THE UNIVERSITY OF MELBOURNE

Research in Distributed Systems

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Research Experience

- **Net Neutrality (MS):** network protocols, protocol blocking, content shaping
- **Cloud and Big Data (PhD):** optimization, performance modelling, resource allocation, job scheduling, reinforcement learning
- **Software Defined Networks (RA):** intent-driven resilient tactical battlefield networks
- **Stream Computing (Post Doc):** real-time social media data analytics, in-memory caching databases

Muhammed Tawfiqul Islam - Google Scholar

Big Data Job Scheduling on Cloud

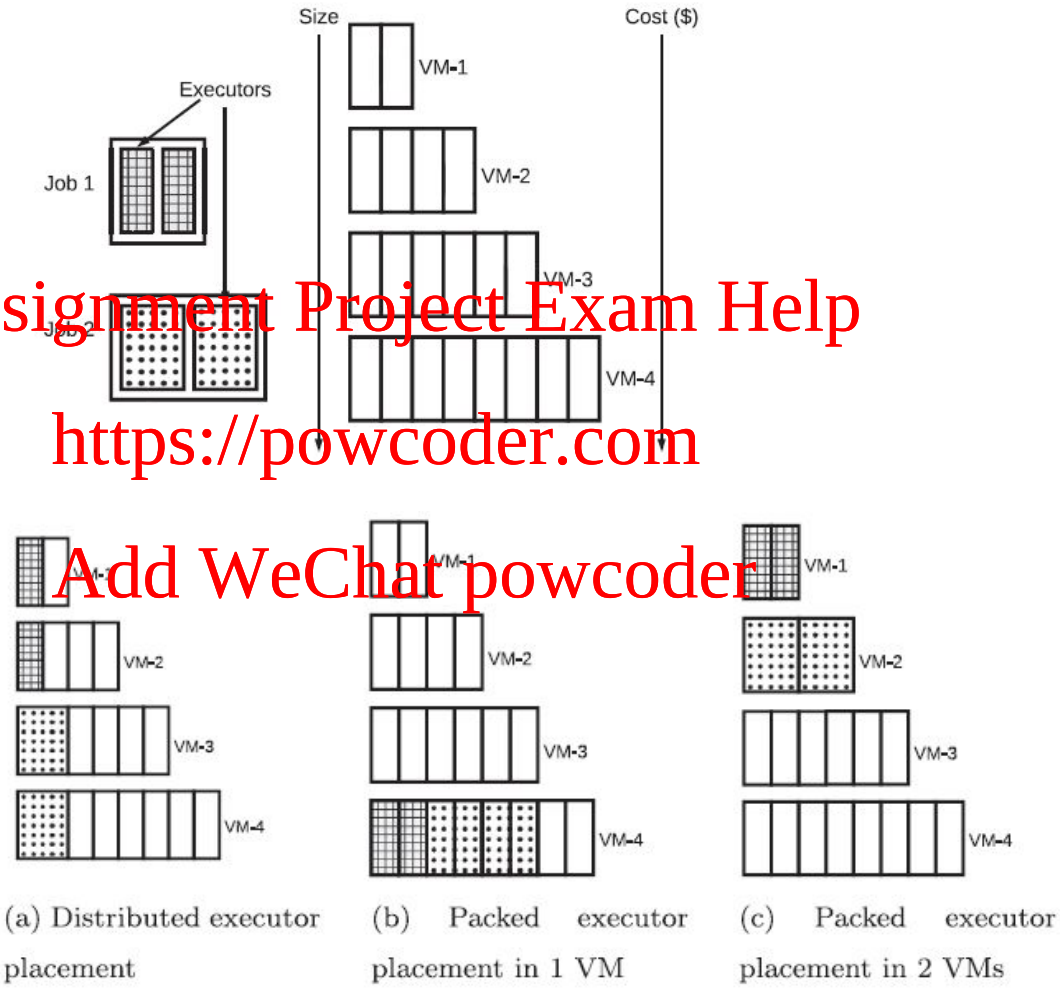
- **Objectives**
  - Scheduling Big Data Applications in a cloud-deployed cluster, while reducing the cost of VM usages of the whole cluster, prioritize critical/deadline-constrained applications
  - Scheduling Big Data Applications in a hybrid cluster composed of local and Cloud VMs, leverage pricing models to reduce cost, provide deadline guarantee

Big Data Job Scheduling on Cloud

- **Limitations of Existing approaches**
  - Homogeneous VM assumption leads to resource wastage
  - Performance-aware, but not Cost-efficient
  - No separation between normal and time-critical jobs
  - Multiple executors cannot be placed in the same VM
  - Does not consider pricing model of different VM instance types, and cost efficiency in a hybrid setup

- **Research Contributions:**
  - Four Job Scheduling Algorithms which prioritize critical jobs and tightly pack jobs in fewer VMs to reduce cost
  - Real implementation of a job scheduling framework on top of Apache Mesos Cluster Manager. Can be extended to add new policies.
  - RM_Simulator: event-based simulator for simulating scheduling policies for big data applications
  - Experiments on Apache Spark Jobs

Problem Formulation (Cloud-based Cluster)



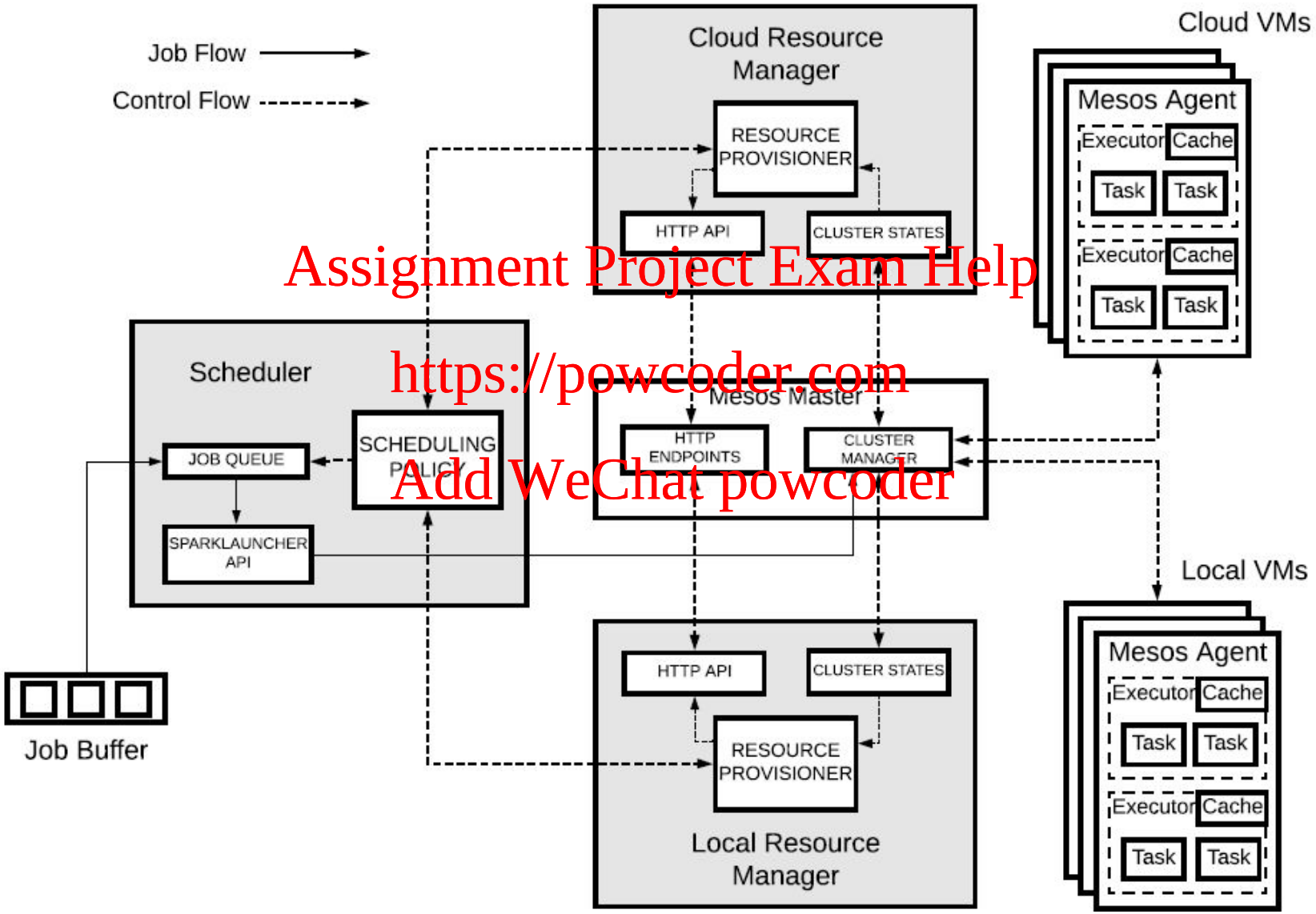
Example scheduling scenarios

Proposed Algorithms

- **Solution Approach (cloud-based cluster):**
  - Best-Fit-Heuristic (BFD): Unifies resource dimensions (CPU, Memory), finds a placement of a job which is cost-effective, and reduces unused resources
  - Integer Linear Programming (ILP): Tight packing of jobs with cost-minimization objective

- **Solution Approach (hybrid cluster):**
  - First Fit Heuristic (FF): Use local, then Cloud
  - Greedy Iterative Optimization (GIO): Relaxes the problem from per-job to per-executor basis, uses the pricing model of VMs and job profile information to find the cheapest placement for each executor

System Implementation



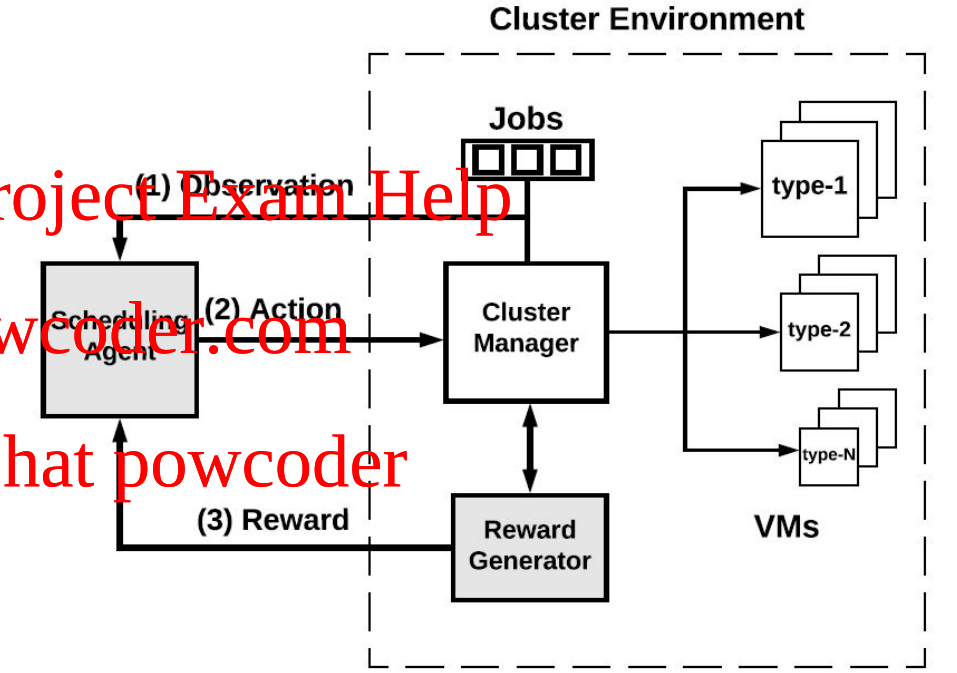
RL-based Job Scheduling

- **Limitations of Existing approaches**
  - Cannot learn cluster or application characteristics for efficient optimization of objective
  - Need to be tuned for different scenarios
- **Research Contributions:**
  - RL Model for the job scheduling problem
  - Reward formulation (encoding of multiple objectives)
  - RL environment implementation for a Cloud-deployed cluster
  - DRL agents (DQN and REINFORCE) to learn inherent characteristics

- **Solution Approach:**
  - Set expected balance between cost-optimized and time-optimized objective
  - DRL agents learn to schedule and optimize objectives entirely by continuous interaction with the cluster simulation environment

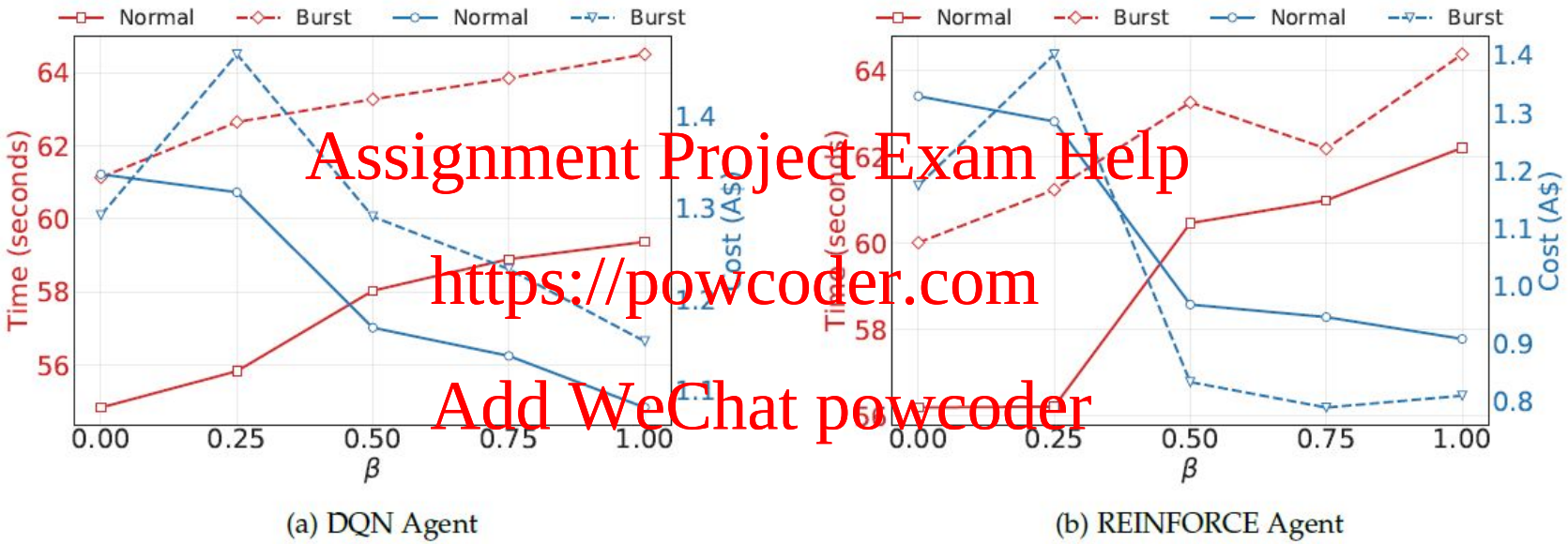
RL Model

- Agent observation is made from job requirements and cluster resource details
- Agent takes an action
- Receives a reward and observes another state
- Learns through interaction with the environment
- Agent has no prior knowledge of job arrival, job type, resource constraints, objectives
- Maximizing expected reward = optimizing target objectives
- **Built and trained on TensorFlow Agents framework.**

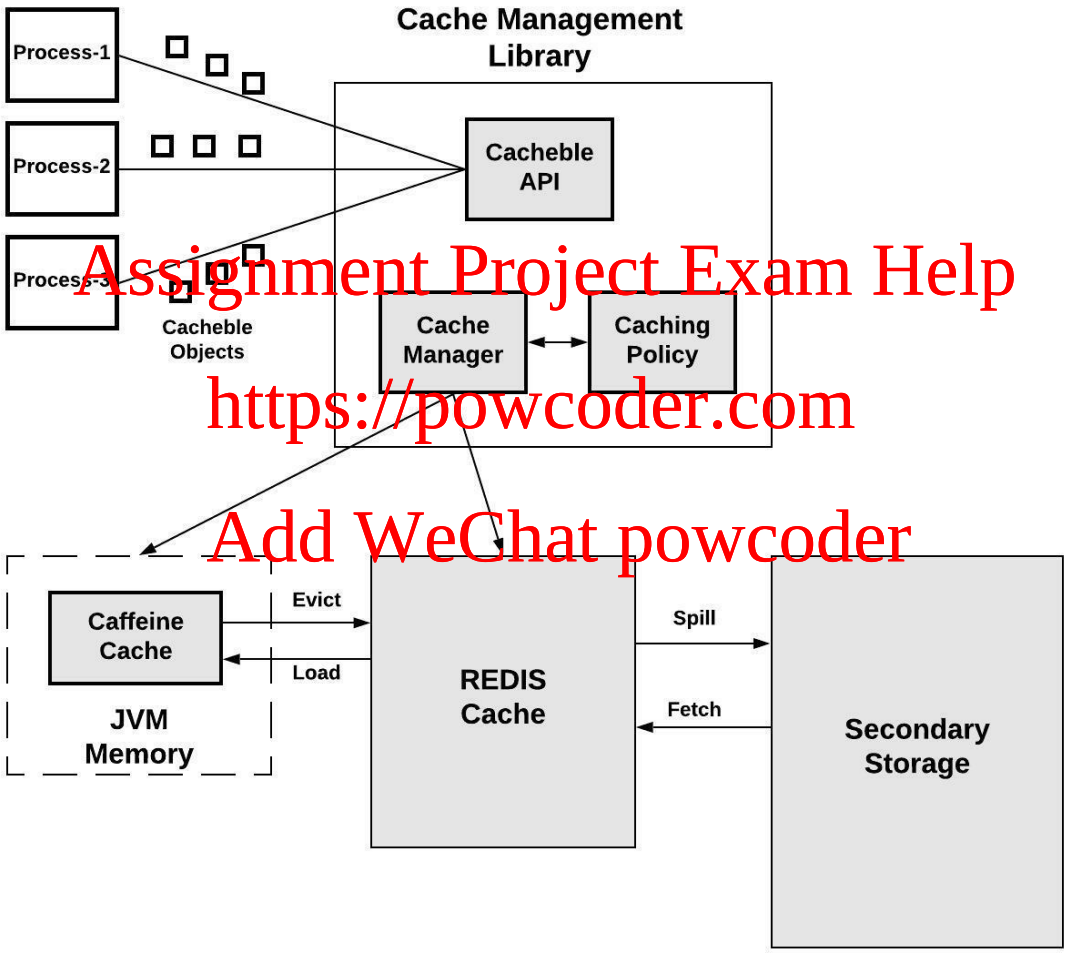


Performance Evaluation

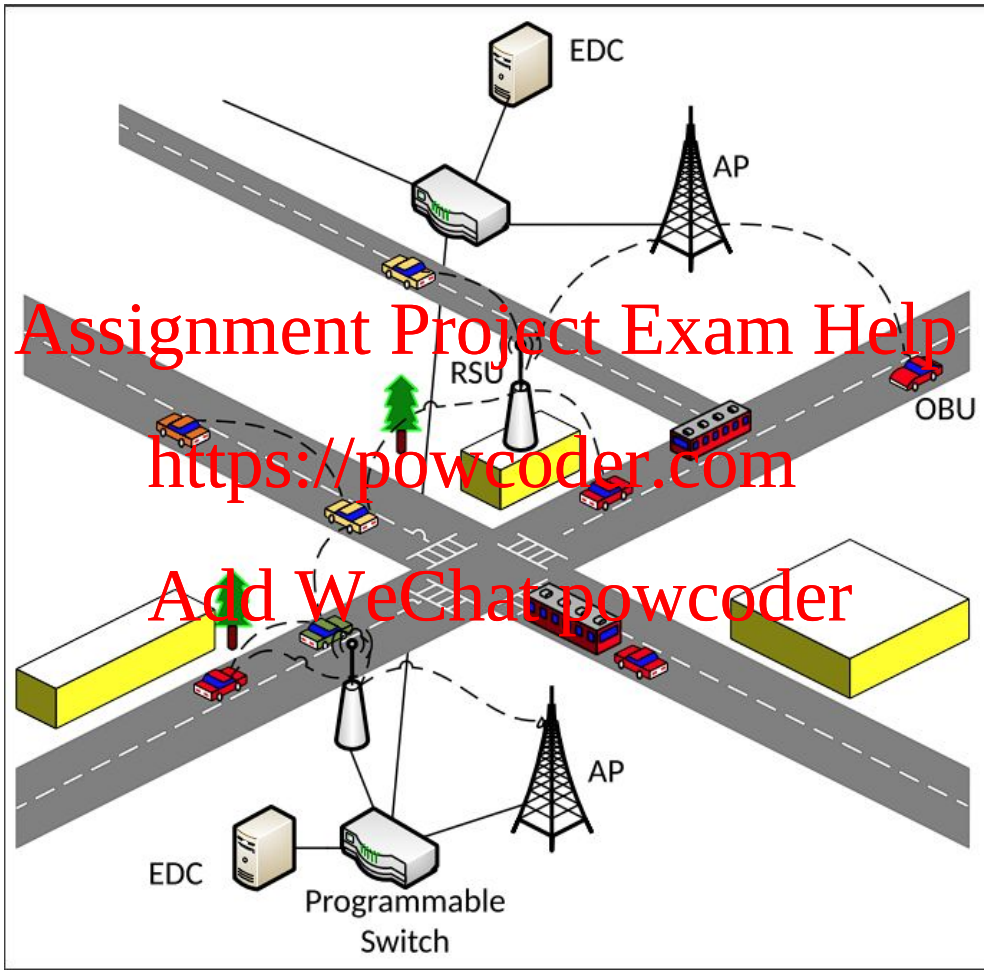
- Trade-offs between multiple objectives



Multi-level Caching Architecture for Stateful Stream Computation



Intent-based Framework for Vehicular Edge Computing



Questions?

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