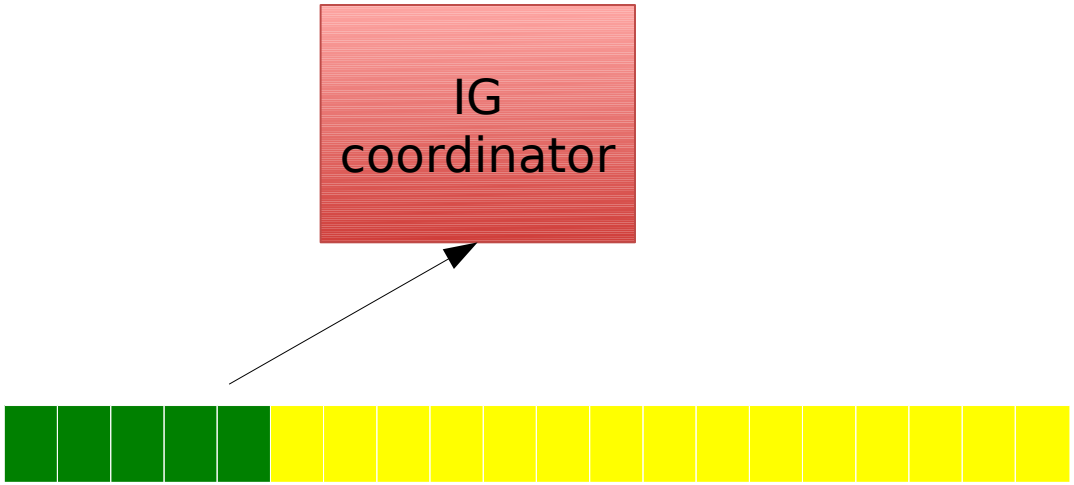
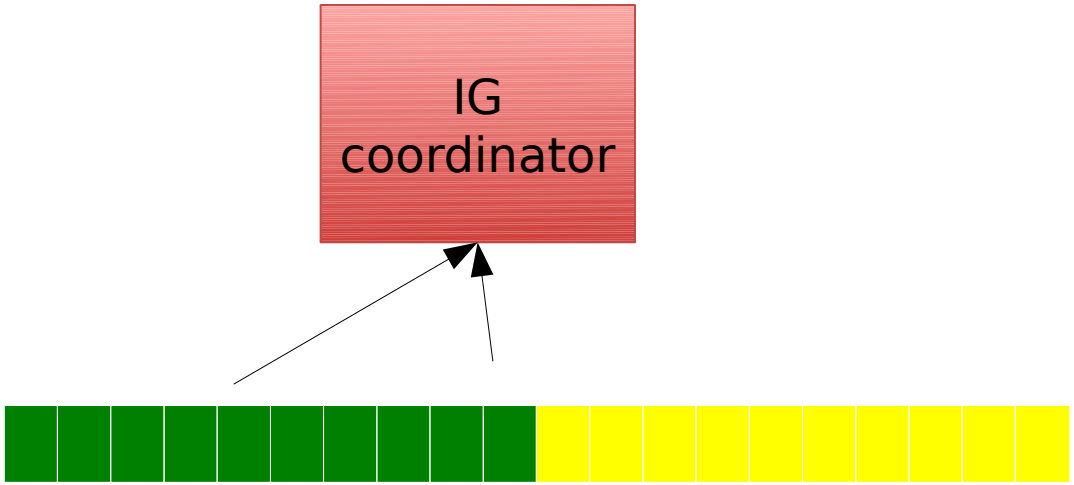
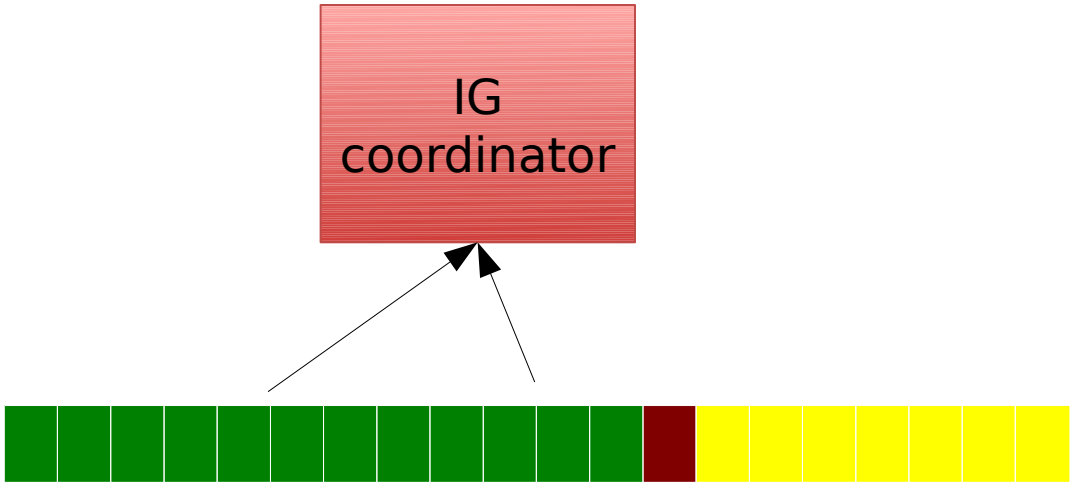


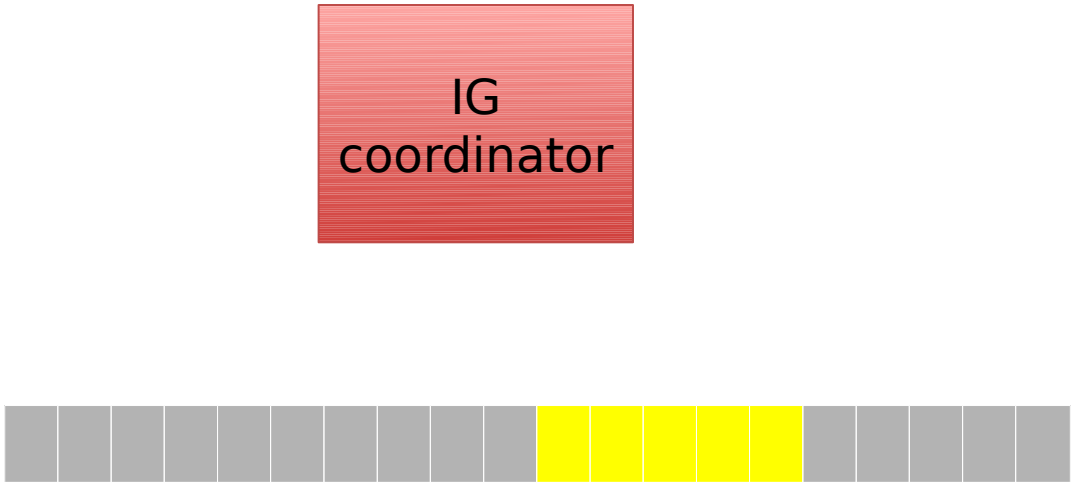
Crash Culprit sending every 5th



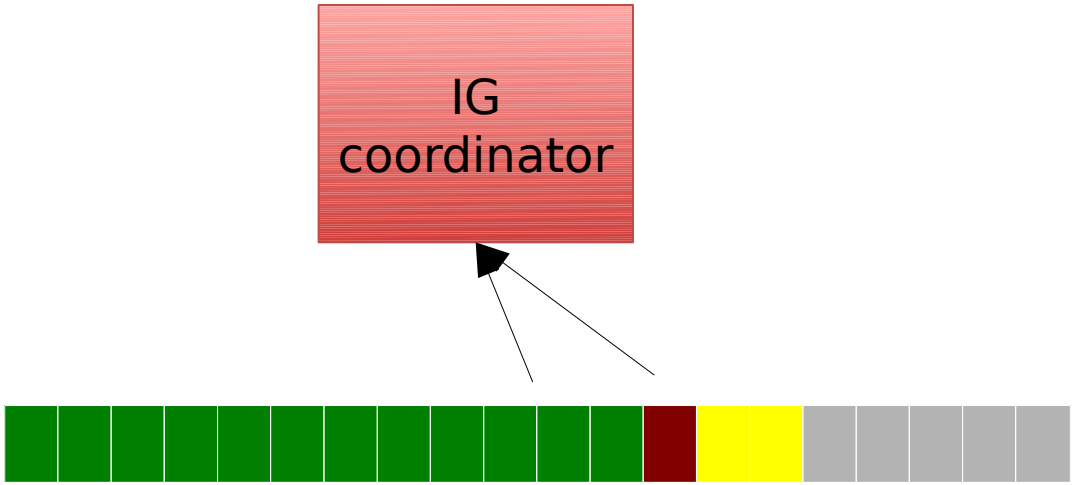
Crash Culprit Sending 5th



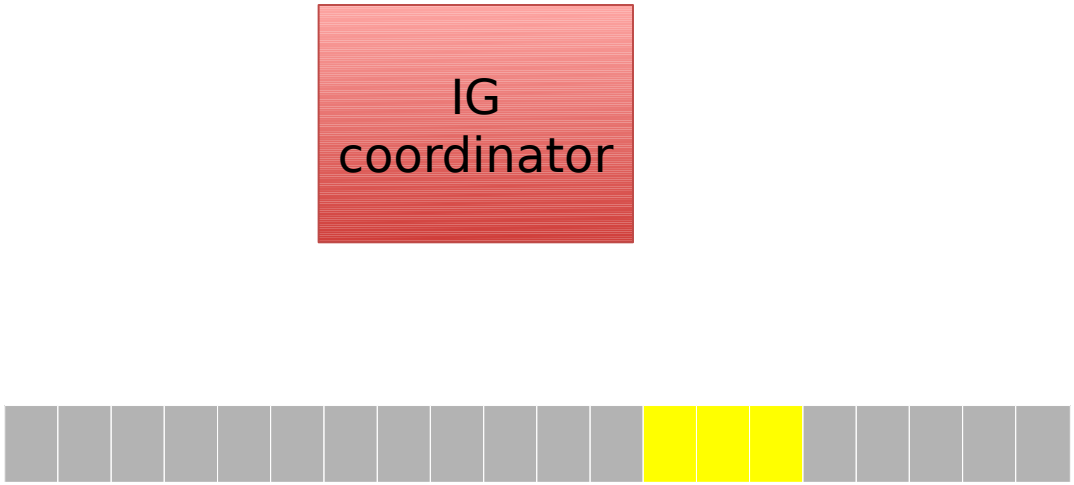
Crash Culprit Sending every 2nd



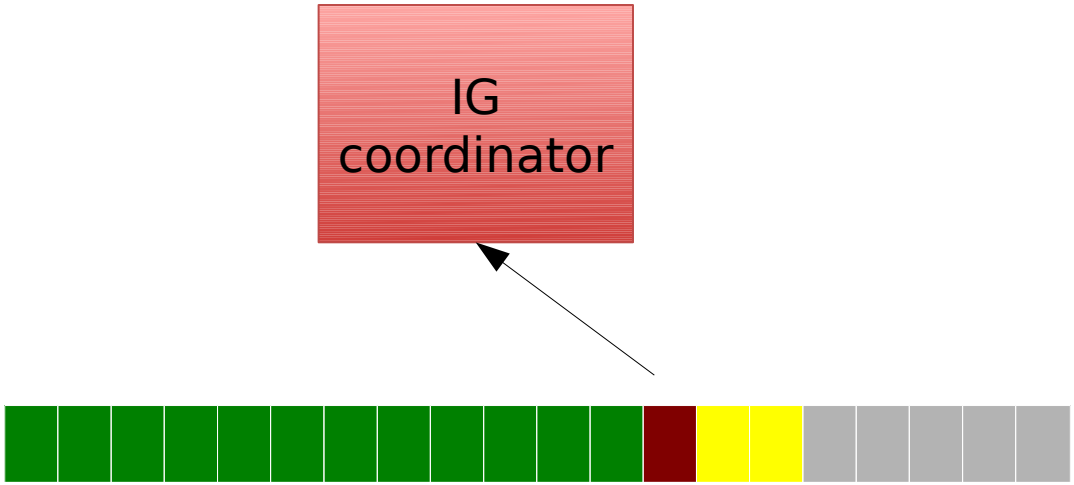
Crash Culprit Sending every 2nd



Crash Culprit Sending every tuple



Crash Culprit Sending every tuple



Agent & Coordinator APIs

Agent Class
init(args)
tags = observeRecord(record, tags)
receiveMessage(source, message)
finish()

Agent Messaging
sendToCoordinator(message)
sendToAgent(agentId, message)
sendDownstream(message)
sendUpstream(message)

Coordinator Class
init(args)
receiveMessage(source, message)
output = finish()

Coordinator Messaging
sendToAgent(agentId, message)

Applications Developed Using IG

# of requests	feature	lines of code (Java)
7	crash culprit determination	141
5	row-level integrity alerts	89
4	table-level integrity alerts	99
4	data samples	97
3	data summaries	130
3	memory use monitoring	N/A
3	backward tracing (provenance)	237
2	forward tracing	114
2	golden data/logic testing	200
2	step-through debugging	N/A
2	latency alerts	168
1	latency profiling	136
1	overhead profiling	124
1	trial runs	93

In Paper

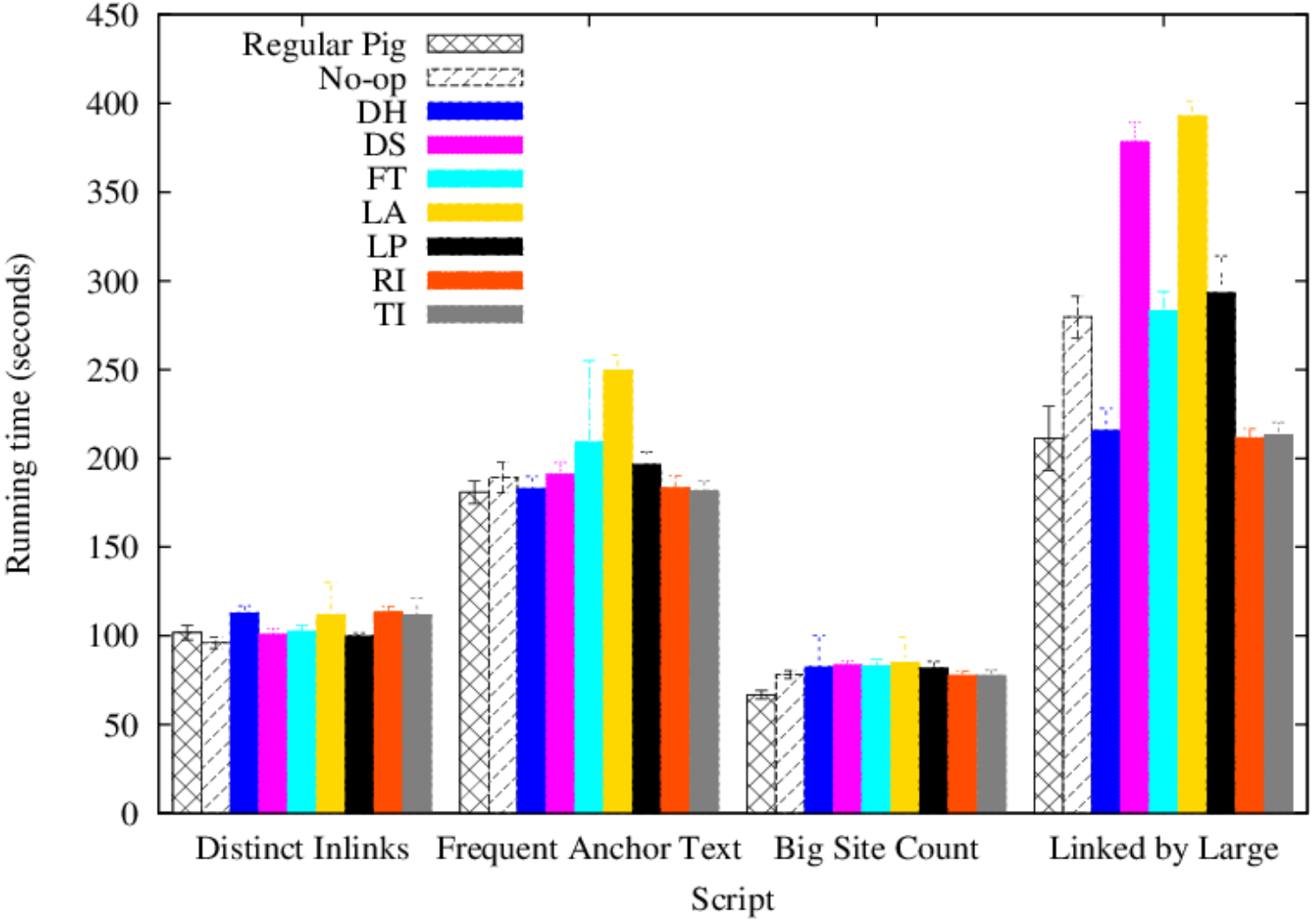
Semantics under parallel/distributed execution
Messaging & tagging implementation
Limitations
Performance experiments
Related work

Performance Experiments

15-machine Pig/Hadoop cluster (1G network)
Four dataflows over a small web crawl sample (10M URLs):

Dataflow Program	Early Projection Optimization ?	Early Aggregation Optimization ?	Number of Map-Reduce Jobs
Distinct Inlinks	N	N	1
Frequent Anchortext	Y	N	1
Big Site Count	Y	Y	1
Linked By Large	N	Y	2

Dataflow Running Times



Related Work

XTrace, etc.
taint tracking
aspect-oriented programming

Summary / Status

- Users have a long wish-list for “debuggability”
  - Make a general framework rather than tool for each
  - Addressed most features with few lines of code
- Rather than implement them as separate features in the Pig core, we built a layer on top
- IG (called Penny) is open source. Accepted into Apache Pig v0.9 release (http://pig.apache.org)

The End