



**Twin Cities  
ANSYS User Meeting**

# **Hardware for FEA/CFD**

**Wednesday, June 29<sup>th</sup>**

**3:00-5:00 PM**

**Sizing, purchasing & configuring hardware for FEA / CFD:  
Multi-core HPC, GPU's, RAID's, Interconnects and more to  
be discussed including benchmarks and lessons learned.**

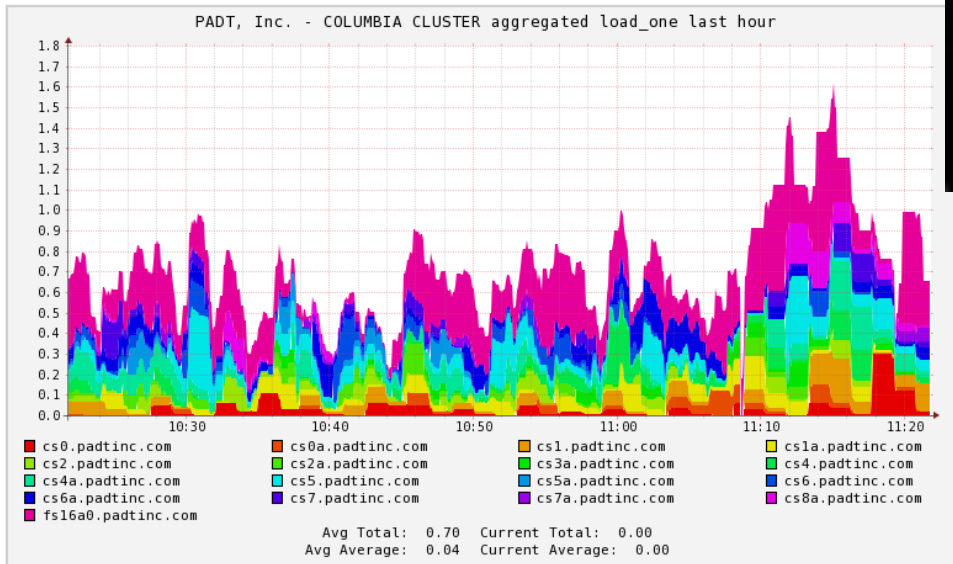
*Presented by industry maven David Mastel of PADT*

Join your fellow ANSYS users in the Twin Cities area for an ANSYS user meeting including technical presentation with handouts.

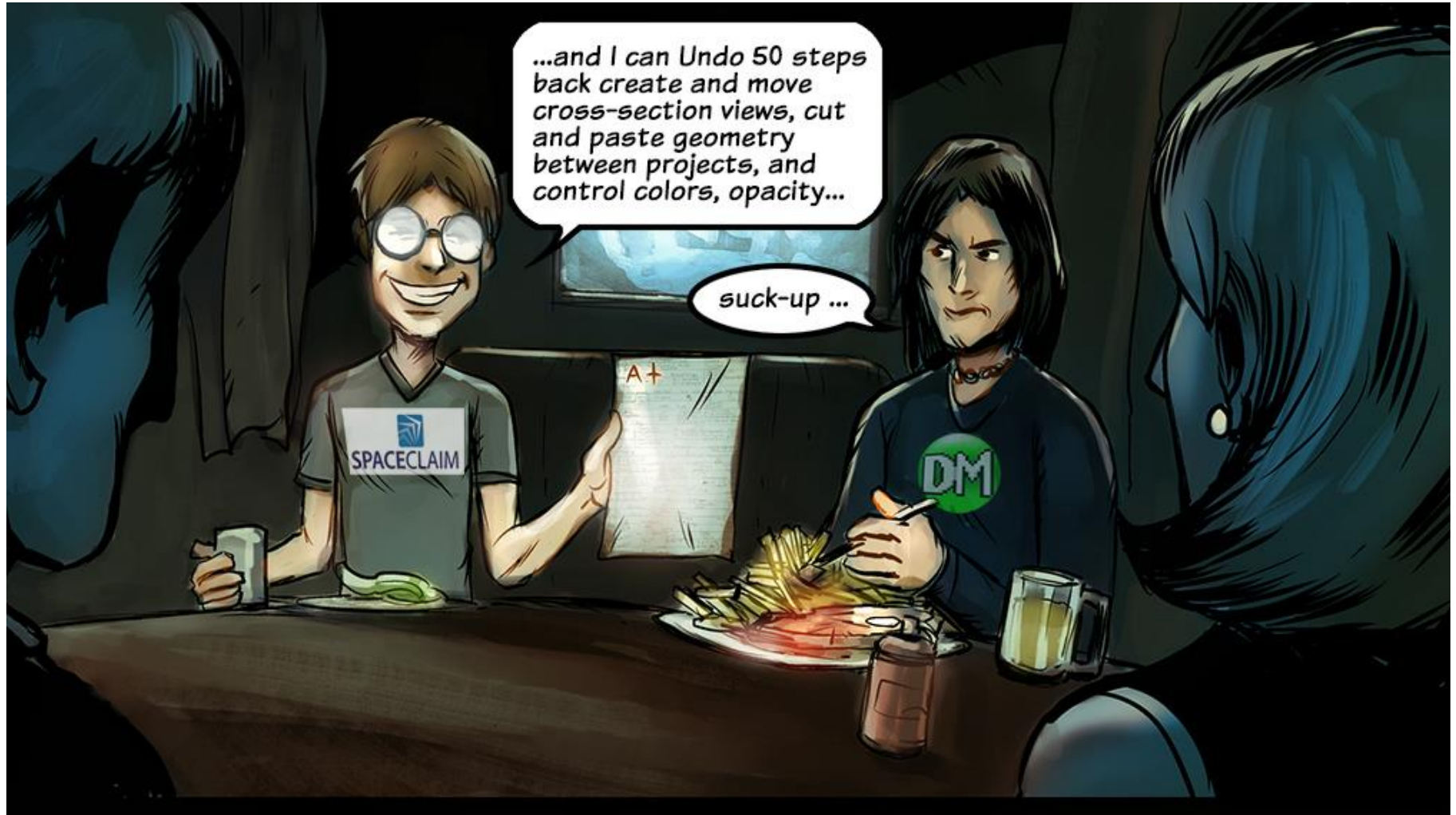
After the presentation, this informal setting encourages users to exchange experiences with ANSYS features, products, and methods new and old

# Agenda

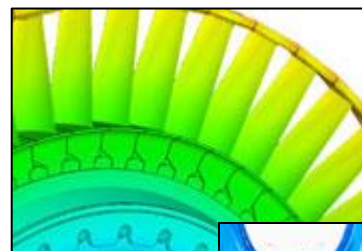
- Introduction to living in a Numerical Simulation world
- Hardware & Tools for HPC
- HPC Tips and Tricks
- Next Steps
- Q & A







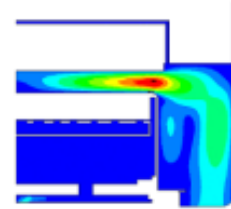
# Phoenix Analysis & Design Technologies





# "We Make Innovation Work"

- *PADT is an Engineering Services Company*
  - *Mechanical Engineering Products and Services*
  - *21 years of growth and happy customers*
  - *Any Industry, World Wide*
  - *Small to Large Companies*
  - *HQ in Tempe, Arizona*
  - *Offices in*
    - *Torrance, CA*
    - *Littleton, CO*
    - *Albuquerque, NM*
    - *Murray, UT*
    - *CEI in Phoenix*
  - *Reseller for: ANSYS, Stratasys, Flownex, Geomagic*
  - *Our own Products: CUBE Simulation Computers and SCA 3D Printed Part Cleaners*



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# People

- 84 Experienced and Motivated Employees
- Education is Critical to Company Success



- Industry Experience Plays more Significant Role



- Diverse Disciplines
  - Mechanical, Electrical, Manufacturing Engineering
  - Technicians, Business Administration, IT
  - Sales Staff



# 1000's of Customers



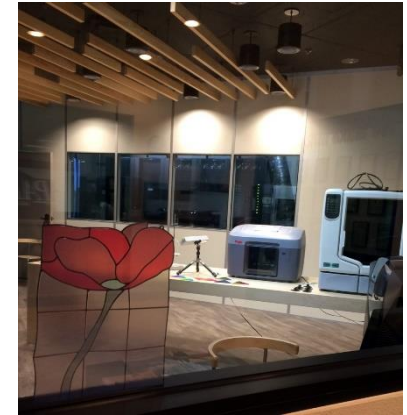
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# Facility & Tools

- 25,000 ft<sup>2</sup> at ASU Research Park in Tempe, Arizona
  - 40,000 ft<sup>2</sup> building owned by PADT
  - Onsite Labs: Clean Room, Medical, General
  - Machine Shop
  - Training, Seminar and Meeting Space
- Offices in Torrance, California; Littleton, Colorado; Albuquerque, New Mexico; Salt Lake City, Utah.
- Robust and Powerful Compute Infrastructure
  - 2,000+ Linux64 cores
  - Redundant office, database and communication servers
  - Powerful desktop systems
- World-Class CAD/CAE Tools
  - SolidWorks, Pro/E, SolidEdge, NX, Inventor
  - ANSYS Product Line
  - 3D Systems & Stratasys



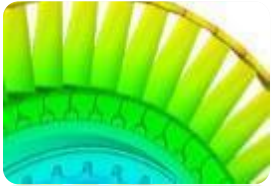
OFFICES





# Synergy

- Three Business Groups to Provide Focused Resources
- Flexibility of People and Tools Across Functions



## Sales & Support

ANSYS Sales & Support  
Flownex Sales & Support  
CUBE Simulation Computers  
Stratasys and Object 3D  
Printers Sales & Support

Mentoring & Training



## Engineering Services

Semiconductor Equipment  
Medical Devices  
Alternative Energy  
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## Manufacturing Technology

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SLA – SLS – FDM – Polyjet

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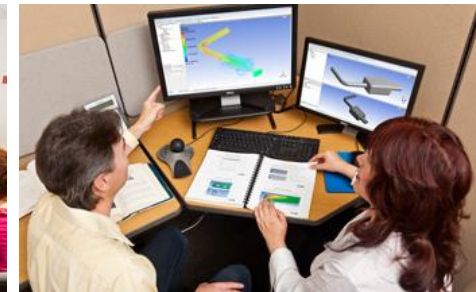
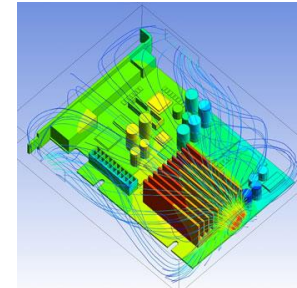
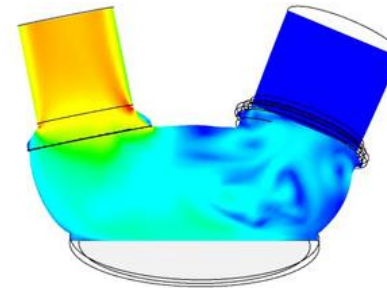
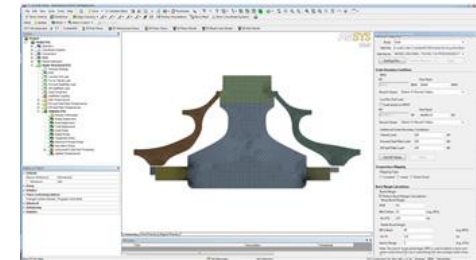
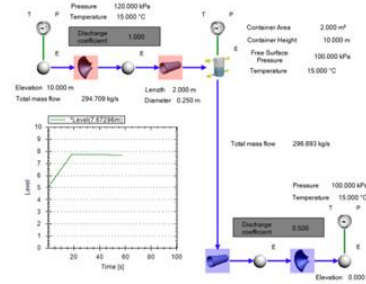


# Simulation Sales & Service

World Class FEA and CFD Sales, Consulting & Training

**ANSYS** Channel Partner

- Training & Mentoring
  - ANSYS, Inc. and Related Training at PADT or on-site
  - Classes or one-on-one
- Technical Support
  - Timely, real-world and practical
- Consulting
  - Thermal, Structural, Dynamics, CFD, Electromagnetics and most other mechanical simulations
  - Tool Customization
  - Accurate, timely and affordable
- Sales
  - Full line of ANSYS, Inc. products
  - Flownex Fluid-Thermal System Simulation
  - CUBE Simulation Computers



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# Product Development

Full research, design and development of machinery and systems

- Energy Systems
  - Custom pumps and blowers
  - Solar Systems and Sub-Systems
  - Alternative Energy and Hybrids
- Semiconductor Manufacturing Equipment
  - Subsystem design
  - Alpha machine development
- Medical Devices
  - Complete device development and design
  - Considerable surgical device experience
  - QSR compliant process
- Other
  - Any complex and difficult system that requires a high level of engineering



# Manufacturing Technologies

- Stratasys FDM and Polyjet Sales & Support
- On-site High Quality Rapid Prototyping
  - Selective Laser Sintering (SLS)
  - Stereolithography (SLA)
  - Fused Deposition Modeling (FDM)
  - PolyJet
  - Model Making
  - NC Machining
- Rapid Injection Molding
  - Soft Tooling
  - Epoxy Tooling
  - Liaison to offshore manufacturing
- Inspection
  - Cross Sectional and Laser Scanning
- Manufacture and Distribute Support Cleaning Systems - SCA



[SupportRemoval.com](http://SupportRemoval.com)





# PADT Blog on All Things ANSYS: *The Focus*

PADT, Inc. – The Blog

The Focus: [www.padtinc.com/blog](http://www.padtinc.com/blog)



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## Do you have an Internet of Things Strategy? PADT Can Help

Posted on [May 25, 2016](#) by [Eric Miller](#)



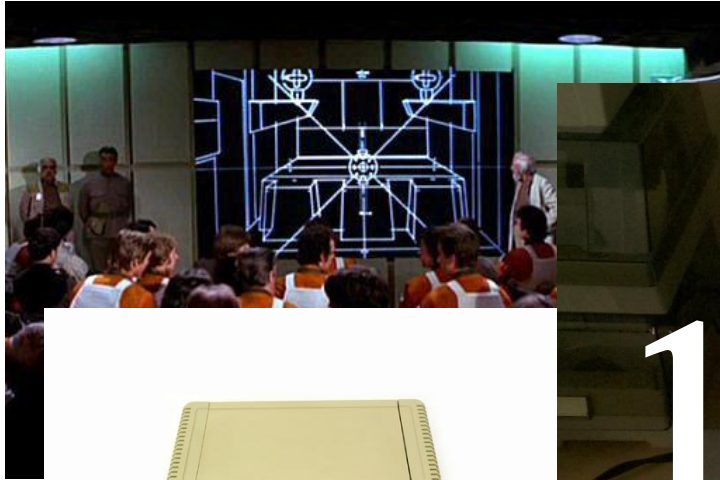
*"It is not just a trend, it is a Tsunami. One day you will wake up and see a giant wave headed your way, and that wave will be the Internet of Things!"*

This was the opening line from a presentation given by the VP of sales for a major engineering software company. It got



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# David...



# 1977

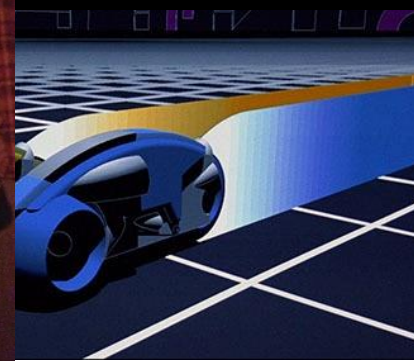
```
Current date is Tue 1-01-1980
Enter new date:
Current time is 21:35:24.18
Enter new time:

The IBM Personal Computer DOS
Version 2.00 (C)Copyright IBM Corp 1981, 1982, 1983

A>dir

Volume in drive A has no label
Directory of A:\

COMMAND  COM   17664   3-08-83  12:00p
FORMAT   COM    6016   3-08-83  12:00p
CHRDISK  COM    6400   3-08-83  12:00p
SYS      COM    1408   3-08-83  12:00p
DEBUG    COM   11904   3-08-83  12:00p
SLOOP    COM     32    1-01-80   7:44p
6 File(s)      292864 bytes free
```





# Trends in the world of Engineering Simulation

- The hardware and software environment in our Numerical Simulation world is just plain different. It has been a sustained progress type of year
- All of the portal's!



- Internet of things - <http://www.padtinc.com/iot/>
  - The networking of all with the purpose to collect and exchange data
  - We love information that our data provides



# Roadblocks for Engineering Simulation

- Seek Balance And Do Not Fear

FOMO: The fear of missing out



## 1. Costs

- What is your budget
- What is a balanced compute system?
- Redundancy, Tracking, and Monitoring to watch for system hardware or software failures
  - Kills performance & solving efficiency
  - Quality platinum level components in reality are less than 5% what if can kill a system
  - You are better off losing a job or data on a rare occasion than having a slow system

## 2. Security can be just as bad

- Many bad IT decisions made because of low probability security threats – isolate the machine instead.

## 3. Example:

- A fast-and-loose system may be down 5% of the available run time
- A “tight” system is 25% to 50% slower.



# My life in IT

- I may not understand or we just don't know what the heck you do.
- IT has constant bombardment and expectations from end-users wanting the latest greatest in toys.
- You may need to fix their perception of you.
- Take your IT Manager out to lunch!



# System Configuration

Set it & Forget it?

Well sort of...

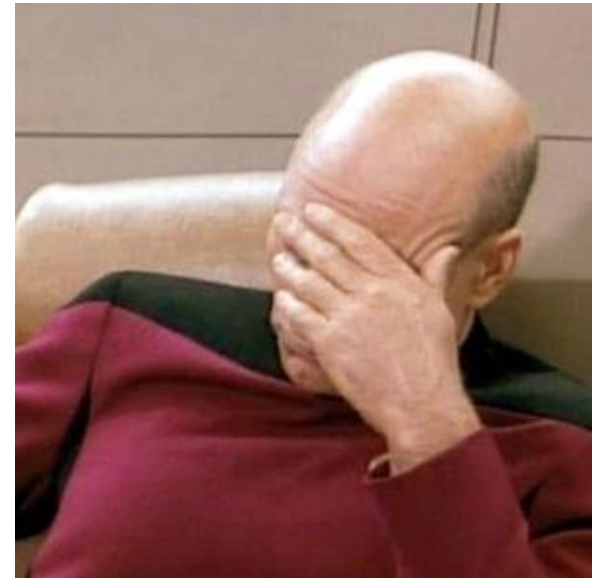
- At minimum
  1. Block out a yearly maintenance window on HPC clusters
  2. For HPC/numerical simulation workstations, a minimum of every six months

What do I look for when running a maintenance?

- Hardware firmware and bios
- Hardware drivers
- Operating System patches

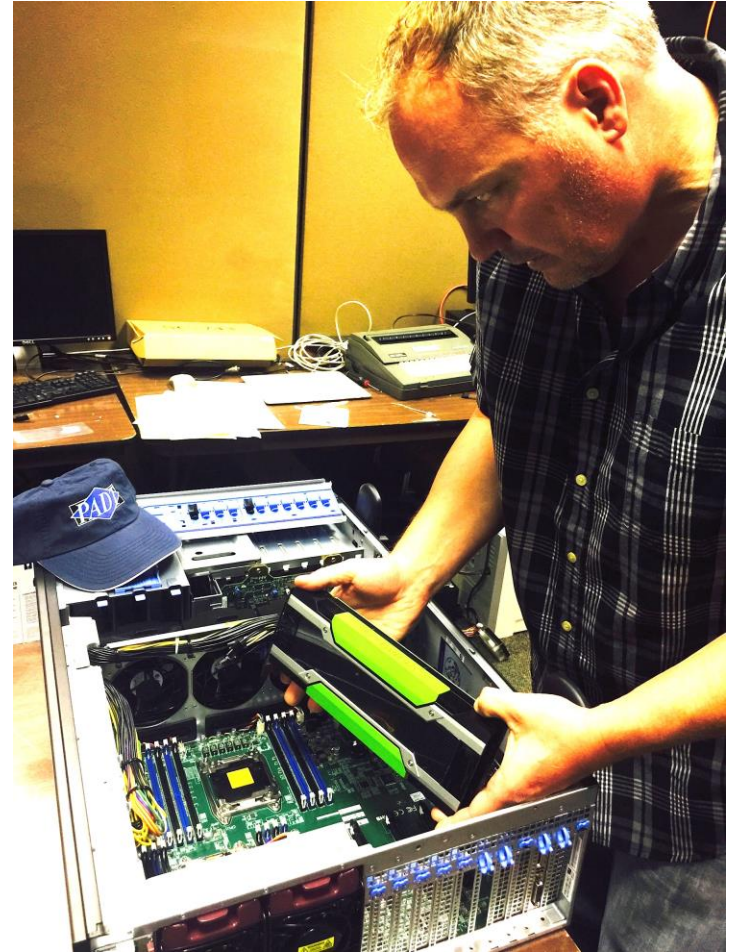
Horror stories for you

1. File system corruption
2. System halts
3. low-level updates not done since implementation.



# GPU Computing

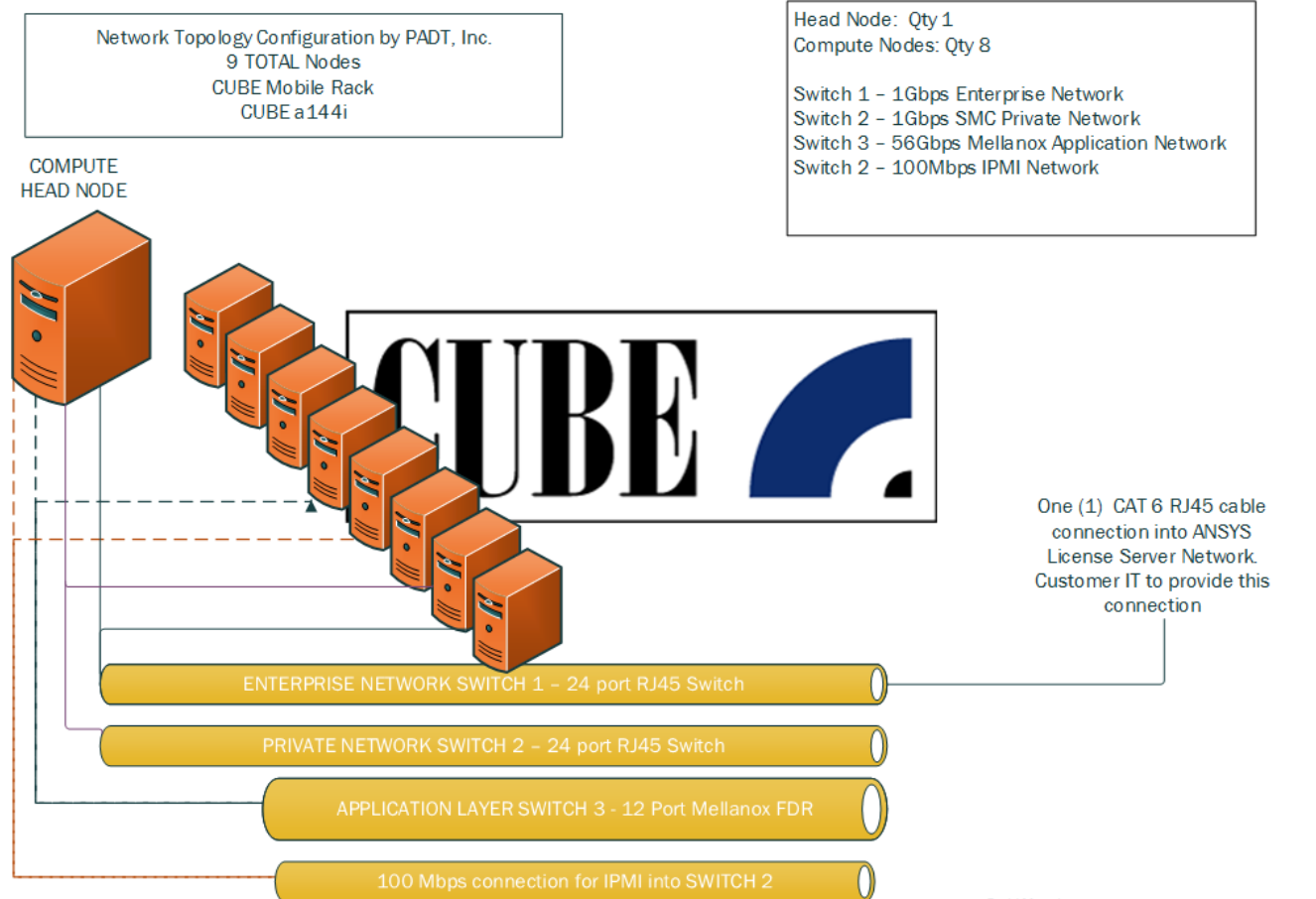
- What is the deal with GPU's?
  - GPU'S Explained
  - GPU's and ANSYS Software
  - Lessons learned on Implementing GPU's
- 1. Recommend using more than one
  - 1. Recently used 10 Nvidia Tesla's
  - 2. Ten Compute Nodes
    - 1. Bottle neck – CPU
    - Interconnect was 10Gbps
- 2. System configuration:
  - 1. Extreme speed
  - 2. High Ram to keep solve in memory





# GPU Computing

- When running distributed your CPU Interconnect speed is just as critical
  - 100Gbps Ethernet now available
  - 56Gbps



David Mastel  
Manager, Information Technology - Chief HPC Architect  
Phoenix Analysis & Design Technologies  
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Tempe, AZ 85284

# GPU Computing (Cont.)

- Razor Core
  - External GPU Bay
    - Thunderbolt™3 – USB-C
- The future
- Limitations



# CPU - INTEL yay! AMD ☹️

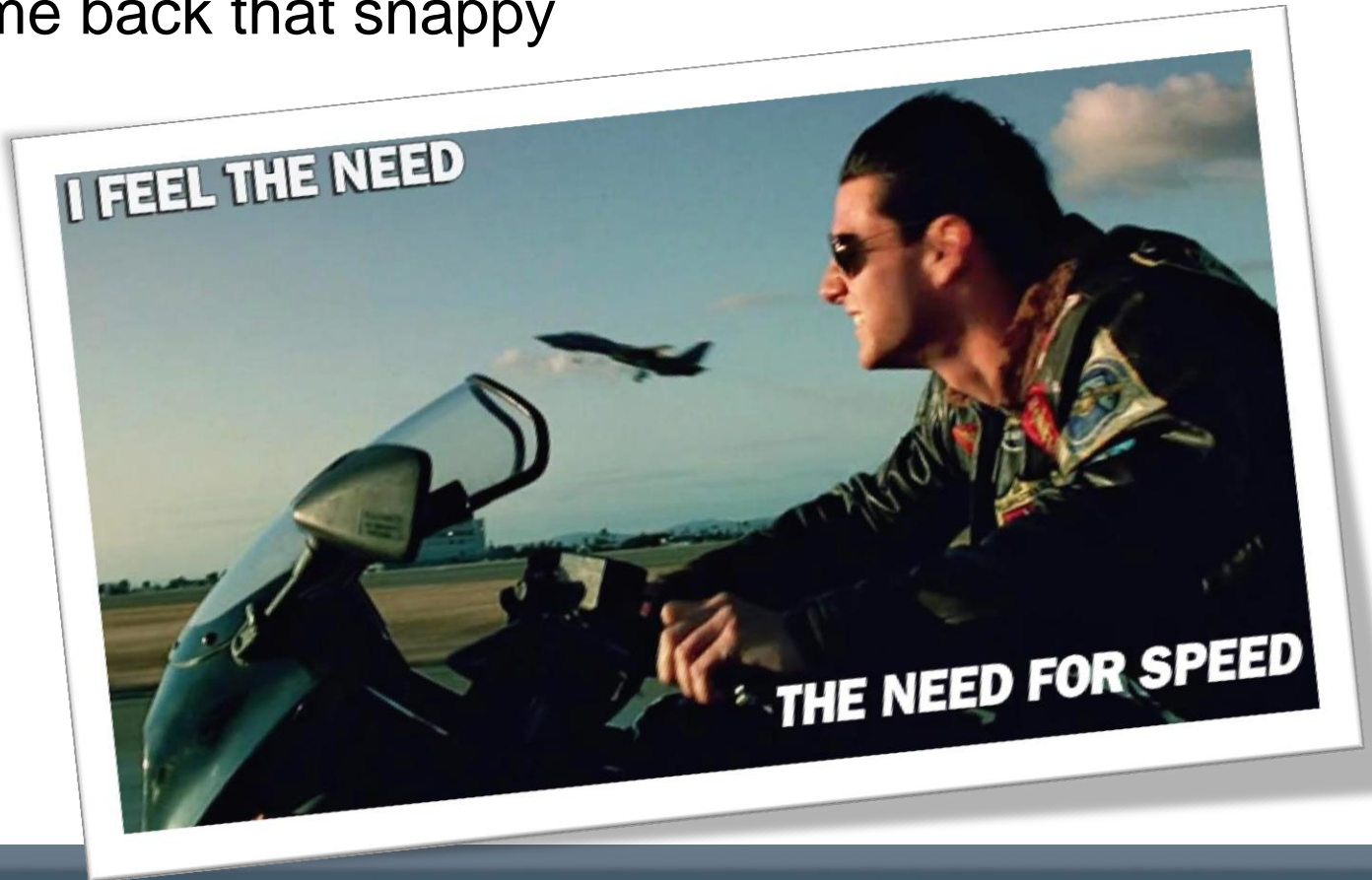
- CPU update XEON E5-2600 v4 (Broadwell)
  - Officially launched
  - Socket compatible replacement

CPU	Xeon E5-2600 v3 (Haswell-EP)	XEON E5-2600 v4 (Broadwell-EP)
Cores Per Socket	Up to 18	Up to 22
Threads Per Socket	Up to 36 threads	Up to 44 threads
Last-level Cache (LLC)	Up to 45MB	Up to 55MB
QPI Speed (GT/s)	2 x QPI 1.1 channel speed 6.4, 8.0, 9.6 GT/s	
PCIe Lanes/Controllers/Speed(GT/s)	40 /10 / PCIe* 3.0 (2.5, 5, 8 GT/s)	
Memory Population	4 channels of up to 3 RDIMM or 3 LRDIMMS	Added + 3DS RDIMM
Max Memory Speed	Up to 2133 MHz	Up to 2400 MHz



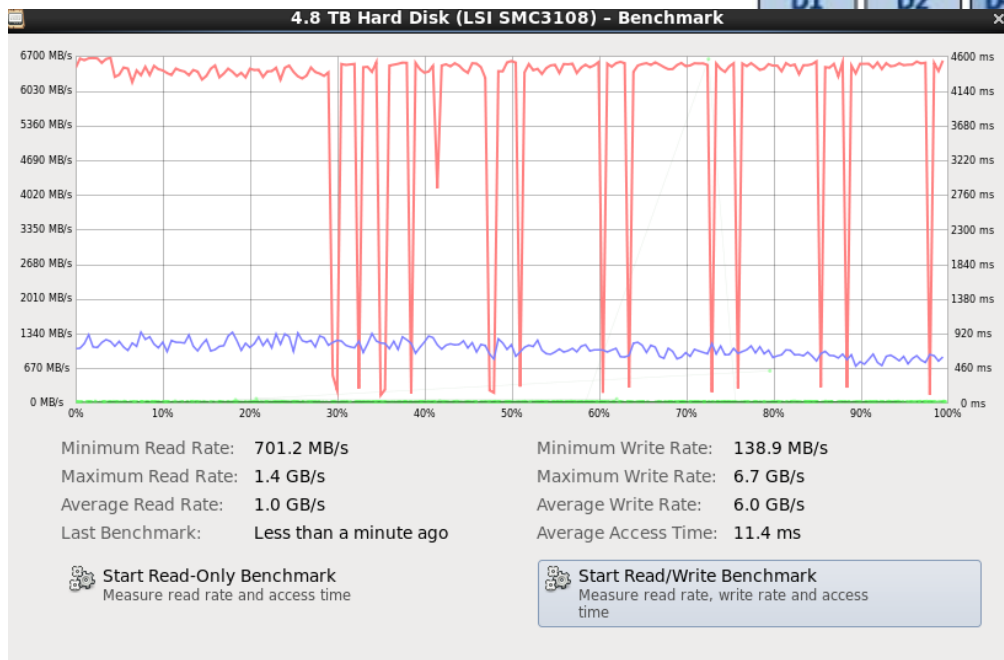
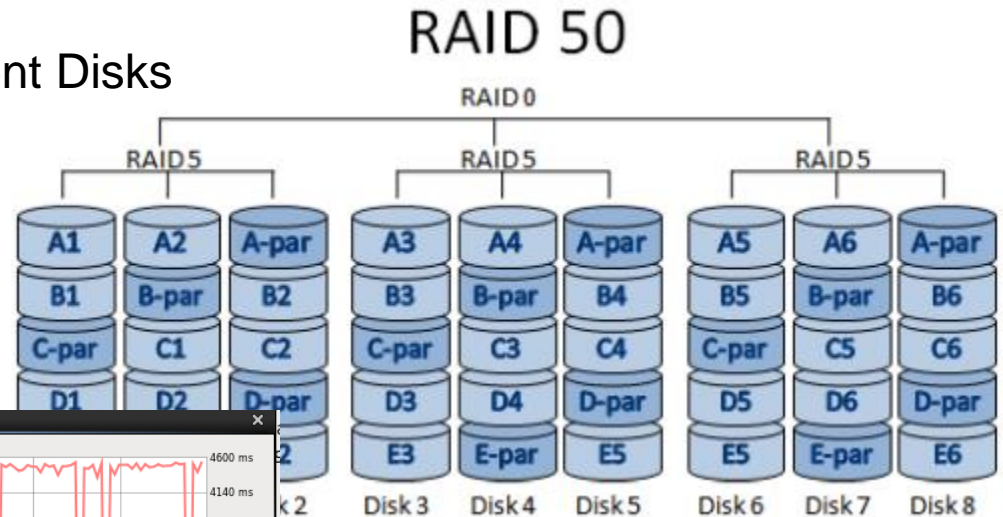
# Disk I/O

- Understanding Simulation, I/O
  - Extremely heavy I/O
  - Need for speed
  - Bring me back that snappy feeling



# Disk I/O – (Cont.)

- RAID Basics
  - Redundant Array of Independent Disks
- Things to Avoid
  - Raid 1, Raid 5, single disk
- What I use?



# It's a Solid State



- Next Generation SSD Technology
  - >7x lower latency than SAS 3.0(12Gbps)
  - 6x the bandwidth of SATA 3.0(6Gbps) SSD's
- Highest Performance up to 3GB/s Read and 460K IOPS Per drive
- Satisfies the Performance Demands of VDI, Cloud, Storage, and Server Caching
- 2.5" U.2 (SFF-8639) Form Factor serviceability advantage

vs. standard SSD cards

- Hot-swap protects against surprise add/remove



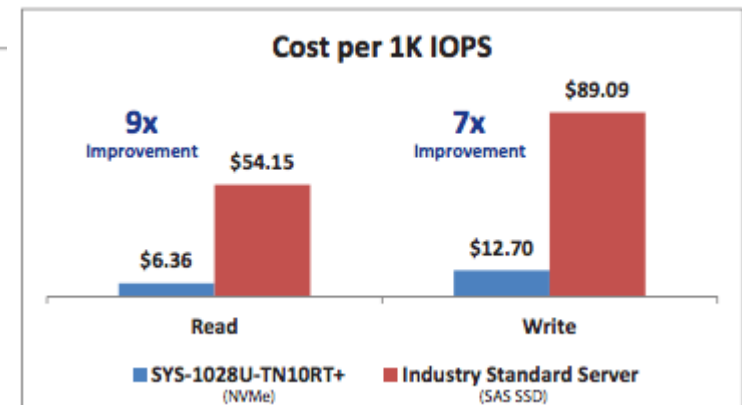
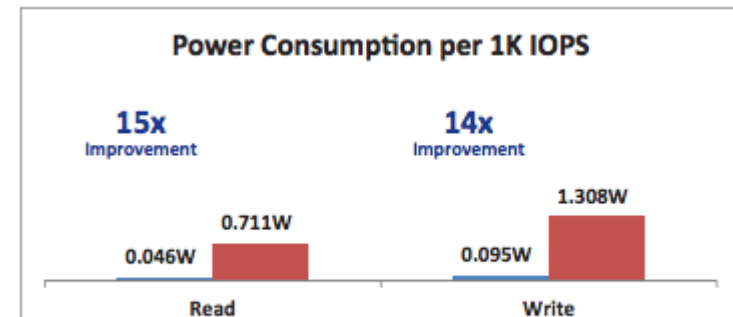
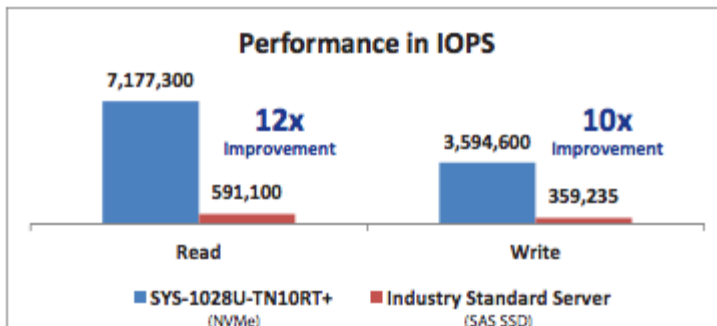
# It's a Solid State (cont.)



- Sustained progress?
  - I/O takes a leap forward

## Test Results

Chart 1 compares the SYS-1028U-TN10RT+ with 10 NVMe SSDs to the Industry Standard 1U 10 Bay Server with 10 SAS3 SSDs and we found a 12x performance gain in read IOPS and a 10x performance gain in write IOPS.



# Tools

- Biggest asset is your ANSYS Solver Output File or ?
  - What to look for in your output file
    1. ANSYS FEA
    2. ANSYS CFD
- HPC Cluster Management Tools
  - Is it time?
    - When is it time to take it to the next level
    - Implement an HPC Compute Cluster Manager
      1. Ganglia
      2. Bright Compute Cluster Manager
      3. Windows 2012 R2 Standard HPC
        - Diagnostic tools
      4. Resource Monitoring
      5. IT and Engineering Management Reports

# Solving Across Your Enterprise Network

- Scheduling & Queuing Systems

- This means money!

- 1. “Linux costs money” – Ken Camino

- 2. Open Source vs. Third Party supported

- Windows 2012 R2 Standard HPC Management

- Bright Compute Cluster Management

- Torque with MOAB

- a) Torque is open source and free

- b) MOAB you will need to purchase licenses

	Native Scheduling	3 <sup>rd</sup> party scheduler support	Remote submission	Interactive	Simultaneous design points (workbench)
ANSYS RSM	Yes	Yes	Yes	No	Yes
FLUENT Launcher	No	Yes	Yes	Yes	No
CFX Solver Manager	No	Yes*	Yes	No	No
ANSYS EKM	Yes (RSM)	Yes (RSM)	Yes	No	Yes (WB & RSM)

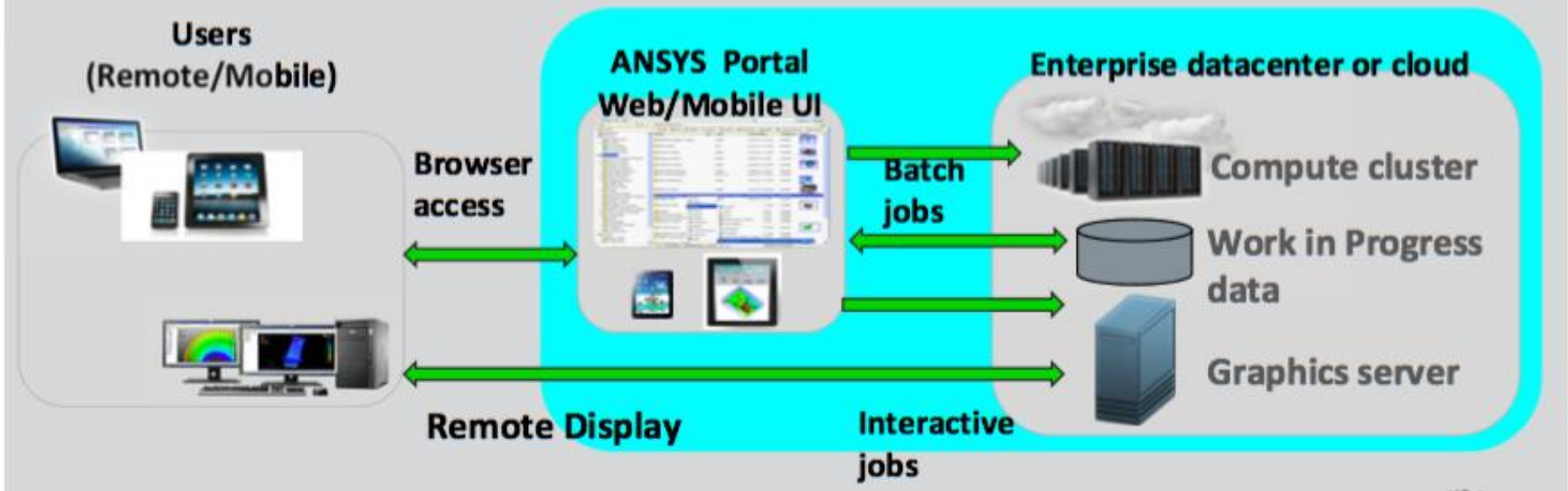


# Solving Across Your Enterprise Network

- Why We Solve Remote
  - Use shared resources
  - Systems optimized for solving, not pre/post
  - Be able to do other things on our desktop
- ANSYS RSM & ANSYS EKM
  - Default submission tool
  - Built in to ANSYS, easy to use and deploy
  - Handles moving files around for you
  - Not a queuing system, but can be linked to queuing software

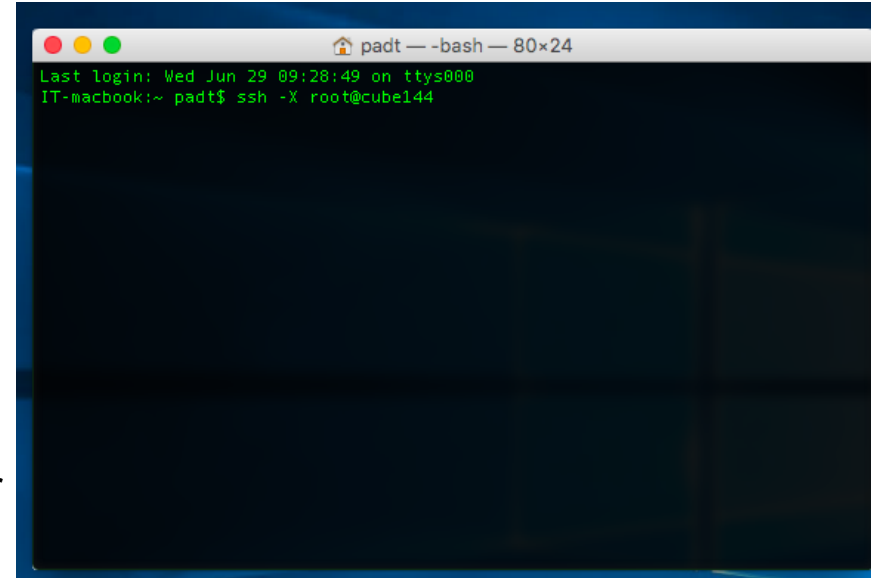
# ANSYS EKM

## ANSYS<sup>®</sup> ANSYS EKM



# Some Challenges

- Manual Remote Solve
  - Do you have access?
    1. SSH, VNC, Remote Desktop
  - Move Files:
    1. Mounting is best
    2. Or use FTP, SCP or WinSCP
- Visualization on Remote Systems
  - Really changing and getting better
    1. Remote Desktop or VNC
    2. NX
    3. NICE
- Network Speed is critical
  - Hardware VPN for remote
  - Point-to-Point connection is best
  - Dedicated Network within a LAN or WAN

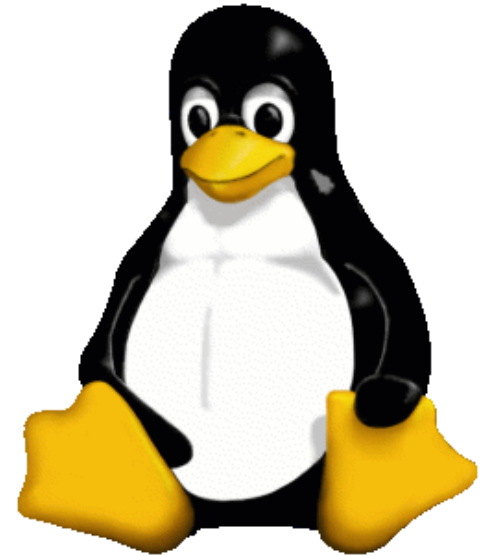
A terminal window titled 'padt -- -bash -- 80x24' with a dark background and green text. The text shows a successful SSH connection: 'Last login: Wed Jun 29 09:28:49 on ttys000' followed by 'IT-macbook:~ padt\$ ssh -X root@cube144'.

```
padt -- -bash -- 80x24
Last login: Wed Jun 29 09:28:49 on ttys000
IT-macbook:~ padt$ ssh -X root@cube144
```



# Benchmark Tools

- ANSYS Benchmark Suite
  - Available download through the ANSYS Customer Portal
- Linux Live CD
  - Disk Utility
  - This is how I quickly measure disk I/O
- USB boot drive for updating firmware and BIOS
- Using the programs and real world test model to show speedup
  - CAD Programs
  - UGS NX
  - PRO/e

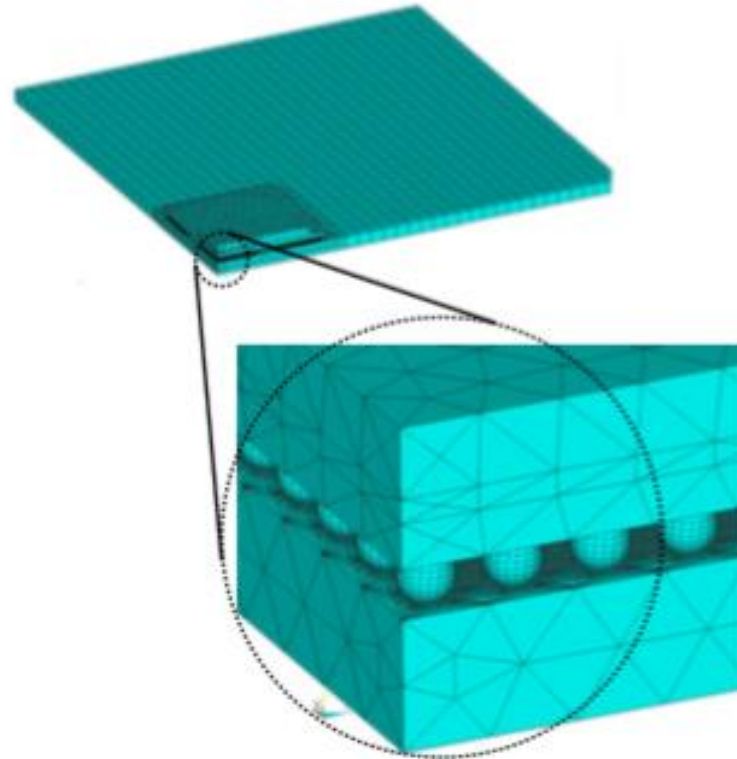


# System Configuration

- The Reality Of Benchmarks
  - ANSYS standard benchmark models
    1. AMD
    2. INTEL XEON v2, v3 & v4 CPU benchmarks
  - This data can be used to prove the case and need for:
    1. Increased HPC Compute hardware
    2. Increased amount of ANSYS HPC licensing
- High-Speed interconnects make a difference
  - But they and your software need to be configured correctly
  - InfiniBand
  - Distributed computing, Using MPI is critical
    1. Install the Platform MPI on your numerical simulation machines
    2. INTEL MPI is best with latest generation INTEL XEON CPU's
    3. MS MPI on Windows HPC
      1. Also installing platform MPI on your Windows HPC Cluster is okay

# Benchmarks Data – FEA SP5

V15sp-5	Sparse solver, symmetric matrix, 6000k DOFs, transient, nonlinear, structural analysis with 1 iteration	NVIDIA, Intel <sup>2</sup>	Large sized job for direct solvers, should run incore on machines with 128 GB or more of memory, good test of processor flop speed if running incore and I/O if running out-of-core
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V15sp-5 Benchmark Model



# Benchmarks Data – FEA SP5

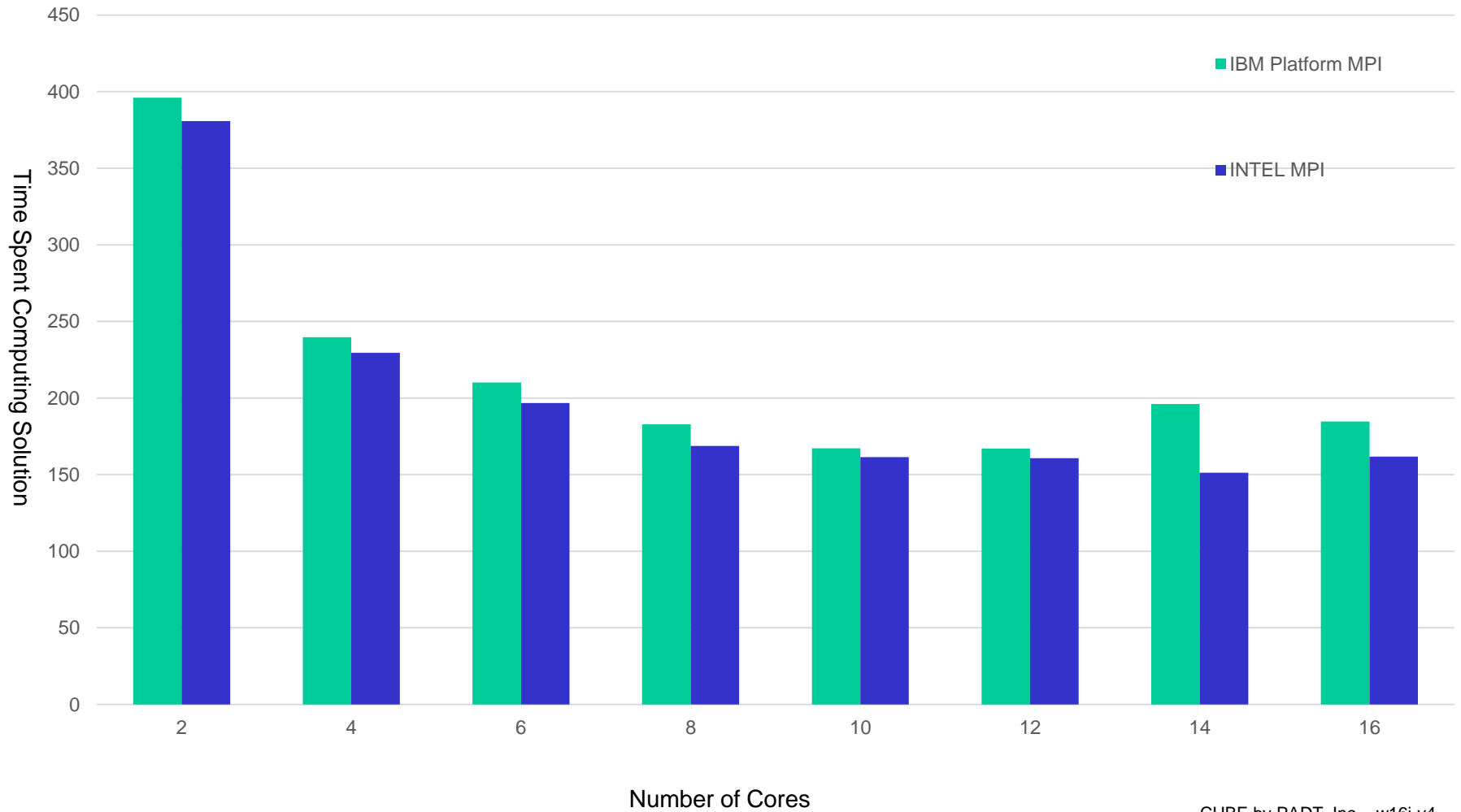
ANSYS FEA SP5 Benchmark	
Cores	2015 CUBE Intel® Xeon® e5-2667V3
8	398.1
24	241.2
54	89.3
63	86.3
72	81
128	68



Cores	TIME SPENT COMPUTING THE SOLUTION	TIME SPENT COMPUTING THE SOLUTION	The Speedup
	IBM Platform MPI	INTEL MPI	
	2016 CUBE w16i-v4	2016 CUBE w16i-v4	
2	396.1	380.9	1.04
4	239.7	229.6	1.04
6	210.1	196.7	1.07
8	182.9	168.7	1.08
10	167.2	161.4	1.04
12	167.1	160.7	1.04
14	196.1	151.3	1.30
16	184.7	161.7	1.14

# Benchmarks – MPI throwdown

ANSYS BGA v15-SP5 Benchmark

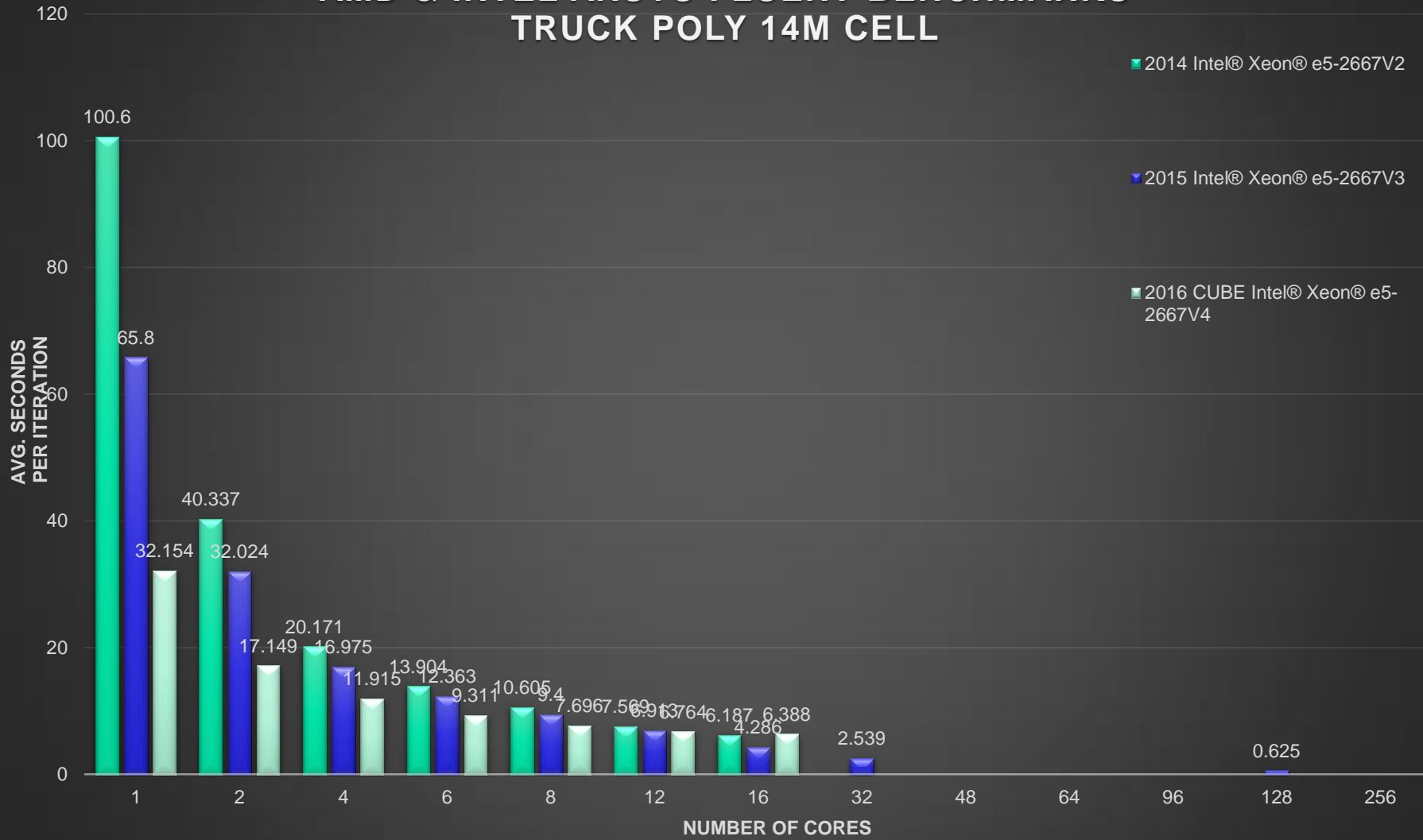


CUBE by PADT, Inc. - w16i-v4  
5/11/2016 - DM



# Benchmarks Data - CFD

## AMD & INTEL ANSYS FLUENT BENCHMARKS TRUCK POLY 14M CELL





# Benchmarks Data

- ANSYS .out files
  - Compute Bound
  - I/O Bound
- ANSYS Benchmarks Test Runs
  - Determine amount of cores
  - Run at least 50 iterations

```
Total CPU time for main thread      :    105.9 seconds
Total CPU time summed for all threads :    119.1 seconds

Elapsed time spent pre-processing model (/PREP7) :    0.0 seconds
Elapsed time spent solution - preprocessing      :    10.3 seconds
Elapsed time spent computing solution           :    83.5 seconds
Elapsed time spent solution - postprocessing     :    3.9 seconds
Elapsed time spent post-processing model (/POST1) :    0.0 seconds

Equation solver computational rate      : 319444.9 Mflops
Equation solver effective I/O rate      : 26540.1 MB/sec

Maximum total memory used               : 48999.0 MB
Maximum total memory allocated           : 54896.0 MB
Maximum total memory available           :    128 GB

+--- END DISTRIBUTED ANSYS STATISTICS ---+

*-----*
|                                     |
|                               DISTRIBUTED ANSYS RUN COMPLETED |
|                                     |
|-----|
|                               Release 14.5.7           UP20130316           WINDOWS x64 |
|-----|
| Database Requested(-db)  512 MB   Scratch Memory Requested           512 MB |
| Maximum Database Used    447 MB   Maximum Scratch Memory Used       4523 MB |
|-----|
|
| CP Time      (sec) =           119.01           Time = 15:41:54 |
| Elapsed Time (sec) =           117.000           Date  = 10/21/2013 |
|
```

# Optimize Ideals

- Optimize your hardware for what you do
  - Run the correct benchmarks that fit your field of expertise
- Don't let fear drive your hardware, let speed drive it
- Check with experts to make sure you have the Software configured correctly
  - ANSYS software reseller or community
    1. [www.xansys.org](http://www.xansys.org)
    2. <http://www.ansys-blog.com/>
    3. [www.padtinc.com/blog](http://www.padtinc.com/blog)

# Next Steps

## Next steps if you **HAVE** compute hardware:

- Review your hardware, software, and configuration every six months
  - Compute Bound?
  - I/O Bound?
- Upgrade or reconfigure to get greater value
- Add capacity and/or speed
  - If memory bound, RAM, RAM, RAM
    1. Order of magnitude speedup
  - CPU upgrade
  - GPU/Accelerators
  - Buy more ANSYS HPC tasks licenses!
  - Disk space is cheap, spending time dealing with files is not
- Have an outside party do an evaluation and make recommendations

# Next Steps (cont.)

## Next steps if you **NEED** compute hardware:

- Gather a group of benchmark cases
- Measure your current performance (for ROI calculations)
- Buy for speed, not fear
- Remember that Simulation is Different
- Does your hardware & software vender truly understand numerical simulation?
  - Get multiple quotes
  - Ask your ANSYS software reseller for tips
  - Read the ANSYS manual
    - How I learned how to expand my understanding of ANSYS
    - Distributed or parallel computing
    - Run the benchmarks



# Conclusions

## Got HPC?

- Say Yes to HPC
- Does HPC matter?
- Does having the right tools to get the job done matter?
- Look at module approach for upgrade

- Understand your specific Engineering Simulation process & environment

- What does your company really need vs. what the HPC marketing is telling me that I need

- Workstation, server, department cluster, company cluster



# Questions?

