Software-based Performance Counters in Open MPI

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Tool Support in Open MPI

High-Level Information

The PMPI Interface ☺

- MPI standard compliant ☺
- Full support in Open MPI ☺

Low-Level Information

The MPI_T Interface 😐

- MPI standard compliant ☺
- Little to no MPI_T pvars ☹

The Peruse Interface ☹

- Not MPI standard compliant ☹
- No widespread adoption ☹

Proposed Solution

Software-based Performance Counters (SPCs)

- Instrumentation of Open MPI with integer counters
  - Low-level information (ex. number of unexpected messages)
  - High-level information (ex. number of times MPI functions are called)
- Fine-grained performance metrics
  - Updated as soon as the information is available
- Registered as MPI_T pvars

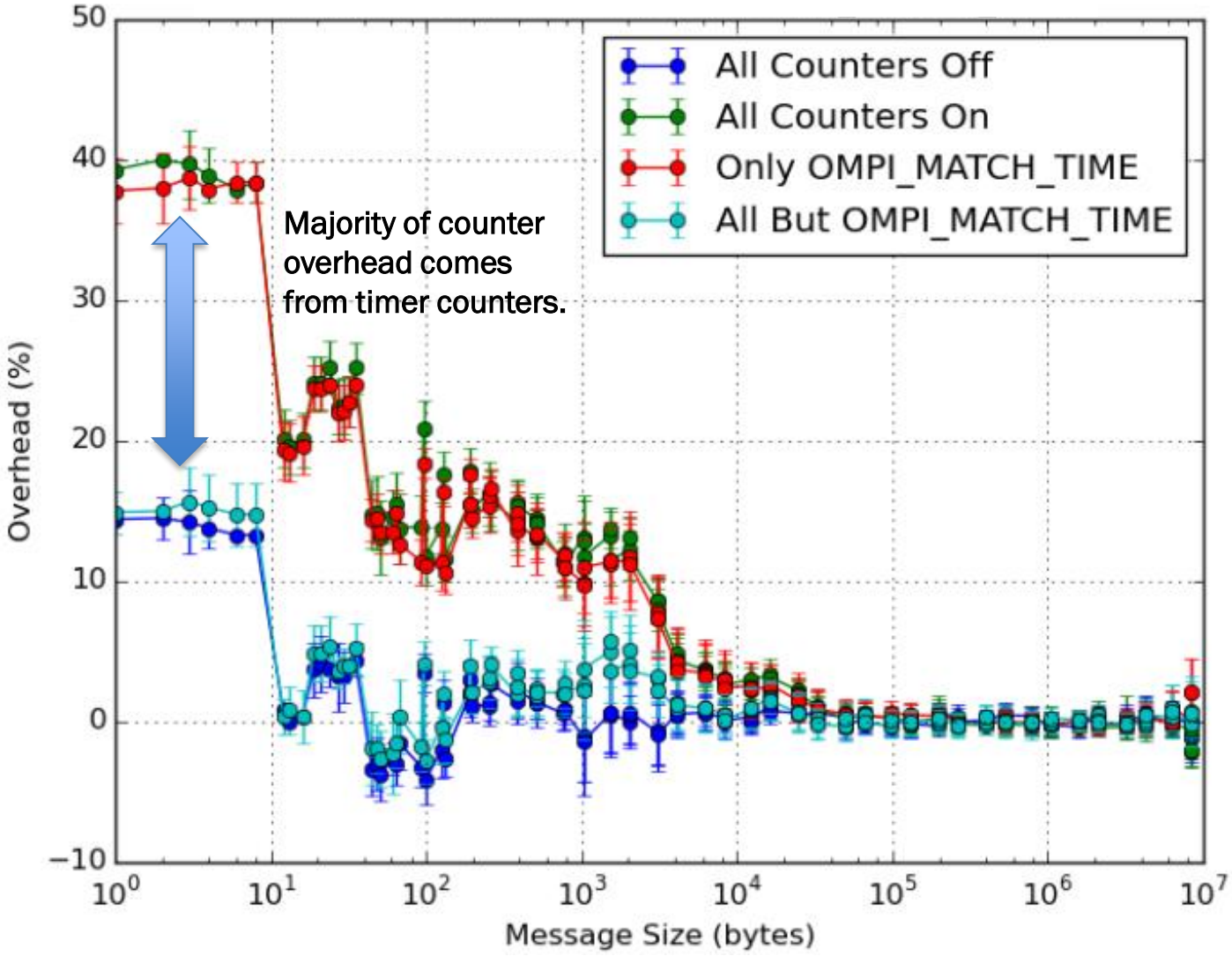
Types of SPCs

- Regular Counters
  - Increment/decrement each time a certain event happens
- Timer Counters
  - Increment with the number of cycles spent in some event
  - Must be converted to time before reporting
- High Watermark Counters
  - Keep track of the highest a given value has been
  - Resets to current value level upon reading
- Bin Counters
  - Stores multiple categories of the same counter in bins
  - i.e. number of messages sent eagerly vs. otherwise

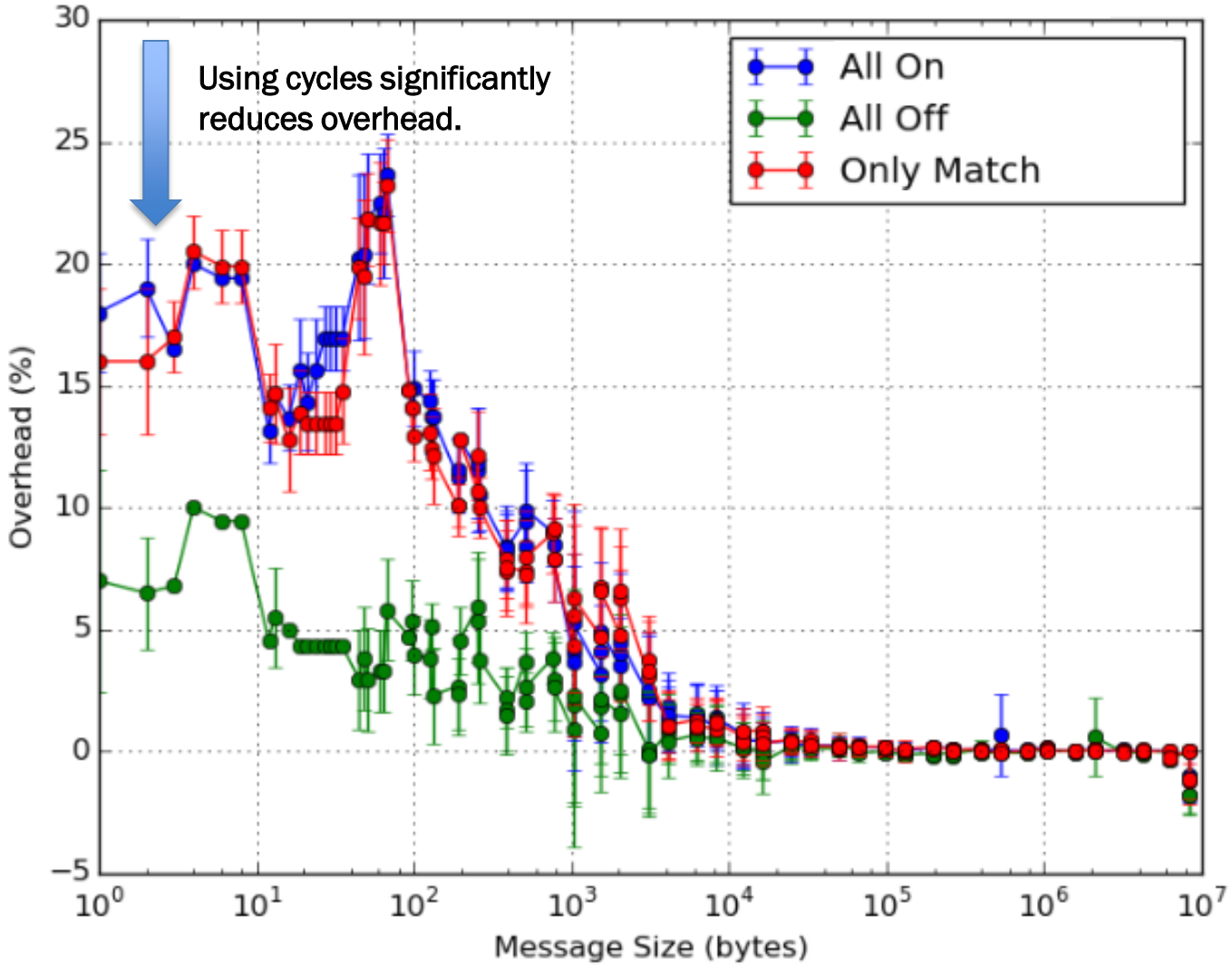
Reducing PMPI Burden

- Overlapping capabilities handled by SPCs
  - Counts of function calls
- Reduces overhead if PMPI is not used
  - No additional function call overhead
- Frees PMPI interface for other uses

SPC Worst-Case Overhead (microseconds)



SPC Worst-Case Overhead (cycles)



Accessing SPCs

- MPI_T pvars
  - All SPCs can be accessed through MPI_T
- Use mmap interface to access SPCs
  - One SPC pvar gives path to XML file used for mmap interface
  - One data file per rank stored locally
  - Optionally record periodic snapshots
  - Accessible through RMA operations
- Print to stdout
  - Not advisable for large runs
  - Post-run analysis report (in-progress)

SPC Use Examples

- Identify performance bottlenecks
  - More MPI usage on certain ranks
  - Higher unexpected messages or queue lengths
- Identify program phases
  - Record snapshots and analyze differences in counters in fixed intervals
  - Possibly use this to increase snapshot frequency
- Help Open MPI developers diagnose issues in Open MPI
  - Out of sequence message issue

Identifying Open MPI OOS Problem

- Used SPCs to identify problematic number of out of sequence messages in *vader* and *openib* BTLs.

Table 1: Results of the MADNESS *moldft* tests using five water molecules. The counter values are the average of 10 runs with 18 threads per run of the simulation.

Counter	*openib*	*vader*	*tcp*
Total Time (sec)	626.41	440.95	518.54
OMPI_UNEXPECTED	126, 339.4	21, 654.5	14, 868.5
OMPI_OUT_OF_SEQUENCE	1, 222, 397.6	134, 631.0	0.0
OMPI_MATCH_TIME	282, 910.2	369, 343.7	251, 844.7
OMPI_OOS_MATCH_TIME	317, 157.8	32, 742.9	0.0

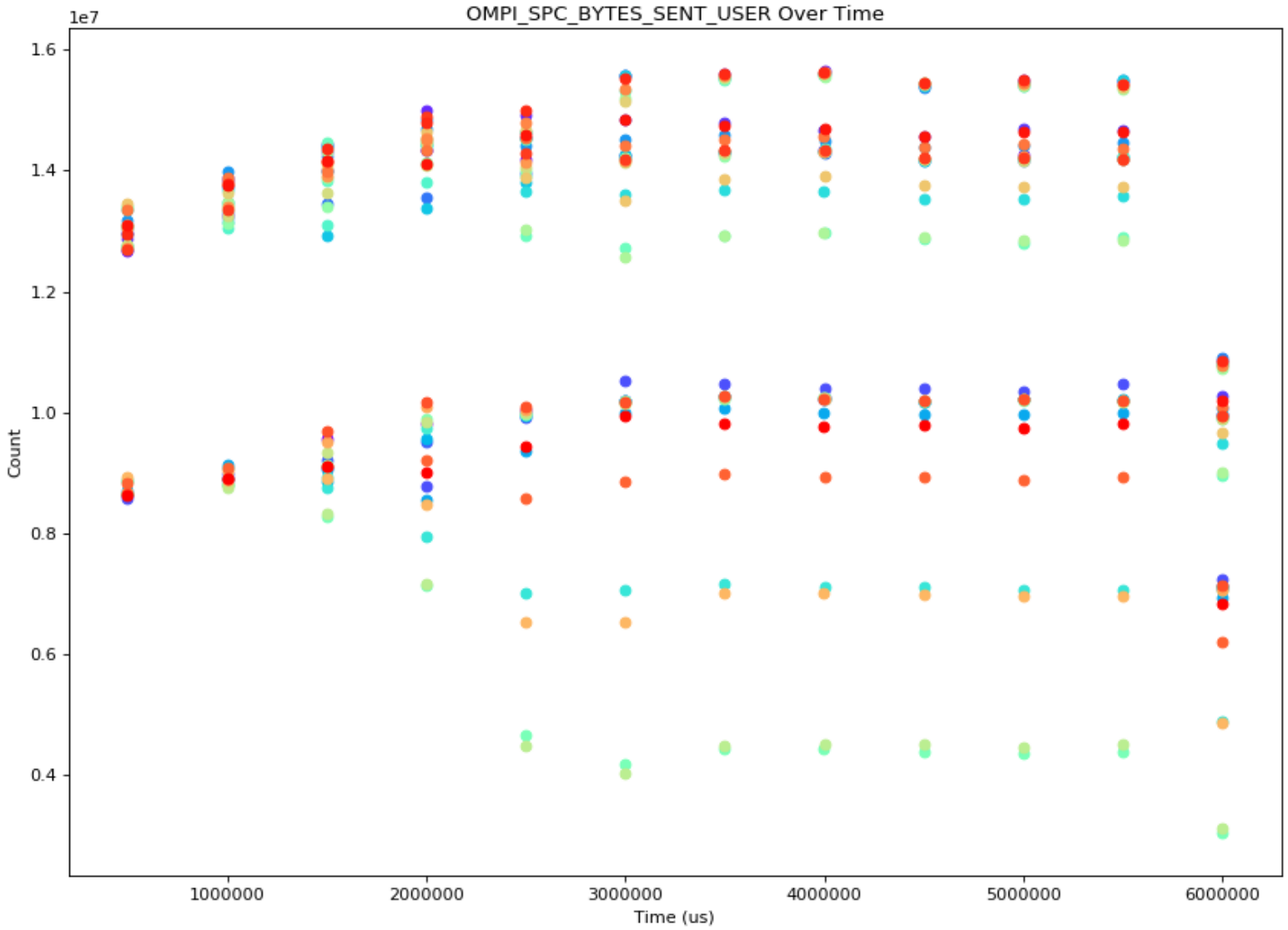
Table 2: Results of the *pairwise* benchmark with a window size of 256 messages, message size of 64 bytes, and an iteration count of 100 using the *openib* BTL.

Threads	Message Rate (msg/sec)	Receives	OOS Messages	% OOS	Wall Time (us)	Match Time (us)	OOS Match Time (us)
2	601, 773.54	56, 320	16, 633	29.53%	85, 598	9, 634	9, 875
4	476, 174.73	112, 640	47, 216	41.92%	218, 807	34, 312	51, 196
8	162, 458.93	225, 280	112, 813	50.08%	1, 260, 863	96, 465	729, 187

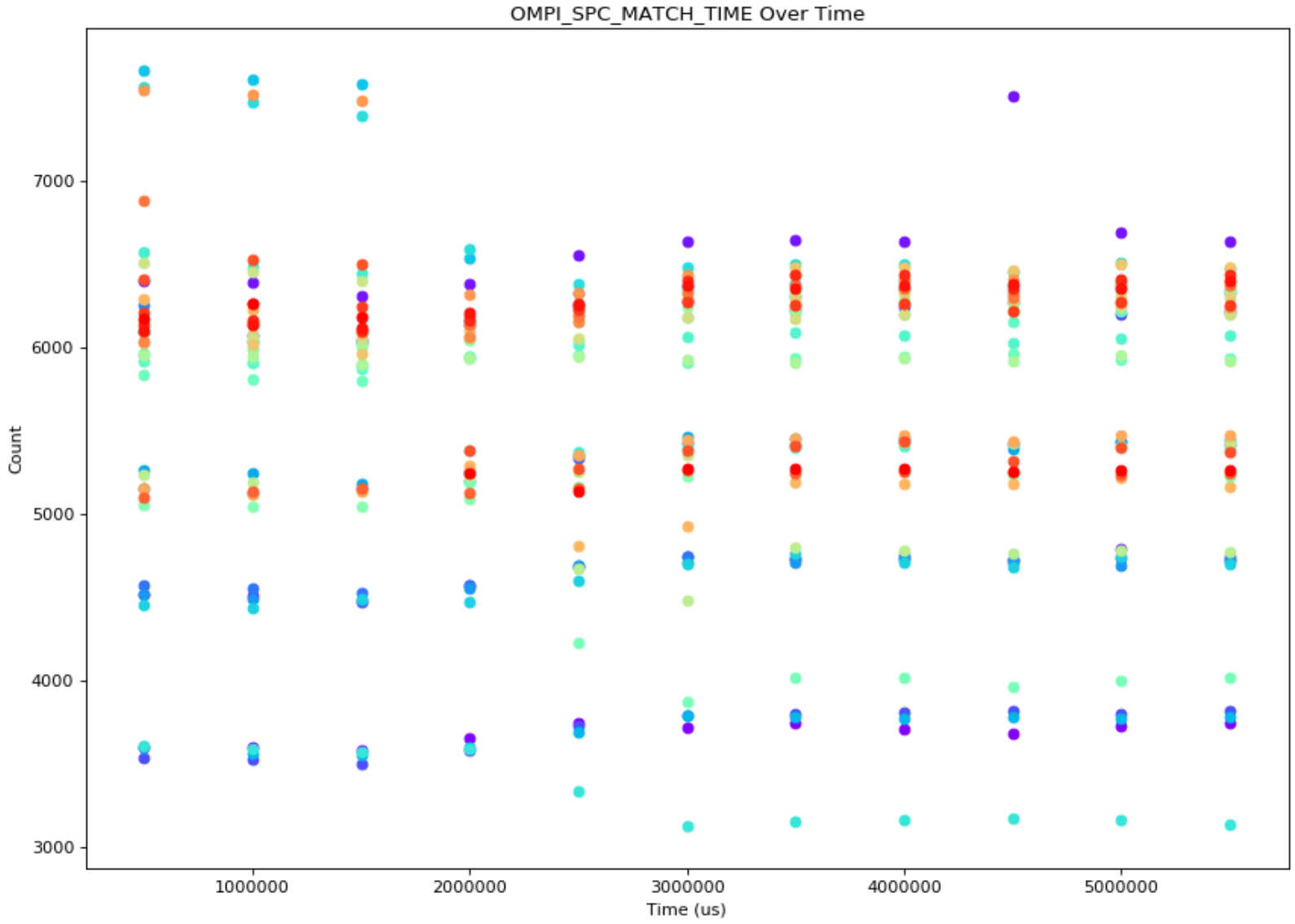
LAMMPS Example

- *indent* Example
  - Has more communication than most examples
- Used the mmap interface
  - Record snapshots every 0.5 seconds
- Run parameters
  - 2 nodes
  - 2 CPU sockets per node
  - 40 processes (20 procs/node)

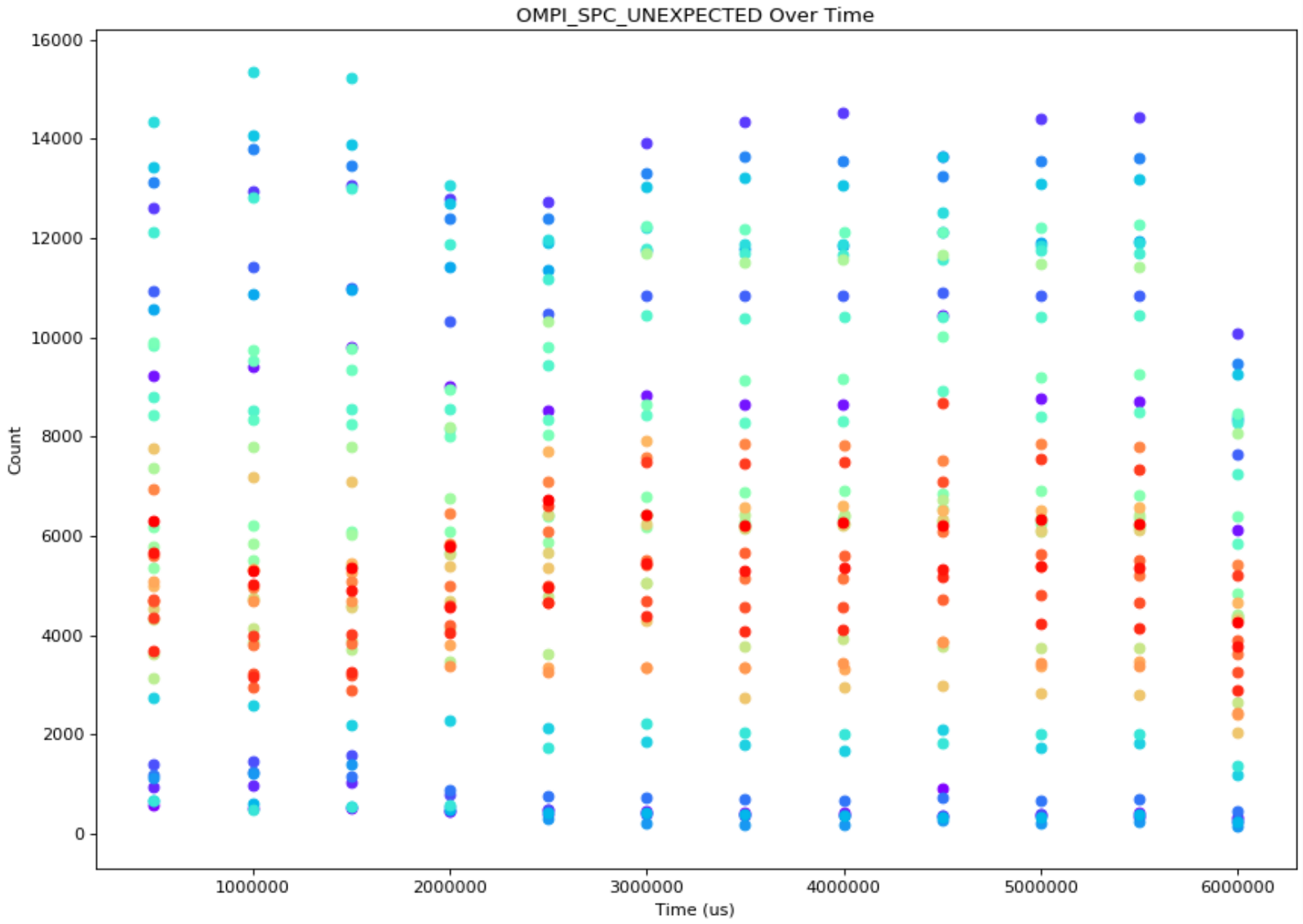
LAMMPS Example (Bytes User)



LAMMPS Example (Match Time)



LAMMPS Example (Unexpected)



Current/Future Work Open for Collaboration

- Program phase detection
  - Looking at differences in counters over time to identify program phases
- Post-mortem analysis and report
  - Give suggestions for improvements
- Tool adoption of SPCs
  - Anyone interested?
- Survey of CORAL mini-apps
  - Show the MPI usage over time
  - Analyze queue usage (unexpected messages, matching time, etc…)