CloudBATCH: A Batch Job Queuing System on Clouds with Hadoop and HBase

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Outline

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Introduction - Motivation

- Users have hybrid computing needs
  - Legacy programs dispatched by traditional cluster systems
  - MapReduce programs requiring Hadoop
- Hadoop is incompatible with traditional cluster management systems
  - Hadoop is yet another system to manage cluster machines
  - Administrative barriers for deploying dedicated Hadoop cluster on existing cluster machines
  - Using Hadoop on public clouds (Amazon) is not cost-effective for large scale data processing tasks
- CloudBATCH makes it possible to
  - Use Hadoop to manage clusters for both legacy and MapReduce computing needs

Introduction – CloudBATCH

- CloudBATCH is built on top of Hadoop (job execution) and HBase (META-data management) with a scalable architecture where there is no single point of failure
- What CloudBATCH can do
  - Batch job queuing for legacy applications besides MapReduce jobs
  - Job queue management with individually associated policies, user access control, job priority, pre-scheduled jobs, etc.
  - Transparently handle jobs with simple non-NFS file staging needs
  - Task level fault tolerance against machine failures
  - Work complementarily with Hadoop schedulers, such as setting the minimum number of node allocation guaranteed to each queue
  - The HBase table records can also serve as a good basis for future data provenance supports
- What CloudBATCH cannot do
  - MPI-type jobs, reserve actual compute nodes, etc.

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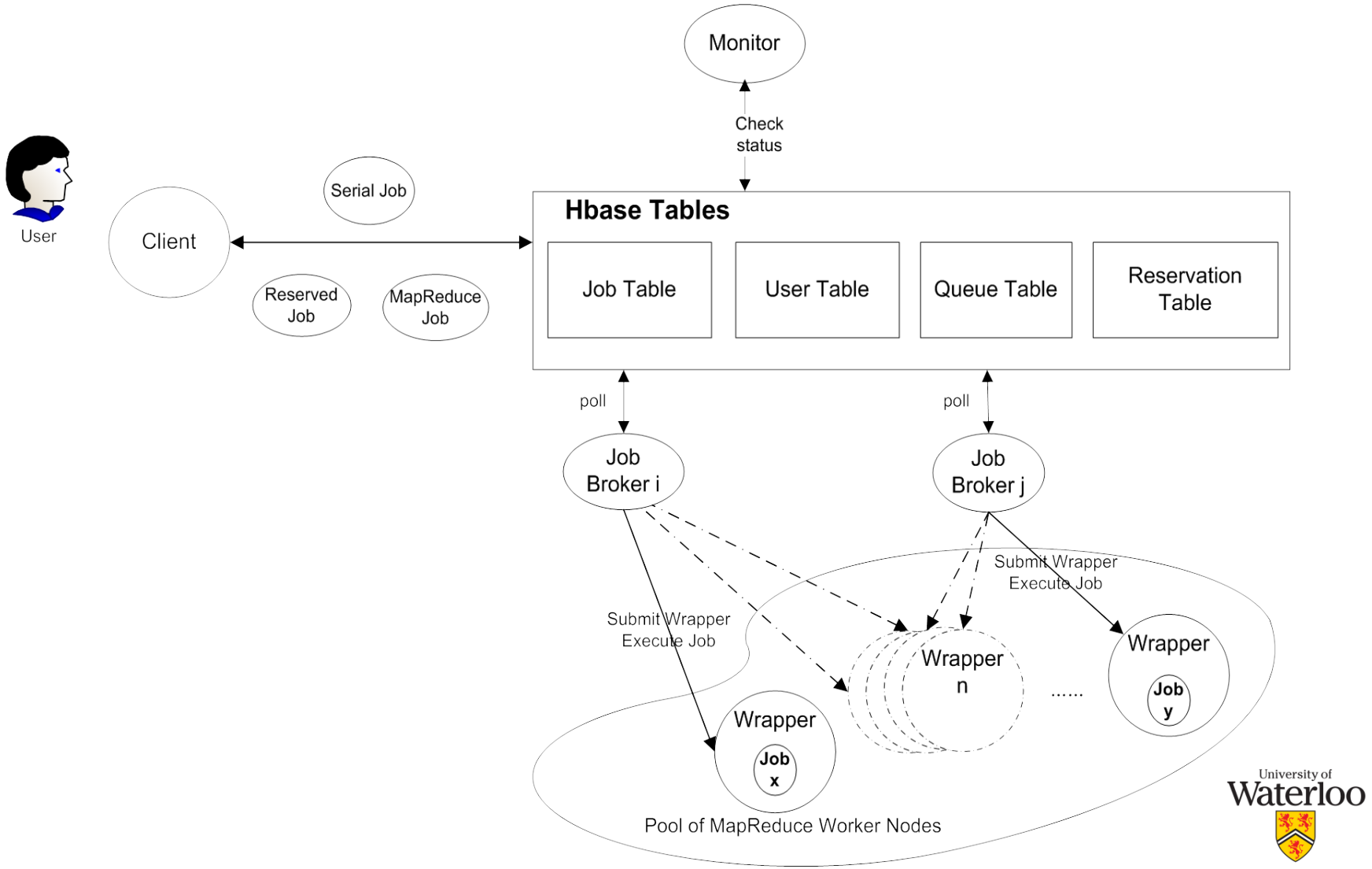
Introduction - Related Work (1)

- Hadoop Schedulers
  - Focus on optimizing task distribution and execution
  - Do not provide rich functionality for cluster level management, such as user access control and accounting, and advanced job and job queue management
- Hadoop On Demand (HOD)
  - Creates a Hadoop cluster on-the-fly by running Hadoop daemons through the cluster resource management system on a set of reserved compute nodes
  - Does not exploit data locality for MapReduce jobs because the nodes where the Hadoop cluster is created on may not host the needed data at all
- Sun Grid Engine (SGE) Hadoop Integration

Introduction - Related Work (2)

- Sun Grid Engine (SGE) Hadoop Integration
  - Claims to be the first cluster resource management system with Hadoop integration
  - Creates a Hadoop cluster on-the-fly like HOD with better data locality concerns
  - Potential risks of overloading a compute node as a result of catering for data locality concerns (non-exclusive node usage)
  - Shares a major drawback with HOD: a possible significant waste of resources in the Reduce phase, or in the case of having unbalanced executions of Map tasks
    - Because the size of the on-the-fly cluster is statically determined at the beginning by users, normally according to the number of Map tasks
    - On-the-fly Hadoop cluster is not shared across job submissions

System Design - Overview



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System Design – Client

- **Clients** accept job submission commands from users
  - Check user credentials , determine queue/job policy, add job to CloudBATCH system by inserting job information into an HBase table called "Job Table"

JobID	QueueID: serial	QueueID: bioinformatics	JobType:serial	JobType:MapReduce	JobType:Reserved	Priority:1	Priority:5
23	Y		Y			Y	
24		Y		Y		Y	
25	Y		Y		Y		Y

JobID	StartTime	EndTime	SubmitTime	QueuedTime	Job Length Limit	Status: submitted	Status: queued	Status: running	Status: failed	Status: succeeded
23			t1		1200000	Y				
24	t4		t2	t3	600000			Y		
25			t5		1200000	Y				

JobID	UserAlice	UserBob	Groupdefault	Groupbio	Command	JobDescription	AbsolutePath1	AbsolutePath2
23	Y		Y		Command1	mpeg encoder	RelativeFileDir1	
24		Y		Y	Command2	bio sequence		RelativeFileDir2
25		Y		Y	Command3	space weather		

System Design – Broker and Monitor

- **Brokers** constantly poll the Job Table for a list of jobs with "Status:submitted" status
- For every job on the list
  - Changes the job status to "Status:queued"
  - Submits to the Hadoop MapReduce framework a "Wrapper" program for job execution
  - Note: if the Wrapper fails directly after being submitted, jobs could stay in "Status:queued" forever. This is handled by the "Monitor" program
- **Monitors** set a time threshold T, periodically poll the Job Table for jobs that stay in the "Status:queued" status for a time period longer than T, and change their status back to "Status:submitted"

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System Design – Wrapper

- **Wrappers** are Map-only MapReduce programs acting as agents to execute user programs at compute nodes where they are scheduled to run by the underlying Hadoop schedulers
- When a Wrapper starts at some compute node:
  - Grabs from the HBase table the necessary job information and transfers files that need to be staged to the local machine
  - Updates the job status to "Status:running"
  - Starts the job execution through commandline invocation, MapReduce and legacy jobs alike
- During job execution:
  - Checks the execution status such as total running time to follow job policies, and terminates a running job if policies are violated
- After job execution completes:
  - Either successful or failed, the Wrapper will update the job status ("Status:successful" or "Status:failed") in the Job Table,
  - Performs cleanup of the temporary job execution directory
  - Terminates itself normally

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System Design - Discussion

- Limitations
  - No support for MPI-type applications
  - Jobs must be commandline based, no interactive execution
- Data consistency under concurrent access
  - Guard against conflicting concurrent updates to Job Table
    - Multiple Brokers updating conflicting job status
  - Solution: use transactional HBase with snapshot isolation
- Performance bottleneck
  - Multiple number of system components (Brokers, etc.) can be run according to the scale of the cluster and job requests
  - The bottleneck is at how fast concurrent clients can insert job information to the Job Table

Future Work

- Monitors are still not fully explored for our prototype and may be extended in the future for detecting jobs that have been marked as "Status:running" but actually failed
- Further test the system under multi-queue, multi-user scenarios with heavy load and refine the prototype implementation for trial production deployment in solving real-world use cases
- Exploit the usage of CloudBATCH to make dedicated Hadoop clusters useful for the load balancing of legacy batch job submissions to other coexisting traditional clusters

Thank you! And Questions?

- Please contact me at:
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- Thank you!

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