PROPHESY

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Parallel Finite Element Earthquake Rupture Simulations on Quad- and Hex-core Cray XT Systems

Xingfu Wu, Benchun Duan and Valerie Taylor

Texas A&M University

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Outline

- Introduction
- Hybrid MPI/OpenMP Implementation
- Execution Platforms
- Benchmarks and Result Verification
- Performance Evaluation
- Summary

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Ground Motion of the 2008 Ms 8.0 Wenchuan earthquake (China)

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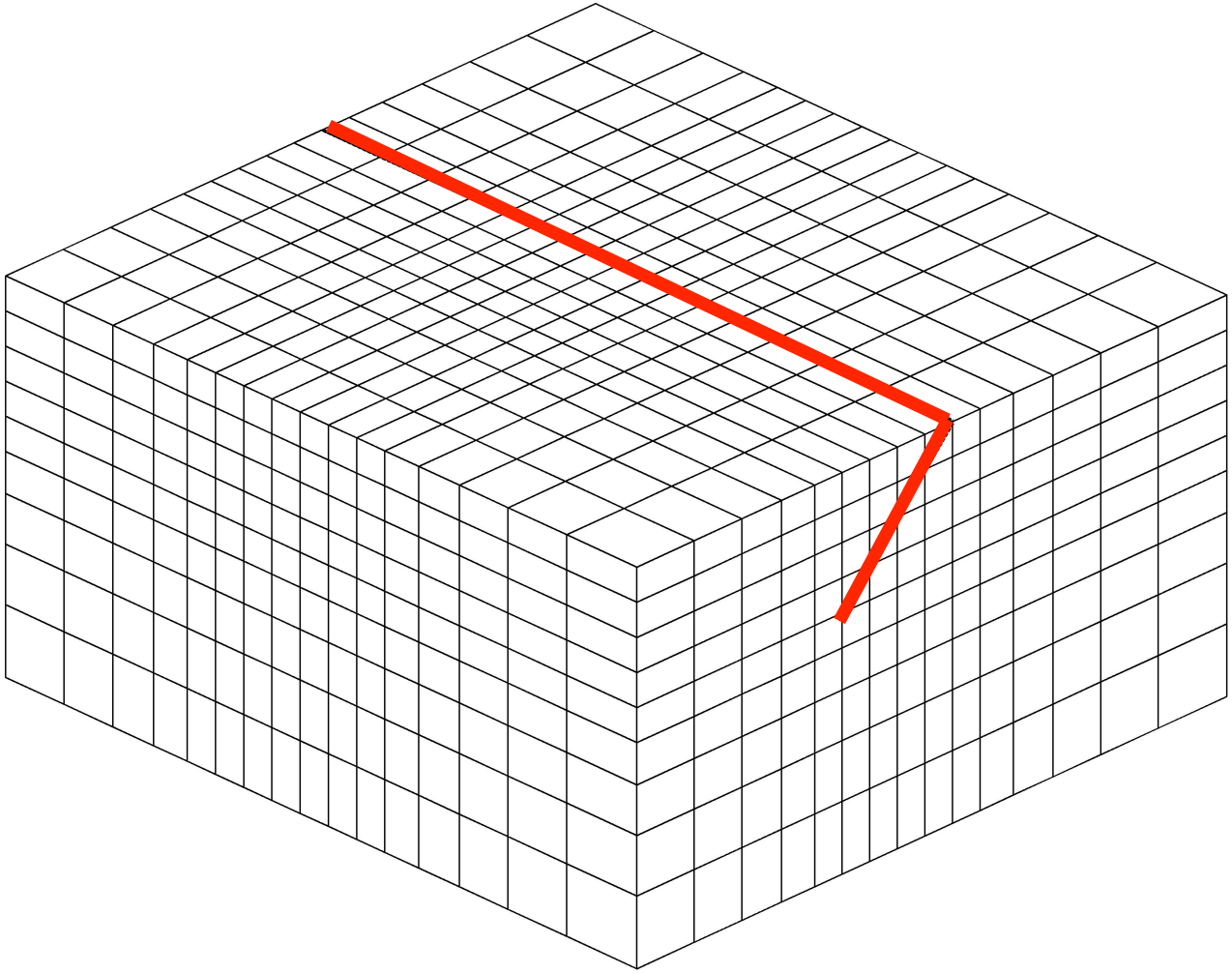
3D Mesh Model



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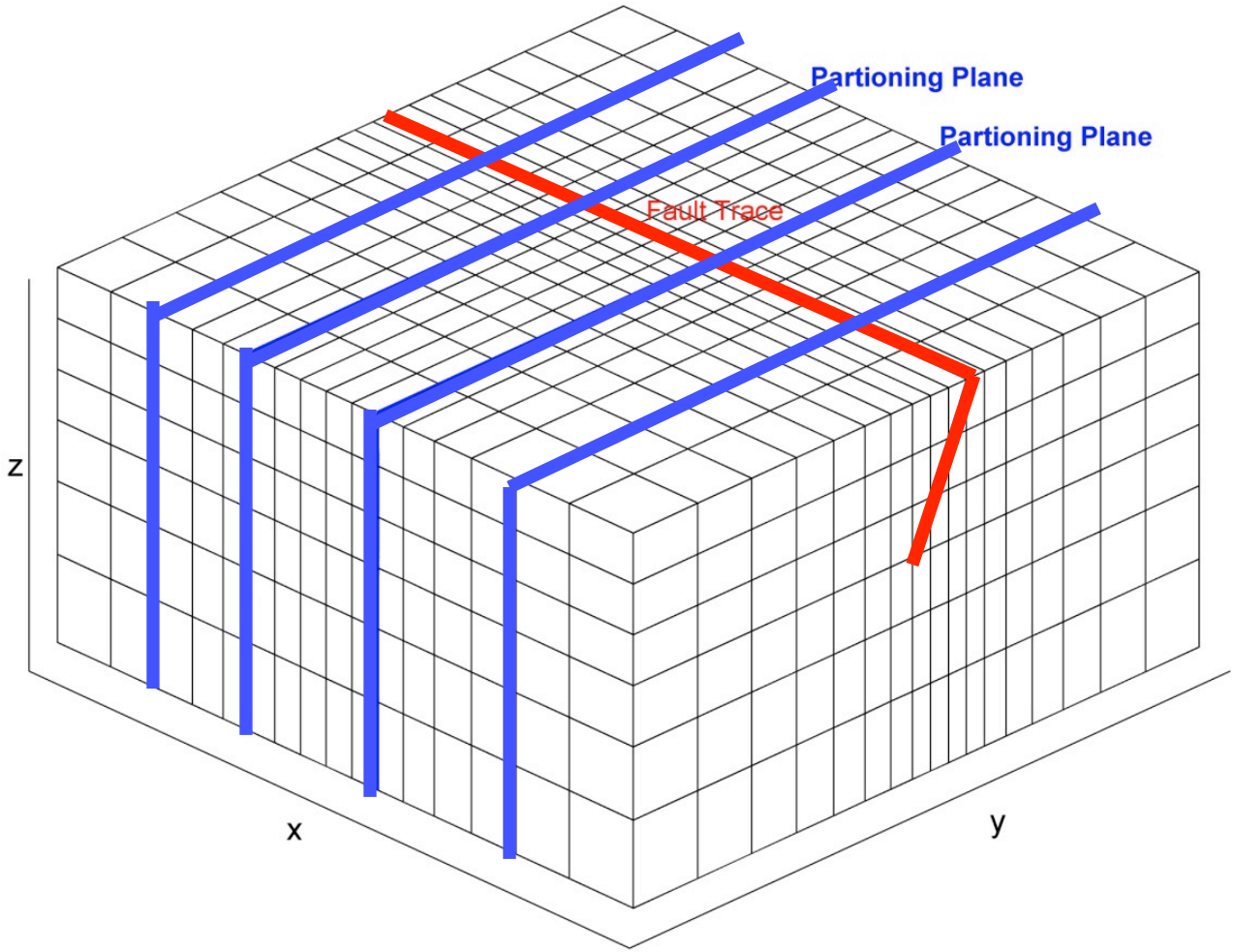
3D Mesh Model



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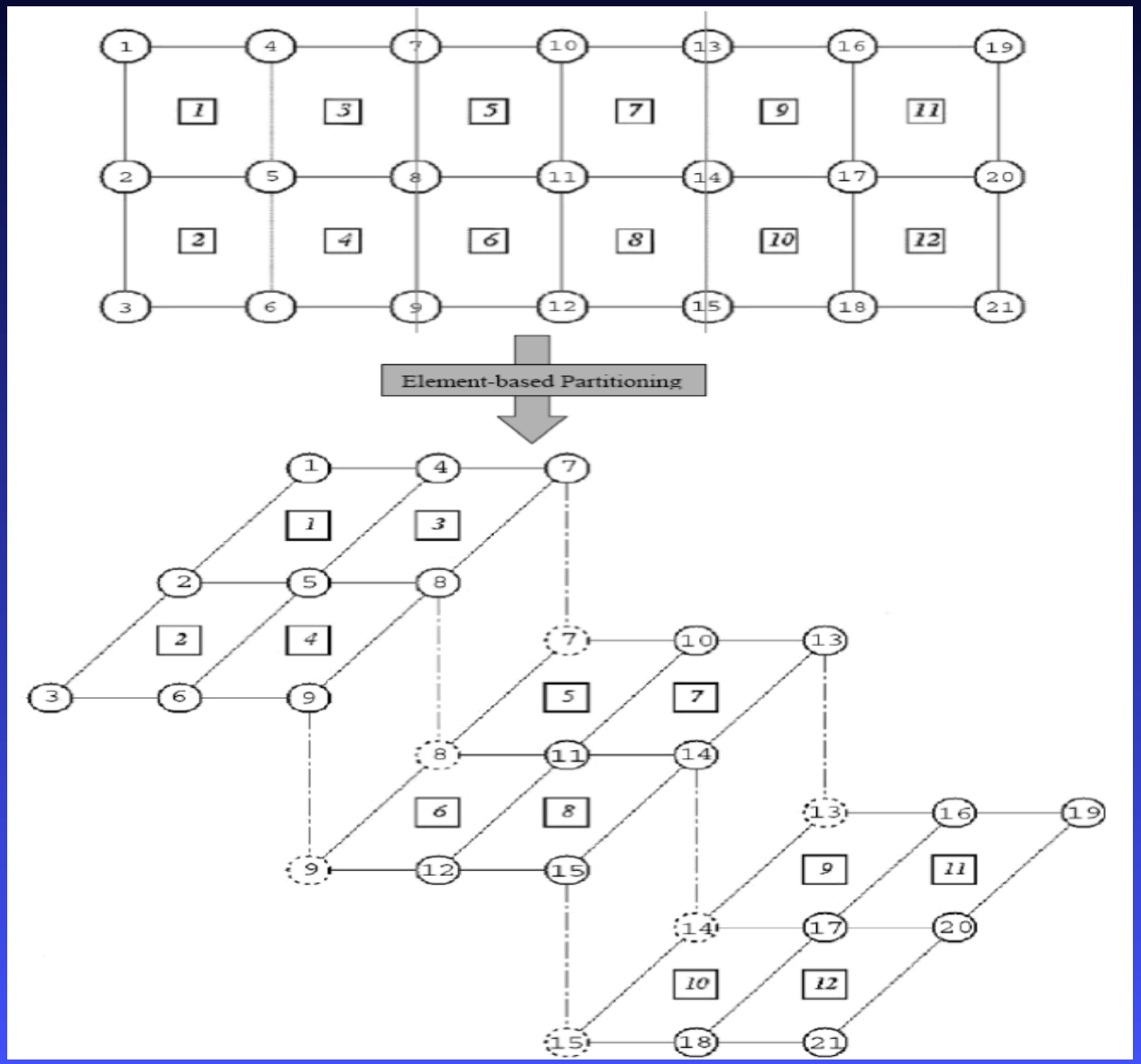
Element-based Partitioning Scheme



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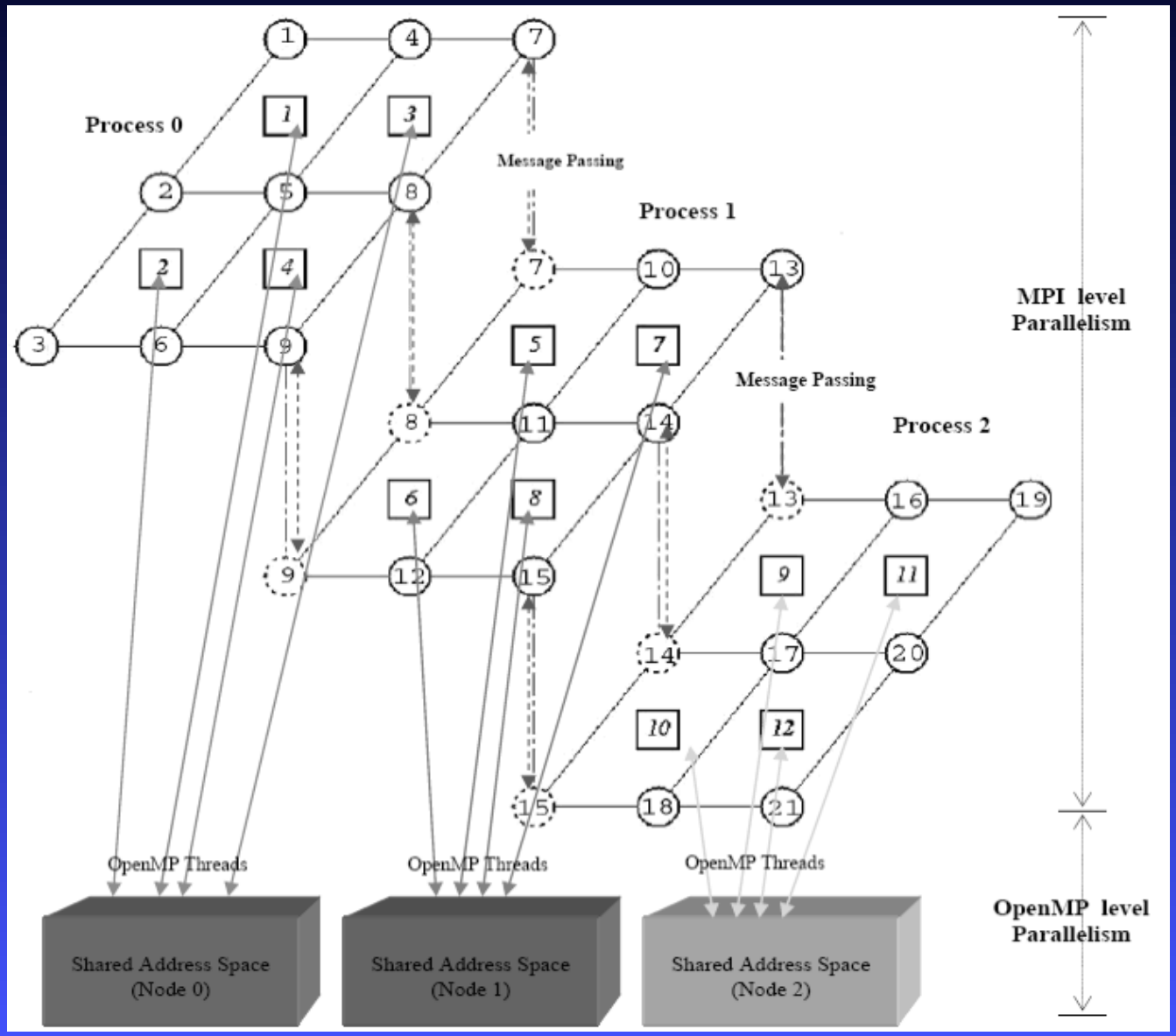
Hybrid MPI/OpenMP Approach



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Execution Platforms

Configurations	JaguarPF (XT5)	Jaguar (XT4)
Total Cores	224,256	31,328
Total Nodes	18,688	7,832
Cores/Socket	6	4
Cores / Node	12	4
CPU type	AMD 2.6GHz hex-core	AMD 2.1GHz quad-core
Memory/Node	16GB	8GB
L1 Cache/Core, private	64 KB	64 KB
L2 Cache/Core, private	512KB	512KB
L3 Cache/Socket, shared	6MB	2MB
Compiler	ftn	ftn
Compiler Options	-O3 -mp=nonuma -fastsse	-O3 -mp=nonuma -fastsse

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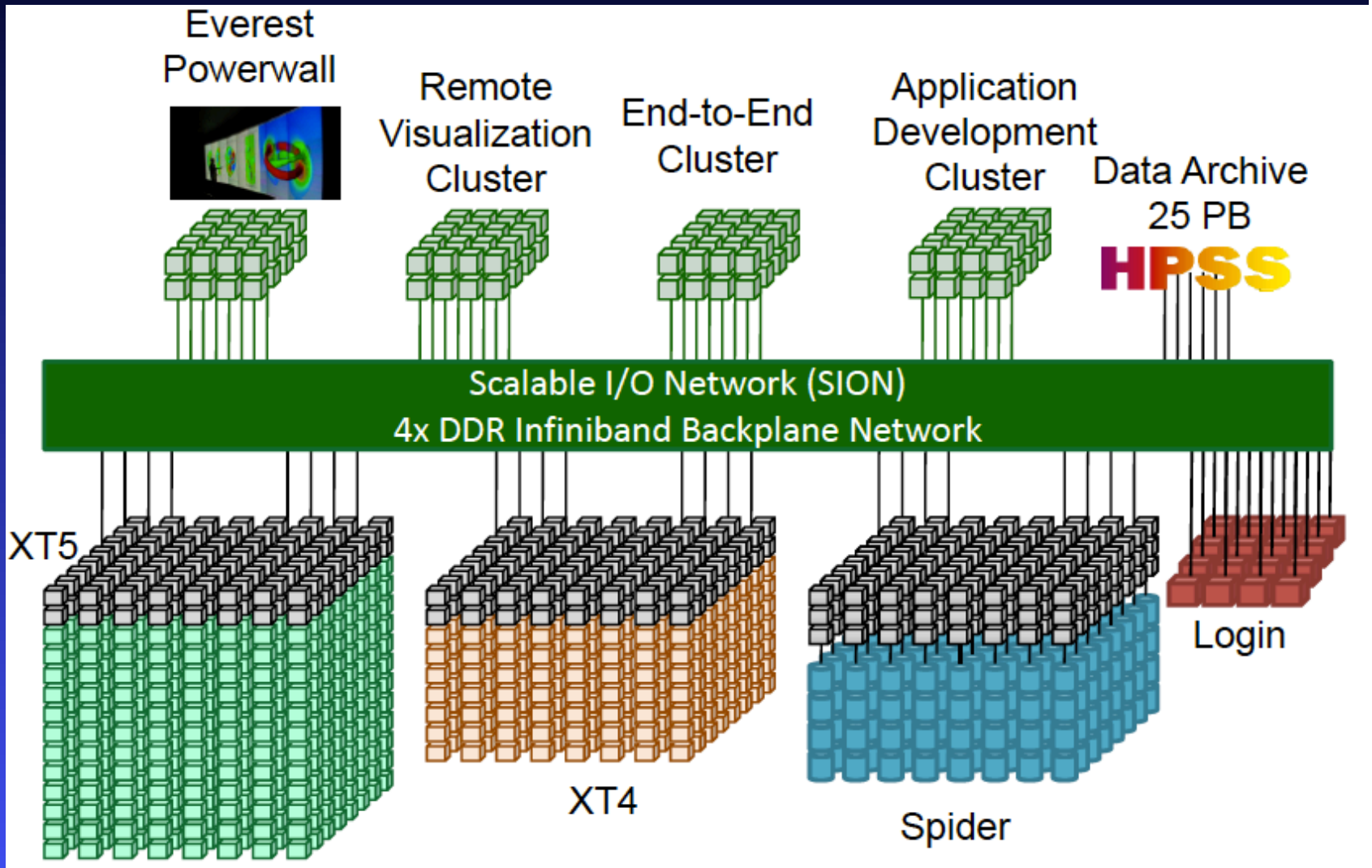
ORNL Cray XT4/5 Supercomputer



Source: ORNL National Center for Computational Science

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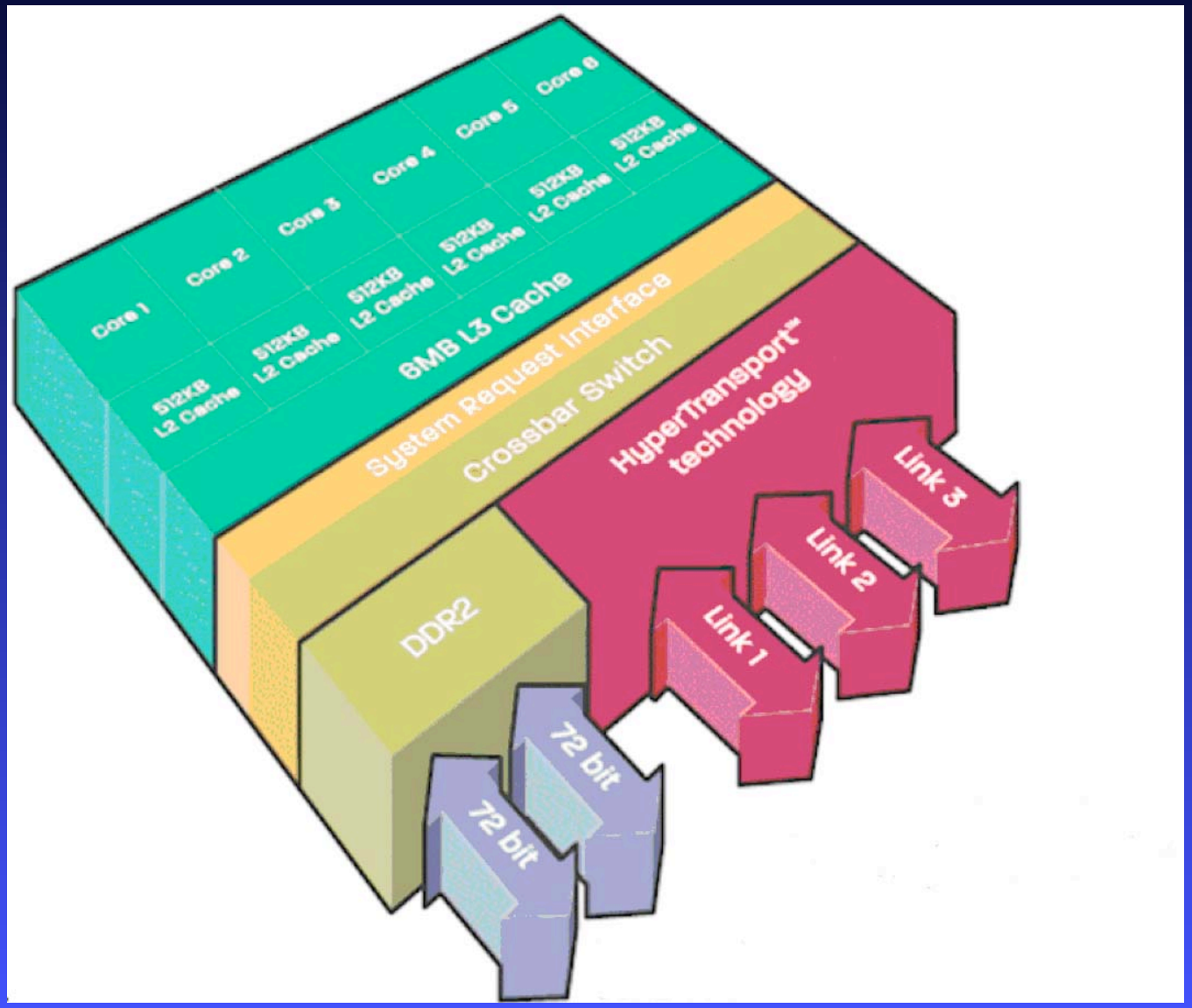
AMD Hex-core Opteron



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Benchmark Problem TPV210

Parameters	TPV210-100m	TPV210-50m
Element size	100 m	50 m
Total elements	~ 25,000,000	~100,000,000
Time step (sec)	0.008	0.004
Termination Time (seconds)	15	15
nxt	477	829

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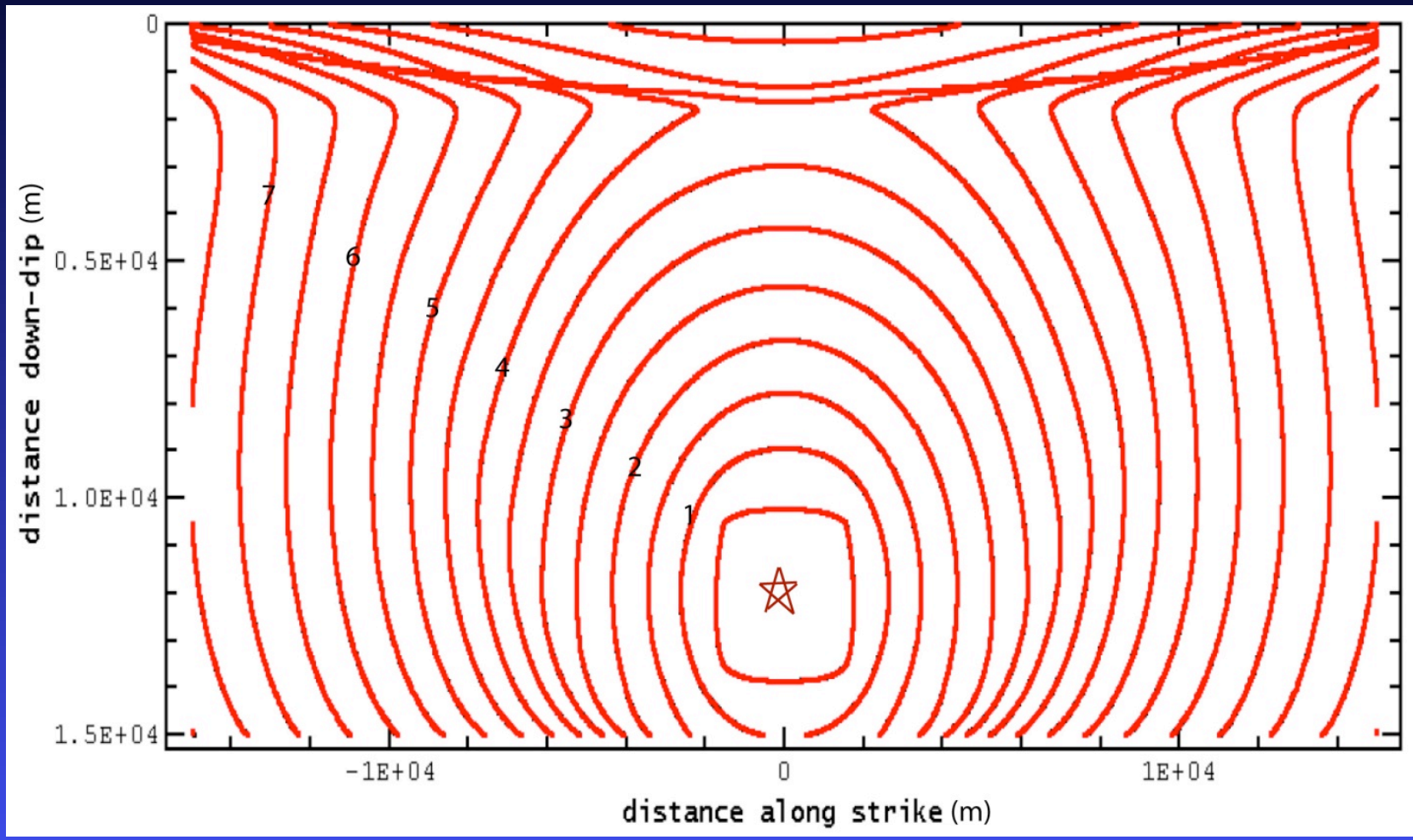
Rupture time contours



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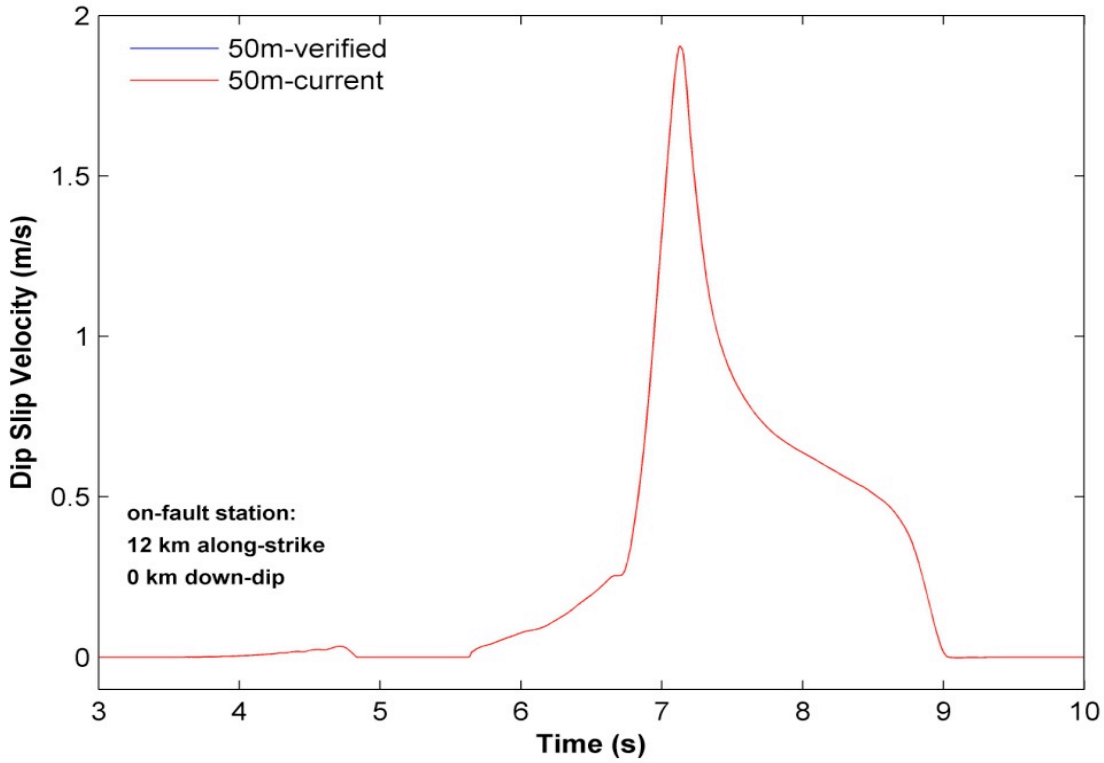
Dip Slip Velocity



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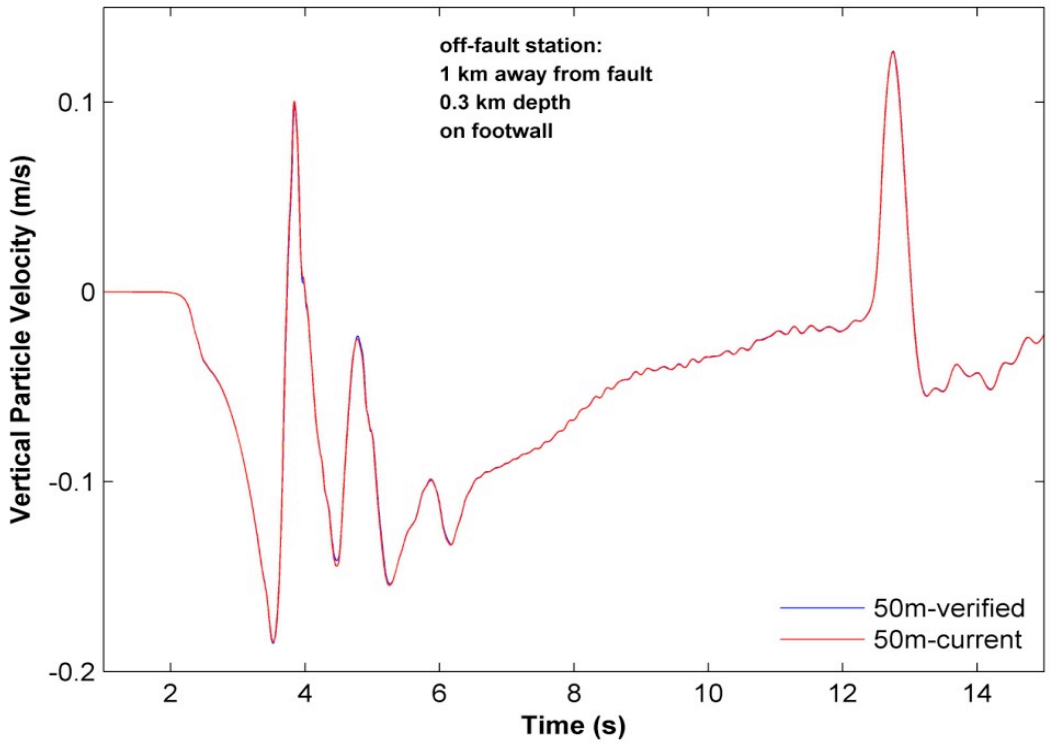
Vetical Particle Velocity



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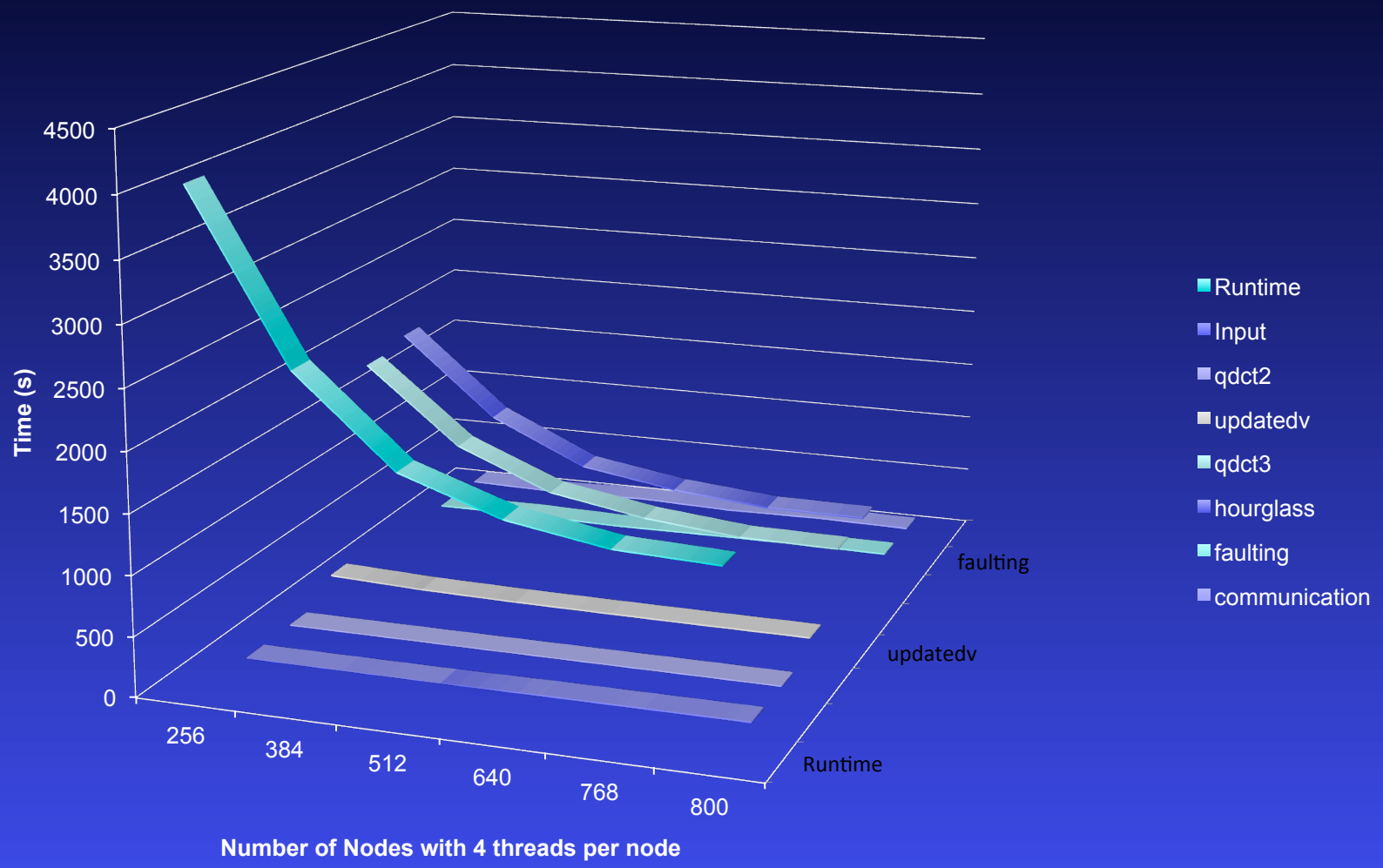
Function-level Performance for TPV210 with 50m on Cray XT4



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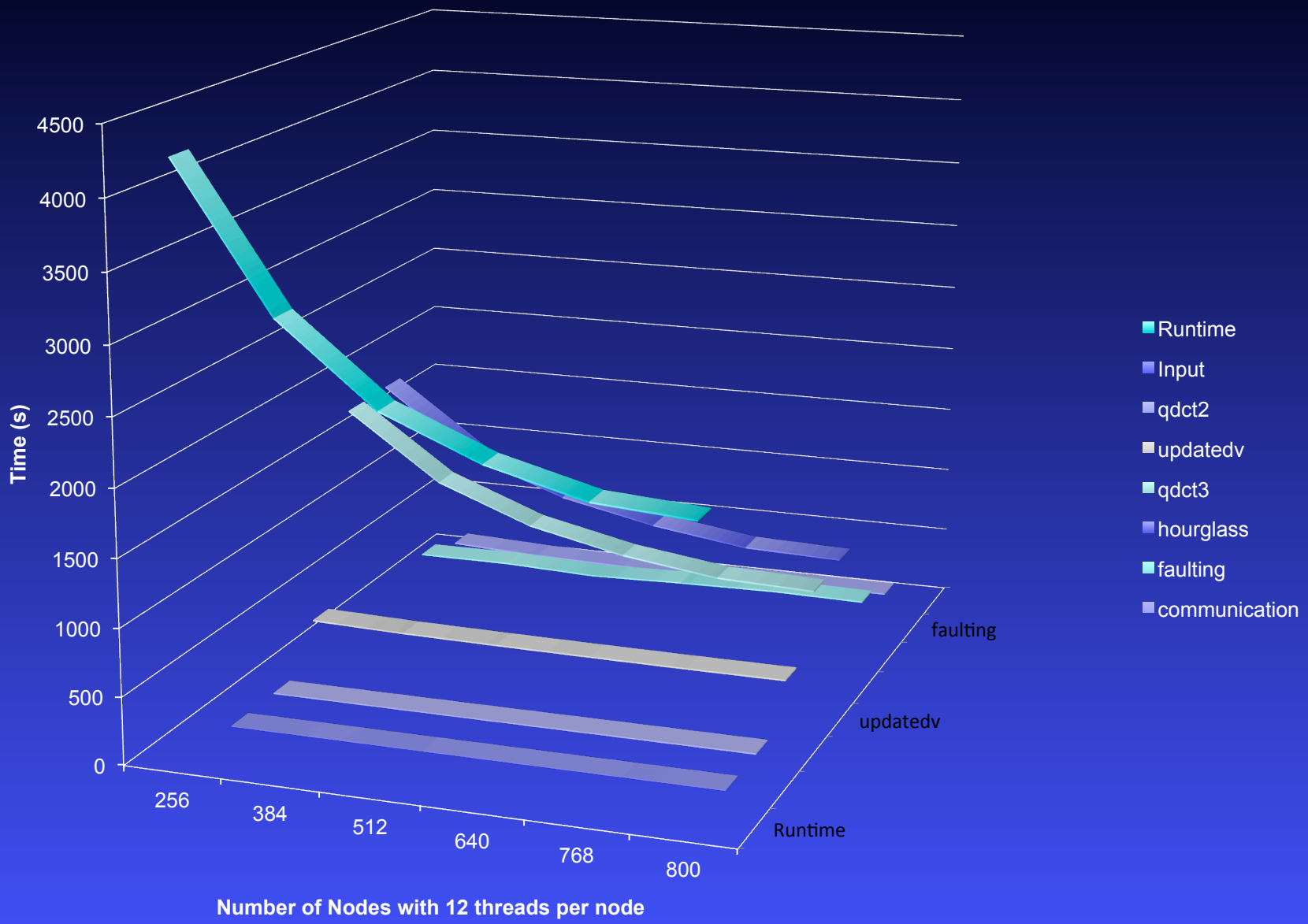
Function-level Performance for TPV210 with 50m on Cray XT5



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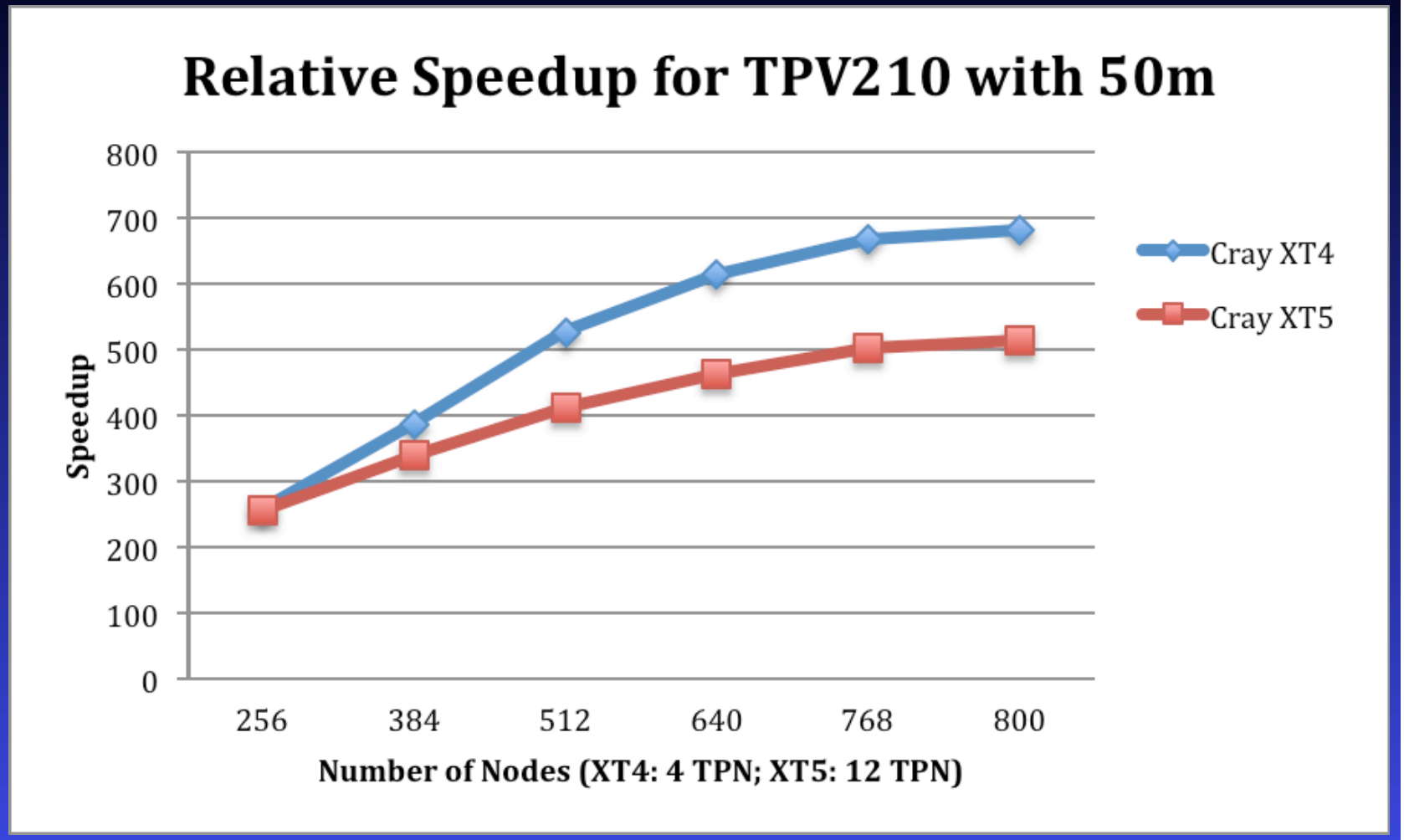

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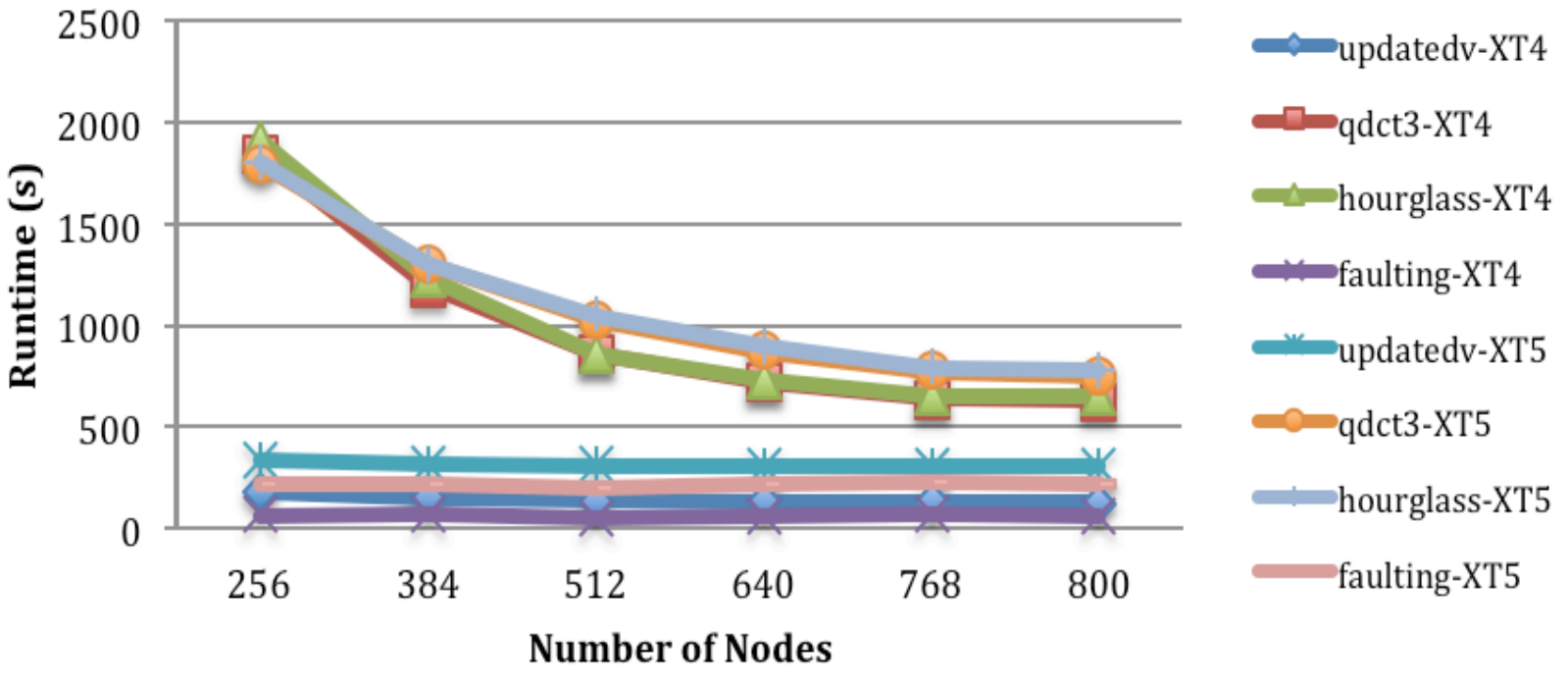
Function-level Performance Comparison for TPV210 with 50m on Cray XT4 and XT5 Systems



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Percentage Difference for updatedv

Number of Nodes	updatedv-XT4 (s)	updatedv-XT5 (s)	% difference
256	176.87	339.29	91.83
384	145.91	321.53	120.36
512	133.83	313.45	134.22
640	128.82	308.36	139.37
768	125.97	305.27	142.34
800	125.89	305.13	142.38

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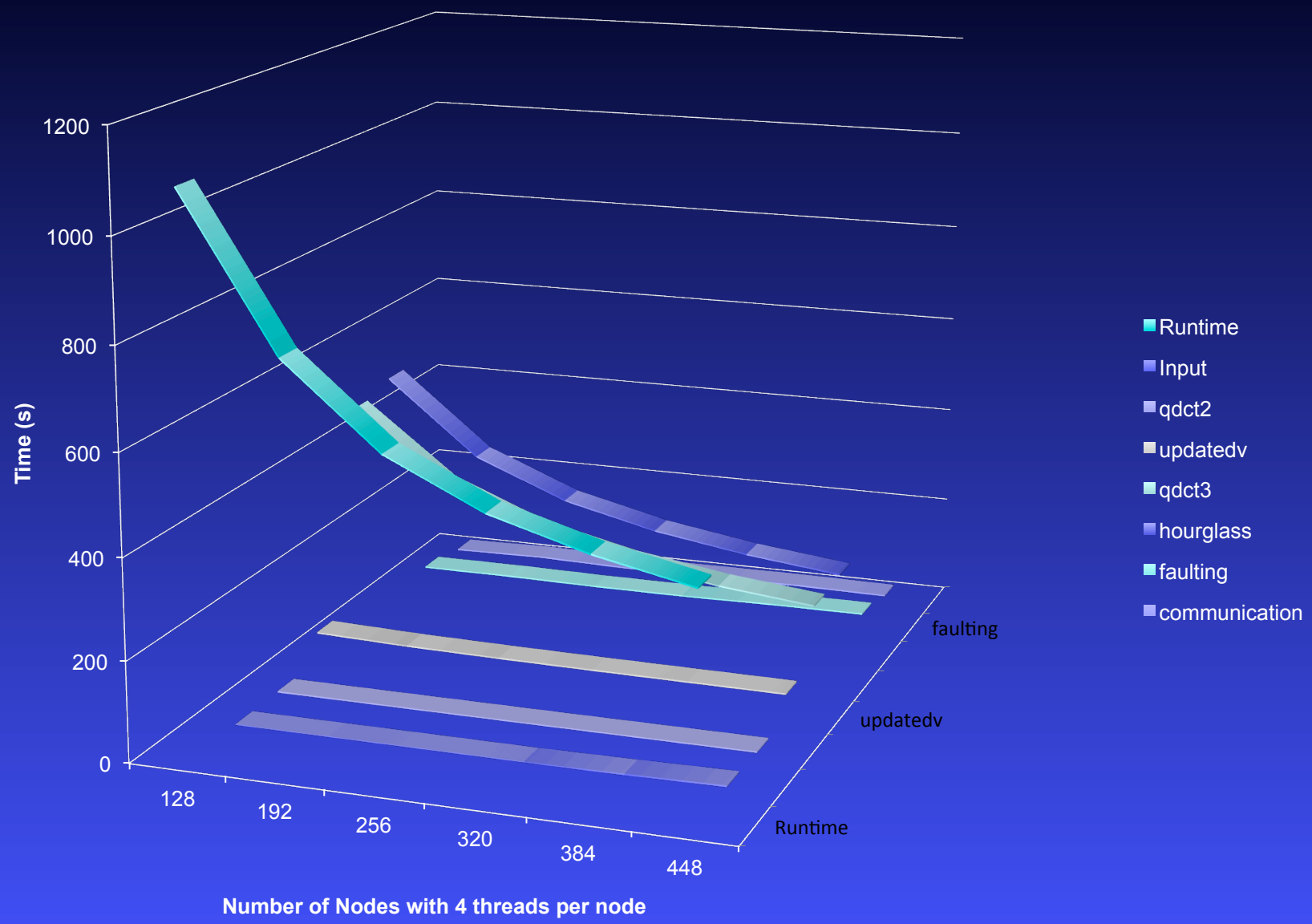
Function-level Perfomrance for TPV210 with 100m on Cray XT4



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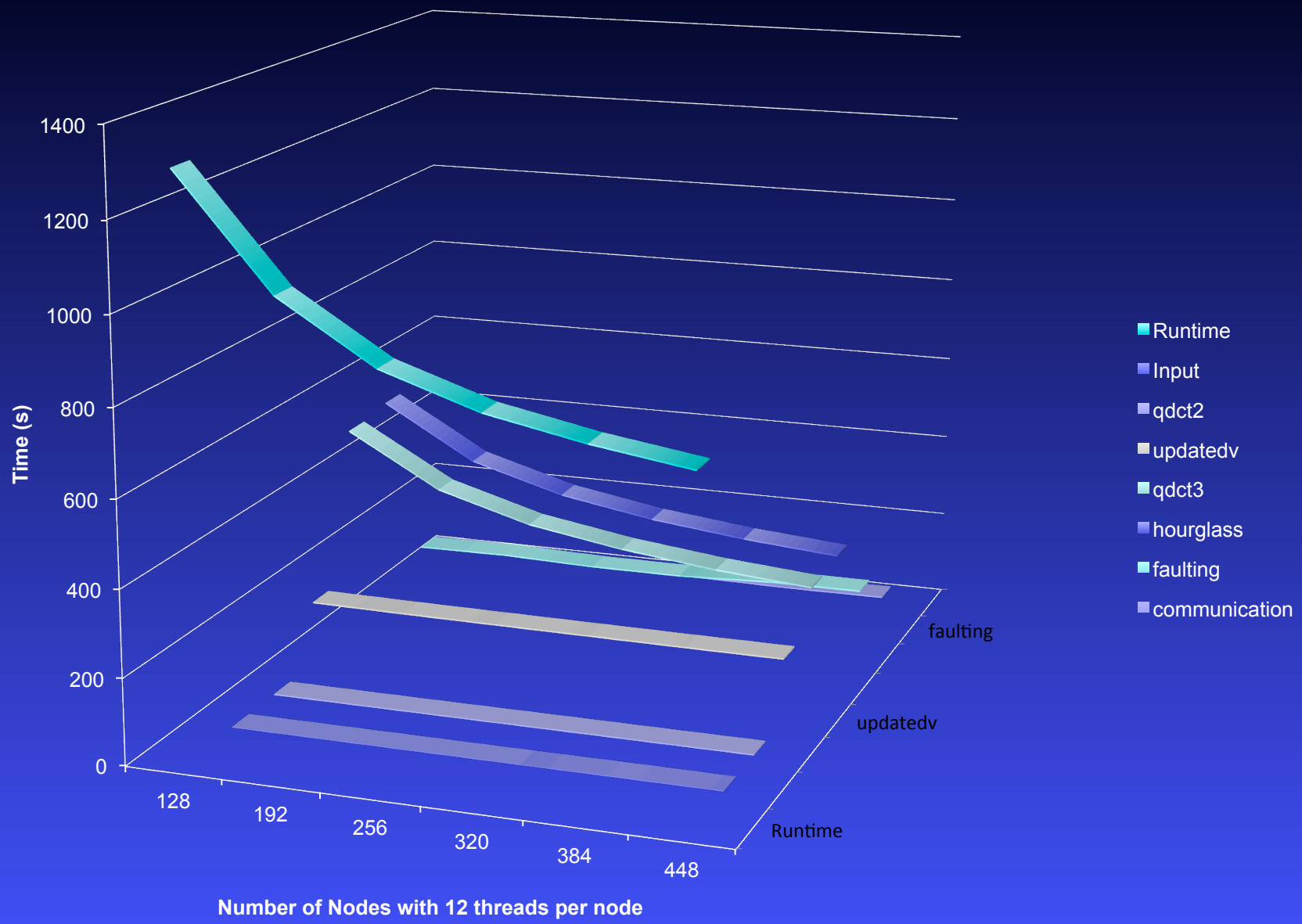
Function-level Performance for TPV210 with 100m on Cray XT5



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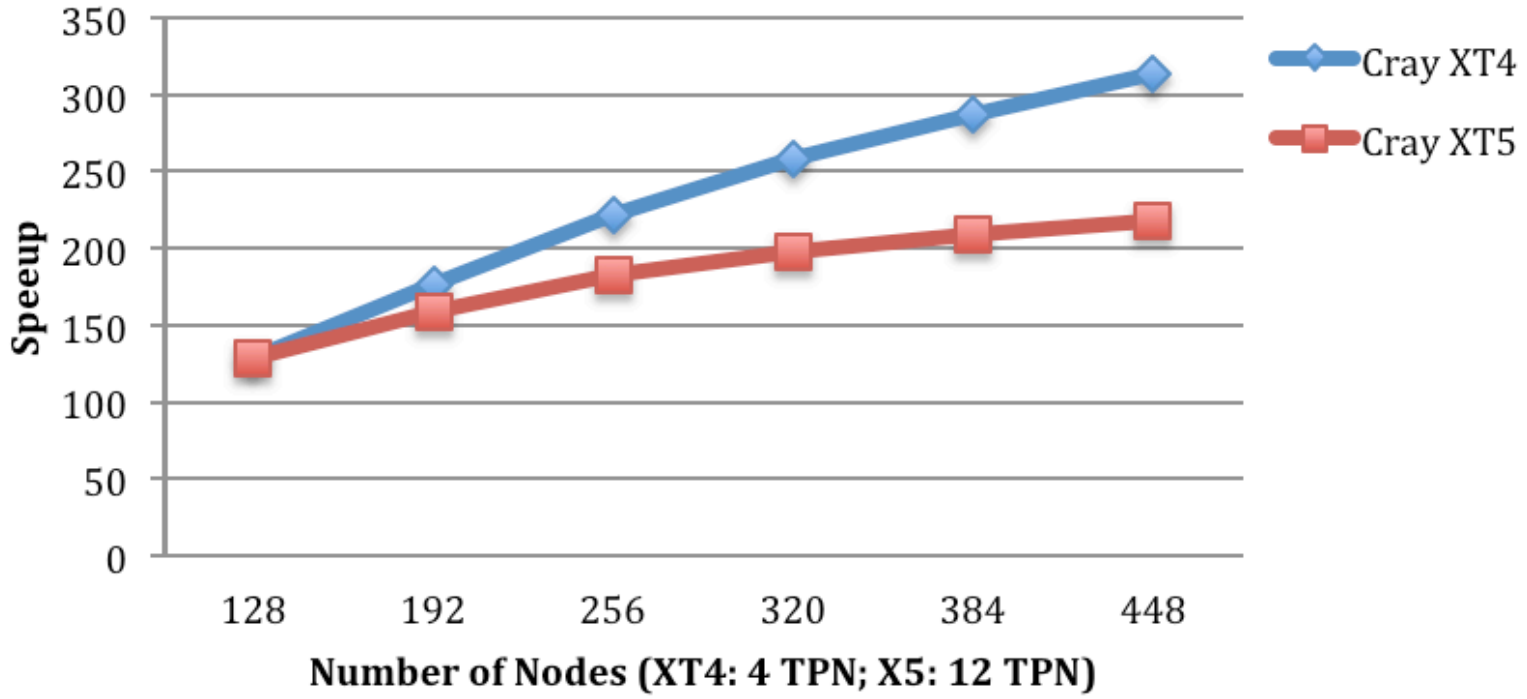

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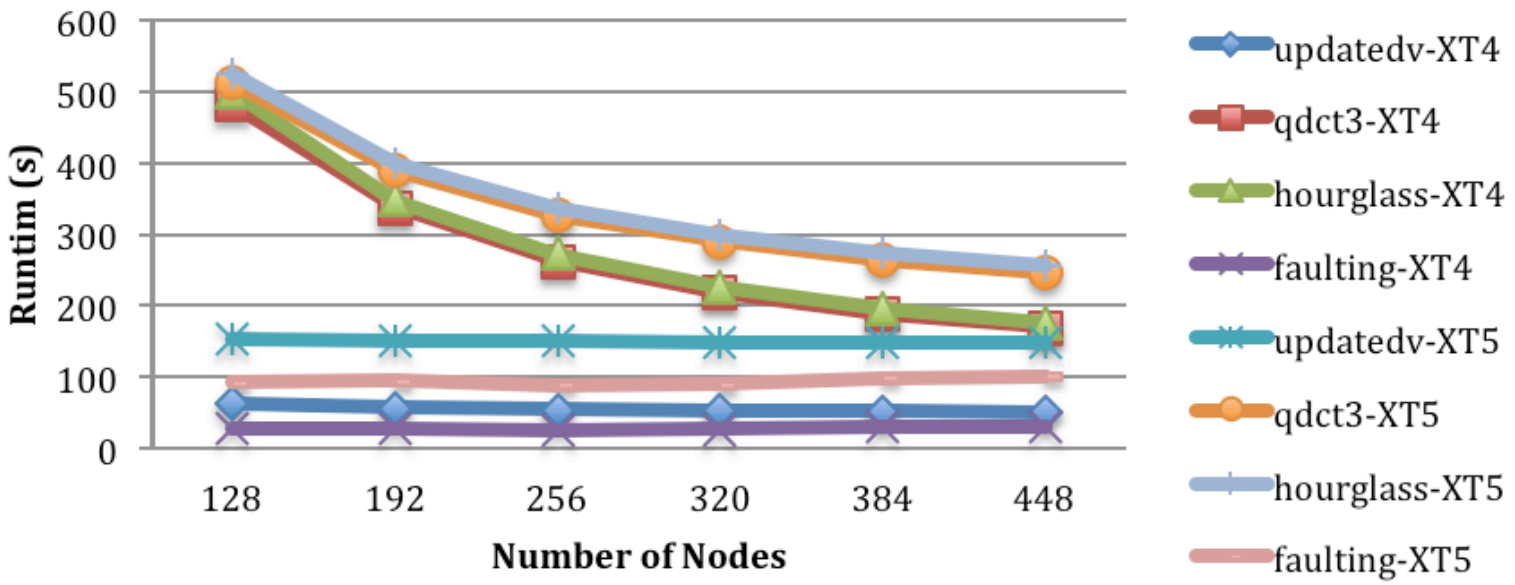
Function-level Performance Comparison for TPV210 with 100m on Cray XT4 and XT5 Systems



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Summary and Future Work

- Integrated a 3D mesh generator into the simulation, and used MPI to parallelize it
- Presented our hybrid MPI/OpenMP implementation
- The hybrid finite element earthquake simulation has the accurate output results and good scalability
- For the future work, we plan to improve the memory requirements of the hybrid simulation code by partitioning the entire model domain in X-, Y- and Z-D