Performance Analysis of a Large-Scale Cosmology Application on Three Cluster Systems

Zhiling Lan and Prathibha Deshikachar

Department of Computer Science
Illinois Inst. of Tech.
Chicago, IL 60616
lan@iit.edu

Outline

- Introduction
- Overview of cosmology application
- Description of the cluster systems
- Performance results
- Summary and future work

Motivation

- Cosmology simulations require a large amount of computer power
- Emerged platform: Cluster systems

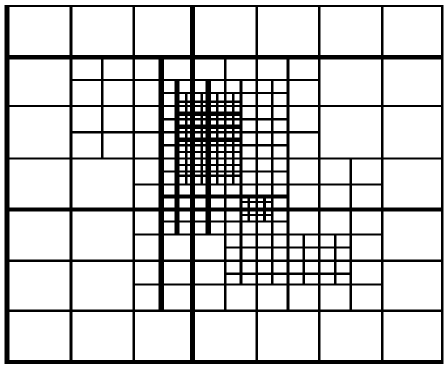
- Two objectives:
  - Demonstrate the great potential of using clusters
  - Identify the performance issues associated with different clusters

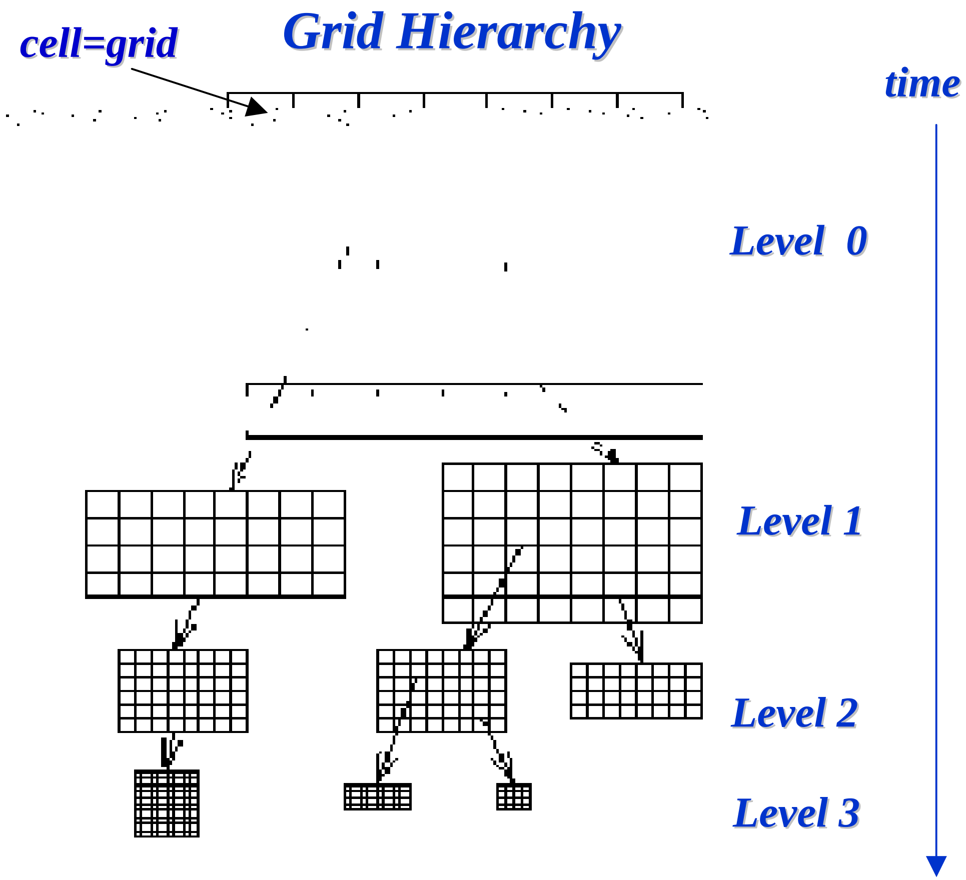
Structured Adaptive Mesh Refinement

- Developed by M. Berger et al.
- Spatially- and temporally- adaptive algorithm
  - Provide fine granularity in local regions requiring high resolution dynamically
- Widely used in many applications
  - cosmology
  - structured analysis
  - fluid dynamics

SAMR Grid Hierarchy

Overall SAMR grid





A nested hierarchy of overlapping grids of increasingly fine resolution in both space and time (refinement factor = 2)

ILLINOIS INSTITUTE OF TECHNOLOGY

Transforming Lives. Inventing the Future. www.iit.edu

ENZO Code

- Provided by G.Bryan and M.Norman
- A parallel implementation of SAMR
- Primarily intended for use in astrophysics and cosmology
  - Solves coupled equations of gas dynamics, dark matter dynamics ...
- C++ and Fortran77 with MPI calls

IBM SP2

- Peak performance: 1.7 teraflops
- 62nd on the current TOP 500 list
- Contains 1,152 Power3 CPU (375MHz) organized as 144 SMP nodes
- Interconnect: the Colony switch, a proprietary IBM interconnect

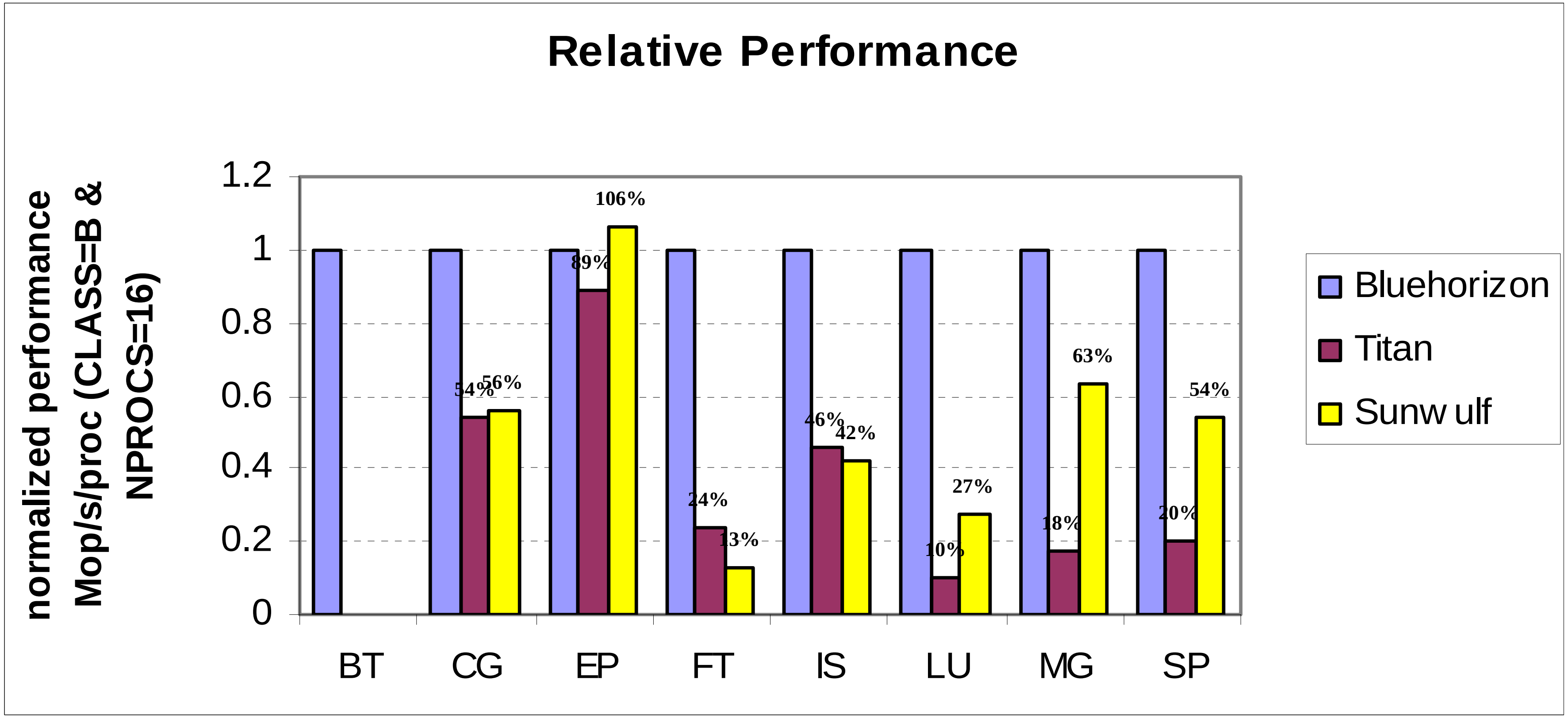
IA-64 Linux Cluster

- Peak performance: 1.024 teraflops
- 111st on the current TOP 500 list
- Contains 160 IBM IntelliStation Z Pro 6894 servers (Intel 800MHz Itanium 1, dual-processor)
- Interconnect: Myrinet 2000 & Gigabit Ethernet

SUN Cluster

- Peak performance: ?
- not on the current TOP 500 list
- Contains one four-processor E450 server (UltraSPARC II 480 MHz) and 63 SUN Blade workstation 100 (UltraSPARC IIe 500 MHz)
- Interconnect: Fast Ethernet

NPB Comparison

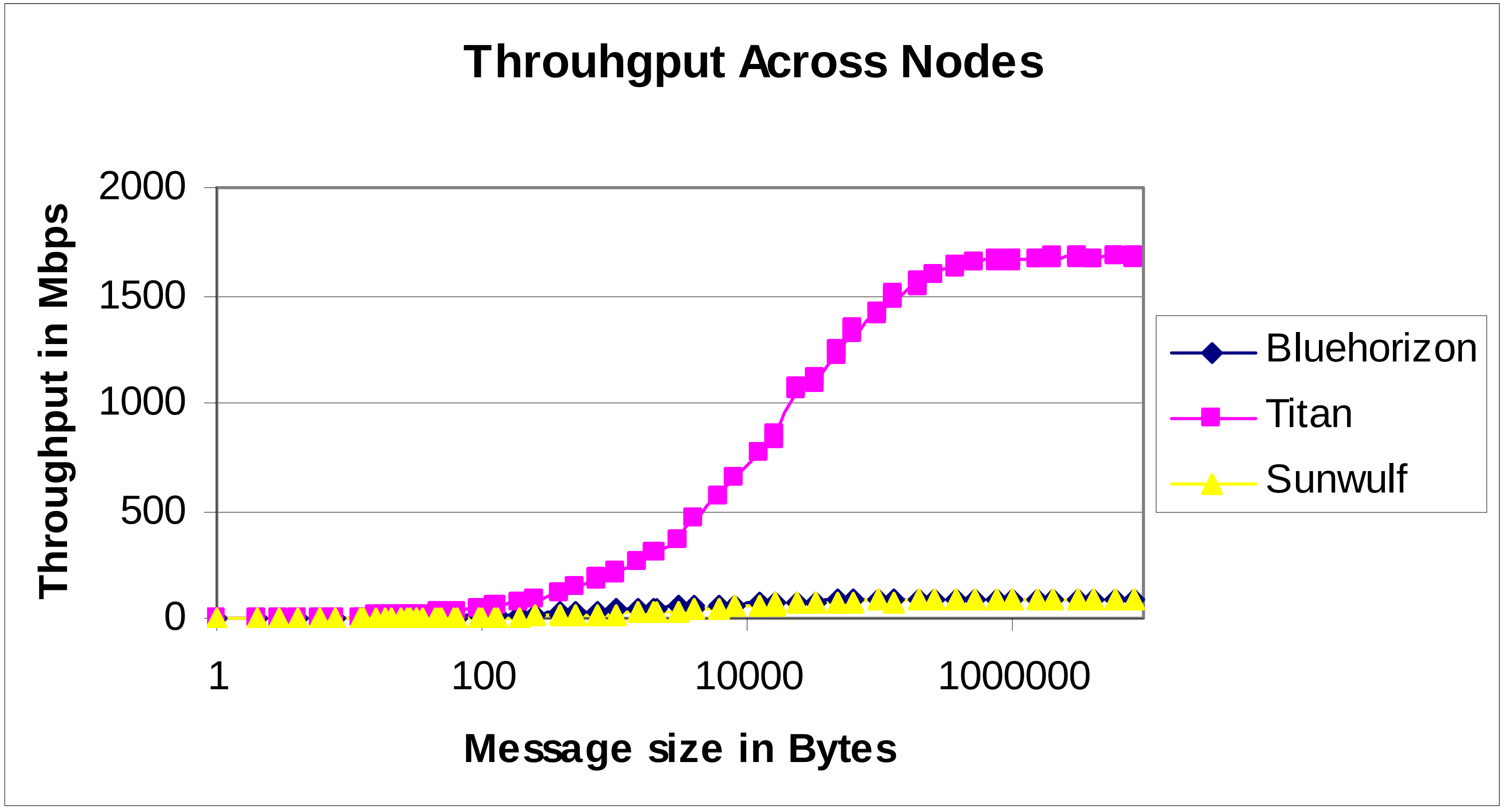


☞ Bluehorizon (1.0); Sunwulf(0.52); Titan(0.37)

ILLINOIS INSTITUTE OF TECHNOLOGY
Transforming Lives.Inventing the Future.www.iit.edu

NetPIPE Comparison (1/2)

NetPIPE Comparison (2/2)



☞ Maximum throughput:

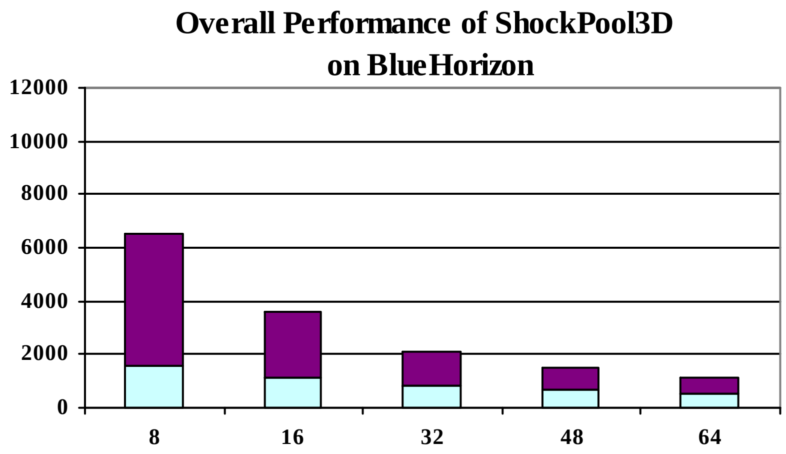
Bluehorizon (87Mbps);Titan(1681Mbps);Sunwulf(84Mbps)

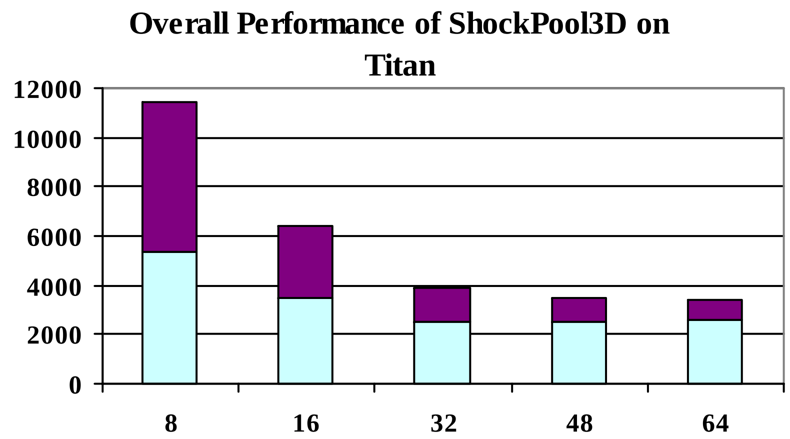
Experiments

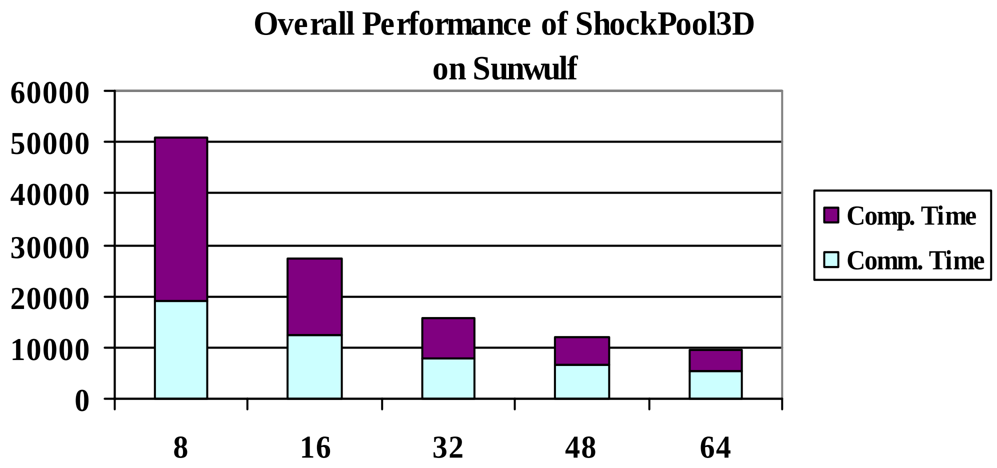
- Three systems are used:
  - IBM SP2 *bluehorizon* at SDSC;
  - IA-64 Linux cluster *titan* at NCSA;
  - SUN cluster *sunwulf* at IIT
- Two real datasets:
  - AMR64 & ShockPool3D

Dataset	Initial Size	Final Size	# of Adaptions
AMR64	32*32*32	4096*4096*4096	2500
ShockPool3D	50*50*50	6000*6000*6000	600

Overall Performance(1/2)





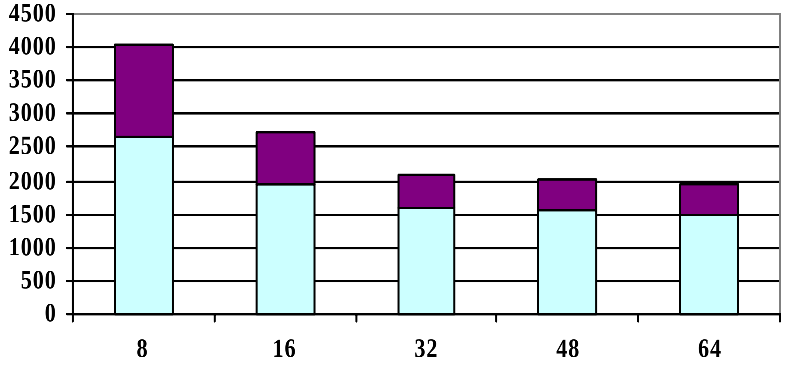


- Bluehorizon (1.0); Sunwulf(0.127); Titan(0.486)

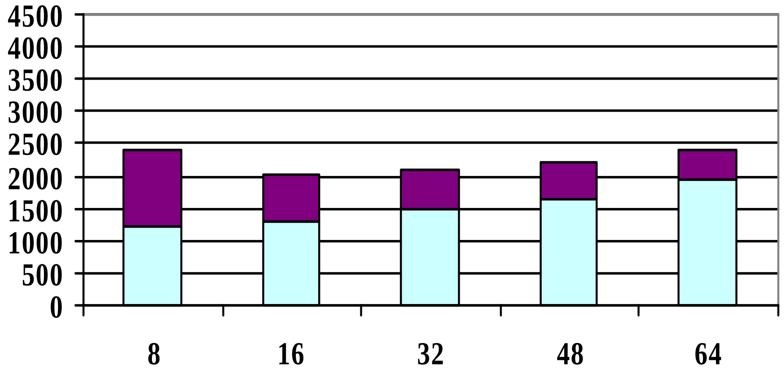
ILLINOIS INSTITUTE OF TECHNOLOGY
Transforming Lives. Inventing the Future. www.iit.edu

Overall Performance(2/2)

Overall Performance of AMR64
on BlueHorizon

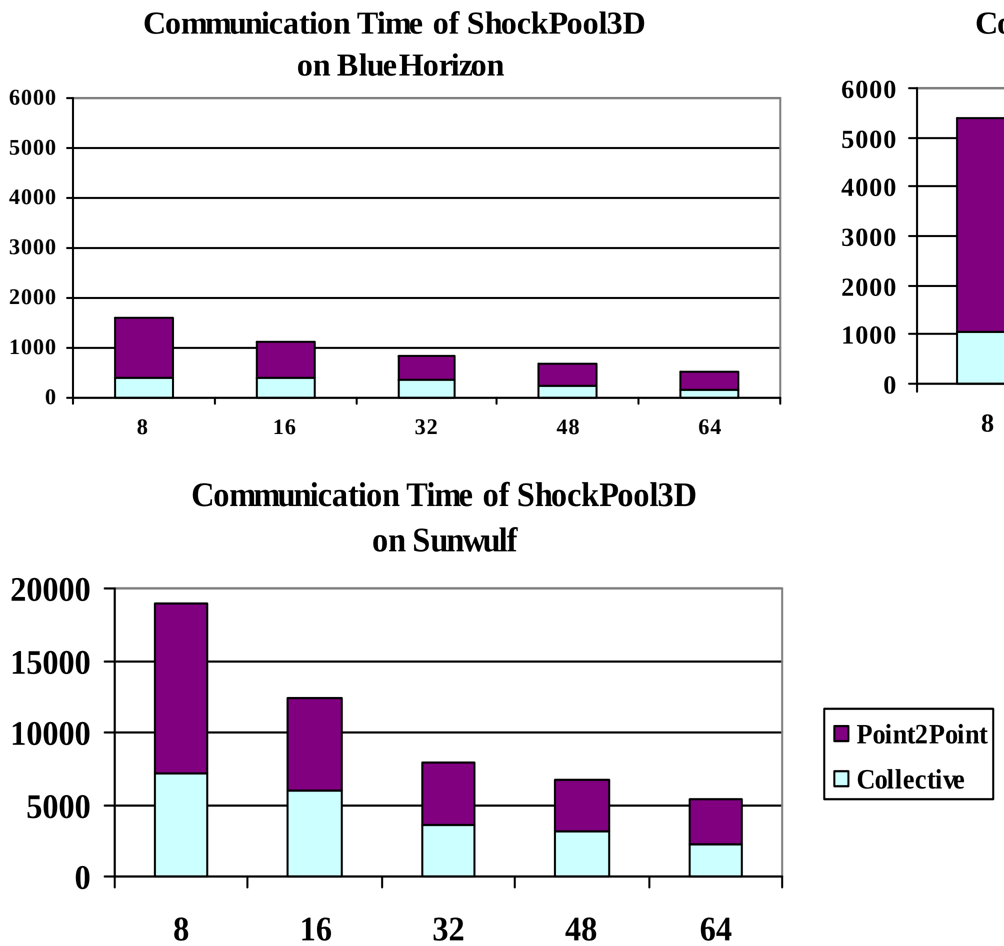


Overall Performance of AMR64
on Titan

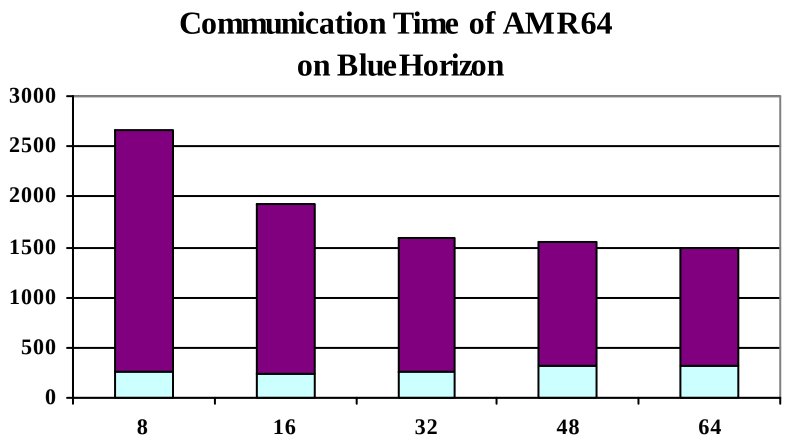


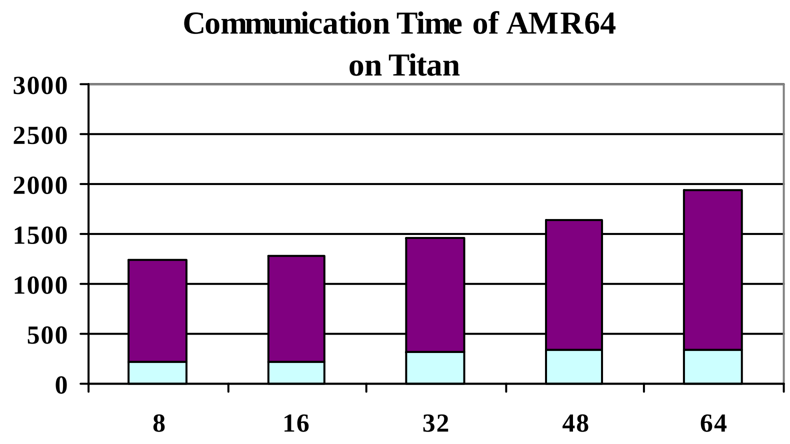
☞ Bluehorizon (1.0);
Sunwulf(?);
Titan(1.153)

Communication Performance(1/2)



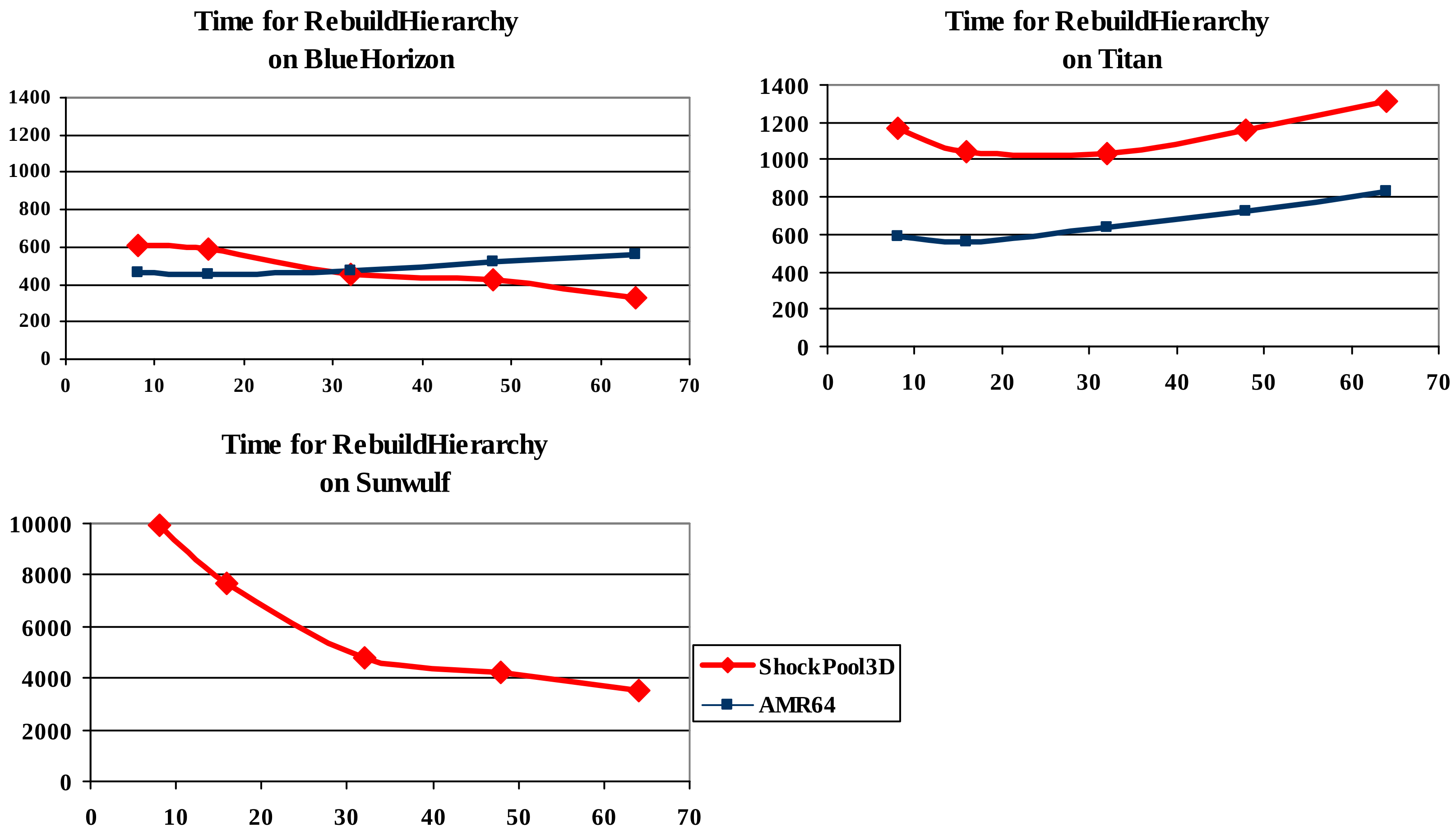
Communication Performance(2/2)





ILLINOIS INSTITUTE OF TECHNOLOGY
Transforming Lives.Inventing the Future.www.iit.edu

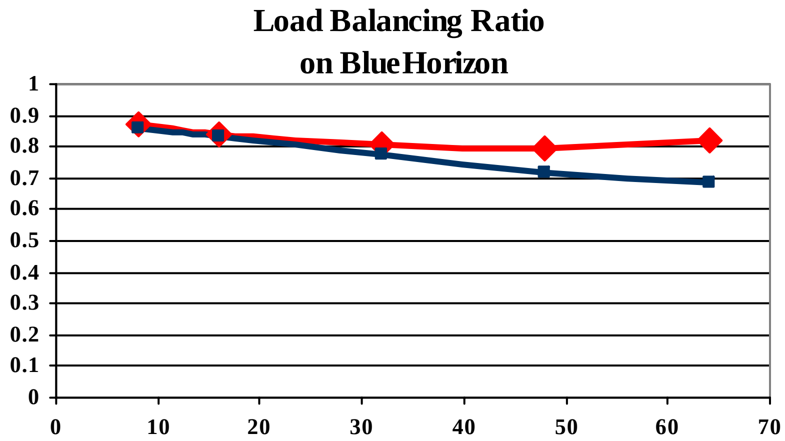
Load-Balance Performance(1/2)

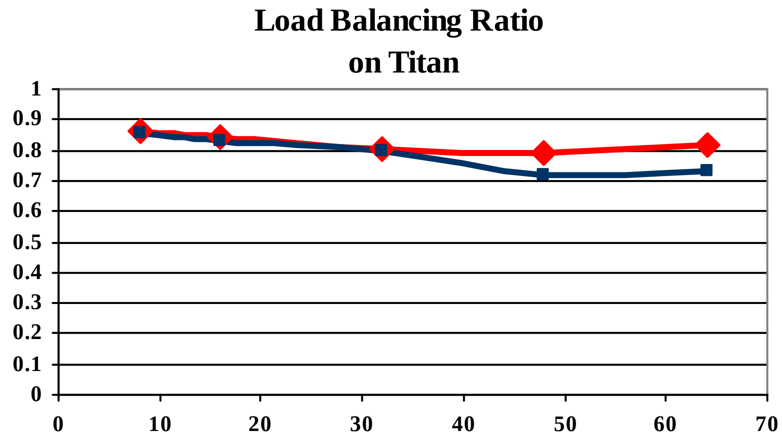


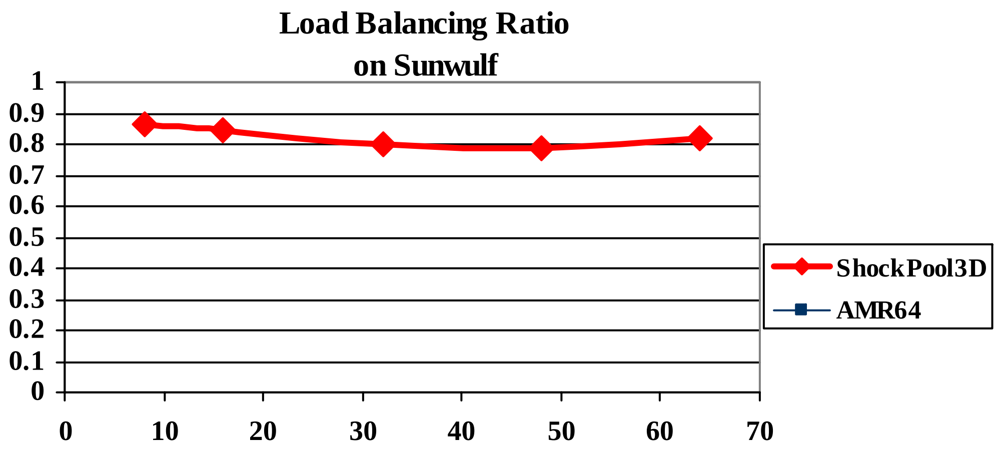
ILLINOIS INSTITUTE OF TECHNOLOGY

Transforming Lives.Inventing the Future.www.iit.edu

Load-Balance Performance(2/2)







$$Ratio = \frac{\sum_{j=1}^{N} \frac{AvgLoad(j)}{MaxLoad(j)}}{N}$$

Analysis Results

- Execution performance depends on both system performance and application characteristics
- The relative performance obtained from NPB does not exactly match the relative performance of the cosmology application
- Cosmology performance on *Titan* is not satisfactory when number of processors is more than 32
- The proposed DLB can achieve the same quality of load balancing on different clusters

Summary & Future Work

- Performance evaluation of a large-scale cosmology application on three different clusters
  - Overall performance; communication characteristics; and load balancing characteristics
- Future work:
  - Exploring large-scale applications on DTF
  - Developing a dynamic load balancing tool for distributed applications

Question?