Design, Status, and Experience with BaBar LTDA

Concetta Cartaro
SLAC

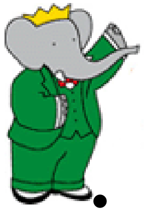
On behalf of

BaBar Computing Group

DPHEP Workshop – Marseille, November 19th, 2012

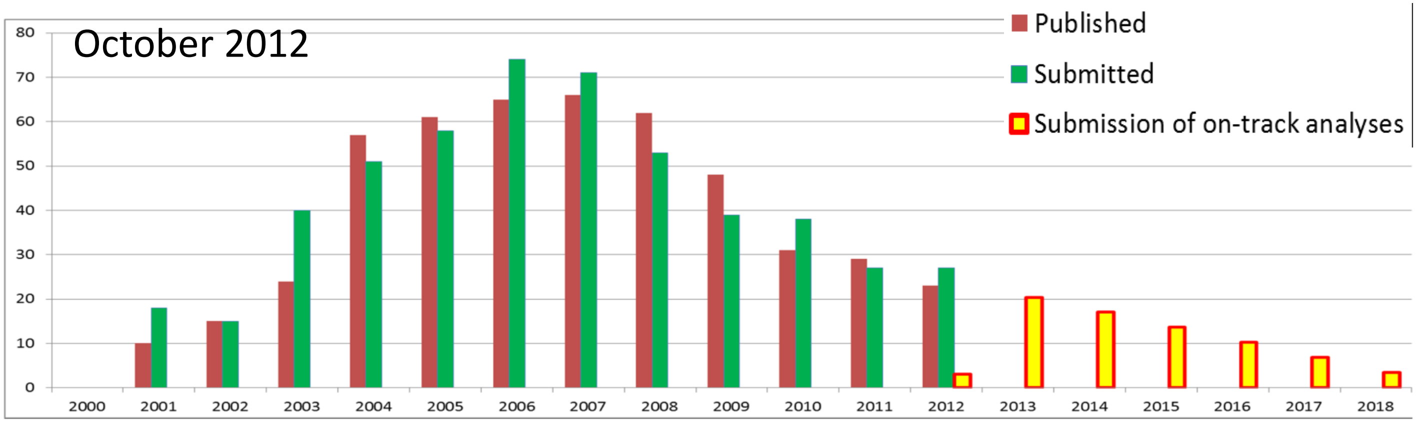
OUTLINE

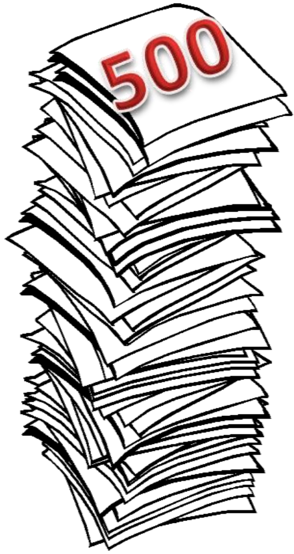
- BaBar data and choices for the future
- The Long Term Data Access project
- Update since May 2012
  - DPHEP hosted @ CHEP 2012
  - `https://indico.cern.ch/getFile.py/access?contribId=12&resId=0&materialId=slides&confId=171962`
- Managing the cluster
- BaBar long term planning
- Conclusions

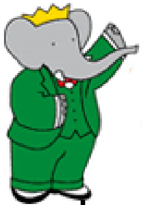


BaBar Data

- BaBar has collected data from Oct 22nd 1999 to Apr 7th 2008
  - 800TB of raw data, 1.2 PB from the last data reprocessing
  - 500th paper accepted on October 16th
    - 508 papers published/accepted/submitted
      - 31 published/accepted in 2012 – 2 more than in 2011
  - 74 on track analyses
    - Plus ~30 analyses progressing slower (generally lacking manpower)
    - Possibilities for new previously unforeseen analyses including discovery analyses
- BaBar (and Belle) data will not be superseded by LHC data
  - Belle II and SuperB will do it in 5-10years
  - Some datasets expected to remain unique for longer (Y(3S) dataset)



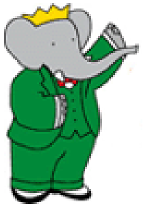




LONG TERM DATA ACCESS

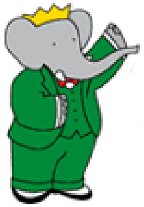
- Insure the ability to support 50 to 80 analysis of the BaBar data until at least 2018 preserving:
  - Data, conditions and calibrations, releases and tools, databases, capability of running production and user jobs
    - This means that in 5 years from now it will be possible to add a new decay mode, produce the MC events and the relevant skims, and perform a completely new analysis developing new selection code, fitting procedures, etc.
  - Documentation
- Providing a stable environment
  - Last validated OS enclosed in a virtualization layer running the BaBar Framework minimizing the effort needed to maintain the system

    → Need to address: hardware support, security risks, keep know-how on OS, Framework, etc…
- Open formats
  - Data format is based on ROOT which is open and will be part of the system
  - Databases will move away from Oracle and will be stabilized on MySql
  - Code is written in open formats: C/C++, Tcl, Perl, Python.
- Data Storage
  - 2PB (including raw data will be stored on tape in two Tier A sites (SLAC, CC-IN2P3)
  - Most used data will sit on disk



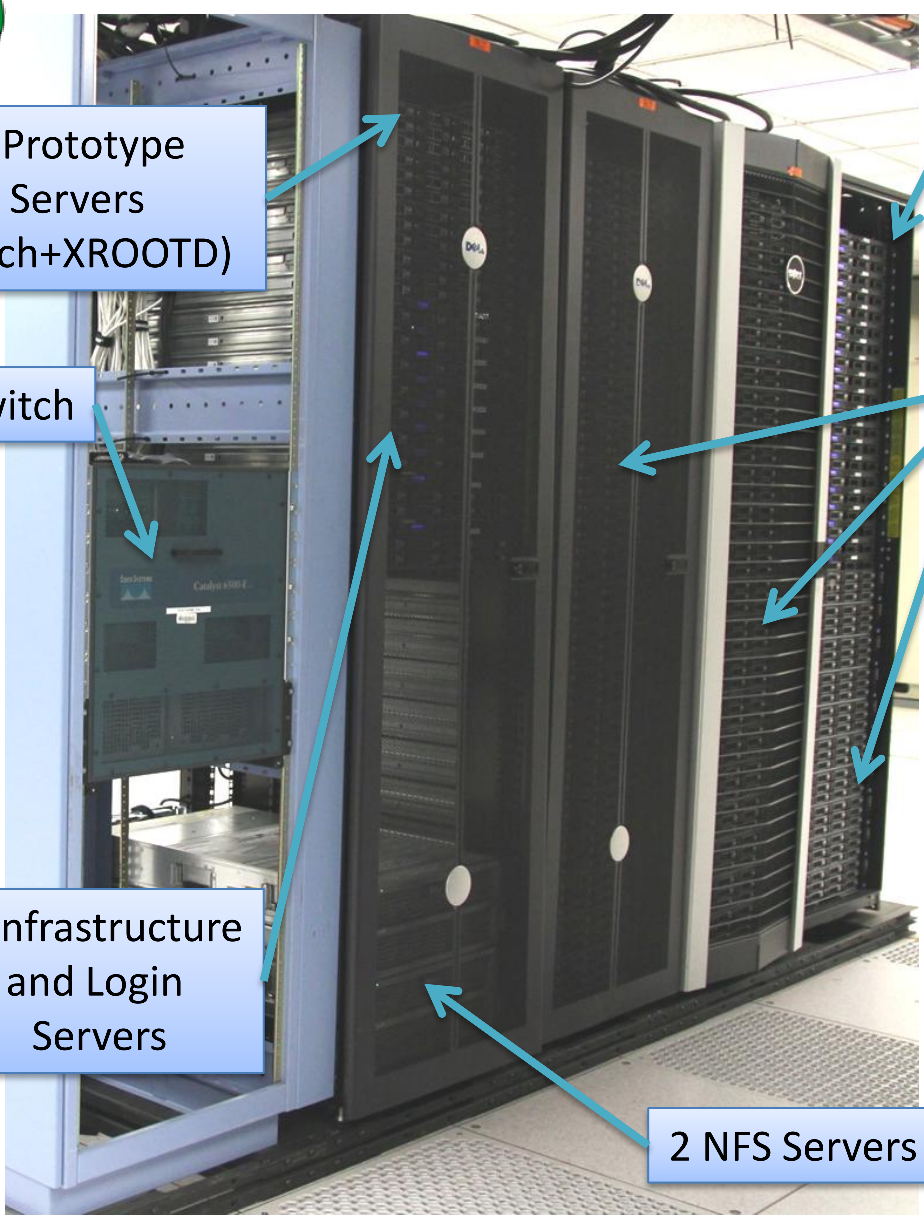
THE LTDA CLUSTER FACTS (I)

- Cisco 6506 network switch with 2x10Gb link card and 192Gb ports
- 9 infrastructure servers (Dell R410/R510)
  - 3 front end machines (**`bbrltda`** load balanced pool), 1 cron server, 1 test server, 2 infrastructure servers (network and identification services), 2 database servers (mirrored)
- 54 batch and storage servers
  - Dell R510: dual 6-core Intel Xeon X5675, 3.07GHz, 48GB RAM, 12x2TB disks
  - 4 were the prototype (dual 6-core Intel Xeon X5670, 2.93GHz, 48GB RAM)
  - 11x2TB disks (no raid) used to stage data through XROOTD
  - 1x2TB used as local scratch
  - 12 physical cores, 24 cores with hyper threading
    - 1 physical core used for the host and the XROOTD services
    - 11 cores (22 w/ hyper-threading) dedicated to batch with one VM per core



The LTDA Cluster Facts (II)

- 20 additional batch servers (new!)
  - Dell R410: dual 6-core Intel Xeon X5675, 3.07GHz, 48GB RAM, 2x2TB disks mirrored (for OS + local scratch)
  - 12/24 cores used to run batch jobs (VMs)
- 2 NFS servers (1 new!)
  - Sun X4540 Thor server: 12 cores, 32 GB memory and 32TB of effective storage
  - One for local home directories and code repositories and one for user data
- The LTDA cluster is in production mode since March 21st 2012
  - On time and on budget
  - 1.33 PB of disk space for data and users
  - 1668 job slots
  - SL4, SL5, SL6 platforms available
- All active BaBarians have a 1GB home directory on the LTDA



4 Prototype Servers (batch+XROOTD)

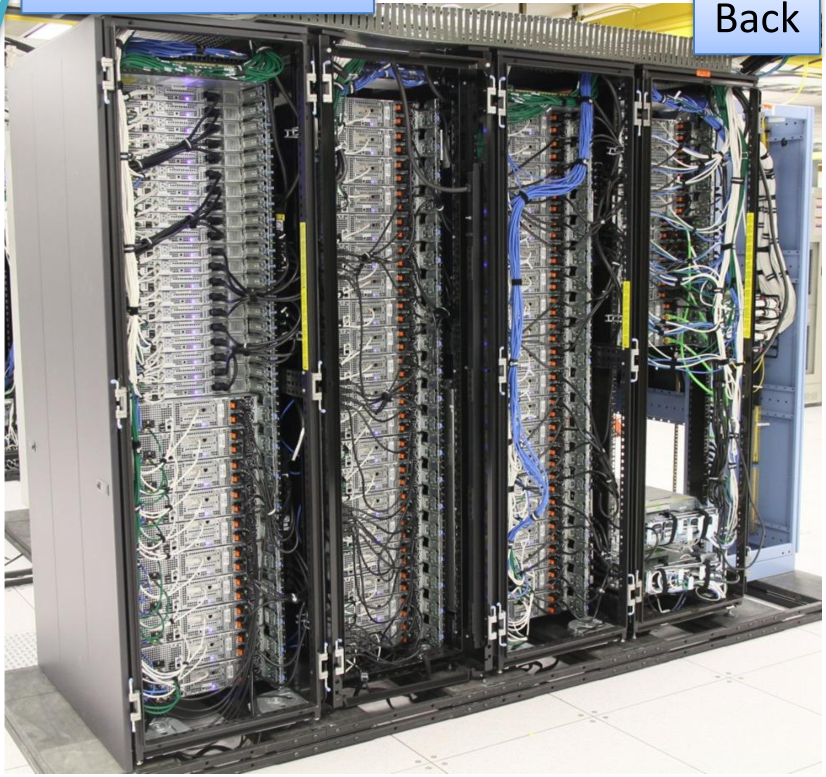
Switch

9 Infrastructure and Login Servers

2 NFS Servers

20 Batch Servers (no XROOTD)

50 Batch and XROOTD Servers



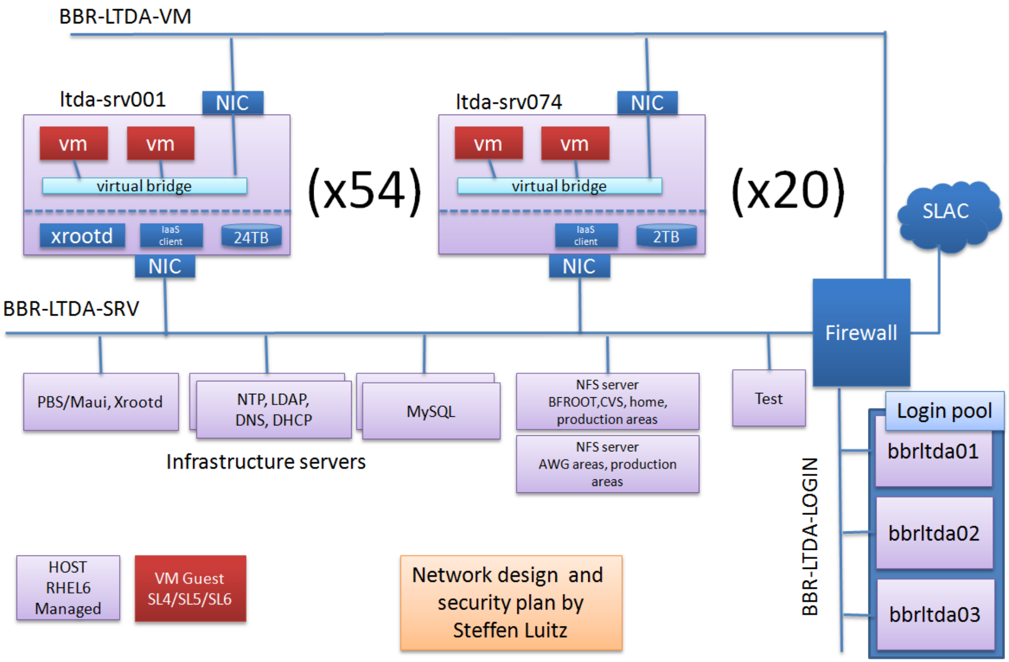
Back

VIRTUALIZATION & NETWORK

- Security threat associated to a VM connected to a network running old OS
  - Images are read-only, qcow2 produces a temporary file with changes to OS and scratch area and it is deleted when the VM's shut down

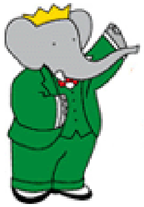
→ Risk based approach assuming that the VMs are compromised

  - Isolation of back versioned components with firewall rules
  - Physical hosts centrally managed by SLAC CD

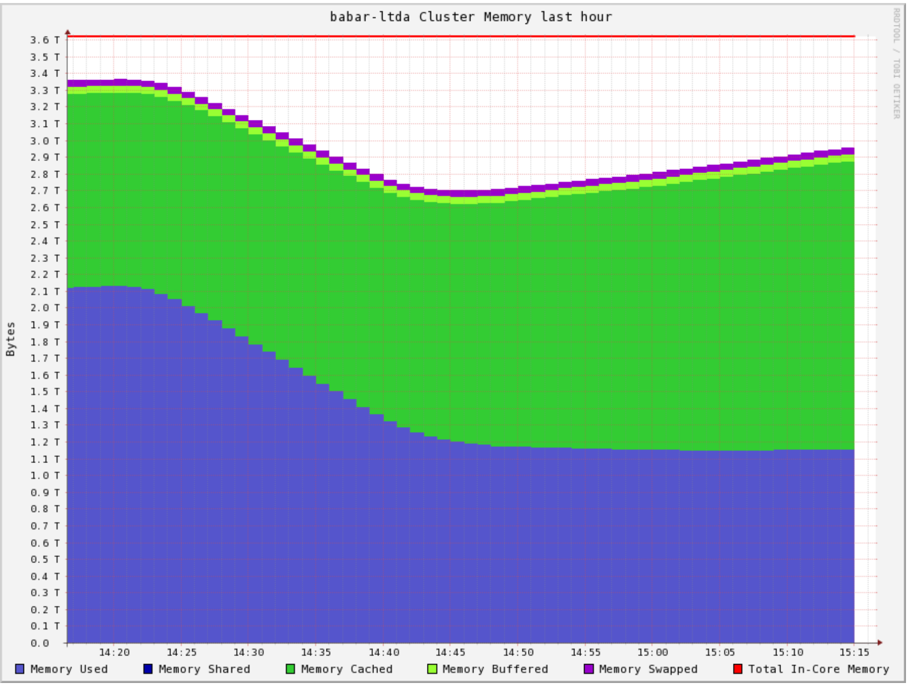


Network design and security plan by Steffen Luitz

- VMs are not allowed to connect to SLAC network or the world
- The Login network is protected from the VM network
  - Allow one way ssh from Login to VM network
  - VMs are not allowed to write over the Login network
- Well defined services between VM network and SRV network
  - Infrastructure (DNS, LDAP, NTP), file service (Xrootd, nfs), batch scheduling
  - LDAP is a subset of the SLAC Kerberos list mapped on /nfs internal home directories
- Allow SRV and Login networks use SLAC infrastructure



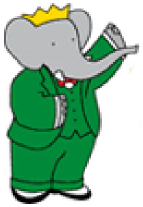
MEMORY USAGE



On a sample analysis with about 1500 parallel jobs the memory usage was reduced from 2.1TB to 1.2TB!!!
Freed memory is used for caching files, but can also be used for memory intensive jobs (merging skim output needs at least 4GB RAM).

- 48GB of RAM/server
  - 24 VMs with 2GB RAM
  - 22 VMs on machines with storage space
    - One physical core left for xrootd
- RAM is also needed for the system itself
- Deduplication for identical blocks already used on filesystems
- "Kernel Samepage Merging" (KSM) introduced in kernel 2.6.32
  - Same memory pages are merged together into a single one among different processes!
  - most effective for a lot of identical processes
    - that's VMs!

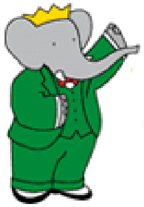
Marcus Ebert



NFS, ZFS AND BACKUPS

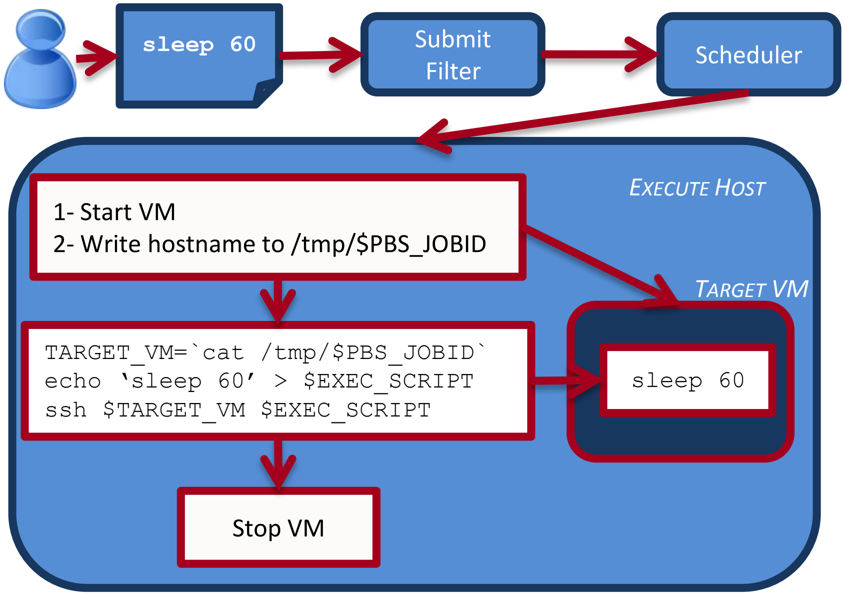
- NFS servers
  - 40TB zpools, 2 hot spares for 32 TB usable space
  - Compression enabled on /home (factor ~2 gain)
- ZFS snapshots implemented for /home and /BFROOT (releases, packages and cvs root directory) for user error recovery
  - snapshots are read-only, so it's protected against user error
  - frequent snapshots every 15min, overwritten every hour; the frequent full hour snapshot becomes the hourly snapshot after the next hour; the midnight hourly snapshot becomes a daily snapshot at next midnight; daily snapshots are overwritten every month; daily backups of the last 30 days snapshots are recursively created for all zfs under the given top zfs in one single operation
    - BFROOT is more slowly changing and no 15 min snapshot is implemented for it
- Tape backup for catastrophic events
  - All areas are backed up to tape every day and kept for 30 days
    - Root files are omitted because they are considered reproducible

Marcus Ebert



JOB SUBMISSION

- PBS/Torque is used to manage the batch resources and Maui is the batch scheduler
- The virtualization layer uses qemu with kvm support directly
  - Moved away from libvirt due to instability
- Need to create the network interface for the VMs
  - 24 MAC addresses per host and usage status stored in local db
- PBS Prologues and Epilogues scripts are used to create and destroy the VM's and the needed network environment

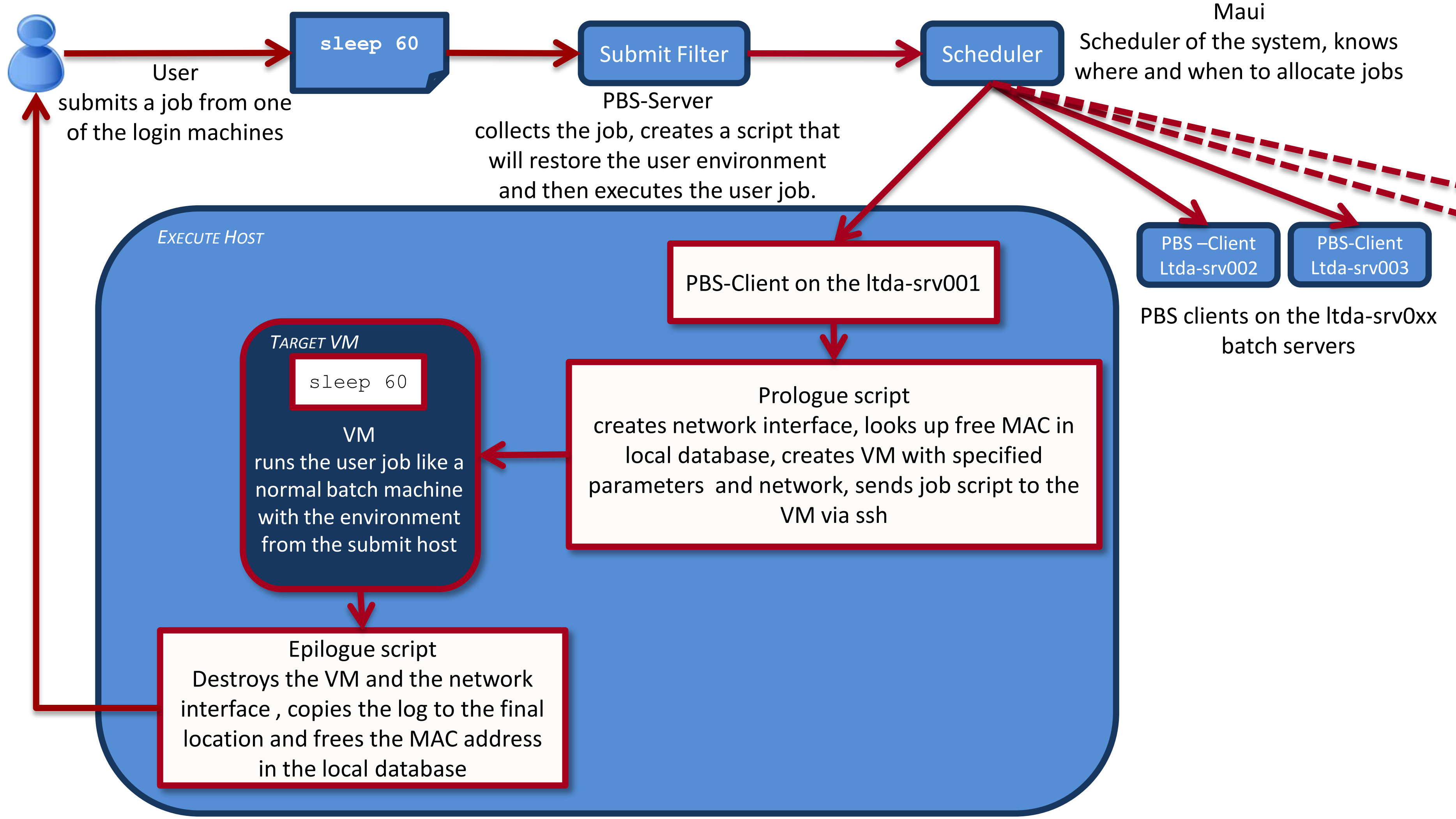


1- Start VM
2- Write hostname to /tmp/$PBS_JOBID

```
TARGET_VM=`cat /tmp/$PBS_JOBID`
echo 'sleep 60' > $EXEC_SCRIPT
ssh $TARGET_VM $EXEC_SCRIPT
```

Marcus Ebert, Kyle Fransham – LTDA developers

A LITTLE MORE DETAIL …



User
submits a job from one
of the login machines

```
sleep 60
```

Submit Filter

PBS-Server
collects the job, creates a script that
will restore the user environment
and then executes the user job.

Scheduler

Maui
Scheduler of the system, knows
where and when to allocate jobs

PBS –Client
Ltda-srv002

PBS-Client
Ltda-srv003

PBS clients on the ltda-srv0xx
batch servers

EXECUTE HOST

PBS-Client on the ltda-srv001

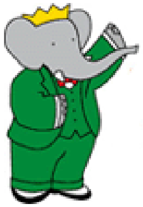
Prologue script
creates network interface, looks up free MAC in
local database, creates VM with specified
parameters and network, sends job script to the
VM via ssh

TARGET VM

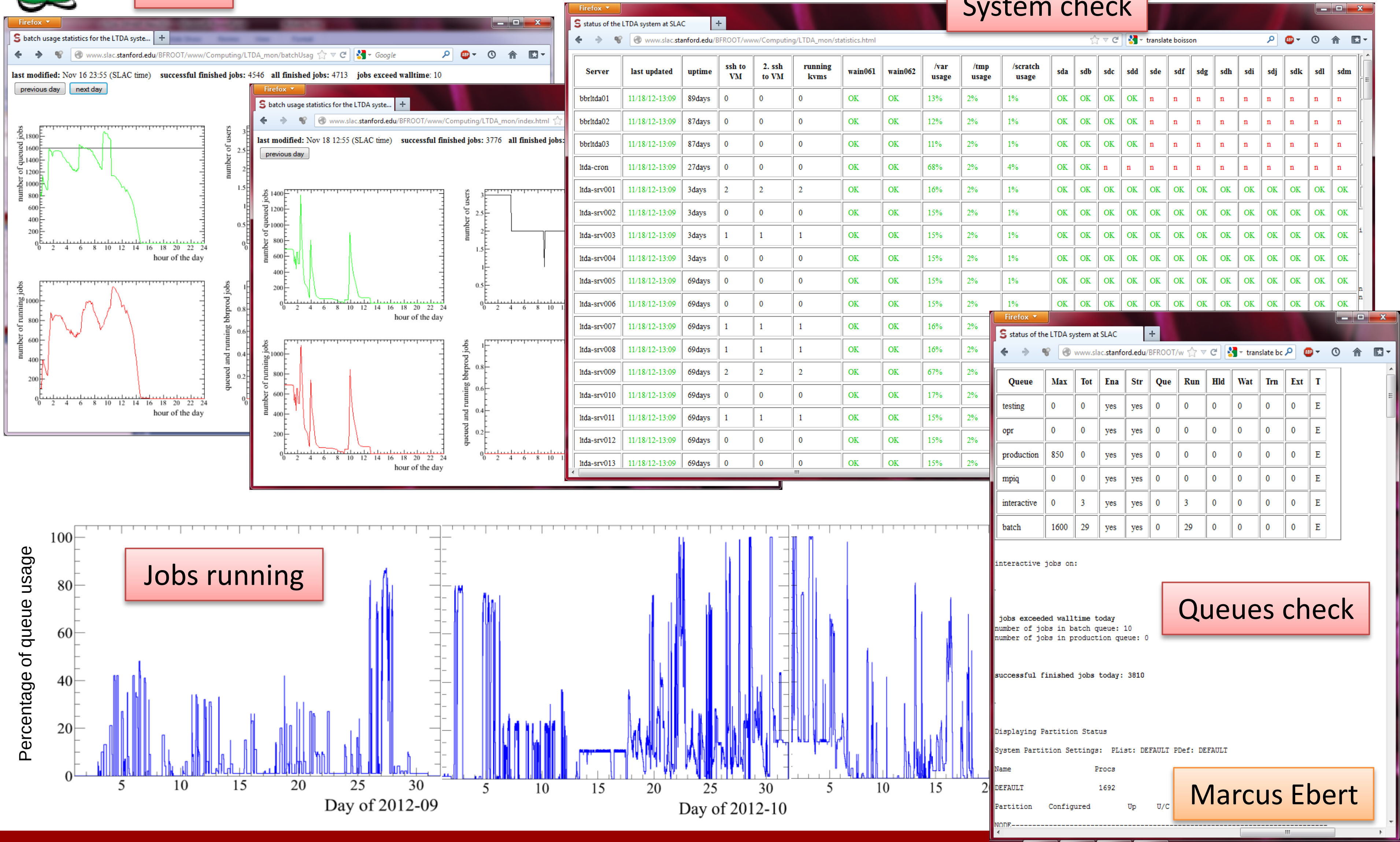
```
sleep 60
```

VM
runs the user job like a
normal batch machine
with the environment
from the submit host

Epilogue script
Destroys the VM and the network
interface , copies the log to the final
location and frees the MAC address
in the local database



MONITORING


Daily
System check
Jobs running
Queues check
Firefox
batch usage statistics for the LTDA syste...
www.slac.stanford.edu/BFROOT/www/Computing/LTDA_mon/batchUsag
Google
previous day
next day
number of queued jobs
number of users
hour of the day
number of running jobs
queued and running bbrprod jobs
www.slac.stanford.edu/BFROOT/www/Computing/LTDA_mon/index.html
status of the LTDA system at SLAC
www.slac.stanford.edu/BFROOT/www/Computing/LTDA_mon/statistics.html
translate boisson
www.slac.stanford.edu/BFROOT/w
translate bc
Percentage of queue usage
Day of 2012-09
Day of 2012-10
0
20
40
60
80
100
5
10
15
20
25
30

last modified: Nov 16 23:55 (SLAC time) successful finished jobs: 4546 all finished jobs: 4713 jobs exceed walltime: 10

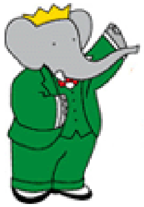
last modified: Nov 18 12:55 (SLAC time) successful finished jobs: 3776 all finished jobs:

Server	last updated	uptime	ssh to VM	2. ssh to VM	running kvms	wain061	wain062	/var usage	/tmp usage	/scratch usage	sda	sdb	sdc	sdd	sde	sdf	sdg	sdh	sdi	sdj	sdk	sdl	sdm
bbrltda01	11/18/12-13:09	89days	0	0	0	OK	OK	13%	2%	1%	OK	OK	OK	OK	n	n	n	n	n	n	n	n	n
bbrltda02	11/18/12-13:09	87days	0	0	0	OK	OK	12%	2%	1%	OK	OK	OK	OK	n	n	n	n	n	n	n	n	n
bbrltda03	11/18/12-13:09	87days	0	0	0	OK	OK	11%	2%	1%	OK	OK	OK	OK	n	n	n	n	n	n	n	n	n
ltda-cron	11/18/12-13:09	27days	0	0	0	OK	OK	68%	2%	4%	OK	OK	n	n	n	n	n	n	n	n	n	n	n
ltda-srv001	11/18/12-13:09	3days	2	2	2	OK	OK	16%	2%	1%	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
ltda-srv002	11/18/12-13:09	3days	0	0	0	OK	OK	15%	2%	1%	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
ltda-srv003	11/18/12-13:09	3days	1	1	1	OK	OK	15%	2%	1%	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
ltda-srv004	11/18/12-13:09	3days	0	0	0	OK	OK	15%	2%	1%	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
ltda-srv005	11/18/12-13:09	69days	0	0	0	OK	OK	15%	2%	1%	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
ltda-srv006	11/18/12-13:09	69days	0	0	0	OK	OK	15%	2%	1%	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
ltda-srv007	11/18/12-13:09	69days	1	1	1	OK	OK	16%	2%														
ltda-srv008	11/18/12-13:09	69days	1	1	1	OK	OK	16%	2%														
ltda-srv009	11/18/12-13:09	69days	2	2	2	OK	OK	67%	2%														
ltda-srv010	11/18/12-13:09	69days	0	0	0	OK	OK	17%	2%														
ltda-srv011	11/18/12-13:09	69days	1	1	1	OK	OK	15%	2%														
ltda-srv012	11/18/12-13:09	69days	0	0	0	OK	OK	15%	2%														
ltda-srv013	11/18/12-13:09	69days	0	0	0	OK	OK	15%	2%														

Queue	Max	Tot	Ena	Str	Que	Run	Hld	Wat	Trn	Ext	T
testing	0	0	yes	yes	0	0	0	0	0	0	E
opr	0	0	yes	yes	0	0	0	0	0	0	E
production	850	0	yes	yes	0	0	0	0	0	0	E
mpiq	0	0	yes	yes	0	0	0	0	0	0	E
interactive	0	3	yes	yes	0	3	0	0	0	0	E
batch	1600	29	yes	yes	0	29	0	0	0	0	E

```
interactive jobs on:


 jobs exceeded walltime today
number of jobs in batch queue: 10
number of jobs in production queue: 0


successful finished jobs today: 3810


Displaying Partition Status

System Partition Settings:  PList: DEFAULT PDef: DEFAULT

Name                    Procs

DEFAULT                  1692

Partition    Configured        Up     U/C

NODE-------------------------------------------------------------------
```

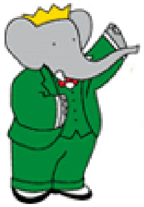
Marcus Ebert



IMPROVING USER EXPERIENCE

- Usually submit a job and wait for the result
- Limitations are due to the restrictions on the VMs
- Interactive VMs for SL4,5,6 platforms are always available to the users in a natural way
  - `ssh sl4` will redirect passwordlessly (shosts) to an interactive VM running SL4
    - No waiting, no special commands
- Skimming tools adapted for user case
  - Create individual skim cycles
  - Easy to define and handle large amounts of jobs
  - All jobs info stored in the database for reproducibility and traceability

Marcus Ebert – LTDA developer
Douglas Smith – BaBar tools and db expert

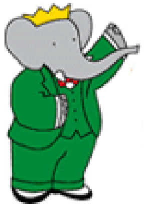


WHAT GOES ON THE LTDA

- LTDA is dedicated to both users and production
  - Both simulation production and skimming run on the system at a constant level (200 slots) when needed
  - One server is dedicated to our OPR (raw data reconstruction application) processing
- The LTDA resources will help BaBar face both the loss of resources within SLAC
  - Dedicated production resources will disappear soon
    - Oracle did not renew the maintenance contract for >5years old SUN equipment
    - Machines turned off as newer hardware arrives (to recover LSF licenses)
- …and the loss of the TierA sites
  - Right now all TierA sites are still supporting BaBar analysis but this may already not be true in the near future
    - INFN Padova will shut down the tape library with raw data backup at the end of the year, and other two sites will run out of BaBar funds at middle/end of 2013

PERFORMANCE TESTS

- VM’s vs SLAC batch queue
  - CPU X5670 @ 2.93GHz vs (x5355 @ 2.66GHz and x5570 @2.93GHz mixed)
  - RH5, HT off → 2.7% in favor of LTDA
- Hyper-threading on/off
  - 40% slower with HT on, but SL6 faster than SL5 by 35% CPU time, 15% wall time
- I/O performance tests
  - XROOTD tested for heavy load and scalability
  - The capability of the cluster exceeded any possible demand of BaBar applications



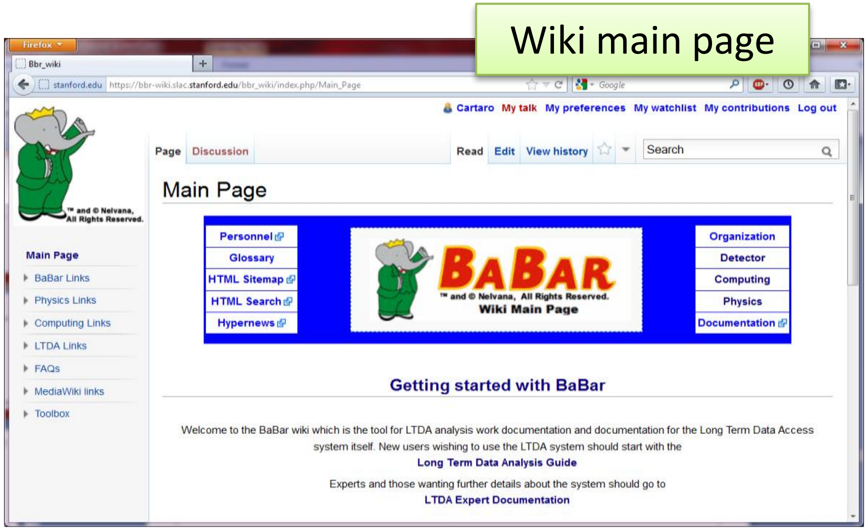
PROBLEMS & SOLUTIONS

- Intrinsic dependency between services running on different machines forced the boot order of the servers
  - Often caused delays during outages
  - **Solution:** Remove the dependencies and use automount on all servers to make the cluster independent of the boot order
- Red Hat updates delivered to all hosts automatically
  - This caused long outages in in the past
    - Kernel update with network bug: VMs not reachable
    - Automount bug caused crashes when used with LDAP
  - **Solution:** Develop a validation system in order to test the updates before delivering them to all hosts
    - Ltda-test server available for testing, validating and releasing updates to the whole cluster
    - Remove not essential software packages to reduce the list of updates

Marcus Ebert

DOCUMENTATION

- Strong push toward documentation clean up, ease of access, and clarity
- All most used and fundamental info are being checked, updated and moved to a Media Wiki server, the *BABAR WIKI*
  - Old pages clearly marked but kept online for archival purposes
  - Detector pages and other pages that will supposedly never change again will be left in their original location


Wiki main page

Main Page

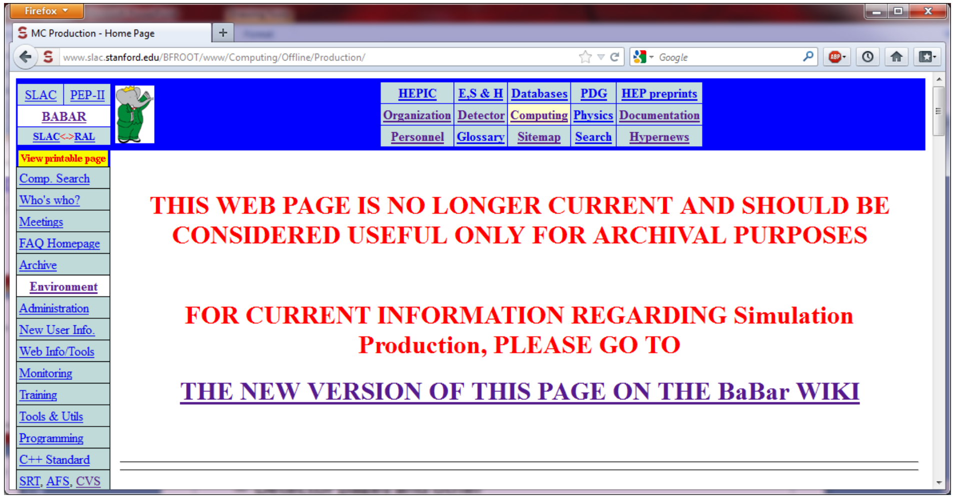
Getting started with BaBar

Welcome to the BaBar wiki which is the tool for LTDA analysis work documentation and documentation for the Long Term Data Access system itself. New users wishing to use the LTDA system should start with the

Long Term Data Analysis Guide

Experts and those wanting further details about the system should go to

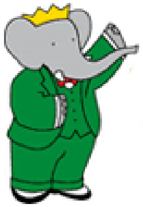
LTDA Expert Documentation



THIS WEB PAGE IS NO LONGER CURRENT AND SHOULD BE CONSIDERED USEFUL ONLY FOR ARCHIVAL PURPOSES

FOR CURRENT INFORMATION REGARDING Simulation Production, PLEASE GO TO

THE NEW VERSION OF THIS PAGE ON THE BaBar WIKI

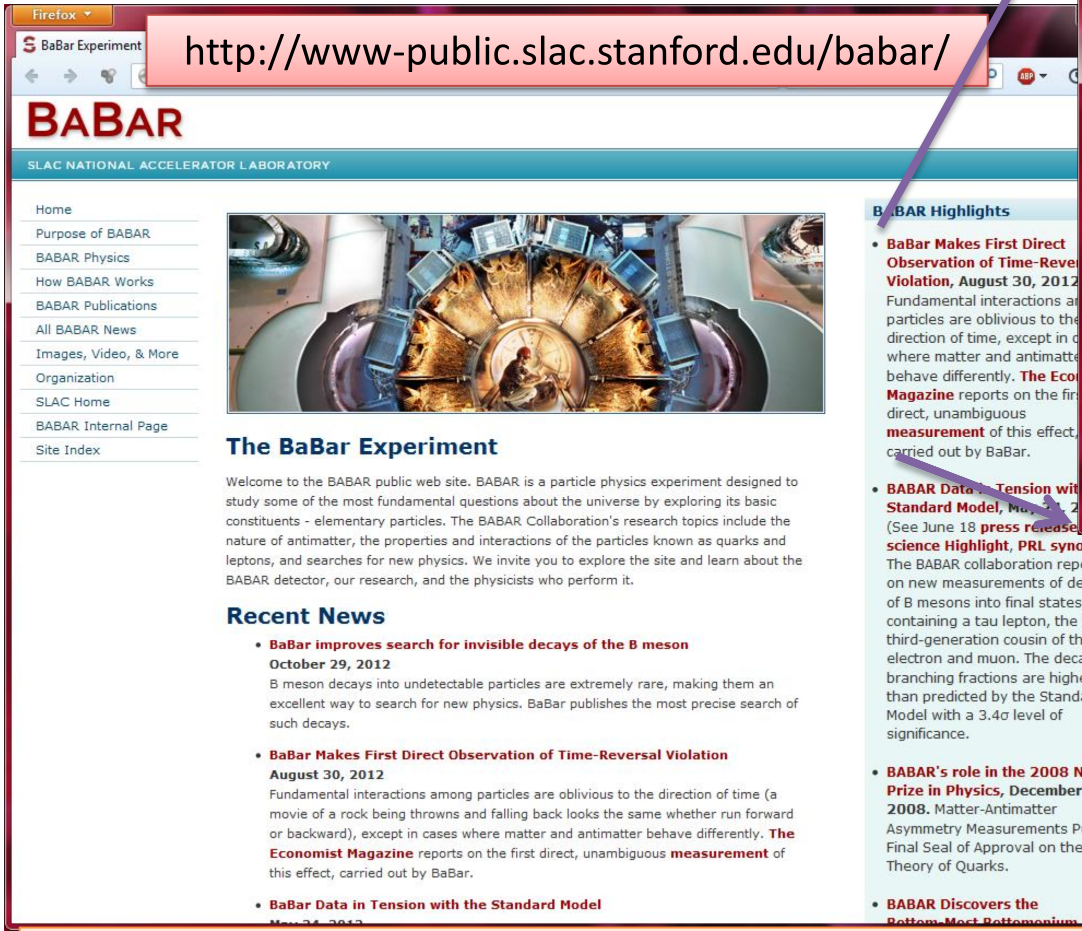


DOCUMENTATION WORKING GROUP

- The effort needed is not trivial
- The Documentation Working Group is coordinating the migration effort aided by an advisory committee
  - Many new students joined the effort but the input from senior members of the Collaboration is fundamental
  - There are 10 official members (plus some less official…) in the DWG but we promote the migration to the wiki as a Collaboration effort
  - Experts sign-off on the content of migrated pages

Matt Bellis, Alessandra Filippi – DWG coordinators

BABAR STILL ROCKS!



http://www-public.slac.stanford.edu/babar/

BABAR

SLAC NATIONAL ACCELERATOR LABORATORY

- Home
- Purpose of BABAR
- BABAR Physics
- How BABAR Works
- BABAR Publications
- All BABAR News
- Images, Video, & More
- Organization
- SLAC Home
- BABAR Internal Page
- Site Index

The BaBar Experiment

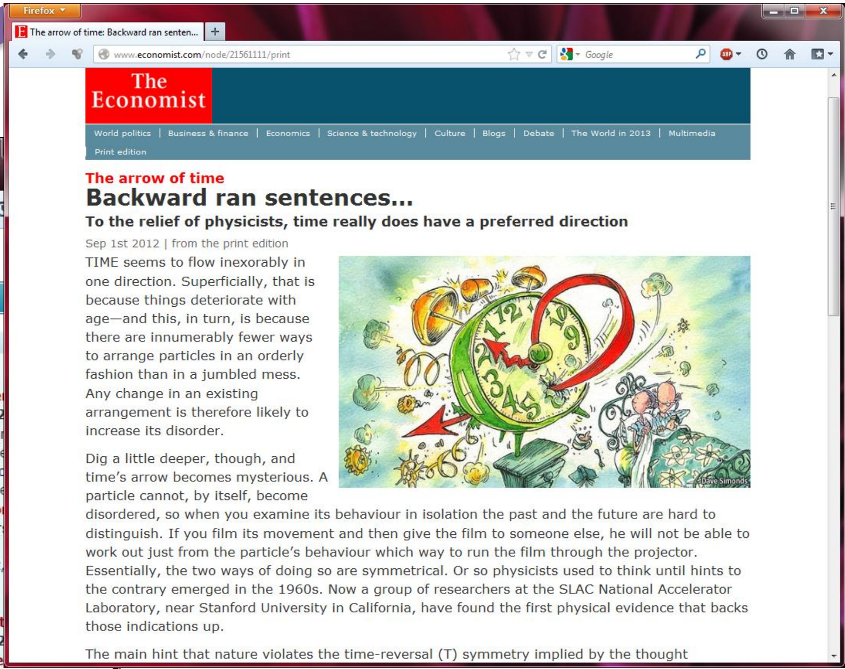
Welcome to the BABAR public web site. BABAR is a particle physics experiment designed to study some of the most fundamental questions about the universe by exploring its basic constituents - elementary particles. The BABAR Collaboration's research topics include the nature of antimatter, the properties and interactions of the particles known as quarks and leptons, and searches for new physics. We invite you to explore the site and learn about the BABAR detector, our research, and the physicists who perform it.

Recent News

- **BaBar improves search for invisible decays of the B meson**
  October 29, 2012
  B meson decays into undetectable particles are extremely rare, making them an excellent way to search for new physics. BaBar publishes the most precise search of such decays.
- **BaBar Makes First Direct Observation of Time-Reversal Violation**
  August 30, 2012
  Fundamental interactions among particles are oblivious to the direction of time (a movie of a rock being throwns and falling back looks the same whether run forward or backward), except in cases where matter and antimatter behave differently. **The Economist Magazine** reports on the first direct, unambiguous **measurement** of this effect, carried out by BaBar.
- **BaBar Data in Tension with the Standard Model**

B BAR Highlights

- **BaBar Makes First Direct Observation of Time-Reve Violation, August 30, 2012** Fundamental interactions a particles are oblivious to the direction of time, except in c where matter and antimatte behave differently. **The Eco Magazine** reports on the fir direct, unambiguous **measurement** of this effect, carried out by BaBar.
- **BABAR Data Tension wit Standard Model, Ma 2** (See June 18 **press release science Highlight**, **PRL synopsis**.) The BABAR collaboration reported on new measurements of decays of B mesons into final states containing a tau lepton, the heavy third-generation cousin of the electron and muon. The decay branching fractions are higher than predicted by the Standard Model with a 3.4σ level of significance.
- **BABAR's role in the 2008 Nobel Prize in Physics, December 8, 2008.** Matter-Antimatter Asymmetry Measurements Put Final Seal of Approval on the Theory of Quarks.
- **BABAR Discovers the**



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Print edition

The arrow of time

Backward ran sentences...

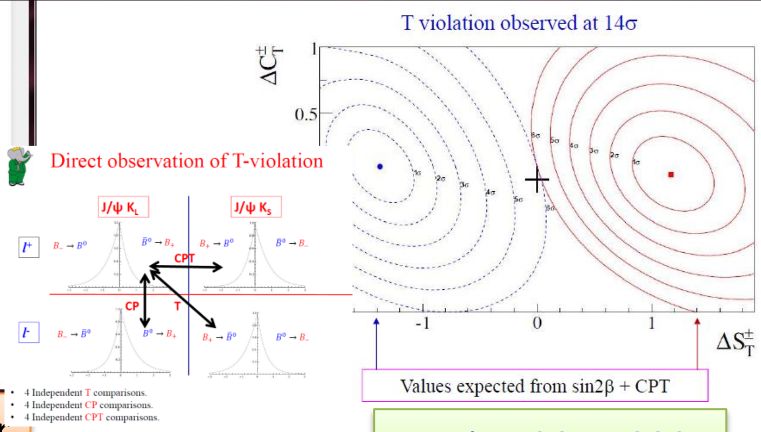
To the relief of physicists, time really does have a preferred direction

Sep 1st 2012 | from the print edition

TIME seems to flow inexorably in one direction. Superficially, that is because things deteriorate with age—and this, in turn, is because there are innumerably fewer ways to arrange particles in an orderly fashion than in a jumbled mess. Any change in an existing arrangement is therefore likely to increase its disorder.

Dig a little deeper, though, and time's arrow becomes mysterious. A particle cannot, by itself, become disordered, so when you examine its behaviour in isolation the past and the future are hard to distinguish. If you film its movement and then give the film to someone else, he will not be able to work out just from the particle's behaviour which way to run the film through the projector. Essentially, the two ways of doing so are symmetrical. Or so physicists used to think until hints to the contrary emerged in the 1960s. Now a group of researchers at the SLAC National Accelerator Laboratory, near Stanford University in California, have found the first physical evidence that backs those indications up.

The main hint that nature violates the time-reversal (T) symmetry implied by the thought



- 4 Independent T comparisons.
- 4 Independent CP comparisons.
- 4 Independent CPT comparisons.

Values expected from sin2β + CPT

BaBar public page: Abi Soffer, former PAC & senior DWG Member

arXiv:1207.5832

Manpower, Expertise & Budget

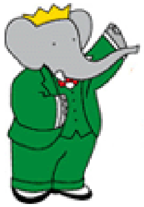
- Designing and maintaining something like the LTDA through the years requires many talents and careful planning
  - *BaBar* experts
    - Releases, databases, data management and documentation
      - Plus virtualization support
    - The Collaboration will have to provide such expertise
      - Difficult to disentangle general BaBar support and LTDA related support, but at the moment 1-1.5 FTE is a good estimate for LTDA only right now
  - Computing experts
    - Network, security, system and networks administration, …
    - 0.5 FTE/year foreseen after 2012
- Costs (not FTEs)
  - Hardware and refreshment program
  - Recharge (somewhat unknown) costs
  - Red Hat entitlements for virtualization
    - Use SL virtual machines to avoid extra cost (SL is not supported at SLAC)

LTDA Beyond the Cluster

- Future of the Collaboration and the data
  - – Time to start thinking about what we will do in the future and what will happen to our data and internal documents
    - Go public? If yes, when and how?
    - Use of Inspire
  - – Very strong opinions within the Collaboration
  - – The challenge will start at our next Collaboration Meeting at the end of January

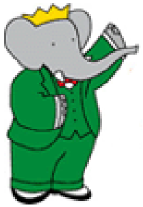
ACKNOWLEDGMENT PAGE

- Thanks to the LTDA developers
  - Coordinator: Tina Cartaro
  - BaBar software expert: Homer Neal
  - Development and system administration of LTDA: Marcus Ebert
  - Network design: Steffen Luitz
  - Virtualization expert: Kyle Fransham
  - System performance and CDB: Igor Gaponenko
  - Databases, tools and production: Douglas Smith and Tim Adye
  - Computing Division experts
    - System setup and adminstration: Booker Bense, Lance Nakata, Randall Radmer and all the Unix-Admin team
    - Xrootd expert: Wilko Kroeger
    - Network setup: Antonio Ceseracciu
    - BaBar-SLAC Computing Division liaison: Len Moss
  - Thanks to the PPA Management and the DOE for the strong support



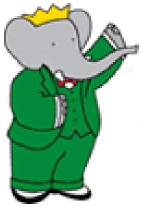
CONCLUSION

- System went into production on March 21st
  - On time and within budget
  - Since then it has been already extended by 20 batch nodes and one more nfs server
- All BaBarians have a LTDA home
  - About 10-15 users very active
- In use for production
  - Behaves like a Tier site
- Improving the setup and fine tuning
  - Unexpected problems from updates took the system down for many days in two occasions
  - Improving user experience
  - Simplify things wherever possible



Q & A

- Why LTDA and not the GRID or the commercial clouds?
  - Code and data is directly accessible from the common NFS area and don't need to be included in the VM image thus allowing memory and startup efficient VM's and easy use of new releases and access to a global CVS repository.
  - Files are directly accessible from the NFS areas instead of needing to copy them to the VM space. A job has the same local read access privileges as those of the user.
  - Many research computing clusters using virtualization allow only certain directories to be mounted for importing files thus resulting in extra effort from the user to create a setup appropriate for batch submission which is often different from the development setup.
  - One can log into the VM that the job is running on and diagnosis resource usage problems.
  - GRID systems are frequently very difficult to debug because one can not directly observe the job as it is processing.
  - One can start interactive VM sessions for development/debugging work.
  - Users will not have to invest time and effort to acquire funds for using a commercial cloud system.
  - A platform equivalent to that for the batch jobs will always be available for development and debugging purposes.
  - The setup allows users to migrate seemlessly to the LTDA system with only a few minor restrictions on what one can do.
- Why doesn't one just use the standard batch system but with VM's?
  - The whole SLAC batch system would have to be adjusted to be behind a firewall to protect against use of insecure platforms and other projects running behind the firewall could be affected.
  - New tools and technologies may allow it in the future
- The lifetimes of the latest RHEL releases have been extended, doesn't it remove the need for the LTDA?
  - No because the expertise and person power will cease to exist to do full release validations and possible update of the hundreds of packages of code every time a new security patch (typically coming along with a new version of glibc) is released.
- What about dependencies on the virtualization system?
  - Look for alternatives (xen, …) and ultimately use hardware emulation
- What were/are the instabilities of libvirt? ie, why is qemu called directly?
  - There have been at least two things which made problems: 1) libvirt crashed often with segfault with no obvious reason; 2) jobs just hang in the queue after the real job within the VM was already finished (VM was for unknown reasons not destroyed and the job not cleared from the queue system after finishing). Sometimes only the VM was killed, but not due to the prologue script but by a direct kill to the process which didn’t freed up the MAC address and let the ssh processes running. Since we changed to call qemu directly, this never happened again. Also the structure is as simple as with libvirt, maybe even simpler since we don't need an additional layer and the use case within the LTDA is very limited. Also using qemu makes it easy to make changes to the base image using the same prologue/epilogue script structure. (it's easy with libvirt tools somehow too, but it's not needed at all and one more reason not to use it in the LTDA case)



PAST PROBLEMS & SOLUTIONS

- **qemu couldn't be started**
  - error message: kvm_create_vm: Interrupted system call
  - for about 0.5% of all jobs
  - jobs listed in the queue until wall time is over
  - known bug of kvm/qemu
  - should be solved in new versions
  - expect this problem to be gone on RHEL6.2
- **maui often shuts down without any hint in the log file**
  - seems to happen always with a high load on the scheduler and the network and more than 600 jobs

→ solution:
  - don't allow torque to push jobs to maui
  - only Maui looks every 10s for new jobs
  - for one schedule cycle only 10jobs/user are considered
  - if there are free nodes and waiting jobs, then let maui wait 4s between sending jobs to the nodes
  - users could also put in their scripts a delay of 1s between submission of jobs

- **very high network usage on some server**
  - due to the loading of one condition file in cond24boot09
  - not seen for cond24boot11

→ solution:
  - reduplicate conditions files on more servers

- **input collections or conditions couldn't be found**
  - to many open connections in xrootd
  - Network problems on the xrootd client hosts
  - connection couldn't be established
  - wrong mounted hard disk

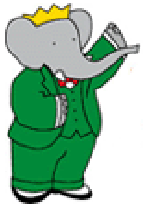
→ solution:
  - correctly mount the hard disk on ltda-srv005
  - reduplicate the conditions on many servers to reduce the load on a single one
  - tune the tcp parameters on all ltda-srv0xx
  - use a timeout in xrood for the connections to the clients

- **NFS server stopped to give new nfs exports out**
  - after some runs with more than 1000VM in parallel no new nfs mounts have been possible
    - this includes the home mount using automounter on the login machines for new logins
    - all existing mounts still worked
  - seems like a limit in the nfs server, maybe in open network ports, was reached

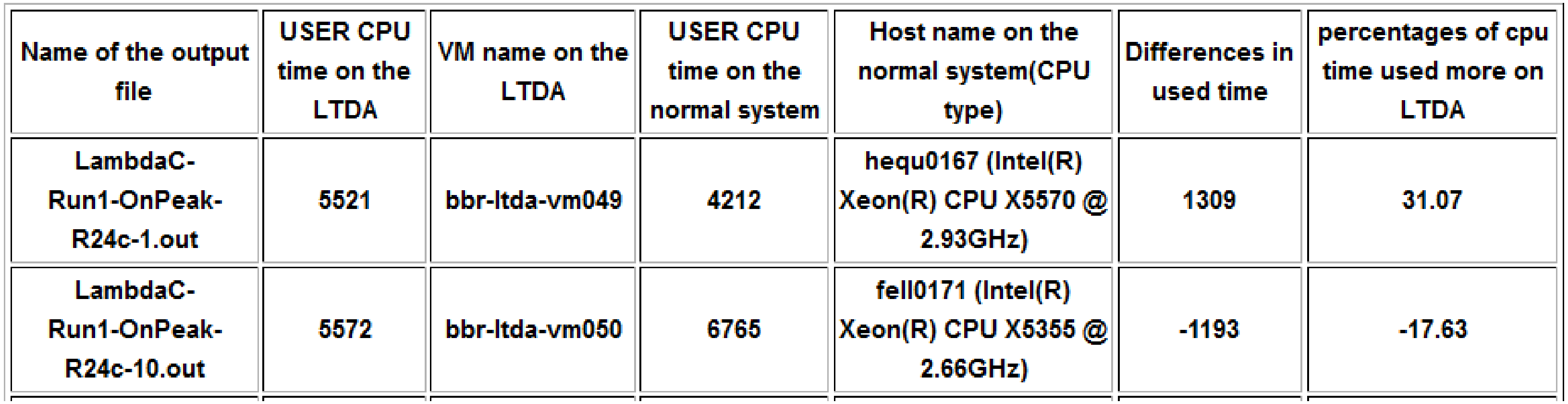
→ solution:
  - unix-admin changed some nfs related settings, we will see in the future if it's enough

Performance Tests

- VM’s vs SLAC batch queue
- Hyper-threading on/off
- I/O performance tests

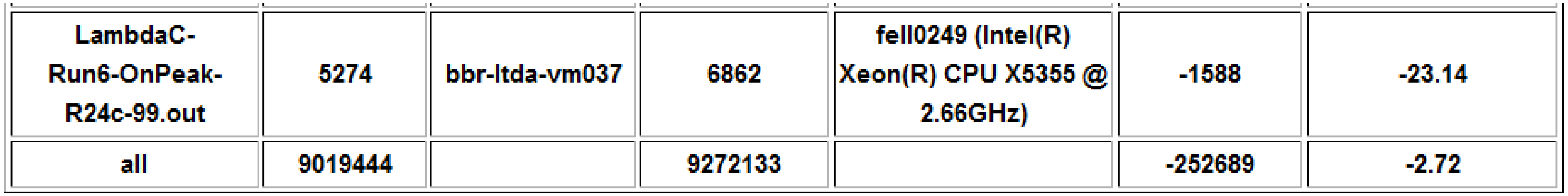


VM VS BARE METAL



Name of the output file	USER CPU time on the LTDA	VM name on the LTDA	USER CPU time on the normal system	Host name on the normal system(CPU type)	Differences in used time	percentages of cpu time used more on LTDA
LambdaC-Run1-OnPeak-R24c-1.out	5521	bbr-ltda-vm049	4212	hequ0167 (Intel(R) Xeon(R) CPU X5570 @ 2.93GHz)	1309	31.07
LambdaC-Run1-OnPeak-R24c-10.out	5572	bbr-ltda-vm050	6765	fell0171 (Intel(R) Xeon(R) CPU X5355 @ 2.66GHz)	-1193	-17.63

~1500 jobs later …



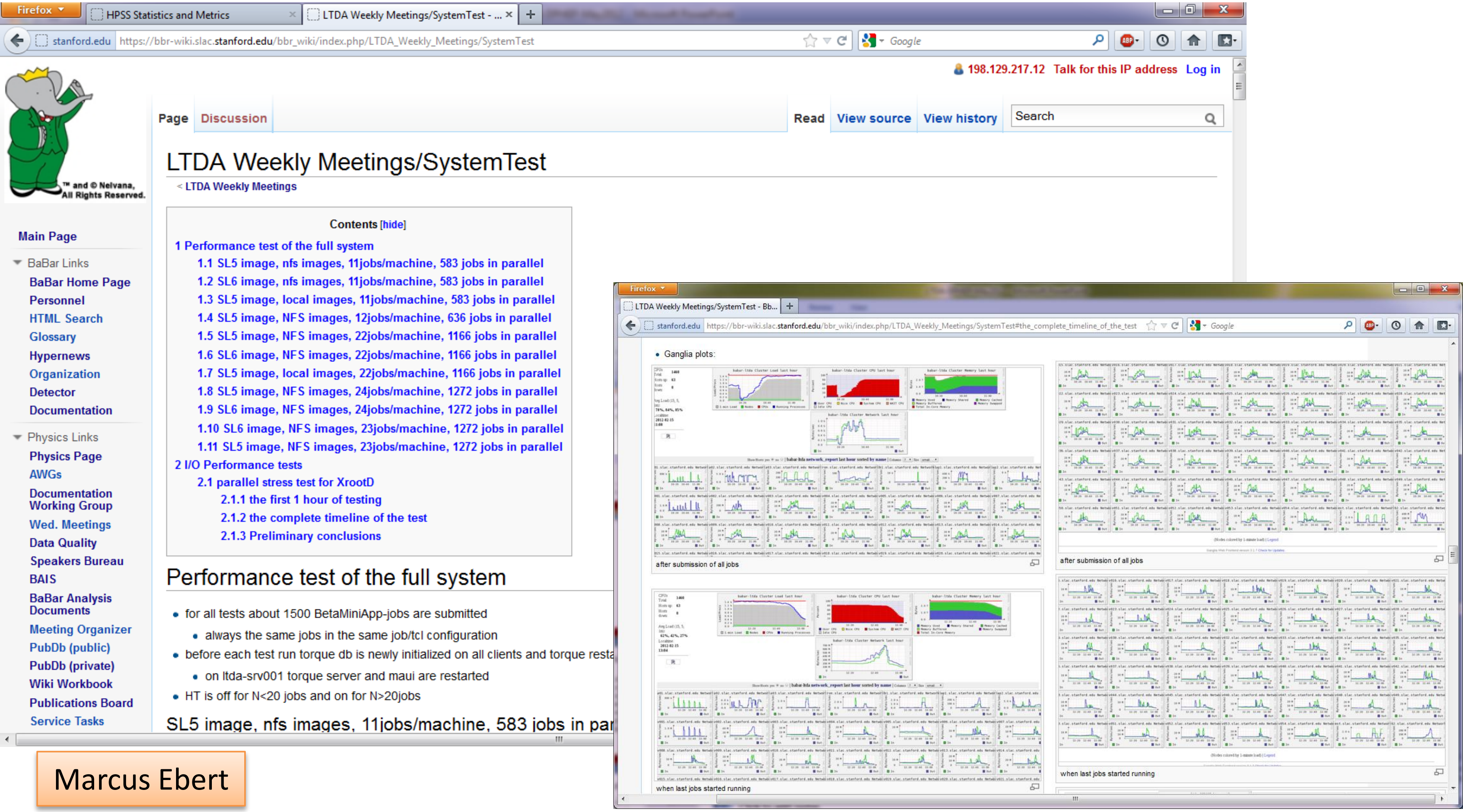
Name of the output file	USER CPU time on the LTDA	VM name on the LTDA	USER CPU time on the normal system	Host name on the normal system(CPU type)	Differences in used time	percentages of cpu time used more on LTDA
LambdaC-Run6-OnPeak-R24c-99.out	5274	bbr-ltda-vm037	6862	fell0249 (Intel(R) Xeon(R) CPU X5355 @ 2.66GHz)	-1588	-23.14
all	9019444		9272133		-252689	-2.72

LTDA host machines:

Intel(R) Xeon(R) CPU X5670 @ 2.93GHz (prototype machines)

Rhel5 / Hyper-threading off

HYPER-THREADING TESTS



LTDA Weekly Meetings/SystemTest

< LTDA Weekly Meetings

Contents [hide]

Performance test of the full system

- for all tests about 1500 BetaMiniApp-jobs are submitted
  - always the same jobs in the same job/tcl configuration
- before each test run torque db is newly initialized on all clients and torque resta
  - on ltda-srv001 torque server and maui are restarted
- HT is off for N<20 jobs and on for N>20jobs

SL5 image, nfs images, 11jobs/machine, 583 jobs in par

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stanford.edu https://bbr-wiki.slac.stanford.edu/bbr_wiki/index.php/LTDA_Weekly_Meetings/SystemTest#the_complete_timeline_of_the_test
Google
babar-ltda Cluster Load last hour
babar-ltda Cluster CPU last hour
babar-ltda Cluster Memory last hour
babar-ltda Cluster Network last hour

- Ganglia plots:

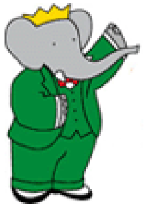
after submission of all jobs

after submission of all jobs

when last jobs started running

when last jobs started running

Marcus Ebert



COMPARISON TABLES

- CPU intensive jobs show no difference when single job or 11 jobs run on a machine
  - but variation for repeated tests is up to 30%
- I/O intensive jobs can be up to 300% slower when 11 jobs run in parallel on a single machine compared to a single job/machine
- BetaMiniApp is about 20% slower when running 11 jobs in parallel on a single machine compared to a single job/machine
- CPU time used for all Run1-6 jobs when running 11jobs/LTDA machine in parallel is comparable to running same jobs on the general SLAC queue
  - LTDA used about 2% less CPU time for all jobs

- CPU time used for a BetaMiniApp job is comparable to HT off when running same number of jobs in parallel
- single BetaMiniApp can use up to 50% more CPU time when running 22jobs in parallel instead of 11
- CPU intensive again independent of the number of parallel jobs
  - <10% slower than HT off
- I/O intensive jobs can be up to 900% slower when running 22jobs/machine compared to a single job

HT off vs HT on

	11 jobs SL5 NFS image	**22 jobs SL5 NFS image**	difference
CPU time	7849934	11243061	+40%
Wall time	8697739	11996994	+38%

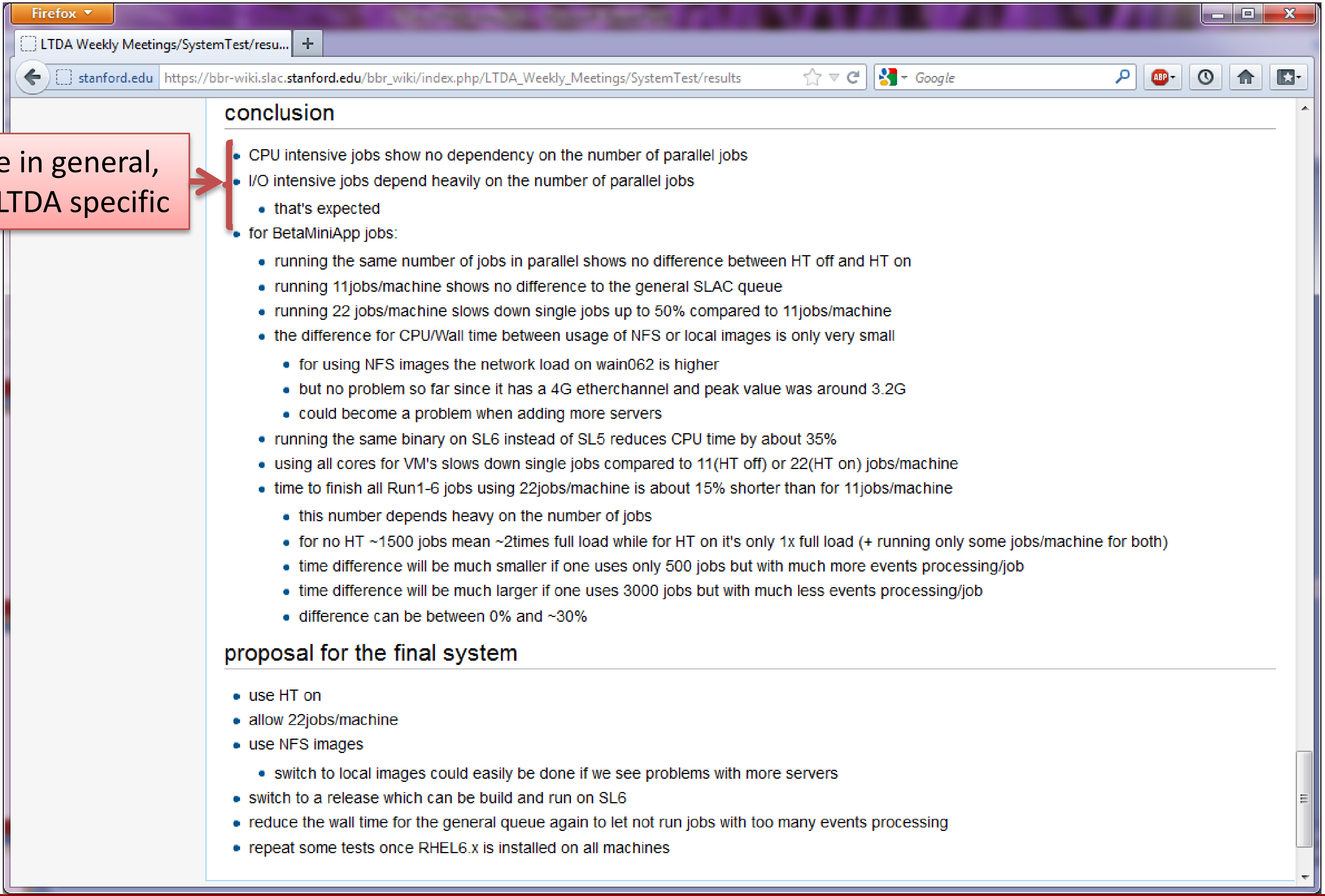
	11 jobs SL6 NFS image	**22 jobs SL6 NFS image**	difference
CPU time	5152806	7286484	+41%
Wall time	7245687	10267120	+42%

SL5 vs. SL6

	11 jobs SL5 NFS image	**11 jobs SL6 NFS image**	difference
CPU time	7829719	5120721	-35%
Wall time	8371660	7200235	-14%

	22 jobs SL5 NFS image	**22 jobs SL6 NFS image**	difference
CPU time	11233998	7249142	-35%
Wall time	11987646	10214567	-15%

RESULTS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stanford.edu
https://bbr-wiki.slac.stanford.edu/bbr_wiki/index.php/LTDA_Weekly_Meetings/SystemTest/results
Google

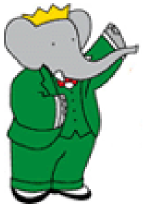
True in general, not LTDA specific

conclusion

- CPU intensive jobs show no dependency on the number of parallel jobs
- I/O intensive jobs depend heavily on the number of parallel jobs
  - that's expected
- for BetaMiniApp jobs:
  - running the same number of jobs in parallel shows no difference between HT off and HT on
  - running 11jobs/machine shows no difference to the general SLAC queue
  - running 22 jobs/machine slows down single jobs up to 50% compared to 11jobs/machine
  - the difference for CPU/Wall time between usage of NFS or local images is only very small
    - for using NFS images the network load on wain062 is higher
    - but no problem so far since it has a 4G etherchannel and peak value was around 3.2G
    - could become a problem when adding more servers
  - running the same binary on SL6 instead of SL5 reduces CPU time by about 35%
  - using all cores for VM's slows down single jobs compared to 11(HT off) or 22(HT on) jobs/machine
  - time to finish all Run1-6 jobs using 22jobs/machine is about 15% shorter than for 11jobs/machine
    - this number depends heavy on the number of jobs
    - for no HT ~1500 jobs mean ~2times full load while for HT on it's only 1x full load (+ running only some jobs/machine for both)
    - time difference will be much smaller if one uses only 500 jobs but with much more events processing/job
    - time difference will be much larger if one uses 3000 jobs but with much less events processing/job
    - difference can be between 0% and ~30%

proposal for the final system

- use HT on
- allow 22jobs/machine
- use NFS images
  - switch to local images could easily be done if we see problems with more servers
- switch to a release which can be build and run on SL6
- reduce the wall time for the general queue again to let not run jobs with too many events processing
- repeat some tests once RHEL6.x is installed on all machines

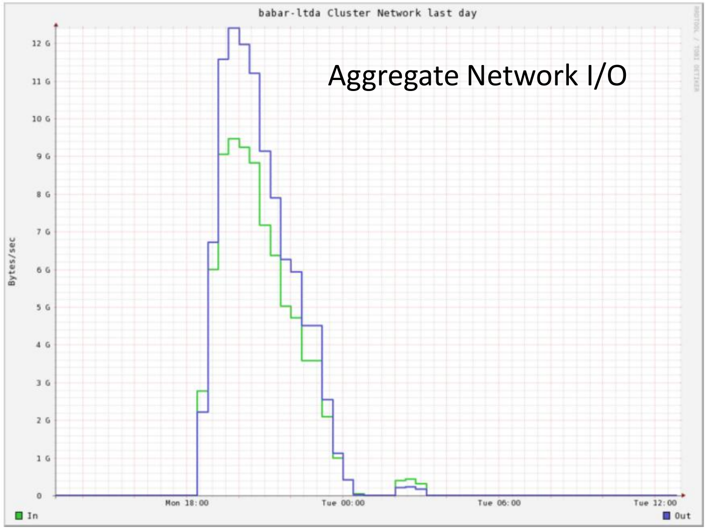


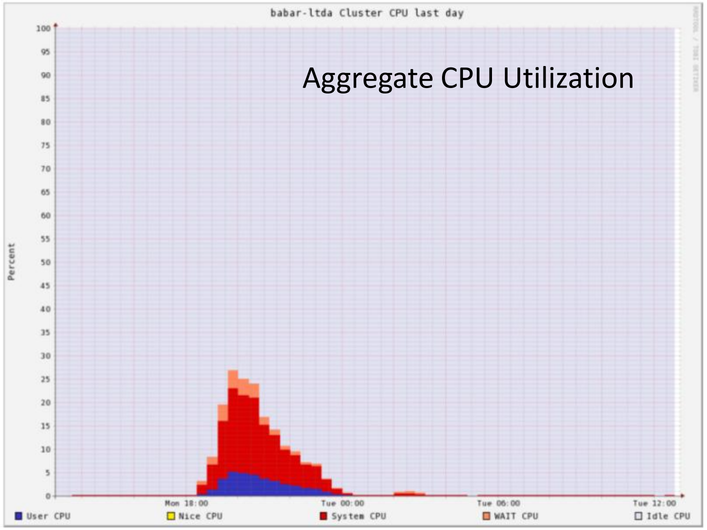
I/O Performance test For Xrootd

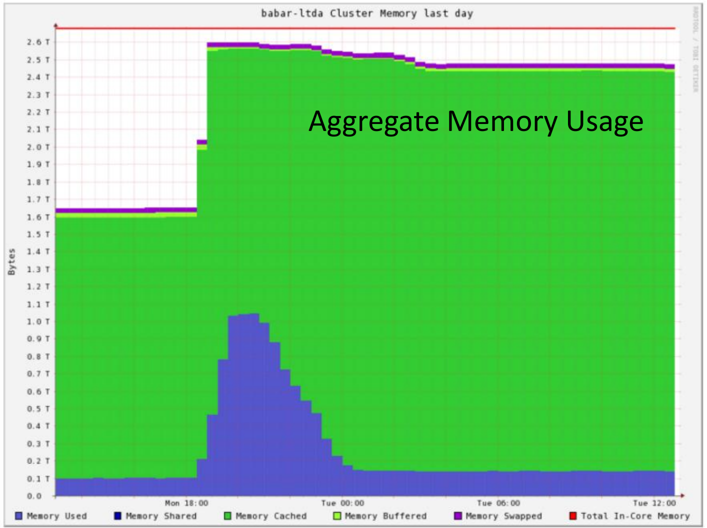
- The main goal of the test was to see how much data can be delivered under extreme load by LTDA XrootD installation to clients processes. Resource (memory and CPU) utilization was also being monitored during the tests using Ganglia. Scalability of the XrootD installation has been tested as well.

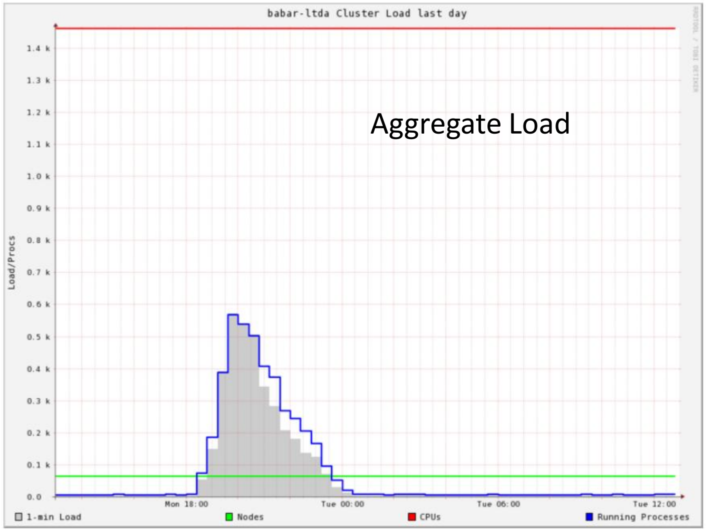
Igor Gaponenko

MONITORING THE TEST

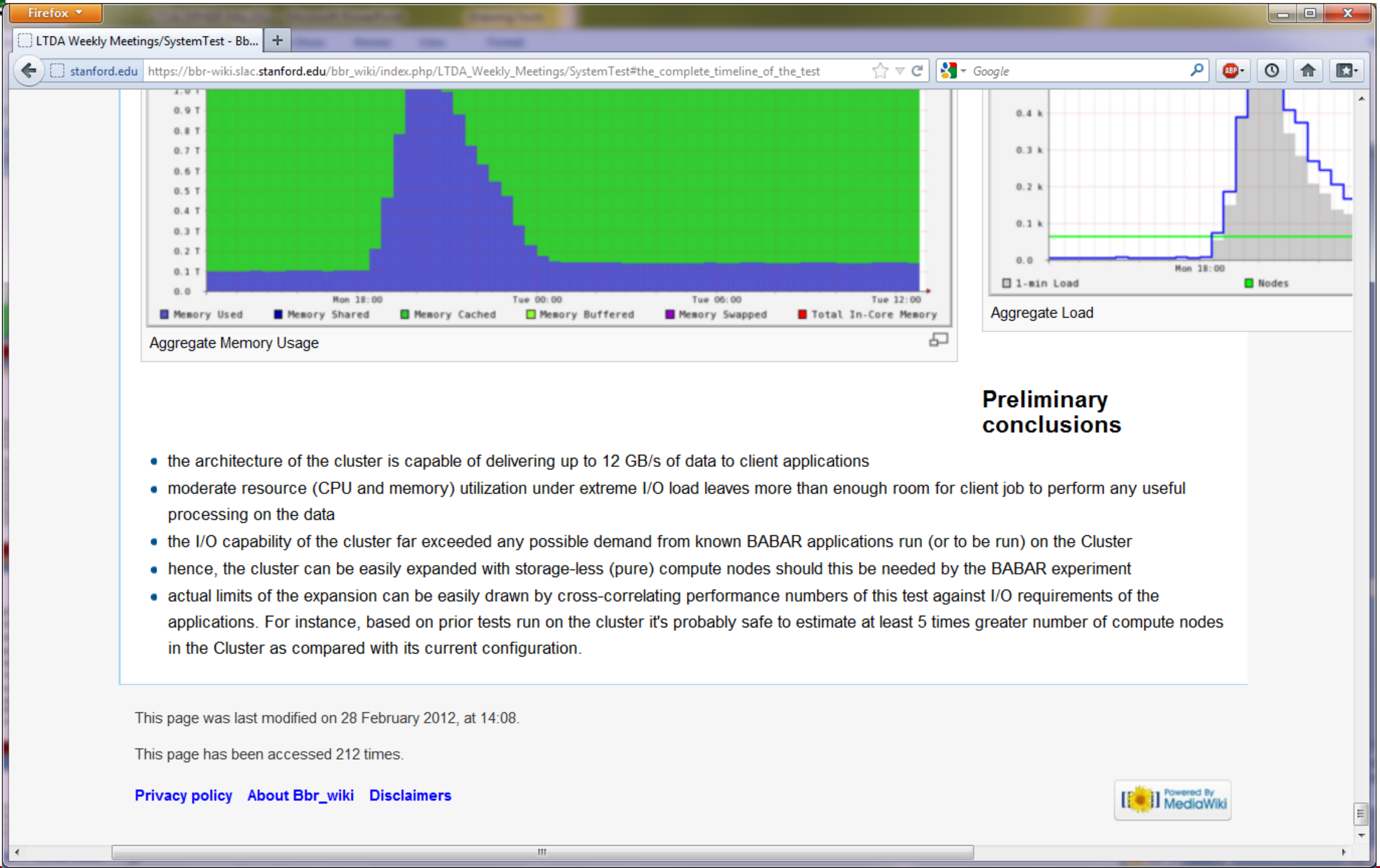

Aggregate Network I/O


Aggregate CPU Utilization


Aggregate Memory Usage


Aggregate Load

RESULTS



Aggregate Memory Usage

Aggregate Load

Preliminary conclusions

- the architecture of the cluster is capable of delivering up to 12 GB/s of data to client applications
- moderate resource (CPU and memory) utilization under extreme I/O load leaves more than enough room for client job to perform any useful processing on the data
- the I/O capability of the cluster far exceeded any possible demand from known BABAR applications run (or to be run) on the Cluster
- hence, the cluster can be easily expanded with storage-less (pure) compute nodes should this be needed by the BABAR experiment
- actual limits of the expansion can be easily drawn by cross-correlating performance numbers of this test against I/O requirements of the applications. For instance, based on prior tests run on the cluster it's probably safe to estimate at least 5 times greater number of compute nodes in the Cluster as compared with its current configuration.

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