panasas

Performance Study:
Abaqus/Standard 6.8-3

Stan Posey
Director, Industry and Applications Market Development
Panasas, Fremont, CA, USA

Bill Loewe, Ph.D.
Sr. Applications Engineer
Panasas, Fremont, CA, USA

Background on Abaqus/Standard Study

Motivation

- Since Apr 2007, SIMULIA and Panasas have made joint investments in a business and technical alliance that ensures Abaqus will fully leverage Panasas PanFS
- This study demonstrates benefits of Panasas parallel file system and parallel storage for Abaqus/Standard 6.8-3 with tests for both single job and mulit-job computing

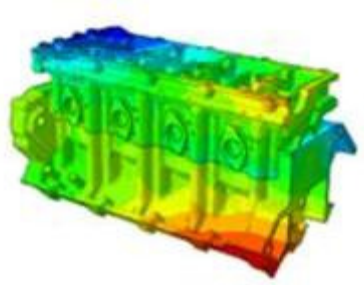
Considerations

- Abaqus is an application from SIMULIA -- not a benchmark kernel
- The FEA model and tests are relevant to customer practice
- All tests were run on a dedicated system at Panasas
- The results were validated by SIMULIA

Panasas Study on Abaqus/Standard 6.8-3

Abaqus/Standard 6.8-3: Model S4b 5M DOF Non-linear Static Analysis

Automotive engine block cylinder head bolt-up



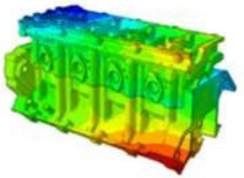
This benchmark is a mildly nonlinear static analysis that simulates bolting a cylinder head onto an engine block. The cylinder head and engine block are meshed with tetrahedral elements of types C3D4 or C3D10M, the bolts are meshed using hexahedral elements of type C3D8I, and the gasket is meshed with special-purpose gasket elements of type GK3D8. Linear elastic material behavior is used for the block, head, and bolts while a nonlinear pressure-overclosure relationship with plasticity is used to model the gasket. Contact is defined between the bolts and head, the gasket and head, and the gasket and block. The nonlinearity in this problem arises both from changes in the contact conditions and yielding of the gasket material as the bolts are tightened.

Three versions of this benchmark are provided: a 700,000 DOF version that is suitable for use with the direct sparse solver on 32-bit systems, a 5,000,000 DOF version that is suitable for use with the direct sparse solver on 64-bit systems, and a 5,000,000 DOF version that is suitable for use with the iterative solver on 64-bit systems.

S4b: 5,000,000 DOF direct solver version	
Input file name:	s4b.inp
Increments:	1
Iterations:	5
Degrees of freedom:	5,236,958
Floating point operations:	1.14E+13
Minimum memory requirement:	4 GB
Memory to minimize I/O:	20 GB
Disk space requirement:	23 GB

Abaqus/Standard I/O Scheme

panasas



Job Task	IO Scheme	IO Operation
start	Work Dir: serial IO	Read nodes, elements and control file
element matrix generation and assembly into global matrix		
matrix factor (dominant phase, as much as 85% of total time, often I/O wait)	Scratch Dir: parallel IO	Factor matrix out-of-core, reads/writes
. . .	. . .	
FBS solve phase, stress recovery, multiple RHS's		
complete	Work Dir: serial IO	Write solution results [100's of GB's of I/O]

CSM implicit solver Abaqus/Standard is direct and single-step, with out-of-core READS and WRITES

-- I/O occurs in the sparse factor phase of the solver

-- this scheme is for static, if an eigen (Lanzcos) solution, then I/O can be VERY heavy

-- NOTE: Abaqus also has an implicit iterative solver

Panasas Study on Abaqus/Standard 6.8-3

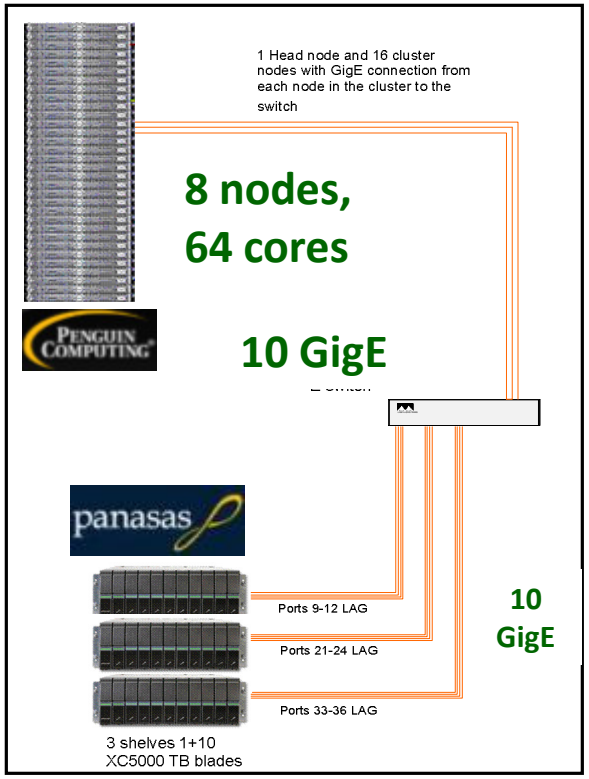
Features of the Hardware System Configurations

Features of Penguin cluster configuration:

- Processors: 2.3GHz QC AMD Opteron
- Nodes: 8 x 2 Sockets x 4 cores; 2 GB/core
- Interconnect: 10GigE
- Local FS: Ext3, single drive per node, 160 GB SATA, 7200 RPM

Features of the Panasas storage system:

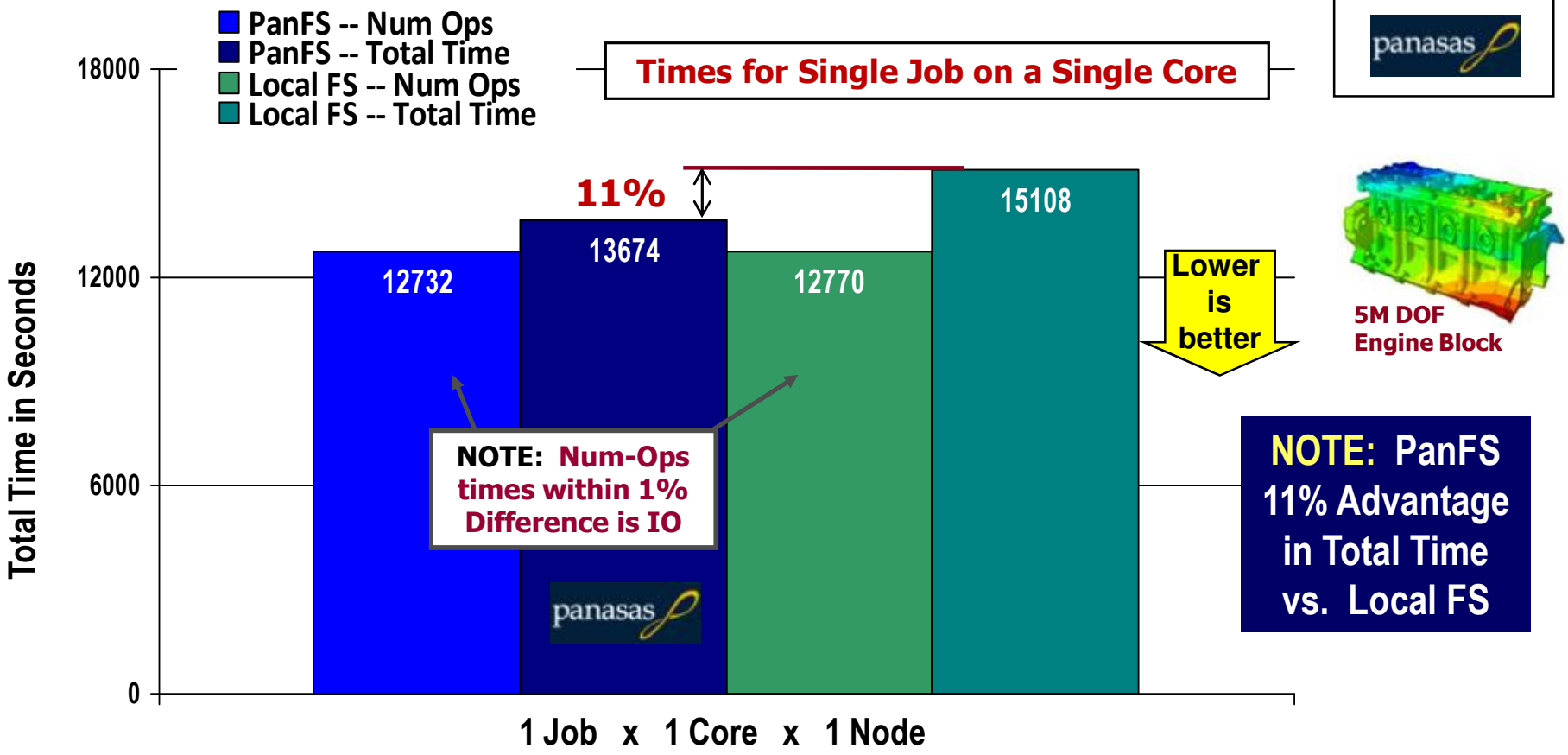
- 3 shelves: 1 director + 10 storage blades
- Each shelf 10 TB, total of 30 TB



NOTE: Panasas total 30 TB in 12U, installed and operational in just 1 hr!

S4b Performance for Single Core

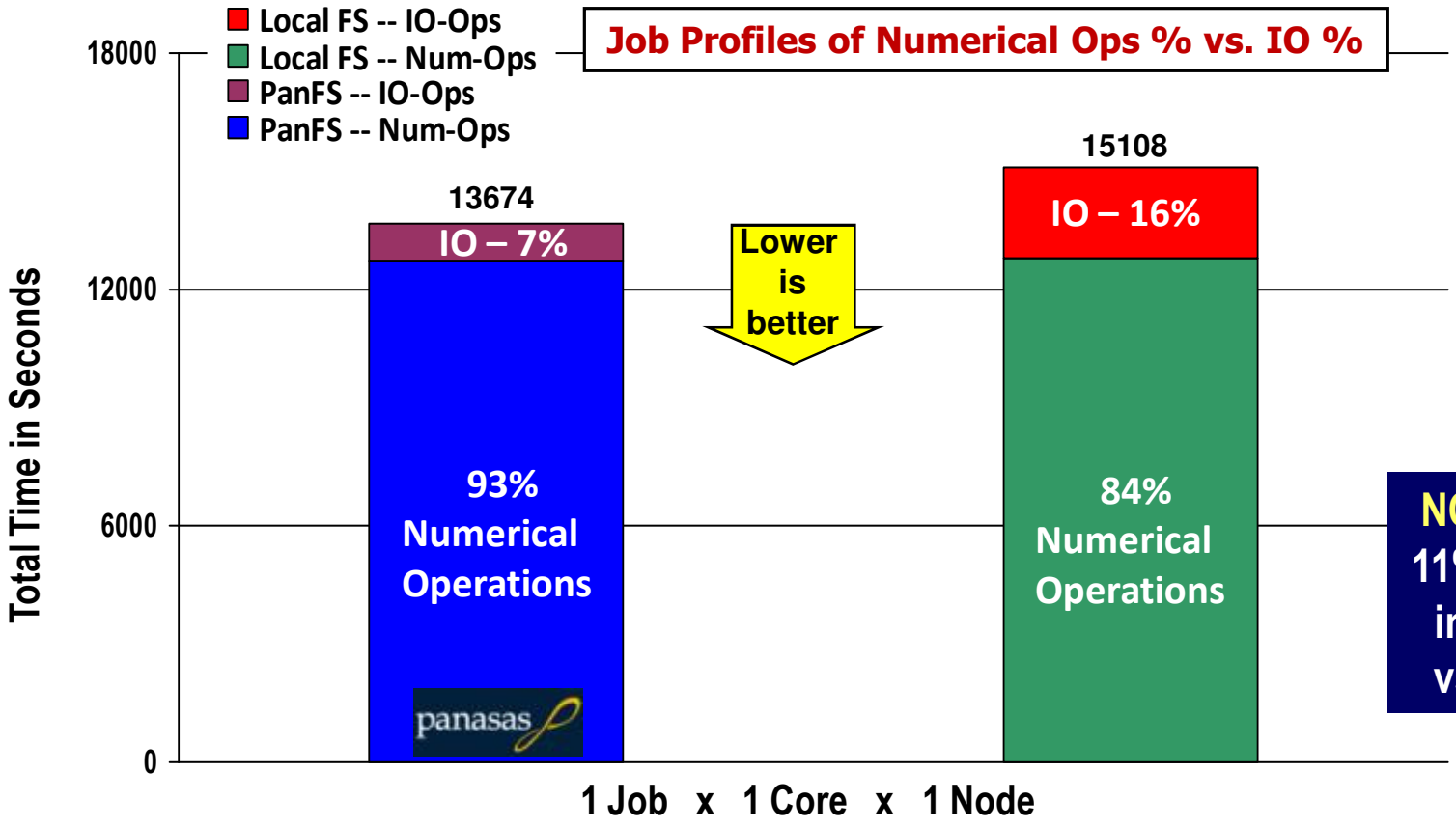
Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS



Numerical vs. IO Computational Profile

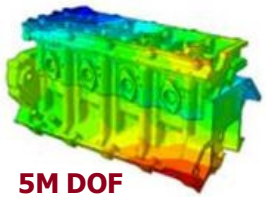
panasas

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS



SIMULIA

panasas

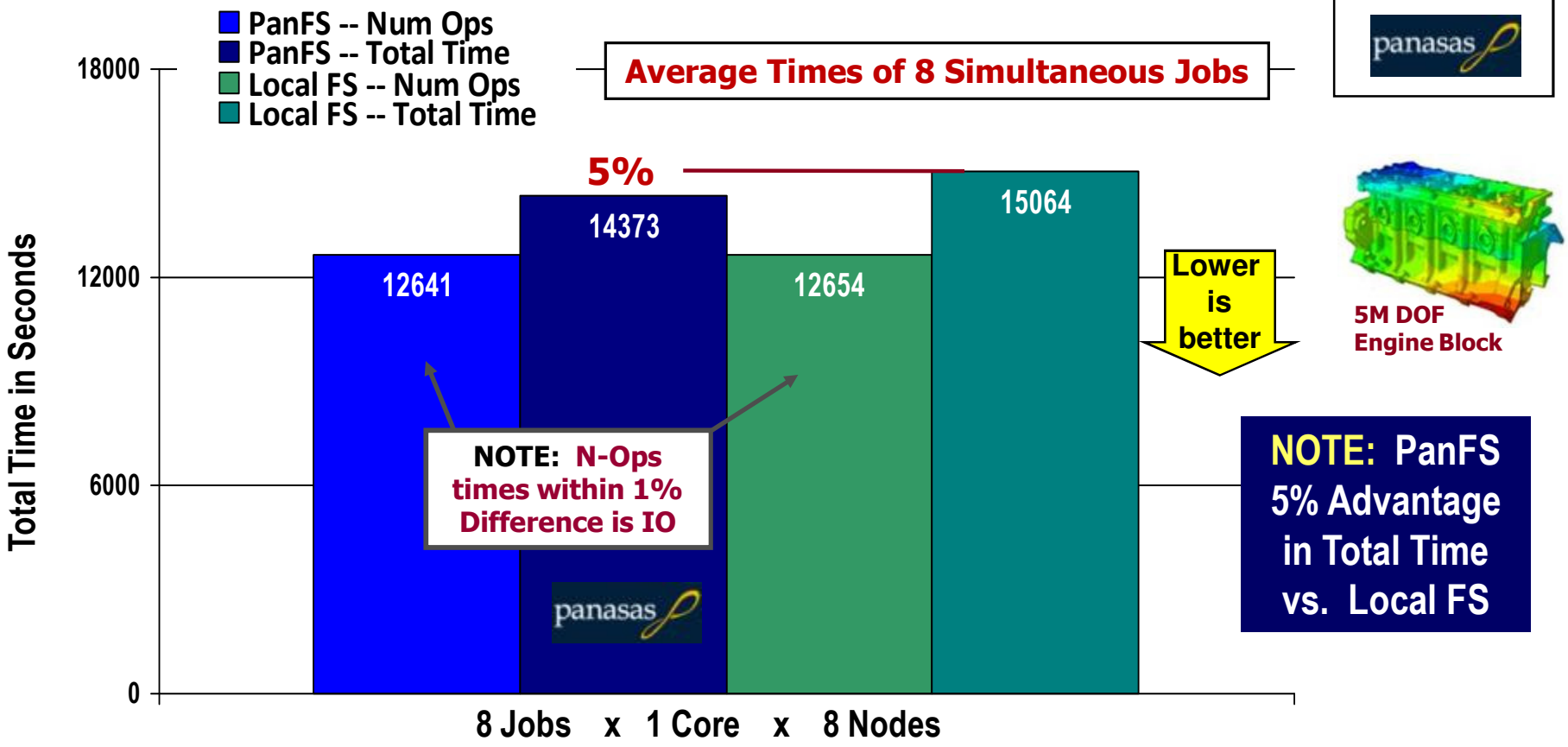


5M DOF Engine Block

NOTE: PanFS 11% Advantage in Total Time vs. Local FS

S4b Performance for 1 Core x 8 Nodes

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS



5M DOF Engine Block

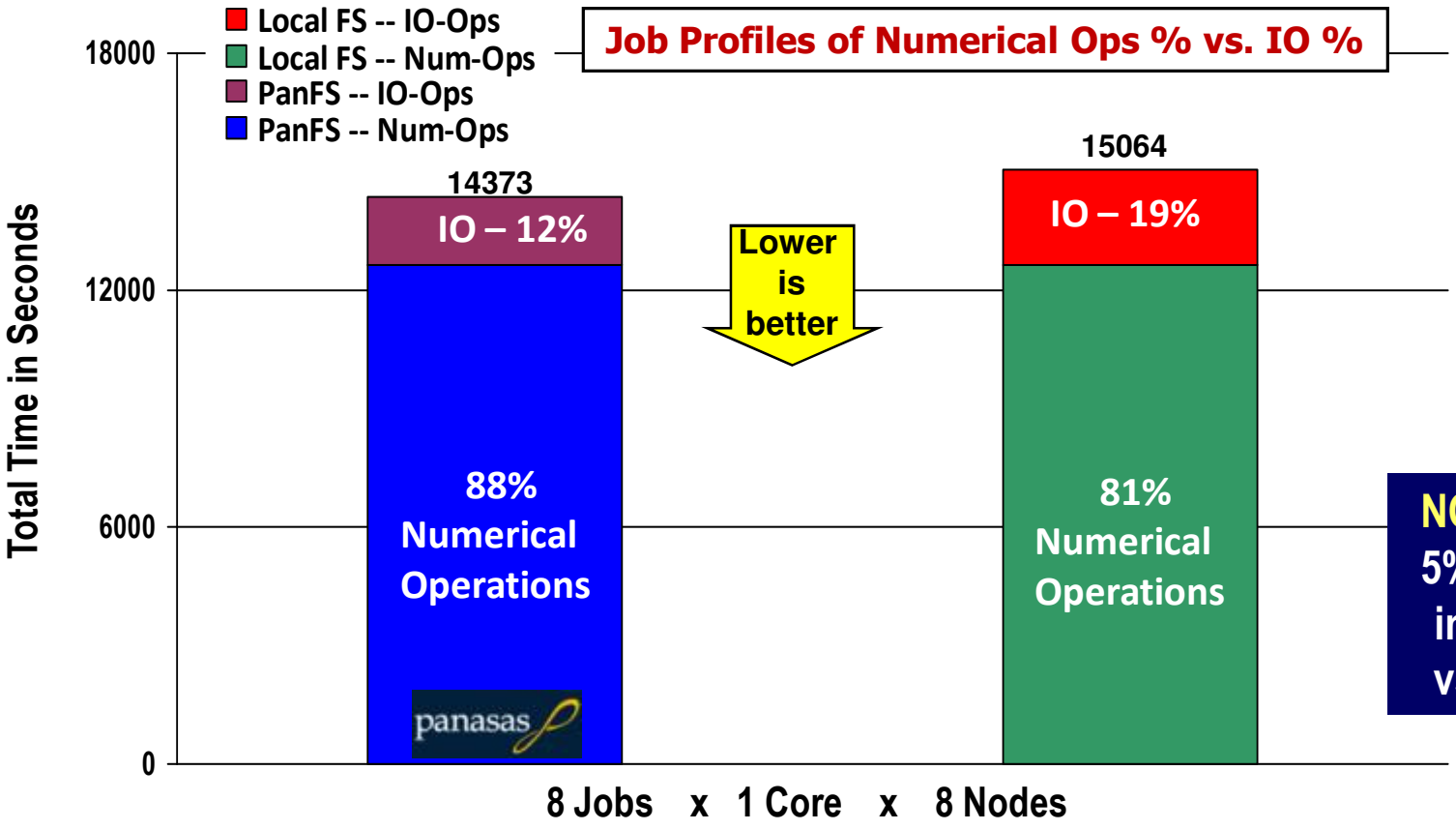
NOTE: PanFS 5% Advantage in Total Time vs. Local FS

Average of 8 Jobs | Each on 1 Core | Each on 1 Node | 7 Cores Idle on Each Node

Numerical vs. IO Computational Profile

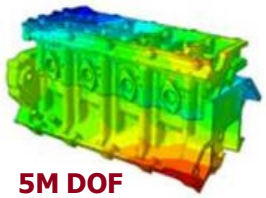
panasas

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS



SIMULIA

panasas



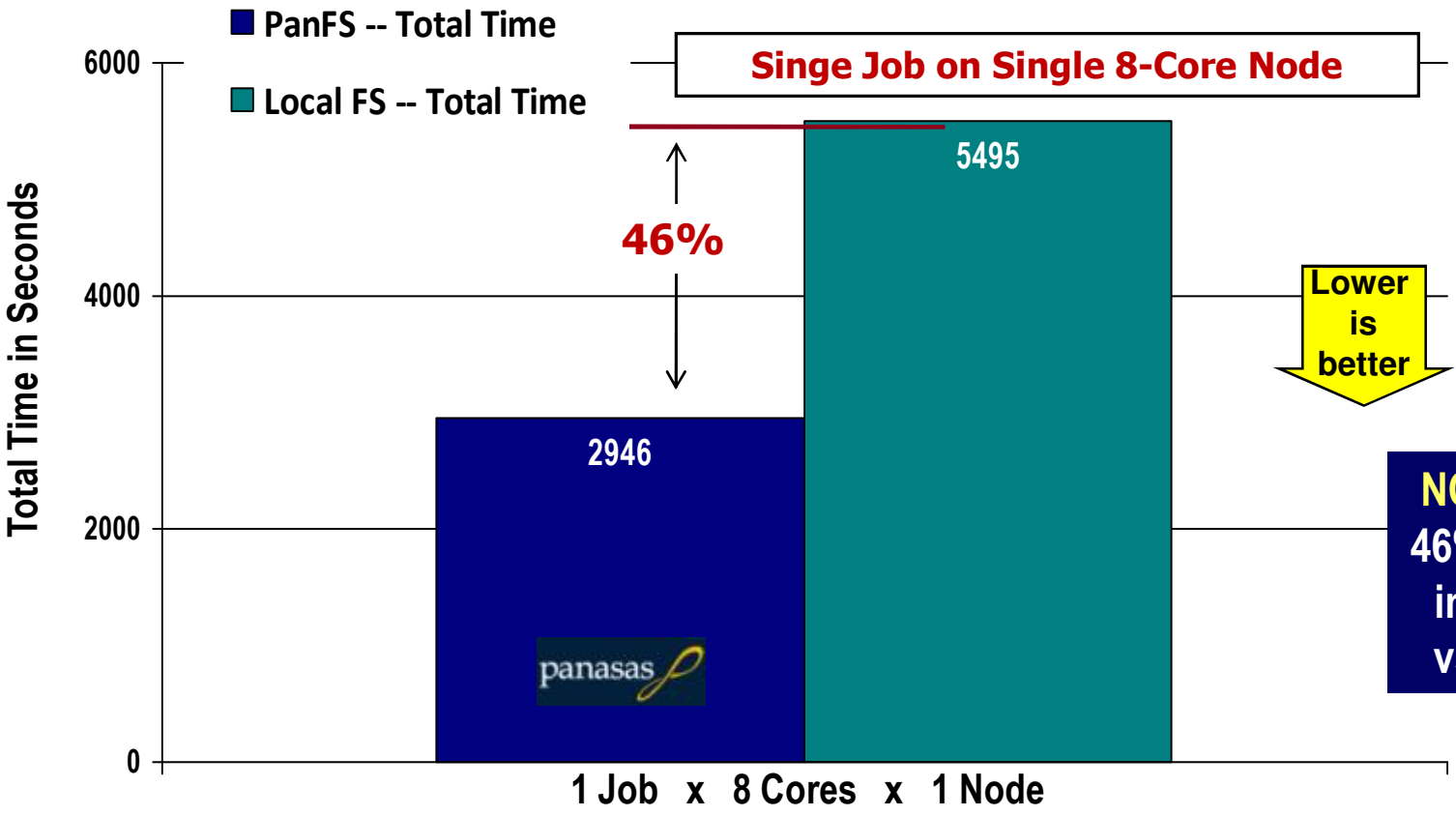
5M DOF Engine Block

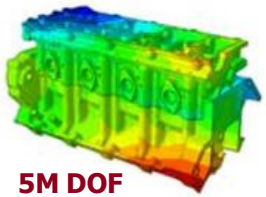
NOTE: PanFS 5% Advantage in Total Time vs. Local FS

Average of 8 Jobs | Each on 1 Core | Each on 1 Node | 7 Cores Idle on Each Node

S4b Performance for 8 Cores x 1 Node

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS





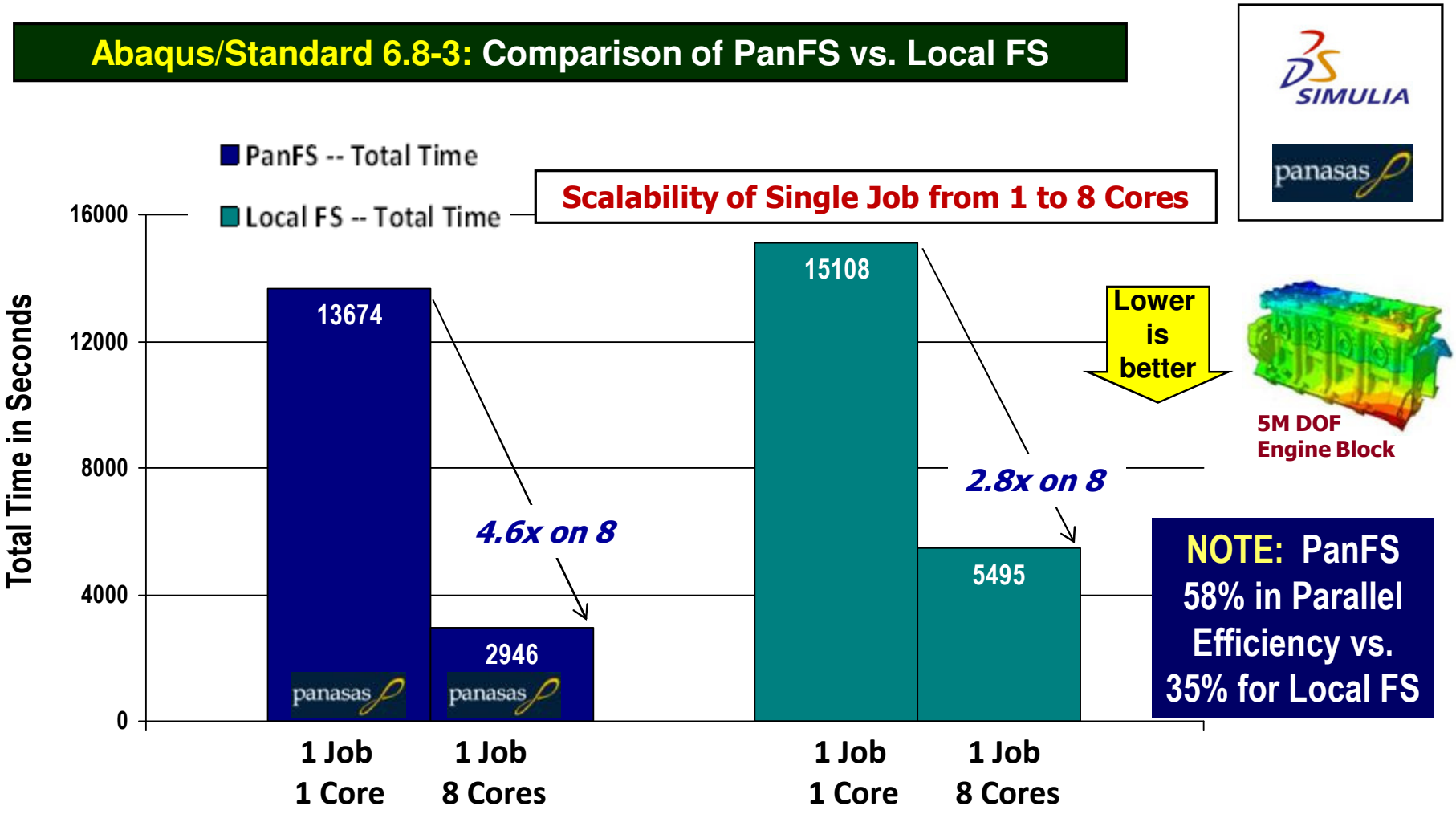
5M DOF Engine Block

NOTE: PanFS 46% Advantage in Total Time vs. Local FS

S4b Performance for Single Job Scaling

panasas

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS



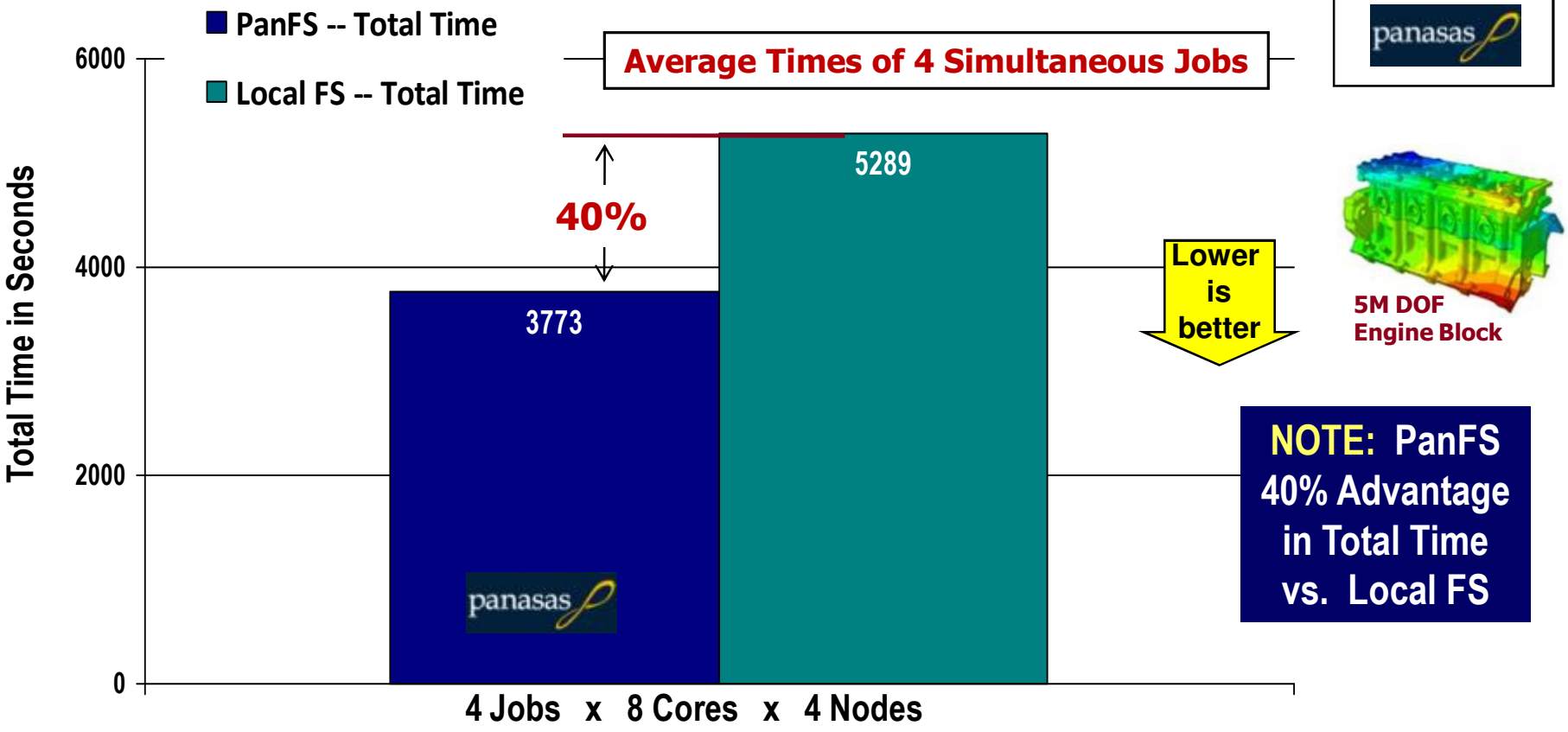
S4b Performance for 8 Cores x 4 Nodes

panasas

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS

SIMULIA

panasas



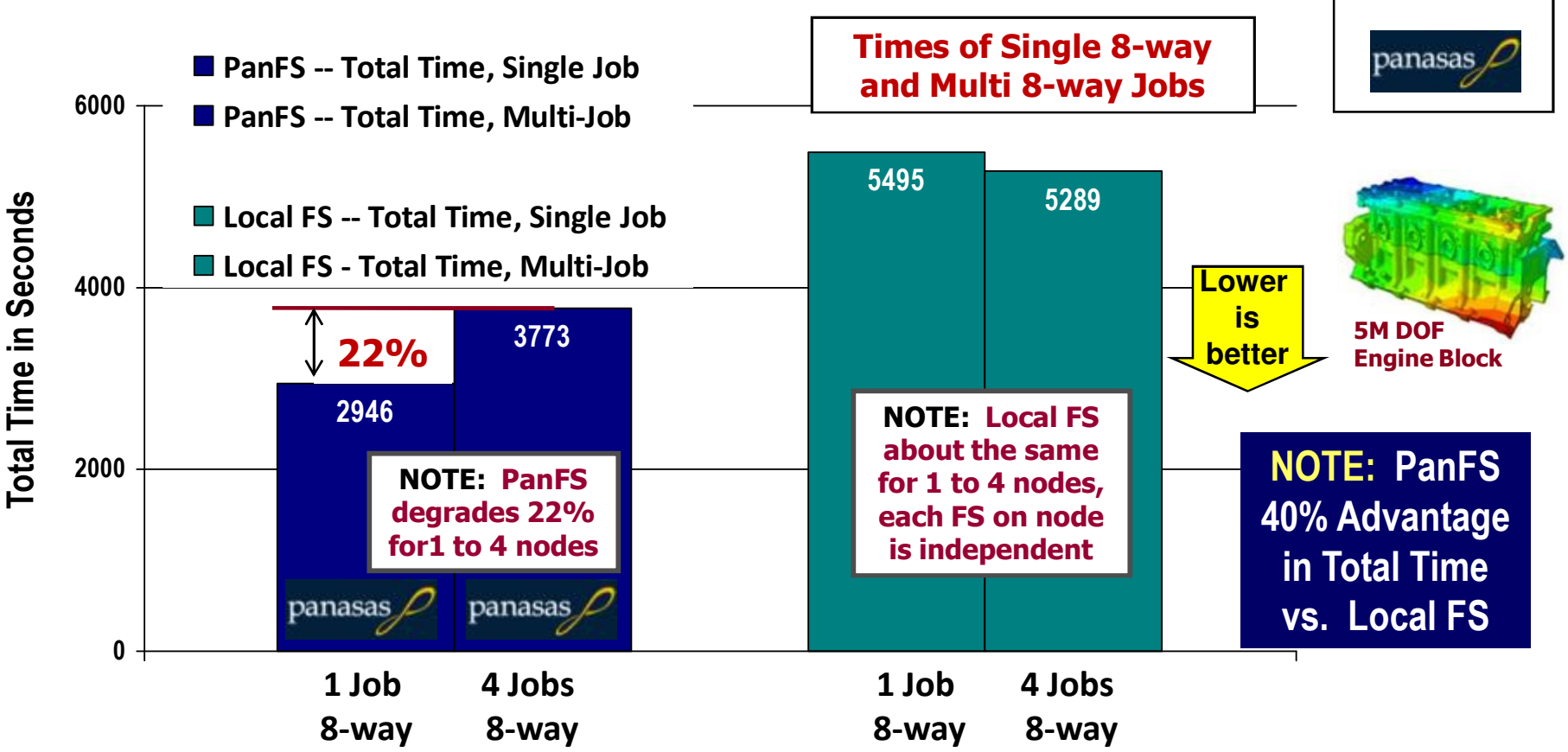
5M DOF Engine Block

NOTE: PanFS 40% Advantage in Total Time vs. Local FS

Average of 4 Jobs | Each Job on 8 Cores | Each Job on 1 Node Using All 8 Cores

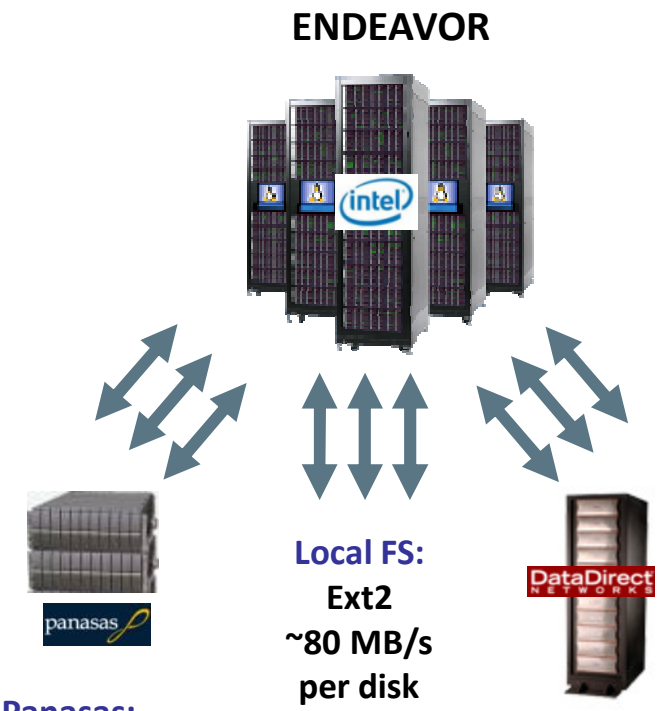
S4b Performance for Single vs. Multi-Job

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS



Panasas and Intel Abaqus S4b Study

Intel ENDEAVOR Xeon Cluster
Location: Intel HPC Customer Enabling Center, Dupont ,WA
Vendor: Intel; 80 nodes; 640 c ores; 18 GB memory per node
CPU: Intel Xeon (Nehalem) QC, 2.8 GHz, 8 cores per node
Interconnect: Infiniband
File Systems: Panasas PanFS; Lustre on DDN; Local disk
Operating System: **RHEL** Linux v5.2

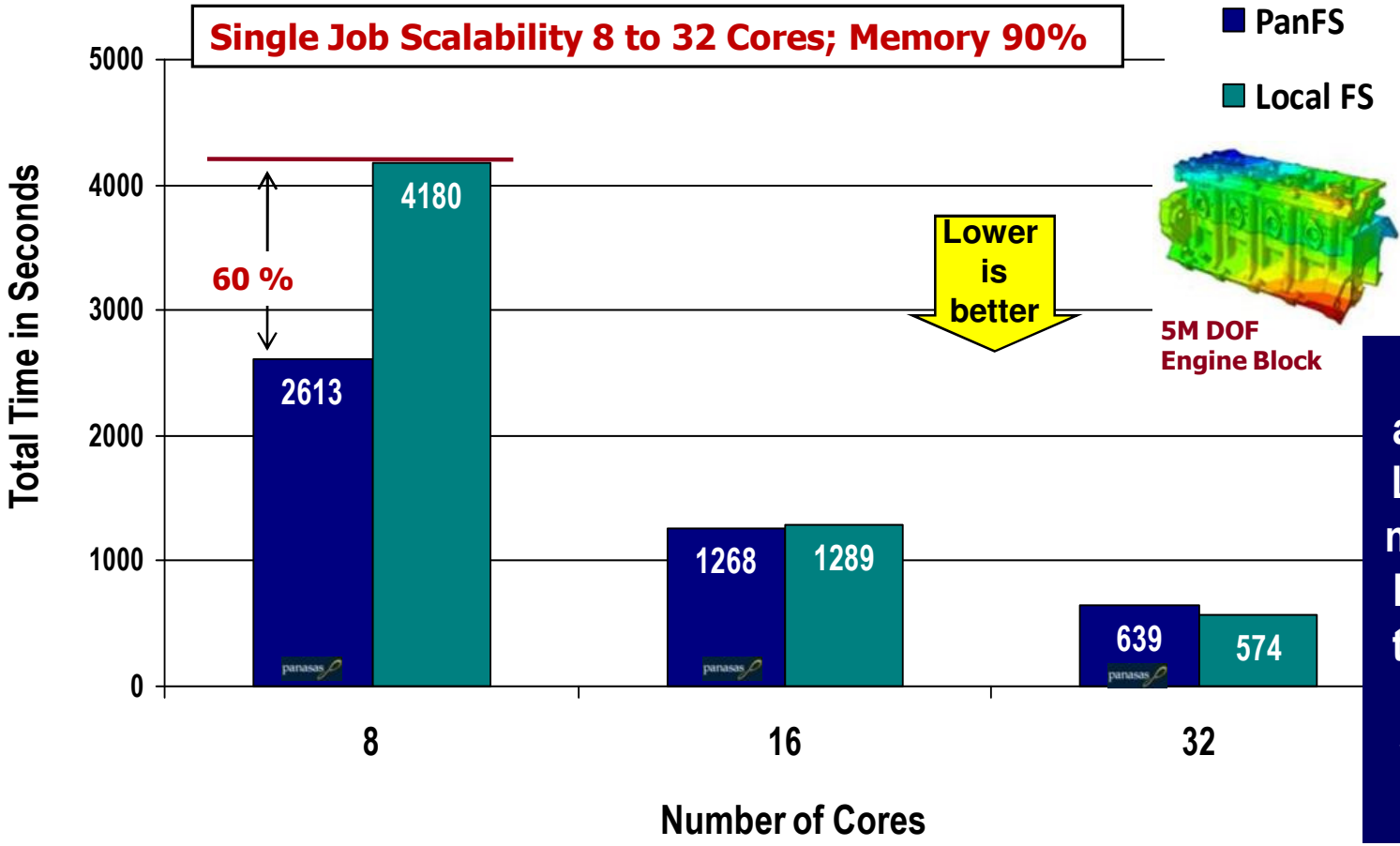


ENDEAVOR File Systems and Storage

- **PanFS:** 2 Shelves AS6000 (1+10 and 2+9), 38 TB FS; network connected through 10GigE switches and IB router, ~ **1.2 GB/s**
- **Lustre:** DDN storage, 100 TB FS, ~ **5 GB/s**
- **Local FS:** Ext2 FS, 370 GB SATA drive, **80 MB/s** per disk

S4b Performance for Single Job Scaling

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS Ext2

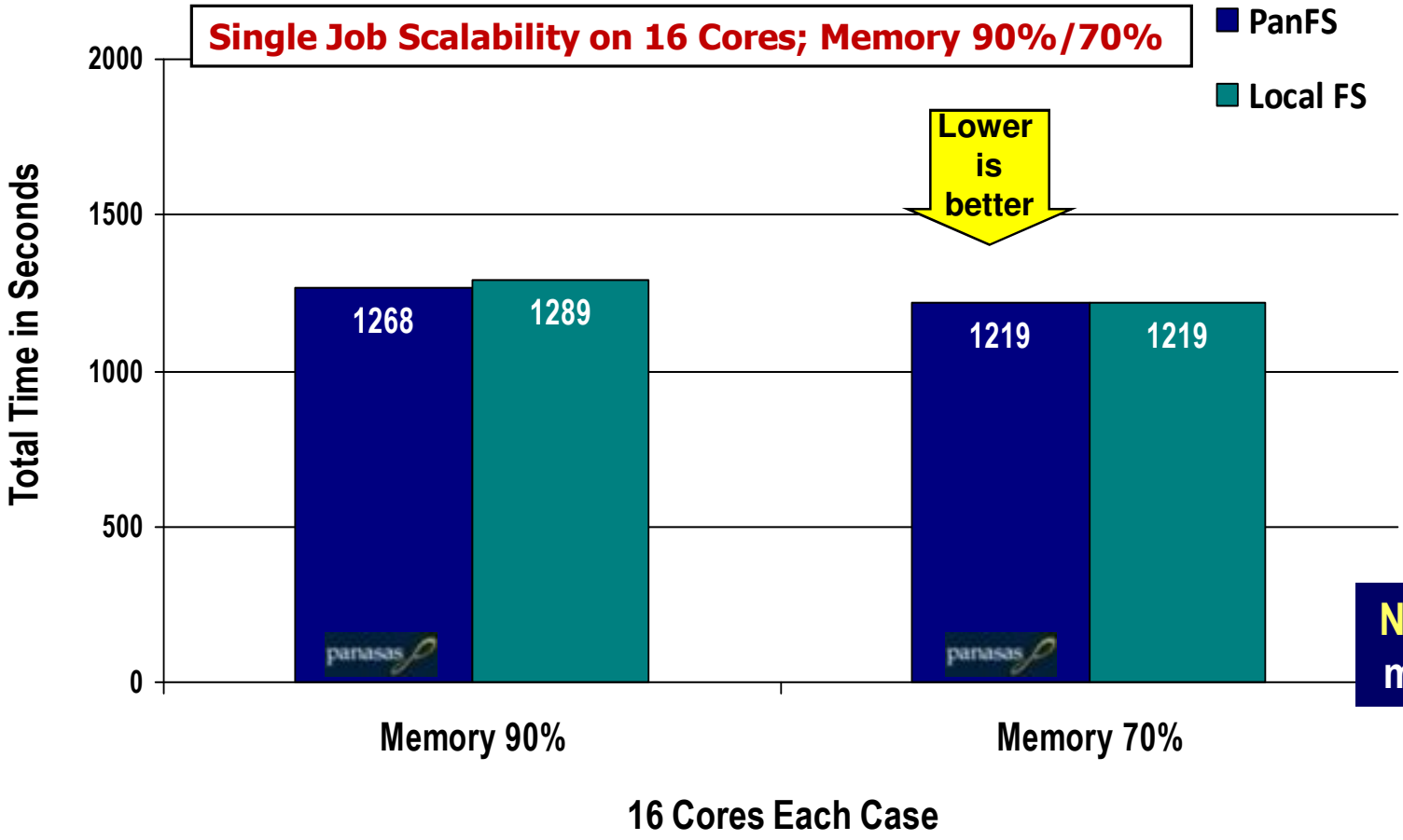


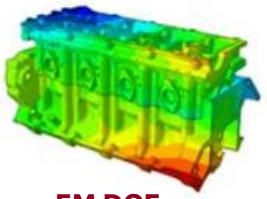
5M DOF Engine Block

NOTE: PanFS advantage over Local for single node case when IO is heavy – in the same range for 2-4 nodes when job goes in-memory

S4b Performance for Single Job Scaling

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS Ext2



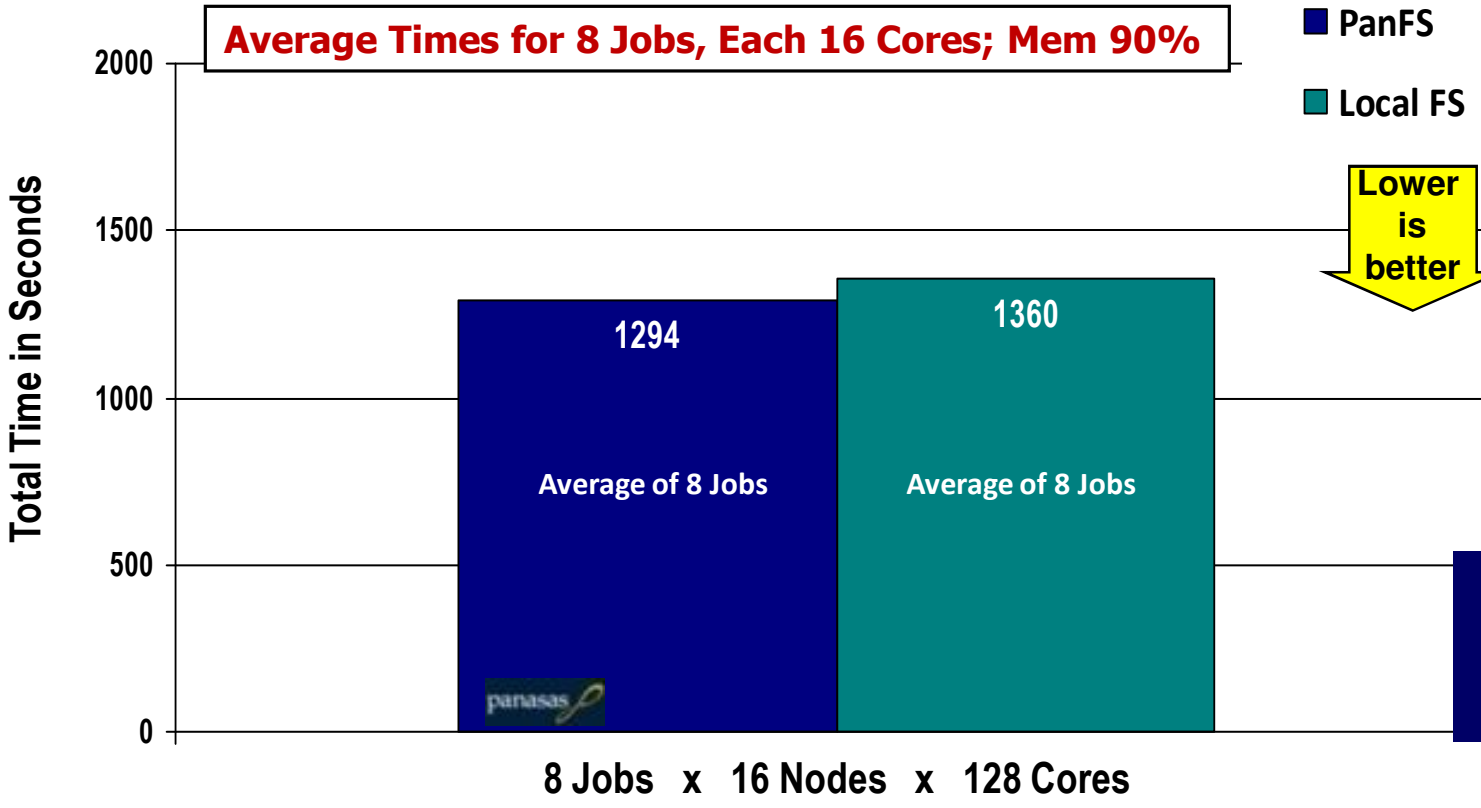


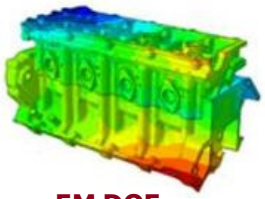
5M DOF
Engine Block

NOTE: Effect of memory setting

S4b Performance for Multi-Job Thru-put

Abaqus/Standard 6.8-3: Comparison of PanFS vs. Local FS Ext2





5M DOF
Engine Block

NOTE: PanFS and Local FS difference ~ 5%

Average Times for 8 Jobs | Each Job on 2 Nodes | Each Job on 16 Cores | Total 128 Cores

Questions

panasas

For more information,
call Panasas at:

1-888-PANASAS
(US & Canada)

00 (800) PANASAS2
(UK & France)

00 (800) 787-702
(Italy)

+001 (510) 608-7790
(All Other Countries)

Thank You