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Cyberscience: Computational Science and the Rise of the Fourth Paradigm

GROUP: 1 QUANTITY: 1	SYSTEM PRICE: $19,024.72 GROUP TOTAL: $19,024.72
Base Unit:	PowerEdge C6100 Chassis w/ 4 System Boards and support for 2.5" Hard Drives (224-8427)
Processor:	Intel Xeon X5650, 2.66Ghz, 12M Cache,Turbo, HT, 1333MHz Max Mem (317-4052)
Processor:	Intel Xeon X5650, 2.66Ghz, 12M Cache,Turbo, HT, 1333MHz Max Mem (317-4052)
Processor:	Intel Xeon X5650, 2.66Ghz, 12M Cache,Turbo, HT, 1333MHz Max Mem (317-4052)
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Processor:	Intel Xeon X5650, 2.66Ghz, 12M Cache,Turbo, HT, 1333MHz Max Mem (317-4052)
Processor:	Thermal Heatsink (317-3410)
Processor:	Thermal Heatsink (317-3410)
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Processor:	Thermal Heatsink (317-3410)
Processor:	Dual Processor Option (317-4928)
Memory:	48GB Memory (12x4GB), 1333MHz Dual Ranked RDIMMs for 2 Processors, Optimized (317-3394)
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Memory:	48GB Memory (12x4GB), 1333MHz Dual Ranked RDIMMs for 2 Processors, Optimized (317-3394)
Memory:	Info, Memory for Dual Processor selection (468-7687)
Hard Drive:	500GB 7.2K RPM SATA 2.5" Hard Drive (342-0974)
Hard Drive:	500GB 7.2K RPM SATA 2.5" Hard Drive (342-0974)
Hard Drive:	500GB 7.2K RPM SATA 2.5" Hard Drive (342-0974)
Hard Drive:	500GB 7.2K RPM SATA 2.5" Hard Drive (342-0974)
Hard Drive:	CARR,HD,2.5,2LED,C6100,MLK (342-1032)
Hard Drive:	CARR,HD,2.5,2LED,C6100,MLK (342-1032)
Hard Drive:	CARR,HD,2.5,2LED,C6100,MLK (342-1032)

Honors 352, Class #0.14
August E. (Gus) Evrard, PhD

Fall 2010

University of Michigan

today

* lecture: Flux hardware, CI Days highlights, and GRID computing intro

* **in-class exercise**: consider fundamental requirements for SC design

* group project updates next Tuesday

* reading quiz this Sunday

Date: 9/20/10 8:55:11 AM   Customer Name: UNIV OF MICHIGAN

TOTAL QUOTE AMOUNT:	$19,024.72		
Product Subtotal:	$19,024.72		
Tax:	$0.00		
Shipping & Handling:	$0.00		
Shipping Method:	Ground	Total Number of System Groups:	1

GROUP: 1 QUANTITY: 1	SYSTEM PRICE: $19,024.72 GROUP TOTAL: $19,024.72
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Hard Drive:	CARR,HD,2.5,2LED,C6100,MLK (342-1032)

4-node order for Flux cluster from Dell Computer

2 x hex-core cpu's per node = 48 cores

12 x 4Gb memory per node = 192 Gb (4 Gb per core)

500 Gb disk drive per node = 2.0 Tb

Hard Drive:	CARR,HD,2.5,2LED,C6100,MLK (342-1032)
Operating System:	No OS, No Utility Partition (420-3323)
Operating System:	No OS, No Utility Partition (420-3323)
Operating System:	No OS, No Utility Partition (420-3323)
Operating System:	No OS, No Utility Partition (420-3323)
NIC:	Mellanox QDR Dual Port 40 Gb/s Infiniband HCA Daughtercard, PE C6100 (317-3413)
NIC:	Mellanox QDR Dual Port 40 Gb/s Infiniband HCA Daughtercard, PE C6100 (317-3413)
NIC:	Mellanox QDR Dual Port 40 Gb/s Infiniband HCA Daughtercard, PE C6100 (317-3413)
NIC:	Mellanox QDR Dual Port 40 Gb/s Infiniband HCA Daughtercard, PE C6100 (317-3413)
Documentation Diskette:	C6100 MLK Documentation (330-8719)
Feature	2.5" Onboard SATA Controller for 1-6 HDs (342-0065)
Feature	Onboard SATA Controller (342-0726)
Feature	2.5" Onboard SATA Controller for 1-6 HDs (342-0065)
Feature	2.5" Onboard SATA Controller for 1-6 HDs (342-0065)
Feature	2.5" Onboard SATA Controller for 1-6 HDs (342-0065)
Feature	Onboard SATA Controller (342-0726)
Feature	Onboard SATA Controller (342-0726)
Feature	Onboard SATA Controller (342-0726)
Feature	C6100 Static Rails, Tool-less (330-8483)
Service:	Basic: Business Hours (5X10) Next Business Day On Site Hardware Warranty Repair 2Year Extended (907-2772)
Service:	Basic: Business Hours (5X10) Next Business Day On Site Hardware Warranty Repair Initial Year (908-3960)
Service:	SATA Hard Drive Ltd Warranty with Basic Support, 2 Year Extended (993-9412)
Service:	SATA Hard Drive Ltd Warranty with Basic Support, Initial Year (994-4500)
Service:	Dell Hardware Limited Warranty Extended Year (907-4098)
Service:	Dell Hardware Limited Warranty Initial Year (907-4207)
Service:	DECLINED CRITICAL BUSINESS SERVER OR STORAGE SOFTWARE SUPPORT PACKAGE-CALL YOUR DELL SALES REP IF UPGRADE NEED (908-7899)
Installation:	On-Site Installation Declined (900-9997)
Misc:	Power Supply,1100W, Redundant Capable (330-8537)
Misc:	Power Supply,1100W, Redundant Capable (330-8537)
Misc:	Label,Regulatory,750/1100W, C6100 (330-8720)
Misc:	Powercord,125Volt,15Amp,10Foot (330-6870)
Misc:	Powercord,125Volt,15Amp,10Foot (330-6870)

4-node order for Flux

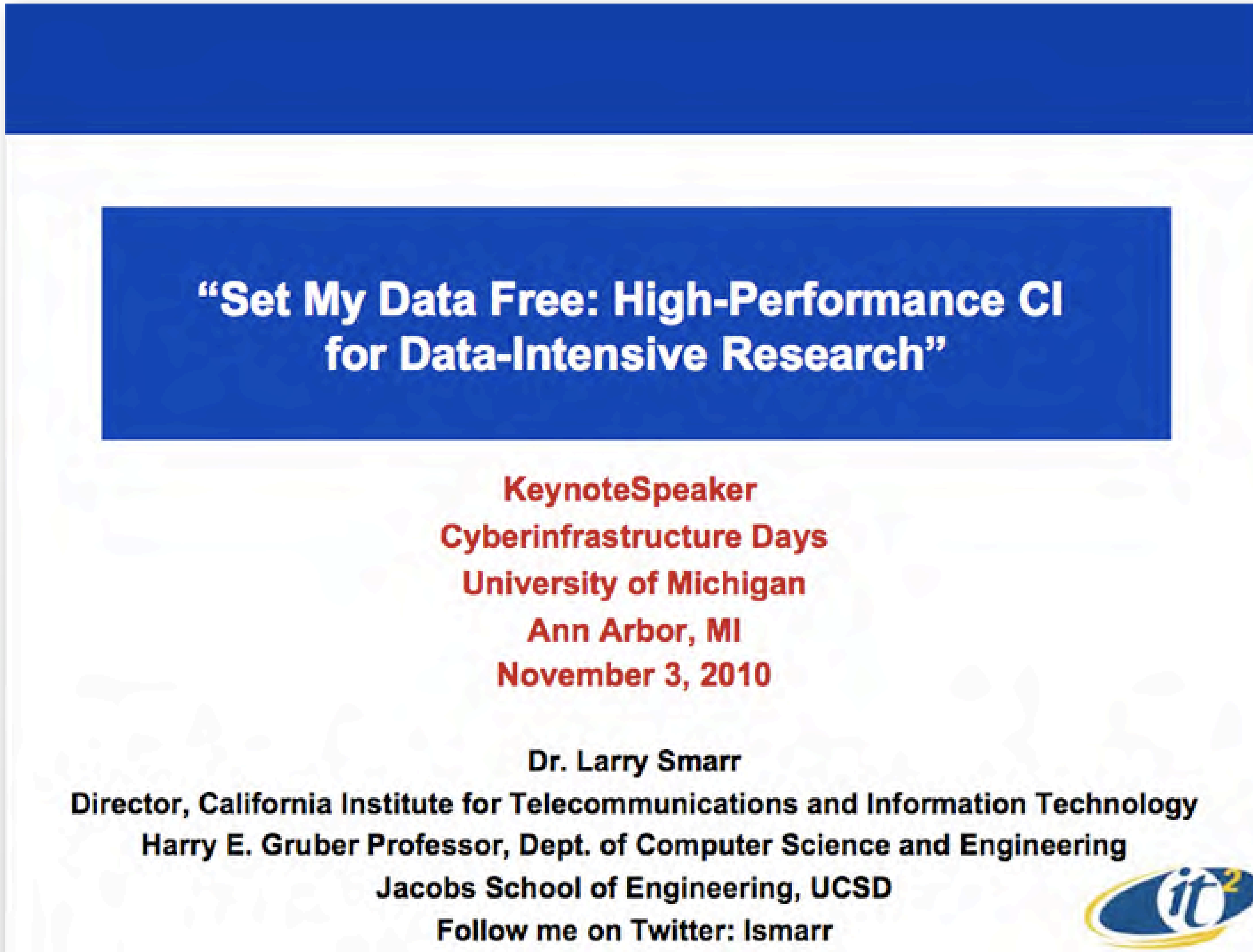
40 Gb/s infiniband network port per node

2 x 1100 Watt power supply (two nodes run off one supply)

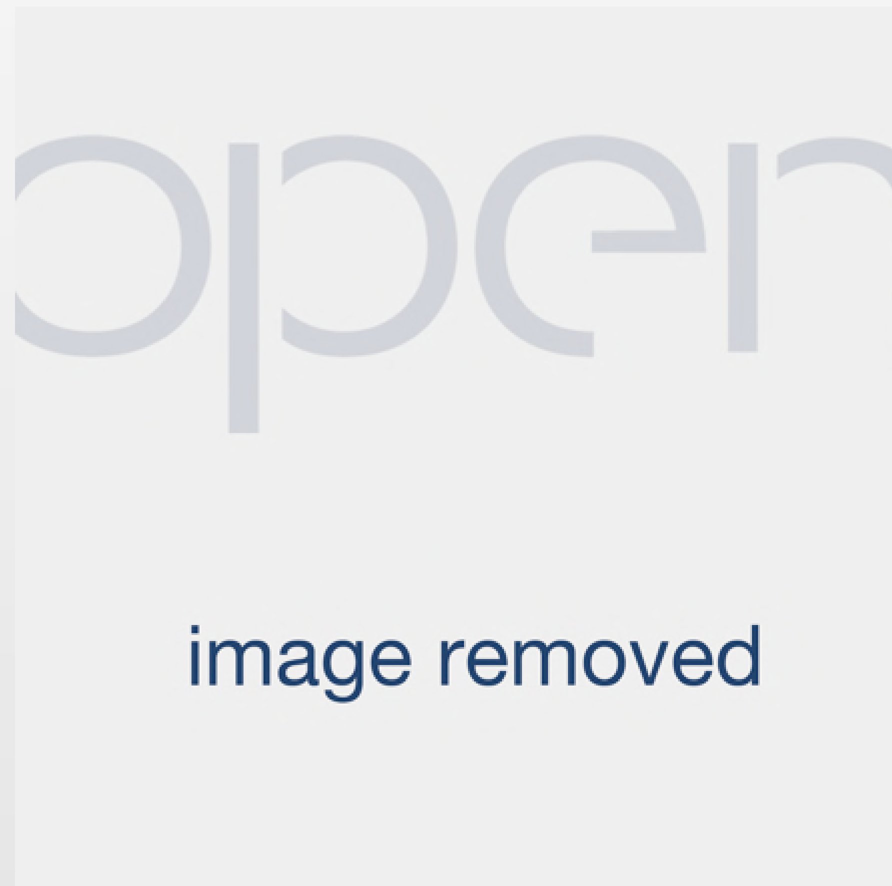
bit-tech review of westmere chip (vs. AMD opteron) 31 March 2010

QuickPath interconnect (motherboard network) http://en.wikipedia.org/wiki/Intel_QuickPath_Interconnect

Cyberinfrastructure Days: highlights from keynote Larry Smarr

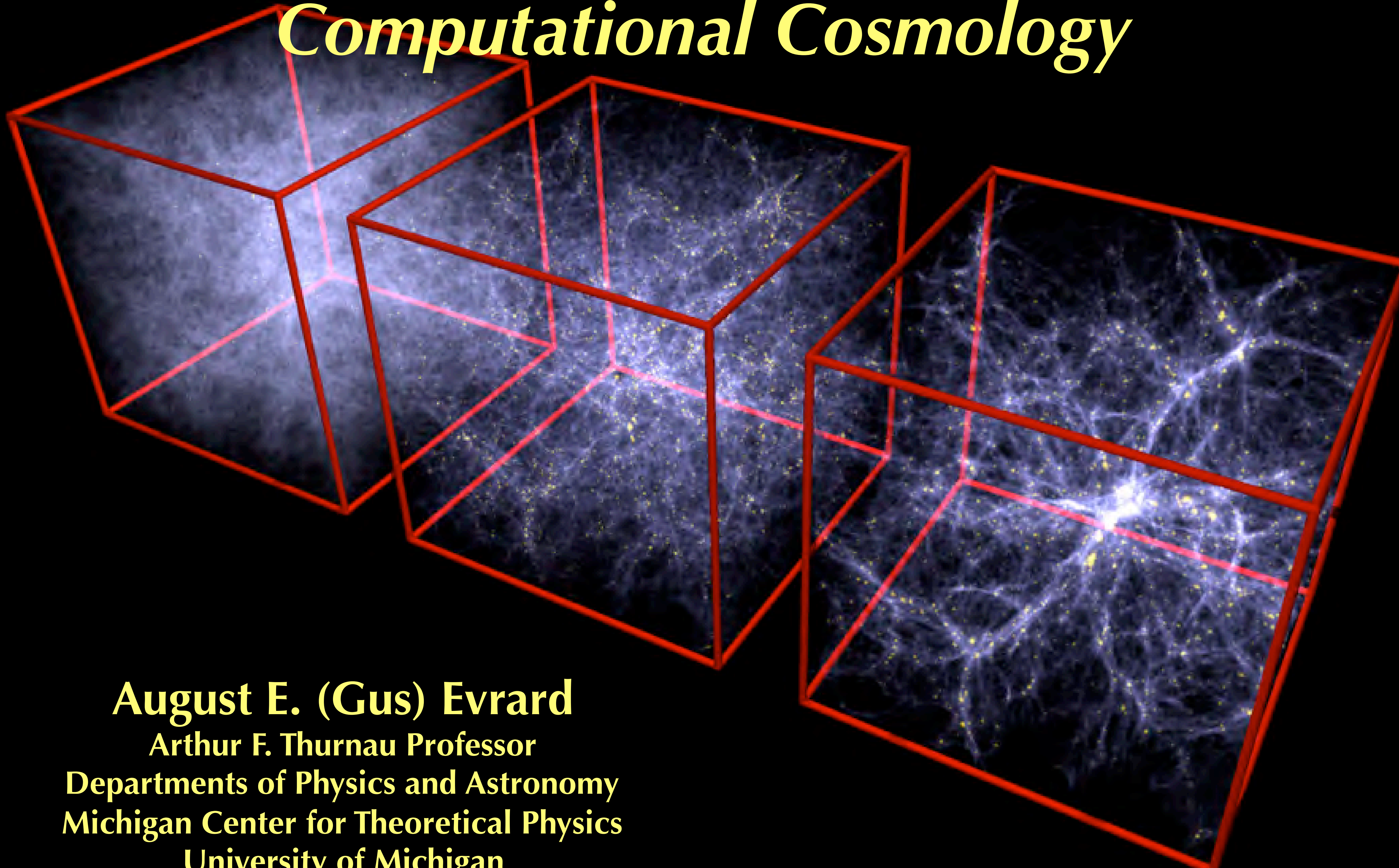


 Larry Smarr, Cyberinfrastructure Days



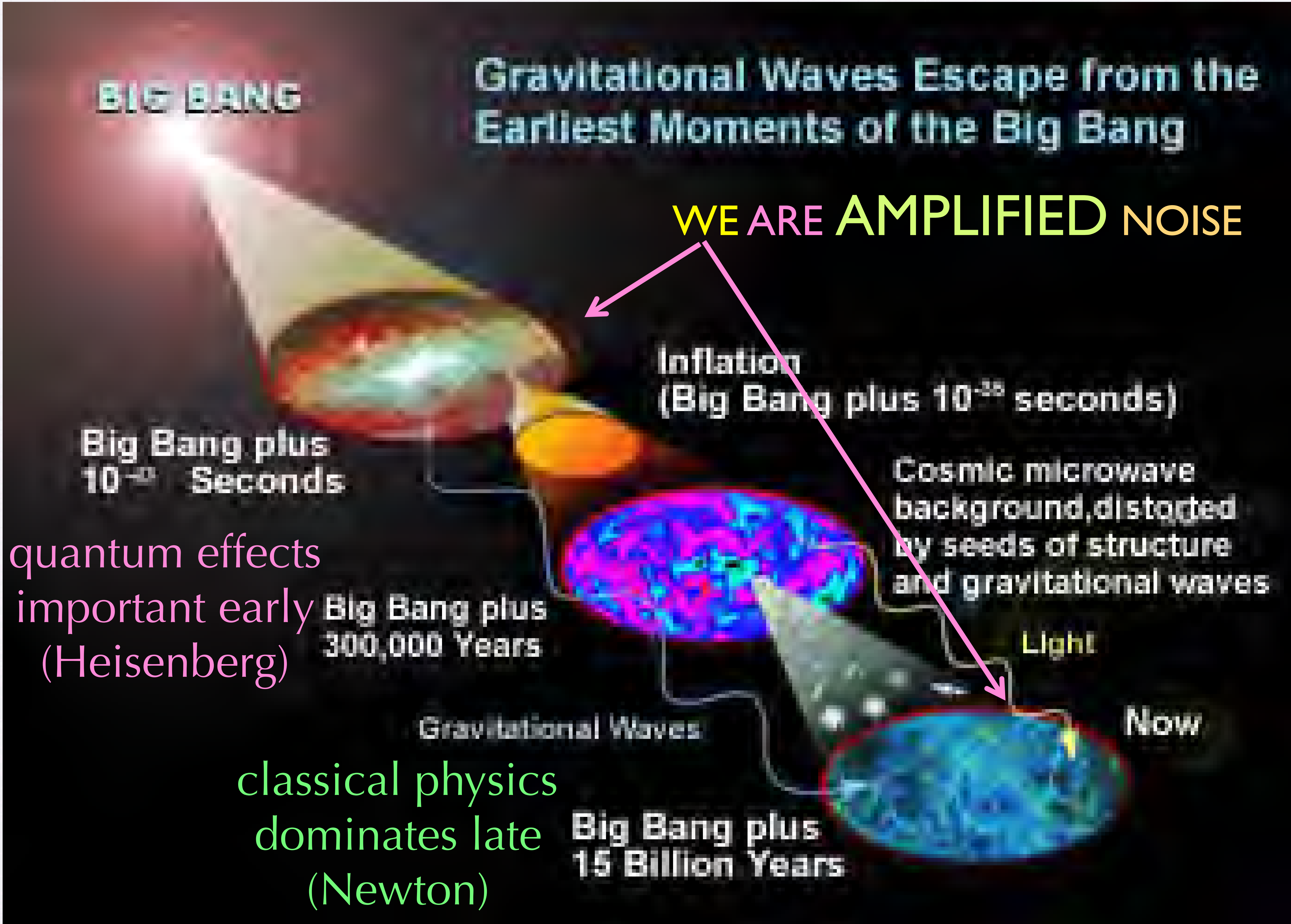
Please go to the original slide show on this talk at http://lsmarr.calit2.net/presentations?slideshow=5656616 and reference slides 15, 16, 18, 19, 22, and 23, which have been removed from this presentation.

Computational Cosmology



August E. (Gus) Evrard
Arthur F. Thurnau Professor
Departments of Physics and Astronomy
Michigan Center for Theoretical Physics
University of Michigan

 Volker Springel, Max-Planck-Institute for Astrophysics.



BIG BANG
Gravitational Waves Escape from the Earliest Moments of the Big Bang
WE ARE AMPLIFIED NOISE
Inflation
(Big Bang plus 10 seconds)
Big Bang plus 10 Seconds
Cosmic microwave background, distoted by seeds of structure and gravitational waves
quantum effects important early (Heisenberg)
Big Bang plus 300,000 Years
Light
Gravitational Waves
Now
classical physics dominates late (Newton)
Big Bang plus 15 Billion Years

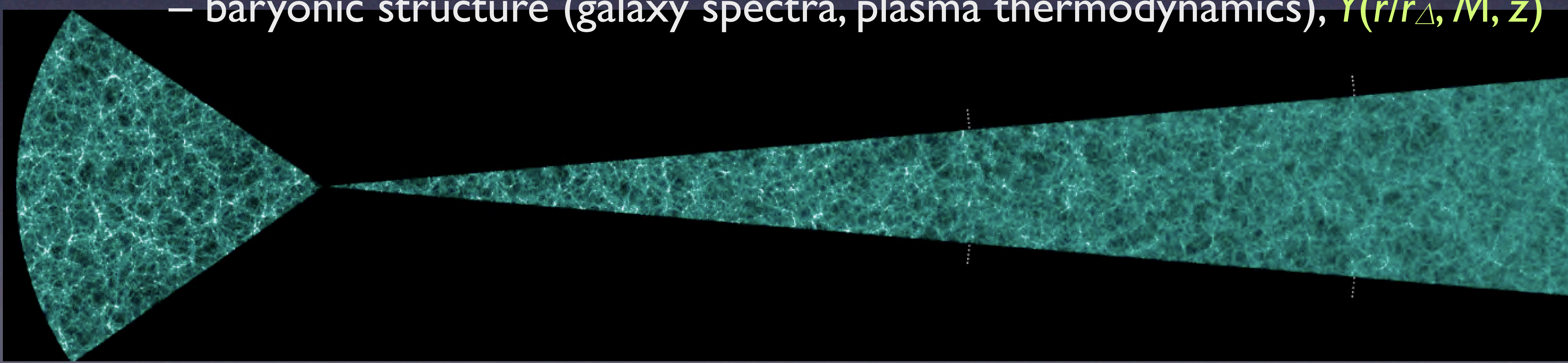
2010 paradigm of cosmological **large-scale structure** (**LSS**)

LSS: a hierarchical web of quasi-equilibrium bound structures – ***halos*** – that emerge via gravitational amplification from a noise field imposed by inflation.

Computational Cosmology: model LSS as a multi-fluid, self-gravitating system evolved from known initial conditions.

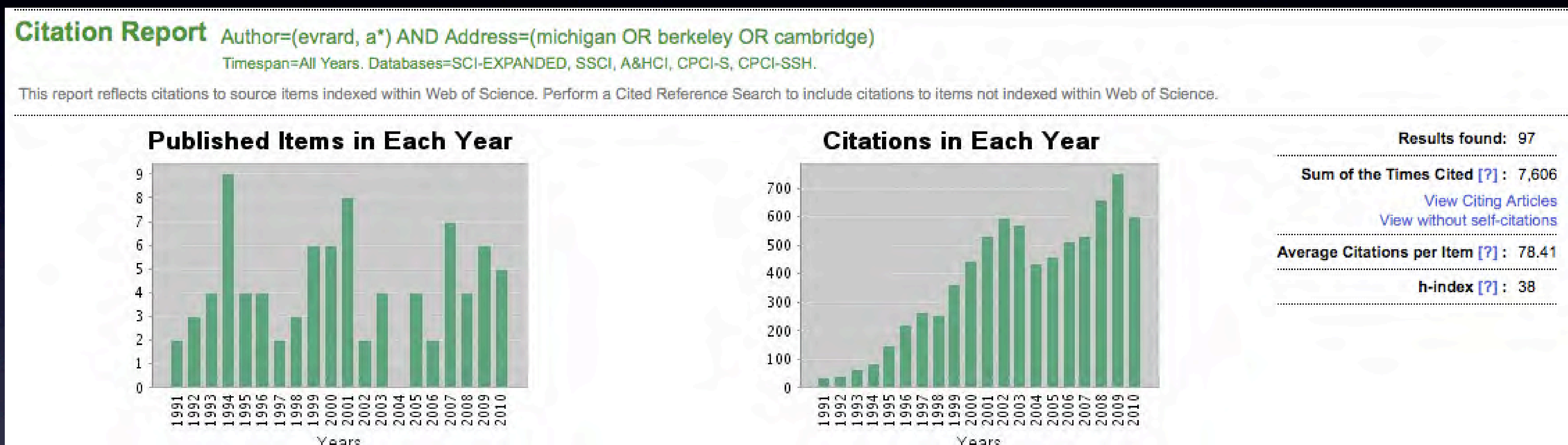
Simulations calibrate key enabling ingredients of ***Halo Model***

- space density, $n(M, z)$
- spatial N-point correlations (e.g., autocorrelation function), $b(M, z)$
- internal halo structure (kinematics, substructure), $X(r/r_\Delta, M, z)$
- baryonic structure (galaxy spectra, plasma thermodynamics), $Y(r/r_\Delta, M, z)$



 Gus Evrard and Andrzej Kudlicki, Max-Planck-Institute for Astrophysics.

evrard group research



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#	Item		2006	2007	2008	2009	2010	Total
			514	534	660	750	601	7,606
1.	Title: Simulations of the formation, evolution and clustering of galaxies and quasars Author(s): Springel V, White SDM, Jenkins A, et al. Source: **NATURE** Volume: **435** Issue: **7042** Pages: **629-636** Published: **JUN 2 2005**	**Sim**	88	133	189	223	170	818
2.	Title: The mass function of dark matter haloes Author(s): Jenkins A, Frenk CS, White SDM, et al. Source: **MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY** Volume: **321** Issue: **2** Pages: **372-384** Published: **FEB 21 2001**	**Sim**	91	63	67	83	57	734
3.	Title: THE BARYON CONTENT OF GALAXY CLUSTERS - A CHALLENGE TO COSMOLOGICAL ORTHODOXY Author(s): WHITE SDM, NAVARRO JF, EVRARD AE, et al. Source: **NATURE** Volume: **366** Issue: **6454** Pages: **429-433** Published: **DEC 2 1993**	**Sim+Data**	[illegible]	15	18	19	20	688
4.	Title: Mass estimates of X-ray clusters Author(s): Evrard AE, Metzler CA, Navarro JF Source: **ASTROPHYSICAL JOURNAL** Volume: **469** Issue: **2** Pages: **494-507** Part: **Part 1** Published: **OCT 1 1996**	**Sim**	31	31	20	22	12	482
5.	Title: Properties of the intracluster medium in an ensemble of nearby galaxy clusters Author(s): Mohr JJ, Mathiesen B, Evrard AE Source: **ASTROPHYSICAL JOURNAL** Volume: **517** Issue: **2** Pages: **627-649** Part: **Part 1** Published: **JUN 1 1999**	**Data**	33	16	25	16	8	386
6.	Title: The L-X-T relation and intracluster gas fractions of X-ray clusters Author(s): Arnaud M, Evrard AE Source: **MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY** Volume: **305** Issue: **3** Pages: **631-640** Published: **MAY 21 1999**	**Data**	22	26	21	13	11	320
7.	Title: FORMATION AND EVOLUTION OF X-RAY-CLUSTERS - A HYDRODYNAMIC SIMULATION OF THE INTRACLUSTER MEDIUM Author(s): EVRARD AE Source: **ASTROPHYSICAL JOURNAL** Volume: **363** Issue: **2** Pages: **349-366** Part: **Part 1** Published: **NOV 10 1990**	**Sim**	5	4	8	6	9	268
8.	Title: EXPECTATIONS FOR X-RAY-CLUSTER OBSERVATIONS BY THE ROSAT SATELLITE Author(s): EVRARD AE, HENRY JP Source: **ASTROPHYSICAL JOURNAL** Volume: **383** Issue: **1** Pages: **95-103** Part: **Part 1** Published: **DEC 10 1991**	**Theory**	14	13	9	7	7	242
9.	Title: The Santa Barbara cluster comparison project: A comparison of cosmological hydrodynamics solutions Author(s): Frenk CS, White SDM, Bode P, et al. Source: **ASTROPHYSICAL JOURNAL** Volume: **525** Issue: **2** Pages: **554-582** Part: **Part 1** Published: **NOV 10 1999**	**Sim**	20	19	17	22	10	241
10.	Title: Galaxy clusters in Hubble volume simulations: Cosmological constraints from sky survey populations Author(s): Evrard AE, MacFarland TJ, Couchman HMP, et al. Source: **ASTROPHYSICAL JOURNAL** Volume: **573** Issue: **1** Pages: **7-36** Part: **Part 1** Published: **JUL 1 2002**	**Sim**	18	19	22	23	15	201

current research and collaborators

galaxy clusters as massive halos

Fisher forecasts

Huterer
Cunha
Erickson

optical + sub-mm surveys
*SDSS, **DES** +*
South Pole Telescope

McKay
Wechsler (Stanford)
Hao (Fermilab)
Kravtsov (Chicago)
Koester (Chicago)
McMahon
Miller
Ricker (UIUC)
Rozo (Chicago)
Rykoff (UCSB)
Sheldon (BNL)
Johnston (JPL)
Becker (Chicago)
+ DES Collaboration

LSS simulations

Rasia
Stanek
Nord
Chen
Rudd (IAS)
Pearce (Nottingham)
+ Virgo Consortium

LoCuSS (X-ray)

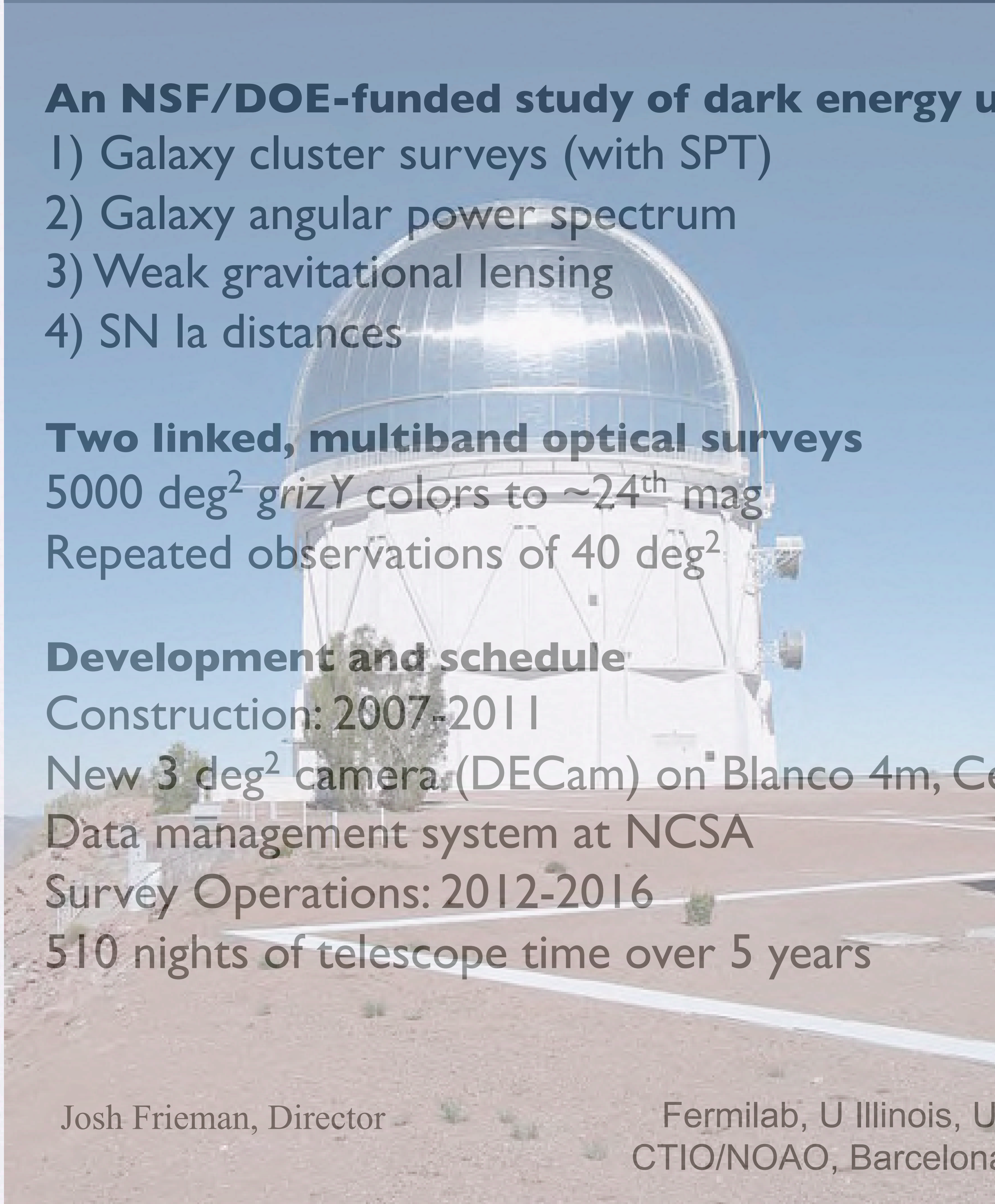
G. Smith (Birmingham)
+ LoCuSS Collaboration

grad student
postdoc
faculty

Evrard Group @ Michigan, August 2009

Anbo Chen - Carlos Cunha - Brandon Erickson - AEE - Greg Green - Rashad Brown - Mitch Adler
Jounghun Lee - Elena Rasia - Rebecca Stanek - Gary Foreman
Brian Nord

Dark Energy Survey is nearing operation



An NSF/DOE-funded study of dark energy using four techniques

1) Galaxy cluster surveys (with SPT)
2) Galaxy angular power spectrum
3) Weak gravitational lensing
4) SN Ia distances

Two linked, multiband optical surveys

5000 deg^2 *grizY* colors to ~24th mag

Repeated observations of 40 deg^2

Development and schedule

Construction: 2007-2011

New 3 deg^2 camera (DECam) on Blanco 4m, Cerro Tololo

Data management system at NCSA

Survey Operations: 2012-2016

510 nights of telescope time over 5 years

The Collaboration

Fermilab — The Fermi National Accelerator Laboratory

Chicago — The University of Chicago

NOAO — The National Optical Astronomy Observatory

United Kingdom DES Collaboration
- UCL - University College London
- Cambridge - University of Cambridge
- Edinburgh - University of Edinburgh
- Portsmouth - University of Portsmouth
- Sussex - University of Sussex
- Nottingham - University of Nottingham

DES-Brazil Consortium
- ON - Observatorio Nacional
- CBPF - Centro Brasileiro de Pesquisas Fisicas
- UFRGS - Universidade Federal do Rio Grande do Sul

OSU — The Ohio State University

TAMU — Texas A&M University

Munich—Universitäts-Sternwarte München
- Ludwig-Maximilians Universität
- Excellence Cluster Universe

UIUC/NCSA — The University of Illinois at Urbana-Champaign

LBNL — The Lawrence Berkeley National Laboratory

Spain DES Collaboration
- IEEC/CSIC - Instituto de Ciencias del Espacio,
- IFAE - Institut de Fisica d'Altes Energies
- CIEMAT - Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas

Michigan — The University of Michigan

Pennsylvania — The University of Pennsylvania

ANL — Argonne National Laboratory

Santa Cruz-SLAC-Stanford DES Consortium
- Santa Cruz - University of California Santa Cruz
- SLAC - SLAC National Accelerator Laboratory
- Stanford - Stanford University

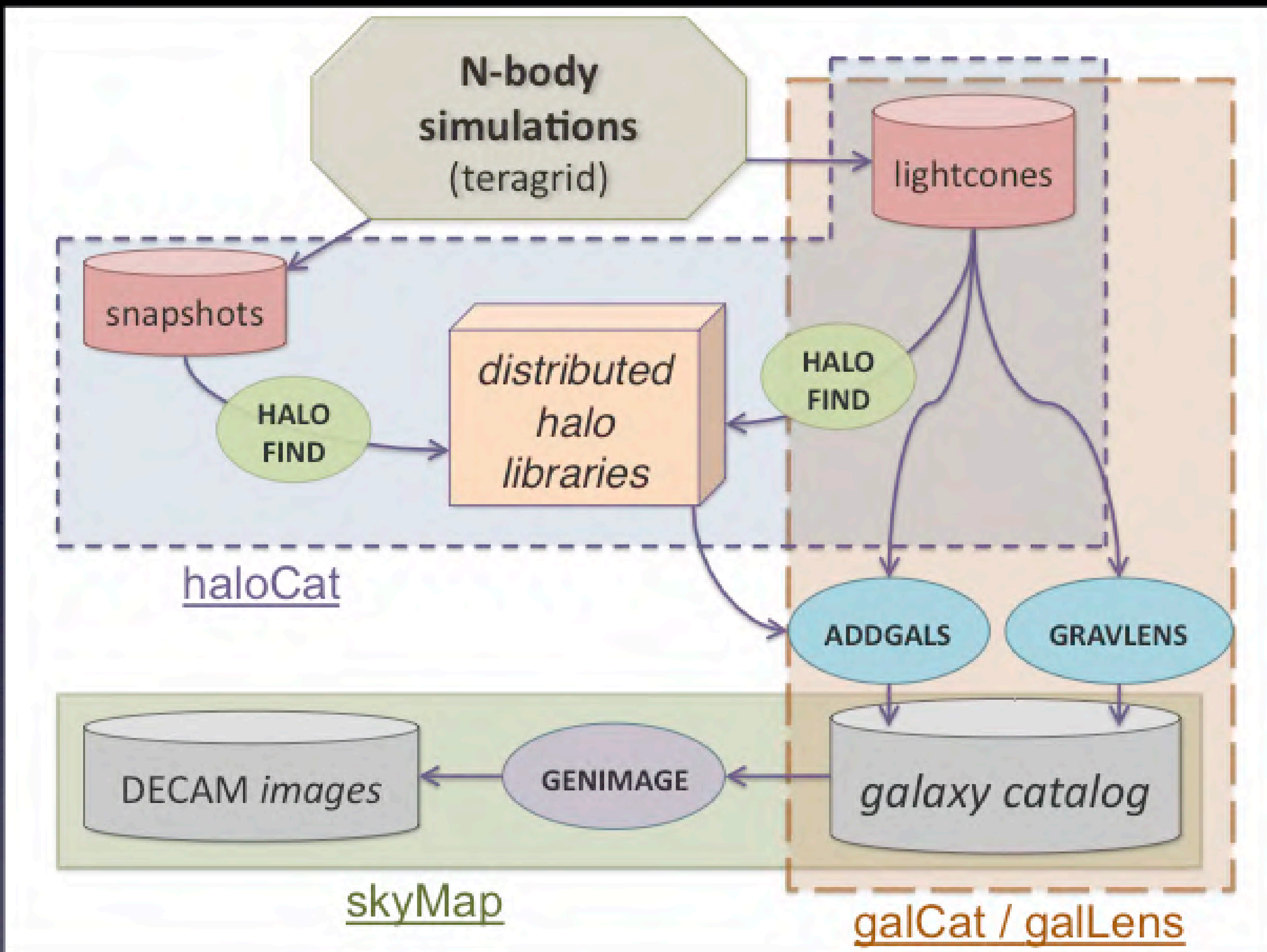
Josh Frieman, Director

Fermilab, U Illinois, U Chicago, LBNL, U Michigan
CTIO/NOAO, Barcelona, UCL, Cambridge, Edinburgh

NSF OCI proposal: distributed workflows to support cosmological survey analysis

NSF Cyberinfrastructure SI2 Proposal

Software Infrastructure for Sustained Innovation



see Brandon Erickson’s poster

A Cosmic Sky Machine (COSMA) for Astrophysics and Cosmology with Clusters of Galaxies

PI: August Evrard, University of Michigan

co-PI: Andrey Kravtsov, University of Chicago

co-PI: Elena Rasia, University of Michigan

co-PI: Paul Ricker,, University of Illinois

co-PI Risa Wechsler, Stanford Univ. & SLAC

Collaborators:

Stefano Borgani, dell'Universita di Trieste & INAF, Italy

Luiz DaCosta, Observatorio Nacional, Brazil

Klaus Dolag, Max-Planck-Institut fur Astrophysik

Claudio Gheller, CINECA, Italy

Gerard Lemson, Max-Planck-Institut fur Astrophysik

Huan Lin, Fermi National Laboratory, USA

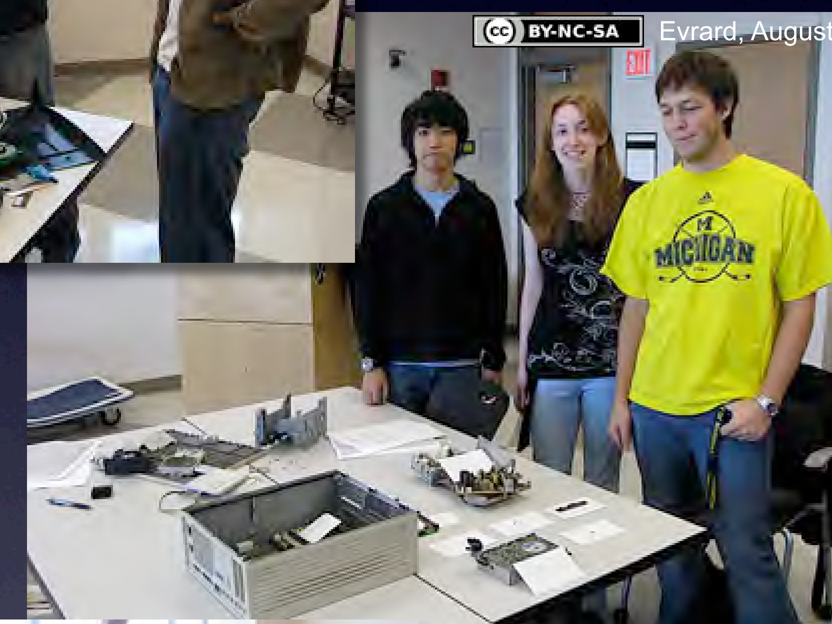
there is not an app for this! (yet...)

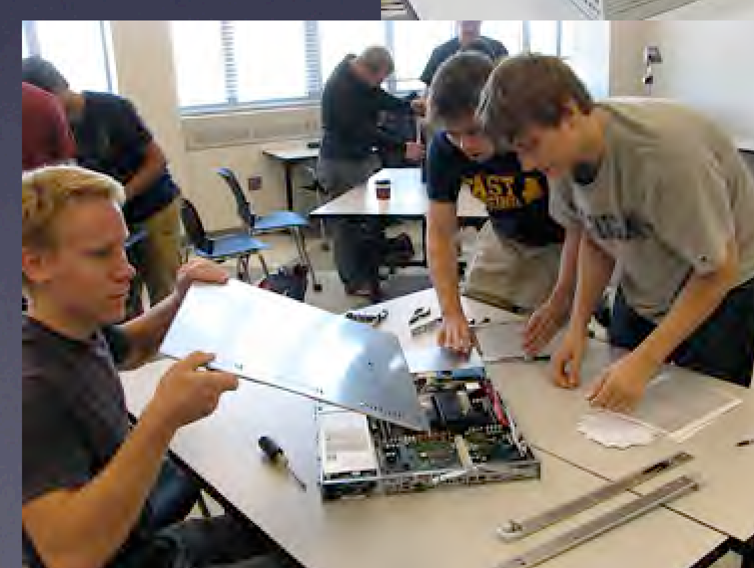
New course @UM! Honors 352

Cyberscience: Computational Science and the Rise of the Fourth Paradigm

Course Goals: Students who have taken this course should:

1. be able to explain what computation means in the context of scientific inquiry, and provide examples of the different roles that computing plays in the sciences;
2. be aware of the cyberinfrastructure elements that power computational science, including
    * hardware, software and network components, their historical development and their mutual interactions,
    * data management processes, including authorization, authentication, and securitization of networked resources, and
    * institutional roles, including facilities management, governance, and publication of digital assets.
3. appreciate current challenges to scholarship associated with cyberinfrastructure, such as
    * the environmental impact of large-scale computing nature of scientific publication, peer review, and career advancement,
    * costs, benefits and risks to research institutions.





grid computing

* grid reference is by analogy to the power grid

Goal: seamless, `plug-n-play' access to compute resources and services from a remote device/client/user.

Enable collaborative activities across ***virtual organizations***

* required elements

– hardware, software and network infrastructure Ch 1

– authentication and authorization model (security, billing) Ch 5

– user interfaces Ch 2

– job schedulers

– standards bodies

– funding sources (R&D, deployment, maintenance)

(*beowulf*) cluster

* locally networked set of Commercial Off-The-Shelf (COTS) computers

"thirty men's heft of grasp in the gripe of his hand."

* benefits

– affordable

– scaleable

* drawbacks

– distributed memory

– difficult to program

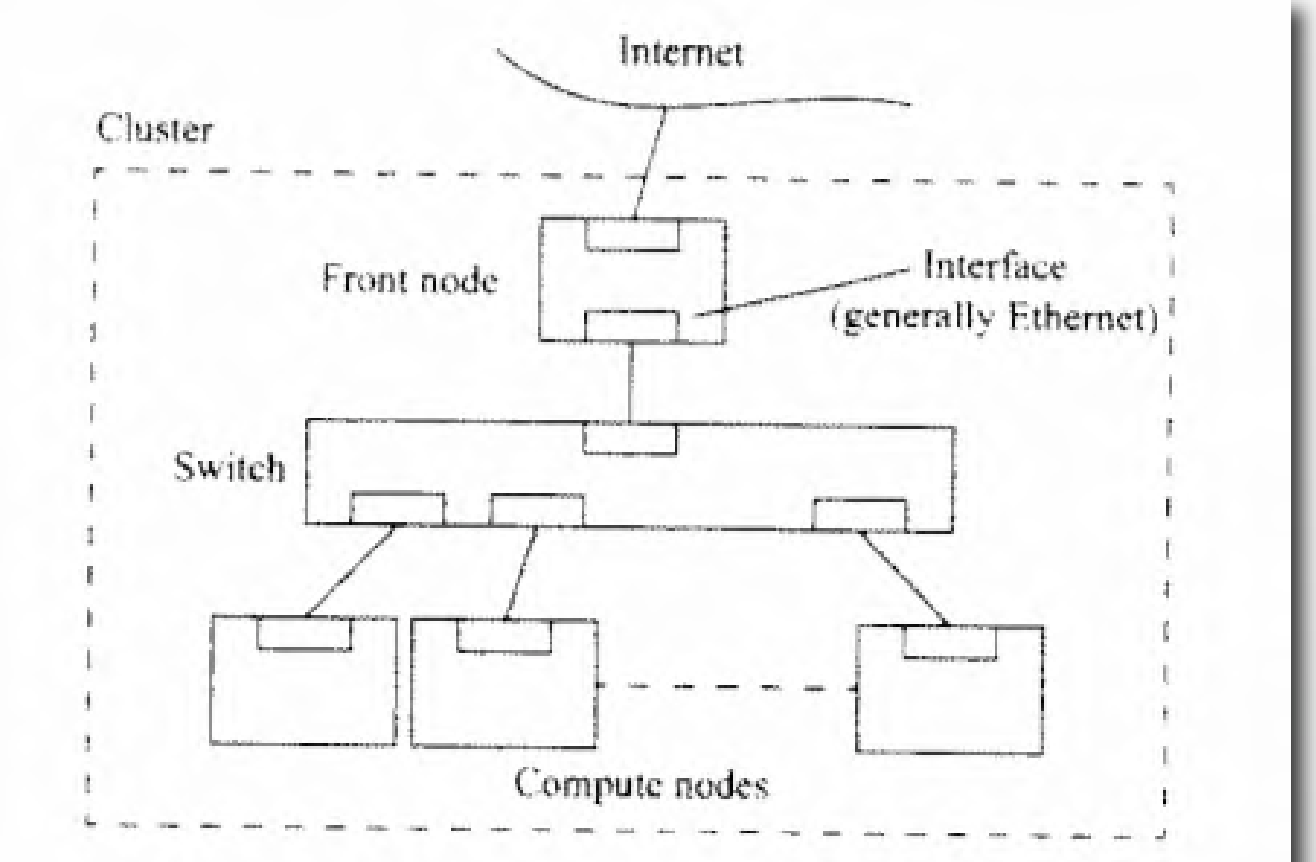


Figure 1.1 Typical cluster computing configuration.

Globus toolkit

* offers mechanisms to enable a distributed computing environment, with tools to support

– communication

– resource location

– resource scheduling

– authentication

– data access

* philosophy

– no centralized control

– standard, open protocols

– non-trivial Quality of Service (QoS)

"Together, the various Globus toolkit modules can be thought of as defining a metacomputing virtual machine. The definition of this virtual machine simplifies application development and enhances portability by allowing programmers to think of geographically distributed, heterogeneous collections of resources as unified entities."

 Ian Foster and Carl Kesselman, "Globus: A Metacomputing Infrastructure Toolkit," The International Journal of Supercomputer Applications and High Performance Computing, 1997.

GLOBUS: A METACOMPUTING INFRASTRUCTURE TOOLKIT

Ian Foster

MATHEMATICS AND COMPUTER SCIENCE DIVISION
ARGONNE NATIONAL LABORATORY
ARGONNE, IL 60439

Carl Kesselman

INFORMATION SCIENCES INSTITUTE
UNIVERSITY OF SOUTHERN CALIFORNIA
MARINA DEL REY, CA 90292

Summary

The Globus system is intended to achieve a vertically integrated treatment of application, middleware, and network. A low-level toolkit provides basic mechanisms such as communication, authentication, network information, and data access. These mechanisms are used to construct various higher level metacomputing services, such as parallel programming tools and schedulers. The long-term goal is to build an adaptive wide area resource environment (AWARE), an integrated set of higher level services that enable applications to adapt to heterogeneous and dynamically changing metacomputing environments. Preliminary versions of Globus components were deployed successfully as part of the I-WAY networking experiment.

The International Journal of Supercomputer Applications and High Performance Computing
Volume 11, No. 2, Summer 1997, pp. 115-128

history of grid computing concepts

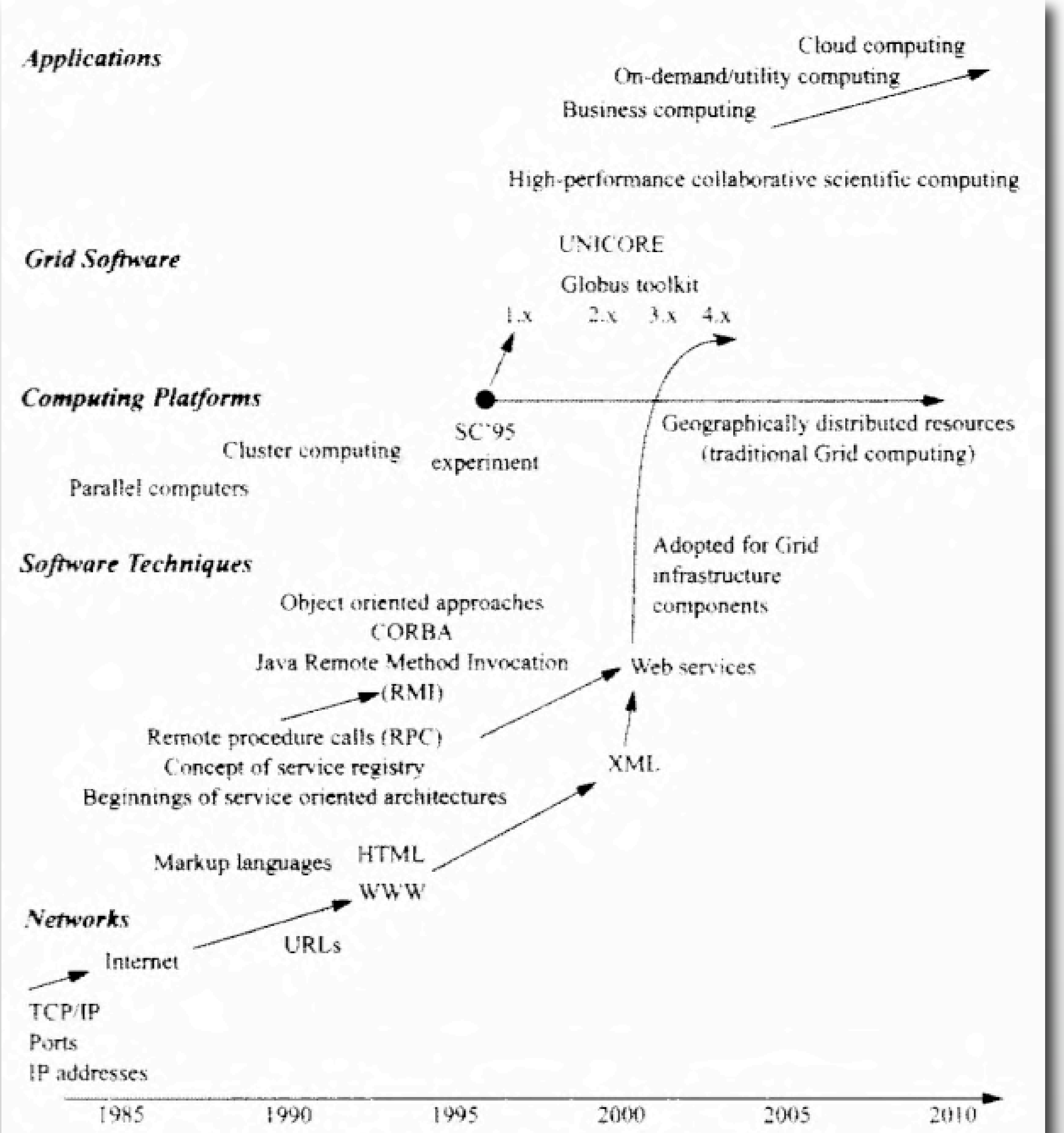
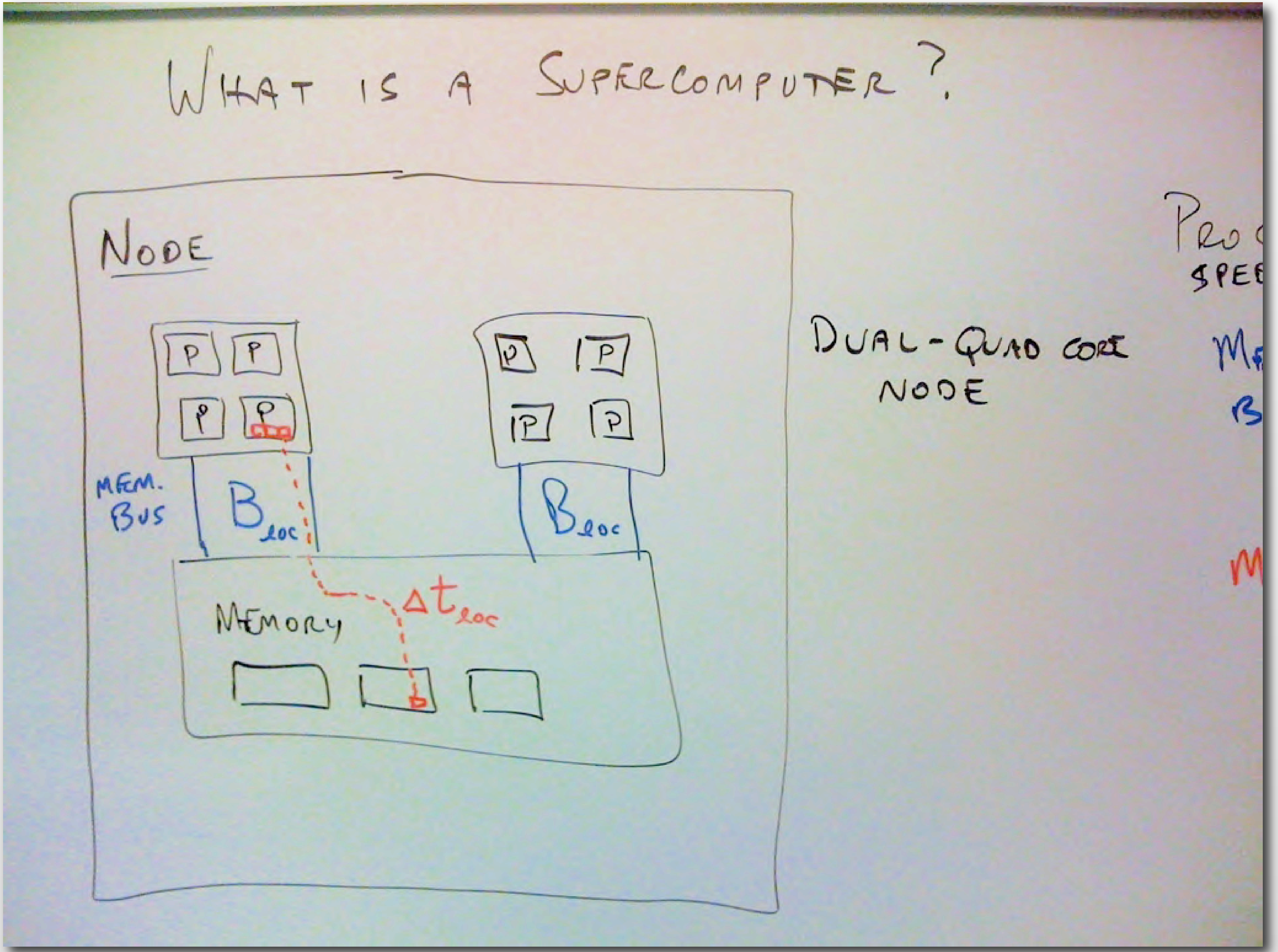
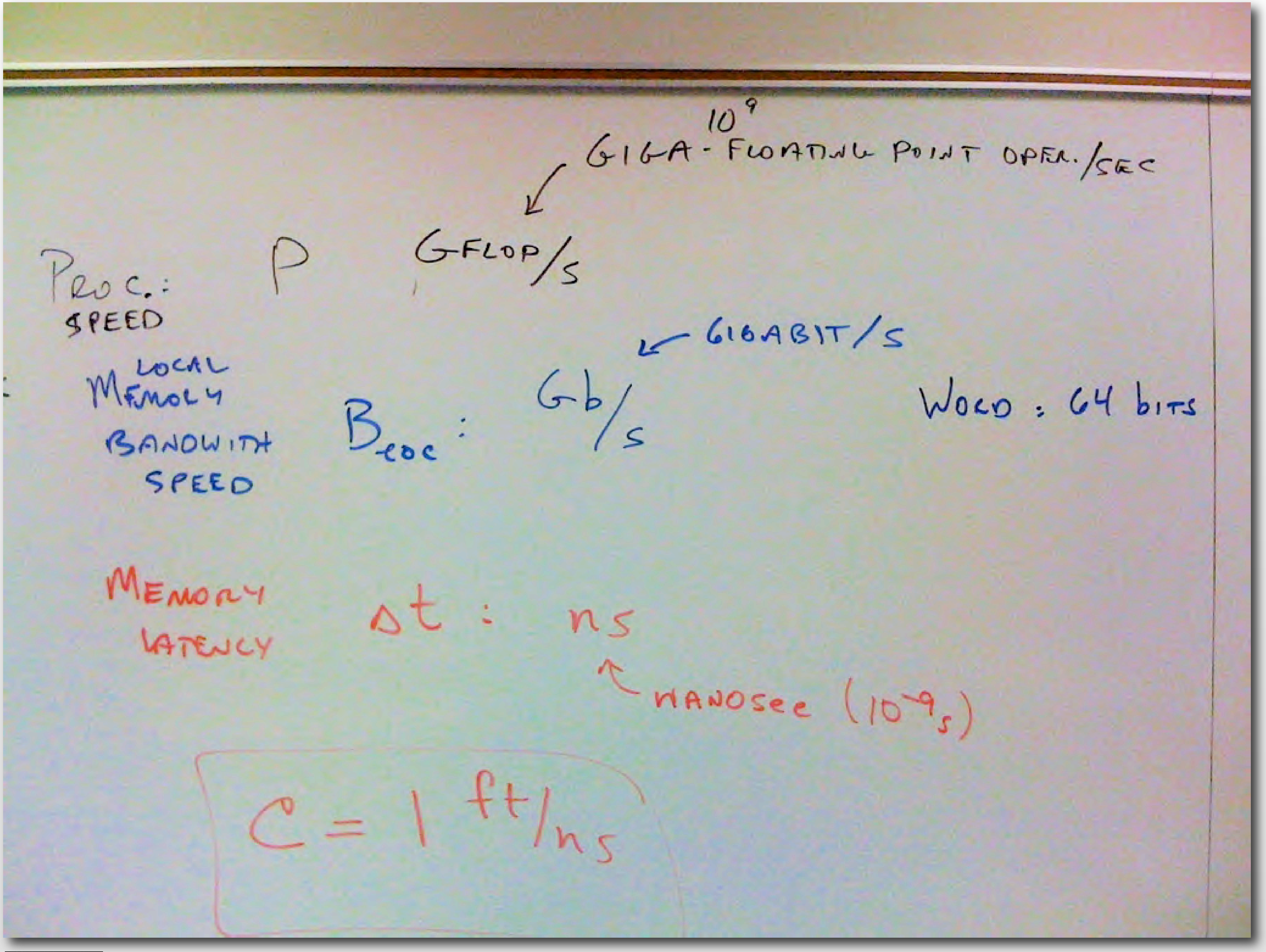


Figure 1.2 Key concepts in the history of Grid computing.

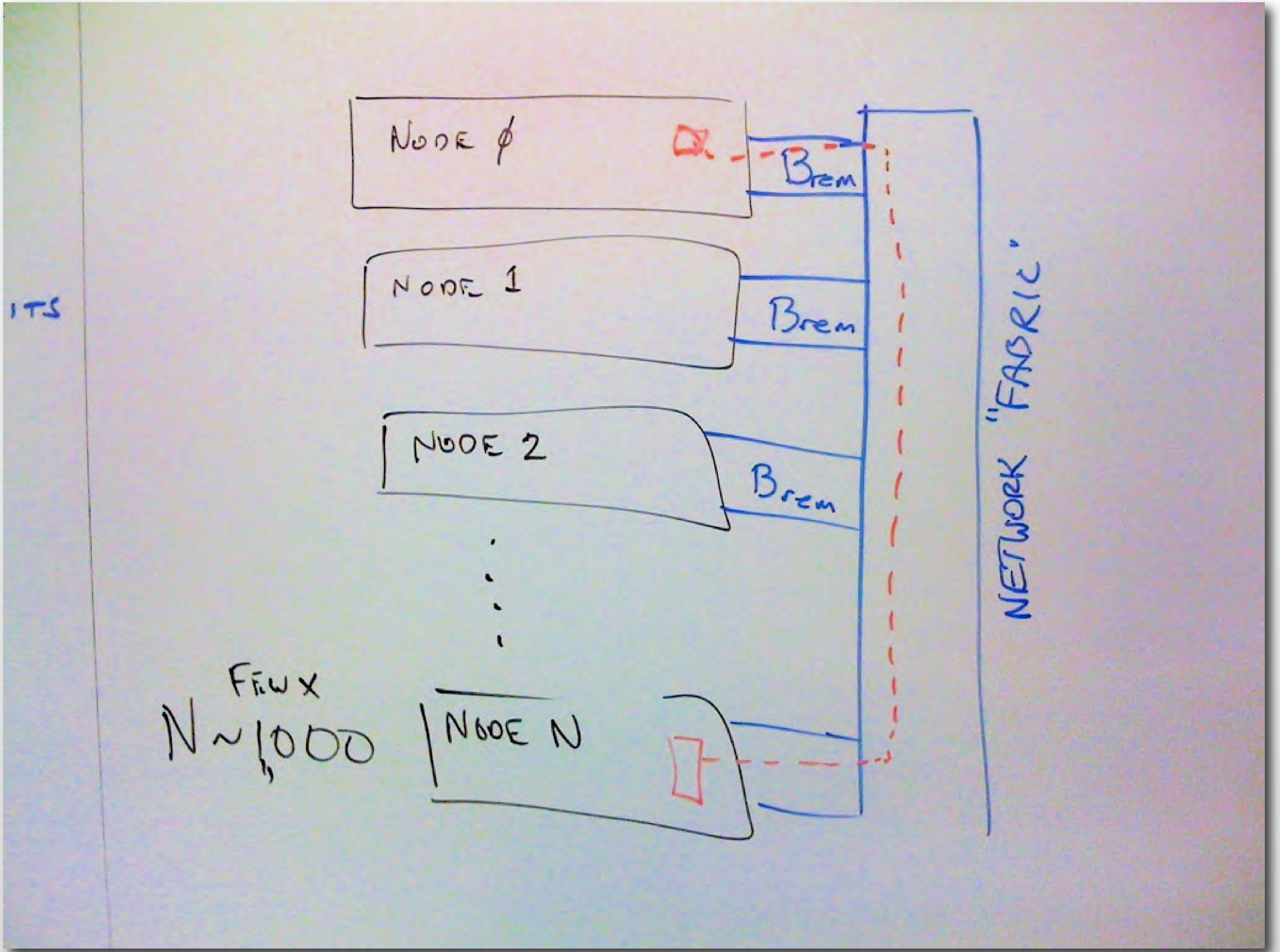
exercise: board 1



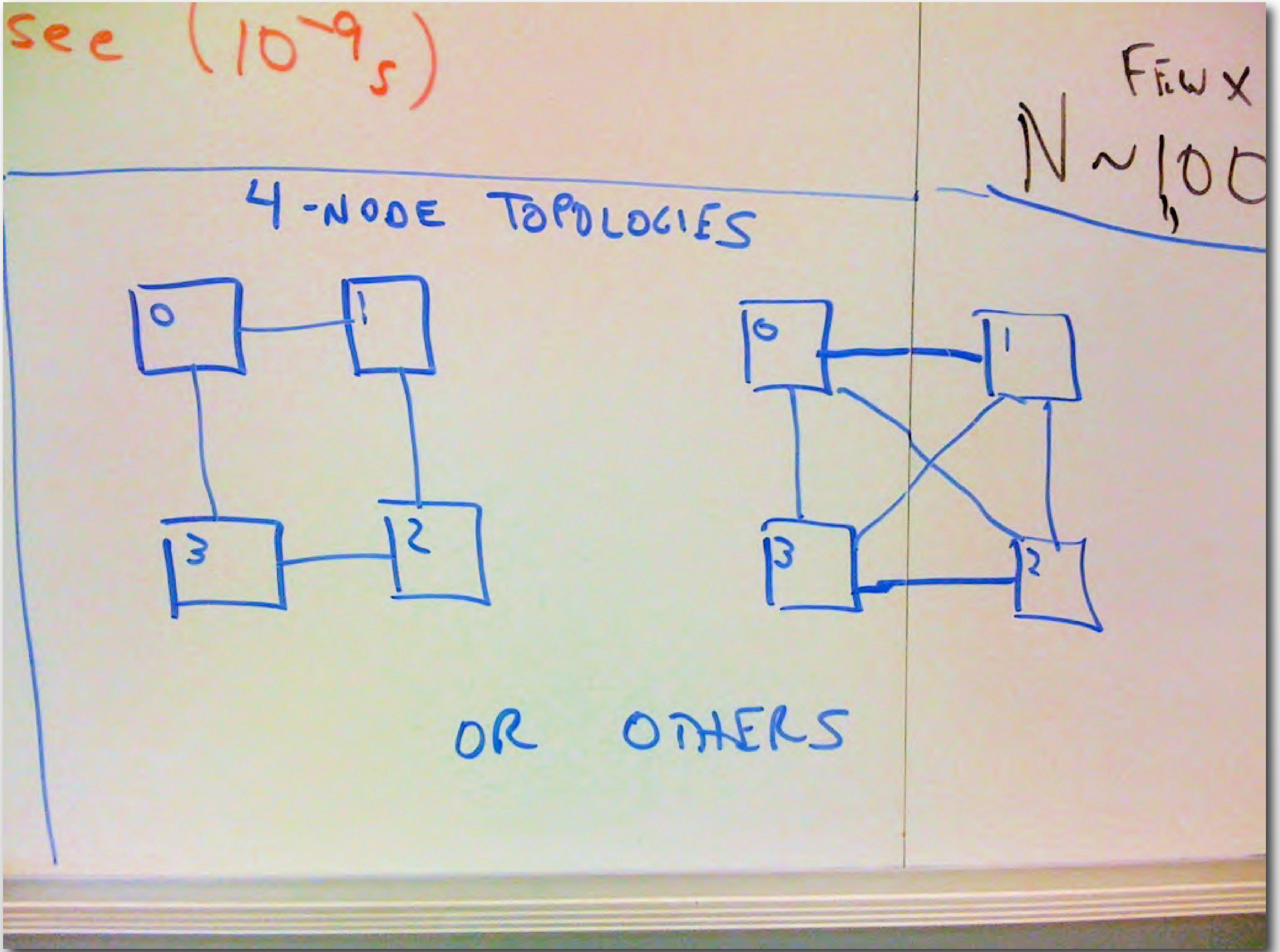
exercise: board 2



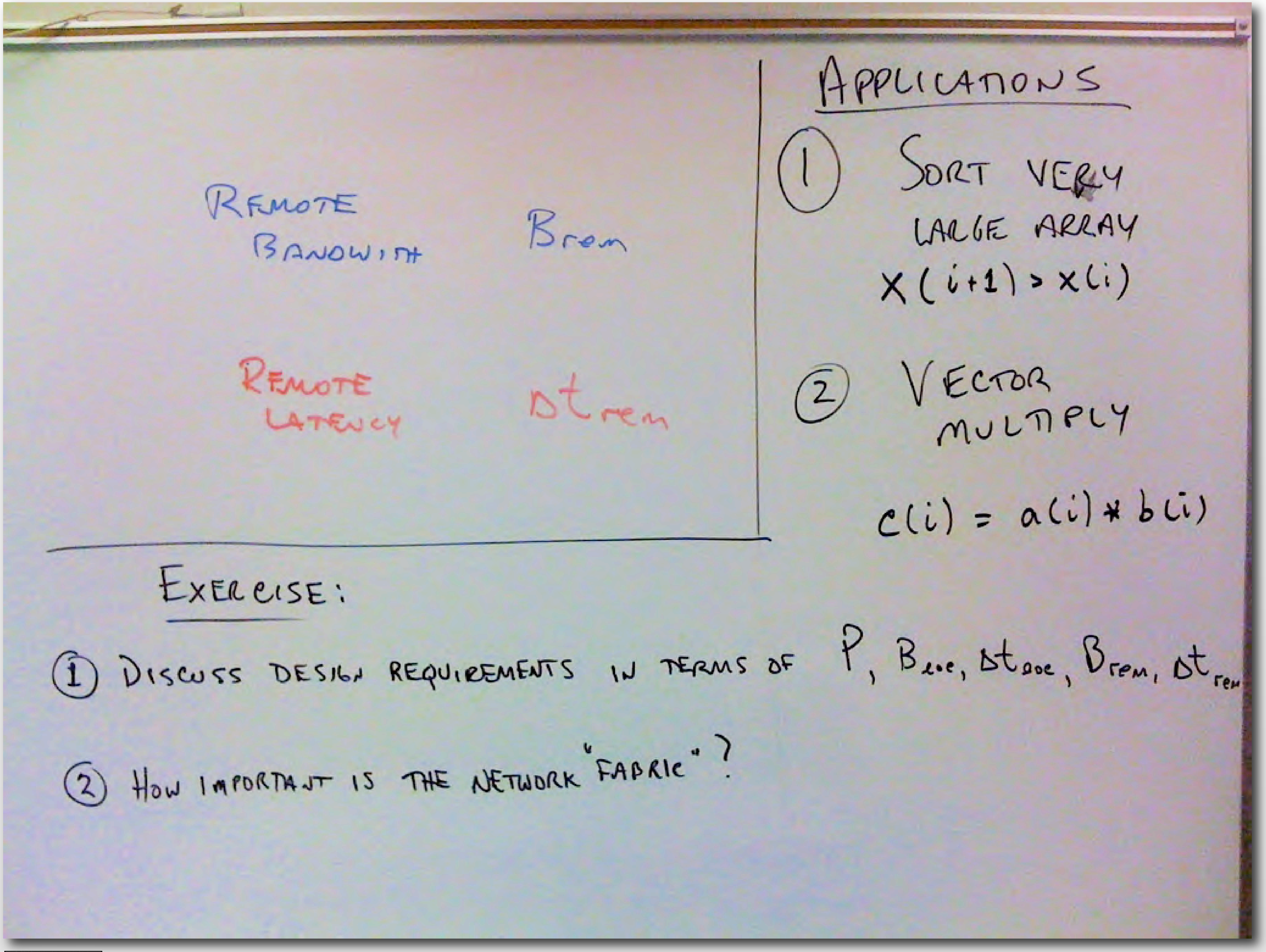
exercise: board 3



exercise: board 4



exercise: board 5



Additional Source Information

for more information see: http://open.umich.edu/wiki/CitationPolicy

Slide 3: Source Undetermined

Slide 5: Source Undetermined

Slide 6: Source Undetermined

Slide 7: Larry Smarr, "Set My Data Free: High-Performance CI for Data-Intensive Research," Cyberinfrastructure Days, http://lsmarr.calit2.net/presentations?slideshow=5656616.

Slide 8: Volker Springel, Max-Planck-Institute for Astrophysics.

Slide 9: United States Federal Government, http://science.nasa.gov/media/medialibrary/2010/03/31/BigBang2b.jpg

Slide 10:Gus Evrard and Andrzej Kudlicki, Max-Planck-Institute for Astrophysics.

Slide 11, Image 1 (top): http://apps.isiknowledge.com
Slide 11, Image 2 (bottom, left): United States Federal Government, National Science Foundation
Slide 11, Image 3 (Bottom, right): United States Federal Government, NASA

Slide 12: Screenshot of search results from http://apps.isiknowledge.com.

Slide 13: A. E. Evrard, University of Michigan

Slide 14: A. E. Evrard, University of Michigan

Slide 15: David Walker, "4m-Victor M. Blanco Telescope," Wikimedia Commons, http://en.wikipedia.org/wiki/File:4m-Victor_M._Blanco_Telescope.jpg, CC: BY-SA 3.0, http://creativecommons.org/licenses/by-sa/3.0/

Slide 16: Source Undetermined

Slide 17 (all images): A. E. Evrard, University of Michigan

Slide 19: Source Undetermined

Slide 20: Foster and Kesselman, The International Journal of Supercomputer Applicantions and High Performance Computing, 1997, 11:2, 115-128.

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Slide 22: A. E. Evrard, University of Michigan

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