A Profiling Toolkit for HPC in Tiers 2 and 3

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ProfiT-HPC Toolkit

Data collection and storage

The data is collected by the metric collectors (Telegraf or PfiTCollect) and stored in the timeseries database (InfluxDB). The toolkit supports the most popular batchsystems, Slurm and LSF.

Data aggregation and job analysis

The aggregation routine reduces and exports the job metrics. Job analysis aims to detect pathological, low performance or inefficient resource allocation cases by means of defined decision trees.

Reports and recommendations

The toolkit provides *text* and *pdf* reports with performance data and recommendations for improvement based on job analysis. Interactive dashboards show aggregated metrics and indicators. They allow detailed realtime visualization using Grafana.

Structure of the toolkit and dataflow

The modules developed within ProfiT-HPC are shown in Figure 1 in **green**.

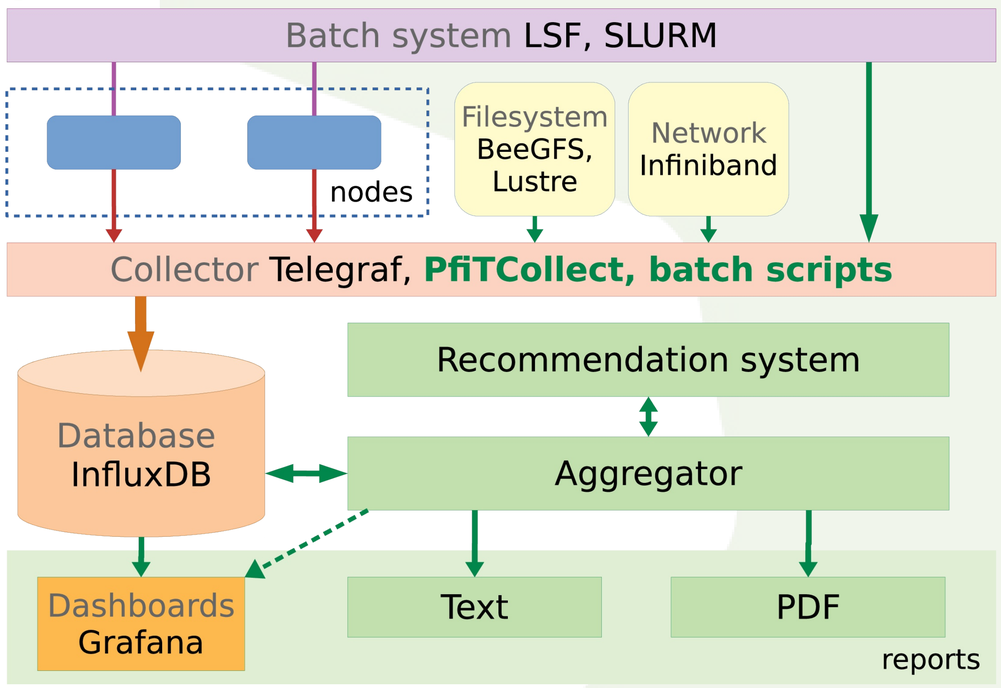


Fig. 1: The structure of ProfiT-HPC toolkit

Job Analysis

Recommendations

The toolkit uses programmable rules to provide recommendations for users. Rules are formed by *attributes*, which are properties of the job with a fixed set of values they can take. Particular combinations of attributes with specified values form the *rules*.

Decision trees

With such attributes, the rules can be represented as a decision tree. Figure 2 shows an example of a partial decision tree used to generate the recommendations in the presented reports. However, when rules become more complicated, building comprehensive decision trees is not a trivial process; various algorithms, such as *RBDT-1 [1]*, are used to generate shorter trees.

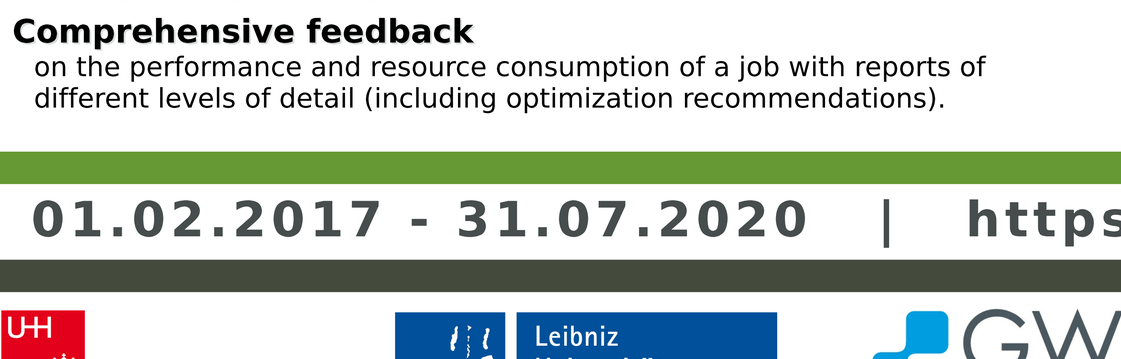


Fig. 2: The partial decision tree used in examples

[1] *Amany Abdelhalim, Issa Traore, and Youssef Nakkabi. 2016. Creating Decision Trees from Rules using RBDT-1. Comput. Intell. 32, 2 (May 2016), 216–239. doi.org/10.1111/coin.12049*

Reports and Recommendations

```
                        General Information
-------------------------------------------------------------------------------
User Name:                              theuser
JobID:                                  2837739
Used Queue/Partition:                   gpu
Used Nodes:                             3
Requested Compute Units:                12
                                         ...

          CPU utilization. Mean values + high water mark (hwm) values
-------------------------------------------------------------------------------
                |          CPU usage          |      memory used      |  memory  |
    nodes       |  cores  | total[%] |  hwm[%]  | hwm[GiB] |mean[GiB] |alloc[GiB]|
----------------+---------+----------+----------+----------+----------+----------+
       dge009|         4|       100|       100|      0.60|      0.59|     20.97|
                                        ...

          GPU utilization. Mean values + high water mark (hwm) values
-------------------------------------------------------------------------------
                                GPU                                |      CPU      |
    nodes       |    ID     |  usage   |  usage   |  memory  |  # proc  |  usage   |
                |   [bus]   |  mean[%] |  hwm[%]  |  hwm[%]  |  total   |  hwm[%]  |
----------------+-----------+----------+----------+----------+----------+----------+
       dge009|         02|         1|         4|         4|         2|        50|
                |         03|         1|         4|         4|         2|        50|
                                        ...

                Per node IO and network. Sums and rates
-------------------------------------------------------------------------------
                                IO                  |       Infiniband       |
    nodes       |  read (sum)   |  write (sum)  | receive[/sec] |  send[/sec]    |
----------------+---------------+---------------+---------------+----------------+
       dge009|      23.88 MiB|           0 B|      17.37 MiB|      17.28 MiB|
                                        ...

                              Recommendations
-------------------------------------------------------------------------------
- All GPUs have low usage, which might be caused by misconfiguration of
  the application/job
- Some GPUs have more than 1 process using them at the same time. Check
  the balance between CPU processes and amount of used GPUs
```

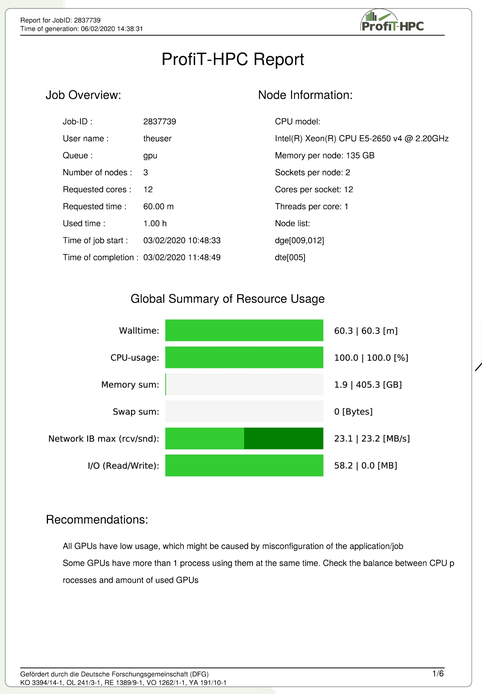
Text report

provides a short summary of the job with various metrics and recommendations.

The report is designed to be configurable. The text report can be printed at the end of the job to user's shell, saved as a text file or sent via email.

Recommendations indicate possible problems in the job and can be used as a starting point of investigating job issues.

Additional time series are available in the other report types.


Report for JobID: 2837739
Time of generation: 06/02/2020 14:38:31

ProfiT-HPC Report

Job Overview:

Job-ID :	2837739
User name :	theuser
Queue :	gpu
Number of nodes :	3
Requested cores :	12
Requested time :	60.00 m
Used time :	1.00 h
Time of job start :	03/02/2020 10:48:33
Time of completion :	03/02/2020 11:48:49

Node Information:

CPU model:	Intel(R) Xeon(R) CPU E5-2650 v4 @ 2.20GHz
Memory per node:	135 GB
Sockets per node:	2
Cores per socket:	12
Threads per core:	1
Node list:	
	dge[009,012]
	dte[005]

Global Summary of Resource Usage

Walltime:	60.3 | 60.3 [m]
CPU-usage:	100.0 | 100.0 [%]
Memory sum:	1.9 | 405.3 [GB]
Swap sum:	0 [Bytes]
Network IB max (rcv/snd):	23.1 | 23.2 [MB/s]
I/O (Read/Write):	58.2 | 0.0 [MB]

Recommendations:

All GPUs have low usage, which might be caused by misconfiguration of the application/job
Some GPUs have more than 1 process using them at the same time. Check the balance between CPU processes and amount of used GPUs

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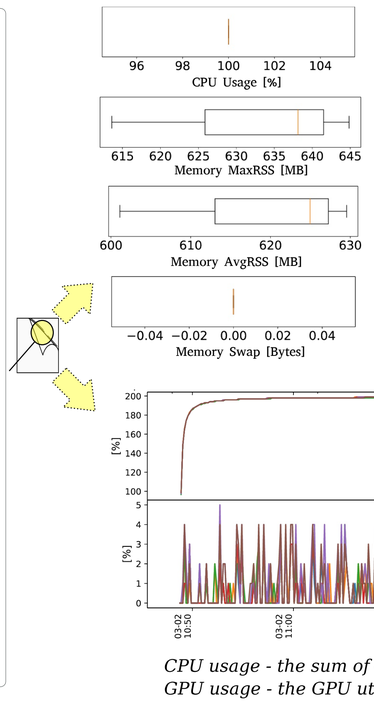

CPU usage - the sum of CPU usage of processes using the GPU
GPU usage - the GPU utilization

PDF report

provides additional information in a more comprehensive way.

It includes distributions (5 point boxplots) and time series data.

The first page is sufficient to get a short summary of the job and recommendations.

Interactive dashboards

Dashboards are accessable during or after the job execution, for instance, as a color coded global job indicators or as process (or node) usage distribution as bar chart diagrams shown in the Figure 3.

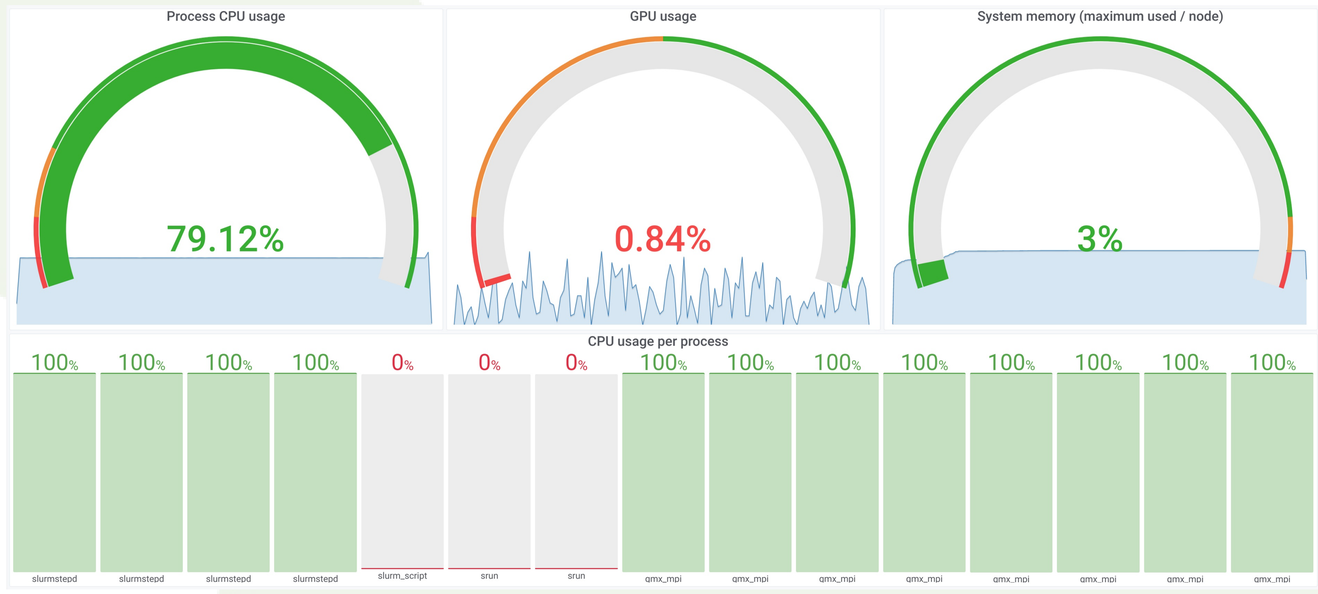

Fig. 3: An example of Grafana dashboards. Charts show low GPU usage and nearly 100% CPU usage of all processes of the job

Goals

Increase awareness
of the importance of HPC applications performance (issues and parameters) for the large number of new users typical for Tier 3 systems; provide necessary background for transfer to Tier 2 systems

Automatic metric collection and data storage
with no or minor systems performance impact

Automatic performance analysis
of the job and generating recommendations for optimization

Comprehensive feedback
on the performance and resource consumption of a job with reports of different levels of detail (including optimization recommendations).

Achievements

Development of complete monitoring, analysis and reporting toolkit
including metric collector, job analysis, recommendation system and report generation

Automatic collection of metrics from various sources
process and node based (for shared and non-shared nodes)

Automatic job performance analysis
detects pathological and low performance cases

Automatic report generation with recommendations
offering different levels of details for review of performance and resource consumption of a job and formulation of recommendations for improving code or job parameters

Tool has been successfully deployed on the targeted systems

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