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Sibylla: To Retry or Not To Retry on Deep Learning Job Failure

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Shared multi-tenant GPU clusters today

Shared GPU cluster is commonly used to run DL workloads

Resource scheduling
Storage for data & model
Failure handling

Problem: Job failure of DL training

Unsuccessful job completion with job failures (resource waste)

Prior studies: failure root cause and impact analysis [1, 2]

How to deal with various failures
to enhance the cluster resource utilization?

[1] Jeon et al. "Analysis of Large-Scale Multi-Tenant GPU Clusters for DNN Training Workloads." in ATC 2019
[2] Zhang et al. "An Empirical Study on Program Failures of Deep Learning Jobs." in ICSE 2020

Two types of job failures

Deterministic failure (**DT failure**)

- Failure will repeat with retry on failure

  Ex) Syntax errors, API misuse, corrupted data

Non-deterministic failure (**NDT failure**)

- Failure is transient and can be overcome with retry on failure

  Ex) Network failures, MPI daemon errors

Existing approaches for failure handing

Fixed number of retries on failed jobs

- (+) Increase job success rate (retrying NDT failures)
- (−) Waste resources (retrying DT failures)

Termination of failed jobs

- (+) Avoid worthless retry on DT failures
- (−) Lower job success rate (not retrying NDT failures)

Sibylla: Predicting DT vs. NDT failure

Goal No retry on DT failure and retry on NDT failure

Failure classifier in Sibylla

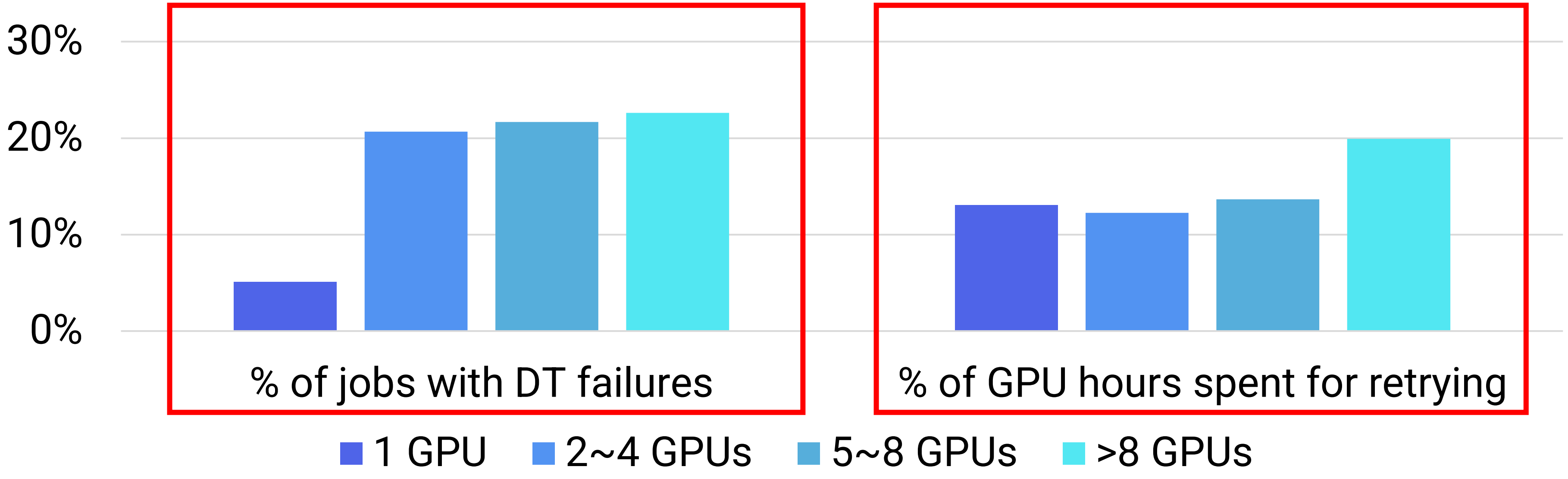
1. Highly accurate with various training error logs
2. Continuously updating without human intervention

Opportunity on predictive retry

Analysis using Microsoft Philly trace [1]

Resource inefficiency caused by DT failures

- 5–23% of jobs experience DT failures across job sizes
- 12–20% of GPU hours are wasted for retrying DT failures



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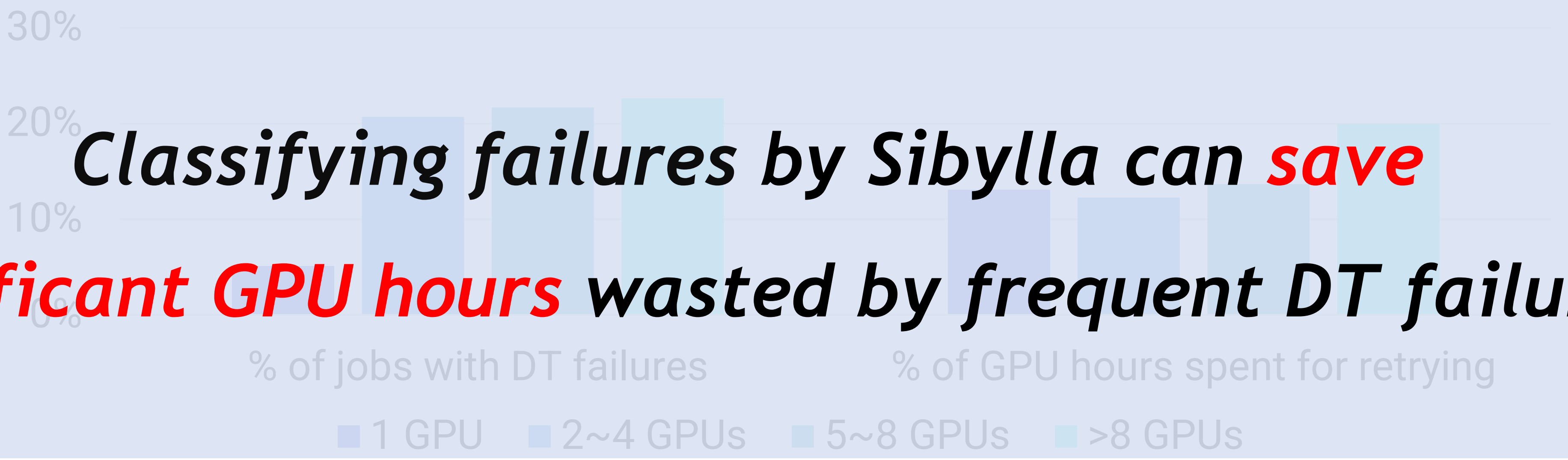

Classifying failures by Sibylla can save

Significant GPU hours wasted by frequent DT failures!

Sibylla: Predicting DT vs. NDT failure

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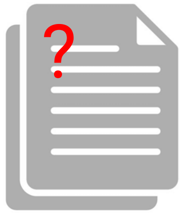
Failure classifier in Sibylla

1. Highly accurate with various training error logs
    - RNN model-based classifier for determining DT/NDT
2. Continuously updating without human intervention

Data source: stderr/stdout streams

Challenge Unstructured and diverse log formats



Failed job log

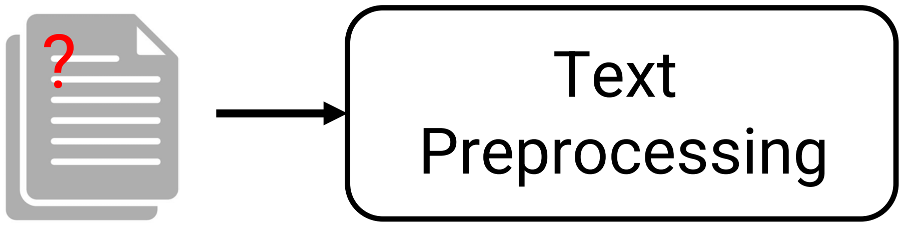
```
in forward(self, x, hidden)
---> 17  x, hidden= self.lstm(x,hidden)

torch\nn\modules\module.py in _call_impl(self, *input, **kwargs)
--> 727  result = self.forward(*input, **kwargs)

torch\nn\modules\rnn.py in forward(self, input, hx)
--> 234  result = _impl(input, hx, …)

TypeError: rnn_tanh() received an invalid combination of arguments - got
(Tensor, Tensor, list, …), but expected one of: * (Tensor, Tensor, Tensor, …)
didn't match because some of the arguments have invalid types: (Tensor,
Tensor, !list!, …)
```

Sibylla: Text preprocessing



Failed job log

Loading input is finished
Loading output is finished
Model loading success

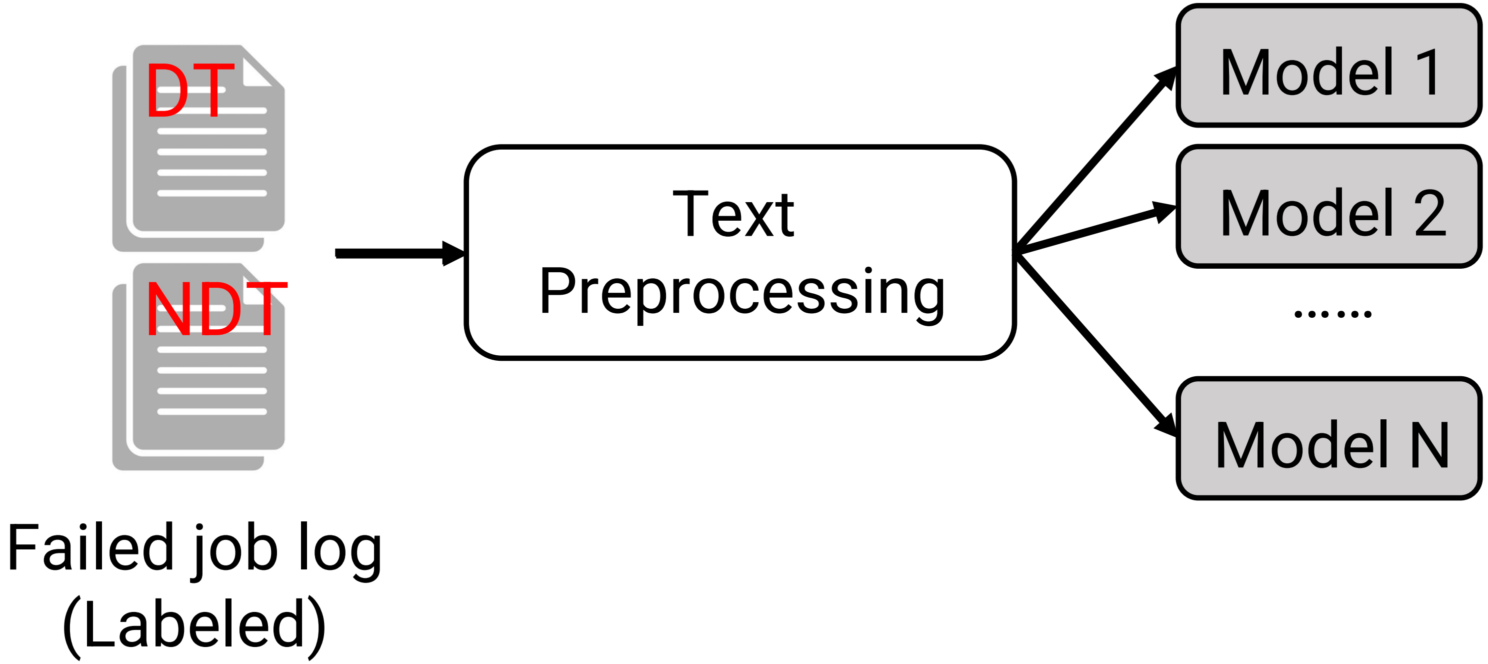
→

Loading * is finished
Model loading success

→

[0.3, 0.2, ……, 0.6]
[0.6, 0.3, ……, 0.1]

Sibylla: Training phase



Log data correctly labeled by domain experts

RNN models (e.g., LSTM, GRU) to build the classifier

Sibylla: Predicting DT vs. NDT failure

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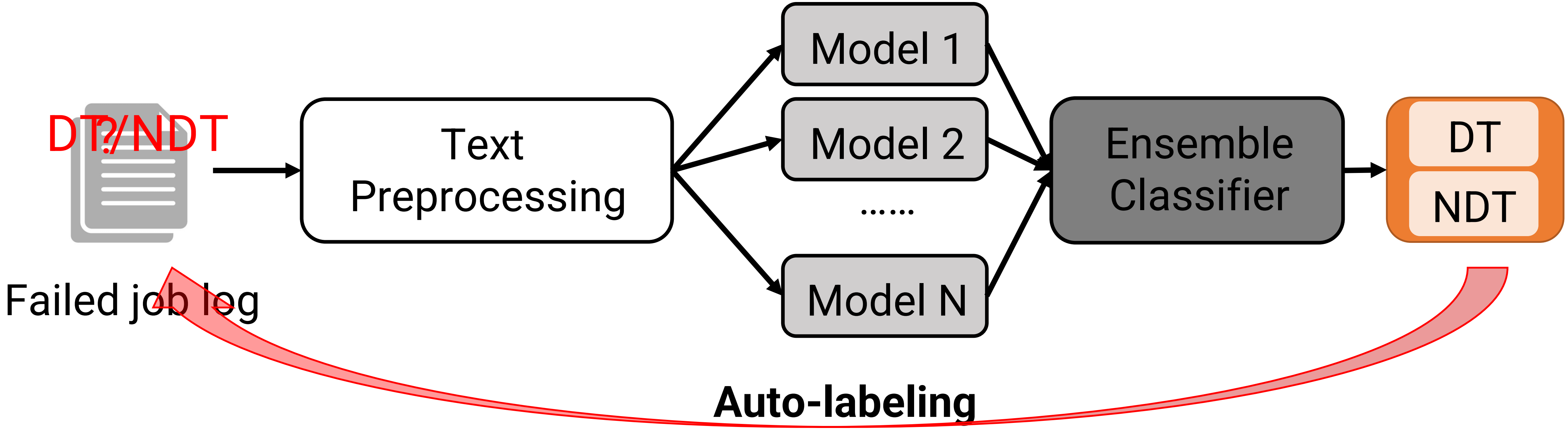
Failure classifier in Sibylla:

1. Highly accurate with various training error logs
2. Continuously updating without human intervention
   - Auto-labeling mechanism with classifier's decision

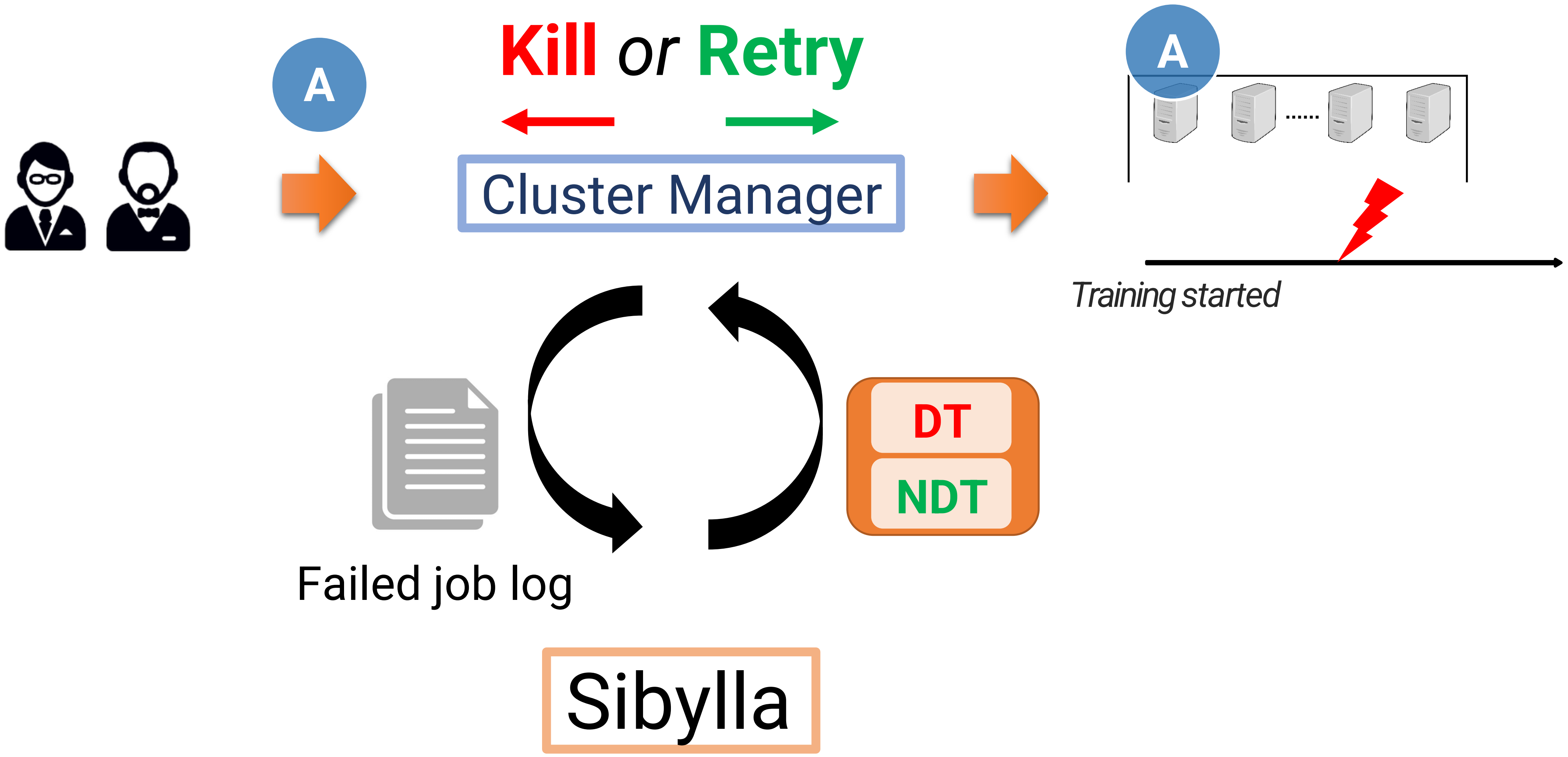
Sibylla: Auto-labeling phase



Online logs auto-labeled for incremental model update

Auto-labeling based on an ensemble method

Tying all together



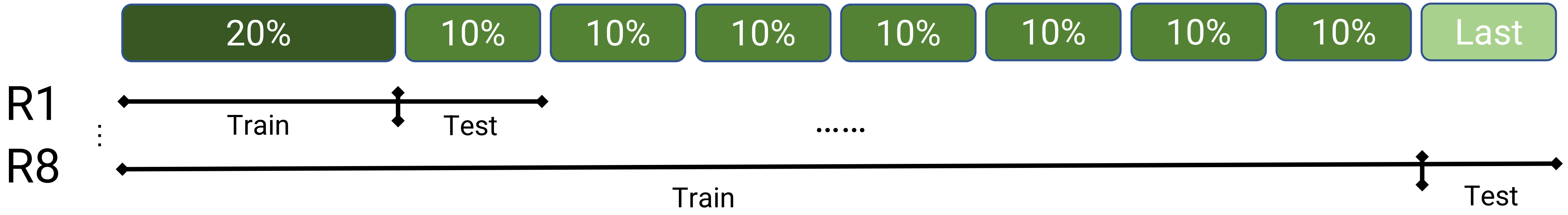
Can *Sibylla* improve cluster efficiency?

Data collection

- 97 logs from a datacenter operator & 159 logs from Stack Overflow
- Augmented from 256 (97+159) to 4468 failure logs

Training strategy

- 20% for initial training, then each 10% auto-labeled for updating classifier

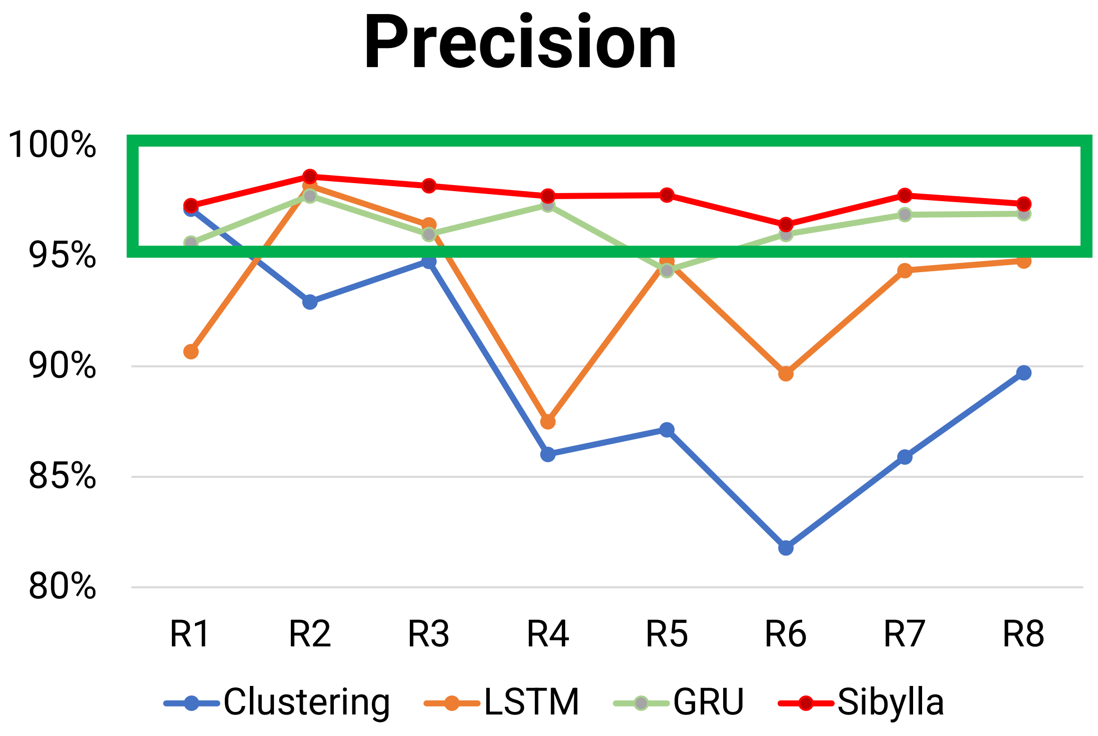


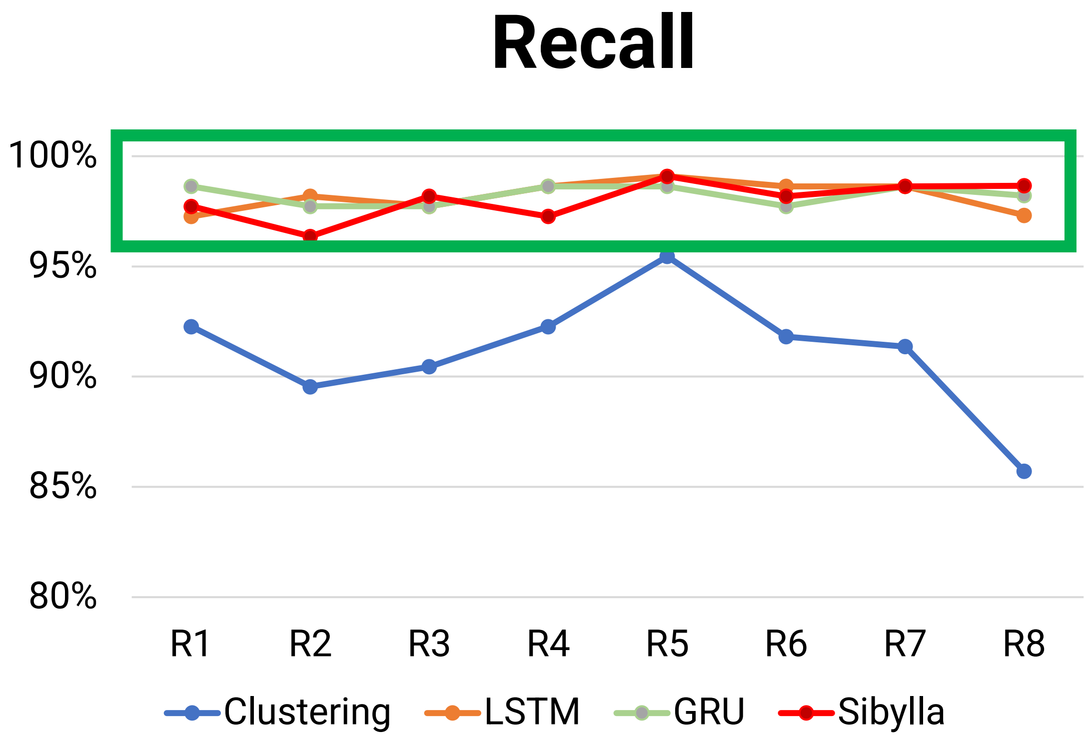
Comparison to Clustering, LSTM, GRU, and Oracle

[1] Gu et al. "Tiresias: A GPU Cluster Manager for Distributed Deep Learning." In NSDI 2019 https://github.com/SymbioticLab/Tiresias

Can *Sibylla* classify failure type well?

Sibylla outperforms other methods in classifying NDT failures





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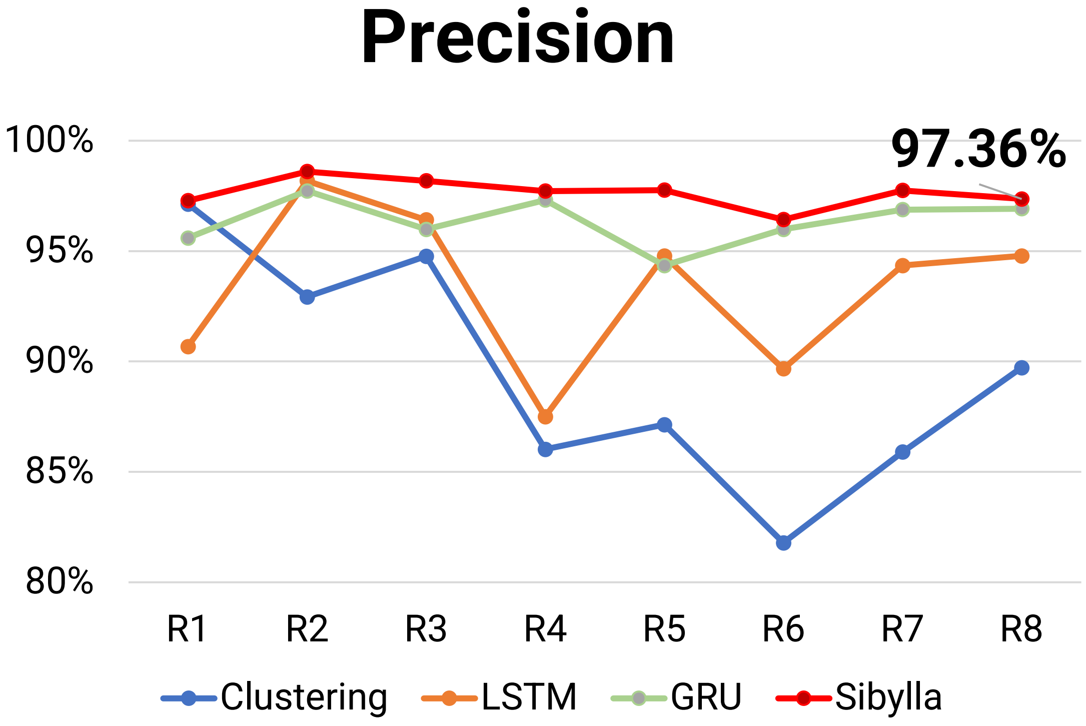

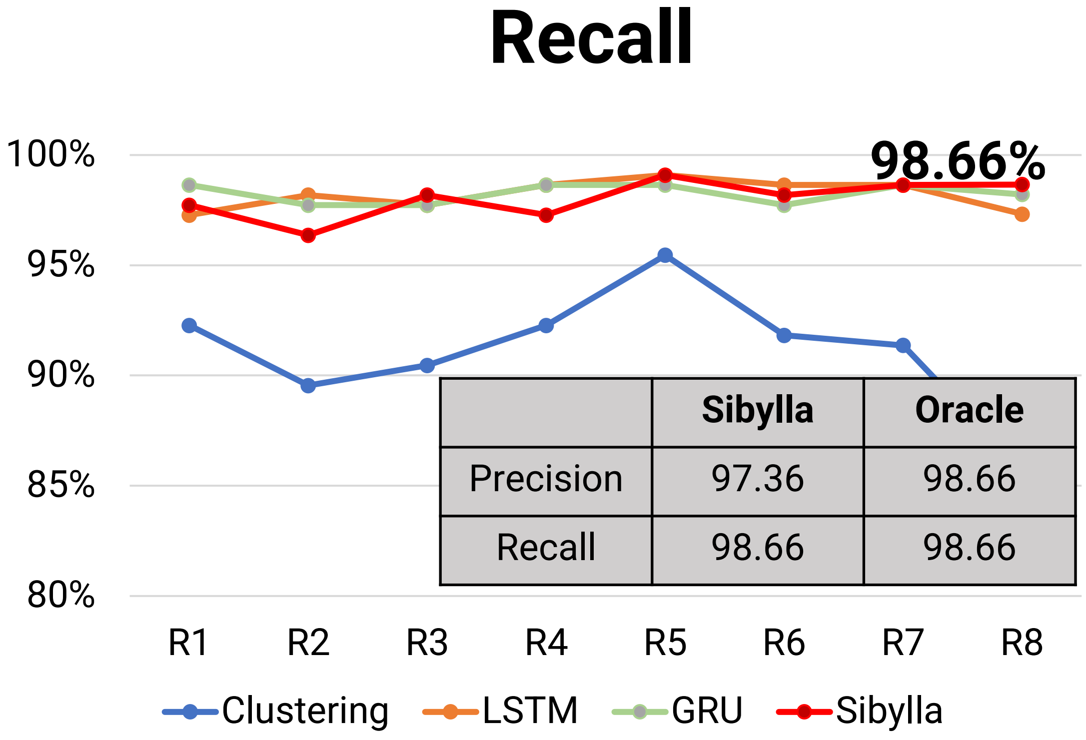

	Sibylla	Oracle
Precision	97.36	98.66
Recall	98.66	98.66

Can *Sibylla* improve cluster efficiency?

Trace-driven simulation

- Job scheduling trace from Microsoft Philly
- Job execution simulator from Tiresias [1]

Three job scheduling policies

- Smallest Job First (SJF), 2D-LAS (DLAS), 2D-Gittins index (GITTINS)

Cluster specification

- 200 nodes, each 8 GPUs, 256GB of host memory, and 64 CPU cores

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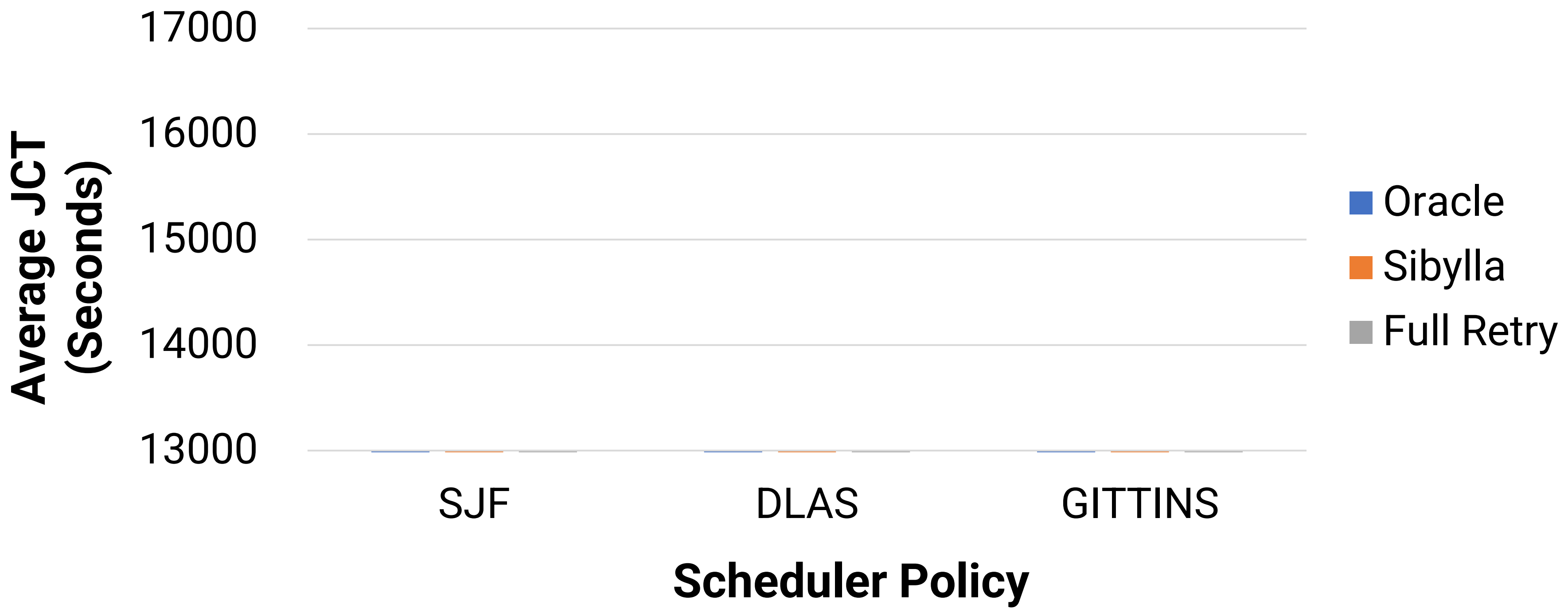
Can *Sibylla* improve cluster efficiency?

Comparison to

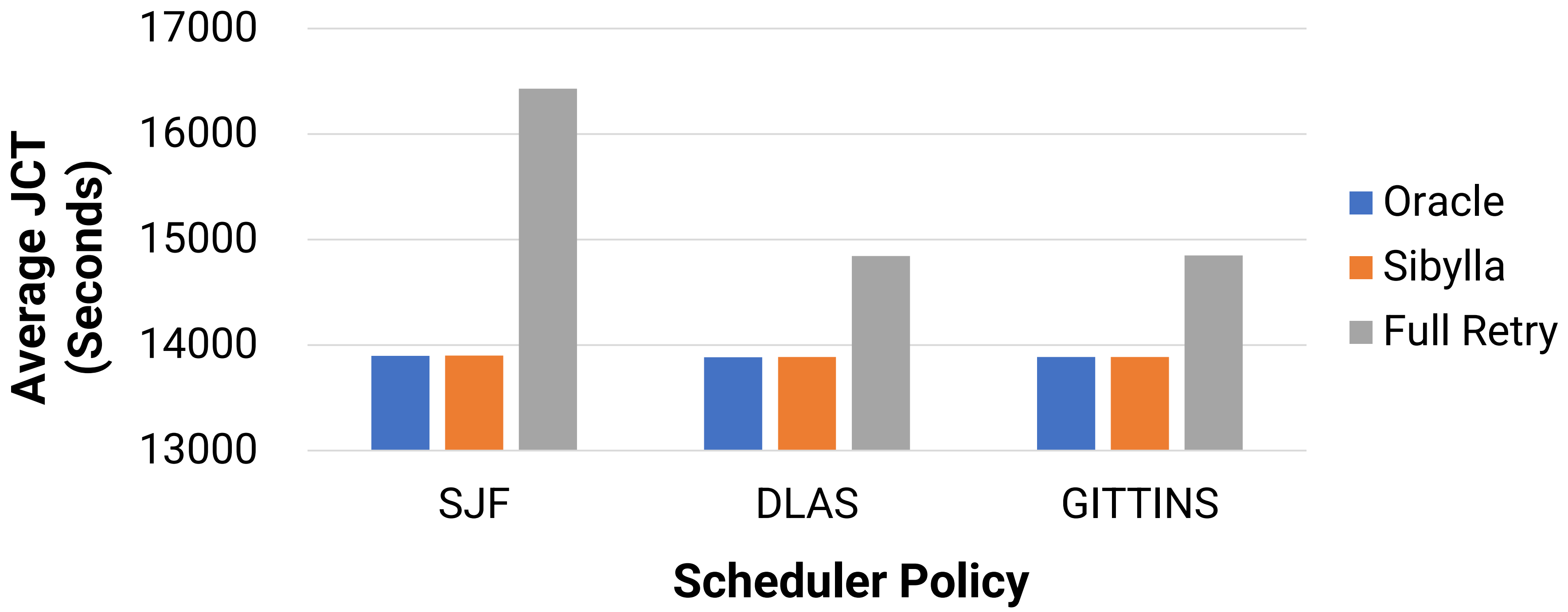
- Oracle: 100% correct predictions
- Full Retry: Retrying jobs w/o prediction (same as *Philly*)



Can *Sibylla* improve cluster efficiency?

Job completion time with Sibylla

- Improves 15.4% for SJF, 6.5% for DLAS and GITTINS than Full Retry
- Worsens only 1.0% compared with 100% correct prediction



Can *Sibylla* maintain job success rate?

Success rate on predictive retry

- Misprediction on failed job leads to lower job success rate

Compared to *Full Retry*

- *Full Retry* has highest job success rate
- *Sibylla* is lower the job success rate by only ***0.06%*** from ***75.04%***

Conclusion

Job failure classifier

- *Sibylla*, predicting DT and NDT to help cluster kill DT and retry NDT

Performance of *Sibylla*

- *Sibylla* achieves consistently high performance on classifying failures
- Predictive retry with *Sibylla* can improve cluster efficiency