History-Based Harvesting of Spare Cycles and Storage in Large-Scale Datacenters

Yunqi Zhang, George Prekas, Giovanni Matteo Fumarola, Marcus Fontoura, Inigo Goiri, Ricardo Bianchini.
University of Michigan and Microsoft Research

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Presenter: Yi-Ning Chang

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Outline

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2. Behavior Patterns
3. Co-location Techniques
4. Experiment
5. Conclusion

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Introduction

- Overprovision resources in datacenters
  - Low tail latency requirement
  - Provisioned for peak load
  - Unexpected load spikes and failures
- A way to increase utilization and reduce costs in datacenters is to co-locate their latency-critical services and batch workloads.
- Harvest spare compute cycles and storage space for co-location purpose.

Challenges

- Interactive services “own” the servers
- Resource availability
  - Interactive services performance
  - Resource availability dynamics - task killing
- Data storage co-location
  - Data availability
  - Data durability

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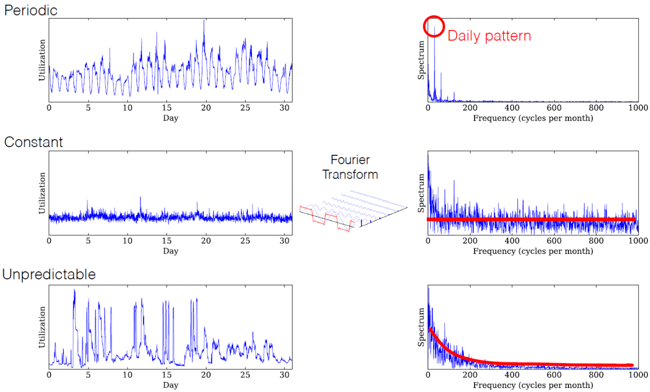
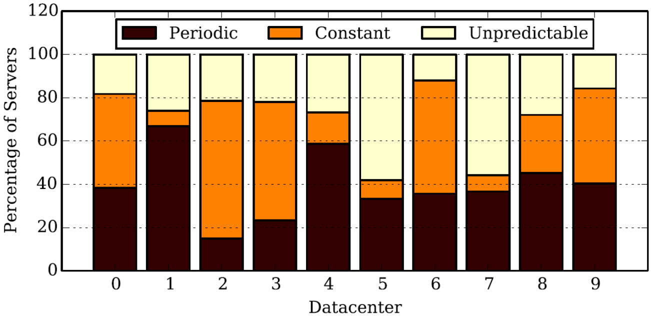
Resource Utilization

- Identify three main classes of primary tenants.



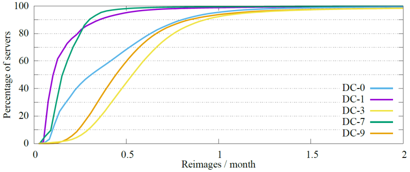
Resource Utilization

- Percentages of servers per class.

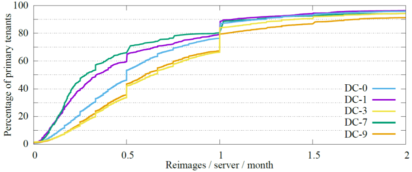


Disk Reimaging

- Per-server number of reimages in three years.



- Per-tenant number of reimages in three years.



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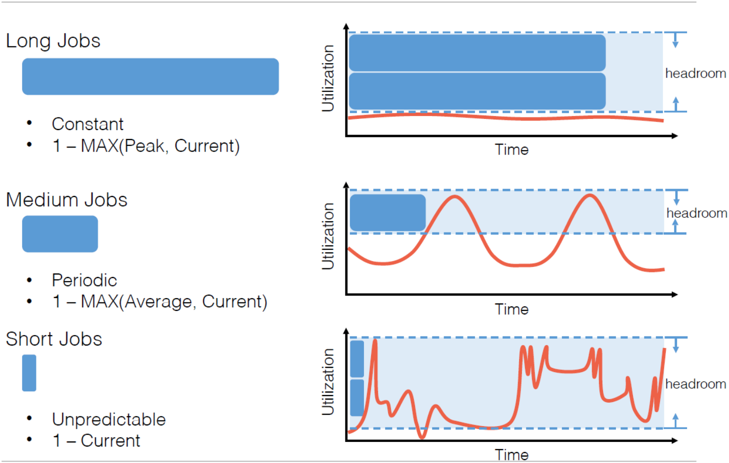
History-Based Task Scheduling



Task Scheduling

- Fast Fourier Transform (FFT)
  - Get 3 patterns.
- Clustering algorithm
  - K-means algorithm
  - Average and peak utilizations
- Class selection algorithm

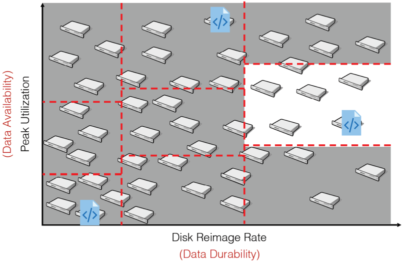
Class Selection Algorithm

Algorithm 1 Class selection algorithm.

Given: Classes C, Headroom($type$,c), Ranking Weights W
function SCHEDULE(Batch job J)
    J.type = Length (short, medium, or long) from its last run
    J.req = Max amount of concurrent resources from DAG
    for each $c \in C$ **do**
        c.weightedroom=Headroom(J.type,c) $\times$ W[J.type,c.class]
    end for
    $F = \{\forall c \in C |$ Headroom(J.type,c) $\geq J$.req$\}$
    if $F \neq \emptyset$ **then**
        Pick 1 class $c \in F$ probabilistically $\propto c$.weightedroom
        return $\{c\}$
    else if Job J can fit in multiple classes combined **then**
        Pick $\{c_0, \ldots, c_k\} \subseteq C$ probabilistically $\propto c$.weightedroom
        return $\{c_0, \ldots, c_k\}$
    else
        Do not pick classes
        return $\{\emptyset\}$
    end if
end function

History-Based Data Placement

- Data availability
  - Diverse in utilization pattern.
- Data durability
  - Diverse in reimaging pattern.



Replica Placement Algorithm

Algorithm 2 Replica placement algorithm.

```
Given: Storage space available in each server, Primary reimaging
       stats, Primary peak CPU util stats, Desired replication R
function PLACE REPLICAS(Block B)
    Cluster primary tenants wrt reimaging and peak CPU util
        into 9 classes, each with the same total space
    Select the class of the server creating the block
    Select the server creating the block for one replica
    for r = 2; r ≤ R; r = r + 1 do
        Select the next class randomly under two constraints:
            No class in the same row has been picked
            No class in the same column has been picked
        Pick a random primary tenant of this class as long as
            its environment has not received a replica
        Pick a server in this primary tenant for the next replica
        if (r mod 3) == 0 then
            Forget rows and columns that have been selected so far
        end if
    end for
end function
```

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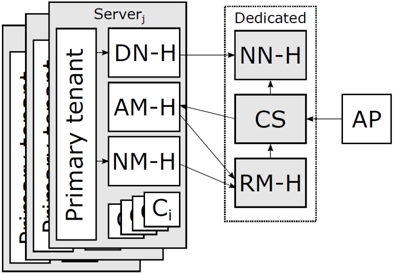
System Implementation

- Overview of YARN-H, Tez-H, and HDFS-H in a co-location scenario.

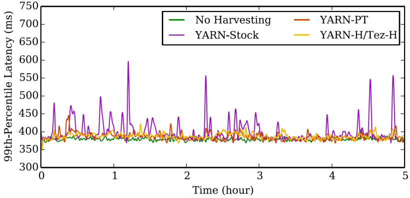


Evaluation

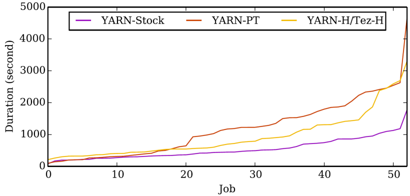
- Environment:
  - 102-server cluster
- Primary tenant (interactive service):
  - Apache Lucene search engine with utilization trace
- Batch task:
  - TPC-DS benchmark

Batch Task Scheduling

- Interactive services performance

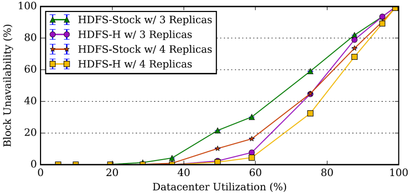


- Job duration - reducing task killing

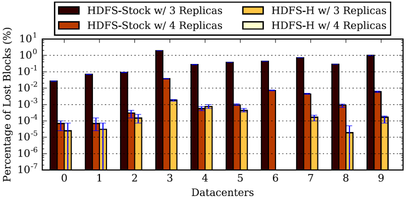


Data Placement

- Data availability



- Data durability



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Conclusion

- Embody knowledge of the existing primary workloads, and leverage historical utilization.
- Improve batch job performance while protecting primary workloads.
- Eliminate data loss and unavailability in many scenarios.

Future Work

- Paper
  - Isolation and security in public cloud.
- Project
  - Network utilization.
  - Constraint of Ethernet bandwidth.