## High Performance Computing Systems (CMSC714)

## Lecture 8: Perf. Analysis & Visualization



## Abhinav Bhatele, Department of Computer Science

# Summary of last lecture

- Task-based programming models and Charm++
- Key principles:
  - Over-decomposition, virtualization
  - Message-driven execution
- Automatic load balancing, checkpointing, fault tolerance





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# **Tracing tools**

- Record all the events in the program with timestamps
- Events: function calls, MPI events, etc.

Vampir visualization: <u>https://hpc.llnl.gov/software/development-environment-software/vampir-vampir-server</u>



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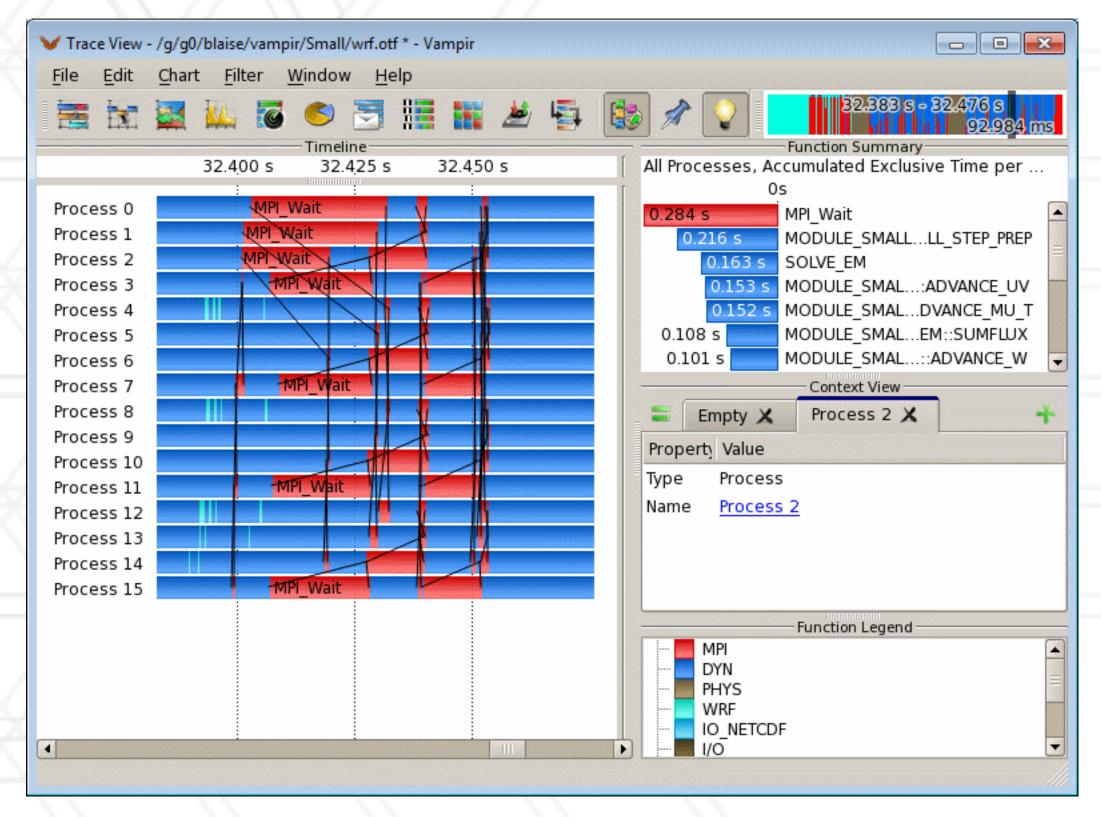


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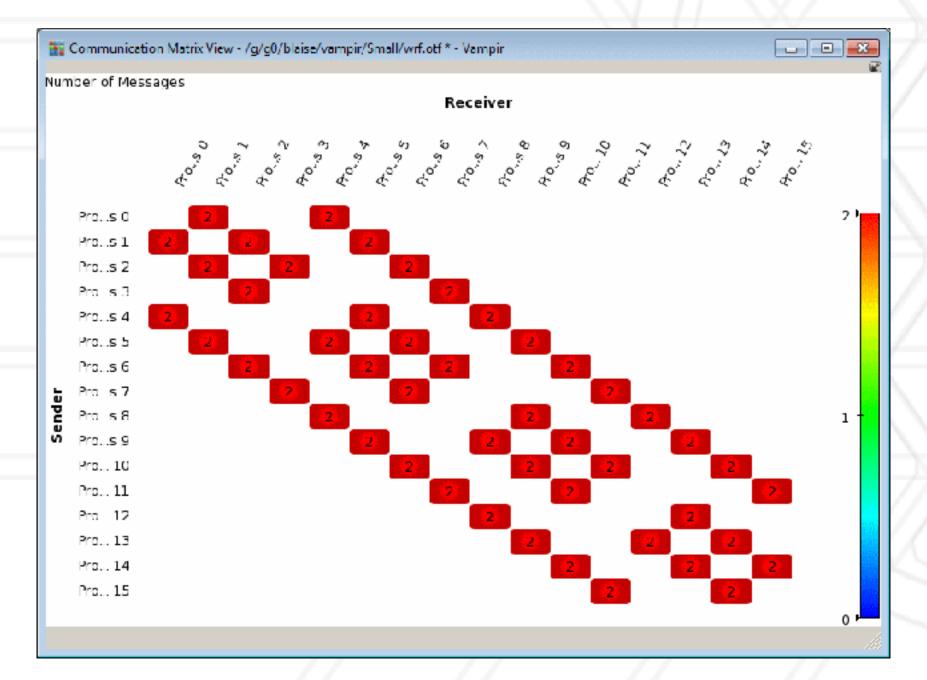


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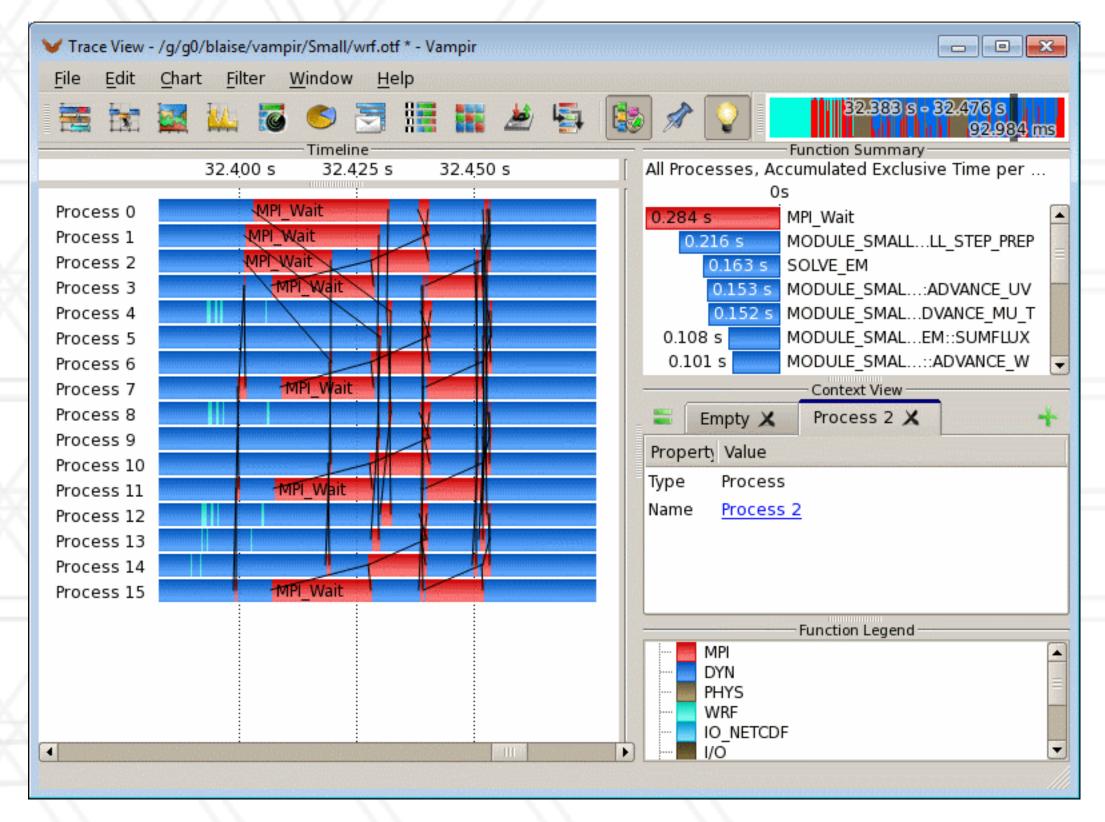
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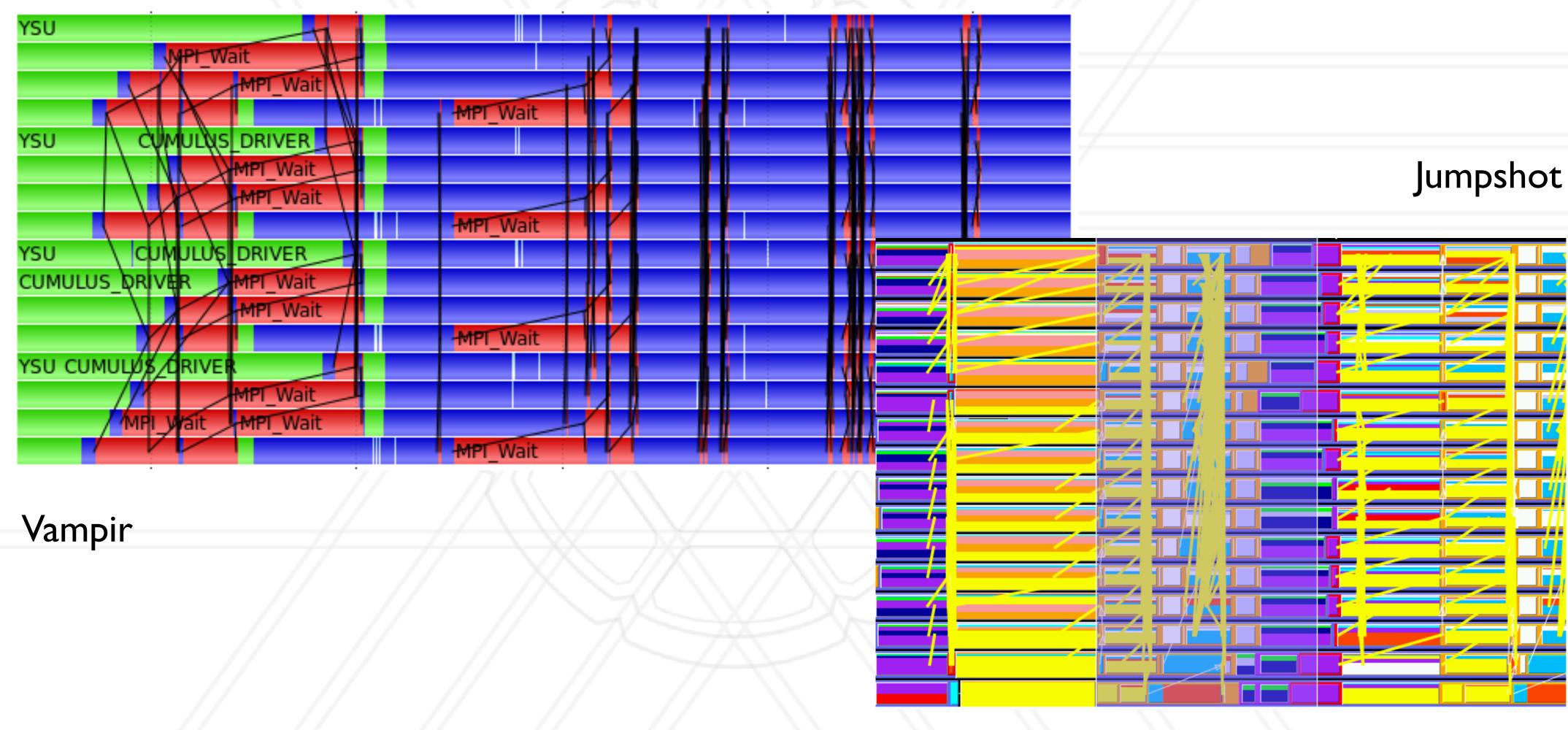


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## **MPI trace visualization**

- Process 0
- Process 1
- Process 2
- Process 3
- Process 4
- Process 5
- Process 6
- Process 7
- Process 8
- Process 9
- Process 10
- Process 11
- Process 12
- Process 13
- Process 14
- Process 15





LIVE RECORDING

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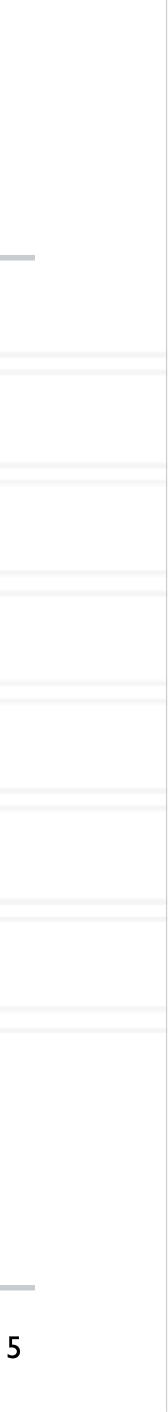
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# **Projections Performance Analysis Tool**

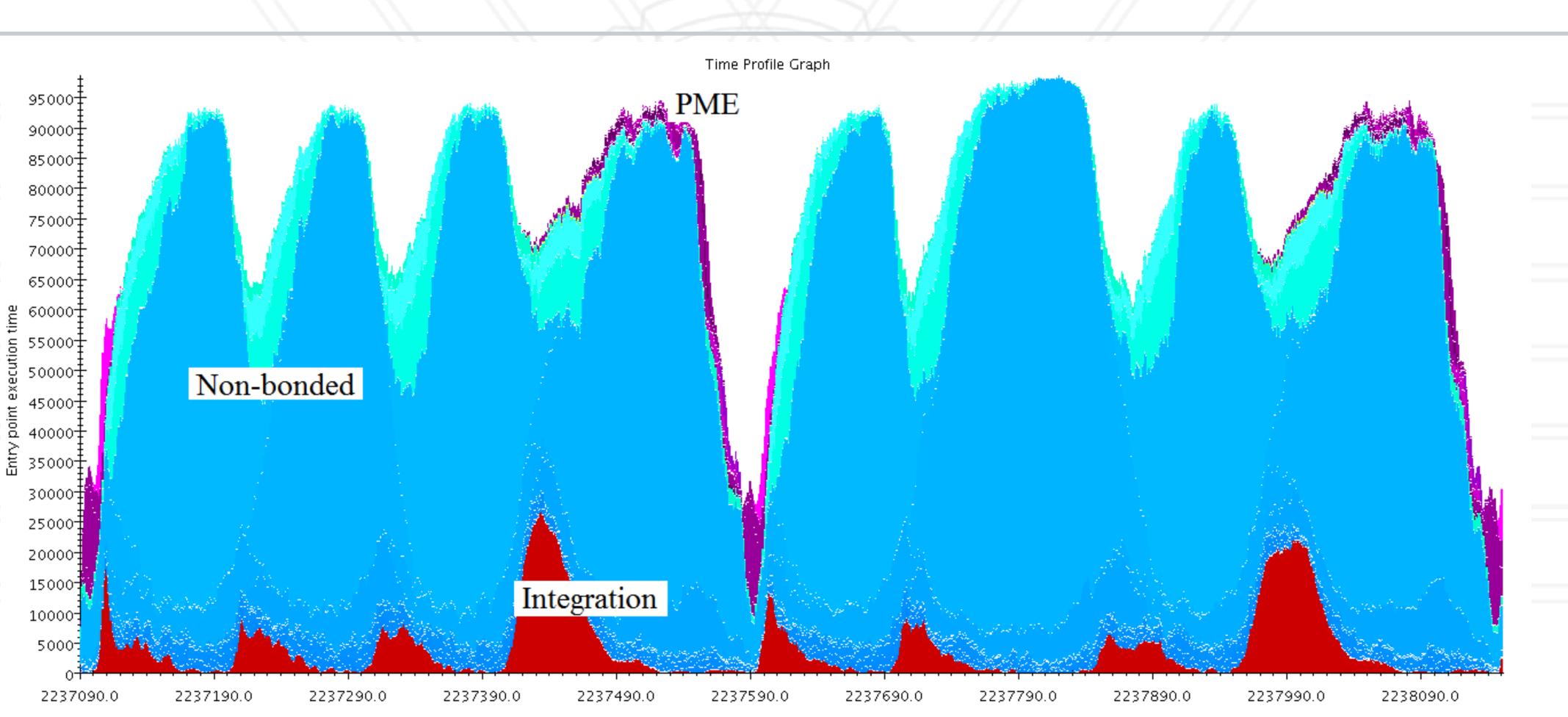
- For Charm++/Adaptive MPI programs
- Instrumentation library
  - Records data at the granularity of chares (Charm++ objects)
- Java-based GUI



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## **Time Profile**



Time Interval (0.100ms)

https://charm.readthedocs.io/en/latest/projections/manual.html

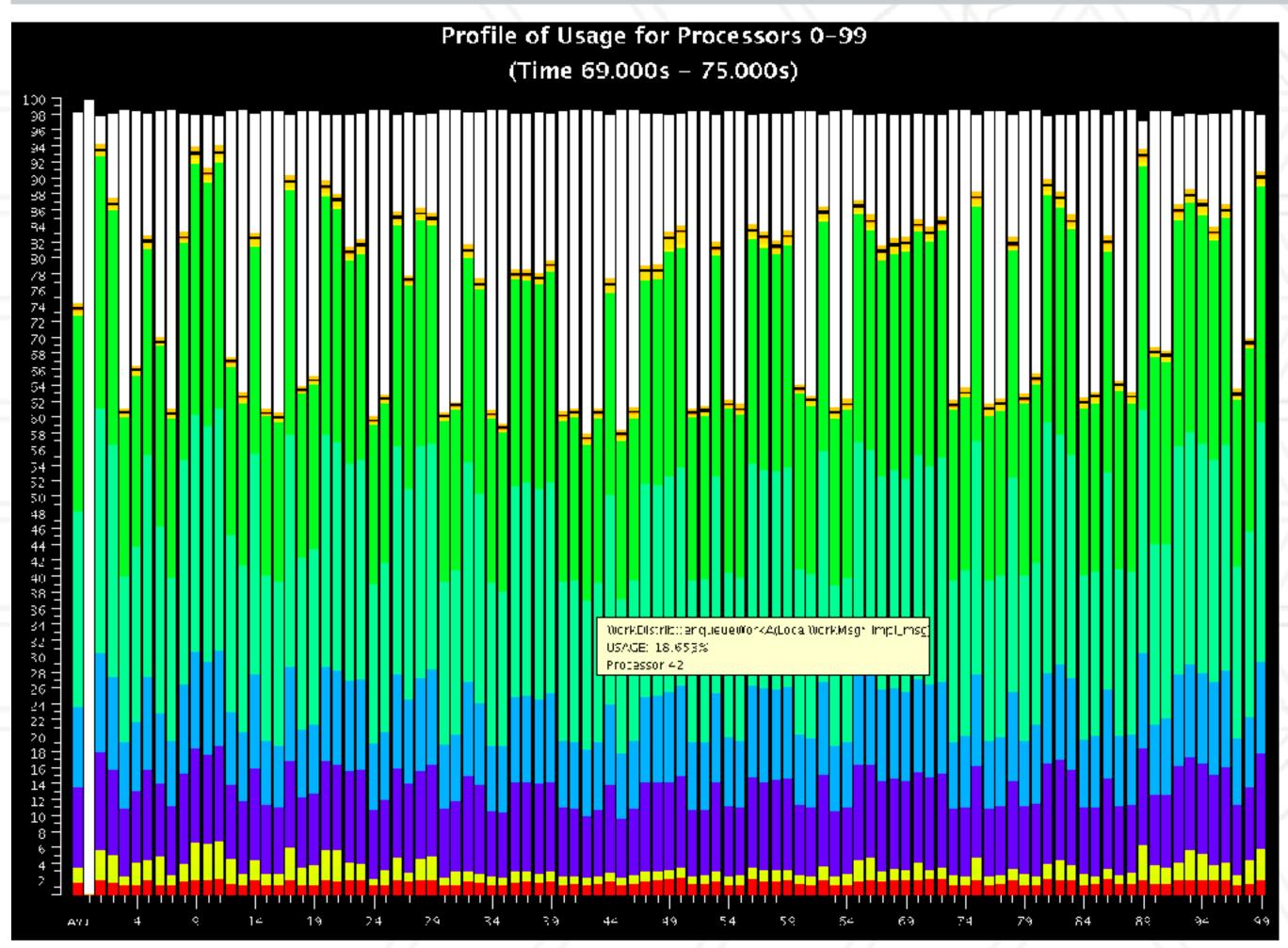


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## LIVE RECORDING

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## **Usage Profile & Histogram View**



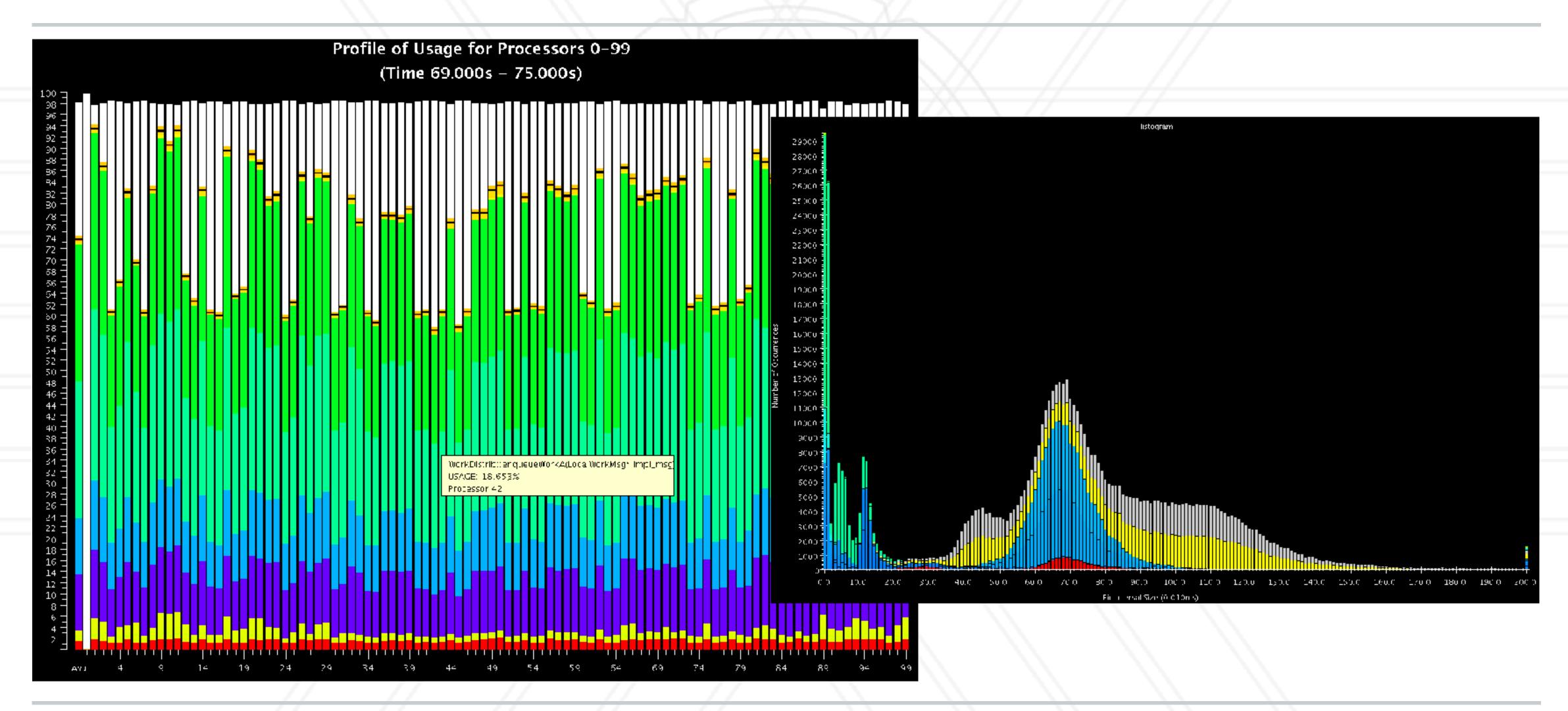


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## **Usage Profile & Histogram View**





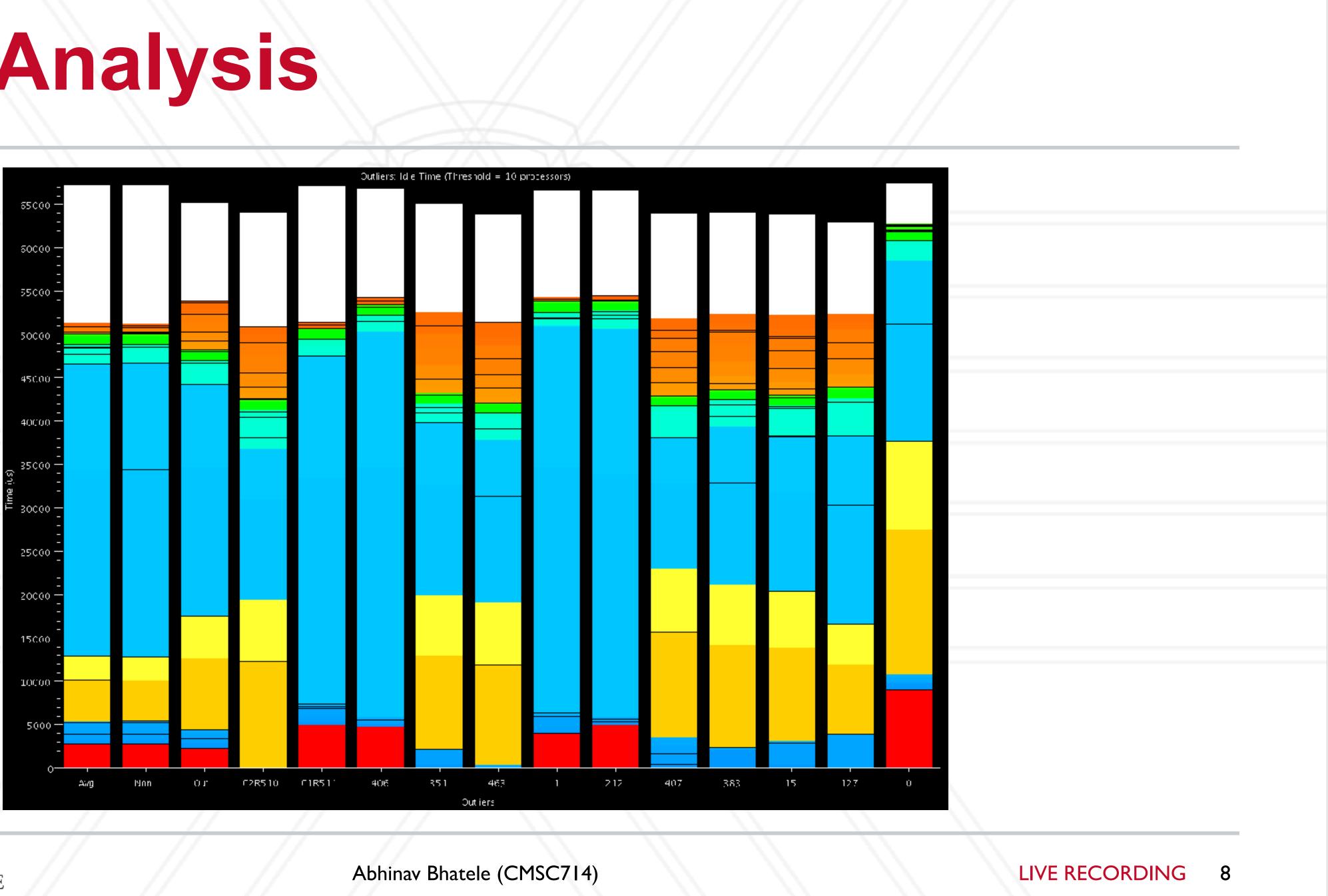
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LIVE RECORDING

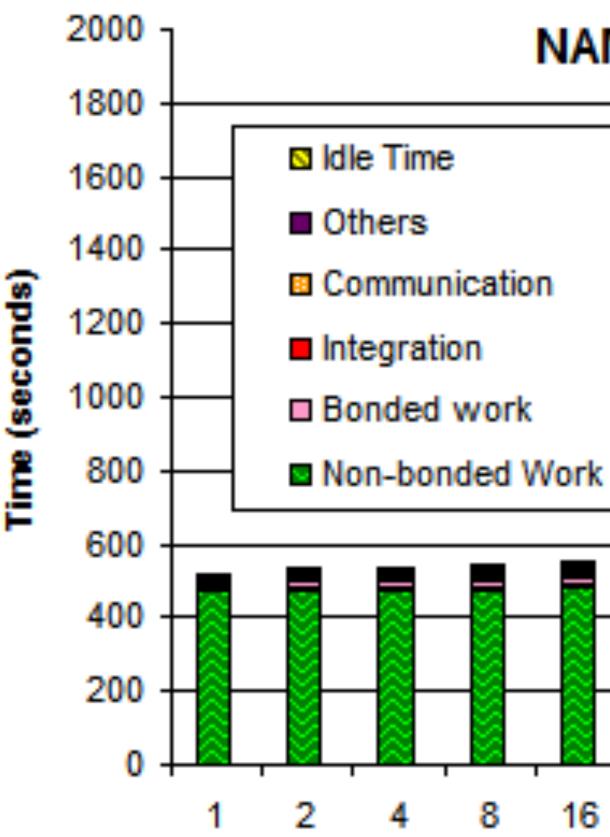
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## **Outlier Analysis**





# Scripting for multi-run comparisons





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Processors

# NAMD on Blue Gene/L 256 512 1024 2048 4096 64 128 32



## Limitations of current analysis tools

- Support their own unique format(s)
- Limited support for saving or automating analysis
- Most tools only support viewing one dataset at a time
- Lack capabilities to sub-select and focus on specific parts



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13		
76	inline void globalSumArray(float *dest, int ien)	
77		
78	QMP_sum_float_array(dest, len);	
75		
50		
51	//! Low level hook to QMP_global_sum	
52		
53	수는 그는 것 같아요. 이 의 수는 것 같아요. 이 이 이 이 이 이 이 이 이 이 이 이 이 이 이 이 이 이 이	
6 54		
55		
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57	/// Global sum on a multi1d	
88	template <class t=""></class>	
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## hpcviewer's GUI

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## Limitations of current analysis tools

- Support their own unique format(s)
- Limited support for saving or automating analysis
- Most tools only support viewing one dataset at a time
- Lack capabilities to sub-select and focus on specific parts

## Do not enable programmatic analysis of the data by the end user



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hpcviewer's GUI



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## Hatchet

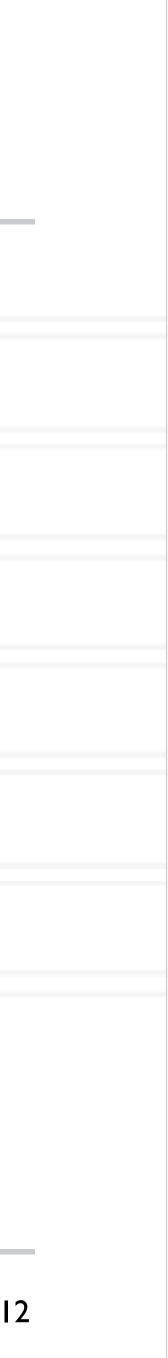
- A Python-based library to enable programmatic analysis
- Creates an in-memory representation of the graph
- Leverage pandas which supports multi-dimensional tabular datasets
  - Use graph as structured index to index pandas dataframes
- A set of operators to sub-select and/or aggregate profile data
- A set of operators to compare multiple datasets



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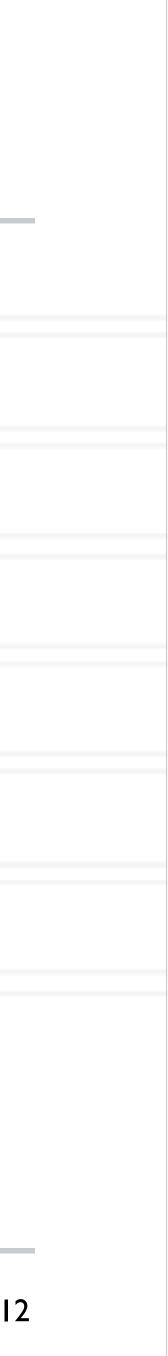


 Pandas is an open-source Python library for data analysis







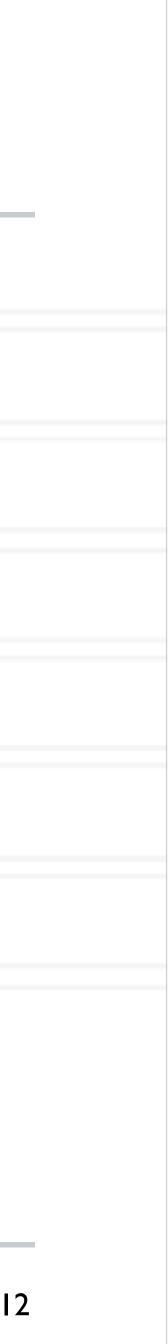


- Pandas is an open-source Python library for data analysis
- Dataframe: two-dimensional tabular data structure
  - Supports many operations borrowed from SQL databases



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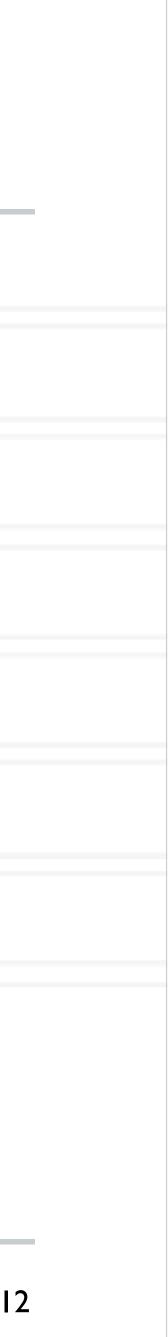
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	4	{'name': 'solvers'}	solvers	100.0	10.0	
	5	{'name': 'hypre'}	hypre	65.0	30.0	
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- MultiIndex enables working with highdimensional data in a 2D data structure



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	4	{'name': 'solvers'}	solvers	100.0	10.0				
		5	{'name': 'hypre'}	hypre	65.0	30.0			
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# **Central data structure: a GraphFrame**

- Consists of a structured index graph object and a pandas dataframe
- Graph stores caller-callee relationships
- Dataframe stores all numerical and categorical data



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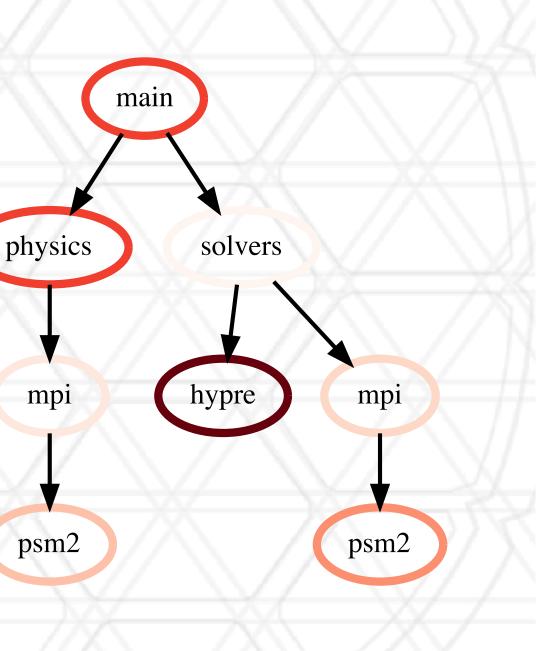




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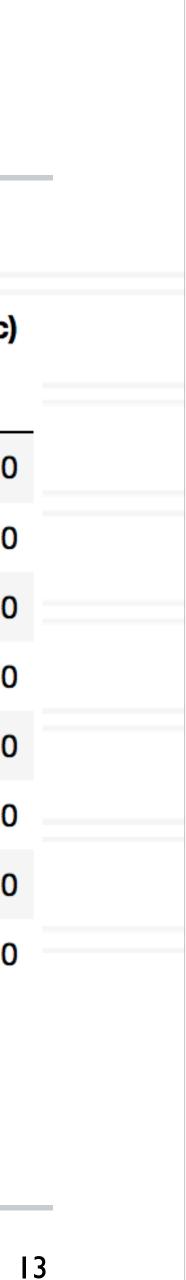


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	main	main	0	main	40.0	200.0
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physics solvers	mpi	mpi	2	mpi	5.0	20.0
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	hypre	hypre	5	hypre	65.0	65.0
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	psm2	psm2	7	psm2	25.0	25.0





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## Questions?



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