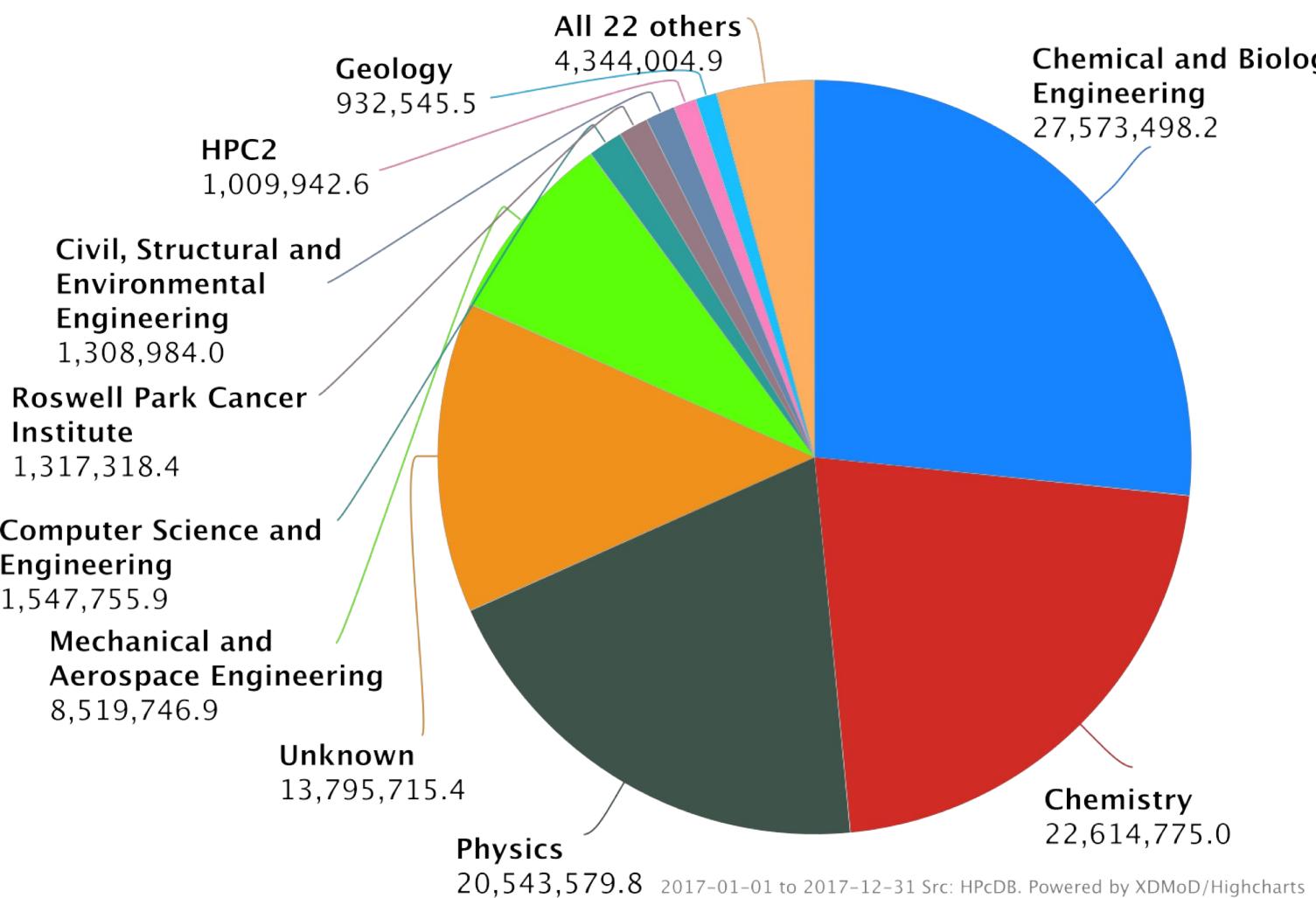


Studying Effects of Meltdown and Spectre Patches on the Performance of HPC Applications Using Application Kernel Module of XDMoD

Nikolay A. Simakov, Martins D. Innus, Matthew D. Jones, Ohad Katz,
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Thomas R. Furlani

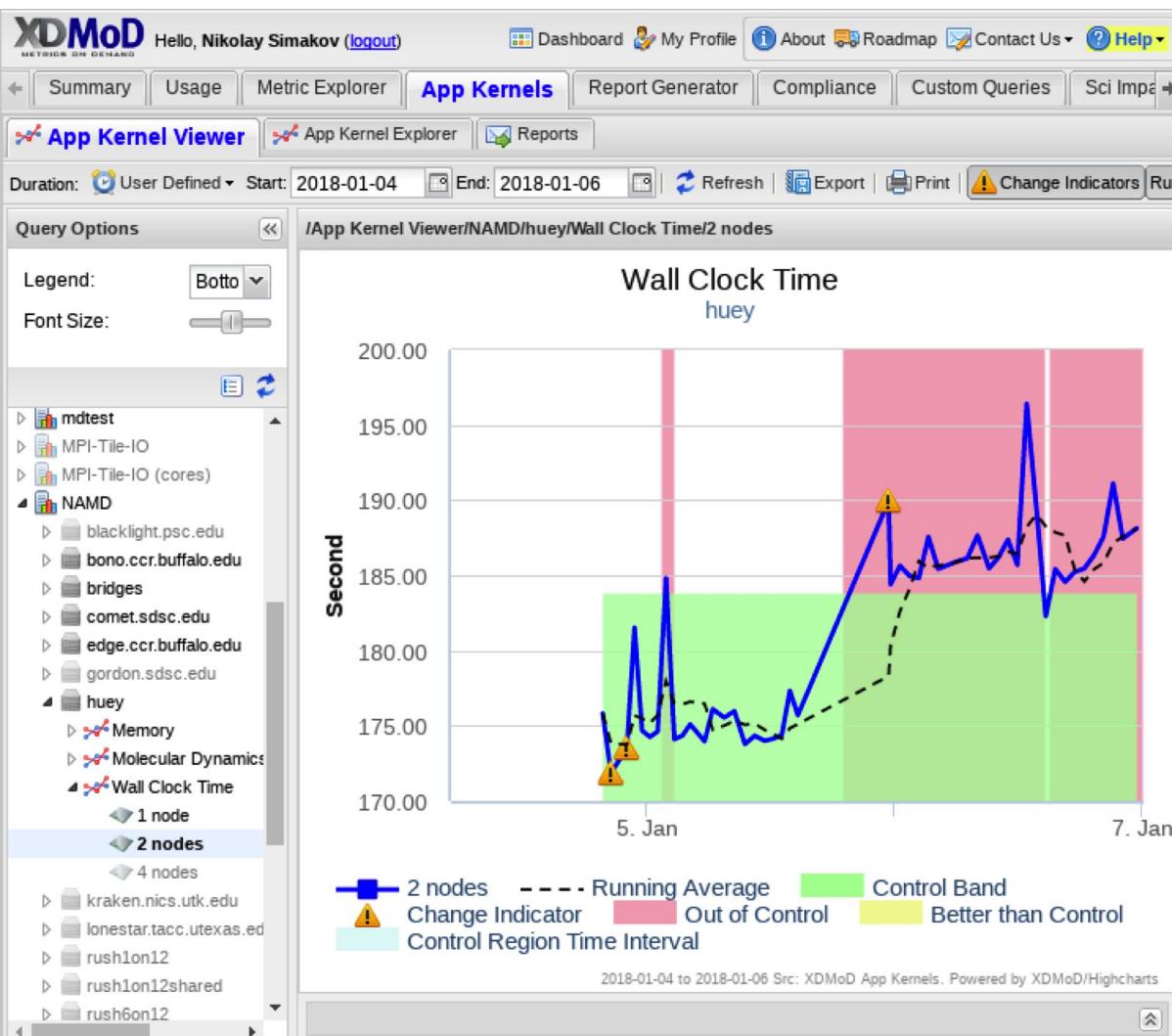


Center for Computational Research, University at Buffalo



- Regional HPC Center
- Serving academic and industry users from Western NY
- 11,408 Cores (798 Nodes) Academic Cluster
- 3,456 Cores (216 Nodes) Industry Cluster
- 500 active users and 200 PI
- 104 millions cores hours delivered in 2017
- Develop XDMoD, a tool for HPC resources usage and performance monitoring

Application Kernel Performance Monitoring Module of XDMoD



- Application kernels:

- Based on benchmarks or applications
- Computationally lightweight (Short runtime)
- Run repeatedly on high performance computing (HPC) clusters in order to track the Quality of Service (QoS) provided to the users.
- They have been successful in detecting a variety of hardware and software issues, some severe, that have subsequently been corrected, resulting in improved system performance



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Meltdown and Spectre Vulnerabilities

Vuln- rability	Description	Remedy
Meltdown	Rogue Data Cache Load Exploit uses speculative cache loading to allow a local attacker to be able to read the contents of memory	Kernel patches: Kernel Page Table Isolation
Spectre, Variant 1	Bounds Check Bypass Bounds-checking exploit during branching	Kernel patches
Spectre, Variant 2	Branch Target Injection Indirect branching poisoning attack that can lead to data leakage.	Microcode update and kernel patches



<https://meltdownattack.com/>
<https://access.redhat.com/security/vulnerabilities/speculativeexecution>
<https://access.redhat.com/articles/3311301>

Application Kernels



Application	Description
NWChem	Computational chemistry code with wide range of methods from molecular mechanics and molecular dynamics to full <i>ab initio</i> calculations.
GAMESS-US	An <i>ab initio</i> computational chemistry code
NAMD	A parallel molecular dynamics code that was specifically designed for high performance simulations on large HPC clusters
Enzo	Adaptive mesh refinement code for astrophysical simulation of cosmological structure formation
Graph500	A benchmark that measures the performance of breadth-first search on a graph
HPCC	Collection of seven tests: (1) Linpack; (2) matrix multiplication; (3) memory bandwidth; (4) parallel matrix transpose; (5) random memory access; (6) fast Fourier transform; and (7) bandwidth and latency
IMB	Benchmarking MPI routings
IOR	Parallel file systems benchmark using portable operating system interface (POSIX), MPI-IO, and hierarchical data format 5 (HDF5) interfaces.
MDTest	Metadata file system operation benchmark



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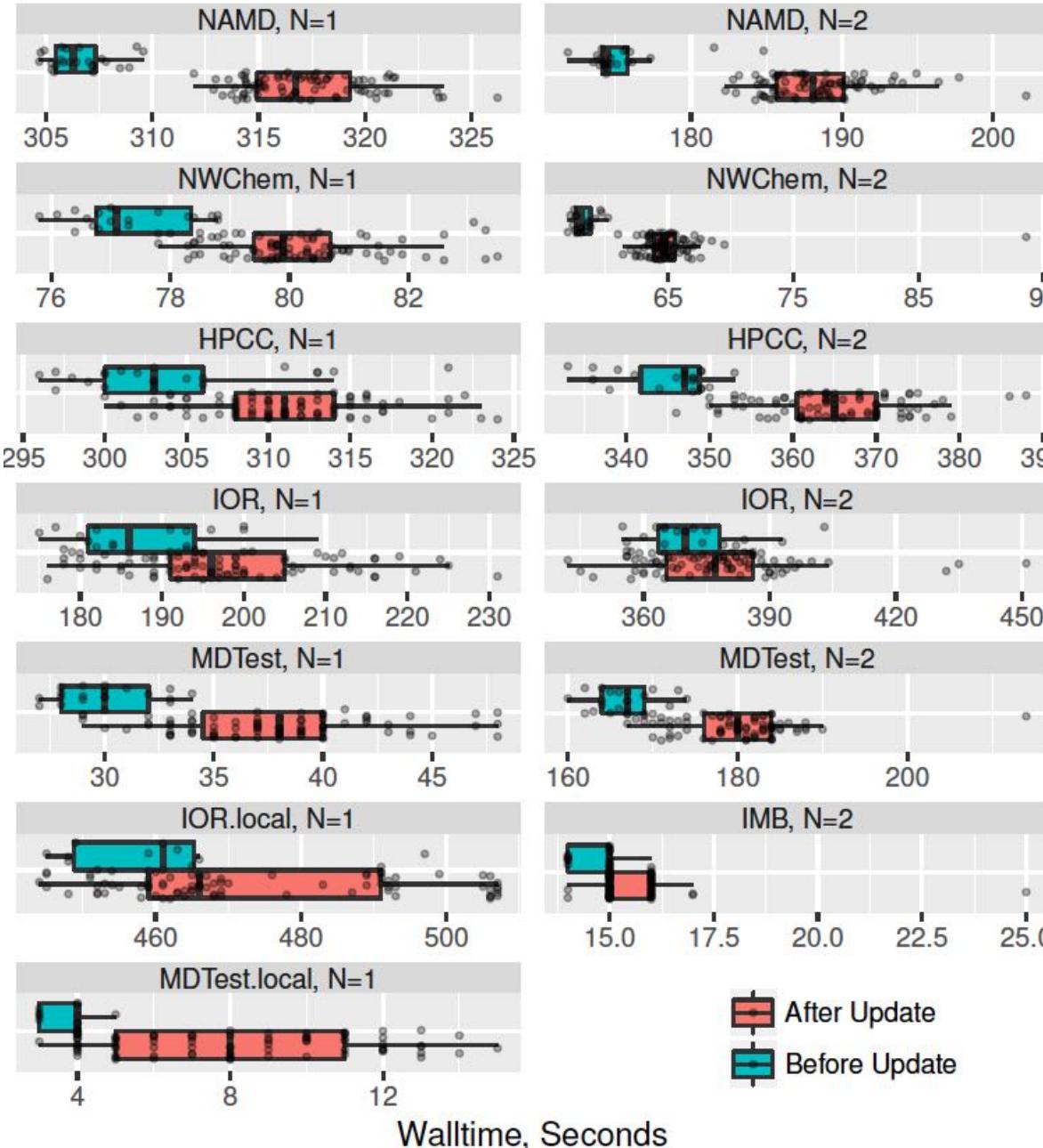
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Test System and Used Updates



- Test cluster
 - Few nodes separated from production cluster, for developmental purposes
 - Eight-core nodes with two Intel L5520 CPUs and 24GiB RAM
 - Connected by QDR Mellanox Infiniband
 - Parallel filesystem: 3 PB IBM GPFS storage system shared with other HPC resources in CCR.
 - CentOS Linux - 7.4.1708.
- A new kernel and linux-firmware were installed to address the Meltdown and Spectre vulnerabilities
 - kernel-3.10.0-693.5.2 was updated to kernel-3.10.0-693.11.6
 - This is January, 2018 fixes

Results. Performance Impact. Execution Time



App.Kernel	Difference, %	
	1 Node	2 Nodes
NAMD	3.3	6.9
NWChem	2.6	11.4
HPCC	2.2	5.3
IMB		4.1
IOR	3.7	0.7
IOR.local	2.0	
MDTest	22.9	9.1
MDTest.local	68.0	



Results. Performance Impact. Selected Metrics

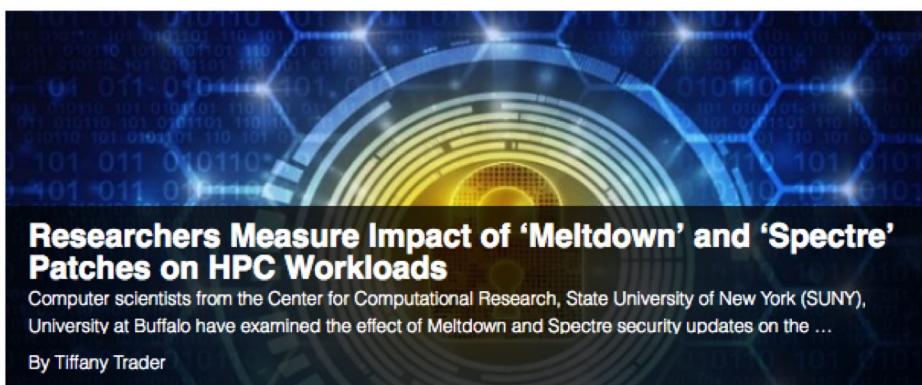
App. Kernel	Nodes	Metrics	Difference, %	Units
NAMD	2	Molecular Dynamics Simulation Performance	-6.6	Second per Day
HPCC	2	High Performance LINPACK Floating-Point Performance	-8.6	MFLOP per Second
		Fast Fourier Transform (FFTW) Floating-Point Performance	-6.4	MFLOP per Second
		Parallel Matrix Transpose (PTRANS)	-9.6	MByte per Second
MDTest	1	Directory creation (single tree directory)	-15.1	Operations/Second
		Directory removal (single tree directory)	-16	Operations/Second
		Directory stat (single tree directory)	-18.4	Operations/Second





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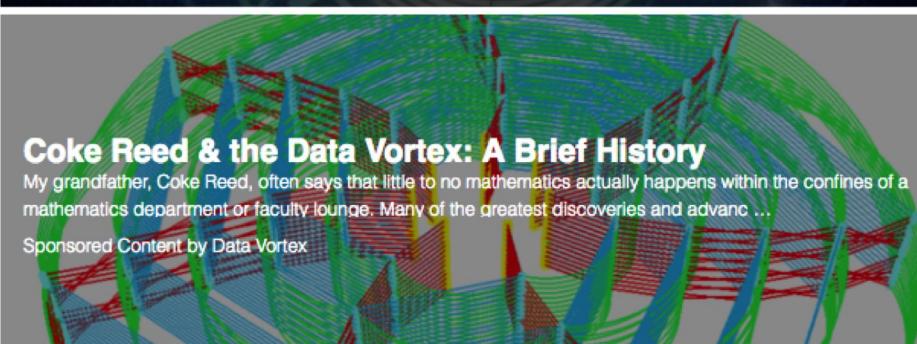
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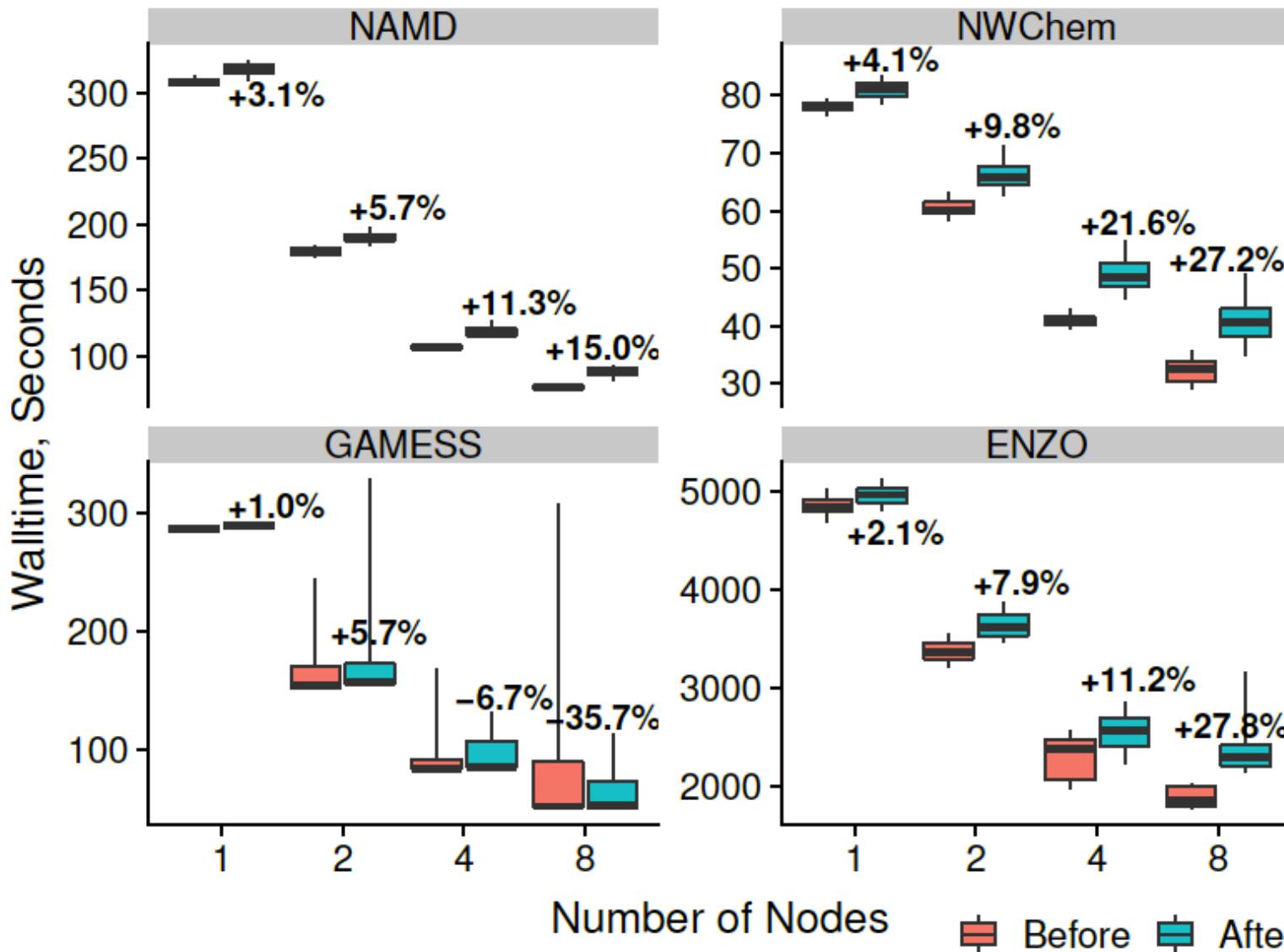
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Parallel Performance Impact



- Analyzed performance metrics from continuous performance monitoring on production CCR UB-HPC cluster
- NAMD, NWChem and ENZO do exhibit a significant degradation of their performance as the number of nodes increases.

Duration: User Defined ▾ Start: 2017-09-09 End: 2018-09-09 Refresh Export Print Change Indicators Available For Report

Query Options

Title:

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Metrics

NAMD

▶  Memory

Molecular Dynamics Simulation

SUPREMM: Average number of

 Wall Clock Time

1 node

 2 node

 4 node

8 node

Resources

 alamo.futuregrid.

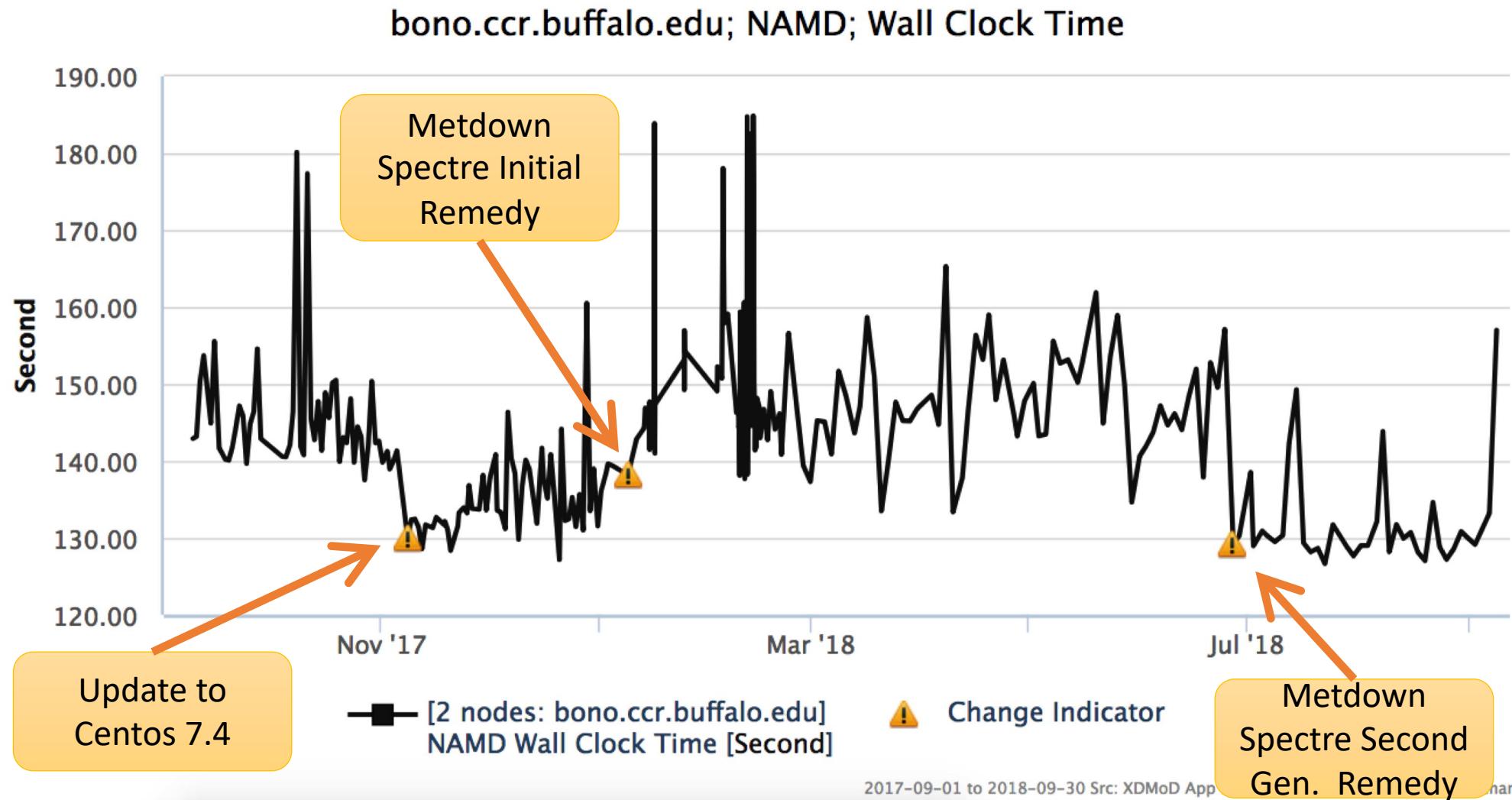
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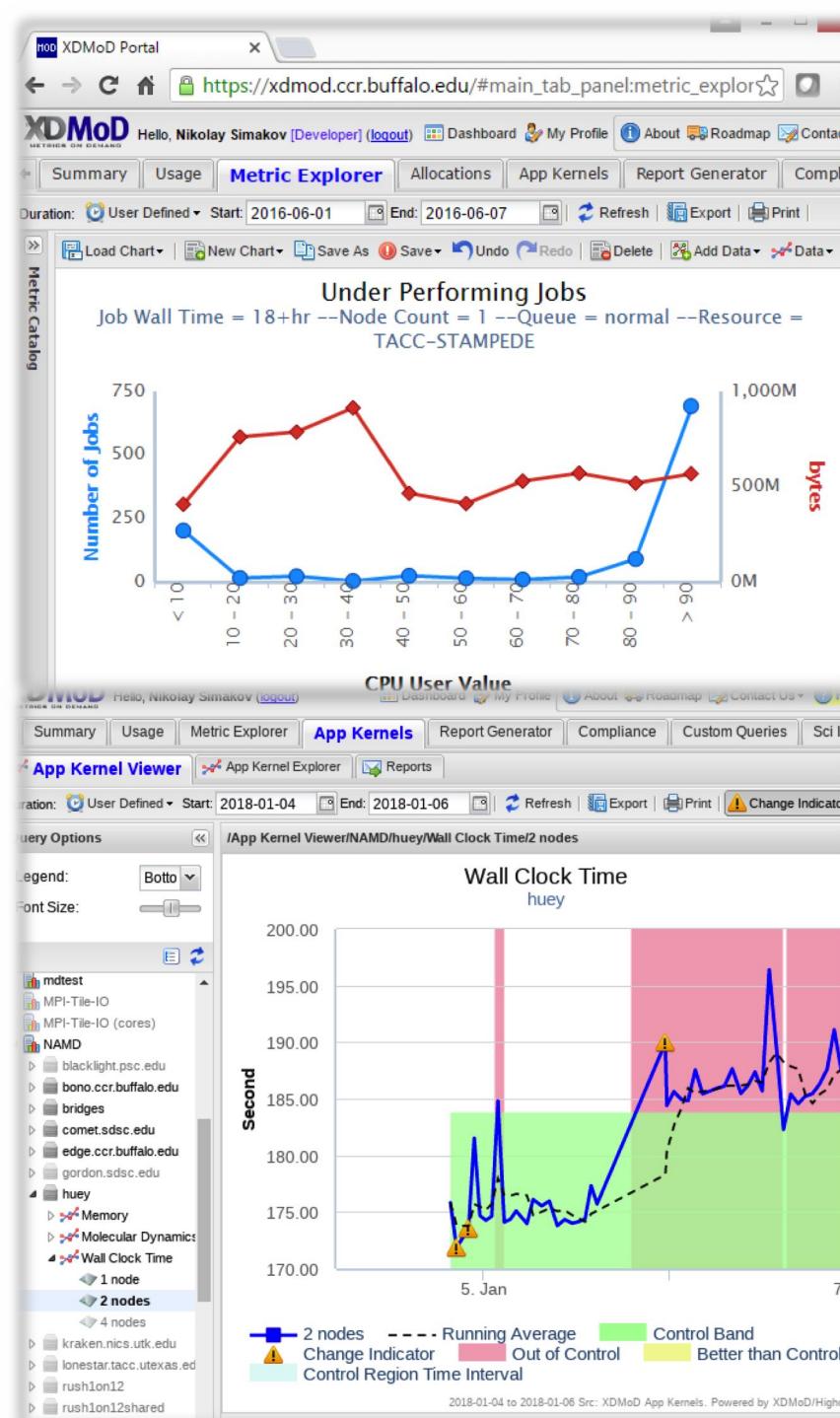
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Conclusions

- In addition to continuous HPC system performance monitoring for quality of service, the application kernel module of XDMoD also allows rapid benchmarking of HPC systems to identify the impact of a particular change on the system.
 - We are planning to improve application kernel performance monitoring module of XDMoD interface to facilitate such benchmarking
- The original security patches have a significant degrading effect on multiple metrics, most notably MPI calls and file metadata operations. Many other metrics show little to no change.
- Overall, scientific applications executed on a single node have a moderate decrease in the performance around 2-4%.
 - However, the performance degradation grows with node count reaching 27% in one case. This most likely is caused by increasing the number of network related system calls.
- Newer fixes significantly reduces the performance impact.

Questions?



- A Tool for HPC resources usage and performance analysis - <http://open.xdmod.org/>
- Provide resources utilization and performance monitoring services for XSEDE systems - <http://xdmod.ccr.buffalo.edu/>
- Slurm Simulator - <https://github.com/ubccr-slurm-simulator>
- Visit Center for Computational Research University at Buffalo Booth (#3144)