Static Scheduling in Clouds

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Motivation (1)

Cloud computing gives the *illusion* of ∞ (virtual) resources.

Actually there is a finite amount of (physical) resources.

We would like to efficiently share those resources:

1. being able to distinguish high priority (serving customer *now*) from low priority (batch) requests;
2. schedule accordingly.

Therefore, we should be able to plan ahead computations.

Motivation (2)

Dynamic Scheduling: use work queues, priorities, but limited.

Without knowledge of jobs, this is the best you can do.

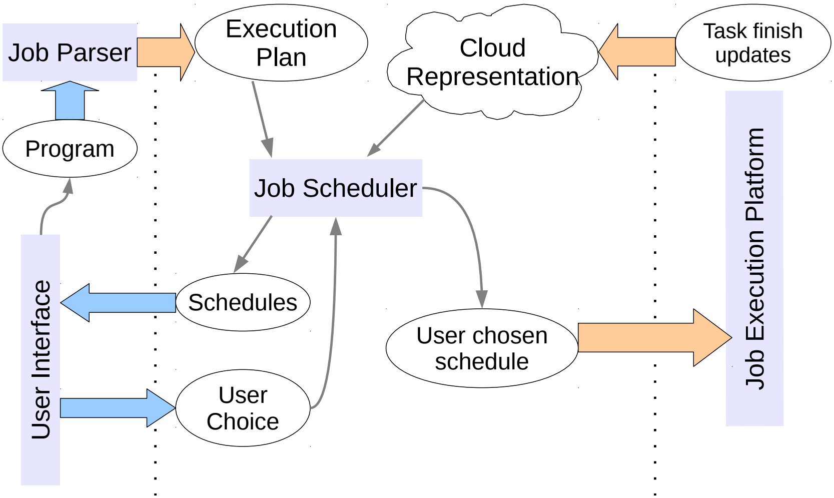
We need to ask the user for:

- what kind of resources his job require;
- a deadline/priority for his job.

In exchange we can give him an expected completion time.

We can also offer choice. (time is money.)

Flextic Overview

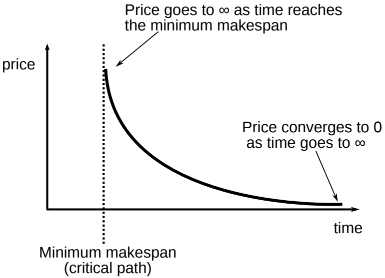


Giving incentive to plan in advance

The scheduler returns not one but many possible schedules with different finish times.

Use a pricing model to associate a cost to the schedules.

Include the "scheduling difficulty" in the cost, give a discount to schedule with later finish time.

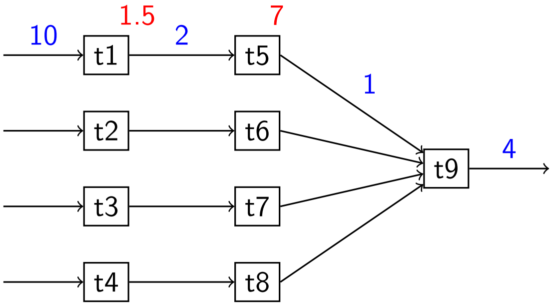


Problem: static scheduling is *hard*.

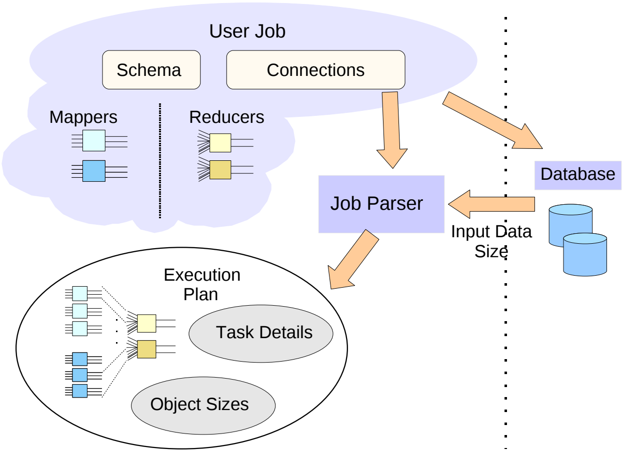
Only possible if the scheduler can handle the work load.

So we set up to make scheduling cheap(er).

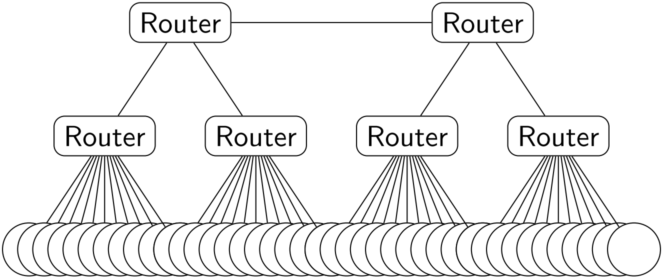
Jobs Model



- A Job is a directed acyclic task (DAG) of tasks.
- Node are marked with worst case duration.
- Edges are marked with data transfer.
- duration and data can be parametric in the input.


User Job
Schema
Connections
Mappers
Reducers
Job Parser
Database
Input Data
Size
Execution
Plan
Task Details
Object Sizes

Infrastructure Model



Datacenter as a tree-like graph:

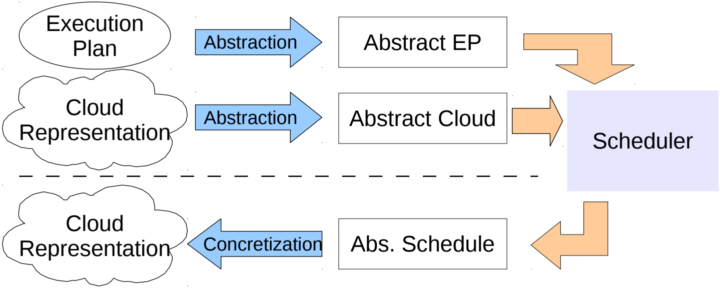
- internal nodes are router;
- leaves are compute nodes (computation speed);
- edges specifies the bandwidth.

Scheduling Large Jobs using Abstraction [EuroSys 2011]

Assumption: job and infrastructure regularity

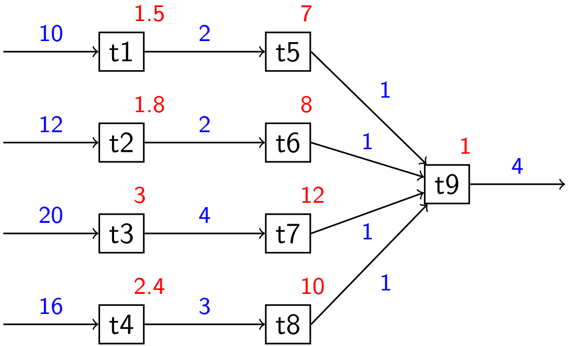
Idea: regularity makes large scale scheduling feasible

How: Using abstraction techniques



Abstraction for jobs:

Group independent tasks as per a topological sort. Merge them into an abstract task.



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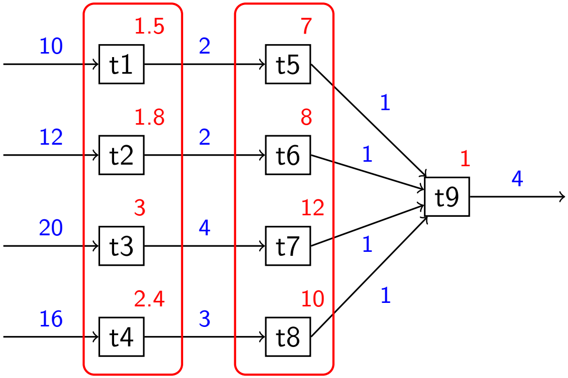

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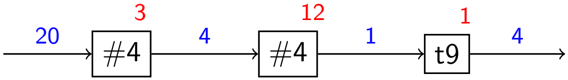

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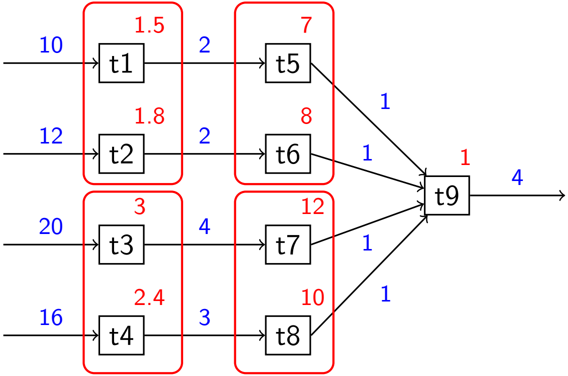

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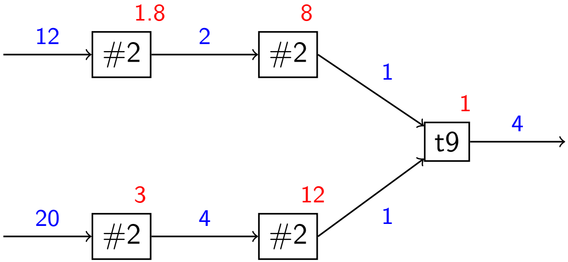
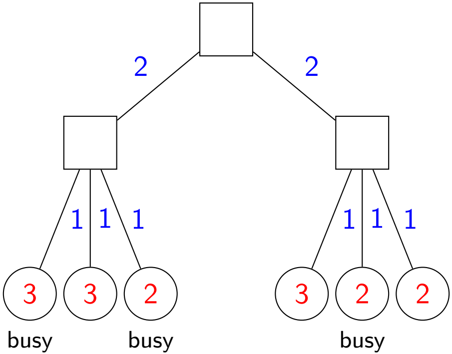


Abstraction for infrastructure:

Merge nodes to according to network topology:



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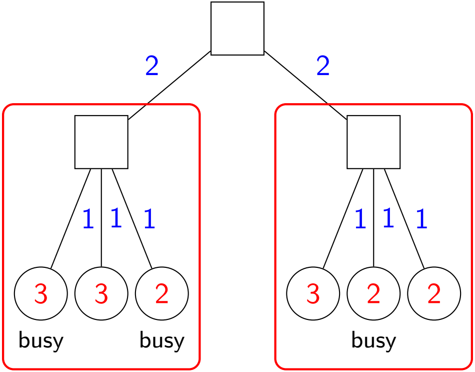

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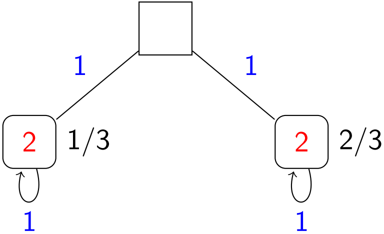
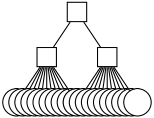
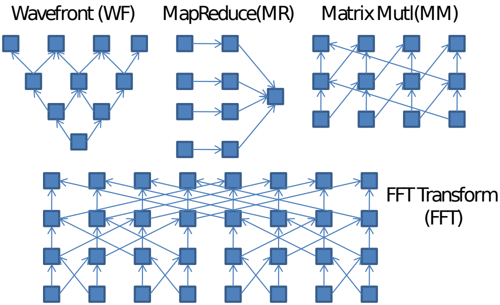


datacenter:



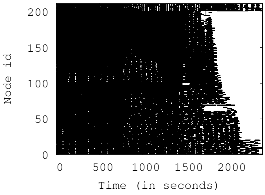
2-tier datacenter
Half of the nodes: speed x,
Other half: speed 1.5 x

On the job side:

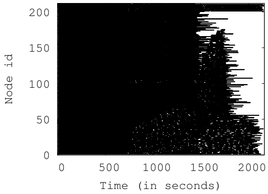


We then compare Fisch and Blind to a concrete greedy scheduler (baseline) on a sequence of 100 jobs (10-5000 tasks each). Latency is given per tasks.

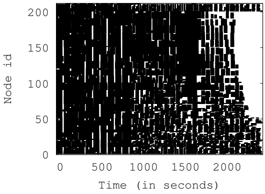
Scheduler	Latency (ms)	Utilization
Baseline	293	96 %
Fisch	0.27	92 %
Blind	0.16	91 %



(b) Fisch

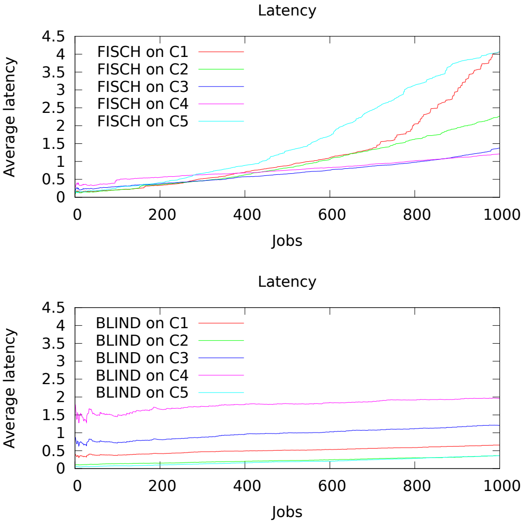


(a) Baseline



(c) Blind

C1: 2000 nodes, 20 per rack
C2: 1600 nodes, 40 per rack
C3: 4000 nodes, 20 per rack
C4: 8000 nodes, 20 per rack
C6: 1000 nodes, 500 per rack



Experiments, part 2: real world

Caution: static scheduling alone will not work.

- Task duration are conservative estimates;
- Variability of the performance of the compute node.

We use static scheduling with backfilling.

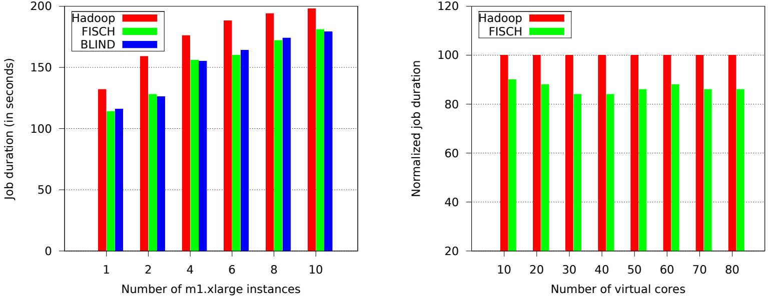
Job:

- The jobs are MapReduce jobs doing image transformation.
- Mapper: 8.1 seconds on average, estimate is 40 seconds
- Reducer: Identity operation

Infrastructure:

- Hadoop streaming version 0.19.0
- Amazon EC2 m1.xlarge instances (15GB RAM, 4 cores)
- Number of mappers = 50 * number of instances

Experiments: compared to Hadoop



Observations:

- The Hadoop framework requires large runtime overhead: results in slowdown of the job execution.
- Static scheduling allows to prefetch data, whereas dynamic scheduling does not

Conclusion

There is an opportunity to apply methods developed to solve computationally hard problem in verification to other area. While preserving a solid theoretical basis.

Questions ?