
# Experiences with Tools at NERSC

**Richard Gerber**

**NERSC User Services**

Programming weather, climate, and earth-system models
on heterogeneous multi-core platforms

September 7, 2011 at the National Center for Atmospheric Research in Boulder, Colorado

U.S. DEPARTMENT OF ENERGY | Office of Science

NERSC National Energy Research Scientific Computing Center

BERKELEY LAB Lawrence Berkeley National Laboratory

- Thanks for the invitation
- My professional goal is to enable scientists to use HPC easily and effectively
- Contribute to important discoveries about how our natural world works
- Make a difference
- So it is an honor & meaningful to me to participate in this conference
- One of my primary roles is as deputy on our next procurement team & we are extremely interested in learning about your experiences with hybrid systems and programming

# Outline

- Recent experiences providing tools
- Observations about tool usage by NERSC users
- What I'd like to see in tools for the HPC community

# Focus

- I'll focus on performance tools
  - Who is the audience?
  - Scientists?
  - CS code engineers?
  - Scientist/engineers?
- Development tools
  - Eclipse: We considered installing this, but concluded users best served by installing themselves in their own directories
  - Compilers: PGI, Cray, HMPP directives-based (your experiences?)
- Debuggers
  - Allinea DDT & Rouge Wave Totalview
  - Both are here and will present today
  - Both are installed and supported at NERSC
  - Generally good experiences, but not extensively used by users

# Disclaimers

- These are my observations and experiences
- Not a review or critique of any given tool
- Not comprehensive survey of tools

# Genesis of This Talk

Hi Richard:

I started looking at the single-core performance on Hopper. The first problem that I encountered was that running the code with <tool name redacted> causes it to crash; so I gave up on that approach. What other profiling tools are you planning to support? I did look at gprof on the code but that also seems to have problems.

Chris

# The Plan

- Provide Chris with tools to scale and test his code's (HiRAM?) performance on NERSC's Cray XE6 Hopper (#5 in Top 500)
- At the same time test and install some tools to benefit all NERSC users
- Report on my successes and survey the tools we would have available at NERSC (including our test GPU system)

# Experience with Chris Kerr

- Chris & I went back and forth over a number of months, trying to install and use various tools.
- All failed
  - Couldn't build a tool with some specific compiler
  - Tool crashed (we did find some bugs)
  - Tool appeared to run, but produced no output
- Chris found a solution for his problem, but it was a lot of work
  - Gettimeofday(), print, somebody's private tool
- My result: no success identifying and installing new tools for our entire user base

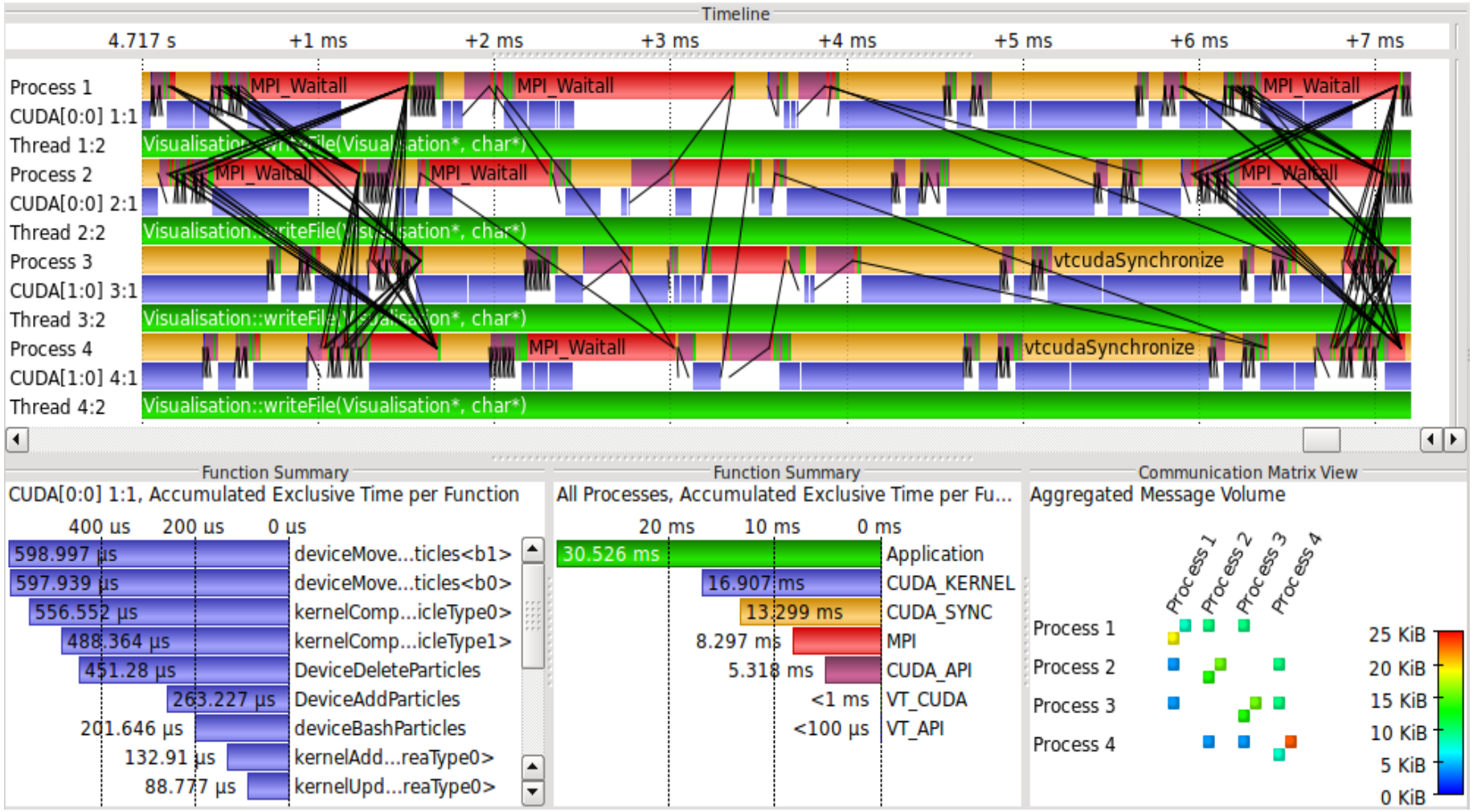
# Experience with NERSC Users

- NERSC has about 4,000 users
  - All levels of sophistication and experience
  - We're committed to supporting both the cutting edge & production HPC computing for the masses
- Users often ask for advice on which tools to use and we give them suggestions
- Our experience is that very few use programming/debugging/development tools
- A few users use a few tools a lot, but many try a tool only once

# Why?

- Extremely effective?
- More likely: Too confusing, difficult, didn't work, don't know how to use, don't know which to use
- It's not that we don't have tools that address specific issues
  - GPU/CUDA tools & compilers
  - TAU, PAPI, HPC Toolkit
  - Craypat, IBM HPC tools, OpenSpeedShop
  - Valgrind
  - Vampirtrace
- But do most users have the resources to learn how to use these tools, esp. when they don't know if there will be any benefit from any given one?

# Vampir w/ CUDA



# Ease of Use

## Use

Follow these **10 STEPS** to perform the basic analysis of your program u
a performance analysis tool, not a debugging tool, start with a fully debu
capable of running to a planned completion or an intentional terminatior
environment modules first. This ensures that the correct links and librari

# Users Want (Need?) Tools

- Users are asking for tools because HPC systems and programming models are changing
- More and more components to worry about
  - CPU (caches, FPUs, pipelining, …)
  - Data movement to main memory, GPU memory, levels of cache
  - I/O
  - Network (message passing)
  - CPU Threads (OpenMP)
  - GPU performance

# Questions to You

- What tools do you use?
- What tools do you want?
- What would you like centers to support?
- Can you get to exascale without tools?

# What I Want in a Tool

- Let the users help themselves
- Work for everyone all (most of?) the time
- Easy to use
- Useful
- Easy to interpret the results
- Affordable ($$ or manpower support costs)
- Simple, supplement existing complex tools
  - Point the way for a “deeper dive” in problem areas

# IPM as A Model

- NERSC's IPM: Integrated Performance Monitoring
- How it works (user perspective)
  - `% module load IPM*`
  - Run program as normal
  - Look at results on the web
- It's that easy!
  - And extremely low overhead, so IPM is examining your production code

* (As long as your system supports dynamic load libs)

# What IPM measures

- IPM "only" gives a high-level, entire-program-centric view
- Still, very valuable guidance
  - Shows whole-run info per MPI task, OpenMP thread, (CUDA under development)
  - Many pieces of data in one place
- Reveals what many users don't know about their code
  - High-water memory usage (per task)
  - Load balance
  - Call imbalance
  - MPI time
  - I/O time

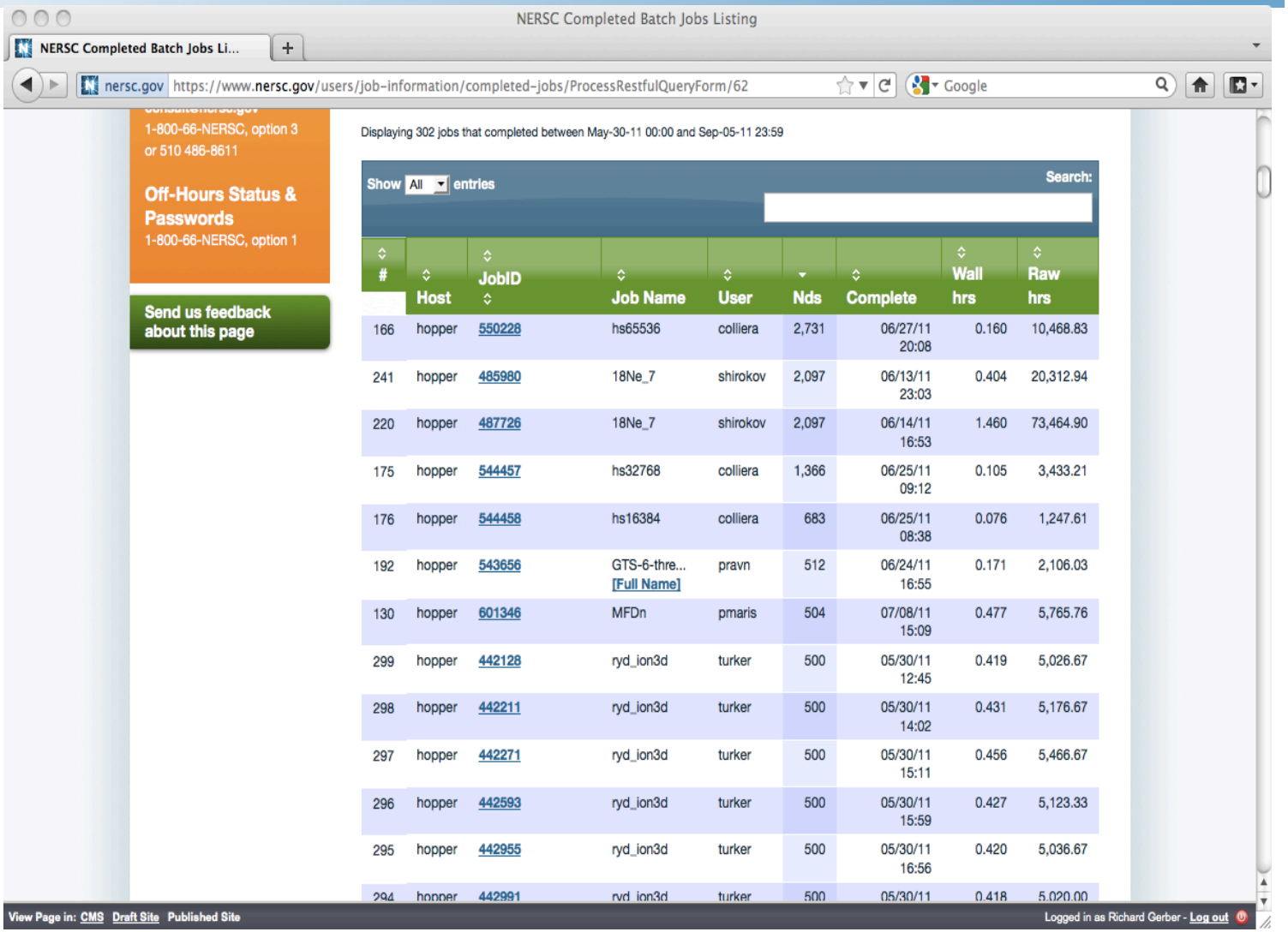
# IPM w/ CUDA: Accuracy

| Benchmark | Kernel Invocations | GPU Kernel Execution Time (sec) | | |
|---|---|---|---|---|
| | | CUDA Profiler | IPM | Difference (%) |
| BlackScholes | 512 | 2.540677 | 2.543700 | 0.12 |
| FDTD3d | 5 | 0.101354 | 0.101550 | 0.19 |
| MersenneTwister | 202 | 1.126475 | 1.127000 | 0.05 |
| MonteCarlo | 2 | 0.001988 | 0.002025 | 1.87 |
| concurrentKernels | 9 | 0.613755 | 0.614000 | 0.04 |
| eigenvalues | 300 | 5.328266 | 5.331000 | 0.05 |
| quasirandomGenerator | 42 | 0.039536 | 0.039736 | 0.51 |
| scan | 3300 | 1.412912 | 1.430200 | 1.22 |

- Benchmarks from the CUDA SDK
  - Run on 1 node of Dirac @ NERSC
    - 2x Nehalem quad core, 1x NVIDIA Tesla C2050 (“Fermi”) GPU
  - Comparison of the results from the CUDA profiler with IPM
  - Very good agreement of the results
  - IPM timings always larger than CUDA profiler (bracketing)

# IPM Examples

Click on your job from a list on the NERSC web site.



# IPM Examples

Click on the metric you are want.

NERSC job details

http://www.nersc.gov/REST/jobs/job_details.php?stepid=732423.sdb&timestamp=1313679078&completion=1313679081

## IPM Summary

| | | | | | |
|---|---|---|---|---|---|
| Executable | | | | | ./wrf.exe |
| Number of tasks | 512 | Aggregate GFlop/sec | 0.1482 | Average GFlop/sec/task | 0.0003 |
| Average wall secs | 8.861e+01 | Aggregate memory (GB) | 32.2626 | Average memory/task (GB) | 0.0630 |
| Average MPI secs/task | 7.898e+01 | MPI time % | 89.14 | Aggregate MPI calls made | 7.027e+07 |

## IPM Summary Statistics - 512 tasks

| Metric | Sum over all tasks | Average (per task) | Task CV (%) | Task Minimum | Task Maxium |
|---|---|---|---|---|---|
| Aggregate Floating Point Operations (Flop x 10**9) | 1.313e+01 | 2.565e-02 | 6.10 | 1.713e-02 | 2.758e-02 |
| GFlop/sec | 1.482e-01 | 2.895e-04 | 6.10 | 1.934e-04 | 3.114e-04 |
| Maximum Memory Usage (GBytes) | 3.226e+01 | 6.301e-02 | 10.12 | 5.701e-02 | 1.947e-01 |
| Time Spent in MPI Routines (sec) | 4.044e+04 | 7.898e+01 | 4.05 | 9.801e+00 | 8.359e+01 |
| Wallclock Time (sec) | 4.537e+04 | 8.861e+01 | 0.10 | 8.848e+01 | 8.895e+01 |

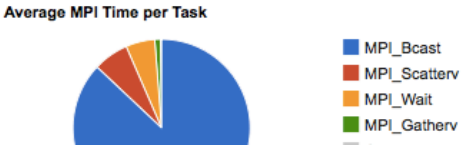
Memory in units of gigabytes; time in seconds.

## Hardware counter statistics - 512 tasks

| Counter Name | Sum over all tasks | Average (per task) | Task CV (%) | Task Minimum | Task Maxium |
|---|---|---|---|---|---|
| PAPI_FP_OPS | 1.161799e+12 | 2.269139e+09 | 6.09 | 1.515023e+09 | 2.439529e+09 |

## MPI Time Statistics - 512 tasks

| Call | Sum over all tasks | Average (per task) | Task CV (%) | Task Minimum | Task Maxium | % of MPI | % of wall |
|---|---|---|---|---|---|---|---|
| MPI_Bcast | 3.517e+04 | 6.869e+01 | 4.48 | 4.342e-01 | 7.269e+01 | 86.969 | 77.520 |
| MPI_Scatterv | 2.589e+03 | 5.057e+00 | 5.79 | 1.059e+00 | 5.540e+00 | 6.403 | 5.707 |
| MPI_Wait | 2.176e+03 | 4.249e+00 | 17.82 | 1.250e+00 | 4.968e+00 | 5.380 | 4.795 |
| MPI_Gatherv | 4.312e+02 | 8.422e-01 | 36.44 | 3.552e-03 | 2.271e+00 | 1.066 | 0.950 |
| MPI_Isend | 5.250e+01 | 1.025e-01 | 11.96 | 7.182e-02 | 1.259e-01 | 0.130 | 0.116 |
| MPI_Irecv | 1.033e+01 | 2.017e-02 | 10.21 | 1.217e-02 | 2.613e-02 | 0.026 | 0.023 |
| MPI_Gather | 1.021e+01 | 1.995e-02 | 502.07 | 1.391e-03 | 1.434e+00 | 0.025 | 0.023 |
| MPI_Comm_rank | 4.563e-01 | 8.913e-04 | 4.74 | 7.799e-04 | 1.404e-03 | 0.001 | 0.001 |
| MPI_Comm_size | 9.629e-02 | 1.881e-04 | 10.65 | 1.462e-04 | 4.859e-04 | 0.000 | 0.000 |
| MPI_Init | 0.000e+00 | 0.000e+00 | 0.000e+00 | 0.000e+00 | 0.000 | 0.000 | |
| MPI_Finalize | 0.000e+00 | 0.000e+00 | 0.000e+00 | 0.000e+00 | 0.000 | 0.000 | |



# IPM Examples

NERSC job details

http://www.nersc.gov/REST/jobs/ipm_summary.php?stepid=619349.sdb&name=gflops&timestamp=1310766809

| Metric | Sum | Mean | Std. Dev. | CV (%) | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Aggregate Floating Point Operations (Flop x 10**9) | 3.011e+02 | 1.470e-01 | 4.946e-03 | 3.36e+00 | 1.395e-01 | 2.161e-01 |
| GFlop/sec | 6.147e-01 | 3.002e-04 | 1.008e-05 | 3.36e+00 | 2.847e-04 | 4.411e-04 |
| Maximum Memory Usage (GBytes) | 4.101e+02 | 2.002e-01 | 9.606e-03 | 4.80e+00 | 1.781e-01 | 2.448e-01 |
| Time Spent in MPI Routines (sec) | 1.228e+06 | 5.995e+02 | 4.984e+01 | 8.31e+00 | 5.177e+02 | 6.801e+02 |
| Wallclock Time (sec) | 1.003e+06 | 4.898e+02 | 6.428e-02 | 1.31e-02 | 4.898e+02 | 4.927e+02 |

CV = Coefficient of Variance = (Standard Deviation / Mean)

Task distribution of *Aggregate Floating Point Operations (Flop x 10**9)* - as a percentage of maximum

The MPI rank is the sum of the column and row indices in the table.

Table Columns: 64

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 94 | 70 | 68 | 67 | 66 | 66 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 |
| 64 | 66 | 65 | 65 | 66 | 66 | 65 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 128 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 67 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| 192 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| 256 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 68 | 68 | 69 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 69 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 68 |
| 320 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 |
| 384 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 67 | 68 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 66 | 67 | 66 | 66 | 66 | 66 |
| 448 | 66 | 66 | 67 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 66 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 68 | 69 | 69 | 70 | 71 | 74 | 99 |
| 512 | 100 | 74 | 72 | 71 | 70 | 69 | 69 | 69 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 67 | 68 | 67 | 68 | 67 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 |
| 576 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 69 | 68 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| 640 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 70 | 69 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| 704 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 69 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 69 | 70 |
| 768 | 69 | 69 | 70 | 69 | 69 | 70 | 69 | 69 | 69 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 69 | 70 | 69 | 70 | 69 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 70 | 70 | 69 | 69 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 69 | 70 | 70 | 69 | 70 | 69 |
| 832 | 70 | 70 | 70 | 69 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 69 | 70 | 69 | 69 | 69 | 69 | 69 | 70 | 70 | 69 | 69 | 69 | 69 | 69 | 70 | 70 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 69 |
| 896 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 960 | 66 | 67 | 67 | 66 | 67 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 65 | 66 | 65 | 66 | 65 | 65 | 65 | 65 | 65 | 66 | 65 | 66 | 65 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 67 | 68 | 70 | 95 |
| 1024 | 100 | 74 | 72 | 71 | 70 | 69 | 69 | 69 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| 1088 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| 1152 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| 1216 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 69 | 70 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| 1280 | 69 | 69 | 70 | 69 | 69 | 70 | 70 | 69 | 69 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 70 | 70 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 69 | 70 | 69 | 70 | 69 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 70 | 70 | 70 | 69 | 70 | 70 | 70 | 69 | 70 | 70 | 70 | 69 | 70 | 70 | 69 | 70 | 69 | 70 |
| 1344 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 69 | 69 | 70 | 69 | 69 | 70 | 69 | 69 | 69 | 69 | 69 | 70 | 69 | 69 | 69 | 69 | 69 | 70 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 68 | 69 |
| 1408 | 68 | 69 | 69 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 1472 | 66 | 67 | 67 | 66 | 67 | 67 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 65 | 66 | 65 | 66 | 65 | 66 | 65 | 65 | 65 | 66 | 65 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 67 | 68 | 70 | 95 |
| 1536 | 94 | 70 | 68 | 67 | 66 | 66 | 66 | 66 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 66 | 65 | 66 | 66 | 66 | 66 | 66 | 65 | 66 | 66 | 66 | 66 | 66 | 66 |
| 1600 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 67 | 66 | 66 | 66 | 67 | 66 | 67 | 66 | 67 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 |
| 1664 | 68 | 67 | 67 | 67 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| 1728 | 69 | 68 | 69 | 68 | 69 | 68 | 68 | 68 | 69 | 68 | 69 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 69 | 69 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 | 69 | 68 | 68 |
| 1792 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 69 | 68 | 69 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 68 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| 1856 | 69 | 69 | 69 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 68 | 69 | 69 | 69 | 69 | 68 | 69 | 68 | 69 | 69 | 69 | 68 | 69 | 68 | 68 | 68 | 69 | 69 | 68 | 68 | 68 | 68 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 |
| 1920 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 68 | 68 | 68 | 68 | 68 | 68 | 67 | 67 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 1984 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 66 | 67 | 67 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 68 | 68 | 69 | 69 | 69 | 70 | 71 | 74 | 99 |

*gflops* vs. MPI Rank

keley
ratory

# IPM Examples

NERSC job details

http://www.nersc.gov/REST/jobs/mpi_functions.php?stepid=619349.sdb&f_name=MPI_Allreduce&timestamp=1310766809

Time spent by each task in *MPI_Allreduce* as a percentage of the maximum value

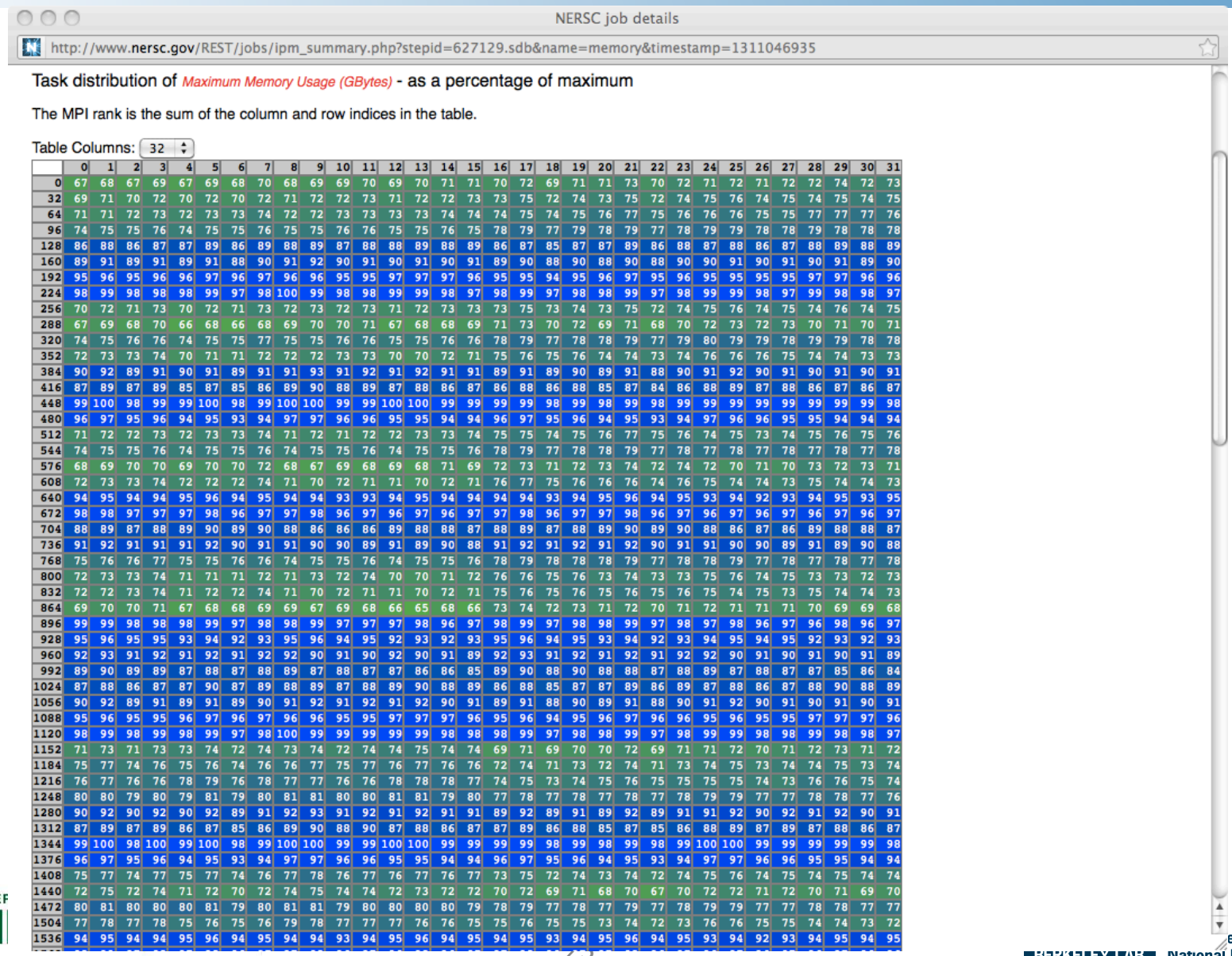
The MPI rank represented by each cell in the table is the sum of the cell's column and row indices.

Table Columns: 48

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 100 | 100 | 100 | 99 | 99 | 98 | 98 | 98 | 98 | 97 | 97 | 97 | 97 | 97 | 97 | 96 | 94 | 95 | 94 | 94 | 94 | 93 | 93 | 93 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 89 | 89 | 88 | 88 | 87 | 87 | 87 | 87 | 87 | 86 | 86 | 86 | 86 | 86 | 86 | 86 |
| 48 | 82 | 82 | 81 | 81 | 80 | 81 | 80 | 80 | 79 | 79 | 79 | 79 | 79 | 80 | 79 | 79 | 79 | 78 | 78 | 77 | 76 | 77 | 76 | 76 | 76 | 77 | 76 | 76 | 76 | 77 | 76 | 76 | 73 | 72 | 73 | 71 | 71 | 71 | 71 | 70 | 70 | 70 | 70 | 70 | 69 | 71 | 70 | 69 |
| 96 | 76 | 77 | 76 | 75 | 75 | 75 | 75 | 74 | 74 | 74 | 75 | 74 | 74 | 75 | 74 | 74 | 75 | 74 | 74 | 73 | 73 | 74 | 73 | 72 | 72 | 72 | 72 | 72 | 72 | 73 | 72 | 71 | 69 | 69 | 69 | 68 | 68 | 68 | 68 | 67 | 67 | 68 | 67 | 67 | 67 | 68 | 67 | 67 |
| 144 | 67 | 66 | 66 | 65 | 64 | 65 | 64 | 64 | 64 | 64 | 63 | 64 | 64 | 64 | 64 | 63 | 55 | 54 | 54 | 53 | 53 | 54 | 53 | 53 | 53 | 54 | 53 | 53 | 53 | 54 | 54 | 53 | 53 | 53 | 52 | 52 | 51 | 53 | 51 | 51 | 51 | 50 | 50 | 50 | 51 | 52 | 51 | 50 |
| 192 | 50 | 50 | 50 | 49 | 49 | 50 | 49 | 49 | 49 | 50 | 49 | 49 | 50 | 50 | 50 | 50 | 49 | 49 | 49 | 48 | 48 | 49 | 48 | 48 | 47 | 47 | 47 | 47 | 47 | 49 | 49 | 48 | 50 | 51 | 51 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 51 | 52 | 52 | 51 |
| 240 | 51 | 51 | 50 | 50 | 50 | 50 | 51 | 50 | 49 | 50 | 49 | 49 | 50 | 51 | 51 | 51 | 58 | 58 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 59 | 58 | 58 | 56 | 56 | 56 | 55 | 56 | 56 | 56 | 55 | 56 | 56 | 57 | 56 | 57 | 58 | 58 | 58 |
| 288 | 58 | 58 | 58 | 58 | 57 | 58 | 58 | 57 | 57 | 58 | 58 | 57 | 58 | 60 | 59 | 59 | 56 | 56 | 56 | 56 | 55 | 56 | 57 | 56 | 56 | 58 | 57 | 57 | 58 | 59 | 59 | 60 | 58 | 58 | 59 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 59 | 59 | 60 | 60 | 61 |
| 336 | 62 | 61 | 62 | 62 | 62 | 63 | 62 | 62 | 63 | 63 | 64 | 63 | 64 | 65 | 65 | 66 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 66 | 67 | 67 | 68 | 61 | 61 | 62 | 61 | 61 | 62 | 62 | 62 | 62 | 63 | 63 | 63 | 63 | 65 | 65 | 66 |
| 384 | 57 | 56 | 56 | 56 | 57 | 57 | 57 | 57 | 58 | 58 | 59 | 58 | 59 | 60 | 60 | 61 | 60 | 59 | 60 | 59 | 59 | 60 | 60 | 60 | 60 | 61 | 61 | 61 | 61 | 63 | 62 | 63 | 69 | 69 | 68 | 68 | 69 | 69 | 69 | 69 | 70 | 70 | 70 | 71 | 70 | 72 | 72 | 72 |
| 432 | 80 | 80 | 80 | 79 | 80 | 80 | 81 | 80 | 80 | 81 | 81 | 81 | 81 | 82 | 82 | 83 | 77 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 77 | 77 | 77 | 77 | 78 | 78 | 79 | 80 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 79 | 79 | 79 | 79 | 80 | 80 | 81 | 82 | 82 |
| 480 | 75 | 75 | 75 | 75 | 75 | 75 | 76 | 75 | 76 | 76 | 76 | 76 | 77 | 78 | 78 | 78 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 79 | 80 | 80 | 80 | 80 | 81 | 82 | 83 | 85 | 92 | 92 | 92 | 92 | 91 | 91 | 91 | 91 | 91 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| 528 | 86 | 87 | 86 | 86 | 85 | 85 | 85 | 85 | 84 | 84 | 84 | 84 | 83 | 83 | 83 | 85 | 84 | 84 | 83 | 83 | 83 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 81 | 78 | 77 | 77 | 76 | 76 | 76 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 |
| 576 | 73 | 73 | 73 | 71 | 71 | 72 | 71 | 71 | 71 | 71 | 71 | 70 | 71 | 71 | 71 | 71 | 68 | 67 | 67 | 66 | 66 | 66 | 66 | 65 | 65 | 65 | 64 | 65 | 64 | 66 | 65 | 64 | 68 | 68 | 68 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 65 | 65 | 66 | 65 | 65 |
| 624 | 65 | 65 | 65 | 64 | 64 | 64 | 64 | 63 | 63 | 63 | 63 | 62 | 63 | 63 | 62 | 62 | 55 | 55 | 55 | 54 | 54 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 51 | 50 | 51 | 50 | 49 | 50 | 49 | 49 | 49 | 49 | 48 | 48 | 49 | 50 | 49 | 48 |
| 672 | 44 | 44 | 44 | 43 | 43 | 44 | 43 | 43 | 43 | 44 | 43 | 43 | 43 | 44 | 43 | 42 | 43 | 42 | 42 | 42 | 41 | 42 | 41 | 41 | 41 | 40 | 40 | 40 | 41 | 42 | 41 | 40 | 41 | 42 | 42 | 41 | 41 | 41 | 41 | 41 | 41 | 42 | 41 | 41 | 41 | 42 | 41 | 41 |
| 720 | 41 | 40 | 41 | 40 | 39 | 40 | 40 | 40 | 38 | 39 | 39 | 39 | 39 | 40 | 40 | 39 | 44 | 44 | 45 | 43 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 45 | 45 | 46 | 45 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 43 | 43 | 44 | 43 | 43 | 44 | 45 | 45 | 44 |
| 768 | 54 | 54 | 53 | 53 | 53 | 54 | 54 | 54 | 53 | 54 | 54 | 54 | 54 | 55 | 55 | 54 | 51 | 52 | 52 | 51 | 51 | 51 | 52 | 51 | 52 | 52 | 52 | 52 | 52 | 53 | 53 | 53 | 52 | 53 | 53 | 53 | 52 | 53 | 53 | 52 | 52 | 53 | 53 | 52 | 53 | 55 | 54 | 54 |
| 816 | 51 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 54 | 53 | 53 | 54 | 55 | 54 | 55 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 55 | 55 | 55 | 56 | 56 | 57 | 58 | 58 | 58 | 58 | 58 | 59 | 59 | 59 | 60 | 60 | 61 | 60 | 61 | 61 | 61 | 62 |
| 864 | 61 | 60 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 61 | 62 | 63 | 63 | 64 | 59 | 58 | 59 | 59 | 59 | 59 | 60 | 60 | 60 | 61 | 61 | 61 | 61 | 63 | 62 | 63 | 55 | 55 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 57 | 57 | 57 | 58 | 58 | 59 |
| 912 | 58 | 58 | 59 | 59 | 58 | 59 | 59 | 59 | 60 | 60 | 60 | 60 | 61 | 62 | 62 | 62 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 69 | 69 | 70 | 71 | 71 | 72 | 79 | 80 | 80 | 79 | 80 | 80 | 81 | 80 | 80 | 81 | 81 | 81 | 81 | 82 | 82 | 83 |
| 960 | 75 | 74 | 75 | 75 | 75 | 75 | 75 | 75 | 76 | 76 | 76 | 76 | 77 | 77 | 78 | 78 | 77 | 77 | 77 | 77 | 77 | 77 | 78 | 78 | 78 | 78 | 79 | 79 | 79 | 80 | 81 | 81 | 74 | 74 | 74 | 74 | 74 | 74 | 75 | 74 | 75 | 75 | 75 | 75 | 76 | 77 | 77 | 77 |
| 1008 | 78 | 78 | 78 | 79 | 79 | 79 | 79 | 79 | 80 | 80 | 80 | 80 | 81 | 83 | 84 | 86 | 92 | 92 | 92 | 91 | 91 | 91 | 91 | 90 | 90 | 90 | 90 | 89 | 90 | 90 | 90 | 89 | 84 | 85 | 84 | 83 | 82 | 82 | 81 | 81 | 81 | 81 | 80 | 80 | 80 | 80 | 80 | 80 |
| 1056 | 82 | 82 | 82 | 81 | 81 | 81 | 80 | 80 | 80 | 80 | 79 | 79 | 80 | 80 | 80 | 80 | 75 | 75 | 74 | 74 | 73 | 74 | 73 | 73 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 71 | 71 | 71 | 70 | 70 | 70 | 70 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 |
| 1104 | 67 | 66 | 67 | 65 | 65 | 65 | 65 | 65 | 64 | 64 | 64 | 64 | 64 | 64 | 65 | 64 | 64 | 69 | 69 | 68 | 67 | 68 | 67 | 67 | 67 | 67 | 67 | 66 | 66 | 67 | 66 | 66 | 64 | 64 | 64 | 63 | 63 | 63 | 62 | 62 | 62 | 62 | 62 | 62 | 62 | 62 | 62 | 61 |
| 1152 | 55 | 55 | 55 | 54 | 53 | 53 | 53 | 53 | 52 | 53 | 53 | 52 | 53 | 53 | 53 | 53 | 51 | 50 | 51 | 50 | 49 | 49 | 49 | 49 | 49 | 49 | 48 | 48 | 48 | 49 | 49 | 48 | 43 | 43 | 43 | 42 | 42 | 43 | 42 | 42 | 42 | 42 | 42 | 41 | 42 | 42 | 42 | 41 |
| 1200 | 43 | 43 | 42 | 43 | 41 | 43 | 42 | 41 | 41 | 41 | 41 | 40 | 41 | 42 | 41 | 40 | 42 | 42 | 42 | 42 | 41 | 42 | 42 | 41 | 41 | 42 | 41 | 42 | 42 | 43 | 42 | 42 | 41 | 41 | 41 | 41 | 40 | 41 | 40 | 40 | 39 | 39 | 39 | 40 | 39 | 41 | 41 | 40 |
| 1248 | 43 | 43 | 43 | 42 | 42 | 43 | 42 | 42 | 42 | 43 | 43 | 42 | 43 | 44 | 44 | 43 | 43 | 43 | 42 | 42 | 43 | 42 | 43 | 42 | 42 | 42 | 42 | 42 | 42 | 43 | 43 | 43 | 53 | 54 | 53 | 53 | 53 | 53 | 53 | 53 | 54 | 54 | 54 | 53 | 55 | 55 | 54 |
| 1296 | 51 | 51 | 51 | 50 | 51 | 50 | 51 | 50 | 51 | 50 | 51 | 50 | 51 | 52 | 52 | 52 | 50 | 51 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 51 | 51 | 50 | 51 | 53 | 52 | 52 | 51 | 52 | 52 | 51 | 51 | 52 | 52 | 52 | 51 | 53 | 52 | 52 | 54 | 55 | 54 | 55 |
| 1344 | 54 | 54 | 55 | 54 | 54 | 55 | 55 | 55 | 54 | 55 | 55 | 55 | 55 | 57 | 57 | 57 | 53 | 53 | 53 | 53 | 53 | 54 | 53 | 53 | 54 | 54 | 55 | 54 | 55 | 56 | 56 | 57 | 56 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 56 | 56 | 56 | 58 | 58 | 59 |
| 1392 | 54 | 54 | 55 | 54 | 55 | 55 | 55 | 55 | 55 | 56 | 56 | 56 | 56 | 58 | 58 | 59 | 56 | 56 | 56 | 56 | 56 | 57 | 56 | 57 | 57 | 57 | 58 | 57 | 58 | 59 | 59 | 60 | 62 | 61 | 62 | 62 | 62 | 63 | 63 | 63 | 63 | 64 | 64 | 64 | 65 | 65 | 66 |
| 1440 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 71 | 70 | 70 | 71 | 71 | 71 | 73 | 73 | 73 | 80 | 81 | 81 | 80 | 81 | 81 | 82 | 81 | 82 | 83 | 83 | 83 | 83 | 84 | 84 | 85 | 78 | 77 | 77 | 77 | 77 | 77 | 77 | 77 | 78 | 78 | 78 | 78 | 79 | 80 | 80 | 80 |
| 1488 | 79 | 79 | 79 | 79 | 79 | 79 | 80 | 80 | 80 | 81 | 81 | 81 | 81 | 83 | 83 | 83 | 77 | 77 | 77 | 78 | 77 | 77 | 78 | 77 | 78 | 78 | 79 | 79 | 79 | 80 | 80 | 79 | 81 | 81 | 81 | 81 | 82 | 82 | 82 | 82 | 83 | 83 | 83 | 84 | 84 | 85 | 86 | 88 |
| 1536 | 98 | 97 | 97 | 96 | 96 | 95 | 95 | 95 | 95 | 94 | 94 | 94 | 94 | 94 | 94 | 94 | 88 | 90 | 89 | 88 | 87 | 87 | 87 | 86 | 86 | 86 | 86 | 85 | 85 | 85 | 85 | 85 | 85 | 84 | 84 | 84 | 83 | 83 | 83 | 83 | 82 | 82 | 83 | 83 | 83 | 83 | 82 | 82 |
| 1584 | 77 | 77 | 77 | 76 | 76 | 76 | 76 | 76 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 75 | 74 | 73 | 73 | 73 | 73 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 70 | 70 | 70 | 69 | 69 | 69 | 69 | 68 | 68 | 68 | 68 | 68 | 68 | 69 | 68 | 68 |
| 1632 | 75 | 76 | 75 | 74 | 74 | 74 | 74 | 74 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 70 | 70 | 69 | 69 | 68 | 69 | 68 | 68 | 67 | 68 | 67 | 67 | 68 | 68 | 68 | 67 | 67 | 67 | 67 | 67 | 66 | 66 | 66 | 65 | 65 | 65 | 65 | 64 | 65 | 66 | 65 | 64 |
| 1680 | 63 | 61 | 62 | 61 | 60 | 61 | 61 | 60 | 60 | 60 | 60 | 60 | 59 | 60 | 60 | 59 | 53 | 53 | 53 | 52 | 52 | 52 | 52 | 52 | 51 | 52 | 51 | 51 | 51 | 51 | 51 | 50 | 53 | 52 | 52 | 52 | 51 | 52 | 52 | 51 | 50 | 50 | 50 | 50 | 51 | 51 | 51 | 50 |
| 1728 | 51 | 51 | 50 | 50 | 49 | 50 | 50 | 49 | 50 | 50 | 50 | 50 | 51 | 50 | 50 | 50 | 49 | 49 | 49 | 48 | 49 | 49 | 48 | 48 | 47 | 48 | 48 | 48 | 48 | 49 | 49 | 48 | 47 | 48 | 48 | 47 | 47 | 47 | 47 | 47 | 47 | 47 | 48 | 47 | 48 | 48 | 48 | 48 |
| 1776 | 48 | 48 | 47 | 47 | 48 | 47 | 48 | 47 | 47 | 47 | 47 | 47 | 48 | 48 | 48 | 47 | 55 | 56 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 56 | 56 | 56 | 56 | 57 | 57 | 56 | 54 | 54 | 54 | 53 | 54 | 54 | 55 | 53 | 54 | 54 | 54 | 53 | 54 | 55 | 55 | 55 |
| 1824 | 53 | 54 | 54 | 54 | 53 | 53 | 53 | 53 | 54 | 55 | 54 | 54 | 55 | 56 | 56 | 56 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 56 | 55 | 55 | 57 | 58 | 57 | 58 | 57 | 57 | 58 | 58 | 57 | 58 | 58 | 58 | 58 | 58 | 59 | 59 | 59 | 60 | 60 | 61 |
| 1872 | 55 | 54 | 55 | 55 | 54 | 55 | 55 | 55 | 55 | 56 | 56 | 56 | 56 | 58 | 57 | 58 | 57 | 56 | 56 | 56 | 56 | 57 | 57 | 57 | 57 | 58 | 57 | 58 | 58 | 59 | 60 | 61 | 56 | 56 | 56 | 57 | 57 | 57 | 57 | 57 | 57 | 58 | 57 | 58 | 58 | 60 | 59 | 60 |
| 1920 | 58 | 58 | 58 | 58 | 58 | 59 | 59 | 59 | 59 | 60 | 59 | 60 | 61 | 61 | 62 | 64 | 63 | 64 | 64 | 64 | 65 | 65 | 65 | 65 | 66 | 66 | 66 | 67 | 67 | 68 | 72 | 71 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 73 | 73 | 73 | 73 | 73 | 75 | 75 | 75 |
| 1968 | 83 | 83 | 83 | 83 | 83 | 84 | 84 | 83 | 84 | 84 | 84 | 84 | 85 | 86 | 85 | 86 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 81 | 82 | 82 | 82 | 82 | 83 | 83 | 84 | 84 | 83 | 82 | 83 | 82 | 82 | 83 | 83 | 83 | 83 | 82 | 82 | 83 | 83 | 83 | 83 | 85 |
| 2016 | 83 | 83 | 83 | 83 | 83 | 83 | 84 | 83 | 84 | 84 | 84 | 84 | 85 | 86 | 86 | 85 | 88 | 89 | 89 | 89 | 89 | 89 | 89 | 89 | 90 | 90 | 90 | 90 | 91 | 92 | 92 | 92 | | | | | | | | | | | | | | | | | | |

Time vs. MPI Rank for *MPI_Allreduce*

# IPM Examples



NERSC job details

http://www.nersc.gov/REST/jobs/ipm_summary.php?stepid=627129.sdb&name=memory&timestamp=1311046935

Task distribution of *Maximum Memory Usage (GBytes)* - as a percentage of maximum

The MPI rank is the sum of the column and row indices in the table.

Table Columns: 32

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 67 | 68 | 67 | 69 | 67 | 69 | 68 | 70 | 68 | 69 | 69 | 70 | 69 | 70 | 71 | 71 | 70 | 72 | 69 | 71 | 71 | 73 | 70 | 72 | 71 | 72 | 71 | 72 | 72 | 74 | 72 | 73 |
| 32 | 69 | 71 | 70 | 72 | 70 | 72 | 70 | 72 | 71 | 72 | 72 | 73 | 71 | 72 | 72 | 73 | 73 | 75 | 72 | 74 | 73 | 75 | 72 | 74 | 75 | 76 | 74 | 75 | 74 | 75 | 74 | 75 |
| 64 | 71 | 71 | 72 | 73 | 72 | 73 | 73 | 74 | 72 | 72 | 73 | 73 | 73 | 73 | 74 | 74 | 74 | 75 | 74 | 75 | 76 | 77 | 75 | 76 | 76 | 76 | 75 | 75 | 77 | 77 | 77 | 76 |
| 96 | 74 | 75 | 75 | 76 | 74 | 75 | 75 | 76 | 75 | 75 | 76 | 76 | 75 | 75 | 76 | 75 | 78 | 79 | 77 | 79 | 78 | 79 | 77 | 78 | 79 | 79 | 78 | 78 | 79 | 78 | 78 | 78 |
| 128 | 86 | 88 | 86 | 87 | 87 | 89 | 86 | 89 | 88 | 89 | 87 | 88 | 88 | 89 | 88 | 89 | 86 | 87 | 85 | 87 | 87 | 89 | 86 | 88 | 87 | 88 | 86 | 87 | 88 | 89 | 88 | 89 |
| 160 | 89 | 91 | 89 | 91 | 89 | 91 | 88 | 90 | 91 | 92 | 90 | 91 | 90 | 91 | 90 | 91 | 89 | 90 | 88 | 90 | 88 | 90 | 88 | 90 | 90 | 91 | 90 | 91 | 90 | 91 | 89 | 90 |
| 192 | 95 | 96 | 95 | 96 | 96 | 97 | 96 | 97 | 96 | 96 | 95 | 95 | 97 | 97 | 97 | 96 | 95 | 95 | 94 | 95 | 96 | 97 | 95 | 96 | 95 | 95 | 95 | 95 | 97 | 97 | 96 | 96 |
| 224 | 98 | 99 | 98 | 98 | 98 | 99 | 97 | 98 | 100 | 99 | 98 | 98 | 99 | 99 | 98 | 97 | 98 | 99 | 97 | 98 | 98 | 99 | 97 | 98 | 99 | 99 | 98 | 97 | 99 | 98 | 98 | 97 |
| 256 | 70 | 72 | 71 | 73 | 70 | 72 | 71 | 73 | 72 | 73 | 72 | 73 | 71 | 72 | 73 | 73 | 73 | 75 | 73 | 74 | 73 | 75 | 72 | 74 | 75 | 76 | 74 | 75 | 74 | 76 | 74 | 75 |
| 288 | 67 | 69 | 68 | 70 | 66 | 68 | 66 | 68 | 69 | 70 | 70 | 71 | 67 | 68 | 68 | 69 | 71 | 73 | 70 | 72 | 69 | 71 | 68 | 70 | 72 | 73 | 72 | 73 | 70 | 71 | 70 | 71 |
| 320 | 74 | 75 | 76 | 76 | 74 | 75 | 75 | 77 | 75 | 75 | 76 | 76 | 75 | 75 | 76 | 76 | 78 | 79 | 77 | 78 | 78 | 79 | 77 | 79 | 80 | 79 | 79 | 78 | 79 | 79 | 78 | 78 |
| 352 | 72 | 73 | 73 | 74 | 70 | 71 | 71 | 72 | 72 | 72 | 73 | 73 | 70 | 70 | 72 | 71 | 75 | 76 | 75 | 76 | 74 | 74 | 73 | 74 | 76 | 76 | 76 | 75 | 74 | 74 | 73 | 73 |
| 384 | 90 | 92 | 89 | 91 | 90 | 91 | 89 | 91 | 91 | 93 | 91 | 92 | 91 | 92 | 91 | 91 | 89 | 91 | 89 | 90 | 89 | 91 | 88 | 90 | 91 | 92 | 90 | 91 | 90 | 91 | 90 | 91 |
| 416 | 87 | 89 | 87 | 89 | 85 | 87 | 85 | 86 | 89 | 90 | 88 | 89 | 87 | 88 | 86 | 87 | 86 | 88 | 86 | 88 | 85 | 87 | 84 | 86 | 88 | 89 | 87 | 88 | 86 | 87 | 86 | 87 |
| 448 | 99 | 100 | 98 | 99 | 99 | 100 | 98 | 99 | 100 | 100 | 99 | 99 | 100 | 100 | 99 | 99 | 99 | 99 | 98 | 99 | 98 | 99 | 98 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 98 |
| 480 | 96 | 97 | 95 | 96 | 94 | 95 | 93 | 94 | 97 | 97 | 96 | 96 | 95 | 95 | 94 | 94 | 96 | 97 | 95 | 96 | 94 | 95 | 93 | 94 | 97 | 96 | 96 | 95 | 95 | 94 | 94 | 94 |
| 512 | 71 | 72 | 72 | 73 | 72 | 73 | 73 | 74 | 71 | 72 | 71 | 72 | 72 | 73 | 73 | 74 | 75 | 75 | 74 | 75 | 76 | 77 | 75 | 76 | 74 | 75 | 73 | 74 | 75 | 76 | 75 | 76 |
| 544 | 74 | 75 | 75 | 76 | 74 | 75 | 75 | 76 | 74 | 75 | 75 | 76 | 74 | 75 | 75 | 76 | 78 | 79 | 77 | 78 | 78 | 79 | 77 | 78 | 77 | 78 | 77 | 78 | 77 | 78 | 77 | 78 |
| 576 | 68 | 69 | 70 | 70 | 69 | 70 | 70 | 72 | 68 | 67 | 69 | 68 | 69 | 68 | 71 | 69 | 72 | 73 | 71 | 72 | 73 | 74 | 72 | 74 | 72 | 70 | 71 | 70 | 73 | 72 | 73 | 71 |
| 608 | 72 | 73 | 73 | 74 | 72 | 72 | 72 | 74 | 71 | 70 | 72 | 71 | 71 | 70 | 72 | 71 | 76 | 77 | 75 | 76 | 76 | 76 | 74 | 76 | 75 | 74 | 74 | 73 | 75 | 74 | 74 | 73 |
| 640 | 94 | 95 | 94 | 94 | 95 | 96 | 94 | 95 | 94 | 94 | 93 | 93 | 94 | 95 | 94 | 94 | 94 | 94 | 93 | 94 | 95 | 96 | 94 | 95 | 93 | 94 | 92 | 93 | 94 | 95 | 93 | 95 |
| 672 | 98 | 98 | 97 | 97 | 97 | 98 | 96 | 97 | 97 | 98 | 96 | 97 | 96 | 97 | 96 | 97 | 97 | 98 | 96 | 97 | 97 | 98 | 96 | 97 | 96 | 97 | 96 | 97 | 96 | 97 | 96 | 97 |
| 704 | 88 | 89 | 87 | 88 | 89 | 90 | 89 | 90 | 88 | 86 | 86 | 86 | 89 | 88 | 88 | 87 | 88 | 89 | 87 | 88 | 89 | 90 | 89 | 90 | 88 | 86 | 87 | 86 | 89 | 88 | 88 | 87 |
| 736 | 91 | 92 | 91 | 91 | 91 | 92 | 90 | 91 | 91 | 90 | 90 | 89 | 91 | 89 | 90 | 88 | 91 | 92 | 91 | 92 | 91 | 92 | 90 | 91 | 91 | 90 | 90 | 89 | 91 | 89 | 90 | 88 |
| 768 | 75 | 76 | 76 | 77 | 75 | 75 | 76 | 76 | 74 | 75 | 75 | 76 | 74 | 75 | 75 | 76 | 78 | 79 | 78 | 78 | 78 | 79 | 77 | 78 | 78 | 79 | 77 | 78 | 77 | 78 | 77 | 78 |
| 800 | 72 | 73 | 73 | 74 | 71 | 71 | 71 | 72 | 71 | 73 | 72 | 74 | 70 | 70 | 71 | 72 | 76 | 76 | 75 | 76 | 73 | 74 | 73 | 73 | 75 | 76 | 74 | 75 | 73 | 73 | 72 | 73 |
| 832 | 72 | 72 | 73 | 74 | 71 | 72 | 72 | 74 | 71 | 70 | 72 | 71 | 71 | 70 | 72 | 71 | 75 | 76 | 75 | 76 | 75 | 76 | 75 | 76 | 75 | 74 | 75 | 73 | 75 | 74 | 74 | 73 |
| 864 | 69 | 70 | 70 | 71 | 67 | 68 | 68 | 69 | 69 | 67 | 69 | 68 | 66 | 65 | 68 | 66 | 73 | 74 | 72 | 73 | 71 | 72 | 70 | 71 | 72 | 71 | 71 | 71 | 70 | 69 | 69 | 68 |
| 896 | 99 | 99 | 98 | 98 | 98 | 99 | 97 | 98 | 98 | 99 | 97 | 97 | 97 | 98 | 96 | 97 | 98 | 99 | 97 | 98 | 98 | 99 | 97 | 98 | 97 | 98 | 96 | 97 | 96 | 98 | 96 | 97 |
| 928 | 95 | 96 | 95 | 95 | 93 | 94 | 92 | 93 | 95 | 96 | 94 | 95 | 92 | 93 | 92 | 93 | 95 | 96 | 94 | 95 | 93 | 94 | 92 | 93 | 94 | 95 | 94 | 95 | 92 | 93 | 92 | 93 |
| 960 | 92 | 93 | 91 | 92 | 91 | 92 | 91 | 92 | 92 | 90 | 91 | 90 | 92 | 90 | 91 | 89 | 92 | 93 | 91 | 92 | 91 | 92 | 91 | 92 | 92 | 90 | 91 | 90 | 91 | 90 | 91 | 89 |
| 992 | 89 | 90 | 89 | 89 | 87 | 88 | 87 | 88 | 89 | 87 | 88 | 87 | 87 | 86 | 86 | 85 | 89 | 90 | 88 | 90 | 88 | 88 | 87 | 88 | 89 | 87 | 88 | 87 | 87 | 85 | 86 | 84 |
| 1024 | 87 | 88 | 86 | 87 | 87 | 90 | 87 | 89 | 88 | 89 | 87 | 88 | 89 | 90 | 88 | 89 | 86 | 88 | 85 | 87 | 87 | 89 | 86 | 89 | 87 | 88 | 86 | 87 | 88 | 90 | 88 | 89 |
| 1056 | 90 | 92 | 89 | 91 | 89 | 91 | 89 | 90 | 91 | 92 | 91 | 92 | 91 | 92 | 90 | 91 | 89 | 91 | 88 | 90 | 89 | 91 | 88 | 90 | 91 | 92 | 90 | 91 | 90 | 91 | 90 | 91 |
| 1088 | 95 | 96 | 95 | 95 | 96 | 97 | 96 | 97 | 96 | 96 | 95 | 95 | 97 | 97 | 97 | 96 | 95 | 96 | 94 | 95 | 96 | 97 | 96 | 96 | 95 | 96 | 95 | 95 | 97 | 97 | 97 | 96 |
| 1120 | 98 | 99 | 98 | 99 | 98 | 99 | 97 | 98 | 100 | 99 | 99 | 99 | 99 | 99 | 98 | 98 | 98 | 99 | 97 | 98 | 98 | 99 | 97 | 98 | 99 | 99 | 98 | 98 | 99 | 98 | 98 | 97 |
| 1152 | 71 | 73 | 71 | 73 | 73 | 74 | 72 | 74 | 73 | 74 | 72 | 74 | 74 | 75 | 74 | 74 | 69 | 71 | 69 | 70 | 70 | 72 | 69 | 71 | 71 | 72 | 70 | 71 | 72 | 73 | 71 | 72 |
| 1184 | 75 | 77 | 74 | 76 | 75 | 76 | 74 | 76 | 76 | 77 | 75 | 77 | 76 | 77 | 76 | 76 | 72 | 74 | 71 | 73 | 72 | 74 | 71 | 73 | 74 | 75 | 73 | 74 | 74 | 75 | 73 | 74 |
| 1216 | 76 | 77 | 76 | 76 | 78 | 79 | 76 | 78 | 77 | 77 | 76 | 76 | 78 | 78 | 78 | 77 | 74 | 75 | 73 | 74 | 75 | 76 | 75 | 75 | 75 | 75 | 74 | 73 | 76 | 76 | 75 | 74 |
| 1248 | 80 | 80 | 79 | 80 | 79 | 81 | 79 | 80 | 81 | 81 | 80 | 80 | 81 | 81 | 79 | 80 | 77 | 78 | 77 | 78 | 77 | 78 | 77 | 78 | 79 | 79 | 77 | 77 | 78 | 78 | 77 | 76 |
| 1280 | 90 | 92 | 90 | 92 | 90 | 92 | 89 | 91 | 92 | 93 | 91 | 92 | 91 | 92 | 91 | 91 | 89 | 92 | 89 | 91 | 89 | 92 | 89 | 91 | 91 | 92 | 90 | 92 | 91 | 92 | 90 | 91 |
| 1312 | 87 | 89 | 87 | 89 | 86 | 87 | 85 | 86 | 89 | 90 | 88 | 90 | 87 | 88 | 86 | 87 | 87 | 89 | 86 | 88 | 85 | 87 | 85 | 86 | 88 | 89 | 87 | 89 | 87 | 88 | 86 | 87 |
| 1344 | 99 | 100 | 98 | 100 | 99 | 100 | 98 | 99 | 100 | 100 | 99 | 99 | 100 | 100 | 99 | 99 | 99 | 99 | 98 | 99 | 98 | 99 | 98 | 99 | 100 | 100 | 99 | 99 | 99 | 99 | 99 | 98 |
| 1376 | 96 | 97 | 95 | 96 | 94 | 95 | 93 | 94 | 97 | 97 | 96 | 96 | 95 | 95 | 94 | 94 | 96 | 97 | 95 | 96 | 94 | 95 | 93 | 94 | 97 | 97 | 96 | 96 | 95 | 95 | 94 | 94 |
| 1408 | 75 | 77 | 74 | 77 | 75 | 77 | 74 | 76 | 77 | 78 | 76 | 77 | 76 | 77 | 76 | 77 | 73 | 75 | 72 | 74 | 73 | 74 | 72 | 74 | 75 | 76 | 74 | 75 | 74 | 75 | 74 | 74 |
| 1440 | 72 | 75 | 72 | 74 | 71 | 72 | 70 | 72 | 74 | 75 | 74 | 74 | 72 | 73 | 72 | 72 | 70 | 72 | 69 | 71 | 68 | 70 | 67 | 70 | 72 | 72 | 71 | 72 | 70 | 71 | 69 | 70 |
| 1472 | 80 | 81 | 80 | 80 | 80 | 81 | 79 | 80 | 81 | 81 | 79 | 80 | 80 | 80 | 80 | 79 | 78 | 79 | 77 | 78 | 77 | 79 | 77 | 78 | 79 | 79 | 77 | 77 | 78 | 78 | 77 | 77 |
| 1504 | 77 | 78 | 77 | 78 | 75 | 76 | 75 | 76 | 79 | 78 | 77 | 77 | 77 | 76 | 76 | 75 | 75 | 76 | 75 | 75 | 73 | 74 | 72 | 73 | 76 | 76 | 75 | 75 | 74 | 74 | 73 | 72 |
| 1536 | 94 | 95 | 94 | 94 | 95 | 96 | 94 | 95 | 94 | 94 | 93 | 94 | 95 | 96 | 94 | 95 | 94 | 95 | 93 | 94 | 95 | 96 | 94 | 95 | 93 | 94 | 92 | 93 | 94 | 95 | 94 | 95 |

# IPM Examples

NERSC job details

http://www.nersc.gov/REST/jobs/mpi_functions.php?stepid=441560.sdb&f_name=MPI_Recv&timestamp=1306769707

Other

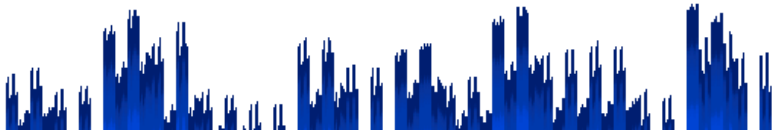
Time spent by each task in *MPI_Recv* as a percentage of the maximum value

The MPI rank represented by each cell in the table is the sum of the cell's column and row indices.

Table Columns: 32

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 74 | 76 | 69 | 70 | 77 | 77 | 70 | 71 | 60 | 62 | 60 | 61 | 64 | 65 | 65 | 64 | 78 | 79 | 72 | 72 | 78 | 79 | 73 | 73 | 63 | 64 | 63 | 64 | 66 | 65 | 66 | 66 |
| 32 | 70 | 71 | 63 | 65 | 72 | 72 | 65 | 66 | 52 | 54 | 53 | 55 | 56 | 57 | 58 | 58 | 71 | 73 | 67 | 68 | 72 | 73 | 67 | 69 | 55 | 55 | 54 | 55 | 58 | 58 | 57 | 57 |
| 64 | 91 | 92 | 88 | 90 | 91 | 93 | 90 | 91 | 76 | 77 | 74 | 76 | 79 | 81 | 79 | 79 | 95 | 98 | 92 | 96 | 98 | 98 | 96 | 96 | 78 | 81 | 77 | 80 | 84 | 84 | 83 | 82 |
| 96 | 86 | 87 | 80 | 80 | 86 | 89 | 81 | 82 | 62 | 63 | 61 | 61 | 65 | 67 | 65 | 65 | 91 | 94 | 83 | 86 | 94 | 94 | 87 | 86 | 64 | 66 | 63 | 65 | 70 | 69 | 69 | 68 |
| 128 | 69 | 71 | 64 | 65 | 70 | 72 | 65 | 66 | 54 | 56 | 53 | 55 | 60 | 60 | 59 | 59 | 69 | 70 | 64 | 65 | 69 | 70 | 65 | 66 | 56 | 57 | 55 | 56 | 60 | 59 | 58 | 58 |
| 160 | 65 | 67 | 57 | 59 | 67 | 68 | 60 | 61 | 42 | 43 | 43 | 44 | 47 | 46 | 47 | 47 | 66 | 67 | 58 | 60 | 67 | 67 | 60 | 60 | 43 | 44 | 45 | 46 | 46 | 46 | 48 | 48 |
| 192 | 86 | 87 | 80 | 81 | 88 | 89 | 82 | 83 | 67 | 68 | 66 | 67 | 71 | 72 | 70 | 70 | 85 | 88 | 81 | 84 | 89 | 88 | 84 | 84 | 68 | 71 | 66 | 69 | 74 | 73 | 72 | 71 |
| 224 | 79 | 79 | 71 | 71 | 80 | 80 | 72 | 72 | 49 | 49 | 49 | 50 | 52 | 52 | 53 | 52 | 76 | 79 | 70 | 73 | 79 | 79 | 73 | 74 | 50 | 52 | 48 | 52 | 55 | 55 | 54 | 54 |
| 256 | 83 | 84 | 81 | 83 | 85 | 85 | 84 | 85 | 69 | 71 | 69 | 70 | 74 | 75 | 74 | 74 | 85 | 86 | 85 | 87 | 86 | 87 | 86 | 87 | 73 | 73 | 71 | 71 | 76 | 75 | 74 | 73 |
| 288 | 72 | 73 | 66 | 68 | 73 | 74 | 69 | 70 | 60 | 62 | 59 | 60 | 64 | 65 | 63 | 63 | 75 | 76 | 69 | 71 | 76 | 76 | 71 | 71 | 63 | 63 | 61 | 61 | 65 | 65 | 64 | 64 |
| 320 | 94 | 95 | 93 | 94 | 93 | 96 | 94 | 95 | 77 | 78 | 75 | 75 | 80 | 81 | 78 | 78 | 99 | 99 | 96 | 96 | 99 | 99 | 98 | 97 | 79 | 80 | 77 | 78 | 83 | 82 | 81 | 80 |
| 352 | 82 | 83 | 74 | 75 | 83 | 84 | 75 | 76 | 61 | 62 | 66 | 66 | 65 | 65 | 69 | 69 | 84 | 85 | 76 | 77 | 85 | 85 | 77 | 78 | 63 | 64 | 66 | 67 | 66 | 66 | 69 | 69 |
| 384 | 84 | 86 | 76 | 78 | 86 | 88 | 79 | 80 | 64 | 64 | 63 | 64 | 68 | 68 | 67 | 67 | 85 | 86 | 77 | 78 | 85 | 86 | 78 | 79 | 65 | 65 | 66 | 66 | 68 | 67 | 69 | 68 |
| 416 | 69 | 70 | 60 | 62 | 71 | 72 | 63 | 64 | 45 | 46 | 46 | 47 | 49 | 50 | 50 | 51 | 68 | 69 | 61 | 62 | 69 | 70 | 62 | 62 | 47 | 47 | 46 | 47 | 49 | 49 | 47 | 49 |
| 448 | 98 | 98 | 99 | 100 | 99 | 98 | 100 | 100 | 85 | 85 | 78 | 77 | 89 | 89 | 81 | 80 | 94 | 94 | 95 | 96 | 94 | 94 | 97 | 97 | 87 | 87 | 78 | 79 | 91 | 90 | 82 | 81 |
| 480 | 82 | 82 | 72 | 73 | 82 | 84 | 74 | 74 | 54 | 54 | 52 | 52 | 56 | 57 | 54 | 55 | 83 | 83 | 72 | 73 | 84 | 84 | 71 | 73 | 54 | 55 | 53 | 54 | 57 | 57 | 55 | 56 |
| 512 | 88 | 89 | 89 | 91 | 90 | 91 | 92 | 93 | 78 | 80 | 78 | 80 | 83 | 84 | 84 | 84 | 93 | 94 | 93 | 95 | 94 | 94 | 95 | 94 | 80 | 81 | 82 | 83 | 85 | 84 | 86 | 85 |
| 544 | 90 | 91 | 79 | 81 | 91 | 93 | 82 | 83 | 63 | 65 | 63 | 64 | 67 | 69 | 68 | 68 | 96 | 97 | 84 | 84 | 98 | 97 | 85 | 85 | 66 | 66 | 66 | 67 | 69 | 68 | 70 | 69 |
| 576 | 76 | 77 | 74 | 75 | 76 | 77 | 76 | 76 | 65 | 65 | 66 | 67 | 67 | 67 | 70 | 70 | 79 | 82 | 77 | 80 | 83 | 82 | 81 | 81 | 67 | 69 | 69 | 71 | 72 | 72 | 74 | 73 |
| 608 | 76 | 77 | 69 | 69 | 76 | 78 | 70 | 71 | 57 | 57 | 57 | 58 | 60 | 59 | 60 | 60 | 79 | 81 | 72 | 75 | 82 | 81 | 75 | 75 | 60 | 62 | 58 | 61 | 64 | 63 | 63 | 62 |
| 640 | 92 | 94 | 85 | 87 | 96 | 96 | 90 | 89 | 75 | 77 | 75 | 77 | 81 | 81 | 81 | 81 | 93 | 94 | 87 | 88 | 94 | 94 | 88 | 88 | 77 | 78 | 76 | 77 | 81 | 80 | 80 | 79 |
| 672 | 86 | 87 | 78 | 78 | 88 | 88 | 80 | 80 | 57 | 58 | 58 | 59 | 62 | 62 | 63 | 63 | 87 | 87 | 78 | 79 | 88 | 87 | 79 | 79 | 59 | 59 | 60 | 60 | 62 | 61 | 63 | 63 |
| 704 | 78 | 79 | 74 | 75 | 80 | 80 | 76 | 75 | 63 | 64 | 63 | 63 | 68 | 67 | 67 | 66 | 78 | 81 | 74 | 77 | 81 | 81 | 77 | 77 | 64 | 67 | 63 | 66 | 70 | 69 | 69 | 67 |
| 736 | 70 | 71 | 65 | 65 | 71 | 71 | 66 | 67 | 52 | 52 | 50 | 51 | 55 | 54 | 53 | 53 | 71 | 73 | 64 | 67 | 74 | 73 | 68 | 68 | 53 | 55 | 52 | 54 | 57 | 57 | 57 | 56 |
| 768 | 94 | 96 | 87 | 88 | 96 | 98 | 90 | 90 | 71 | 73 | 70 | 71 | 75 | 77 | 75 | 75 | 95 | 95 | 87 | 87 | 96 | 96 | 87 | 88 | 74 | 75 | 73 | 74 | 79 | 78 | 77 | 77 |
| 800 | 79 | 80 | 70 | 71 | 81 | 83 | 72 | 73 | 57 | 58 | 62 | 63 | 62 | 62 | 67 | 67 | 80 | 79 | 71 | 71 | 80 | 80 | 71 | 72 | 60 | 60 | 64 | 64 | 63 | 63 | 66 | 67 |
| 832 | 82 | 83 | 77 | 77 | 82 | 84 | 78 | 78 | 63 | 64 | 64 | 64 | 66 | 66 | 67 | 66 | 86 | 86 | 79 | 80 | 87 | 86 | 81 | 80 | 65 | 66 | 64 | 65 | 69 | 68 | 68 | 67 |
| 864 | 69 | 70 | 65 | 65 | 70 | 70 | 65 | 66 | 56 | 56 | 56 | 56 | 59 | 59 | 58 | 58 | 73 | 73 | 67 | 67 | 73 | 73 | 67 | 67 | 58 | 59 | 58 | 59 | 61 | 59 | 61 | 59 |
| 896 | 92 | 92 | 85 | 86 | 93 | 94 | 88 | 88 | 71 | 72 | 69 | 70 | 76 | 75 | 74 | 74 | 92 | 92 | 87 | 88 | 94 | 93 | 88 | 89 | 73 | 73 | 70 | 71 | 76 | 76 | 74 | 74 |
| 928 | 73 | 74 | 64 | 65 | 75 | 76 | 66 | 67 | 43 | 44 | 48 | 49 | 47 | 48 | 53 | 54 | 74 | 73 | 64 | 65 | 73 | 74 | 64 | 66 | 45 | 45 | 51 | 52 | 47 | 48 | 53 | 54 |
| 960 | 74 | 74 | 70 | 70 | 75 | 75 | 71 | 71 | 63 | 64 | 61 | 61 | 66 | 66 | 64 | 63 | 76 | 77 | 72 | 73 | 77 | 77 | 73 | 73 | 63 | 64 | 62 | 62 | 66 | 66 | 66 | 64 |
| 992 | 63 | 63 | 57 | 57 | 63 | 64 | 58 | 58 | 41 | 41 | 42 | 42 | 43 | 42 | 44 | 43 | 61 | 61 | 56 | 57 | 62 | 62 | 56 | 57 | 41 | 41 | 42 | 42 | 43 | 42 | 43 | 43 |

Time vs. MPI Rank for *MPI_Recv*



# Summary

- HPC tools are, in general, difficult to use or require a large investment of time to learn to use and interpret the results
- There is a need for tools to help users get to exascale (or even petascale).
- Simple, easy to use tools would be extremely useful, even if they did not give low-level details