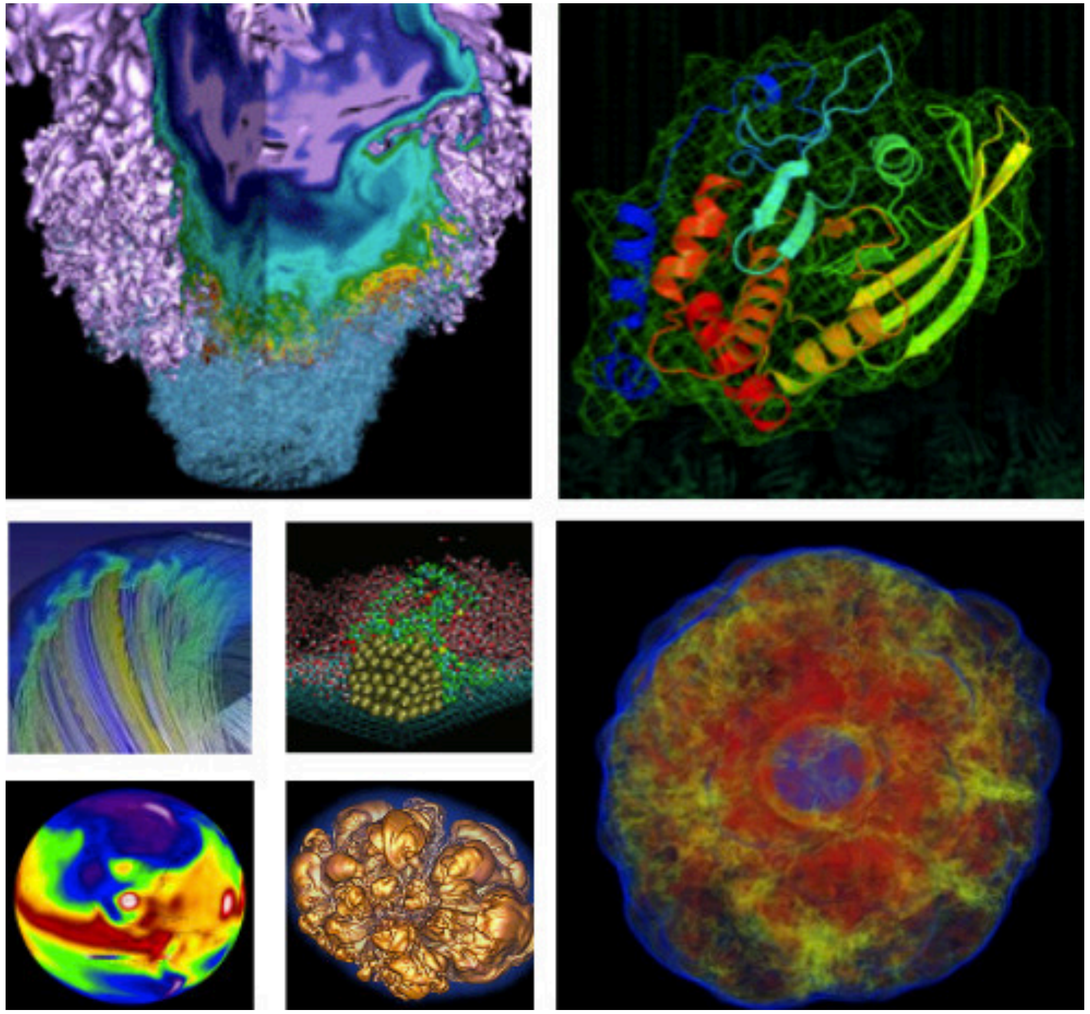
Performance Metric Collection and Analysis

Detect and Identify Applications by Job Signatures



National Energy Research Scientific Computing Center

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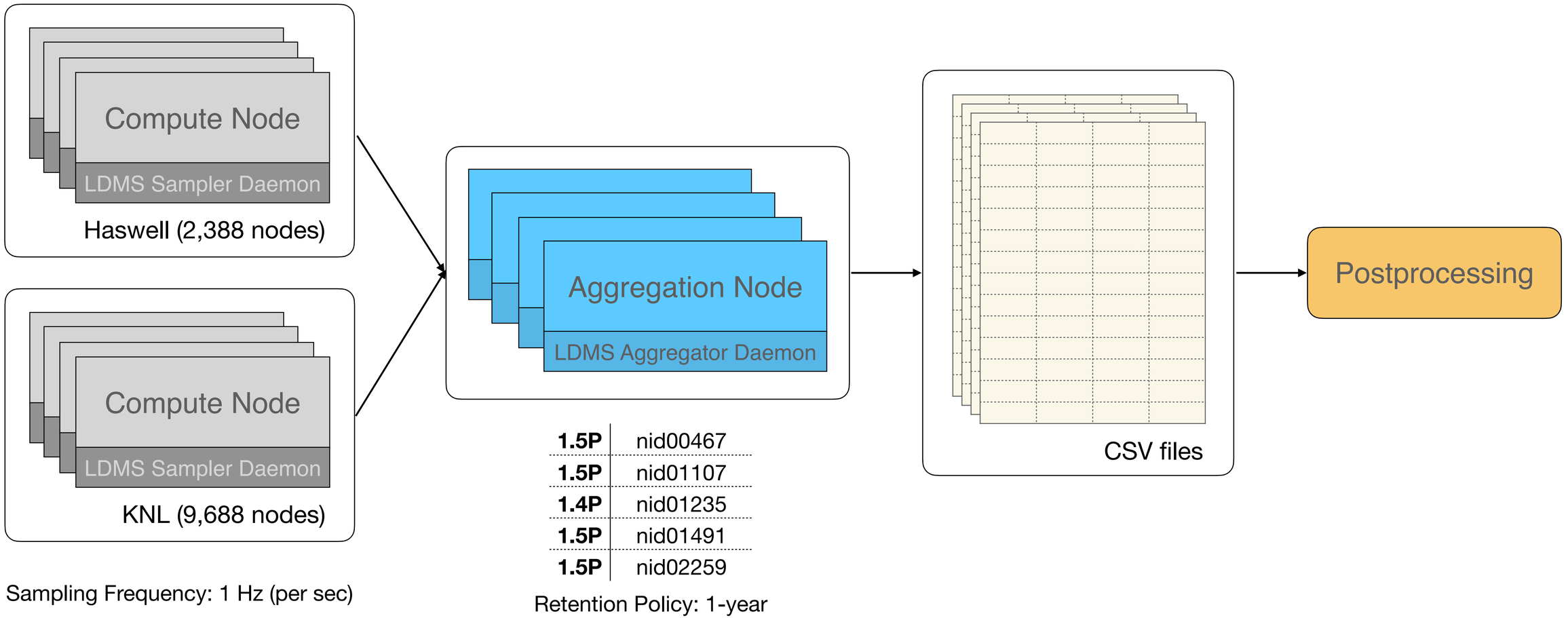
Data collection



Sampling Frequency: 1 Hz (per sec)

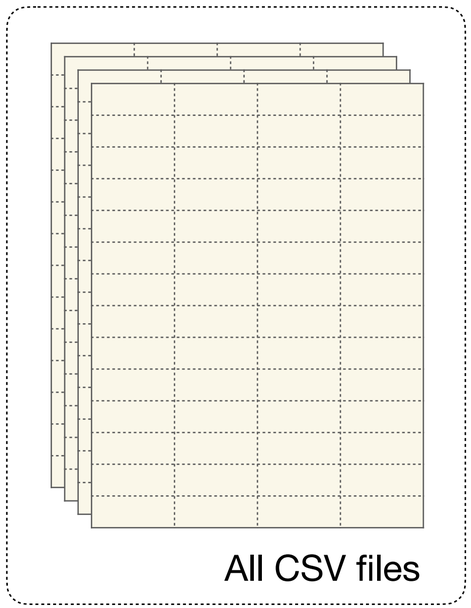
1.5P	nid00467
1.5P	nid01107
1.4P	nid01235
1.5P	nid01491
1.5P	nid02259

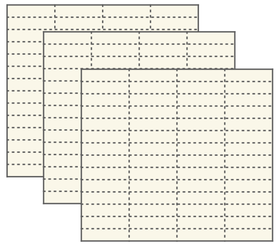
Retention Policy: 1-year

Data volume: ~100 kB/sec/node ~20 TB/day

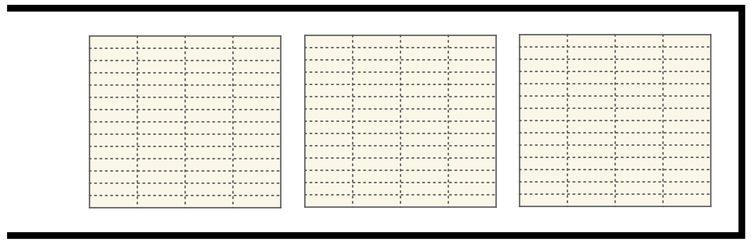
Nersc-ldms workflow

Find CSV files matching some criteria (starttime, endtime)



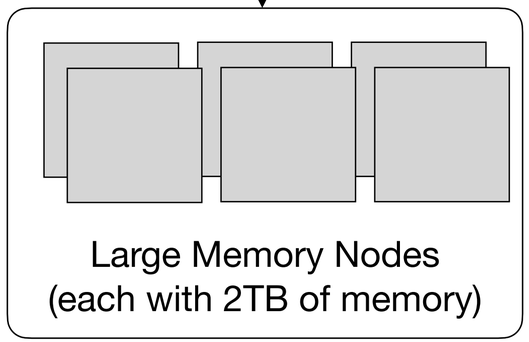


Add CSVs to the work **queue**



Record CSV status
(todo, submitted, done, error)

Submit processing jobs to large memory nodes



<job_id>-cray_aries_sampler-<unique_name>.parquet
<job_id>-lustre_llite-<unique_name>.parquet
<job_id>-meminfo-<unique_name>.parquet
<job_id>-metric_set_nic-<unique_name>.parquet
<job_id>-procstat_Hsw64-<unique_name>.parquet
<job_id>-syspapi_Hsw64-<unique_name>.parquet

Parquet

Write parquet files for each slurm job

Research Topic

Topic: Detect and Identify Applications by Job Signatures

- What is a job signature?
  - The pattern within performance metrics of a job.
- Knowing the applications of jobs is non-trivial.
  - Job names are non-descriptive in most cases.
  - Static analysis of binaries is not enough to detect the same application compiled with different compilers or flags. [1]
  - Static analysis of binaries need a different approach to collect data.
- What can we do with the job signatures?
  - Job signatures offer potential to study a workload by computation motif.
  - Detect and identify application, and optimize scheduling based on knowledge of applications.
  - Detect and block malicious applications such as bitcoin miner.
  - Make procurement/design decisions based on knowledge of typical application requirements

1. Ates, Emre, Ozan Tuncer, Ata Turk, Vitus J. Leung, Jim Brandt, Manuel Egele, and Ayse K. Coskun. "Taxonomist: Application detection through rich monitoring data." In *European Conference on Parallel Processing*, pp. 92-105. Springer, Cham, 2018.

Methodology

- Constructing job signatures:[2]
  - Using entire monitoring traces as signatures.
    - Calculate the distance between pairs of corresponding observations, which requires the two traces be of equal length.
  - Using **statistical summaries** of monitoring traces, or feature vectors, as signatures.
    - Extract features from the raw data.
    - Normalized median, standard deviation, skewness, Kurtosis, Serial Correlation, Nonlinearity, self-similarity, chaos, trend, etc.

2: Combs, Jacob, Jolie Nazor, Rachelle Thysell, Fabian Santiago, Matthew Hardwick, Lowell Olson, Suzanne Rivoire, Chung-Hsing Hsu, and Stephen W. Poole. "Power signatures of high-performance computing workloads." In *2014 Energy Efficient Supercomputing Workshop*, pp. 70-78. IEEE, 2014.

Features

Metric	Sampler
power(W)	cray_aries_sampler
IPC (Instruction Per Cycle)	syspapi_Hsw64, syspapi_Knl272
PAPI_TOT_INS/ PAPI_TOT_CYC	
MemUsed	meminfo
MemTotal - MemFree	

Feature	Function
Median	np.median
Std	np.std
Skewness	scipy.stats.skew
Kurtosis	scipy.stats.kurtosis
Percentile (5%)	lambda: x: np.percentile(x, 5)
Percentile (25%)	lambda: x: np.percentile(x, 25)
Percentile (50%)	lambda: x: np.percentile(x, 50)
Percentile (75%)	lambda: x: np.percentile(x, 75)
Percentile (95%)	lambda: x: np.percentile(x, 95)

Dataset

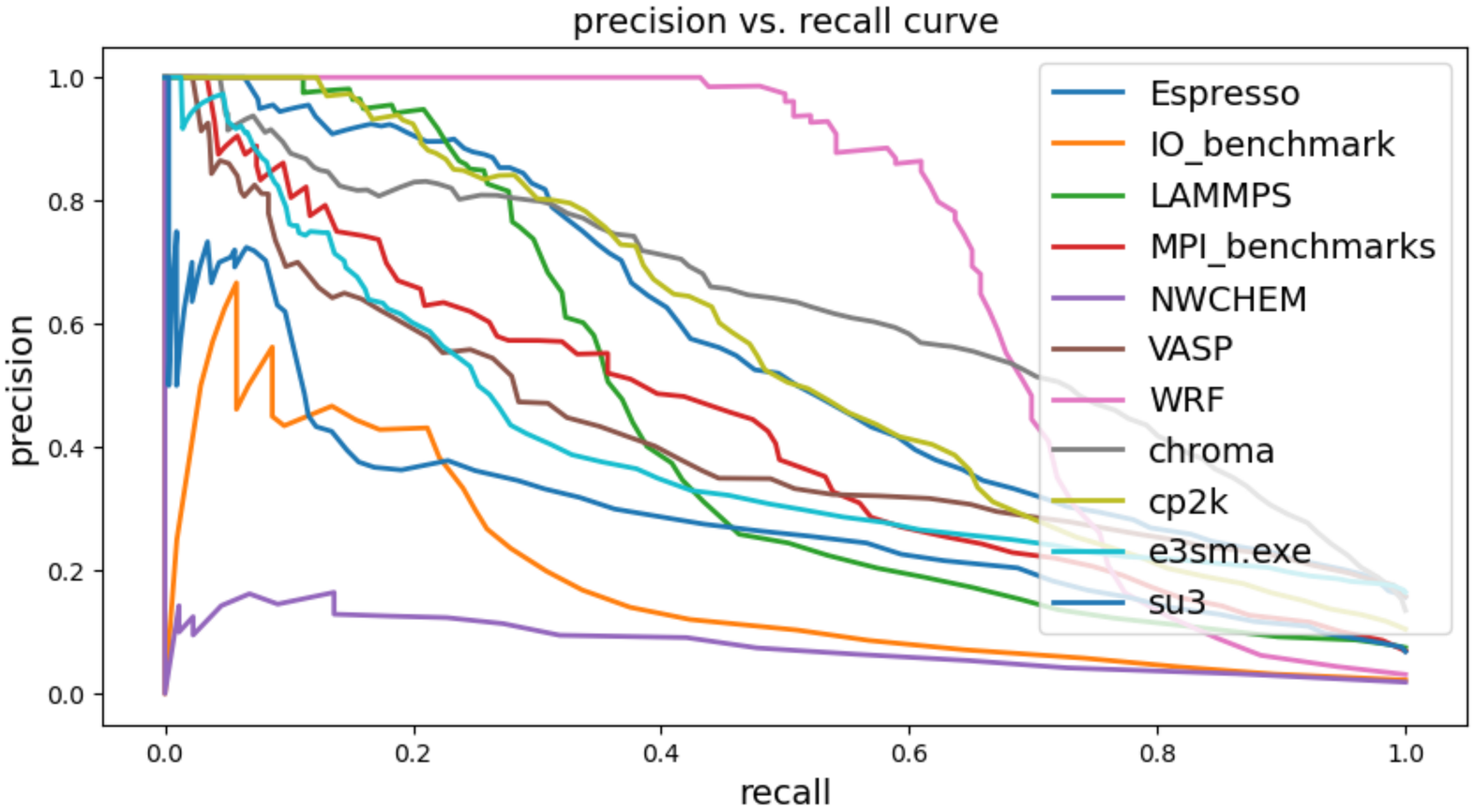
The dataset is generated by the following steps:

- Two months (April and May 2021) of job metadata (843495 records in total) are retrieved from the MySQL database, where the application names are labelled.
- An HPC expert selects the applications with explicit meaningful names.
- The job IDs of the selected applications are used with *nersc_ldms* to obtain the corresponding monitoring metrics.
- These metrics are post-processed and the raw metrics, sampled metrics and extracted features are saved in an HDF file for each job.

There are **18703** job samples.

Machine Learning Model

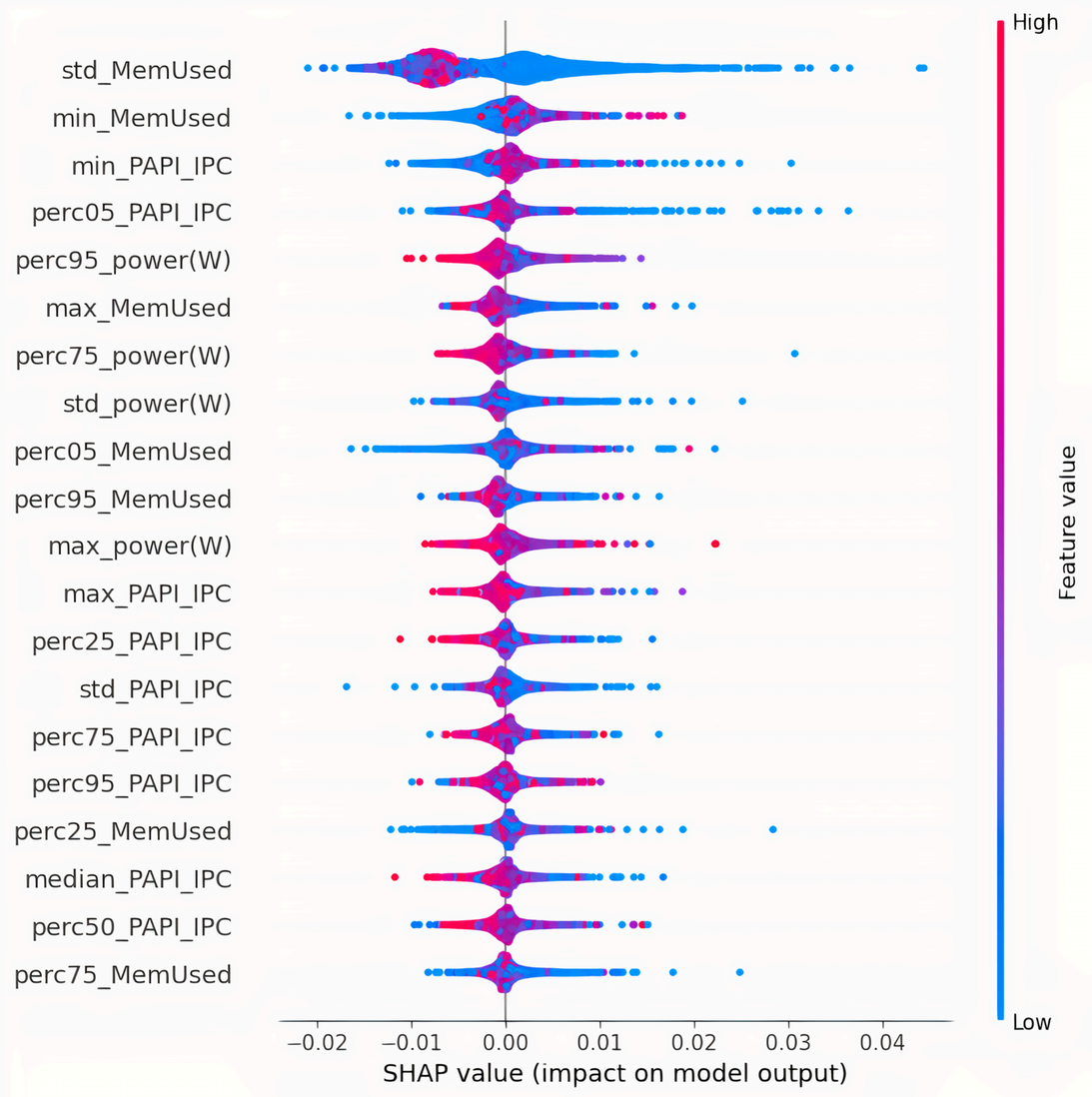
Random Forest: build multiple decision trees and merges them together to get a more accurate and stable prediction.



WRF: a climate simulation application; the variety of workload is relatively small, e.g., the earth is a fixed size and people tend to run with a consistent resolution of physics.

NWChem: a quantum chemistry application which offers a broad range of methods that scale from O(N) to O(N^5) that can be applied to a wide variety of chemical and material systems.

Machine Learning Model



- *std_MemUsed* contributes the most to the predictions of the model.
- *perc75_MemUsed* contributes the least.
- A high value of *std_MemUsed* has a negative impact on the prediction values.

Espresso	IO_benchmark	LAMMPS	MPI_benchmarks	NWCHEM	VASP	WRF	chroma	cp2k	e3sm.ext	su3
0	1	2	3	4	5	6	7	8	9	10