CAKE

Walkthrough

- 1 min ⟶ Introduction
- 4 min ⟶ Section I – Survey
- 3 min ⟶ Section II – Proof of concept of CAKE
- 2 min ⟶ Section III – Research Notes and Conclusion
- 1 min ⟶ Question and Answers

 - this symbol in slide indicates our contributions

Introduction

Cluster **A**llocation for **K**ernel **E**xecution using AI (**CAKE**)

- what it is ?
  - It is a pluggable scheduler framework for better scheduling decisions.
  - Experimental.

Keyterm - Scheduling

Scheduler Primary Constraint : Minimize job latency while maximizing cluster utilization

Key Challenges in Scheduling

Scale Heterogeneous workload Maximize utilization

Little more details

- Cluster – Homogenous / Heterogeneous computers
- Allocation – Scheduling. So run Job J1 in XYZ machine.
- Kernel – Any code of a Job which requires data/compute nodes.
- Execution – Right decision on Right Machine

- AI
  - Used Genetic Algorithm to model the scheduling.
  - Also some research notes on existing work

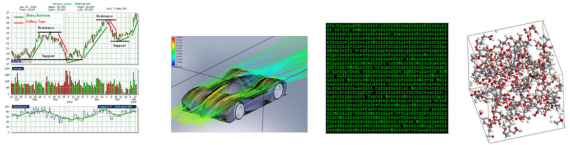


image credit - http://brainz.org/15-real-world-applications-genetic-algorithms/

Section I Survey

Monolithic scheduler.	Two-level scheduling.	Shared-state scheduling.	Distributed scheduling.	Hybrid scheduling.
Borg	**Mesos**	Omega	Sparrow	Hawk
Quasar	**YARN**	Apollo		Tarcil
Paragon		Nomad		Mercury

Other Important papers

Genetic Algorithm

A Review of Machine Learning in Scheduling

Prediction of stability of the clusters in MANET using

MR-GABiT: Map Reduce based Genetic Algorithm

Planning consideration in HPC Clusters

The evolution of cluster scheduler architectures

Section I Survey

Cooperative Batch Scheduling for HPC Systems

I/O-Aware Batch Scheduling for Petascale Computing Systems

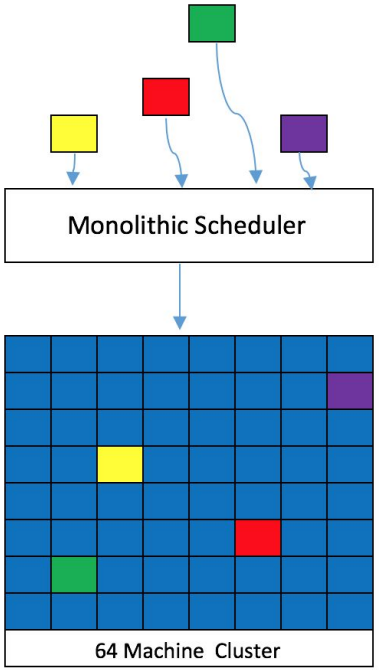
Exploring Plan-Based Scheduling for Large-Scale Computing Systems

A Data Driven Scheduling Approach for Power Management on HPC Systems

[More info - http://www.cs.iit.edu/~zlan/spear.html]

Many Cluster Scheduler : **Monolithic Scheduler**

+ + + Simple and Uniform



Examples -

- Borg
- Hadoop Schedulers
- Kubernetes Schedulers

Google's Borg System

Applications
Web Search
Gmail
Google Docs

Distributed File System
GFS
CFS
Bigtable
Megastore

Scheduling in Borg

- Step1:
  - Finding Feasible nodes
- Step 2:
  - Scoring

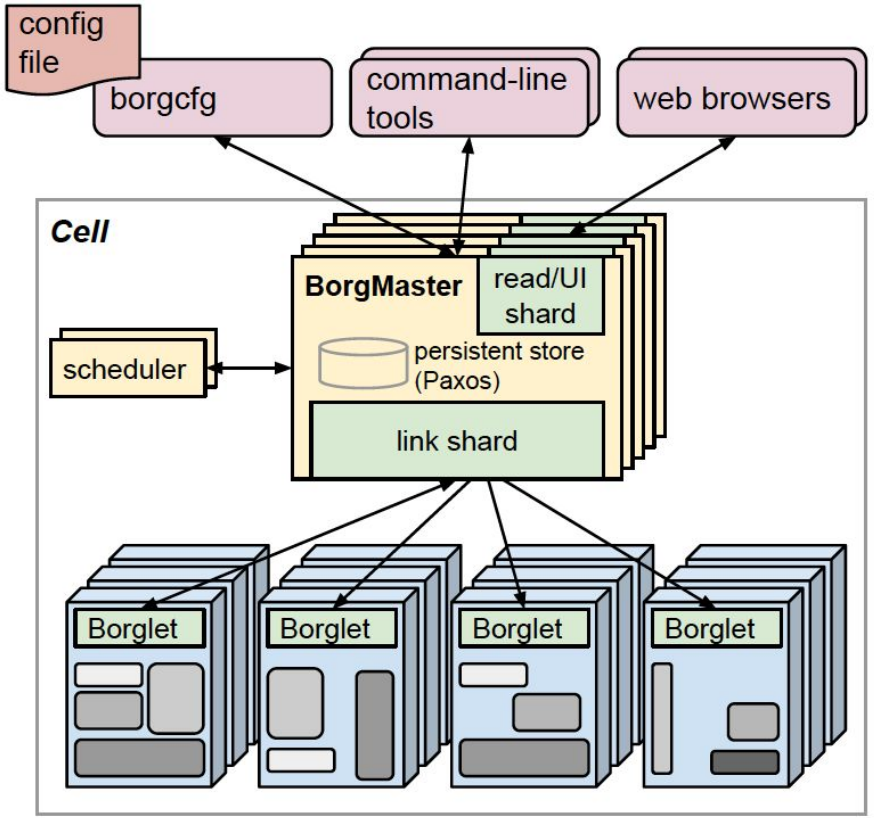
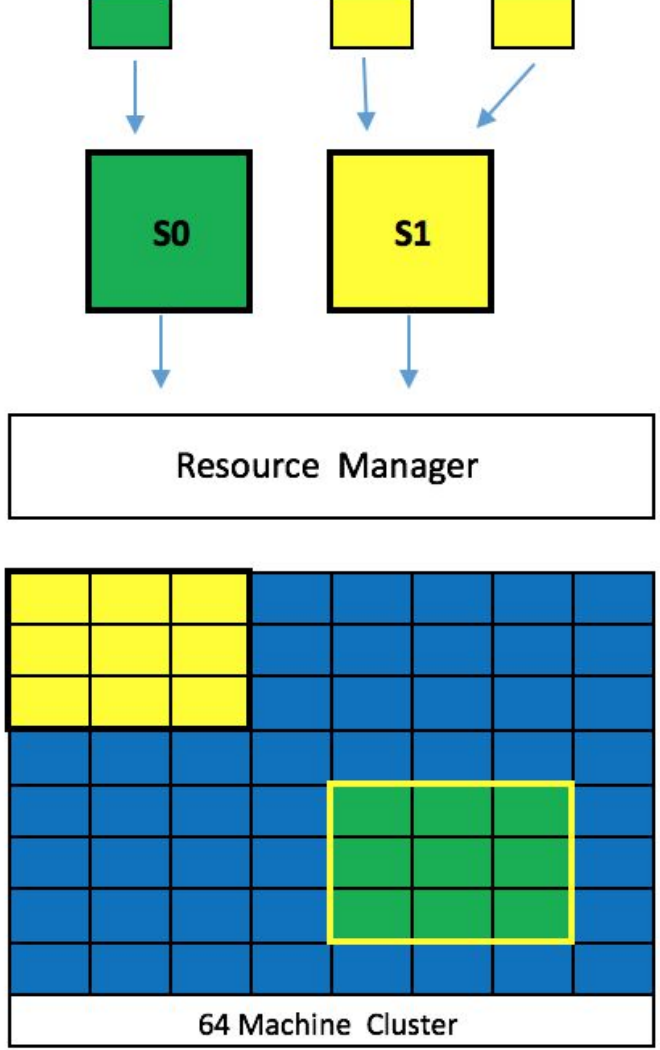


Figure 1: The high-level architecture of Borg. *Only a tiny fraction of the thousands of worker nodes are shown.*

Two Level Schedulers

Scheduler Offers resources to another scheduler.



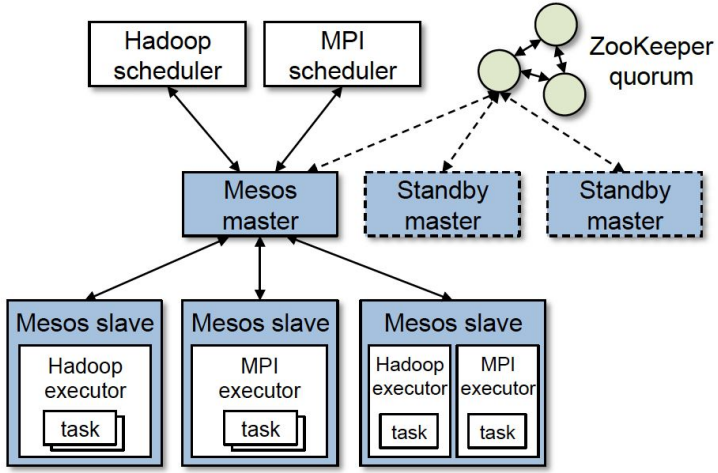


Figure 2: Mesos architecture diagram, showing two running frameworks (Hadoop and MPI).

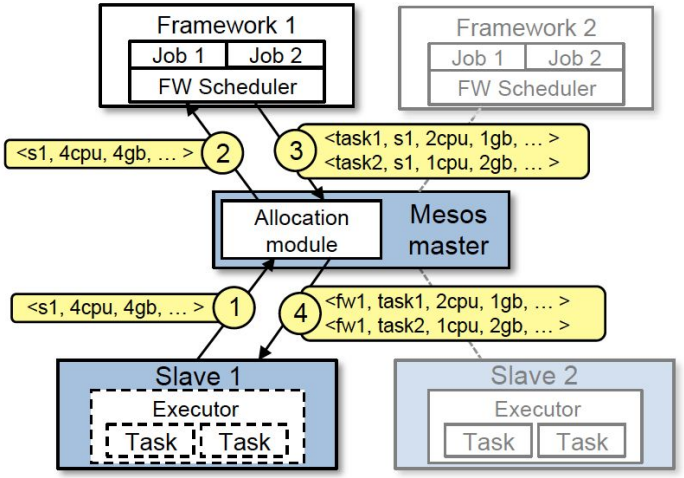


Figure 3: Resource offer example.

MESOS

YARN

- Uses following Scheduling policies
  - FIFO
  - FAIR
  - Dominant Resource Fairness

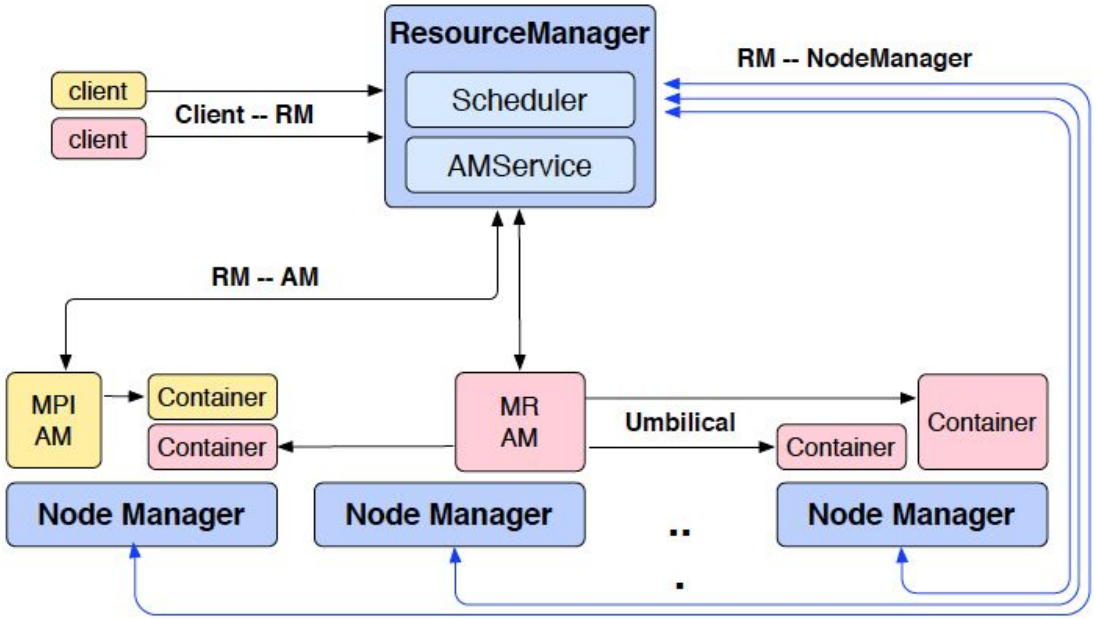


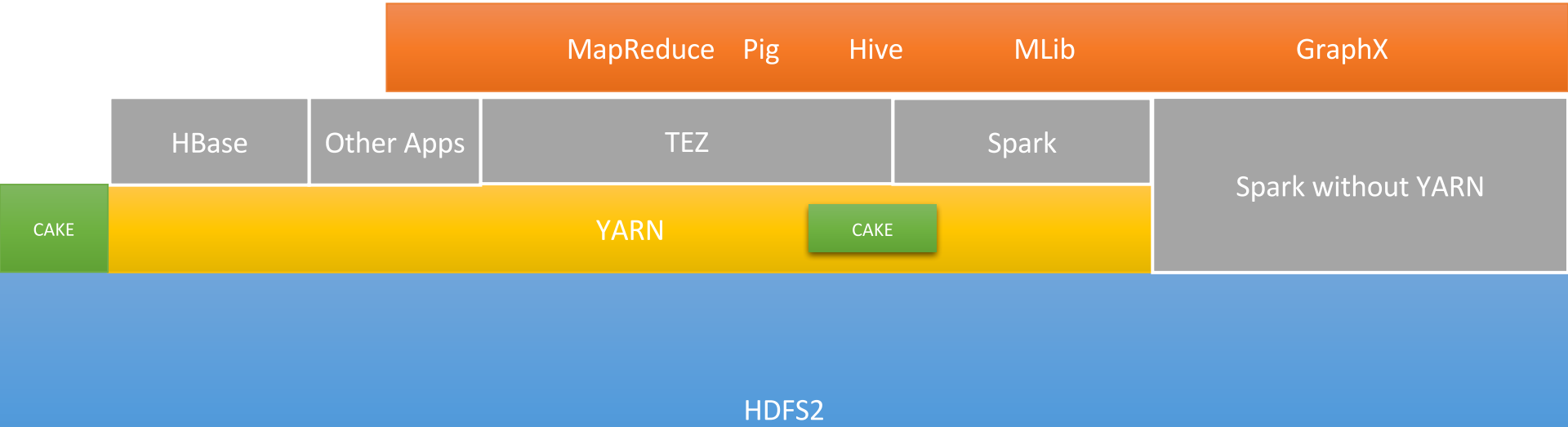
Figure 1: YARN Architecture (in blue the system components, and in yellow and pink two applications running.)

What is **not easy** in two-level scheduling ?

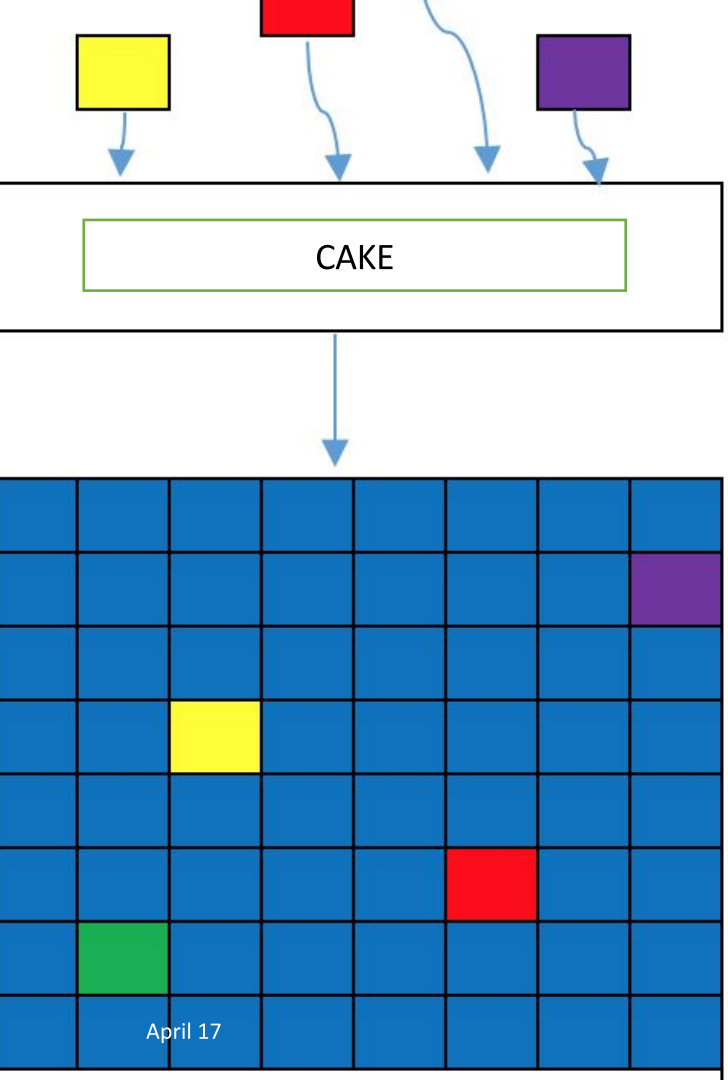
Application-specific schedulers care about many different aspects of the underlying resources, but their only means of choosing resources is the **offer/request interface** with the resource manager. This interface can easily become quite complex

many more... *discussed in report*

Where it fit in technology stack?



Section II
– Proof of concept
CAKE
(Goal, Design, Flow)



- Goal

Framework Design Goals

1. Adaptability to existing Schedulers
2. Adapts to Scale (10 Jobs/sec to 1million Jobs/sec)
3. Extensibility
4. Easy to use...
5. ...

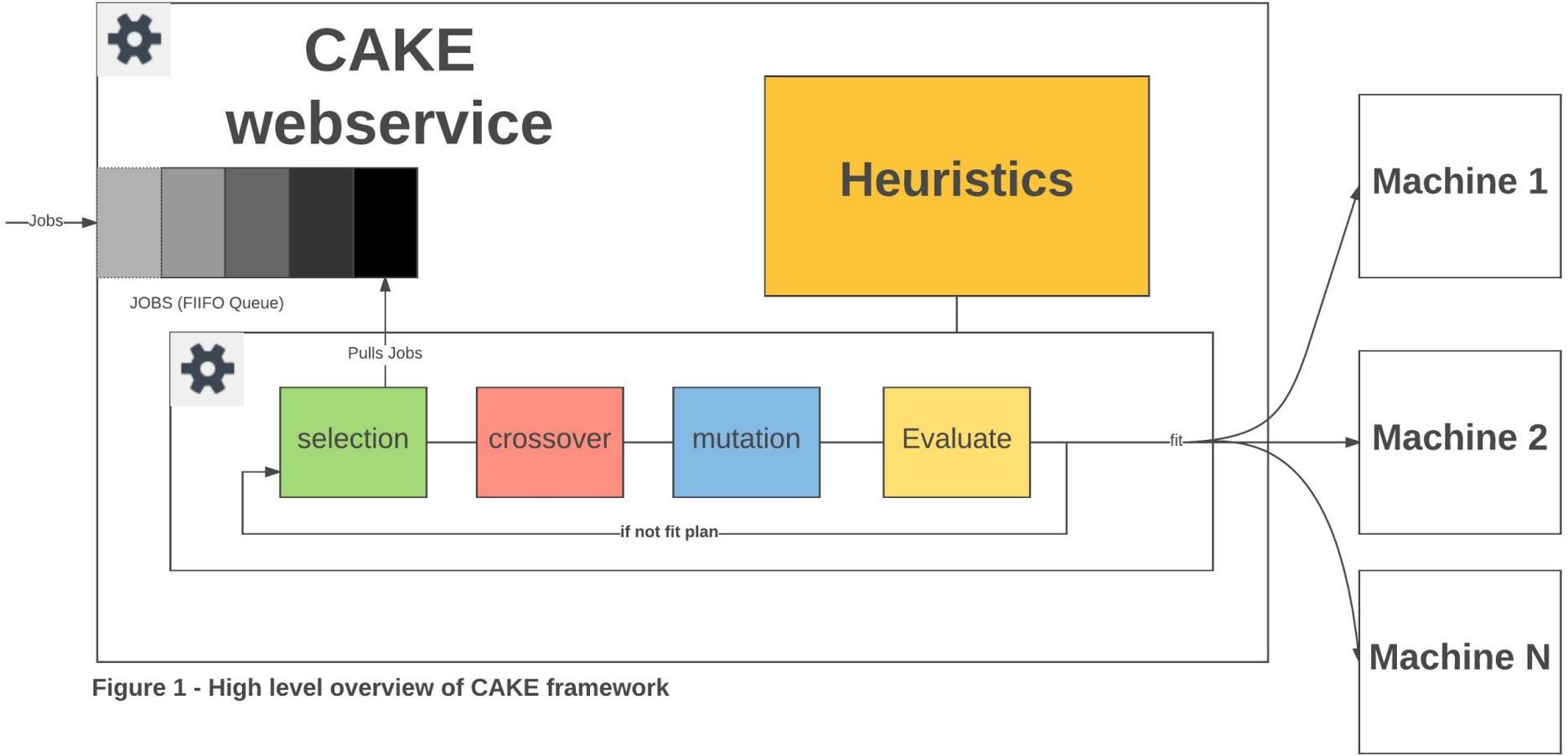


Figure 1 - High level overview of CAKE framework

Output

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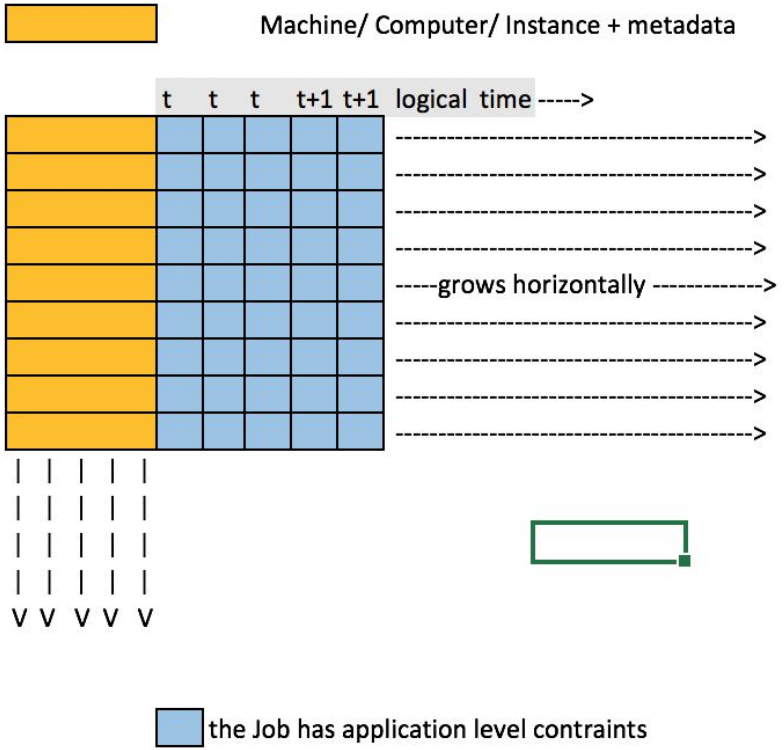
A Single Plan = Machines x Jobs Matrix



test case 1	more jobs	75

Allocation is based on Sequential Order

CAKE Plan 1 for 75 Jobs

Machine 1	1	9	16	24	32	40	48	56	64	71
Machine 2	2	10	17	25	33	41	49	57	65	72
Machine 3	3	11	18	26	34	42	50	58	66	73
Machine 4	4	12	19	27	35	43	51	59	67	74
Machine 5	5	13	20	28	36	44	52	60	68	75
Machine 6	6	14	21	29	37	45	53	61	69	
Machine 7	7	15	22	30	38	46	54	62	70	
Machine 8	8	16	23	31	39	47	55	63	71	

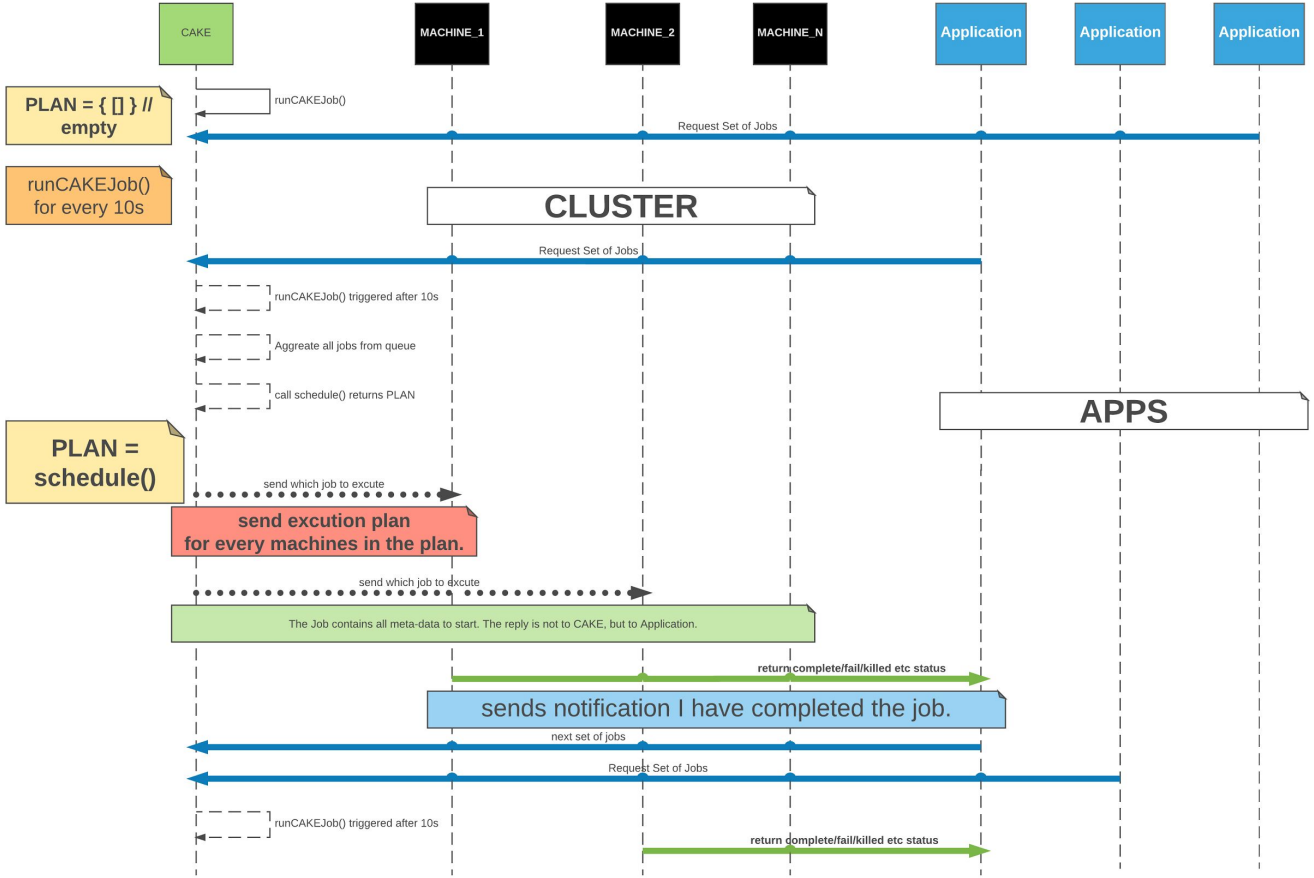
→ Means in Machine 1, Jobs having ID 1,9, 16, 24, 32, 40, 48, 56, 64, 71 will be executed

Example

High Level Sequence Diagram

Execution Flow

- Quite Simple.
- Future work
  - Sequence Diagram for real-world application



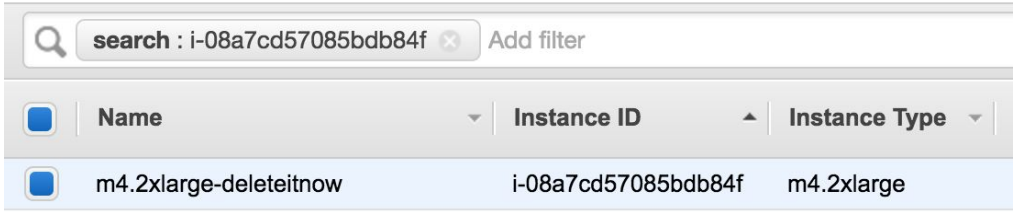
Section III – Research Notes and Conclusion (Results, Critics, Big picture)

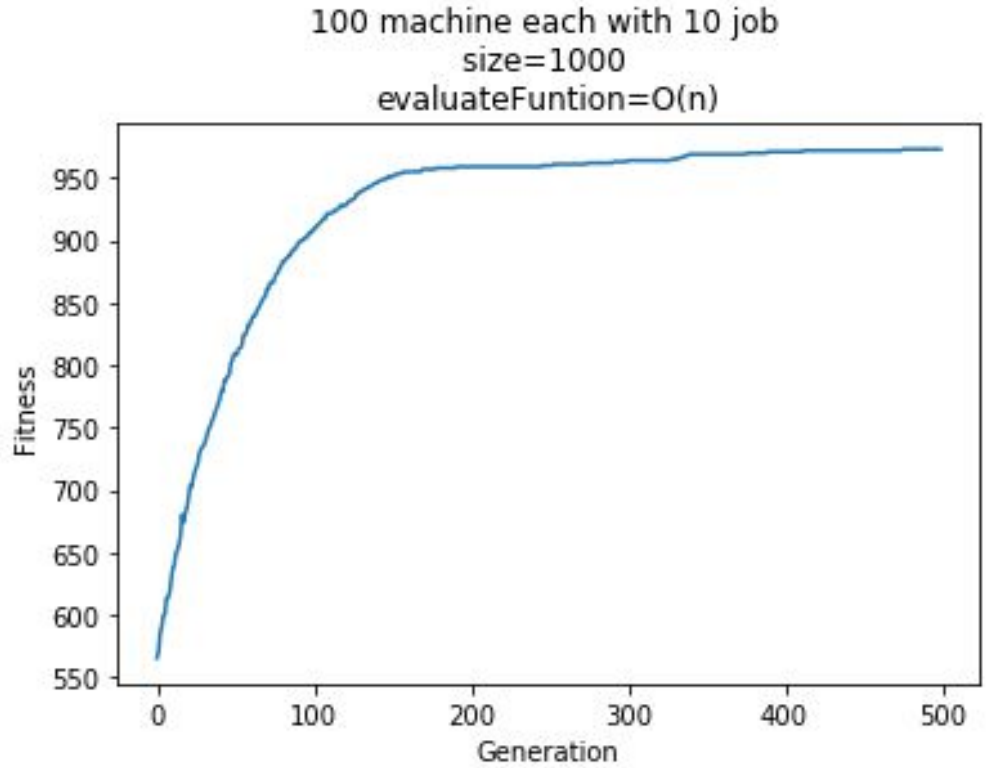
Results

- We wrote GA in Python.
- Not a good Implementation.
  - Serial implementation.
  - Not optimized code.
- For Production- we need to implement it in C++ by leveraging GPU using CUDA.

- Evaluate(schedule, machine,jobs){
  - Check if all the jobs are scheduled.
  - Check if total requirements by all the jobs scheduled on the machine are not exceeding available resources on the machine.
  - Return fitness

- **More analysis & Graphs is in report.**





Critics

- Lot of engineering work
- Latency depends on ***how and where*** CAKE is implemented.
- Complex to write heuristics for evaluate functions
- ...
- ... *written in report*

Knowledge has beginning but no end.

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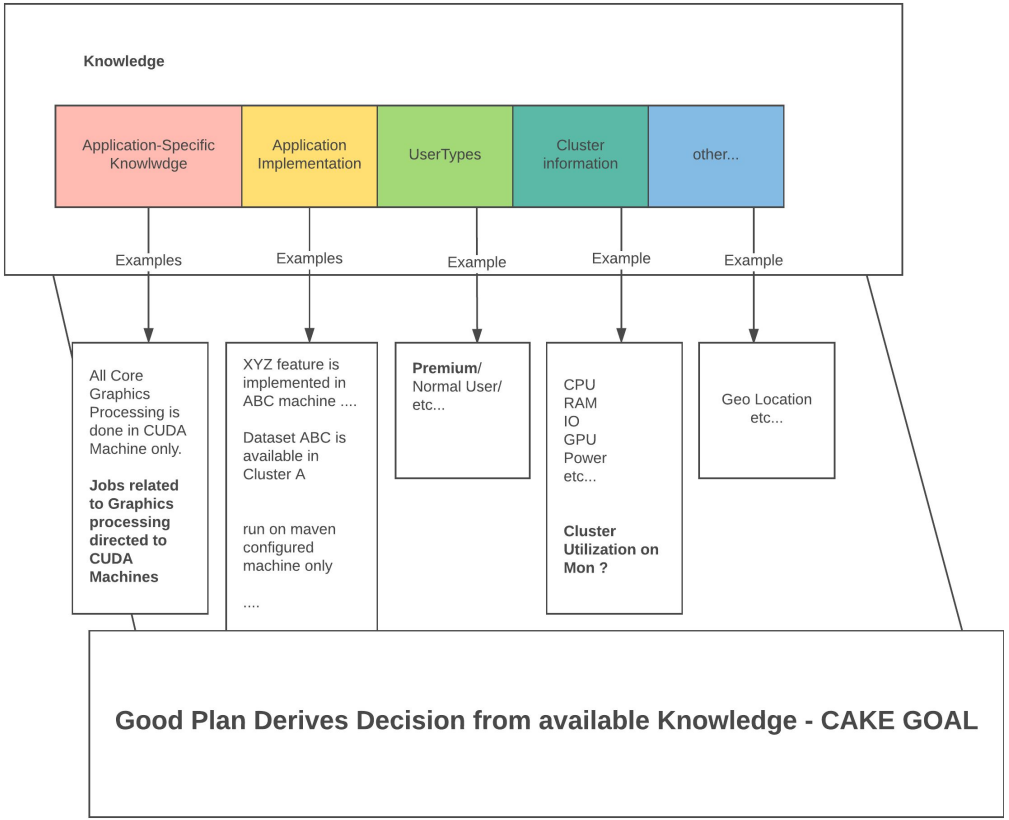
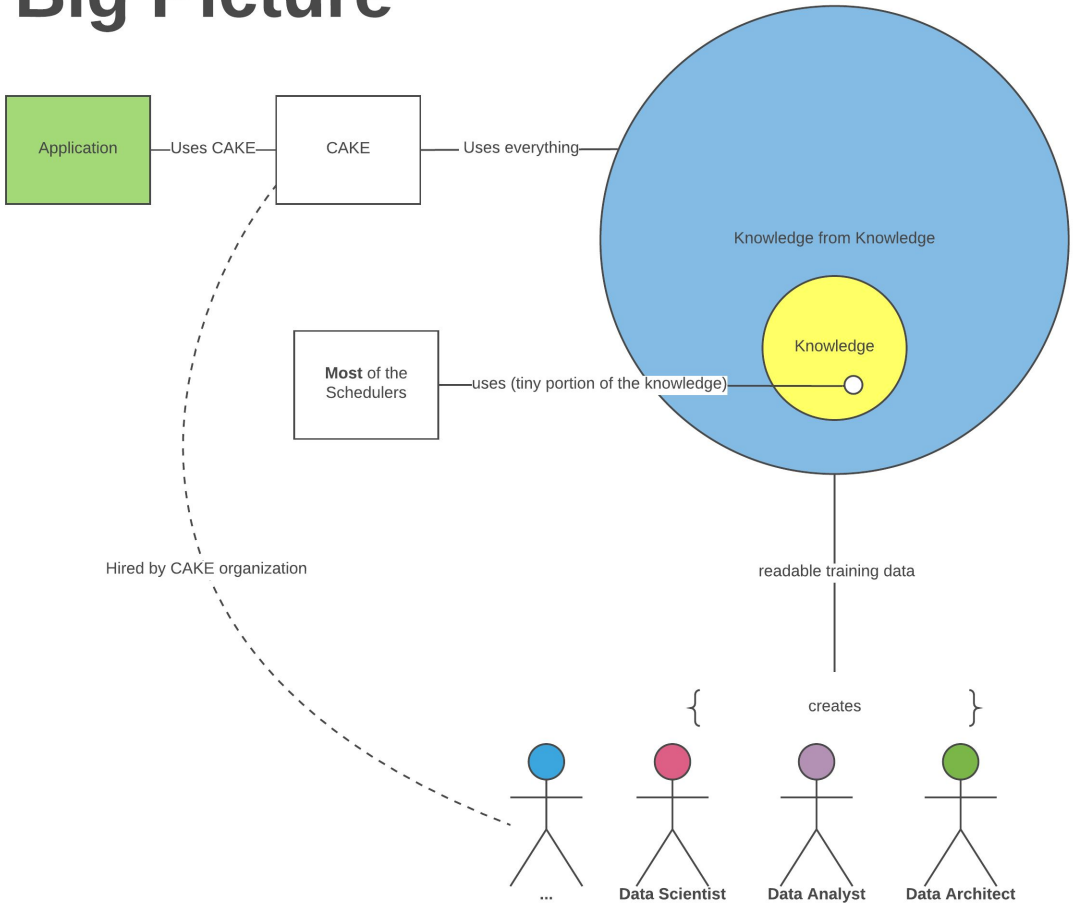


Big Picture


Application
Uses CAKE
CAKE
Uses everything
Knowledge from Knowledge
Knowledge
Most of the Schedulers
uses (tiny portion of the knowledge)
Hired by CAKE organization
readable training data
creates
...
Data Scientist
Data Analyst
Data Architect

FUTURE WORK

Evaluation

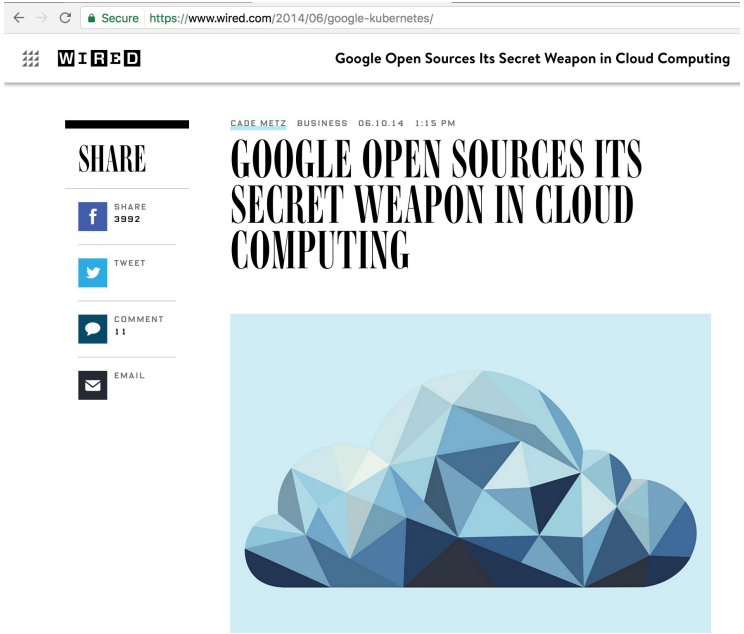
Real-life application testing

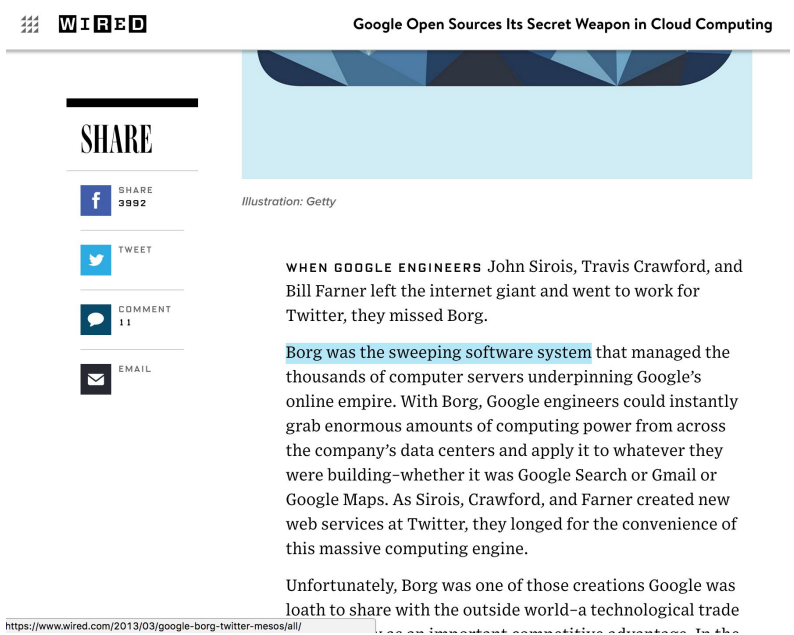
How does CAKE differ from BORG ?

It differs, but it has same underlying design principle , that is scheduling based on scoring.. ***we are aiming to take CAKE framework to be a superset of BORG***.

CAKE is a framework similar to AngularJS, Spring Framework etc... but this is for Scheduling....

CAKE is not **Kubernetes** scheduler, it differs – discussed in report.





Why was Borg Closed source?

...

Artificial Intelligence is the New Electricity - Andrew Ng

Conclusion ...

Advance Concepts(AI,etc) in Scheduling must be unified by all **researchers** in Apache Open Source project, such that any application or organization will not worry about scheduling at all.

CAKE project is our attempt ...

Thank you

-Ajay Ramesh
-Chandra Kumar