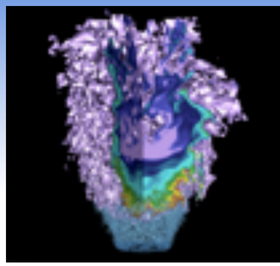
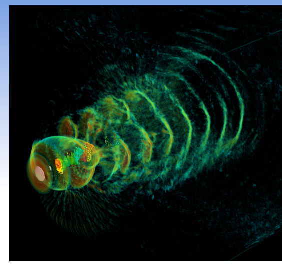
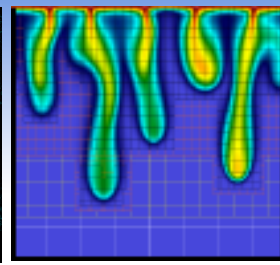
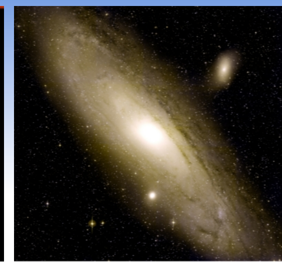
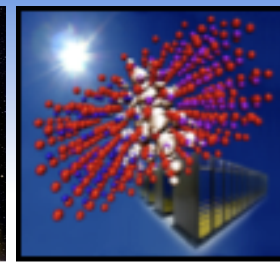
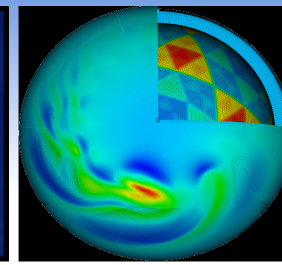

Describing Performance and Resource Needs of DOE Office of Science Workloads

David Skinner

Lawrence Berkeley Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

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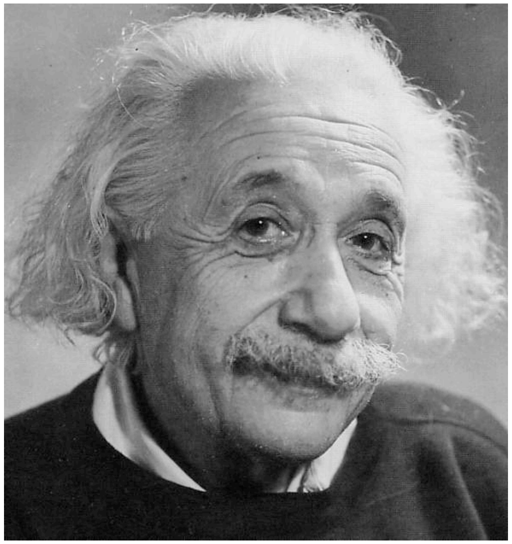
in this talk…

- NERSC, Magellan Overview
- Integrated Performance Monitoring
- Magellan Workload

a quick preface on HPC performance…

Performance is Relative

- **To your goals**
  - Time to solution, $T_{queue}+T_{run}$
  - Efficient use of allocation
  - Do FLOPs even matter?



- **To the**
  - application code
  - input deck
  - machine type/state

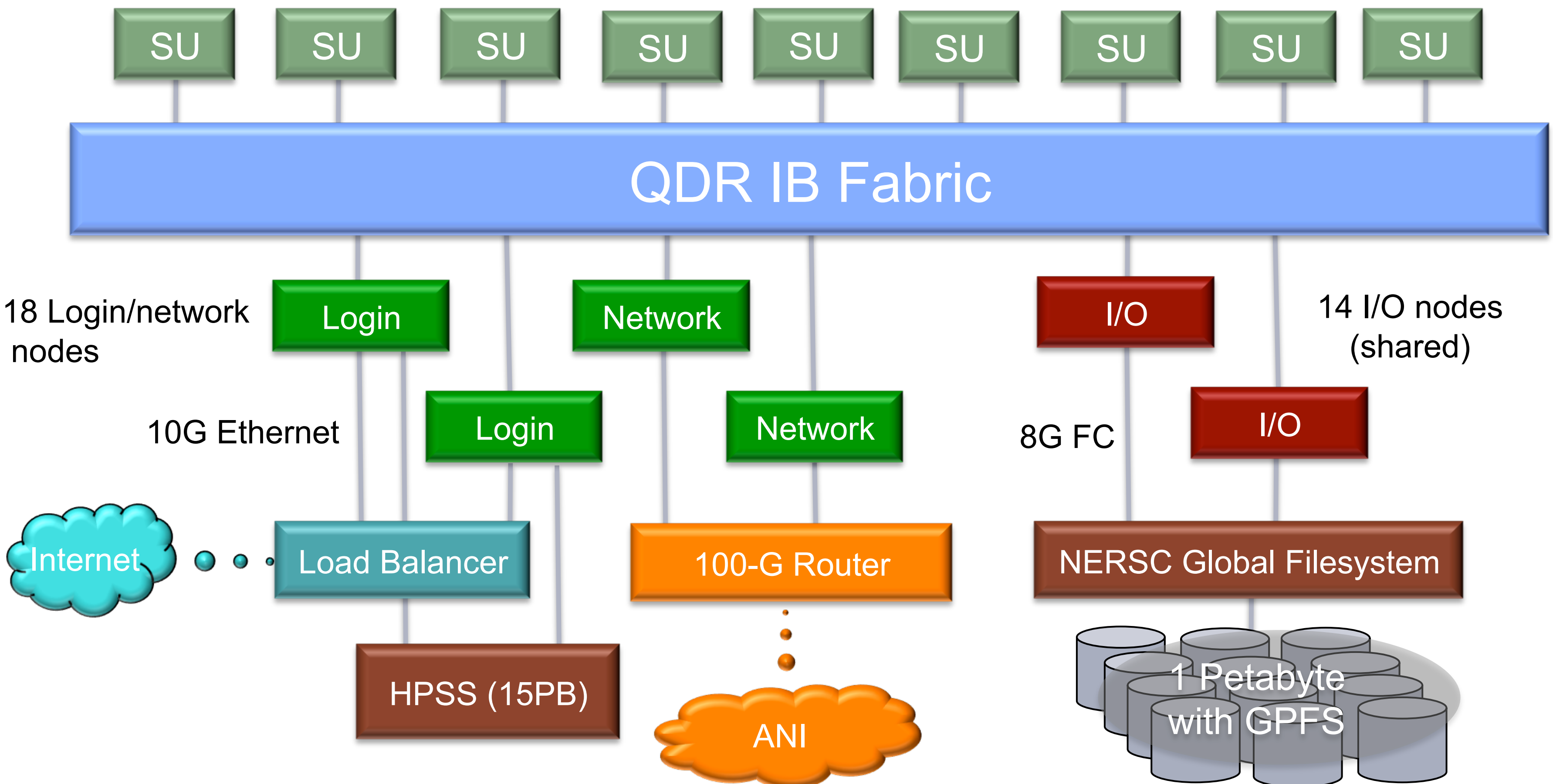
In general the first bottleneck wins.

One Slide about NERSC

- Serving all of DOE Office of Science
  - domain breadth
  - range of scales
- Lots of users
  - ~4K active
  - ~500 logged in
  - ~300 projects
- Science driven
  - sustained performance
- Architecture aware
  - procurements driven by workload needs

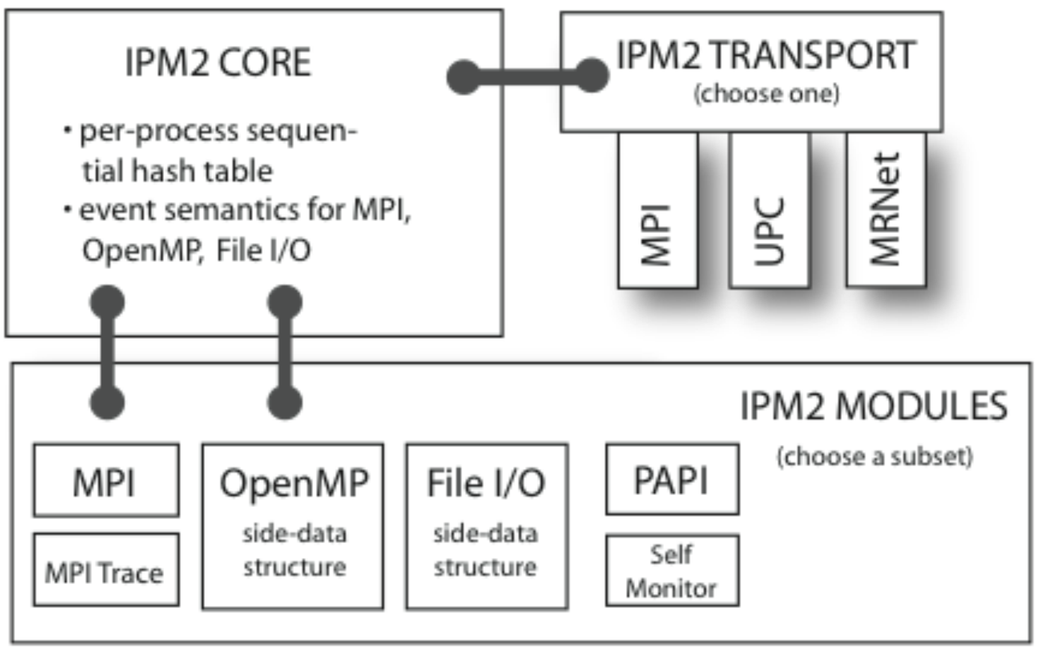
Magellan Test Bed at NERSC
Purpose-built for Science Applications

720 nodes, 5760 cores in 9 Scalable Units (SUs) ➔ 61.9 Teraflops
SU = IBM iDataplex rack with 640 Intel Nehalem cores



IPM Overview

- **IPM = Integrated Performance Monitoring**
- **IPM started as POE+ at NERSC**
  - **"How to profile apps from 400 projects asking for time?"**
- **Lightweight scalable profiling layer**



Provides performance summaries to HPC users and center staff

What can IPM do?

- What's going on overall in my code?
  - How much comp, comm, I/O?
  - Where to start with optimization?
- Provide high level performance numbers with tiny overhead
  - To get an initial read on application runtimes
  - For allocation/reporting, ERCAP perf data
  - To check the performance weather
- How is my load balance?
  - Domain decomposition vs. concurrency (M work on N tasks)

IPM: Origin and Motivation

- One of many: There are lots of good vendor supplied tools, we encourage their use
- Adaptable : If you can’t get what you need from those we can adapt IPM based on your feedback
- Performance Portability: IPM provides long-term continuity to performance data between machines, applications, allocations

Using IPM @ NERSC

1) Do "module load ipm", run normally

2) Upon completion you get

```
##IPM2v0.xx####################################################
######
#
# command   : ./fish -n 10000
# start     : Tue Feb 08 11:05:21 2011   host      : nid06027
# stop      : Tue Feb 08 11:08:19 2011   wallclock : 177.71
# mpi_tasks : 25 on 2 nodes              %comm     : 1.62
# mem [GB]  : 0.24                       gflop/sec : 5.06
…
```

Maybe that's enough. If so you're done.

Have a nice day ☺

Using IPM @ Magellan

1) We “module load ipm” for users silently

2) Upon completion you get normal output (leave no tracks)

3) A logfile is written to a shared space

4) NERSC then analyzes 300K+ application profiles

IPM Profile Report

IPM profile for 5478299.nid00003 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.nersc.gov/projects/SDSA/workload/N6ipm/milc_1024/

Remember Password Get YouTube video

IPM profile for 5478299.nid00003

5478299.nid00003

- Load Balance
- Communication Balance
- Message Buffer Sizes
- Communication Topology
- Switch Traffic
- Memmory Usage
- Executable Info
- Host List
- Environment
- Developer Info

Powered by IPM

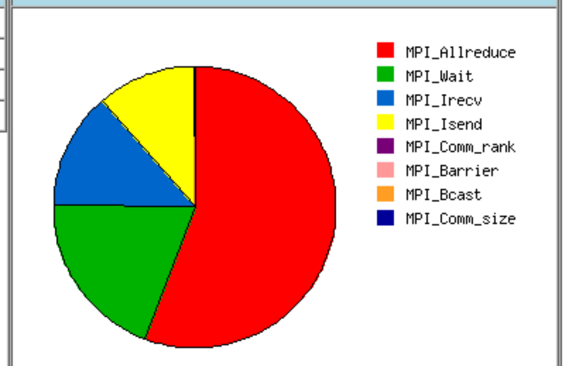
command: ./su3_rmd_ipm			
codename:	unknown	state:	running
username:	unknown	group:	unknown
host:	nid00192 (x86_64_Linux)	mpi_tasks:	1024 on 512 hosts
start:	07/31/08/10:22:15	wallclock:	1.01934e+03 sec
stop:	07/31/08/10:39:14	%comm:	22.3665512120588
total memory:	89.7124593999995 gbytes	total gflop/sec:	996.231781348717
switch(send):	0 gbytes	switch(recv):	0 gbytes

Computation

Event	Count	Pop
PAPI_FP_OPS	1015498895269727	*
PAPI_TOT_CYC	2504745952383680	*
PAPI_TOT_INS	1938008453032501	*
PAPI_VEC_INS	416352019568617	*

Communication

% of MPI Time



Done

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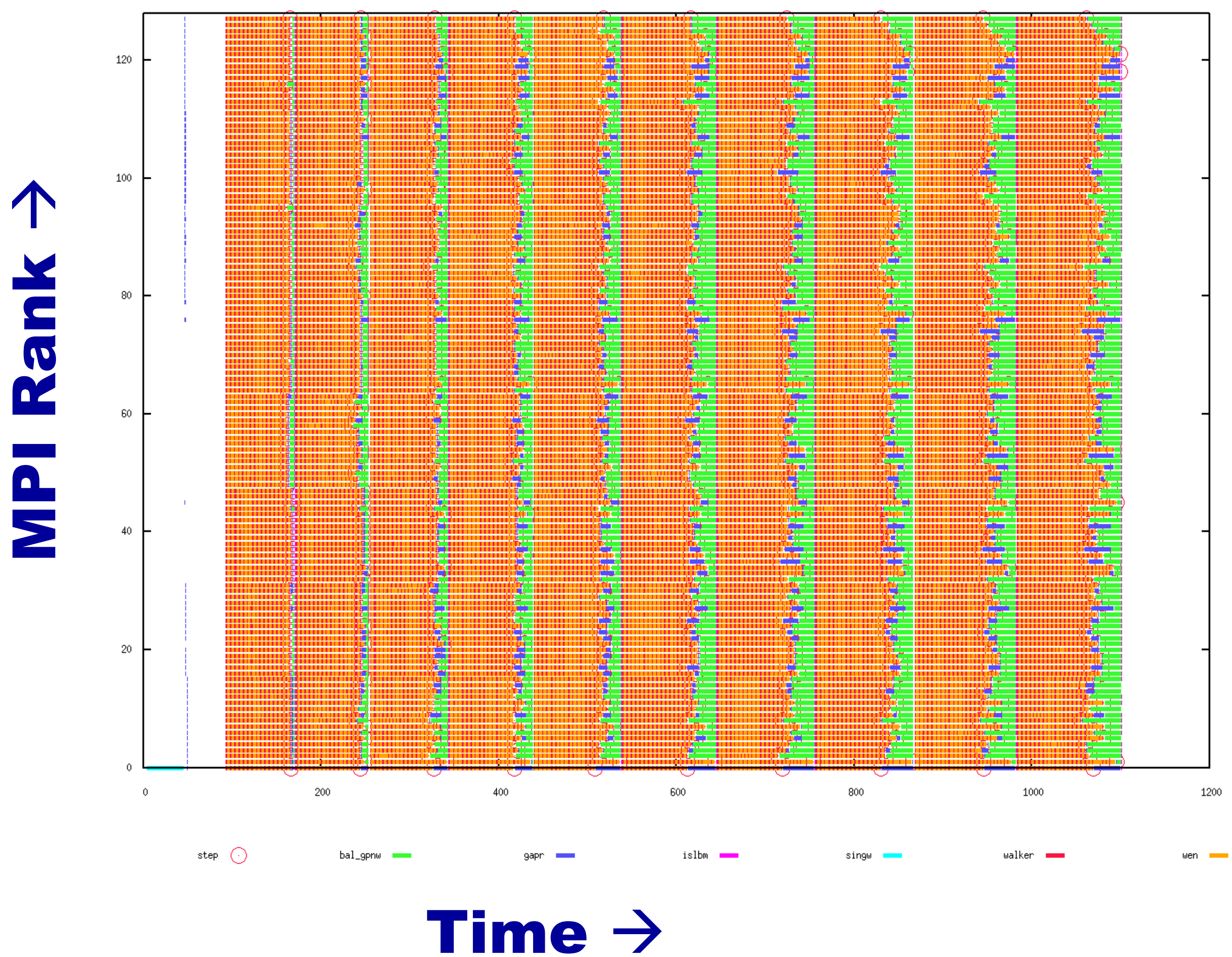
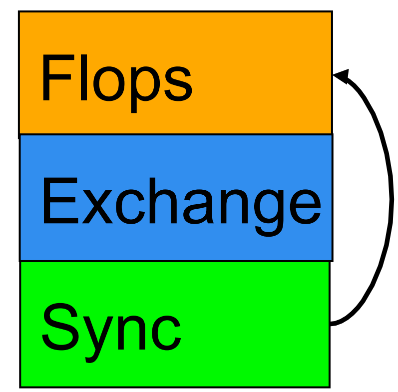
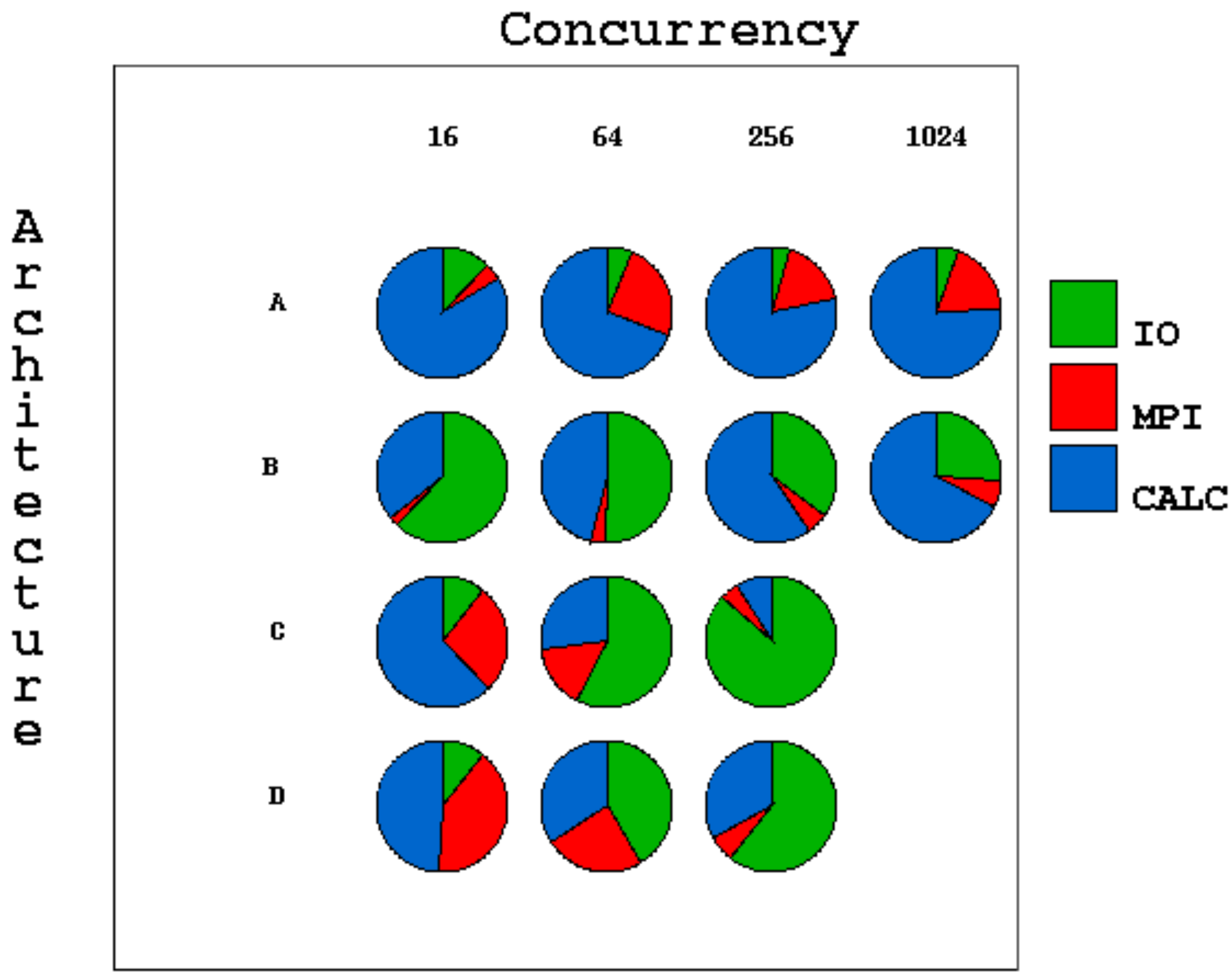
Load imbalance is a common bottleneck

Dynamic disorder:
What we miss with IPM





Performance Portability

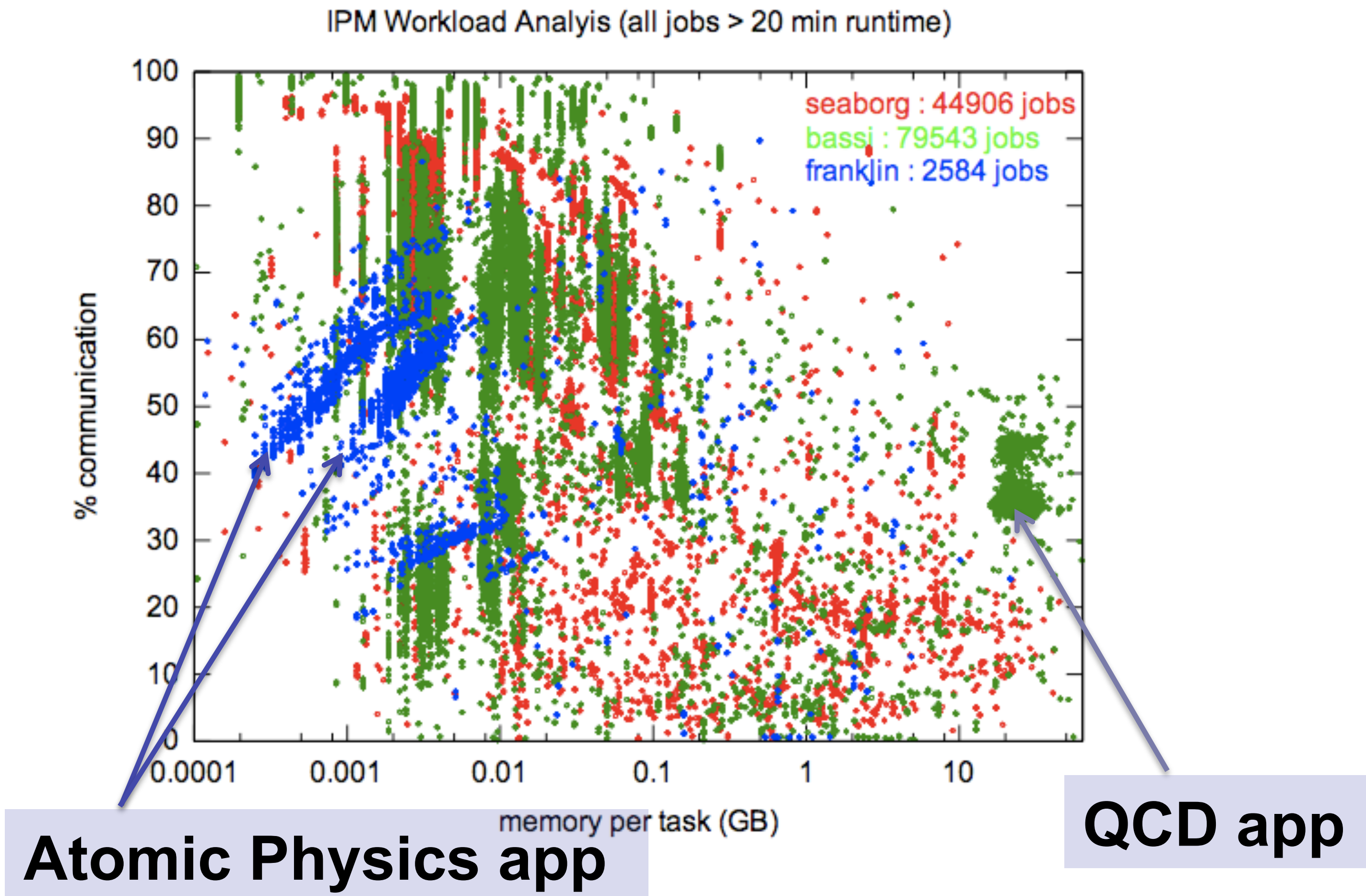


on to workloads…

IPM: Ease of use → It gets used

- We have collected over 300k IPM profiles
  - Jobs running longer than 20min (400k otherwise)
  - Covers a period of 6 years
  - Covers 5 HPC architectures
- This may pave the way for using IPM by default on all NERSC production systems

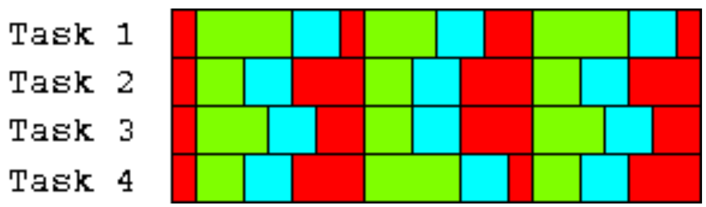
300K IPM Application Profiles



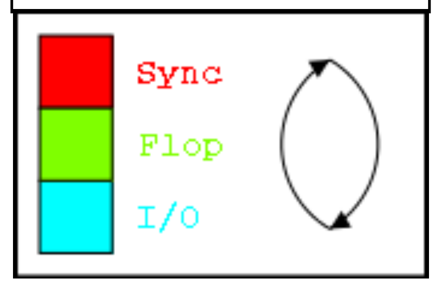
Generalities in Scalability and Performance

Load Balance : cartoon

Unbalanced:



Universal App

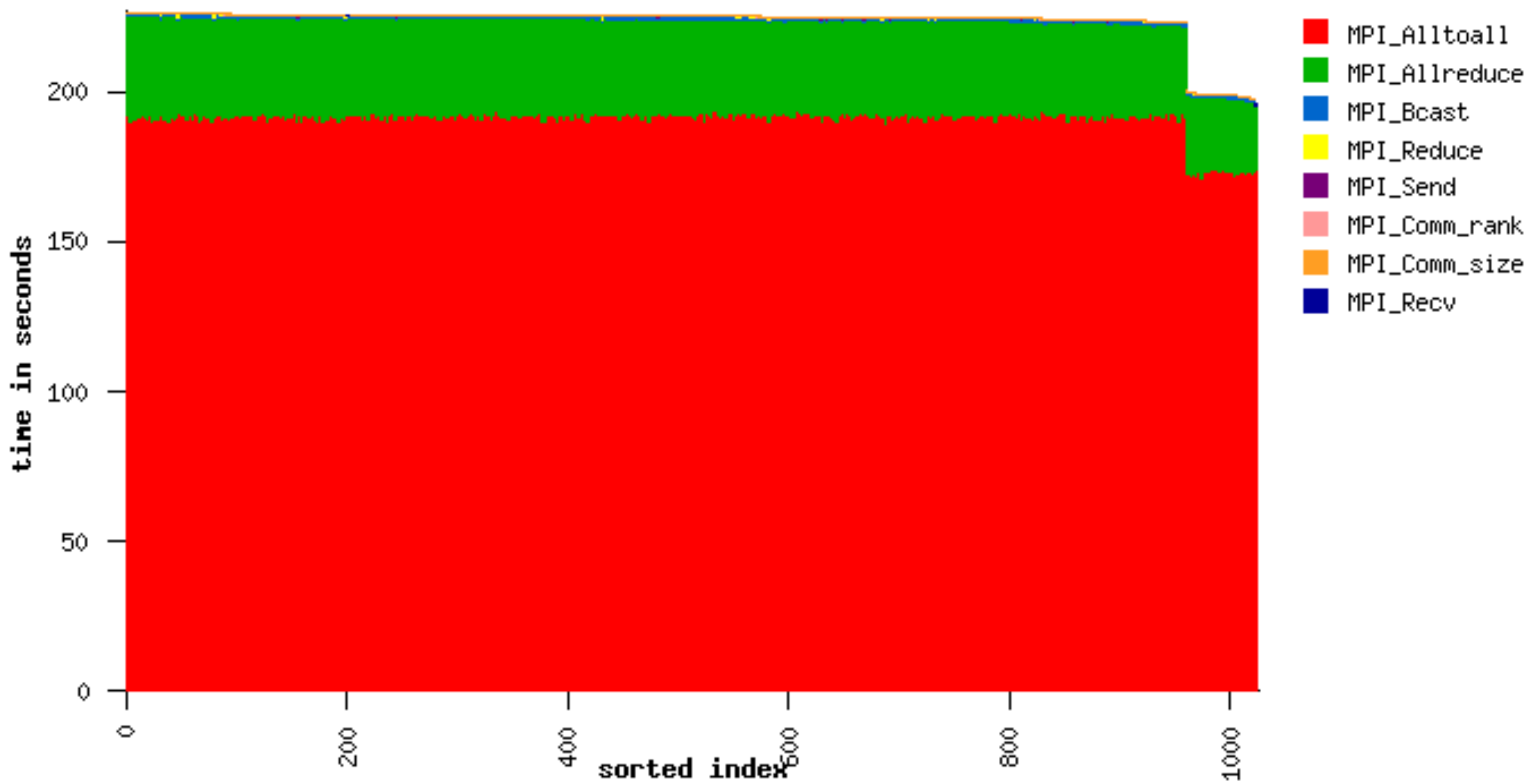


Balanced:

Time saved by load balance

Load (Im)balance

Communication Time: 64 tasks show 200s, 960 tasks show 230s

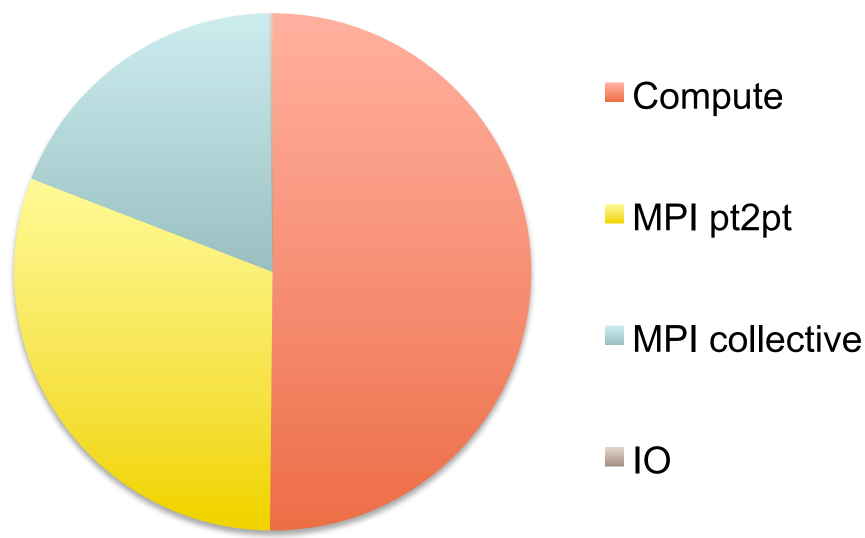


MPI ranks sorted by total communication time

Some specific examples From Magellan

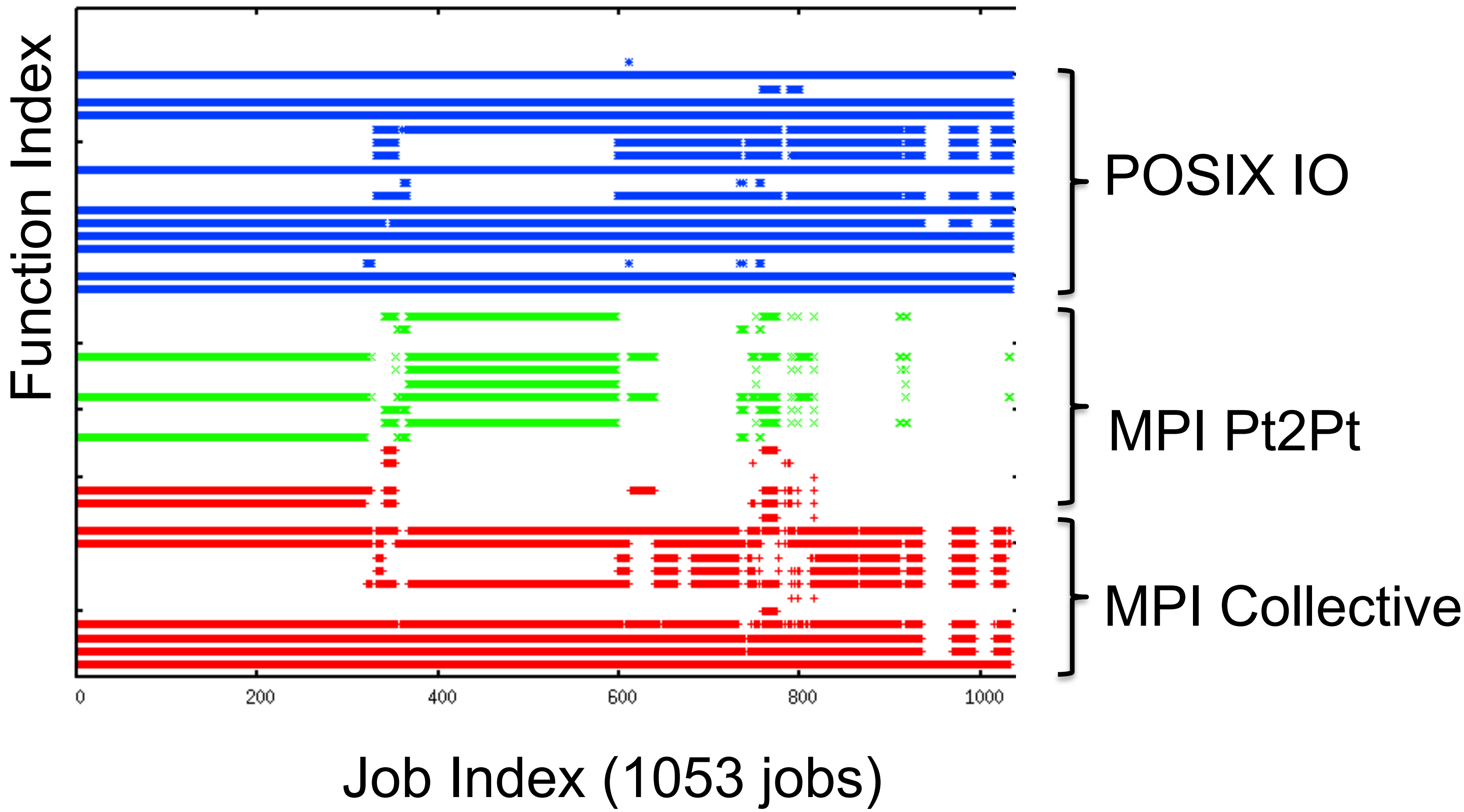
Workload Analysis on Magellan

- Most HPC profiling is done on an opt-in basis. Users deploy tools to understand their code.
- Magellan profiling is system wide, passive, and automatic, a workload approach.
- October 4-27 2010 :
  - 1053 batch jobs
  - 37 users
  - 18 applications
  - 4K cores
  - Preliminary results(*)



(*) does not yet include non-MPI jobs

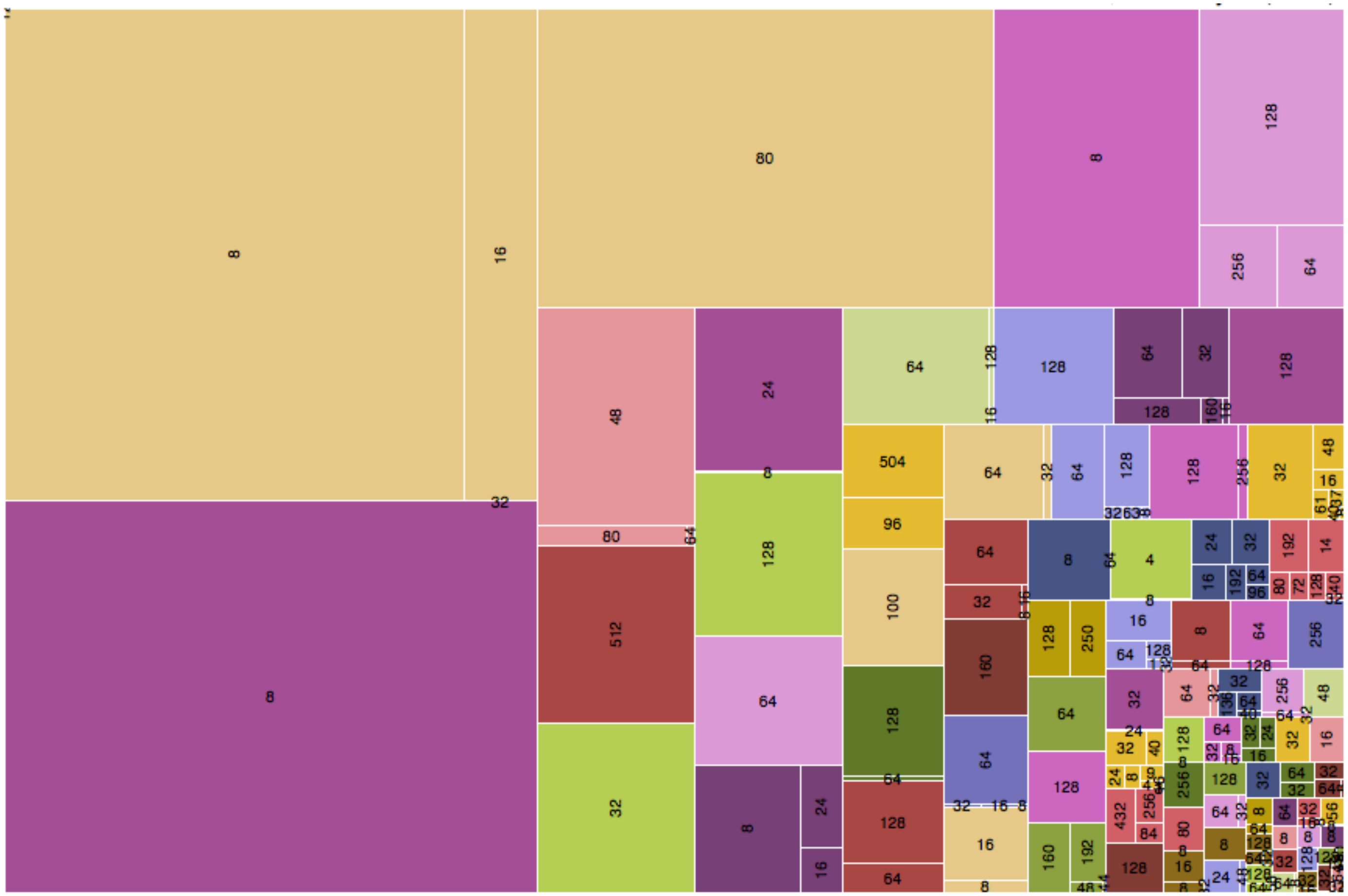
Workload Coverage: which jobs use which resources



Examining 22K Magellan Jobs

207 user-concurrency pairs

size=core-hours
color=user
label=cores

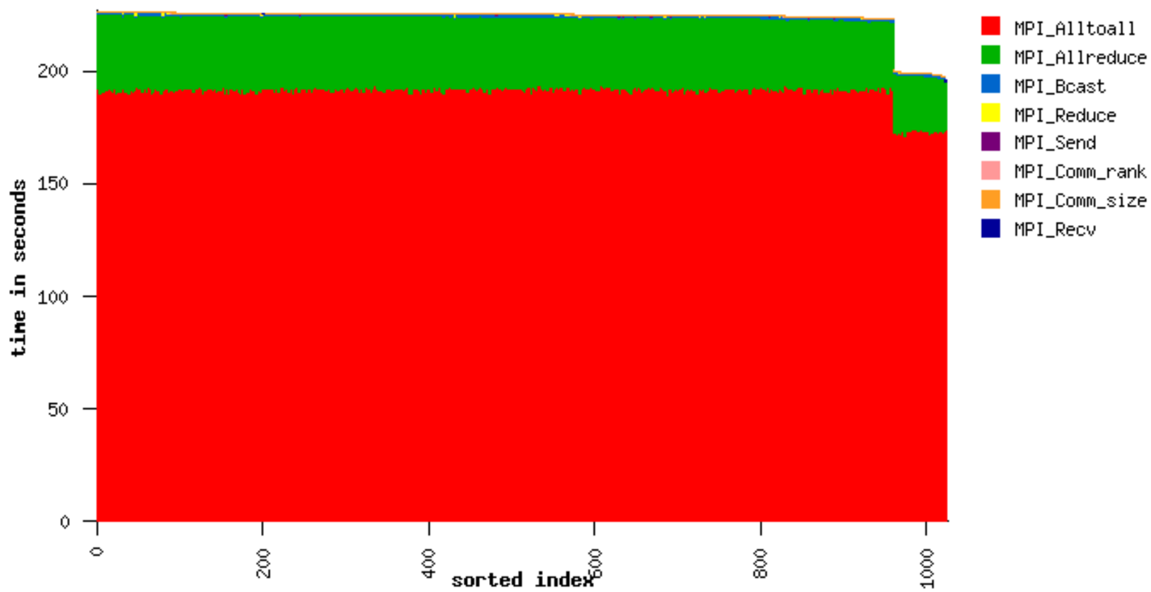


Magellan Worklod

- **How to proceed making workload level statements about resource needs?**
- **How to find bottlenecks?**
- **Each run is potentially distinct: Changes in code, inputs, compilation, runtime, system of study, etc.**
- **Let revisit the familiar case of load imbalance**

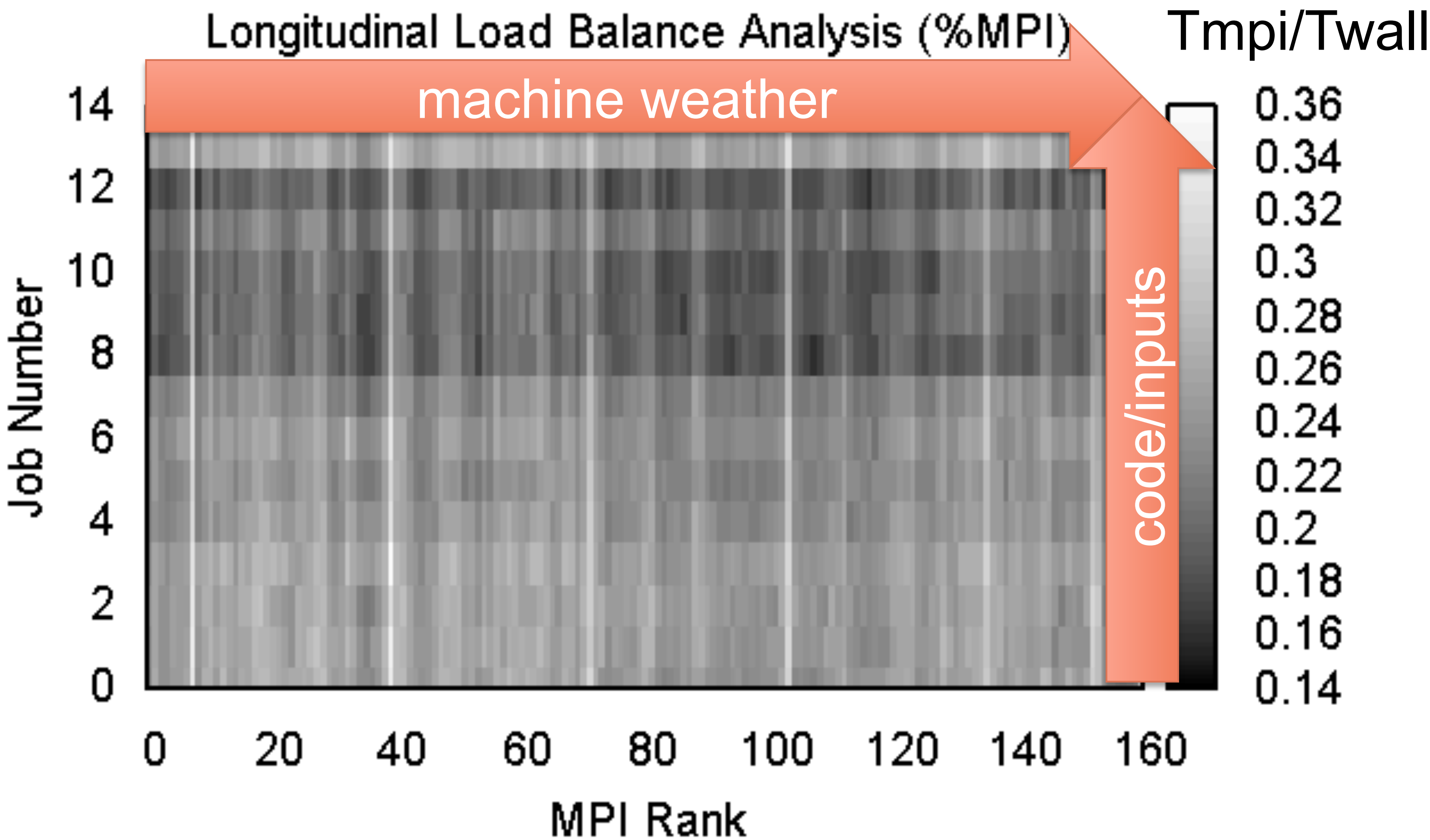
Inferences on workloads

- **What changes between runs?**
- **What stays the same?**

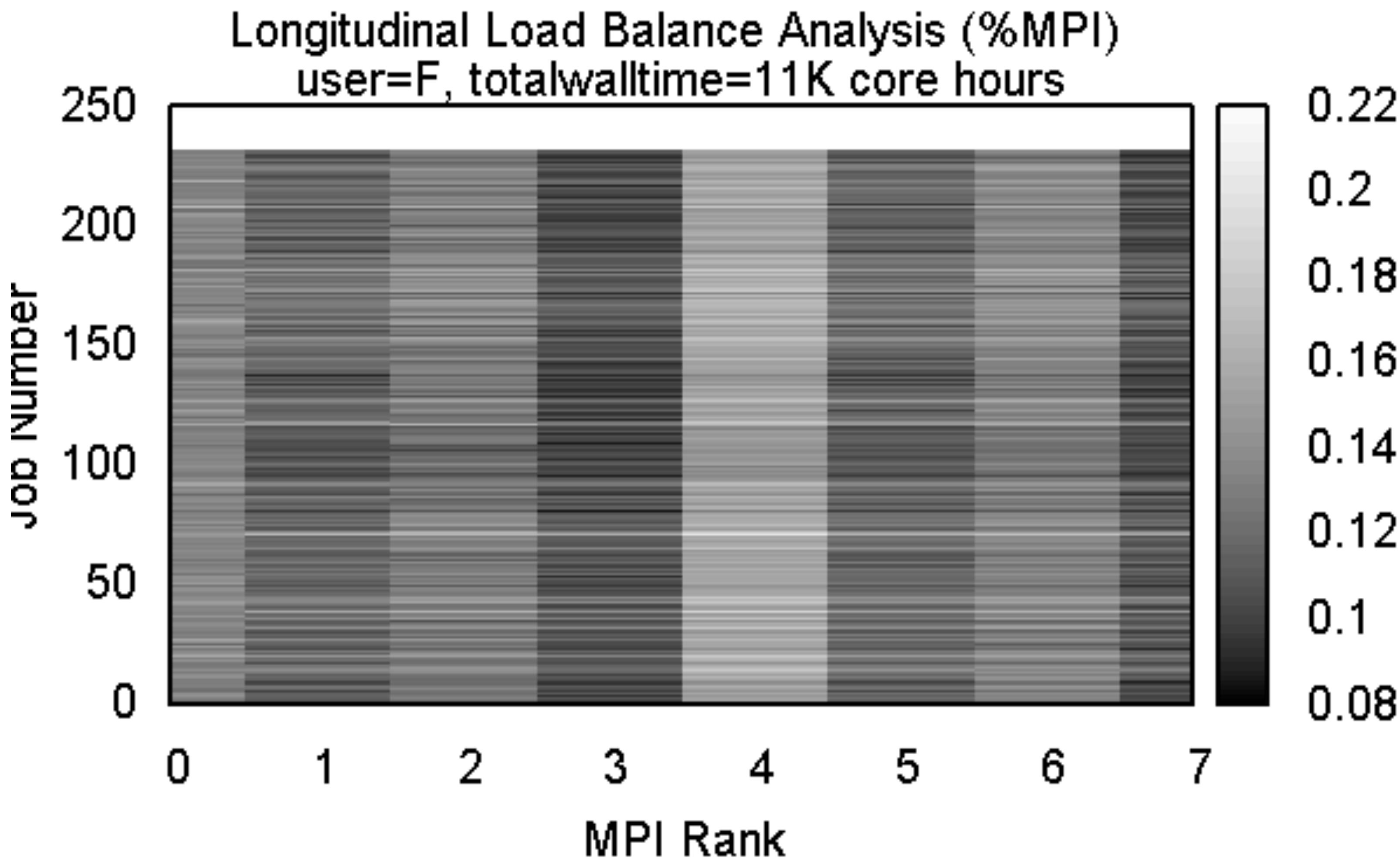


code
input
configs
batch script
runtime
machine
switch traffic

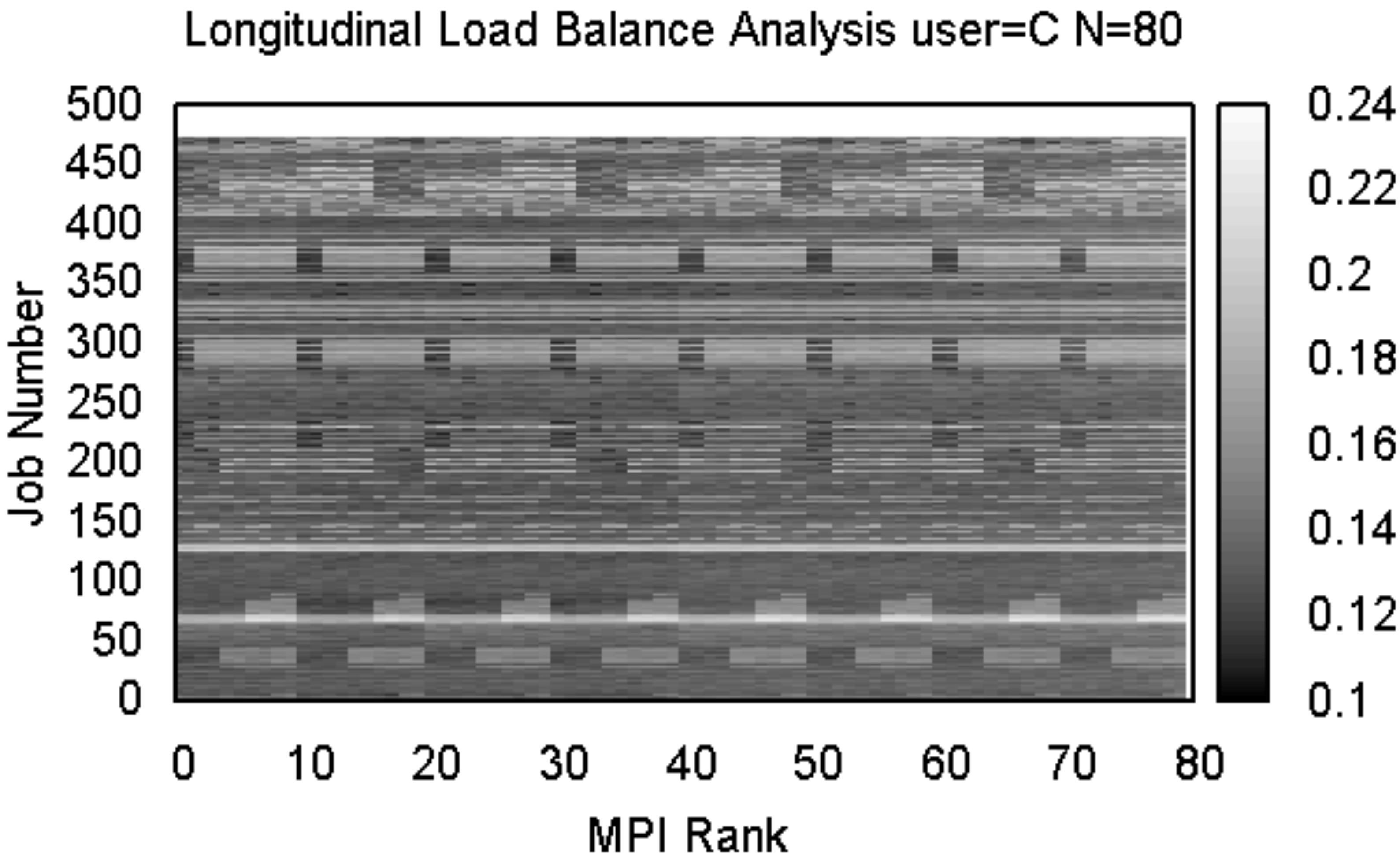
User D runs code A 13 times



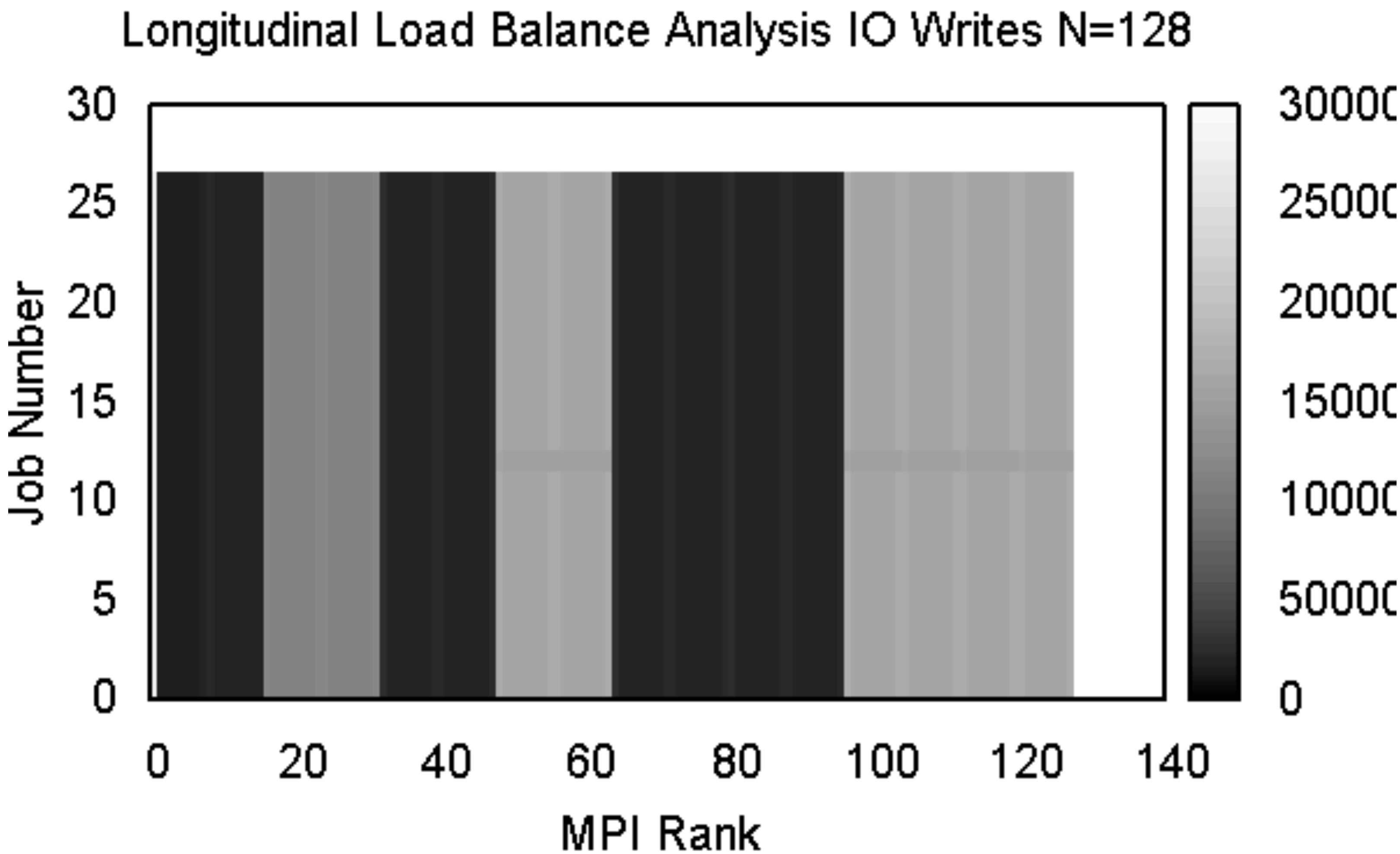
User F runs Code V 220 times



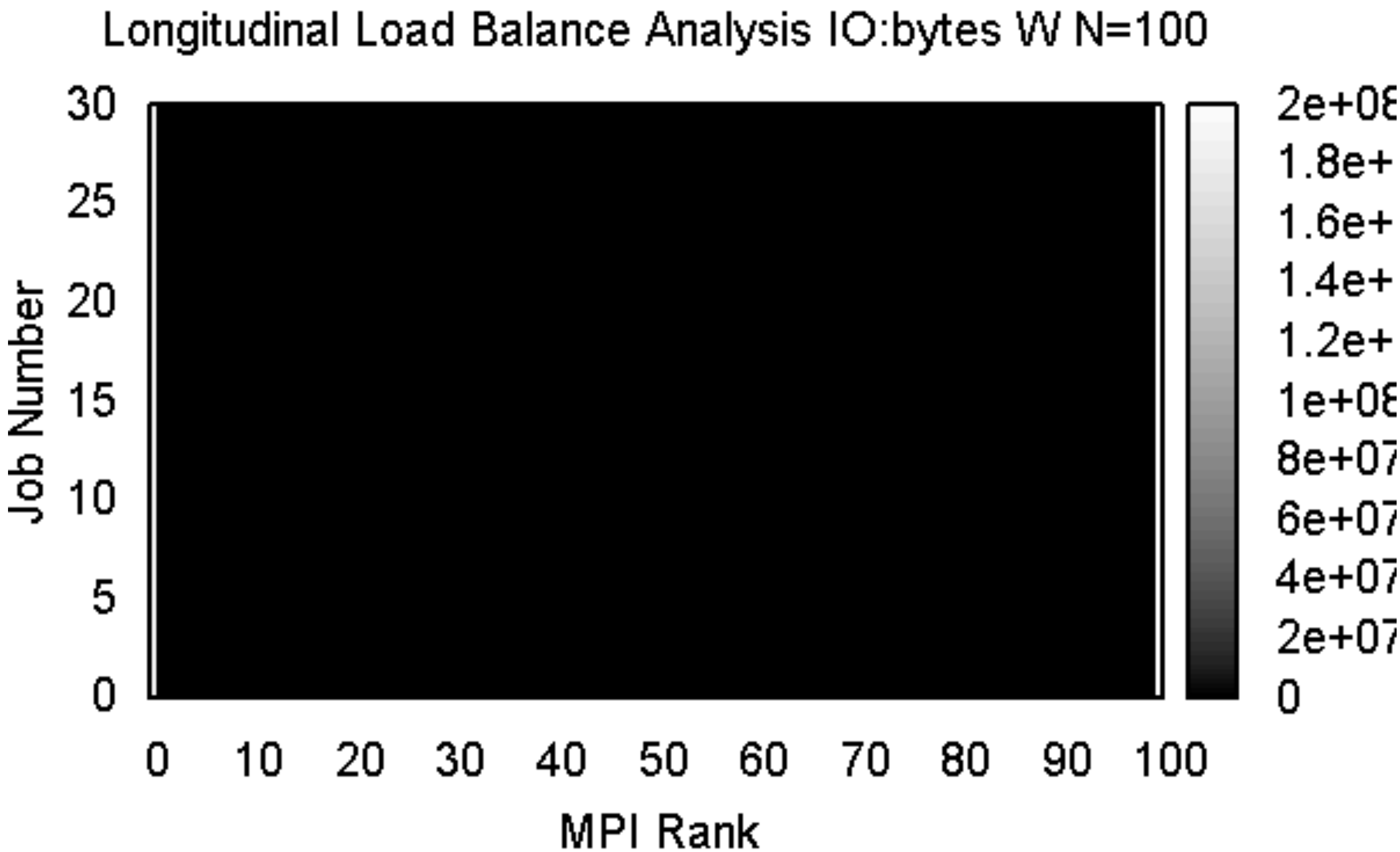
Last two were easy: discontinuities/structure



We can do this with IO too.

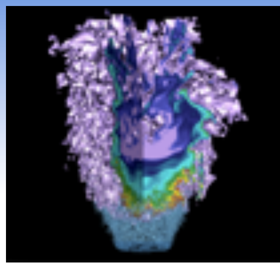
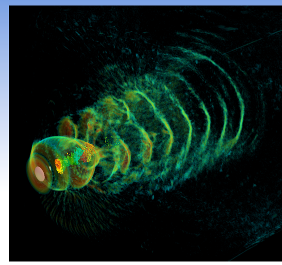
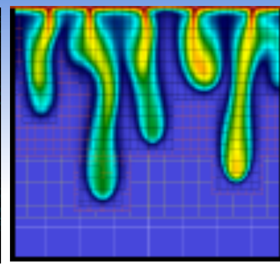
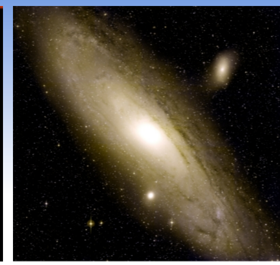
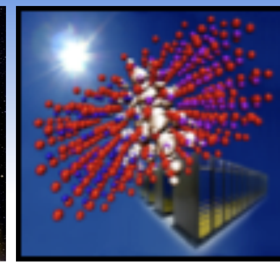
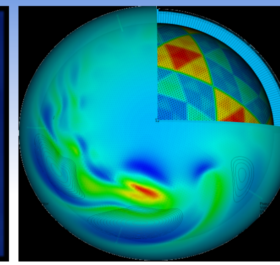


Ever seen this IO strategy?



Conclusions

- "Always on" profiling looks doable/ promising.
- Performance in practice vs. performance in principle.
- Comparison across jobs can allow some confidence in which bottlenecks are worth attention
- If you have ideas about/for IPM, I am interested in collaborations.

Thank you

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