





# Apple Computing for Scientists

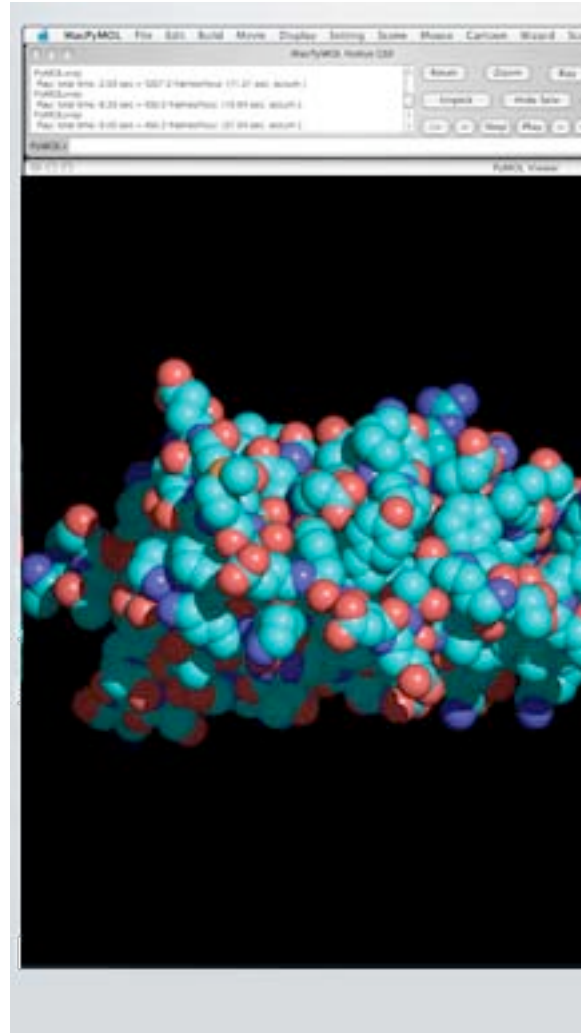
A New Commitment to Research Programs

Dr. Massimo Marino  
ARTS Project Leader  
Apple Scientific & Research Programs

# Messages & Motivations



The man behind it



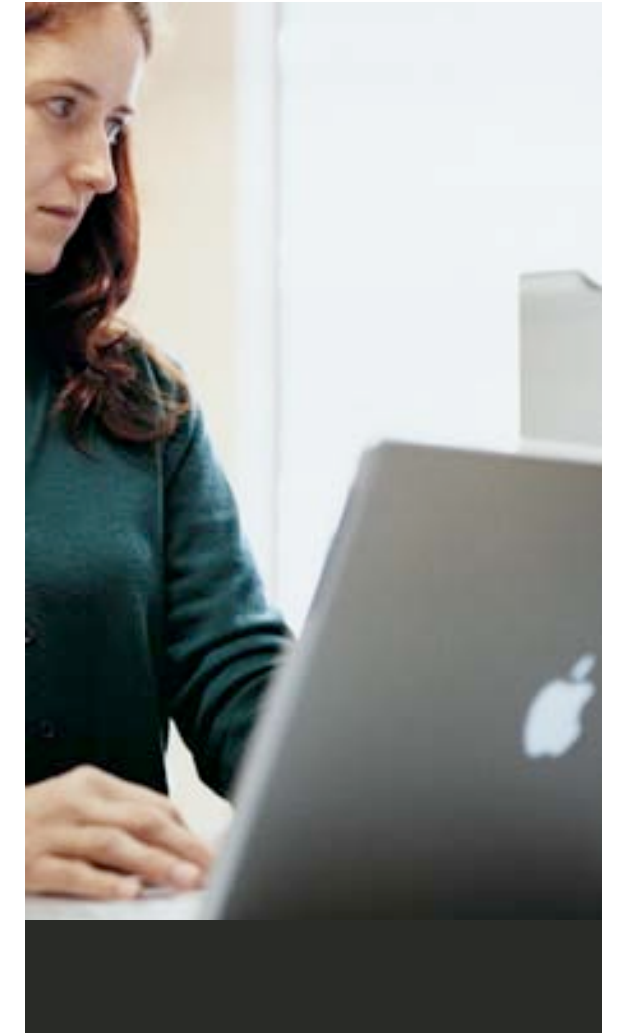
Mac OS X for Science



The ideal platform for scientific computing



In the real world and the ARTS program



On the web



# Where do I come from?

Physicist/Computer Scientist with 17 years presence in the field

1988 - 1997

CERN Laboratory - Switzerland



- Detector R&D
- RD41
- LHC/CMS experiment - Computing Group

1997 - 2005

Lawrence Berkeley National Laboratory - USA



- NERSC (National Energy Research Scientific Computing - DOE)
- BaBar experiment @ SLAC
- LHC/ATLAS experiment @ CERN

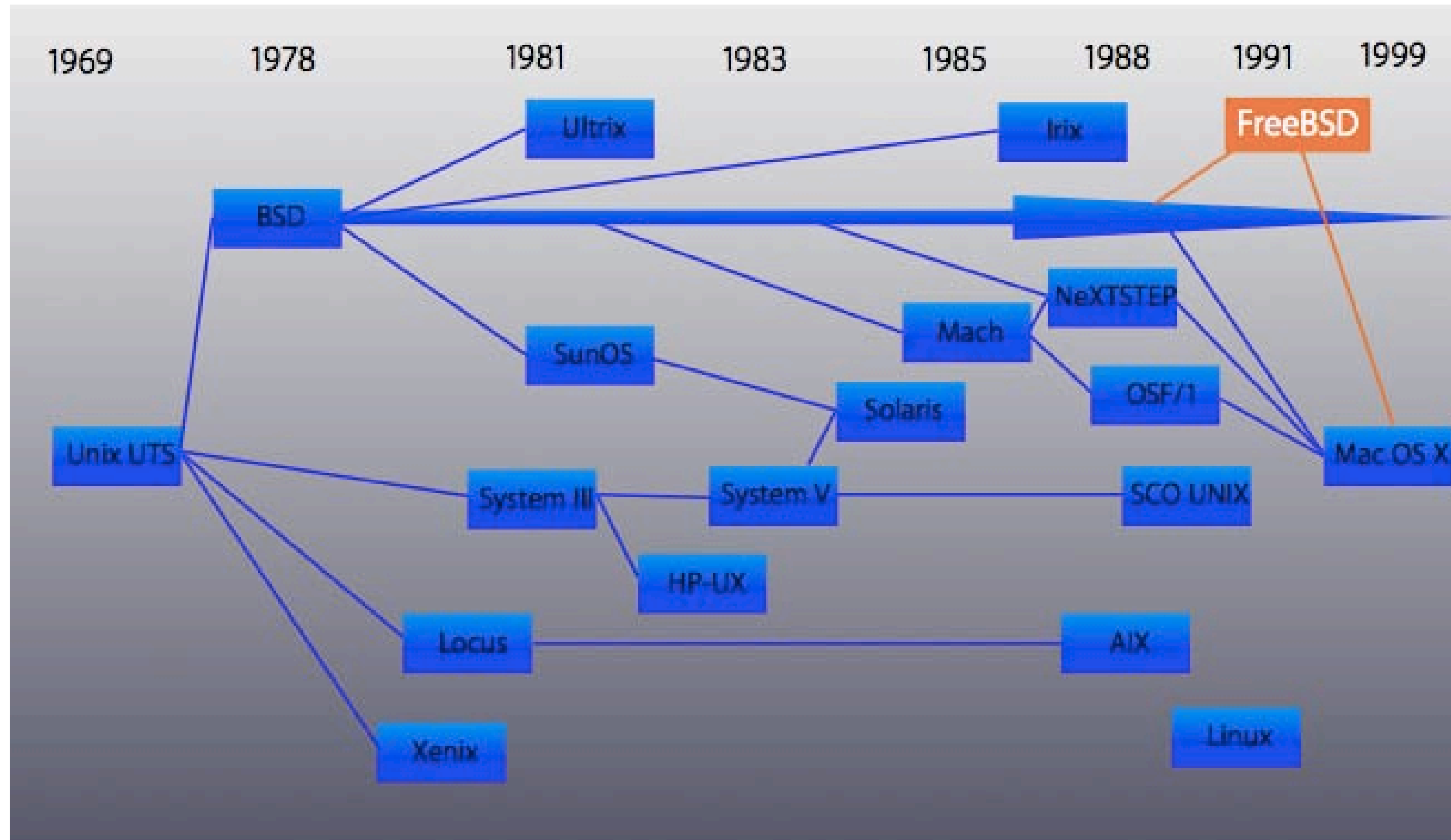


# Computing exposure

- Various Unix flavors
  - Solaris
  - Scientific Linux (SL)
  - Red Hat
  - HP-UX
  - AIX
  - Mac OS X
- Various languages
  - Fortran, Smalltalk, Eiffel, C++, Python,...
- Mac OS
  - HEP fully into Unix workstations
    - Mac mainly platform of choice for graphics and papers
  - On radar screens once Apple had a real OS for scientists: Mac OS X

# Unix Family Tree

## Ancestors of Mac OS X



# Why Unix was the right move

- Highly “compose-able” as operating systems go
  - It’s an onion, not a potato
- Gives Apple a huge amount of open source to leverage
  - critical to the implementation process and evolution progress
- Instant portability for a huge number of important applications (and important users) in SciTech and other fields
- Interoperability with \*BSD, Linux, Solaris and other UNIX-derivatives
  - came almost for free
- Development community is active, innovative and a well-established track record on OS design and security





# The next Unix move

## Pushing forward with Mac OS X 10.5 Leopard

Second Mac OS X version to run natively on intel processors



- 64-bit OS
  - can seamlessly run 32-bit applications and extensions
  - unlike other OSes, only one version of the software
    - anything, be it 64 or 32-bit, runs natively and without penalty
      - Apache2, MySQL, Postfix and Cyrus, iChat Server, QuickTime Streaming Server
- Certified Unix 03 (The Open Group)
  - not just Unix-based
    - Conforming to the Single UNIX Specification: SUS version 3
  - runs any Unix-certified application after recompilation for the Mac platform
    - no changes to the program APIs, no changes to the code
- DTrace (Open Source) & Xray





# DTrace

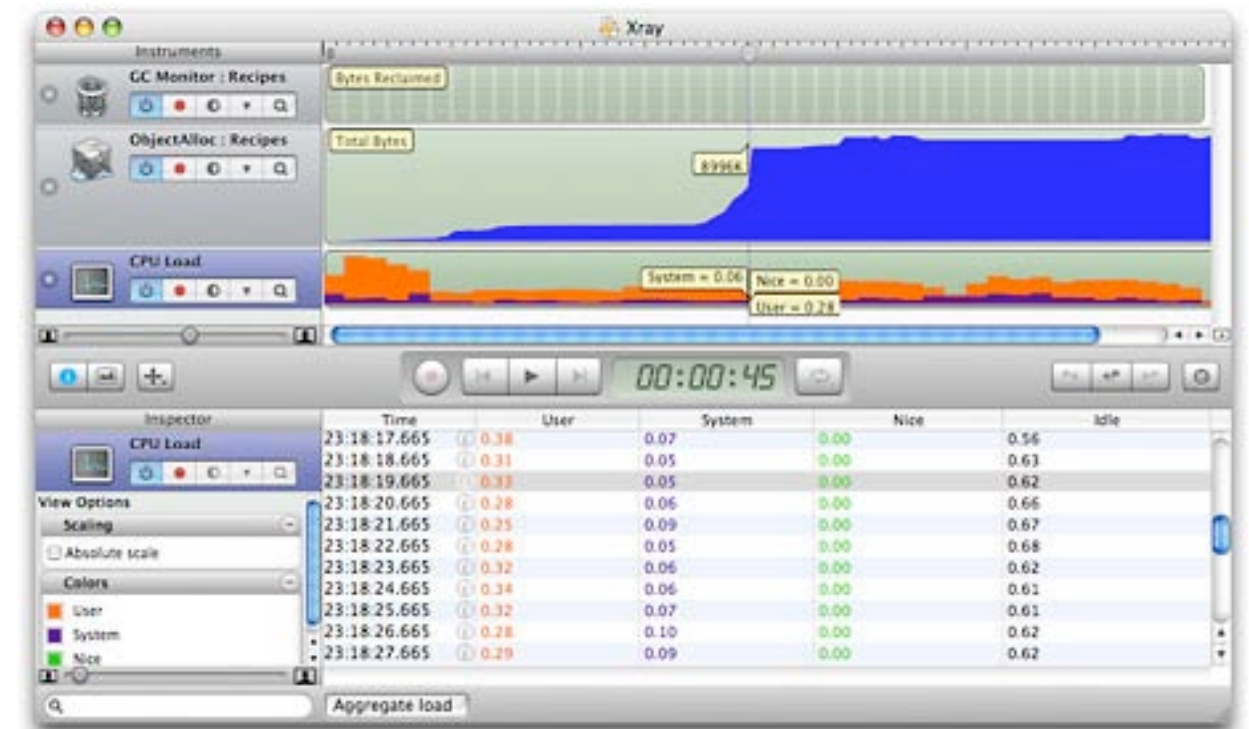
- What is DTrace?
  - DTrace is a comprehensive dynamic framework for the ~~Solaris~~ Mac OS X Operating Environment. DTrace provides a powerful infrastructure to permit administrators, developers, and service personnel to concisely answer arbitrary questions about the behavior of the operating system and user program.

<http://www.opensolaris.org/os/community/dtrace/>



# Xray Brand-new, timeline-based performance visualization tool

- Watch CPU, disk I/O, memory usage, garbage collection, events, and more in the form of graphs tied to time.
- Track UI events in real-time and see how they affect I/O activity and CPU load at the same time
- Scan back and forth through your application's run and see exactly what occurred, and when.
- Xray builds on top of the open source DTrace utility



# Mac OS X for Science

# Today's Scenario

Mac OS X platform: growing in popularity among scientists, researchers and developers in all fields

- Familiarity
  - Unix? Not a niche: it's mainstream
- One complete environment
  - From data analysis to final paper and into conferences too
  - Number crunching and powerful desktop publishing tools
    - even more number crunching with intel ICC
      - [www.intel.com/software/apple](http://www.intel.com/software/apple)
- MORE than one complete environment
  - Boot Camp
  - Parallels

*"Intel compilers deliver superior performance for Apple developers,"* said Rod Mach, Technical Director, High Performance Computing, [Absoft Corporation](#)\*.



# Mac OS X at a glance

## FreeBSD 5.x and Mach 3 based

- NFS, AFP, SMB/CIFS, AFS, Zeroconf Bonjour (SDK for Windows too)
- HFS(++), UFS, iso9660, UDF, FAT, NTFS
- VM, tasks, threads, scheduling and IPC
- >4GB Physical memory

## Supports

- POSIX, IPv6, L2TP/IPSec VPN client and server
- 802.11a/b/g/n wireless protocols (WAP(2), LEAP, PEAP,... authentication)

## Optimized X11 - XFree86 based - Hardware OpenGL rendering

- Native Aqua and X11 apps run side by side





# Cross-Platform Portability

- Easy to port POSIX apps
  - POSIX threads
  - POSIX semaphores
  - POSIX locales
- Easy to port Linux apps
  - SysV IPC
  - Native dlopen in dyld
  - poll/select (kqueue)
- Standard X11 toolkits
- Even easier on intel based Macs
  - Endiannes
  - SSE/2/3 optimization



# Built on Standards

- Standard commands and libraries from FreeBSD
- A full suite of scripting (and programming) languages
  - perl, tcl, python, ruby, php, ...
  - Java
- Every standard shell
  - bash, (t)csh, zsh, ksh
- Standard editors
  - pico, vi(m), emacs (the only one you actually need)
- Standard C compiler suite (and more: Intel compilers)
  - gcc, g++, Objective-C, ...





# Strong OpenSource commitment

## Apple opens up

- New "Mac OS Forge" for Community Projects

- a new community site hosted by Apple, created to support WebKit and other open source projects focused on Mac OS X, especially those looking to transition from OpenDarwin.org.
  - <http://www.macosforge.org/>
  - Sources for Bonjour service discovery and Launchd process management
    - <http://bonjour.macosforge.org/>
    - <http://launchd.macosforge.org/>

- Intel Kernel Sources

- kernel sources for Intel-based Macs (alongside PowerPC), starting with Mac OS X 10.4.7
  - <http://www.opensource.apple.com/darwinsource/tarballs/appl/xnu-792.10.96.tar.gz>

- New Open Source Calendaring Server

- source code iCal Server is now available on Mac OS Forge under the Apache License.
  - <http://collaboration.macosforge.org/>

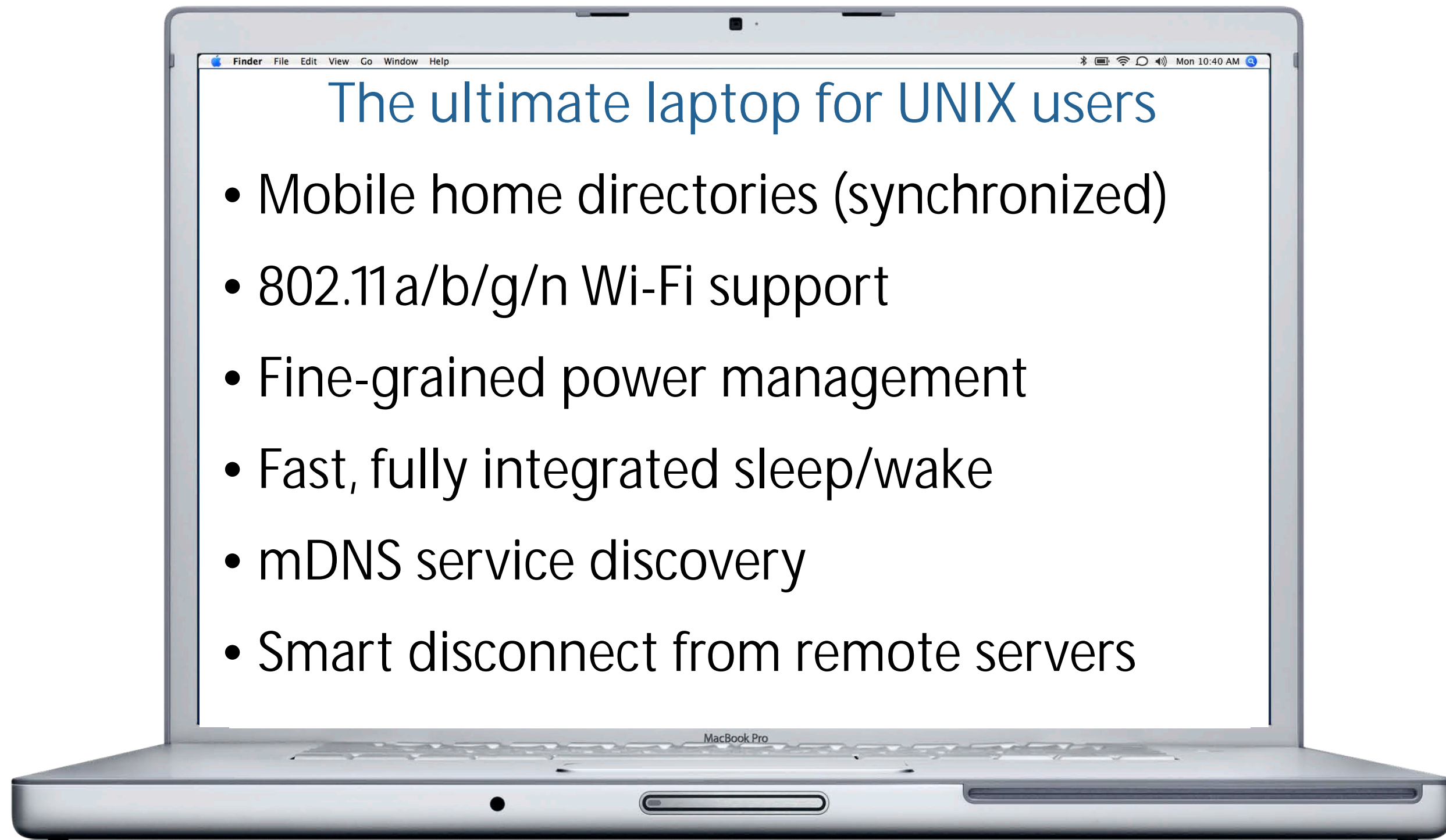


# Mac OS X - not just another UNIX

- Improvements to the Foundations
  - Mac OS X only command line tools and utilities based on FreeBSD
  - fine-grained kernel locking
  - Access control list
  - Spotlight from the command line
- Additional security steps
- IOKit: Object-oriented device driver model provides real kernel extensibility and plug-and-play device configuration
  - UNIX gets truly portable
    - Mobility is finally a real priority
    - Ease of use is finally a real priority



# Mobility



# Security

## Patches - OS & security

- Provided by Apple through built-in 'Software Update' tool
- Apple works closely with security watchdog organizations CERT and FIRST.

## Little traffic

- Really, not a burden for user
  - Mostly concerning standard Unix tools
  - 8 Security Updates in 2006

## DOE Computer Incident Advisory Capability

- No known viruses do exist on Mac OS X after 6+ years from initial release
  - BSD Unix, CDSA (Common Data Security Architecture), Mach

[www.ciac.org/ciac/bulletinsByType/bul\\_vendor\\_list.html](http://www.ciac.org/ciac/bulletinsByType/bul_vendor_list.html)

<http://developer.apple.com/internet/security/securityintro.html>

<http://www.apple.com/server/documentation>



# Mac OS X Security 'hotline'

## Security-announce mailing list

- To subscribe/unsubscribe
  - Via the World Wide Web  
<http://www.lists.apple.com/mailman/listinfo/security-announce>
  - Via email, send message with subject/body 'help'  
[security-announce-request@lists.apple.com](mailto:security-announce-request@lists.apple.com)
- Send submissions to:  
[security-announce@lists.apple.com](mailto:security-announce@lists.apple.com)
- You can reach the managers of the list at  
[security-announce-admin@lists.apple.com](mailto:security-announce-admin@lists.apple.com)



# Mac OS X at a glance

## A dual inheritance

The Unix Philosophy	The Mac Philosophy
Secure	Friendly
Scalable	Usable
Open Standards	Innovations
High Performance	Rich Experience
Rock-solid stability	Plug-and-play devices
Advanced Networking	Plug-and-play networks



# Customers takes

We want the best of both worlds in computer systems. We need fast computing on a grid, and we have to be able to dig deep into the system to program our own algorithms. On the other hand, we want a friendly environment where we can easily manage emails, and write presentations and reports. The Mac can do it all.

Steve Cochard, Project Leader, Laboratoire d'Hydraulique Environnementale, EPFL

We need high performance, friendly and reliable computers. I grew up with Linux and UNIX. I like the power those systems provide. The great thing about Apple is that it has a UNIX foundation, but is also much more flexible, and provides fantastic tools.

Felix Naef, Apple Research & Technology Support (ARTS) Laureate '06, EPFL

Now that Apple has moved to Intel processors, we see real opportunities to use the Mac as our main computational engine. Apple is a very nice solution which offers two environments in one system — UNIX processing power and the world of office applications.

Federico Carminati, CERN LHC/ALICE Computing Coordinator





# The Ideal Platform for Scientific Computing

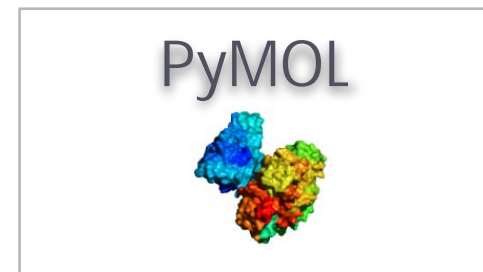
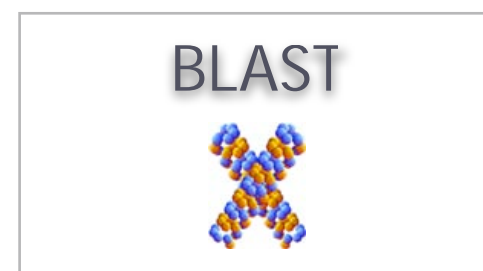
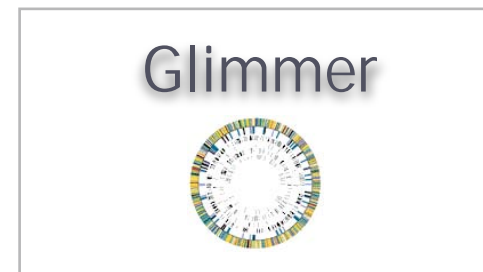
# All the Familiar Tools for the Scientist

For a powerful development platform

Commercial



Open Source



Custom



# IDL The Data Visualization & Analysis Platform

“We have found there is a growing popularity of Mac OS X across a variety of industries for scientific and analysis applications. Providing Mac users with an IDL application that is native to the new Intel architecture, even before some of the standard Mac applications, demonstrates our ongoing commitment to this growing base of IDL users.”



[http://www.itvis.com/idl/mac\\_intel.asp](http://www.itvis.com/idl/mac_intel.asp)

Bill Okubo  
IDL Product Manager





<http://developer.apple.com/business/macmarket/osirix.html>

<http://homepage.mac.com/rossetantoine/osirix/Index2.html>



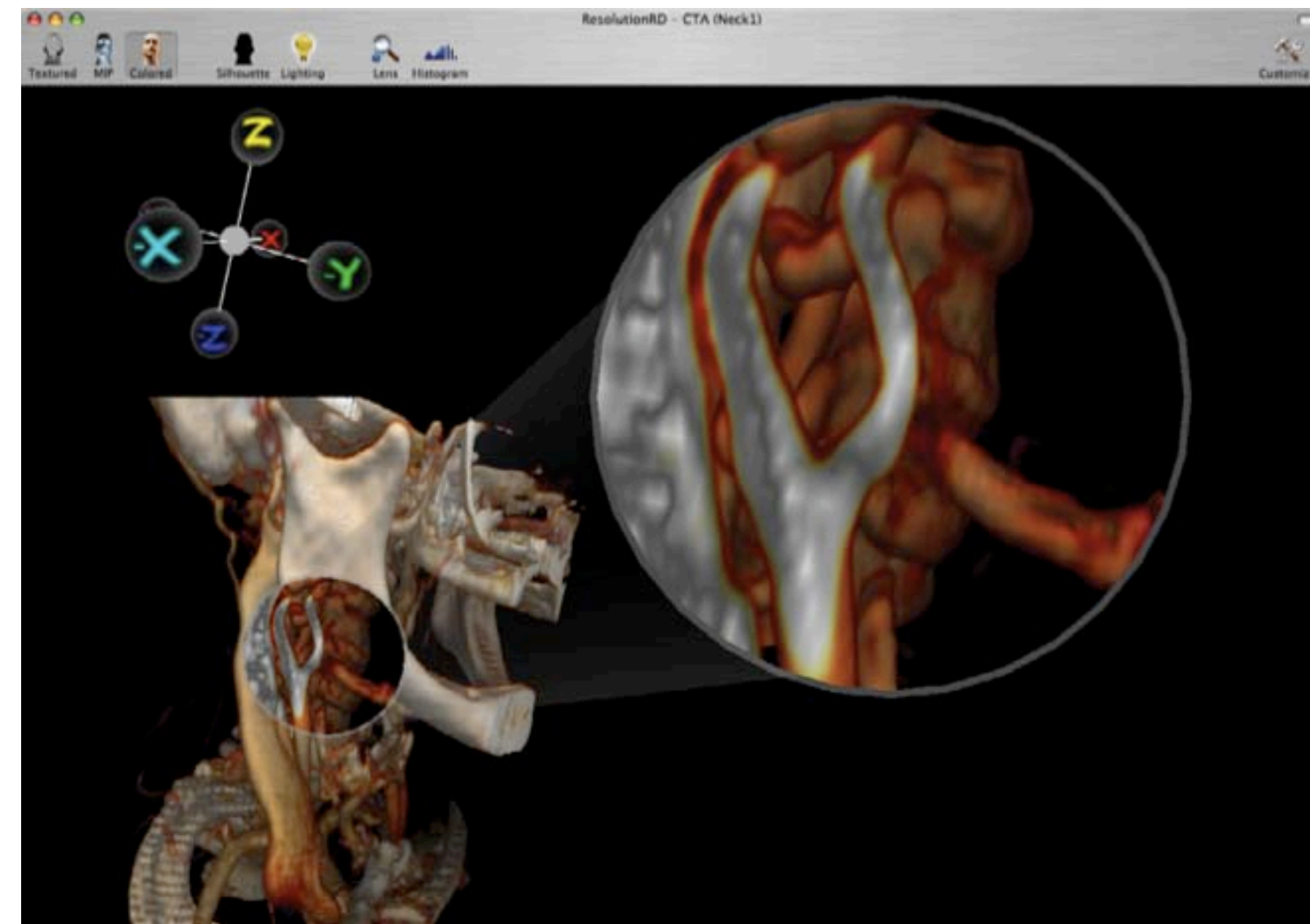
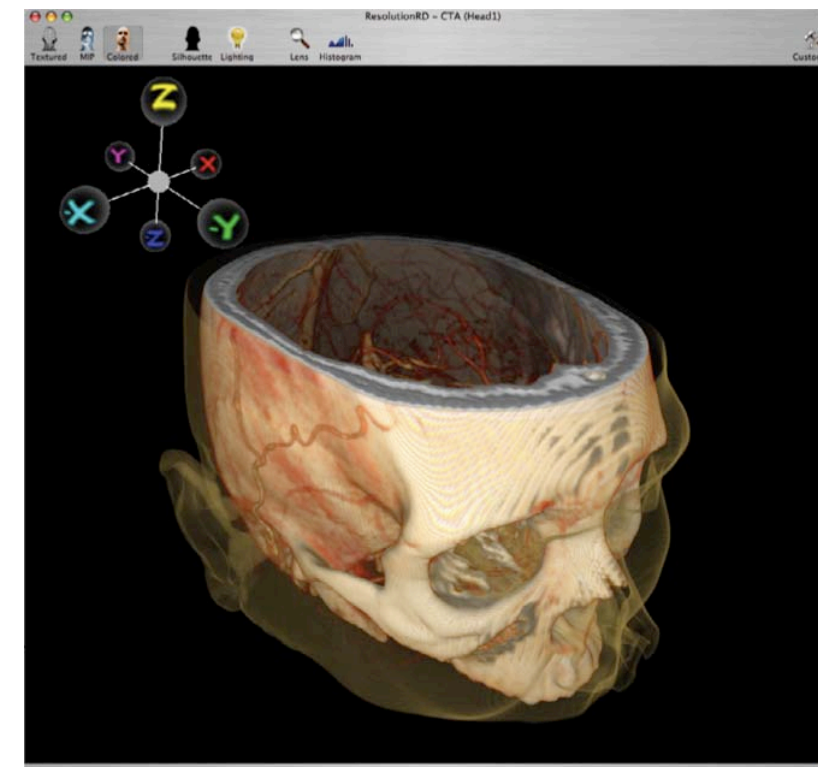


# ResolutionRD™

## Medical Data Interactive 3D

- Real-time, high-quality visualization of large medical image data sets
- Industry first FDA-approved software that delivers 3D volume exploration and analysis tools for medical image data for use on Mac OS X
- 3D data acquired from medical imaging systems including CT, MR, PET and Ultrasound
- View data in RAW, Analyze or TIFF image formats
- Explore in MIP, MPR or full-color shaded or silhouetted for transparency
- Partnership with MacPractice Inc. announced 5th January 2007

Beta program application now



<http://www.apple.com/science/researchsolutions/medicalimaging.html>

<http://www.apple.com/science/casestudy/foothills/>



# A scientists and developers platform

## Integrated development environment

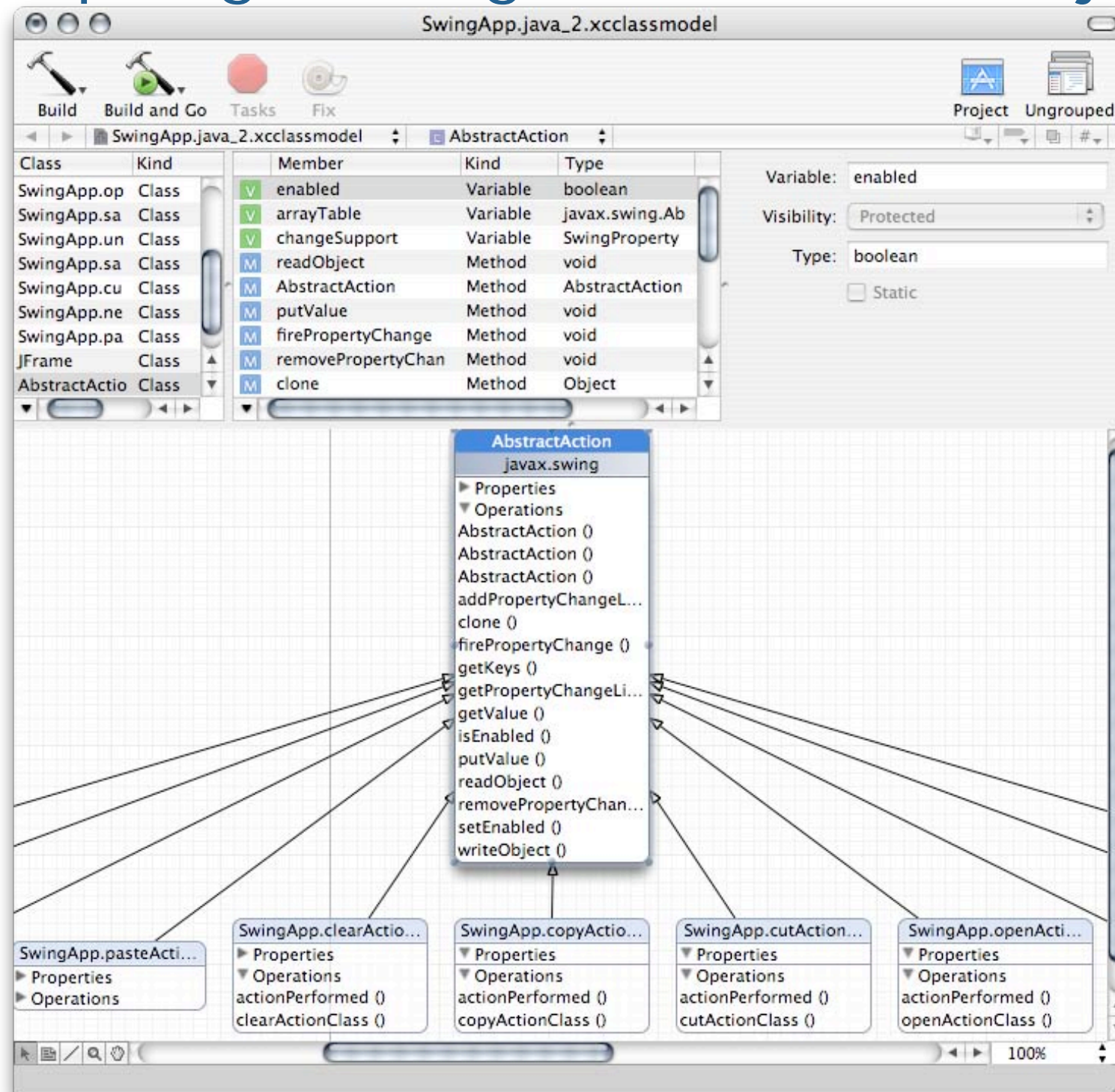
- Xcode - like VisualStudio, kdevelop, Eclipse, etc. Included in Mac OS X
  - Distributed compilation with Zeroconf-Bonjour discovery and use of available Macs on multiple subnets (Dynamic DNS Update) and unicast DNS queries
  - Remote debugging, fix and continue, predictive compilation, distributed builds
- Shark - an impressive profiler. Included in Mac OS X
  - No change to source required in order to profile your code

## Day-to-day tools

- GNU compilers, C, C++, Java, Fortran
- intel sw development products
  - <http://www.intel.com/software/apple>
- a gdb that truly works, cvs, doxygen, perforce, subversion, ...

# Xcode Visualization

Roundtrip engineering for C++, Java, Objective-C





# Shark

Simple (to use) and fast profiling tool for Mac OS X

- Helps you find and fix performance problems
- Works with the language and compiler of your choice
  - C, C++, ObjC, Fortran, Java
  - GCC, CodeWarrior, XLC/XLF, Absoft Fortran, intel ICC
- GUI or scriptable command-line version

CHUD

- <http://developer.apple.com/tools/download/>

Free!



# Getting Started With Shark

With just one click

- Use Start button or hot key to begin profiling
- You're on your way...



# Shark Code Analysis

Annotates code with optimization tips ("!")

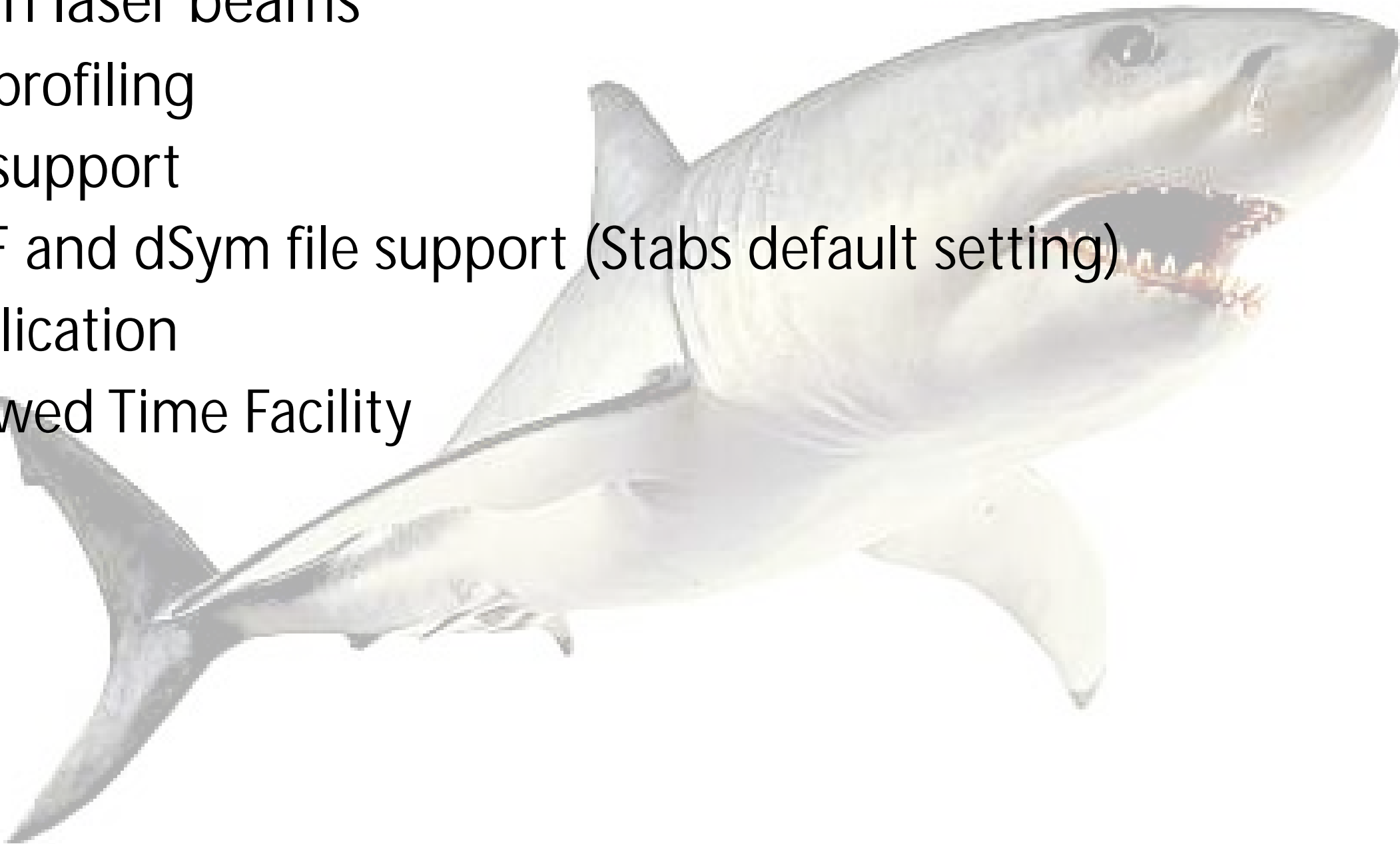
The screenshot shows the Shark Code Analysis tool interface. The title bar reads "Flurry.mshark - Time Profile of Everything [Unknown]". The main window displays a table of code lines with their self-samples, line numbers, code snippets, and optimization tips. The table is as follows:

Self	Line	Code	!	Comment
	256			
0.1%	257	<code>if (s-&gt;p[i].dead.i[k]) {</code>	!	Unroll
	258	<code>continue;</code>		
	259	<code>}</code>		
0.4%	260	<code>deltax = s-&gt;p[i].delta[0].f[k];</code>		
	261	<code>deltay = s-&gt;p[i].delta[1].f[k];</code>		
	262	<code>deltaz = s-&gt;p[i].delta[2].f[k];</code>		
	263			
3.5%	264	<code>for(j=0;j&lt;info-&gt;numStreams;j++)_ {</code>	!	FP precision conv, FP div
18.4%	265	<code>dx = s-&gt;p[i].position[0].f[k] - info-&gt;s...</code>	!	Unroll, AltiVec, Unali...
	266	<code>dy = s-&gt;p[i].position[1].f[k] - info-&gt;s...</code>		
0.8%	267	<code>dz = s-&gt;p[i].position[2].f[k] - info-&gt;s...</code>		
	268	<code>rsquared = (dx*dx+dy*dy+dz*dz);</code>		
	269			
14.2%	270	<code>f = (gravity/rsquared) * frameRateModifier;</code>	!	FP div
1.8%	271	<code>if (((i*4)+k) % info-&gt;numStreams) == j) {</code>	!	Int div
1.9%	272	<code>f *= 1.0f + streamBias;</code>		
	273	<code>}</code>		
55.6%	274	<code>mag = f / (float) sqrt(rsquared);</code>		
	275			
	276	<code>deltax -= (dx * mag);</code>		
	277	<code>deltay -= (dy * mag);</code>		
	278	<code>deltaz -= (dz * mag);</code>		
	279	<code>}</code>		

At the bottom of the window, it shows "222 of 1567 (14.2%) self samples, 1 of 1546 (0.1%) lines selected". The file path is "(100.0%) Smoke.c" and the function is "UpdateSmoke\_ScalarBase()".

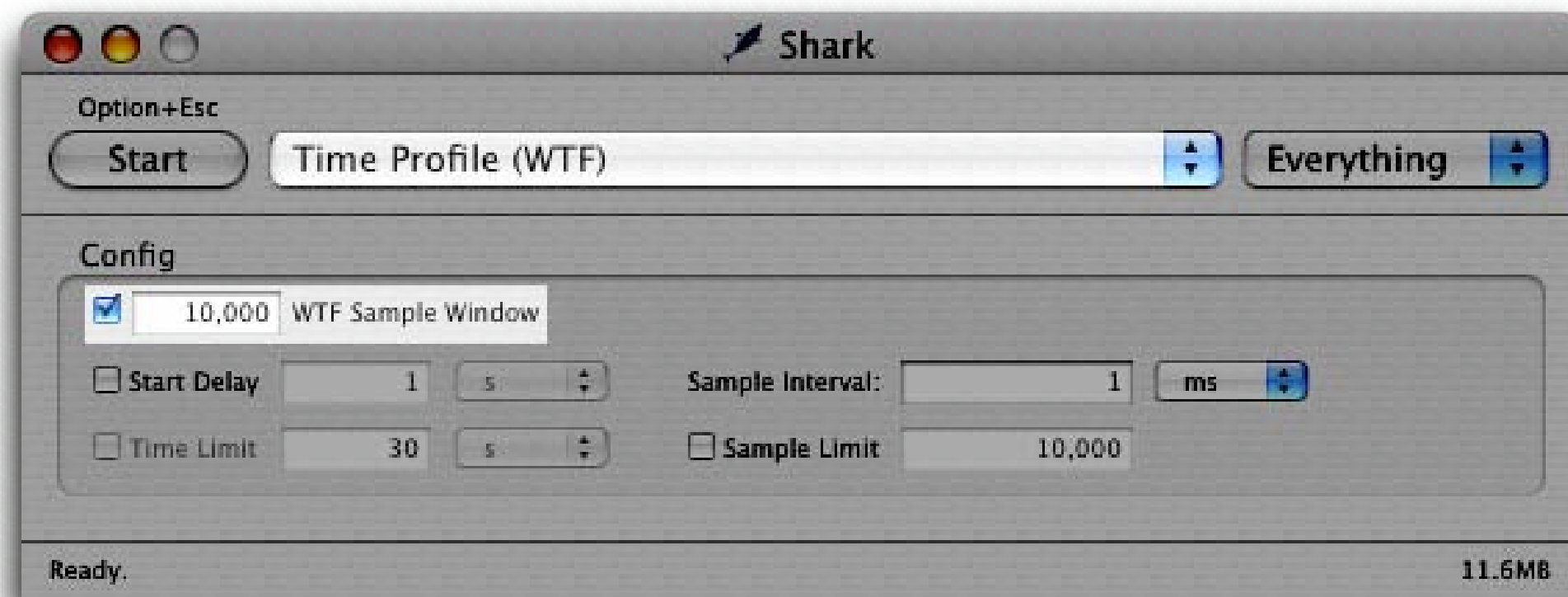
# What Is New?

- Now with laser beams
  - 64-bit profiling
  - UTF-8 support
  - DWARF and dSym file support (Stabs default setting)
  - Symbolication
  - Windowed Time Facility



# Windowed Time Facility (WTF)

- What just happened?
  - Profile hard to repeat events
  - Time Profile or System Trace



# Some additional plusses

Did I mention Open Source yet? [www.opensource.apple.com](http://www.opensource.apple.com)

- OpenSource repositories
  - [fink.sourceforge.net](http://fink.sourceforge.net)
  - New community: “Mac OS Forge” [www.macosforge.org](http://www.macosforge.org)
- GRID
  - [hpc.sourceforge.net](http://hpc.sourceforge.net) [www.nsf-middleware.org/Lists/NMIR8/grids.aspx](http://www.nsf-middleware.org/Lists/NMIR8/grids.aspx)
  - Globus, PyGlobus, MPICH-G2, Octave, Condor, LAM MPI, LSCdataFind, ..

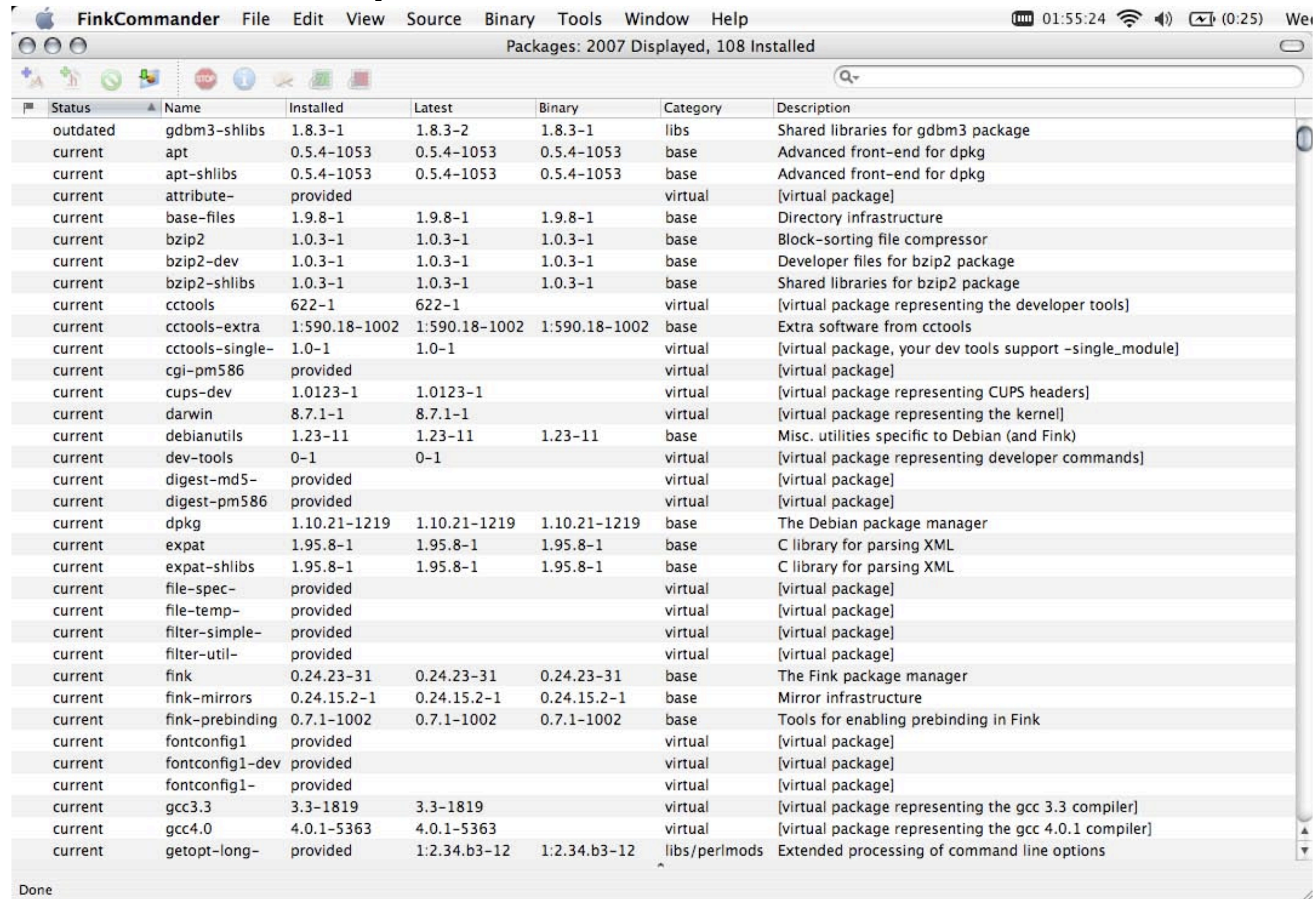
## Multiple OpenSource projects

- Kernel sources (intel & PowerPC)
- Apache-Licensed source code available
  - Bonjour, Launchd and Darwin Calendaring Server
- ...





# Fink Open Source Distribution



The screenshot shows the Fink Commander application window. The title bar reads "FinkCommander" and the menu bar includes "File", "Edit", "View", "Source", "Binary", "Tools", "Window", and "Help". The status bar at the top right shows the time "01:55:24" and other system icons. Below the title bar, a subtitle indicates "Packages: 2007 Displayed, 108 Installed". The main content area is a table with the following columns: Status, Name, Installed, Latest, Binary, Category, and Description. The table lists various packages such as gdbm3-shlibs, apt, apt-shlibs, attribute-, base-files, bzip2, bzip2-dev, bzip2-shlibs, cctools, cctools-extra, cctools-single-, cgi-pm586, cups-dev, darwin, debianutils, dev-tools, digest-md5-, digest-pm586, dpkg, expat, expat-shlibs, file-spec-, file-temp-, filter-simple-, filter-util-, fink, fink-mirrors, fink-prebinding, fontconfig1, fontconfig1-dev, fontconfig1-, gcc3.3, gcc4.0, and getopt-long-. The status of each package is indicated in the "Status" column, with "current" being the most common. The "Description" column provides a brief explanation of each package's function.

Status	Name	Installed	Latest	Binary	Category	Description
outdated	gdbm3-shlibs	1.8.3-1	1.8.3-2	1.8.3-1	libs	Shared libraries for gdbm3 package
current	apt	0.5.4-1053	0.5.4-1053	0.5.4-1053	base	Advanced front-end for dpkg
current	apt-shlibs	0.5.4-1053	0.5.4-1053	0.5.4-1053	base	Advanced front-end for dpkg
current	attribute-	provided			virtual	[virtual package]
current	base-files	1.9.8-1	1.9.8-1	1.9.8-1	base	Directory infrastructure
current	bzip2	1.0.3-1	1.0.3-1	1.0.3-1	base	Block-sorting file compressor
current	bzip2-dev	1.0.3-1	1.0.3-1	1.0.3-1	base	Developer files for bzip2 package
current	bzip2-shlibs	1.0.3-1	1.0.3-1	1.0.3-1	base	Shared libraries for bzip2 package
current	cctools	622-1	622-1		virtual	[virtual package representing the developer tools]
current	cctools-extra	1:590.18-1002	1:590.18-1002	1:590.18-1002	base	Extra software from cctools
current	cctools-single-	1.0-1	1.0-1		virtual	[virtual package, your dev tools support -single_module]
current	cgi-pm586	provided			virtual	[virtual package]
current	cups-dev	1.0123-1	1.0123-1		virtual	[virtual package representing CUPS headers]
current	darwin	8.7.1-1	8.7.1-1		virtual	[virtual package representing the kernel]
current	debianutils	1.23-11	1.23-11	1.23-11	base	Misc. utilities specific to Debian (and Fink)
current	dev-tools	0-1	0-1		virtual	[virtual package representing developer commands]
current	digest-md5-	provided			virtual	[virtual package]
current	digest-pm586	provided			virtual	[virtual package]
current	dpkg	1.10.21-1219	1.10.21-1219	1.10.21-1219	base	The Debian package manager
current	expat	1.95.8-1	1.95.8-1	1.95.8-1	base	C library for parsing XML
current	expat-shlibs	1.95.8-1	1.95.8-1	1.95.8-1	base	C library for parsing XML
current	file-spec-	provided			virtual	[virtual package]
current	file-temp-	provided			virtual	[virtual package]
current	filter-simple-	provided			virtual	[virtual package]
current	filter-util-	provided			virtual	[virtual package]
current	fink	0.24.23-31	0.24.23-31	0.24.23-31	base	The Fink package manager
current	fink-mirrors	0.24.15.2-1	0.24.15.2-1	0.24.15.2-1	base	Mirror infrastructure
current	fink-prebinding	0.7.1-1002	0.7.1-1002	0.7.1-1002	base	Tools for enabling prebinding in Fink
current	fontconfig1	provided			virtual	[virtual package]
current	fontconfig1-dev	provided			virtual	[virtual package]
current	fontconfig1-	provided			virtual	[virtual package]
current	gcc3.3	3.3-1819	3.3-1819		virtual	[virtual package representing the gcc 3.3 compiler]
current	gcc4.0	4.0.1-5363	4.0.1-5363		virtual	[virtual package representing the gcc 4.0.1 compiler]
current	getopt-long-	provided	1:2.34.b3-12	1:2.34.b3-12	libs/perlmods	Extended processing of command line options

[fink.sourceforge.net](http://fink.sourceforge.net)



Dr Massimo Marino, marino.m@euro.apple.com



# Intel Compilers and Performance Libraries

# Compilers Available on Mac OS X

- Intel Architecture
  - IDEs
    - Xcode
    - Eclipse
  - Compilers
    - Apple's GCC compilers (32-bit and 64-bit)
    - Intel's C++ and Fortran Compilers v9.1
    - Intel's C++ and Fortran Compiler v10.0 beta (32-bit and 64-bit)
    - Absoft's Pro Fortran Compiler Suite v9.2



# Intel C++ and Fortran Compilers for Mac OS X

## Support

- ANSI/ISO C/C++ compatible
- Support for FORTRAN 77, 90, and 95
  - some Fortran 2000, 2003 features
- Supports for common extensions



# Intel C++ and Fortran Compilers for Mac OS X

## Key Performance Features

- Auto-vectorization
- Auto-parallelization
- OpenMP
- Whole program analysis and inter-procedural analysis (IPO)
- Profile-guided optimization
- FP-precision model for "strict", "precise", "fast", "except"



# Intel C++ and Fortran Compilers for Mac OS X

## Compatibility

- Source, binary compatibility with GCC/G++ compiler
- No support for Objective-C, but binary compatible
- Universal binaries from either Xcode or lipo



# Intel C++ and Fortran Compilers for Mac OS X

## Xcode IDE integration

- Integrates with Xcode 2.3 and later
- Requires MacOSX 10.4.4 or better
- Full integration for C++ compiler
- Fortran compiler integration is a preview feature

30-day Evaluation Copy





# Intel C++ and Fortran Compiler on Mac OS X

- Version 10.0 Beta
  - Supports 32-bit and 64-bit binaries
  - High Performance Optimizer (New parallelizer and vectorizer)
  - New C++ exception handling
  - Better C++ diagnostics
  - Integration into Eclipse v3.1
  - Static verifier for OpenMP



# Intel Performance Libraries

- Intel Math Kernel Library (Intel MKL)
  - Optimized functions for scientific, engineering, financial applications
  - BLAS levels 1, 2, 3 and LAPACK
  - Sparse solvers, FFTs, vector math
  - Random number generators
- Intel Integrated Performance Primitives (Intel IPP)
  - Image processing and computer vision
  - Digital signal processing
  - Data compression and cryptography
  - Video/audio/speech coding
  - Speech recognition



# Cluster-ready architecture

# Built-in “gridification”

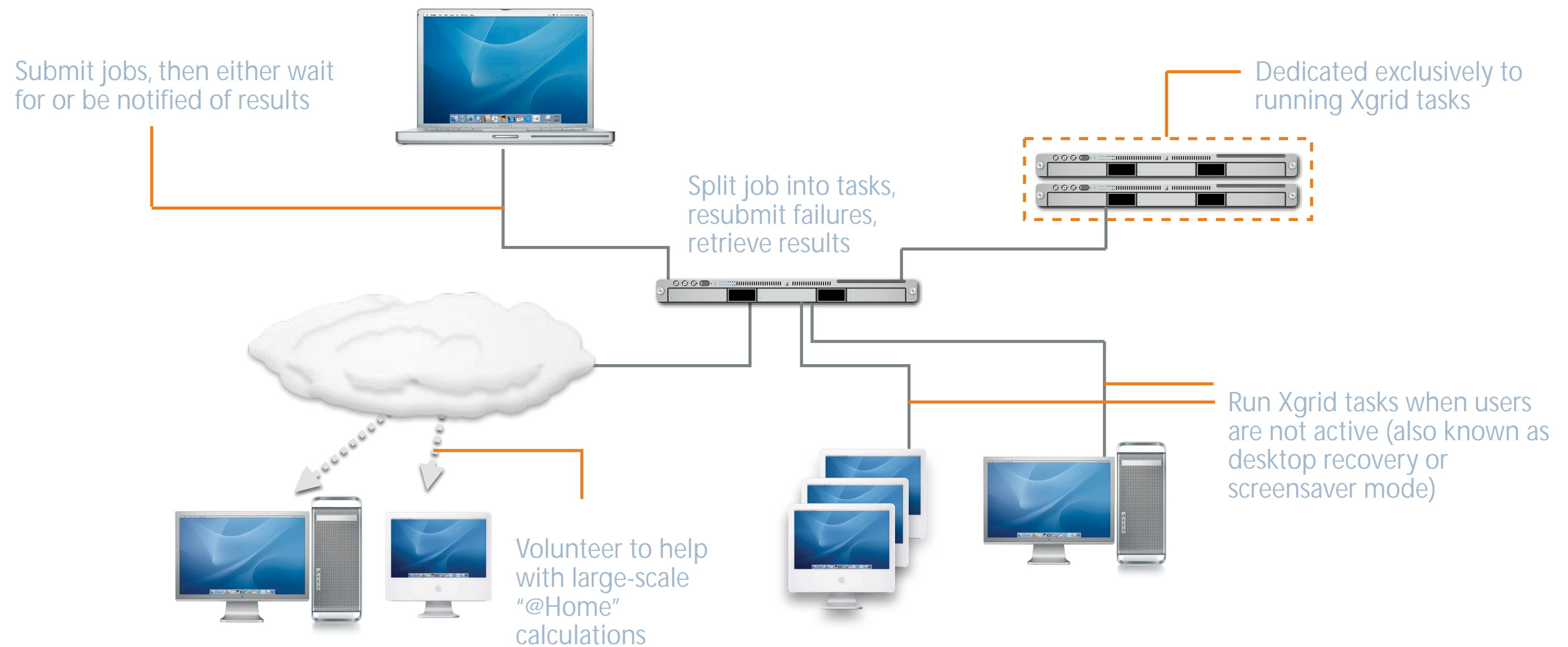
## Apple Xgrid - Distributed computing the easy way

- Cluster-ready architecture
  - fast easy configuration
  - accessible to non IT specialists
- Harness computing power across the network
- Bonjour and DNS lookups support
  - automatic agents/clients/controllers/ discovery
- Both local and remote users
- XML-based open protocol for network comms
- Fault-tolerance features
- Kerberized access



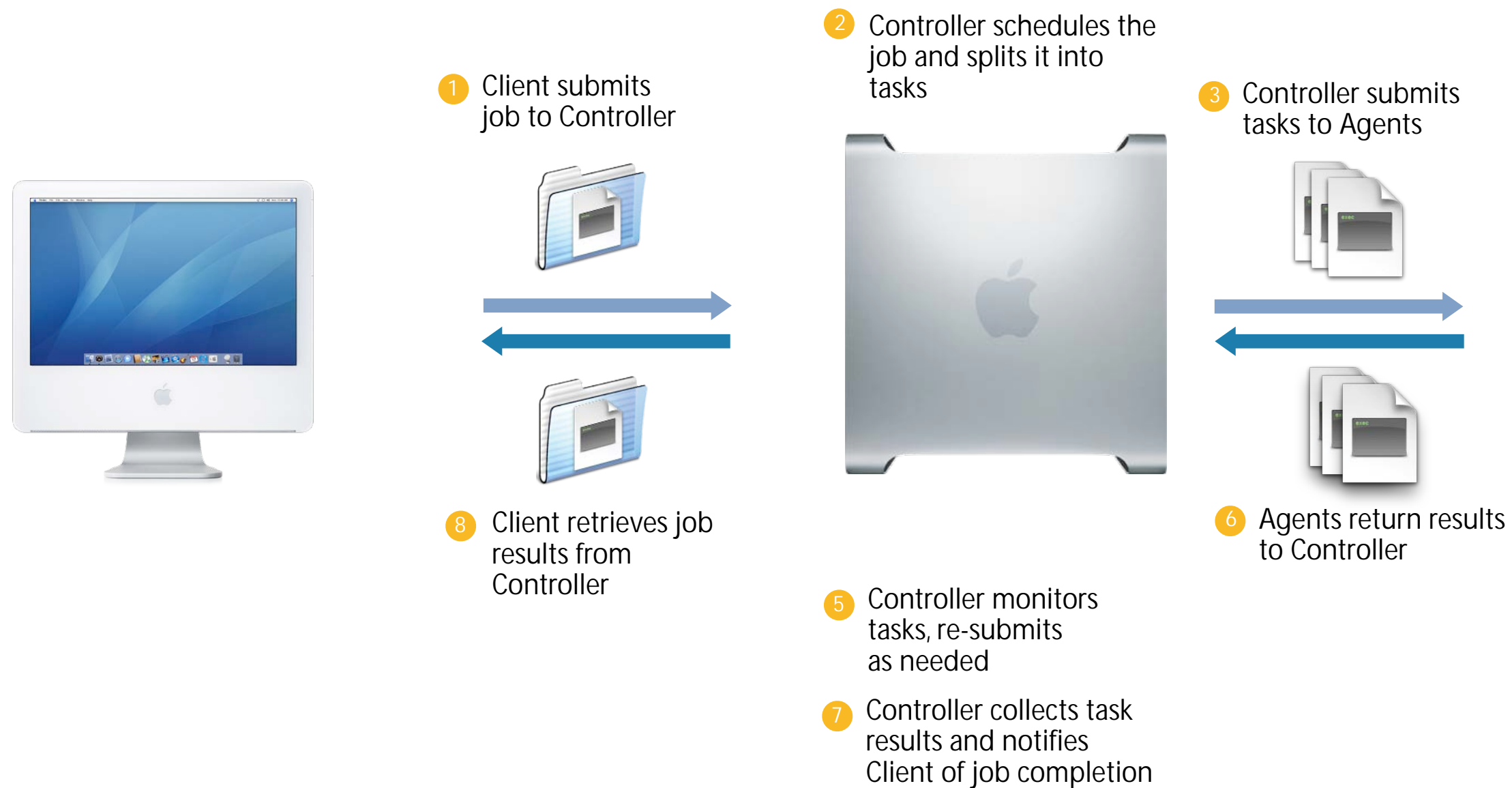
# Three Tier Architecture - Xgrid 1.0

- Client, Controller, and Agent



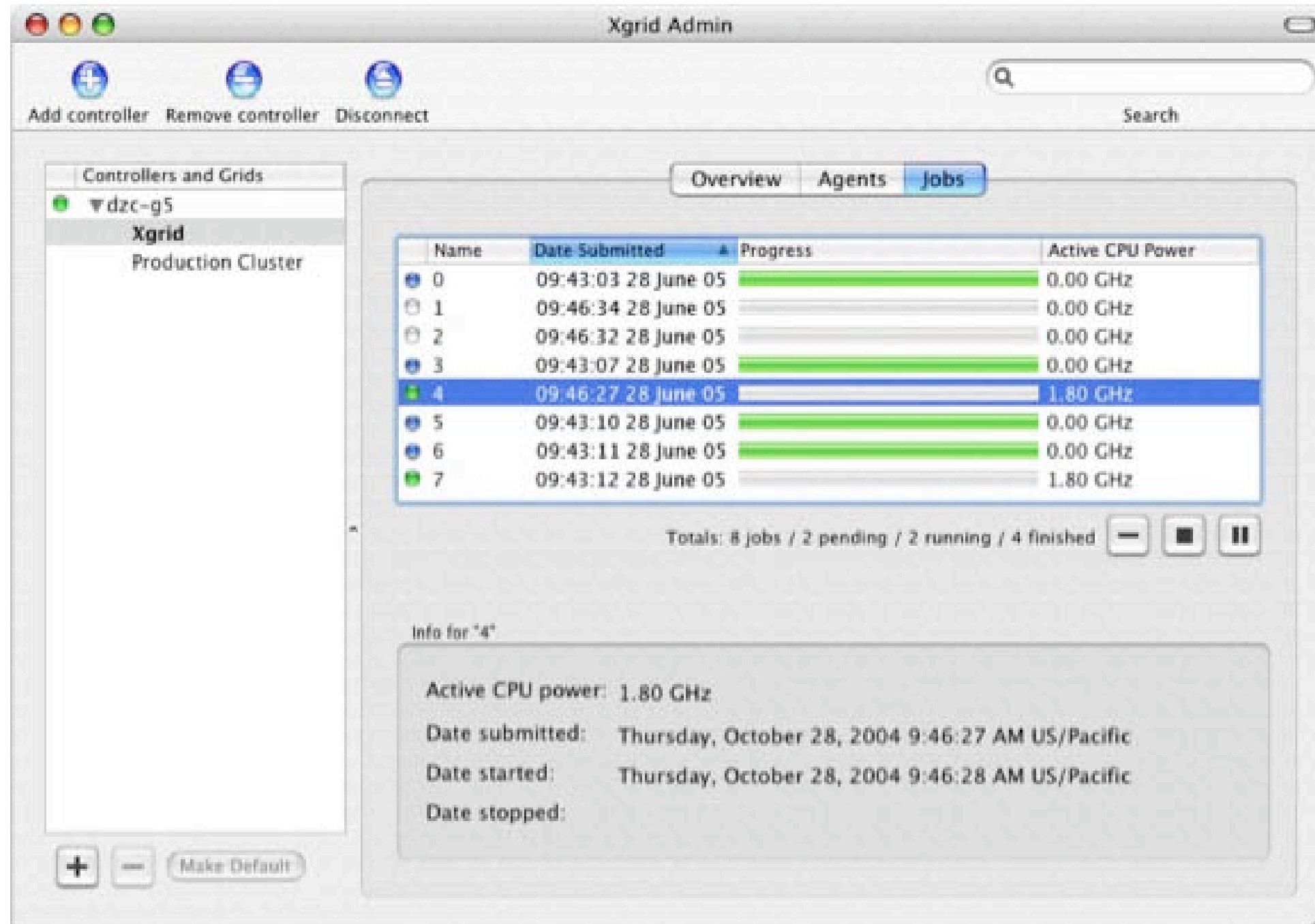
# Xgrid Workflow

- Submit, Monitor, and Retrieve





# Xgrid Admin



The screenshot shows the Xgrid Admin application window. At the top, there are three buttons: "Add controller", "Remove controller", and "Disconnect". A search bar is located on the right. The main area is divided into two panes. The left pane, titled "Controllers and Grids", shows a tree view with "dzc-g5" expanded to show "Xgrid" and "Production Cluster". The right pane has tabs for "Overview", "Agents", and "Jobs". The "Jobs" tab is active, displaying a table of jobs. Below the table, there is a summary: "Totals: 8 jobs / 2 pending / 2 running / 4 finished" and a "Make Default" button. A detailed view for job "4" is shown below, including its active CPU power and submission times.

Name	Date Submitted	Progress	Active CPU Power
0	09:43:03 28 June 05	<div style="width: 100%;"></div>	0.00 GHz
1	09:46:34 28 June 05	<div style="width: 0%;"></div>	0.00 GHz
2	09:46:32 28 June 05	<div style="width: 0%;"></div>	0.00 GHz
3	09:43:07 28 June 05	<div style="width: 100%;"></div>	0.00 GHz
4	09:46:27 28 June 05	<div style="width: 0%;"></div>	1.80 GHz
5	09:43:10 28 June 05	<div style="width: 100%;"></div>	0.00 GHz
6	09:43:11 28 June 05	<div style="width: 100%;"></div>	0.00 GHz
7	09:43:12 28 June 05	<div style="width: 0%;"></div>	1.80 GHz

Totals: 8 jobs / 2 pending / 2 running / 4 finished

Info for "4"

Active CPU power: 1.80 GHz  
Date submitted: Thursday, October 28, 2004 9:46:27 AM US/Pacific  
Date started: Thursday, October 28, 2004 9:46:28 AM US/Pacific  
Date stopped:



# Available MPI Software for Mac OS X

## Best implementations

- Argonne National Labs
  - MPICH-1.2.7
  - Myrinet enabled: MPICH-GM, MPICH-MX
  - Infiniband enabled MVAPICH
  - New: MPICH-2.1—the latest from Argonne
- LAM/MPI
  - Includes native Myrinet and InfiniBand support
- Open MPI
  - Joint venture by LANL, Oak Ridge, HLR Stuttgart, ICL/UT, Livermore, ZIH Dresden, Sandia, ...
  - Is Xgrid enabled
  - Includes native Myrinet and InfiniBand support



# Resources

- Apple Computing Group
  - <http://www.apple.com/acg/xgrid>
- High Performance Computing
  - <http://developer.apple.com/hardwaredrivers/hpc/>
- HPC Solutions
  - <http://www.apple.com/science/researchsolutions/clustercomputing.html>
- HPC External Link
  - <http://hpc.sourceforge.net>



In the real world



## Xgrid@Stanford Widget

front



back



Running on a cluster of more than 500 computers connected to the internet somewhere in the world. 200 on average connected continuously. "This allows us to run a calculation in 1 week instead of a year!! The cluster is happily running past 200GHz" - Universal binary available

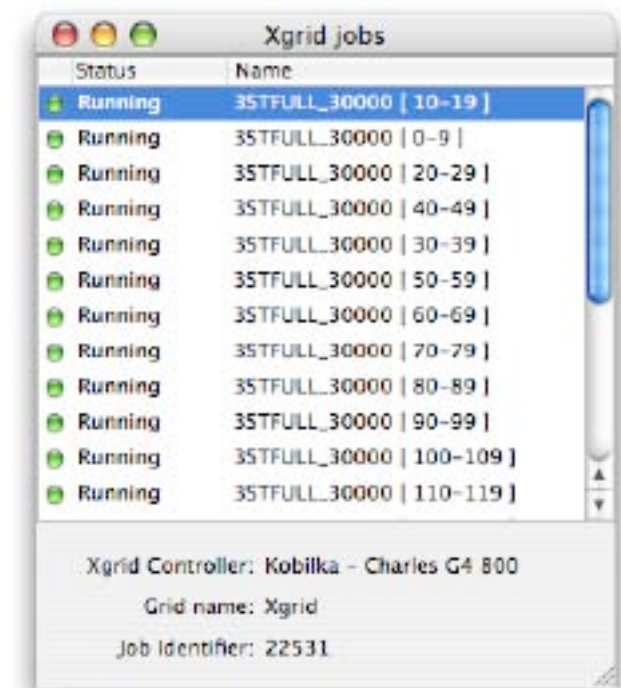
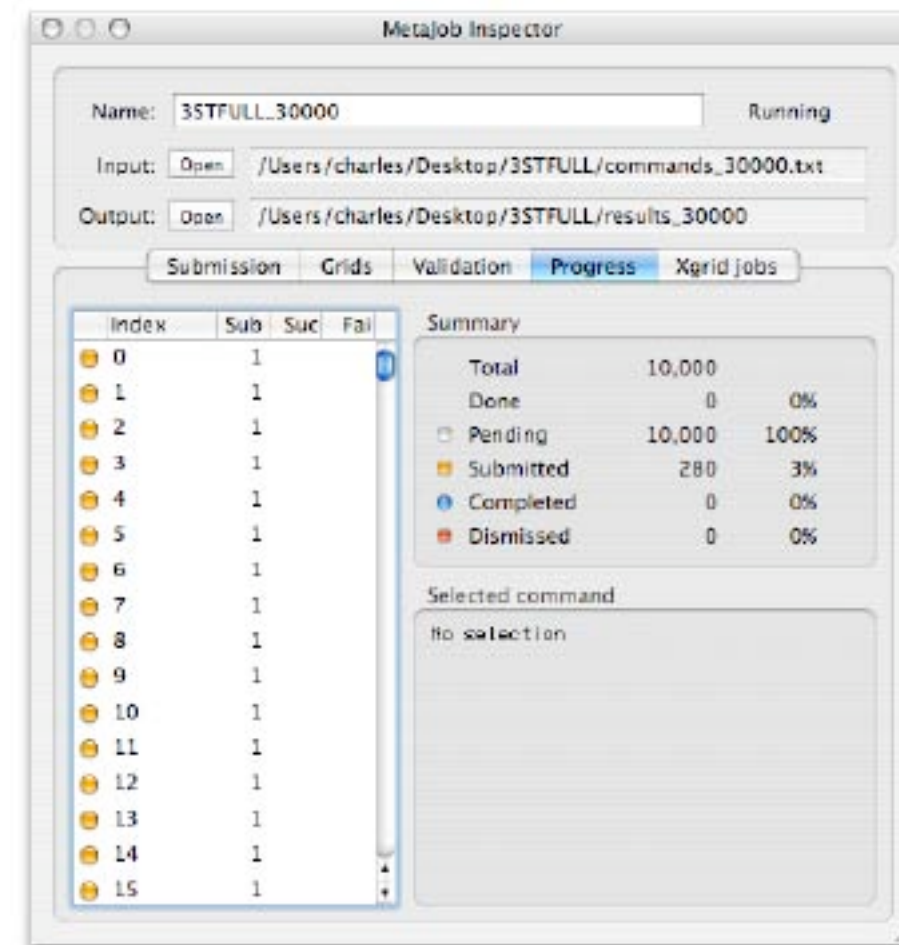
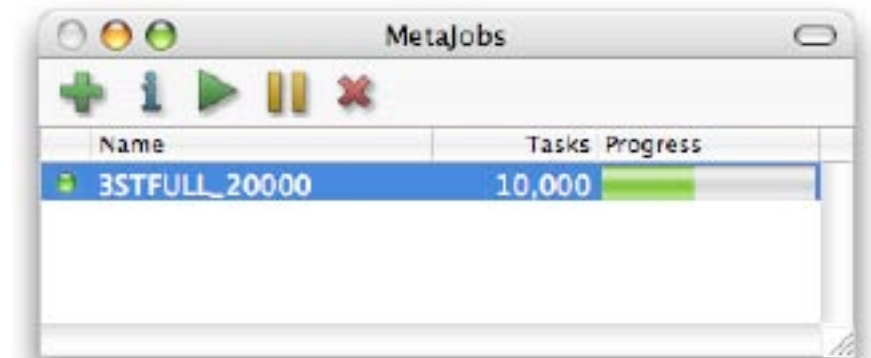
<http://cmgm.stanford.edu/~cparnot/xgrid-stanford/>  
<http://www.mekentosj.com/widgets/xgrid/>







- Gridstuffer
  - Cocoa application to submit multi-task jobs
    - add MetaJob concept
      - several Xgrid tasks combined
      - tasks can run several times
      - be validated
      - rescheduled on failure
      - ...
  - GUI based
  - Uses Core Data to store jobs info
    - Can restart between reboots



<http://cmgm.stanford.edu/~cparnot/xgrid-stanford/html/goodies/GridStuffer-info.html>



# Xgrid RL examples

- Spatial biogeochemical modeling and sensitivity analysis: University of Wisconsin
- Natural Language Processing
- Cryptography and Monte Carlo molecular transport
- Black Hole Astrophysics & Quantum Cosmology - UMass, Dartmouth
- Low autocorrelation binary sequences - Fraser University, Burnaby, British Columbia
- XGrid BLAST - Genentech
- "Jet3D": Jet noise prediction code - NASA Langley Research Center, Hampton, Va.
- Military command and control research - Australian Department of Defence
- AstroVision's Xgrid enabled cluster - live satellite image processing
- Numerical relativity, fluid dynamics and scientific visualization - Nemeaux Xgrid cluster, LSU
- OpenMacGrid - over 1THz (1,000GHz) reached. Open to everyone. Macresearch.org

Google: about 150,000 for "Xgrid research" - about 411,000 for "Xgrid"



# KDSI Kentucky Grid

## Lowering the technology barrier

- Kentucky Datastream Initiative (KDSI)
    - First such collaboration between K-12 schools and a university lab in the U.S.
    - Goal: over 5000 Mac platforms at schools. 2600+ so far participating already.
    - Supported by dedicated Apple back-end systems
    - Mac OS X (client & Server), Xserve, Xgrid
    - Dedicated to cancer research
      - James Graham Brown Cancer Center @ University of Louisville
    - Machines are used 24/7 with no special IT infrastructure but school's own
- "We've reduced data processing jobs that used to take 50 years of CPU time down to 20 days — and we're speeding up our drug discovery by orders of magnitude."

Dr. John Trent, Director of Molecular Modeling and Associate Professor, Departments of Medicine, Biochemistry, and Molecular Biology, and Chemistry; James Graham Brown Cancer Center.

[www.apple.com/education/profiles/louisville/index.html](http://www.apple.com/education/profiles/louisville/index.html)



# Distributed Data Analysis with PROOF

Apple Xserve G5/Intel Cluster - LHC/Alice collaboration

- Parallel event based data analysis on large heterogeneous clusters
- Pull architecture for efficient load balancing
- Low communication overhead, highly parallel
- Integral component of the ROOT system
  - <http://root.cern.ch>

ROOT

An Object-Oriented  
Data Analysis Framework



Call for proposals



Apple solutions in ALICE experiment at CERN

Apple Research & Technology Support

ARTS Laureate - A Window of Science Research Opportunity



<http://www.apple.com/uk/education/profiles/cern/>

Courtesy: Fons Rademakers - CERN/LHC-ALICE





# Apple and Supercomputing

## Pushing the envelope



Virginia Polytechnic Institute and State University





# UCLA Dawson Project

## Plasma Physics Group

- Many platforms evaluated
- 256 DP Xserves G5, Cisco 6500 Gigabit switch and Pooch Pro from Dauger Research
  - 4.403 Tflops/s Rpeak
  - over 2 Tflop/s Rmax\*
  - most efficient supercomputer in the Top500 list at first benchmark
    - 9.6 Gflops per unit (first 128 units)
- Largest cluster at UCLA

\* Linpack benchmark



# Illinois Turing 1536 CPU cluster

Computational Science and Engineering department





# MACH 5

## Multiple Advanced Computer for Hypersonics



Left to right: Senior Scientist Dr. John Medeiros, Program Manager Mike Whitlock and Project Engineer Jeff Highfield

- 25+ Tflop/s
- 3132 CPUs
- Lowest power and HVAC demands

<http://www.apple.com/science/profiles/colsa/>



# GLOW - Grid Laboratory of Wisconsin

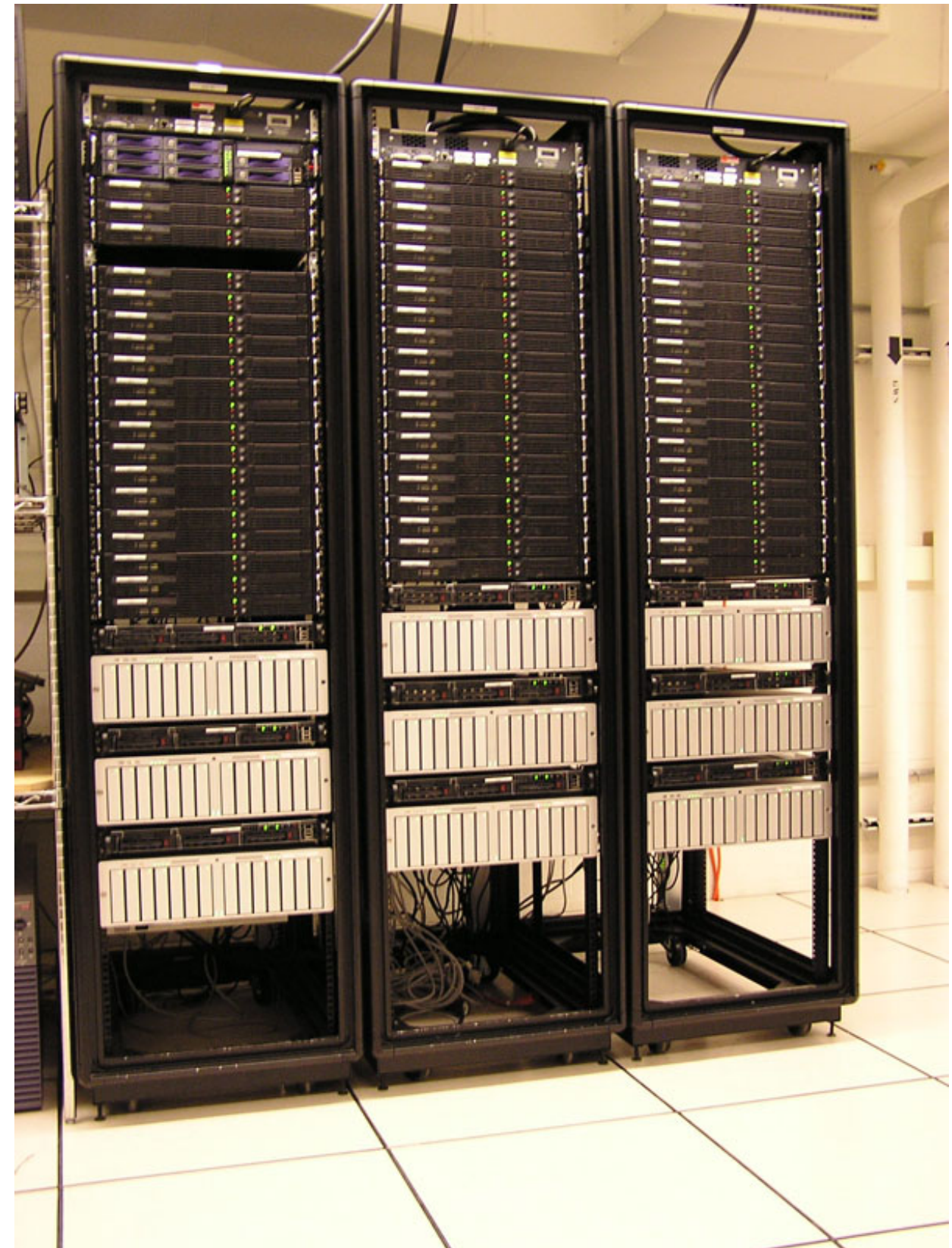
~200TB Xserve RAID storage array

- or 2.75 years of high definition video, 25,000 full length DVD movies, 323,000 CDs, 20 printed collections of the Library of Congress
- Xserve RAIDs attached to a dedicated Linux nodes running Fedora Core via an Apple Fibre Channel PCI-X Card
- holding area for large amounts of data from experiments such as the Compact Muon Solenoid (CMS) and ATLAS experiments at the Large Hadron Collider (LHC) at CERN.





# GLOW - Grid Laboratory of Wisconsin





# University of California, Irvine

## HIPerWall - New Vistas in Scientific Visualization

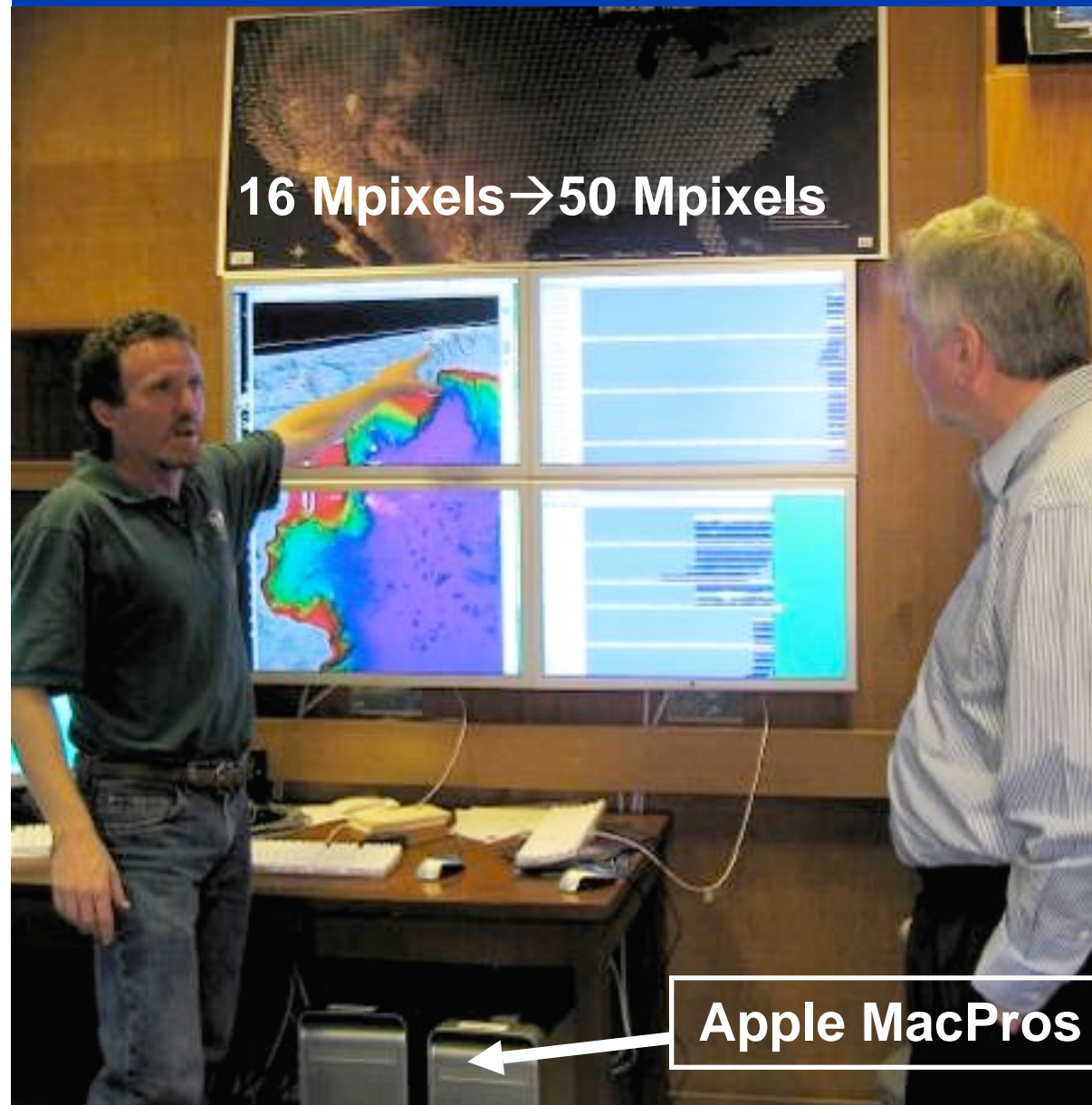
The fifty 30-inch Apple Cinema Displays yield a total display resolution of 200 megapixels, breaking the previous 100-megapixel world record — by doubling it - and approximately ten times the resolution of typical tiled displays.



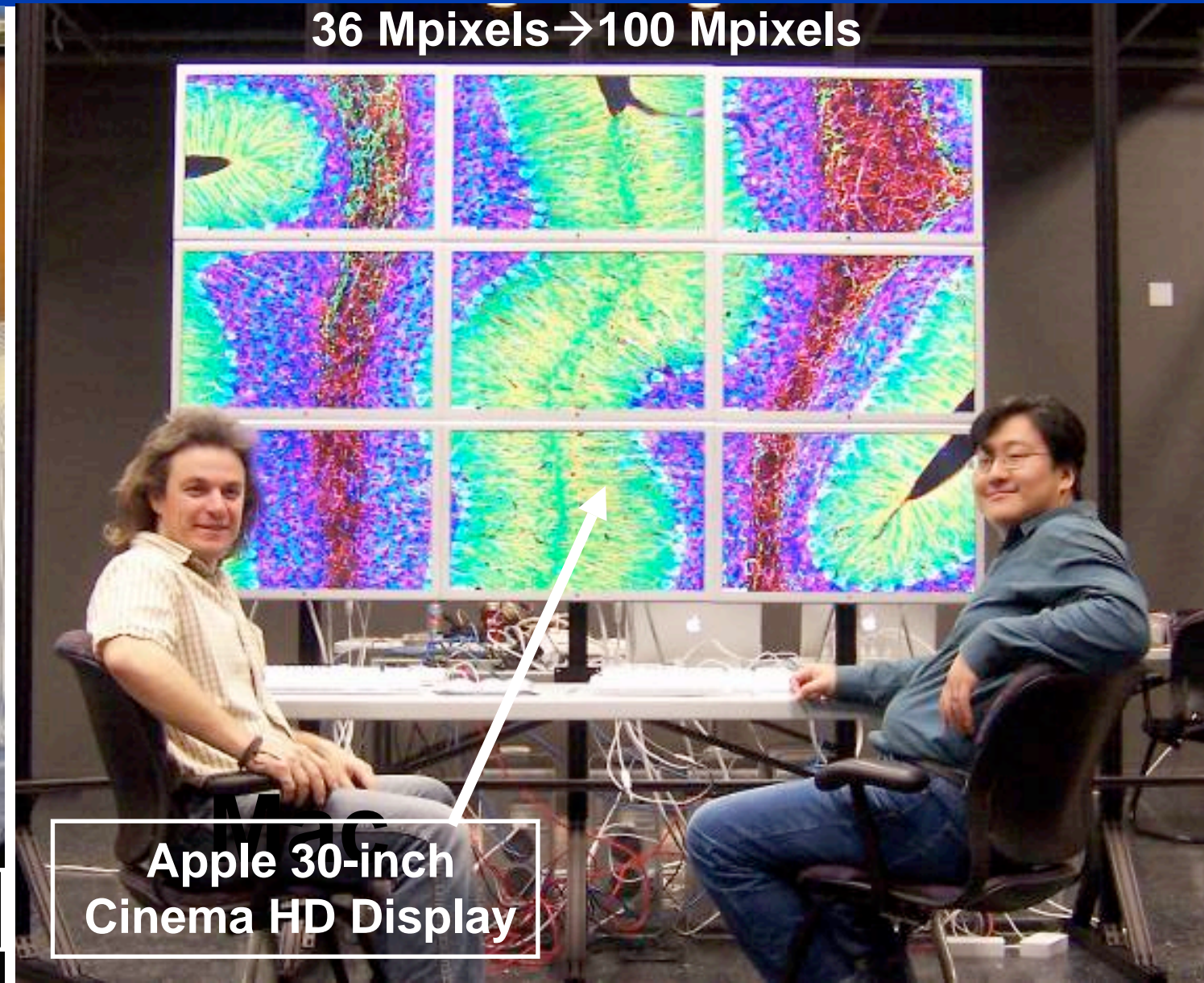
Team member Frank Wessel sums up: "The decision to adopt the Mac platform was based on many factors that included the form factor and resolution of the Apple Cinema Displays, a robust UNIX-based operating system that was tightly integrated with open source components, and the ease of administration and use." - <http://www.apple.com/science/profiles/hiperwall/>



# OptIPuter Scalable Displays Have Been Extended to Apple-Based Systems “iWall Driven by iCluster”



Source: Atul Nayak, SIO  
Collaboration of  
Calit2/SIO/OptIPuter/USArray



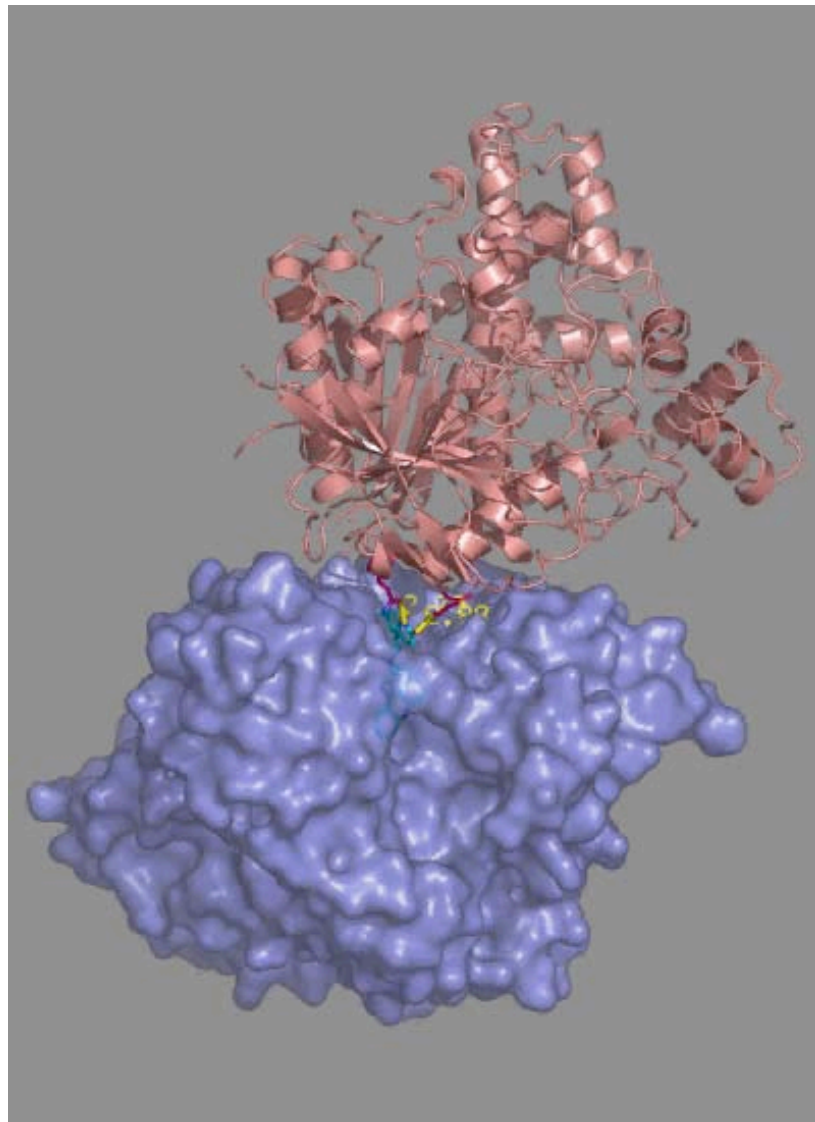
Source: Falko Kuester, Calit2@UCI  
NSF Infrastructure Grant



See GEON Poster: iCluster : Visualizing USArray Data on a Scalable High Resolution Tiled Display Using the OptIPuter







The 3D Theater enables researchers not only to view, in three dimensions, the details of key biological molecules such as proteins and nucleic acids, but even more importantly, to manipulate and design into these molecules lead compounds which hold potential as drug-based therapies for a wide range of disease

- Mac Pro Quad Xeon
- NVIDIA Quadro FX 4500 graphics card
- DLP Projector

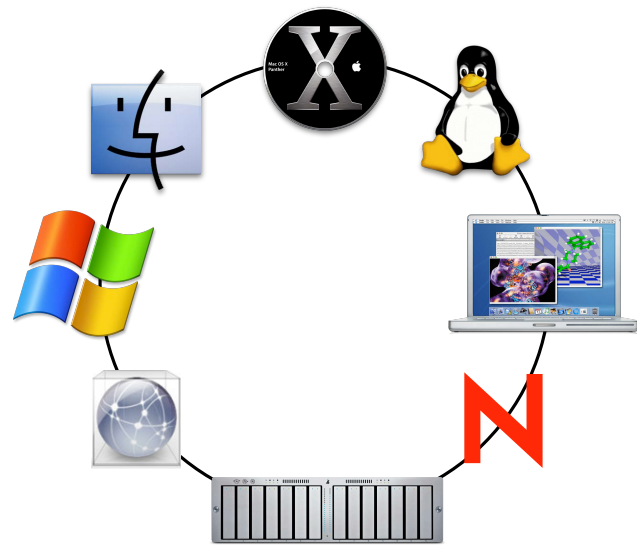


According to Professor Joel Sussman, from the Department of Structural Biology: "This is the only one of its kind available in an academic institution in Europe, and, in terms of performance, one of the top ones in the world. Seeing these structures moving and breathing in 3D helps us apply our very different perspectives, modify the structure images in real time, and test our hypotheses. We now use Apple for all aspects of X-ray data collection and analysis."

The Jean Goldwurm 3D Visualization Theatre was conceived and implemented by [Joel L. Sussman](#), [Harry M. Greenblatt](#), [Michael Elbaum](#) and [Sharon Wolf](#), all of the Weizmann Institute's [Faculty of Chemistry](#).

# The Ideal Computing Platform

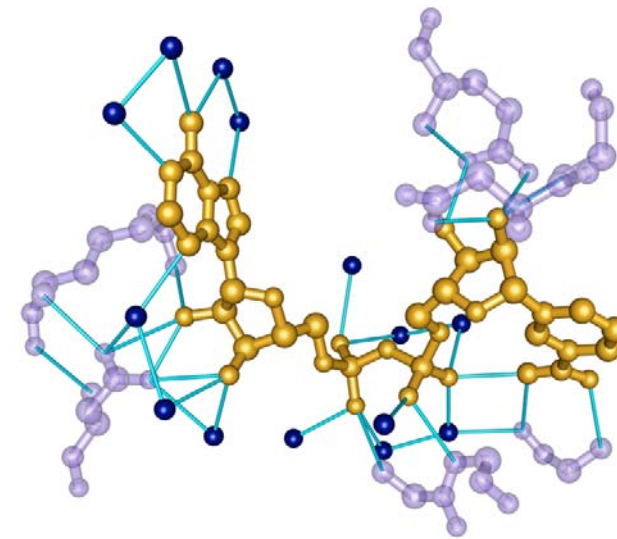
Addresses key workflow and research needs



Platform proliferation and interoperability, a true multi-OS platform



Applications availability and compatibility



Increasing volume and complexity of data



Shrinking budgets

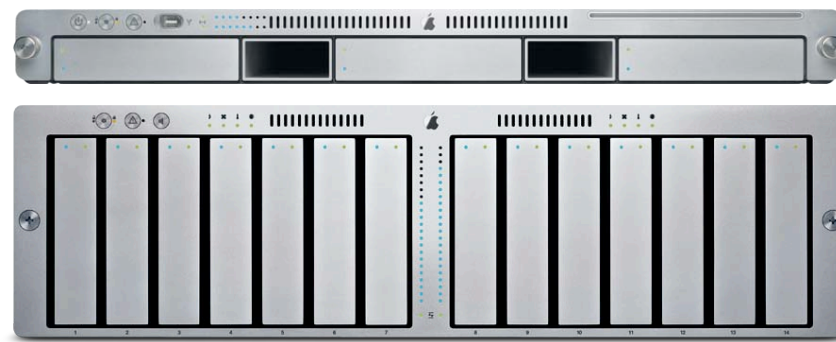


# System software and Integration

One consistent platform for researchers' entire workflow



Clients



Servers and Storage



Clusters

Mac OS X







# ARTS

## Apple Research & Technology Support program

Dr Massimo Marino  
Europe Research & Scientific programs  
ARTS Project Leader  
Apple Computer Europe, Ltd  
[marino.m@euro.apple.com](mailto:marino.m@euro.apple.com)

# ARTS - Apple Research & Technology Support

- WHAT
  - A “Call for Projects” for researchers in leading public research institutions
- WHY
  - To partner in research, share the vision. EU leader in many endeavours
- HOW
  - Dedicated program, participate to the effort of EU research
  - Participating institutions
- The future
  - To support even more research projects (eg, PhD programs as well)
  - Individual researchers
  - Your suggestions

<http://www.apple.com/uk/education/hed/arts/>



What

# WHAT

- A EU-wide “Call for Projects” program to support young researchers in scientific institutions
  - Hardware + Software (\$30,000 value)
  - Apple Developers Connection (ADC) memberships
    - Premiere (Laureate project, \$3,500 value)
    - Select (Researchers working with Apple solutions, \$500 value)
      - <https://connect.apple.com>
  - International ARTS Community of Researchers
    - mailing lists monitored by Apple SEs
    - peer-to-peer communication
  - Diversified support
    - Visits, briefings, etc to be decided with institutions

# WHAT

- Apple as the platform to conduct research
  - Profit from Apple technology, recognition and visibility
  - ARTS Laureate, invitation to World Wide Developers Conference (WWDC) in San Francisco
  - Direct support channel to Apple engineers
  - ADC memberships
  - Grow together
- A message of commitment to promote science & research
  - No strings attached
  - Run internally by participating Institutions
    - with full control and flexibility

Why

# WHY



To become a long-term partner of the scientific community

Strong affinity with scientists

Shared passion for innovation and creativity





# A Broad Diversity of Research

Already enabled by Apple technology



## Life Science

DNA Analysis/Genomics  
Proteomics  
Pathway/Expression Analysis  
Structural Biology



## Physical Science

Chemistry  
Physics  
Geology/GIS  
Astronomy



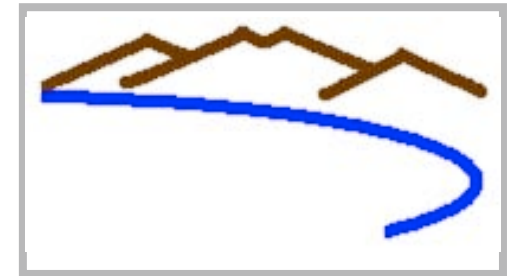
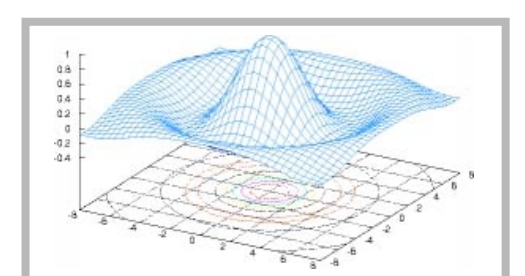
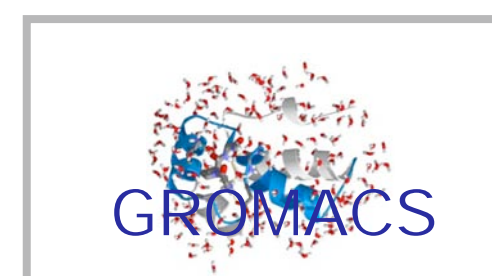
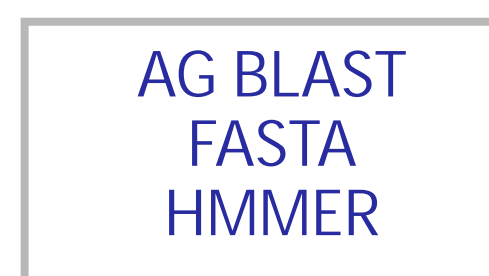
## Cross-Discipline

Visualization/Imaging  
Mathematics/Statistics  
Instrumentation  
Data/Content Management





# Scientific Computing Solutions



How

# HOW

- Participating Research Institutions will
  - Launch ARTS “Call for Projects”
    - ARTS participating Institution to decide and select
      - Field of activities
      - Laureate Project
  - Evaluate proposals based on
    - Impact, relevance to own and related fields, innovation
    - Exploit of Apple technology
  - Use ad-hoc or existing Scientific Selection Committee
- Researcher(s) to provide:
  - Description of a research project
  - Exploit of Apple solutions
  - Submit to Scientific Selection Committee

# HOW

- Visibility
  - ARTS web site
    - Profile of Institution
    - Profile of ARTS Laureate research
    - <http://www.apple.com/uk/education/hed/arts/>
- Invitation to WWDC in San Francisco
- ARTS Laureates to
  - Agree to communicate with peers
  - Agree to be indicated as notable research example in the field

# ARTS today



# ARTS Today

- EPFL
  - 1st ARTS Laureate: Prof. Felix Naef "Simulating Gene Networks and their Evolution"
- Swedish NRM Centre at Göteborg University
  - Dr Victor Jaravine "A platform for real-time high-throughput biomolecular NMR spectroscopy"
- INRIA
- Institut Pasteur
- CERN/LHC ALICE collaboration
- NOCS - National Oceanographic Center, Southampton
- Netherland Cancer Institute (NKI)
- Oxford University
- OSC - Oxford Supercomputing Center
- Max Planck Institute, Cologne
- Cambridge, Bologna, Roma, Naples, Manchester, Paris, Karlsruhe, ...

# Make ARTS a better fit for Research

Long lasting partner, best technology for best researchers

- ARTS to evolve with Researchers' needs
- Mac OS X Leopard
  - Full 64-bit
  - Run 32-bit applications concurrently and at full speed
  - Unix 03 certified
- ARTS for Ph.D. thesis programs
  - Support today the researchers of tomorrow
- ARTS for individual researchers
- Research is a demanding endeavour
  - Your feedbacks: a chance to grow together

ARTS is a first step. Let's  have a long walk together!

# ARTS

## Marrying Talent and Technology

### Apple Research & Technology Support

#### ARTS Laureate – A Window of Science Research Opportunity

The ARTS programme is designed to make Apple technology more accessible to Europe's young scientists. The programme offers young researchers the chance to become an ARTS Laureate and receive US\$30,000 worth of Apple solutions to research technology problems, in the form of hardware, software and support.

Potential candidates must have a postgraduate qualification and be employed by a public-funded science research institution. Each candidate must submit a detailed proposal for a research project, specifying its aims, the likely impact in its own and/or related fields, how the Apple computing solution is intended to be used, and the timescale for the project.

“Apple is now an extremely effective development environment and we know it is likely to be very cost effective.”

Fons Rademakers, ALICE Offline Computing Software Architect, CERN.

The proposed project should lead to original results, publishable in the public domain. Candidates will be expected to deliver status updates, probably six monthly, dependent on the nature and complexity of the project. (Stylistic – these two words always seem to order this way).

The candidates' own institutions will be asked to appraise proposals initially, and produce a final selection from their researcher applicants.

The candidate selected as ARTS Laureate must use Apple solutions to directly support the submitted project proposal. The project, researcher(s) and their institution(s) will be featured as Science Profiles in Apple external publicity.

#### Community of Science Researchers in Europe

The ARTS programme is more than just a one-off prize. It is also a

#### Learn More About ARTS

- [ARTS Programme Overview](#)
- [Eligibility Criteria](#)
- [Terms and Conditions](#)

#### ARTS Laureate Winner

Gene research designed to improve our understanding of cancer and other diseases, undertaken at the [École Polytechnique Fédérale de Lausanne \(EPFL\)](#), has become the first project to receive support from the ARTS programme.

#### Success Stories

Apple solutions are widely used in science research projects in Europe:

- [Scientists at CERN](#) the international particle physics laboratory near Geneva, are using Intel-based Macs to help improve man's understanding of the universe.
- [Researchers in Switzerland](#) are using Apple technology to answer key questions about avalanche flow that have baffled scientists for centuries.
- [ARTS Institutions](#)

#### Want to Talk to Someone?

Let us know if you would

[apple.com/uk/education/hed/arts/](http://apple.com/uk/education/hed/arts/)

# OS X and Science on the Web



[www.apple.com/science](http://www.apple.com/science)

[www.apple.com/science/researchsolutions/](http://www.apple.com/science/researchsolutions/)  
[www.apple.com/science/profiles/](http://www.apple.com/science/profiles/)



**Science** Mac OS X. The platform for discovery.  
Explore the vastness of science with the tools that give you the freedom to focus on your research.

**Seeing the big picture.**  
A 50-megapixel system composed of 30-inch Cinema Displays and Power Mac G5s brings Scripps Institution of Oceanography's ever-growing data sets to life.  
[Read more...](#)

Why Mac for Science   Hardware for Research   Software for Research   Science Solutions   Profiles   Inside the Image

"Our profession is overwhelmingly Macintosh. It's just so much easier to use. It's more dependable. It's more intuitive. It's faster and it's just more elegant."

Scott Thorn Barrows, University of Chicago Medical Center

### The Platform

Combining the power, security, and stability of UNIX with the ease of use of the Mac interface, Mac OS X gives you the ideal platform for scientific computing.



### The Hardware

From notebook computers to desktop systems to clusters, Apple technology provides the flexibility, power, and scalability to meet your IT requirements.

### The Solutions

Advanced tools and applications are the vital link to your research data. Apple solutions for scientific research combine powerful Mac technology with leading edge industry tools for a diversity of research areas.



### Why Mac for Science

Learn why the Mac is the ideal platform for scientists.

- ▶ [The Right Tool for Science](#)
- ▶ [Common Myths](#)
- ▶ [Testimonials](#)
- ▶ [Press](#)



### Knowledge Center:

Accelerate Research. Simplify IT.

Learn how the Mac can increase the productivity of your scientific or IT organization. Explore case studies, white papers, and success stories.


### Webcasts for Researchers

Learn how the Mac is being used in scientific research in this series of free on-demand online seminars.

Apple Confidential

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# MacResearch

Online Community and Resource for Mac OS X in Science

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- additionally one might look  
1 day 21 hours ago
- Datathief  
3 days 10 hours ago
- Order is placed  
5 days 18 hours ago
- Hard cash  
5 days 19 hours ago
- iBabel 2.x  
6 days 10 hours ago

**Who's new**

- nopiedra
- Helicoil
- skong
- warren
- PaulN

**Browse archives**

« January 2006

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15	16	17	18	19	20	21
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**Dauger Research Updates Easy to Use Clustering Software**

By joel at Thu, 2006-01-12 18:58 | News

Pooch is a very interesting High Performance Computing (HPC) alternative to Xgrid on OS X (although Pooch does play along nicely with Xgrid). In many ways Pooch is more mature and intuitive than Xgrid. Like Xgrid, Pooch abstracts much of the complexity of organizing individual computers into logical computing clusters. Ignoring money concerns, Pooch really gives Xgrid a run for its money in the simplicity of its design and the richness of their GUI tools. Their documentation and tutorials are also very good. Of course Xgrid comes "free" with OS X and OS X server and Pooch basic edition is available for US\$175 for the initial compute node, and US\$125 for each additional node. That might put Pooch out of the reach of many small to medium sized research groups. One nice feature of Pooch is that it is still capable of running on OS 9, so if you have a bunch of old machines lying around and you don't want to fork over the cash to upgrade them to OS X, then Pooch might be relatively affordable.



New features for 1.6.5 include:

- Automator - Incorporate Pooch actions into workflows
- Dashboard - View cluster status and activity in an aesthetic environment
- Spotlight - Locate data in Pooch jobs via the system
- Xgrid - Pooch makes Xgrid nodes accessible to users

[add new comment](#)

**User login**

Username:

Password:

- [Create new account](#)
- [Request new password](#)

**Video Podcasting Gets the Message Out for TERRA**

By irjudson at Wed, 2006-01-11 23:32

Montana State University filmmakers use video podcasting to get their message out. The Science and Natural History Filmmaking graduate program produces cutting edge films on such diverse topics as grizzly bears and even NASA's trip to Mars.



The partnership with Montana PBS has

**Poll**

**Will you be buying a MacBook Pro?:**

Yes  
 No  
 Yes, but waiting until the bugs are worked out  
 Would if I had the cash

[add new comment](#) | [older polls](#) | [results](#)

**Active forum topics**

- Sequencer software
- XGrid and MPI
- Grapher and Complex Number representation
- National Instruments
- LTO II Tapes on OSX

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## Recent Articles

How to be a Hardware Detective  
 Apple Remote Desktop 2.2 on the Intel platform  
 Linked Article - How to restore NetInfo Database  
 Demystifying the Transition, System Imaging and Rosetta Webcast slides available  
 Linked Article - "Apple breaks silence on security"

### Next Webcast

TBA

Tuesday, April 18, 2006

## Welcome to MacEnterprise.org!

The MacEnterprise project is a community of IT professionals sharing information and solutions to support Macs in an enterprise. We collaborate on the deployment, management, and integration of Mac OS X client and server computers into multi-platform computing environments. We welcome your participation through suggestions, comments or contributions. Please follow [this link](#) for site registration which will allow you to submit your own articles.

Please join us in discussion on Mac OS X enterprise topics by subscribing to our mailing list. Go to the [MacEnterprise.org list subscription web page](#) and click the "Join or Leave the List" link to get started. The archives of the list are now publicly searchable.

## Electoral Vote - Repairing Permissions with Disk Utility

Using Disk Utility to repair disk permissions is becoming the catch-all fix for solving system instability. It almost has reached the infamous status of rebuilding the Desktop DB in Mac OS 9. Each time something is installed from a package file a "Bill of Materials" file is created in the /Library/Receipts/ directory. Each of these ".bom" files contains a list of files and/or folders that were installed by that package, along with the proper permissions for each item. According to many Disk Utility overviews the .bom files in /Library/Receipts/ are scanned and compared to the actual permissions of each file on the local file system. In reality, it doesn't appear that this is completely true.

[Read more...](#)

## Enable Verbose Network Negotiation on Tiger

Ever wonder what is happening during the network interface negotiation on Tiger? It's very easy to enable verbose logging with a quick and simple change to the IPConfiguration bundle.

[Read more...](#)

## Universal Images - Panacea or Frankenstein's monster?

Recently, several intrepid Mac administrators have demonstrated ways to create a "universally" bootable install of Mac OS X 10.4.5 - a boot disk/image that boots both PowerPC-based and Intel-based Macintoshes. This development could simplify an administrator's life, or usher in a new set of challenges.

[Read more...](#)

## Creating Snapshot Packages with packagemaker

In XCode 2.2, Apple quietly introduced a new snapshot option to packagemaker that can create a package by tracking changes to a specific directory. The man page for packagemaker has been updated, but the current version, XCode 2.2.1, contains a couple of mistakes and no examples. This article hopes to fill in the missing pieces.

[Read more...](#)

## Debugging MCX

MCX debugging has always been a challenge. Not now!

[Read more...](#)

More...

- [How to be a Hardware Detective](#)
- [Apple Remote Desktop 2.2 on the Intel platform](#)
- [Linked Article - How to restore NetInfo Database](#)
- [Demystifying the Transition, System Imaging and Rosetta Webcast slides available](#)
- [Linked Article - "Apple breaks silence on security"](#)





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## User Functions

**Username:**

**Password:**

Don't have an account yet?  
 Sign up as a [New User](#)  
 Lost your [password](#)?

## Who's Online

[maccanada](#)  
 Guest Users: 30

## Poll

**Would you come to an AFP548.com gathering at WWDC?**

- Count me in!
- Only if it's free!
- I'm not going to WWDC.
- No! Sysadmins scare me too much...

[Results](#)

## [Welcome to AFP548](#)

Tuesday, May 30 2006 @ 05:26 am CDT

## Deploying Boot Camp

Wednesday, May 24 2006 @ 09:13 am CDT

Contributed by: [MacTroll](#)

Views: 464

### Handing out Windows with Apple tools.

Mike Bombich has a good [writeup](#) of how to deploy a Windows NTFS partition suitable for booting on an Intel Mac using the included Apple tools that we already use. He leverages some NTFS tools in his latest version of [NetRestore](#) to do this.

A good read whether you intend on using Boot Camp or not.

[Post a comment](#)

Comments (0)

## Faking Filesystem Snapshots on Mac OS X Server

Friday, May 19 2006 @ 07:02 am CDT

Contributed by: [macshome](#)

Views: 1,360

Most other operating systems on the market allow you to make a "snapshot" of a filesystem. Using these snapshots you can provide easy access, and in many cases self-service access, to instant backups of the files and folders. This functionality is usually part of the filesystem and one that HFS, in its now numerous forms, does not support. We can however fake it, and provide easy, self-servicing access backups to our users on some shares, in some cases. We call it the GhettoSnap.

### Read on for more...

[read more](#) (2,479 words) [Post a comment](#)

Comments (0)

## Using OSXS VPN Server with AD Users

Wednesday, May 17 2006 @ 10:26 pm CDT

Contributed by: [MacTroll](#)

Views: 430

### Leveraging RADIUS to fill in where Kerberos falls down.

OS X Server's VPN server has the little-known capacity to do RADIUS authentication. Windows 2000 and 2003 have RADIUS servers built in, part of the Internet Authentication Services (IAS) package. So enable IAS, enable the user for dial-in/VPN authentication and add a small file on the OSXS box at /etc/ppp/postoptions with the RADIUS server's IP address and the shared secret for the RADIUS server and you're off to the races.







Search

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- [alienRAID.org](#)
- [MacEnterprise.org](#)
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Monday, January 15 2007 @ 02:50 PM CST



## Xserve RAID storage installed at South Pole

Contributed by: [das](#) | Views:1429

The University of Wisconsin - Madison IceCube Neutrino Observatory has installed Apple Xserve RAID arrays at its facility currently under construction at the South Pole.

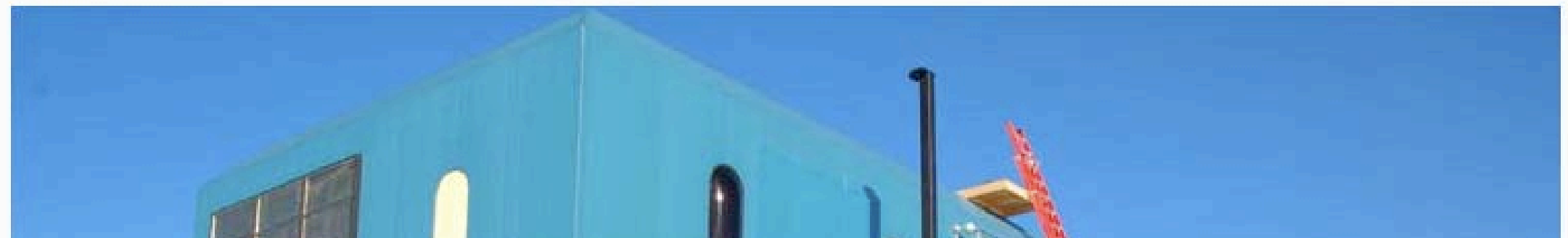
The IceCube Neutrino Observatory, operated by the University of Wisconsin - Madison with a grant from the National Science Foundation, is a research station and laboratory located at the South Pole. The \$271 million project, currently under construction, uses sophisticated detectors in the massive quantities of pure water in the form of ice to detect neutrinos, which it is hoped will reveal more information about the building blocks and origins of the Universe. For more information, please visit the [IceCube web site](#).

The Xserve RAID arrays were installed in support of the science data generated by the detector arrays, as well as support for information technology needs at the South Pole facility. The Xserve RAID's originated in Madison, WI, and then made their way to Christchurch, New Zealand, and then via a US Air Force C-17 transport to McMurdo Station, a US facility on the Antarctic coast. From there, they made their way to the IceCube facility at the South Pole aboard a special ski-equipped LC-130 Hercules aircraft.

One Xserve RAID one is scratch space for data analysis. The IceCube array produces a lot of data, and the researchers try to only transfer the most interesting fraction over the satellite internet connection. This storage will lets researchers sift through some of that data. The less interesting majority is written to tape to ship to Madison, WI, once a year.

The second Xserve RAID provides storage for a backup server, storing snapshots of home directories, web, mysql, postgres, ldap, mail, and a few other critical pieces of data. It is currently configured very conservatively for just over a week of history, but there is expected to be plenty of room for several weeks worth.

*IceCube lab*

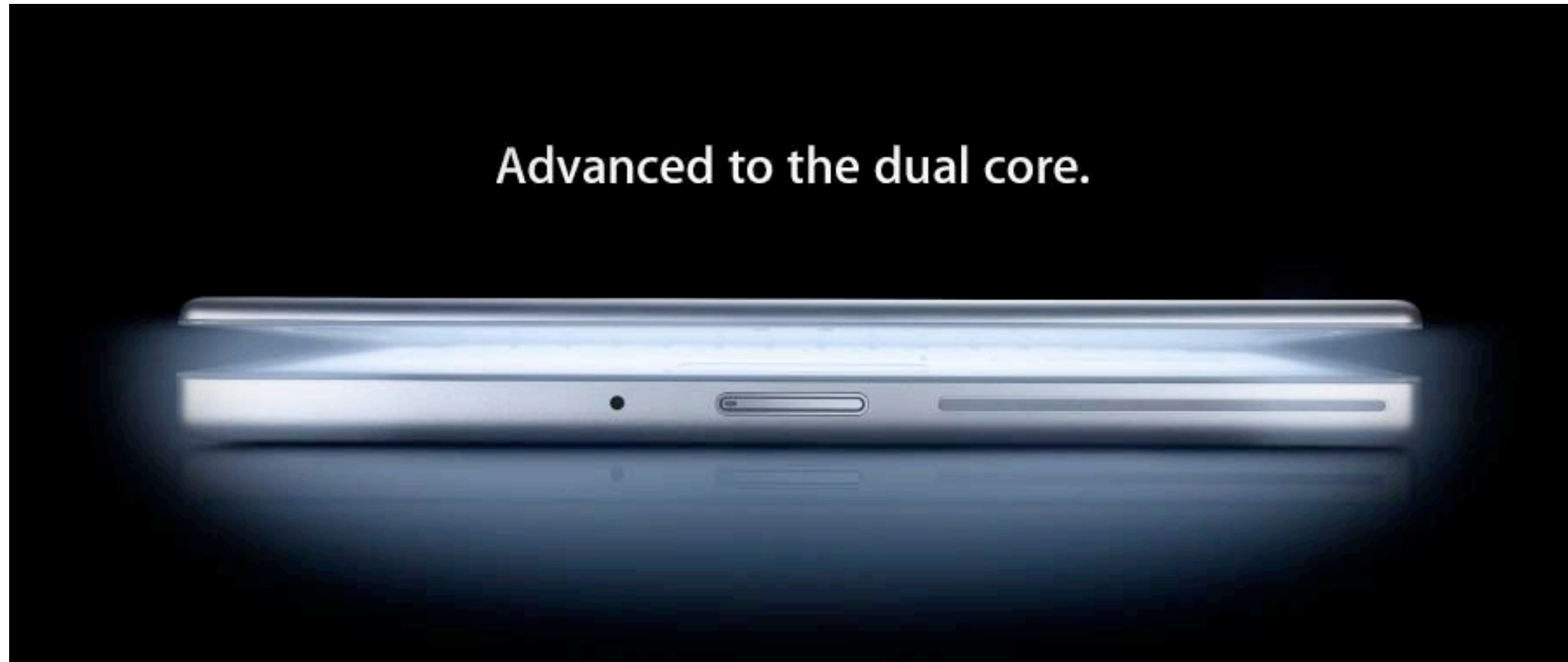


A final message



# Revolution or Evolution?

a bit of both...



Apple and Mac OS X

The Power of Unix

Open Standards

The Simplicity of Mac



Apple and Mac OS X

The Simplicity of Unix

Open Standards

The Power of Mac



# Q&A

95

...and thank you!