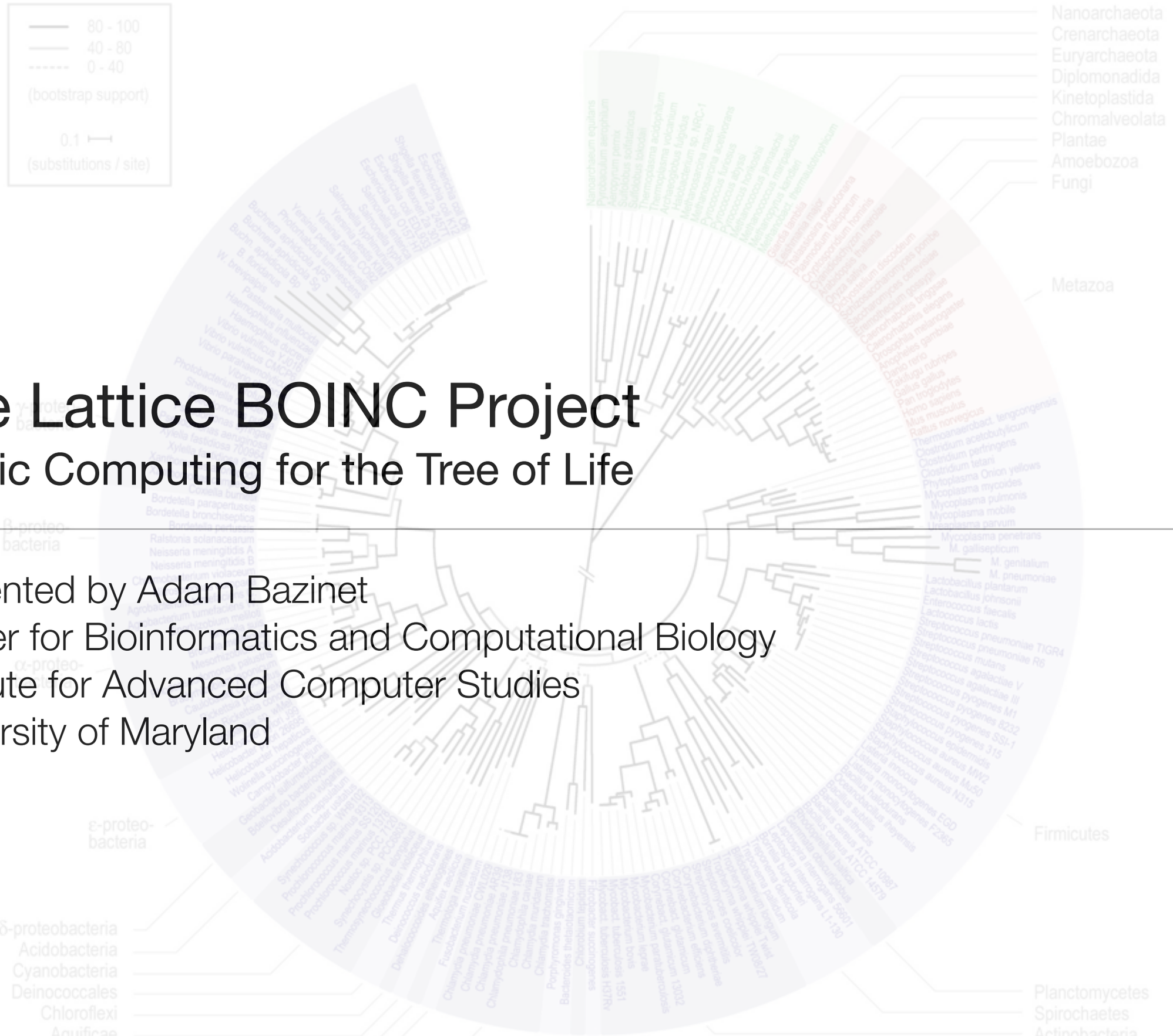


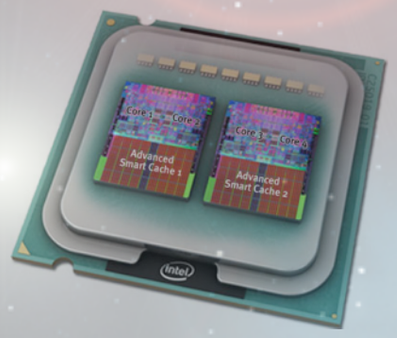
The Lattice BOINC Project

Public Computing for the Tree of Life

Presented by Adam Bazinet
Center for Bioinformatics and Computational Biology
Institute for Advanced Computer Studies
University of Maryland

Parallel computing “universe”

Multi-core



GPU

SMP

Cluster

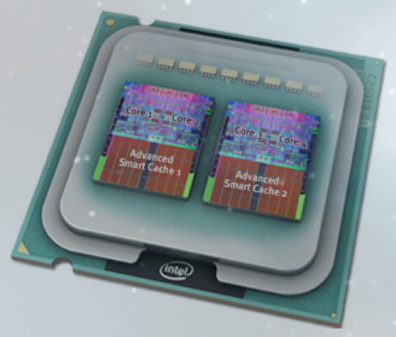
MPP

Grid computing

Parallel computing “universe”

Shared memory

Multi-core

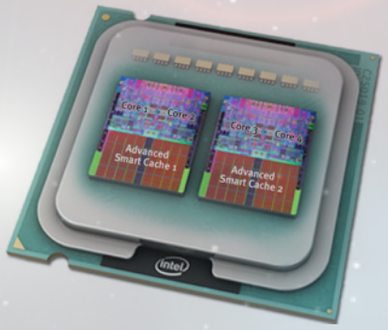


GPU

SMP

Parallel computing “universe”

Multi-core



GPU

SMP

Cluster

MPP

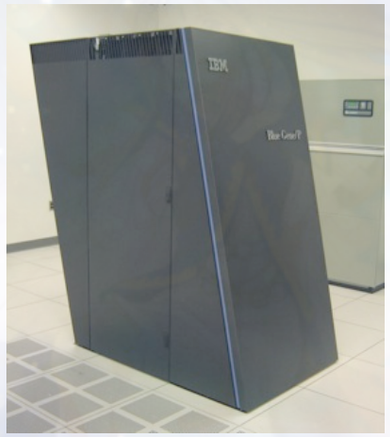
Grid computing

Parallel computing “universe”

Distributed memory

Cluster

MPP



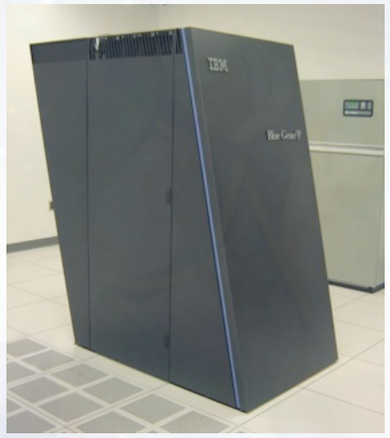
Grid computing

Parallel computing “universe”

“Distributed computing”

Cluster

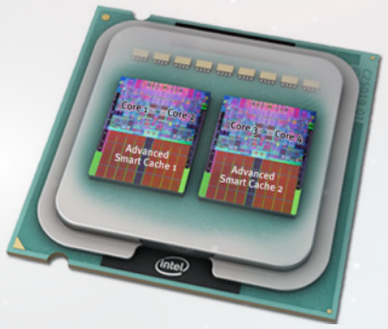
MPP



Grid computing

Parallel computing “universe”

Multi-core



GPU

SMP

Cluster

MPP

Grid computing

Parallel computing “universe”

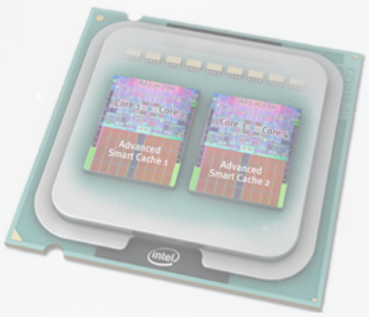
GPU

SMP

Cluster

MPP

Multi-core



Grid computing

Grid computing

BOINC pool

Condor pool

Compute cluster

The Lattice Project: resource characterization

HTC resources

Condor pool

BOINC pool

HTC = high *throughput* computing

HPC resources

Compute cluster

HPC = high *performance* computing

The Lattice Project: resource characterization

Shared

Condor pool

BOINC pool

shared = resources usually have interactive users

Dedicated

Compute cluster

dedicated = resources dedicated to processing

The Lattice Project: resource characterization

Institutional

Condor pool

Compute cluster

institutional = resources belong to an institution

Volunteer

BOINC pool

BOINC

dedicated = resources volunteered by the public

The Lattice Project: resource characterization

Trusted

Condor pool

Compute cluster

trusted = results need not be verified

Untrusted

BOINC pool

untrusted = results need verification

The Lattice Project: resource characterization

Reliable

Condor pool

Compute cluster

reliable = resources are stable and accounted for

Unreliable

BOINC pool

reliable = resources are dynamic and unpredictable

Models of Grid computing

- SERVICE MODEL — a heavyweight, feature-rich model focused on providing access to institutional resources and robust job submission capabilities and security features
  - Well known Service Grids include TeraGrid, Open Science Grid, and EGEE
- DESKTOP MODEL — scavenges cycles from idle desktop computers, which are volunteered by the general public
  - The combined power of hundreds of thousands of desktop computers represents a substantial, readily available resource
  - The most widely used software for tapping this resource is BOINC

THE LATTICE PROJECT

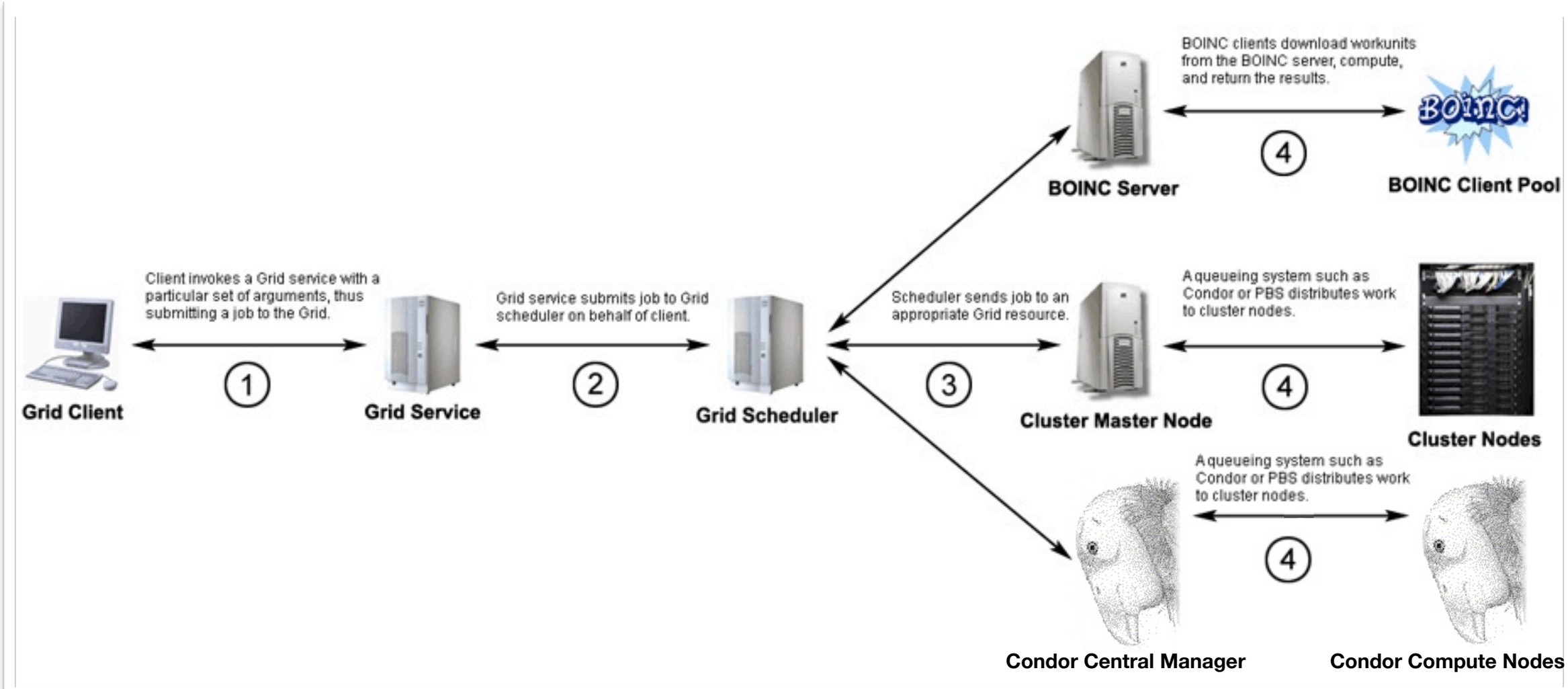
- The first Grid system to effectively combine a Service Grid (using Globus software) and a Desktop Grid (using BOINC software)

- Aimed at sharing computational resources between academic institutions, particularly those in the University System of Maryland

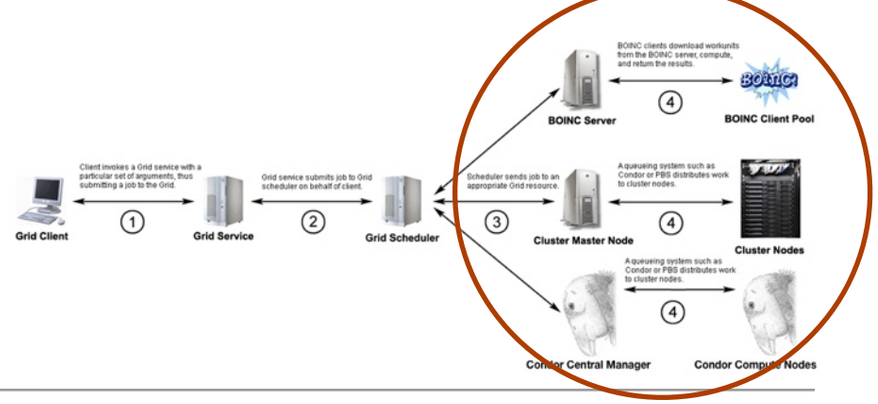
- Focused on enabling large-scale computation, especially for problems in the life sciences

- Development began in 2003 — since then, many different researchers have used the system, racking up over 20,000 CPU years of computation (measured in wall clock time)

The Lattice Project: architecture

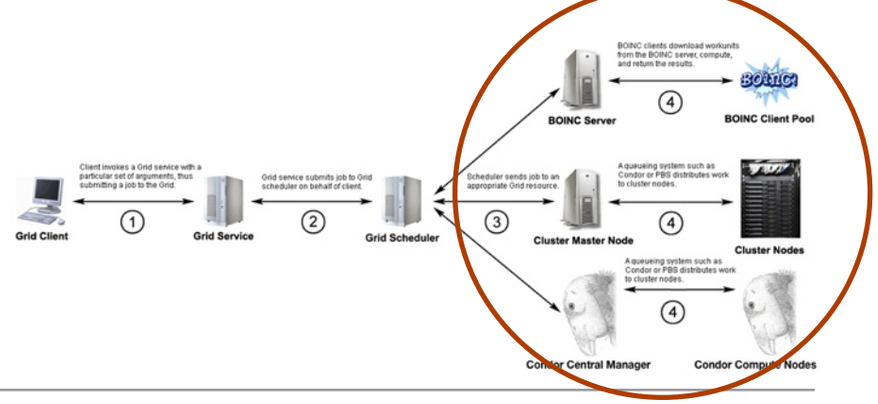


The Lattice Project: resources



- Quick facts about resources:
  - We support three major platforms: Linux (both PowerPC and Intel-based), Windows, and Mac (both PowerPC and Intel-based)
  - Four different institutions are currently tied in to the Grid: UMCP, Bowie State University, Coppin State University, and the Smithsonian NMNH
  - We currently have four Condor pools, four dedicated clusters, and a BOINC project with a steady number of participants
  - We currently have a total of 4000-5000 CPUs

The Lattice Project: resources



http://lattice.umiacs.umd.edu/resources/

UMIACS Condor Pool

252.26 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_LINUX	0	0	490

Disk used: 19.7G / 91.2G

show/hide condor_status

Coppin Condor Pool

64.21 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_WIN	40	0	505

Disk used: 4.5G / 13.4G

show/hide condor_status

Terpcondor Condor Pool

402.59 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_WIN	0	0	185

Disk used: 0.2G / 59.8G

show/hide condor_status

Topaz

0.00 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_OSX	0	0	0

Disk used: 158.4G / 0.9T

Lattice on BOINC

17318.11 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_LINUX	0	0	125
PPC_OSX	0	0	114
INTEL_WIN	0	0	1377

Disk used: 1.2G / 60.7G

Lattice on BOINC web site

Bowie Condor Pool

5.33 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_WIN	0	0	0

Disk used: 5.2G / 72.5G

show/hide condor_status

Xseed

228.19 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
PPC_LINUX	0	0	408

Disk used: 41.4G / 1.1T

Xseed web site | Ganglia

Deepthought

641.87 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_LINUX	0	0	112

Disk used: 345.6G / 2.5T

HPCC web site | Ganglia | Stats

SEIL

325.29 CPU Years

Lattice Jobs

Arch. & OS	Idle	Running	Free CPUs
INTEL_LINUX	0	0	112

Disk used: 67.8G / 122.2G

HPCC web site | Ganglia | Stats

Total Lattice Jobs Idle 40 Running 0

Total Free CPUs* Linux 1247 Windows 2067 Mac OS X 114 ***Grand Total*** 3428

Grid Server Disk Used 1.0G / 74.7G

*NOTE: multi-core machines report each core as a separate CPU.

The Lattice BOINC Project

http://boinc.umiacs.umd.edu/

The Lattice Project
Center for Bioinformatics and Computational Biology

Home | Research | Publications | Personnel

The Lattice Project
About Lattice
Applications
Create Account
Message Boards
Participant Profiles
Questions & Answers
Research Projects
Rules and Policies
Statistics
Teams
Top Computers
Top Participants
Top Teams
Your Account

POWERED BY BOINC

Home

The Lattice Project

About The Lattice Project

- Background and introduction
- Research projects
- Applications

Join The Lattice Project

1. Read our rules and policies
2. Getting started
3. Create account
4. Download BOINC
5. When prompted, enter **http://boinc.umiacs.umd.edu/**

Returning participants

- Your account
- Teams

Community

- Participant profiles
- Message boards
- Questions and answers

Project totals and leader boards

- Top participants
- Top computers
- Top teams
- Other statistics

User of the Day

Bruno Ramone
Cześć boincomaniacy !

w projektach rozprosznych jestem od 2000 roku, kiedy to zainteresował mnie nieziemski wygaszacz projektu...

Project Status

BOINC Server	Results	Users
Scheduler: running	Results ready to send: 2	Total Users: 22152
File Server: running	Results in progress: 815	Total Hosts: 38961
Feeder: running	Workunits in database: 26686	
[Detailed Status]	[Workunit Graveyard]	

News

October 9, 2009 - Server Upgrade
Just upgraded the server software, so please let me know if you notice anything out of place.

August 1, 2009 - Workunit Errors
A number of GARLI jobs were accidentally released with an error in the configuration file that caused the job to terminate incorrectly; these jobs have been removed from the system, and we apologize for this.

[Old News]

News is available as an RSS feed.

BOINC as part of a Grid computing system

- The Lattice BOINC Project is part of a Grid computing system that also incorporates traditional computing clusters and Condor pools

- How it works: a job with a generic description is submitted by a Grid user, which is transformed into either a BOINC workunit, a PBS submit file, or a Condor submit file by the Globus GRAM service

- As a consequence of being hooked up to a general-purpose Grid computing system, our project runs many different types of applications

- As a result, we have had to work harder to manage volunteer expectations since we do not have an endless supply of work and the applications (and workunits within an application) are highly variable

The Lattice BOINC Project: research

- Phylogenetic analysis – GARLI

- Protein sequence comparison – HMMPfam

- Conservation network design – MARXAN

Grid, Public, and GPU Computing for the Tree of Life

- A multi-year NSF award to build an advanced computational system for phylogenetic analysis

- Leverages the Grid system (and hence the Lattice BOINC Project)

- Provides for improving the performance of popular phylogenetic analysis programs (GARLI) using GPGPU frameworks such as OpenCL and CUDA

    - *The BOINC pool is our greatest potential source of modern GPUs*

- Provides for the construction of a web portal interface to facilitate easy and efficient job submission, monitoring, and post-processing

GARLI

- Genetic Algorithm for Rapid Likelihood Inference
- Makes maximum likelihood phylogenetic searches feasible for large datasets
- Avoids calculating the exact “maximized likelihood” for each topology
- Gradually and independently optimizes tree topology, branch lengths, and model parameters

```
ATG---TTC------ATAATTAACATCTTAATACTA---
ATG---CTAAACATCCTAATAACTCACCTAATCAACCCT
ATGACCCTGCCCACCCTAACAAACCTTCTAATCATAACC
ATA---CCC------ATGGCCAACCTCCTACTCCTC---
ATC---CTAAACACTCTACTCACCCACCTCATCAACCCC
ATAGTGTTC------TTTATTAATATCCTAACACTC---
ATAGTGTAC------TTTATTAATATCCTAACACTC---
ATG---TTT------ATAATTAATATCATCTCACTA---
ATG---TTT------ATAATTAACATTCTAACACTC---
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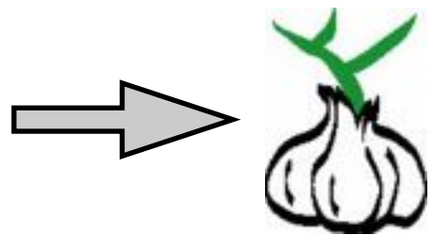
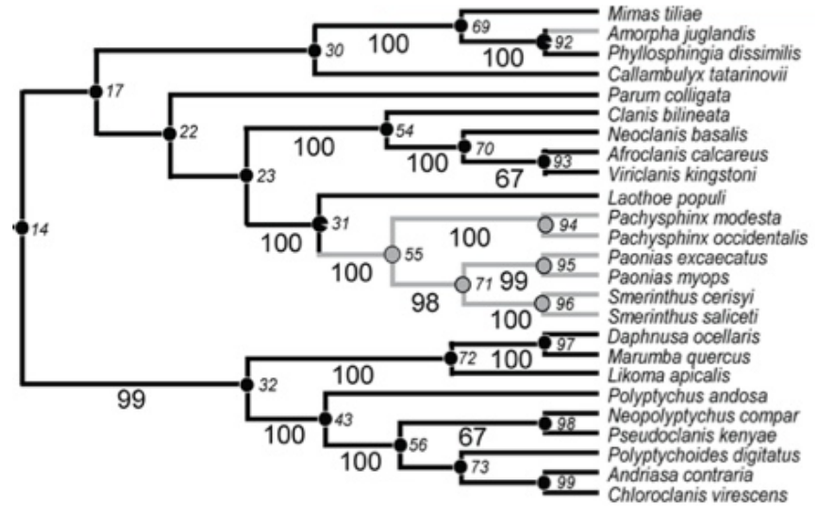




GARLI Web Service - create job

GARLI - Genetic Algorithm for Rapid Likelihood Inference

Version 1.0 - Author(s): Derrick J. Zwickl (zwickl@ku.edu) - Category: Phylogenetics

Job Information

Current user:

akawahar

*** Job name (use only a-z A-Z 0-9 . _):**

General Settings

*** Analysis type:**

ML search

*** Number of replicates (1 - 2000):**

1

Sequence data file *:

GARLI Web Service – view job status

< back to create job

akawahar

ID	Job name	Completed	Total	Status	Created	Remove job
435	27.21.aa.cdn.bp.final	100	100	Retrieved	07/28/10 at 08:47:22 PM EST	[remove]
409	57.21.nt123.ml.P2.final	250	250	Retrieved	07/28/10 at 04:14:57 AM EST	[remove]
408	57.21.dgn.ml.SupF.final	210	250	Running	07/28/10 at 04:12:37 AM EST	[remove]
407	57.21.dgn.ml.SubF_nLeuz.final	250	250	Retrieved	07/28/10 at 04:00:00 AM EST	[remove]
406	57.21.dgn.ml.SubF.final	250	250	Retrieved	07/28/10 at 03:58:29 AM EST	[remove]
405	57.21.dgn.ml.P.final	250	250	Retrieved	07/28/10 at 03:56:47 AM EST	[remove]
404	57.21.dgn.ml.F.final	250	250	Retrieved	07/28/10 at 03:49:17 AM EST	[remove]
403	57.21.dgn.ml.bgr.final	250	250	Retrieved	07/28/10 at 03:47:05 AM EST	[remove]
402	57.21.dgn.ml.bg.final	250	250	Retrieved	07/28/10 at 03:40:47 AM EST	[remove]
401	57.21.nt123.ml.supF.final	250	250	Retrieved	07/27/10 at 02:22:37 PM EST	[remove]
400	57.21.nt123.ml.supf_nLeuz.final	250	250	Retrieved	07/27/10 at 02:21:28 PM EST	[remove]
399	57.21.nt123.ml.subf.final	250	250	Retrieved	07/27/10 at 02:20:10 PM EST	[remove]
398	57.21.nt123.ml.P.final	250	250	Retrieved	07/27/10 at 02:18:21 PM EST	[remove]
397	57.21.nt123.ml.F.final	250	250	Retrieved	07/27/10 at 02:12:09 PM EST	[remove]

GARLI Web Service - view job

< back to job select

Job Status

Job name: 27.21.aa.cdn.bp.final

Progress: 100/100

[Download zipped job files]

Job Files

- 27.21.14793.070910.nex
- garli.conf

postprocessing

- all.boot.tre
- tree_files

Job 1

- stdout

GPUs: background

- GPUs are inexpensive, dedicated numerical processors originally designed for rendering 3D computer graphics

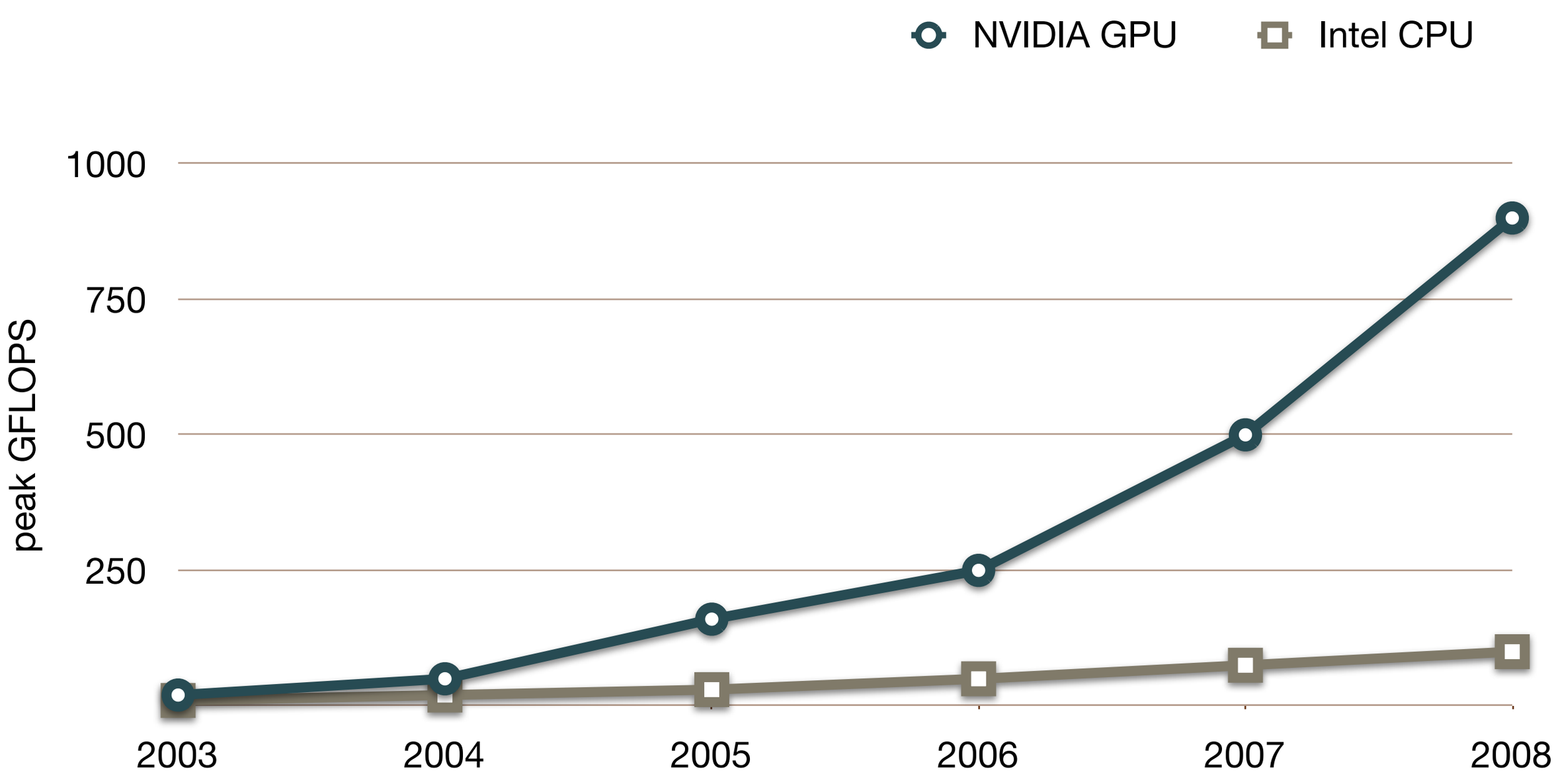
- GPUs contain 100s of processing cores on a single chip

- Each core carries out the same operations in parallel on different input data – single program, multiple data (SPMD) paradigm

- Extremely high arithmetic intensity if one can transfer the data onto and results off of the processors efficiently

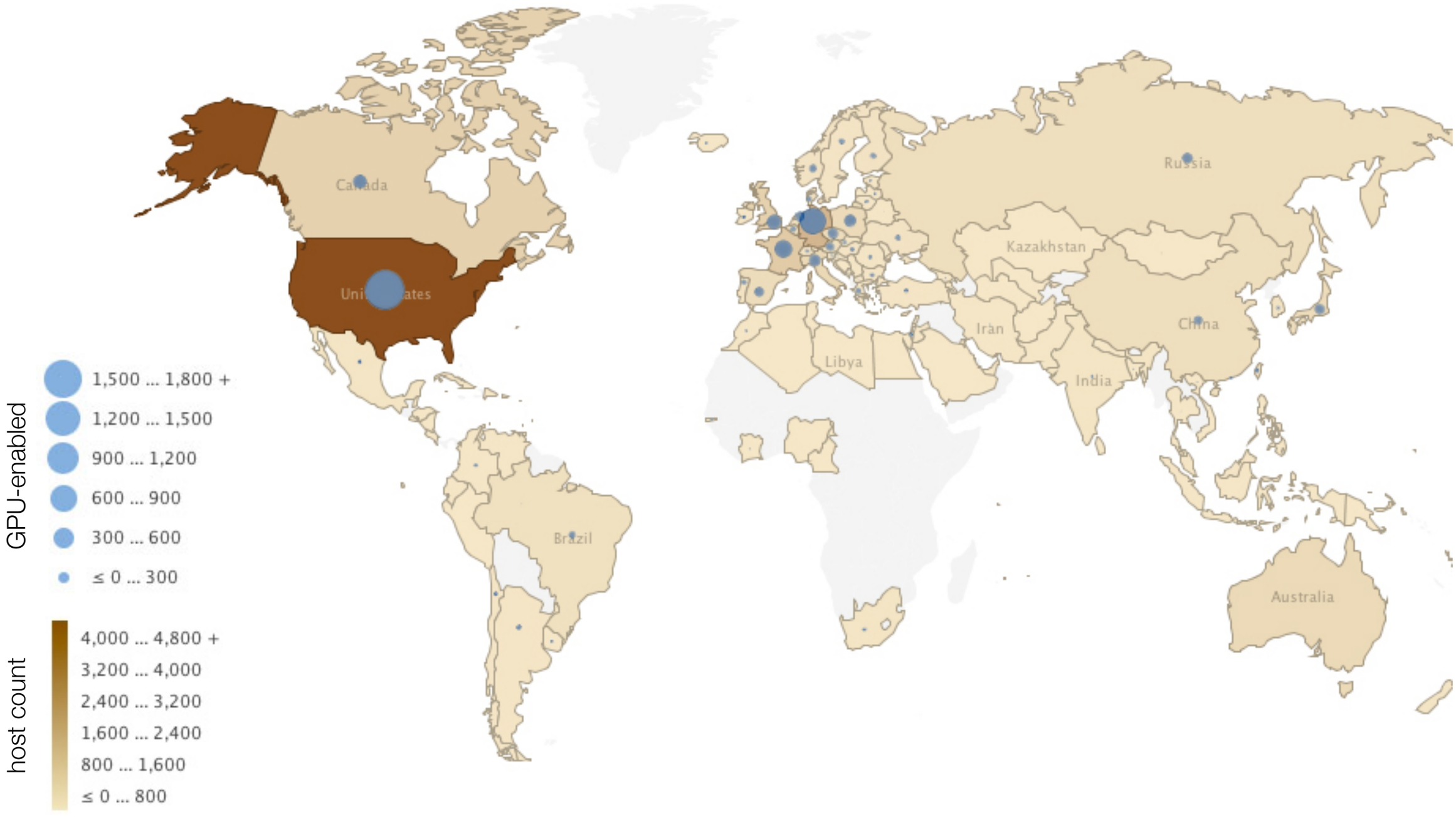
GPUs: background

- general-purpose computing on GPUs



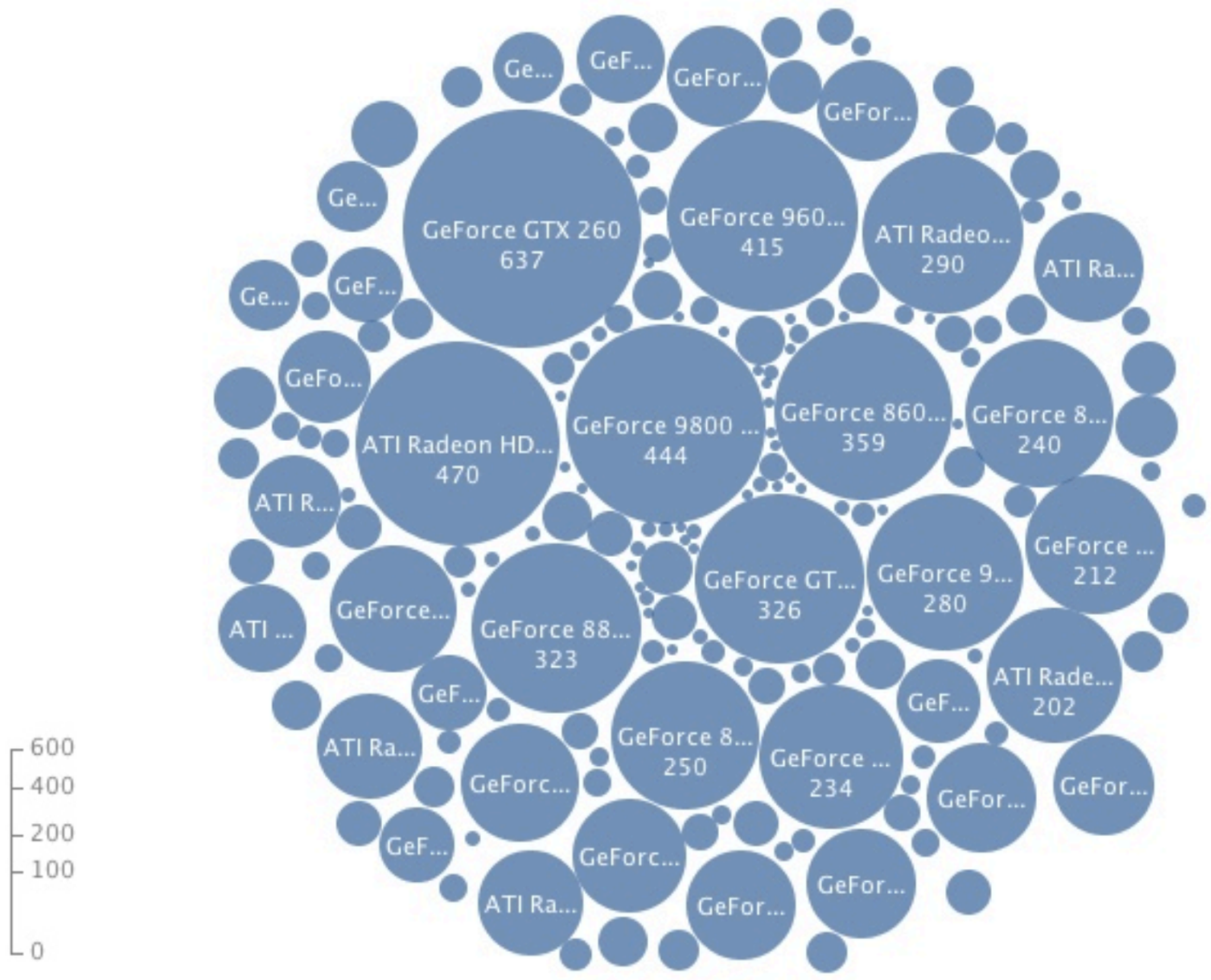
NVIDIA Corporation. CUDA Programming Guide 2.1, 2008

The Lattice BOINC Project: hosts by country



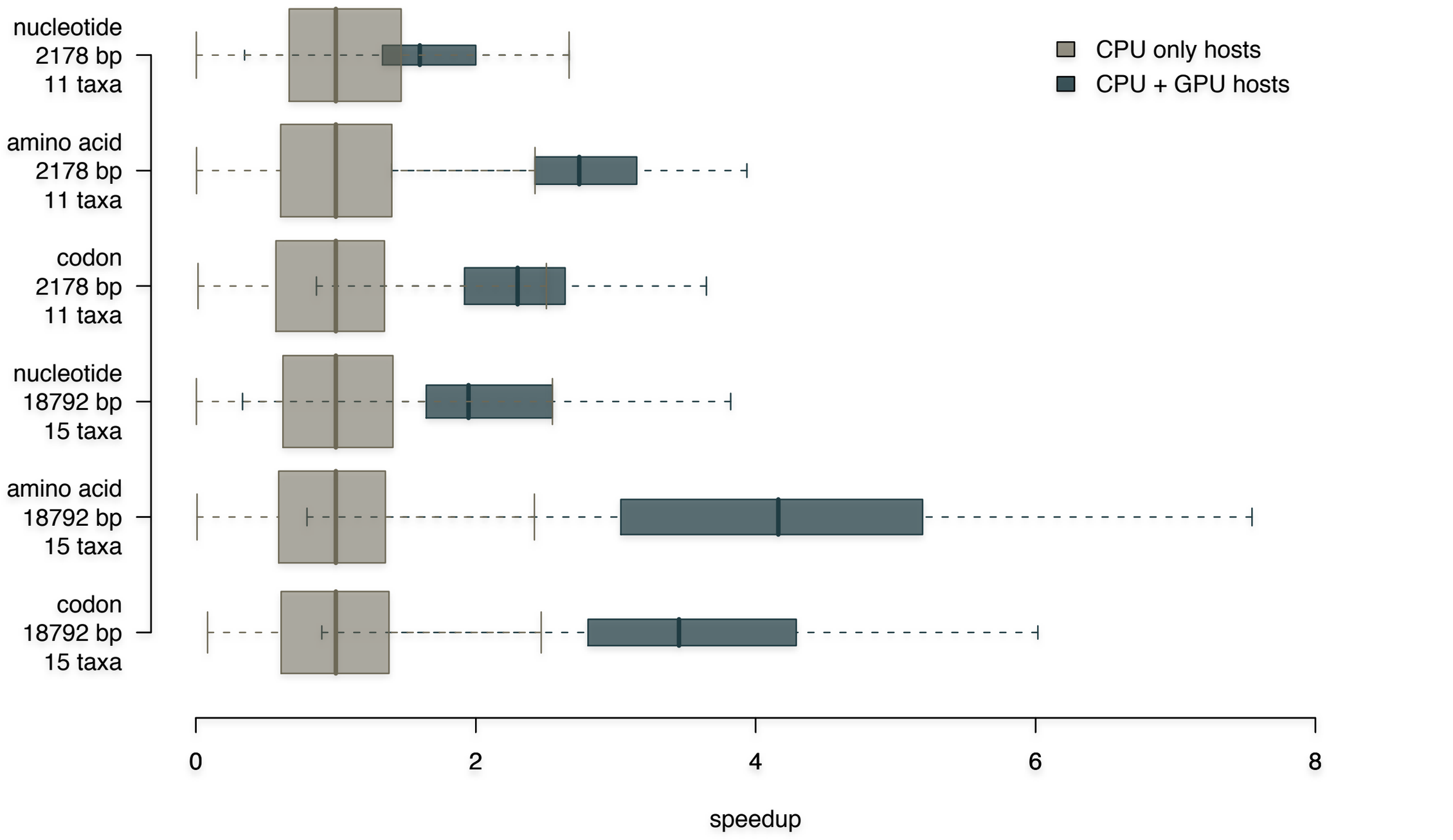
period of January 1st to August 23rd, 2010; total of 15081 hosts (5750 GPU-enabled); created on Many Eyes © IBM

The Lattice BOINC Project: GPU models



period of January 1st to August 23rd, 2010; total of 5750 GPUs; created on Many Eyes © IBM

GARLI-GPU: speedups



1568 hosts (271 GPU-enabled); test from 2009

GARLI on BOINC: challenges and future work

- Checkpointing
  - GARLI only checkpoints in certain phases
- Progress bar updating
  - due to the stochastic GA and flexible stopping conditions, it can be difficult to ascertain progress
- Runtime estimates
  - providing accurate runtime estimates *a priori* is important for a variety of reasons; has been difficult to do so because of the high variance in types of workunits
    solution: machine learning with random forest to estimate runtimes in advance
- Long jobs, short pieces
  - if we could break up workunits into shorter, even-length pieces, we could give our volunteers a more consistent experience, and would probably increase throughput

References

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- Bazinet, A. L., and M. P. Cummings. 2008. **The Lattice Project: a Grid research and production environment combining multiple Grid computing models.** Pages 2-13. In Weber, M. H. W. (Ed.) *Distributed & Grid Computing - Science Made Transparent for Everyone. Principles, Applications and Supporting Communities.* Rechenkraft.net, Marburg.

- Myers, D. S., A. L. Bazinet and M. P. Cummings. 2008. **Expanding the reach of Grid computing: combining Globus- and BOINC-based systems.** Pages 71-85. In Talbi, E.-G. and A. Zomaya (Eds.) *Grids for Bioinformatics and Computational Biology, Wiley Book Series on Parallel and Distributed Computing.* John Wiley & Sons, New York.

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- Myers, D. S., and M. P. Cummings. 2003. **Necessity is the mother of invention: a simple Grid computing system using commodity tools.** *Journal of Parallel and Distributed Computing.* 63:578-589.

- Zwickl, D. J. 2006. **Genetic algorithm approaches for the phylogenetic analysis of large biological sequence datasets under the maximum likelihood criterion.** Ph.D. dissertation, The University of Texas at Austin.

More information

- THE LATTICE PROJECT http://lattice.umiacs.umd.edu/
  http://boinc.umiacs.umd.edu/

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