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

Introduction

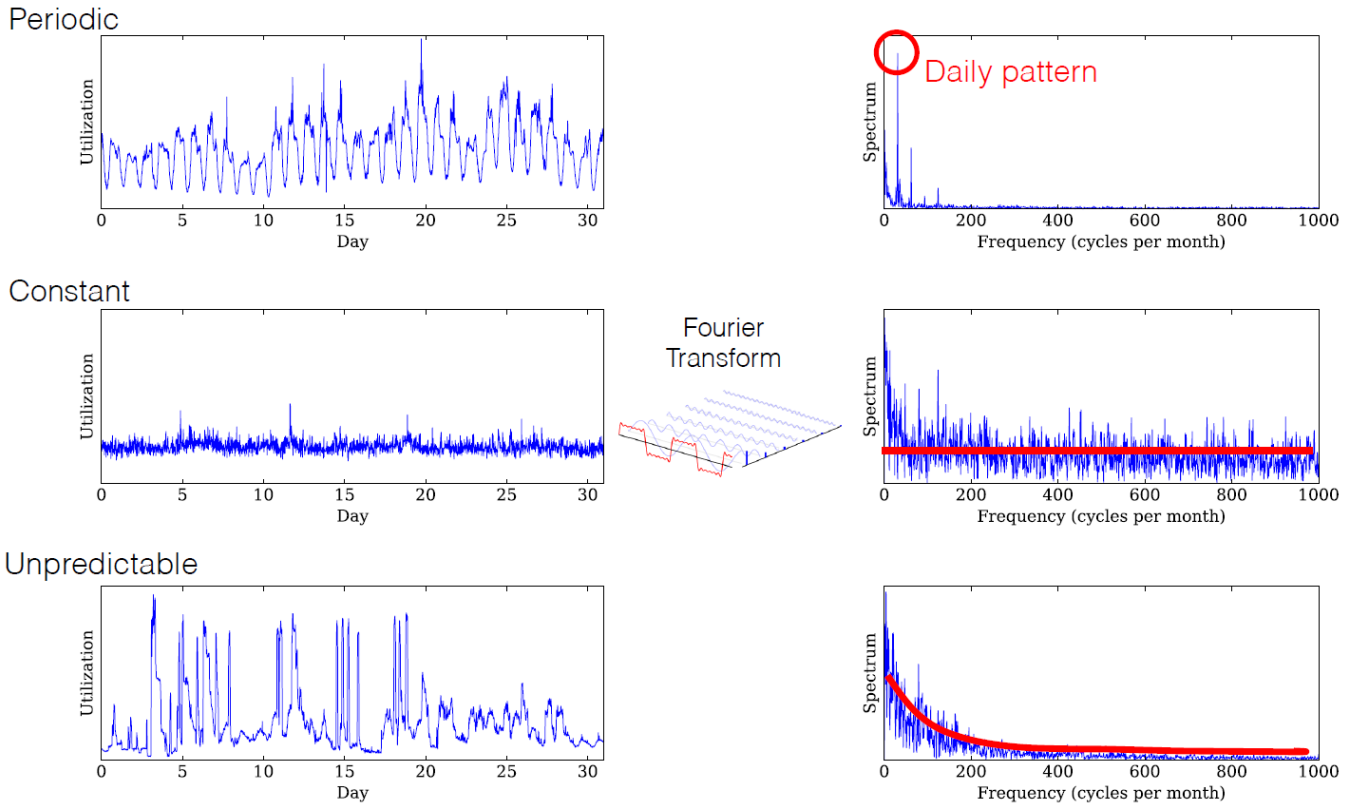
- Overprovision resources in datacenters
  - Low tail latency requirement
  - Provisioned for peak load
  - Unexpected load spikes and failures
- A way to increase utilization and reduce costs in datacenters is to co-locate their latency-critical services and batch workloads.
- Harvest spare compute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

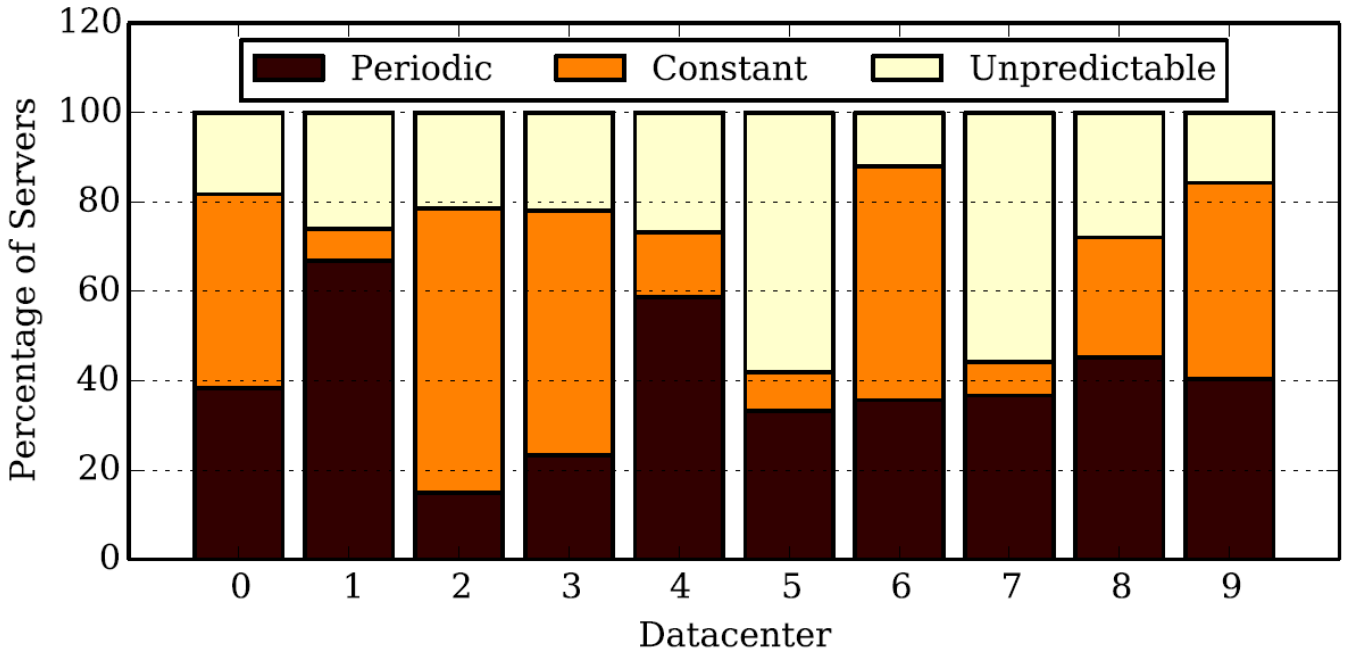
Resource Utilization

- Identify three main classes of primary tenants.



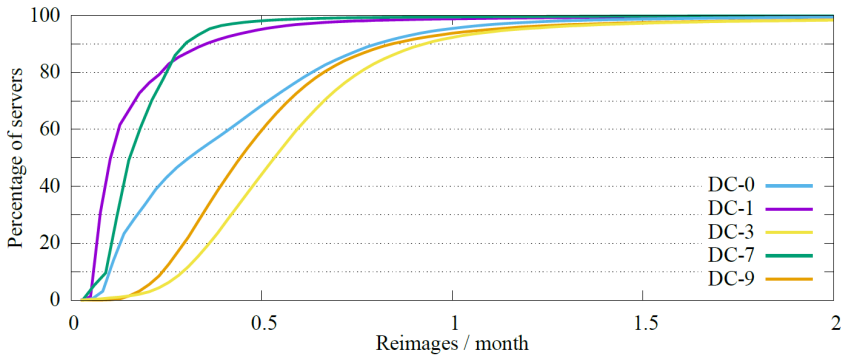
Resource Utilization

- Percentages of servers per class.

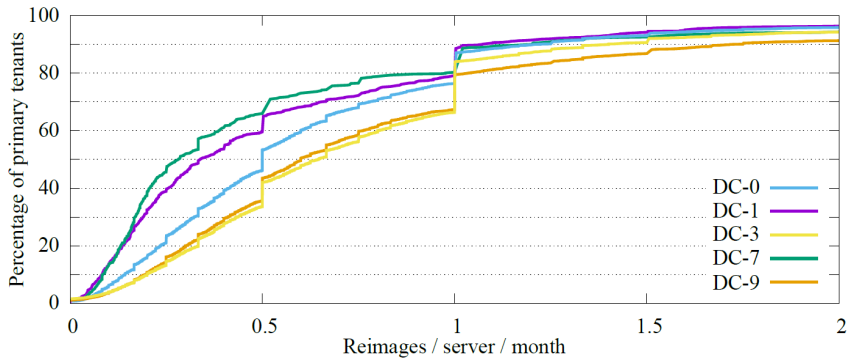


Disk Reimaging

- Per-server number of reimages in three years.



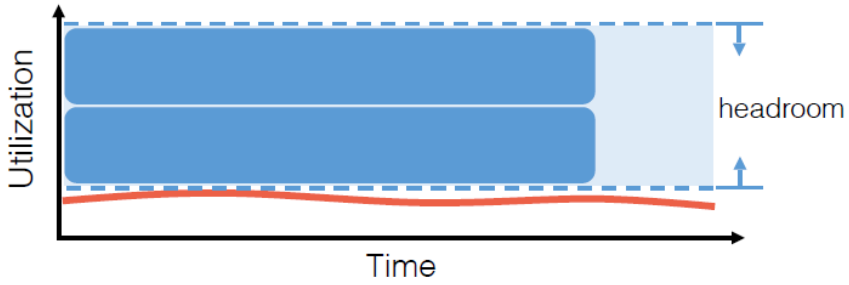
- Per-tenant number of reimages in three years.



History-Based Task Scheduling

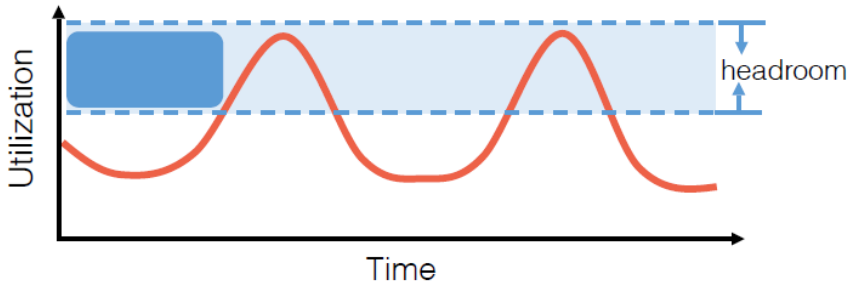
Long Jobs

- Constant
- 1 – MAX(Peak, Current)



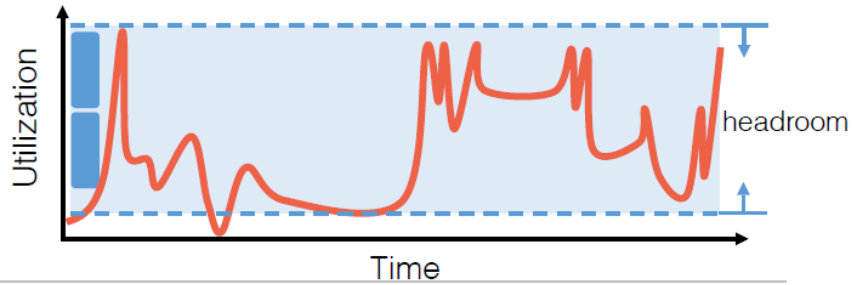
Medium Jobs

- Periodic
- 1 – MAX(Average, Current)



Short Jobs

- Unpredictable
- 1 – Current



Task Scheduling

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

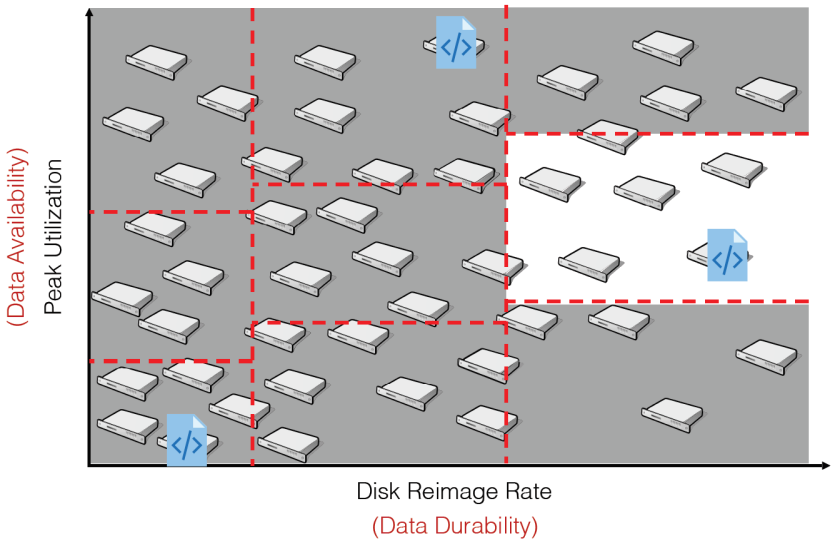
Class Selection Algorithm

Algorithm 1 Class selection algorithm.

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

History-Based Data Placement

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



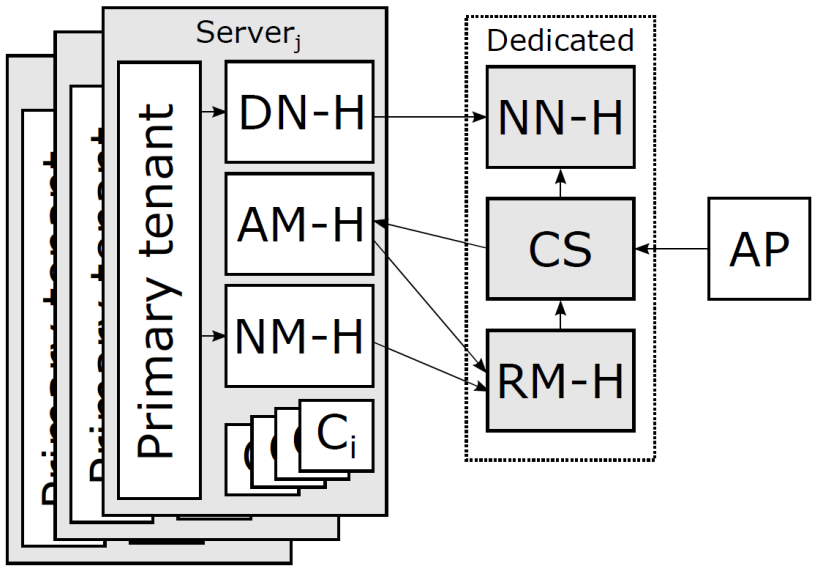
Replica Placement Algorithm

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
```

System Implementation

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

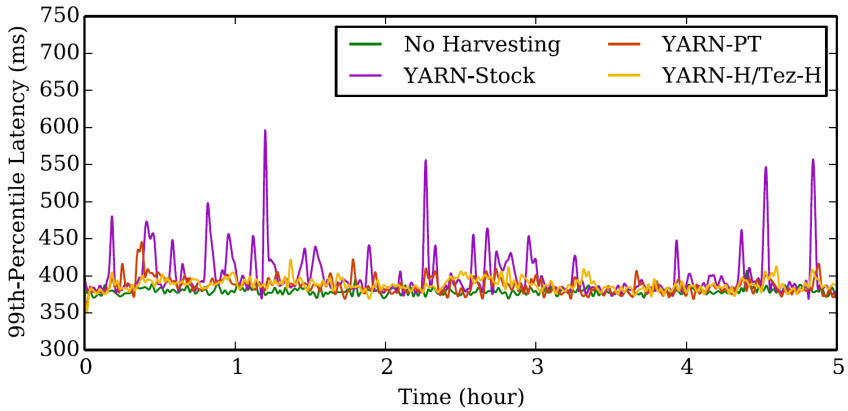


Evaluation

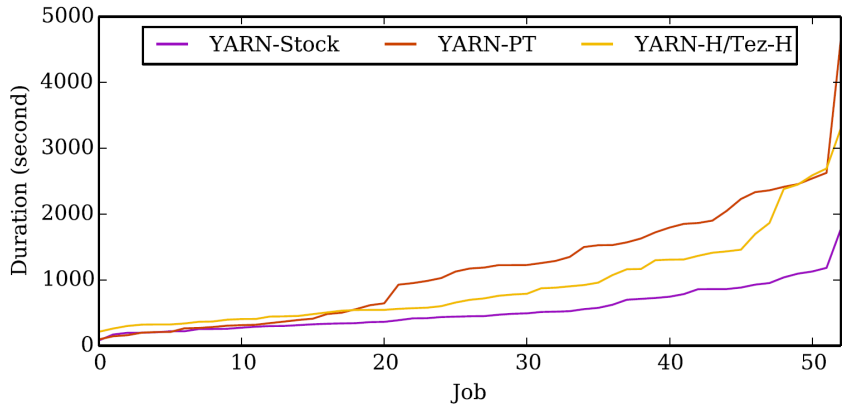
- Environment:
  - 102-server cluster
- Primary tenant (interactive service):
  - Apache Lucene search engine with utilization trace
- Batch task:
  - TPC-DS benchmark

Batch Task Scheduling

- Interactive services performance

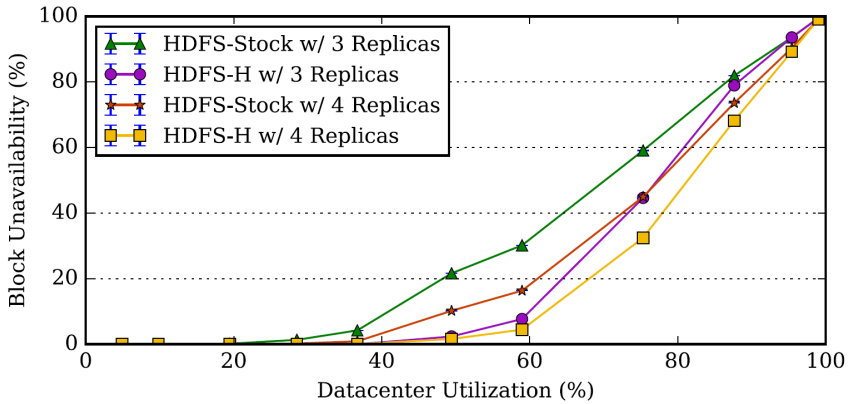


- Job duration - reducing task killing

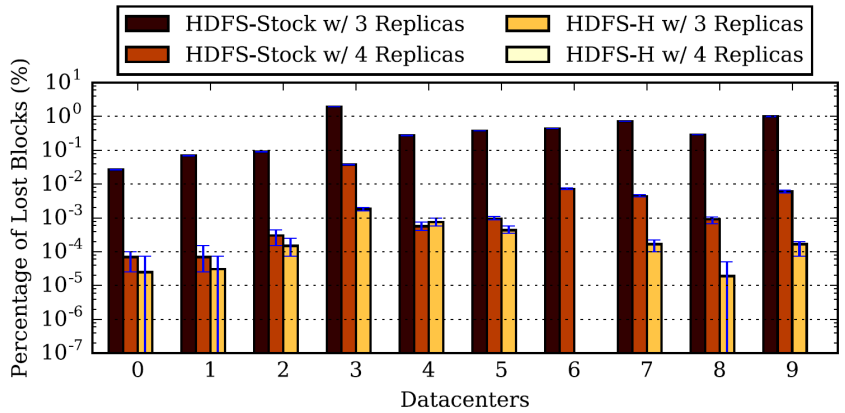


Data Placement

- Data availability



- Data durability



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.