The Paraná Digital Project

Marcos Castilho
Center for Scientific Computing and Free Software
C3SL/UFPR

September, 25th 2008

Managing a Grid of Computer Laboratories
for Educational Purposes

Abstract

- We present a grid-based model for managing hundreds of distributed educational computing laboratories.
- The aim is to dispense the need of specialized staff in each place whilst maximizing the laboratories uptime
- The model was implemented in order to manage more than two thousand laboratories spread across the entire public school network of Paraná State (Brazil)

Motivation

- Computers and the Internet are important for educational purposes
- Cost reduction of computer hardware led to expansion of digital inclusion policies
- The aim is to provide laboratories for every public school

First problems

- The lack of specialized workforce to manage and maintain these laboratories frequently turns them useless
- Computers get obsolete, the software doesn't work properly, computers get infected, among other reasons
- In public schools this situation is worsened by the lack of funds for frequent updates

Problems that seem to have no solution

- It's impossible to have an expert to manage every school
- Educators and students should only worry about the educational use of the system, and not about its technical details
- This demands an effort in order to define a new administration model

Problems do have a solution!

The Grid-based model

- Management tasks are automated
- Self-monitoring systems
- Maintenance costs are minimized
- Dispenses specialized staff in evety laboratory
- Maximises system uptime

The model was implemented in Brazil

- 2.100 schools
- 1.500.000 students
- 57.000 teachers
- 42.000 working points
- 399 cities
- 199,314km^2
- GNU/Linux software, under Free Software licence (GPL)
- Up and running since June, 2006

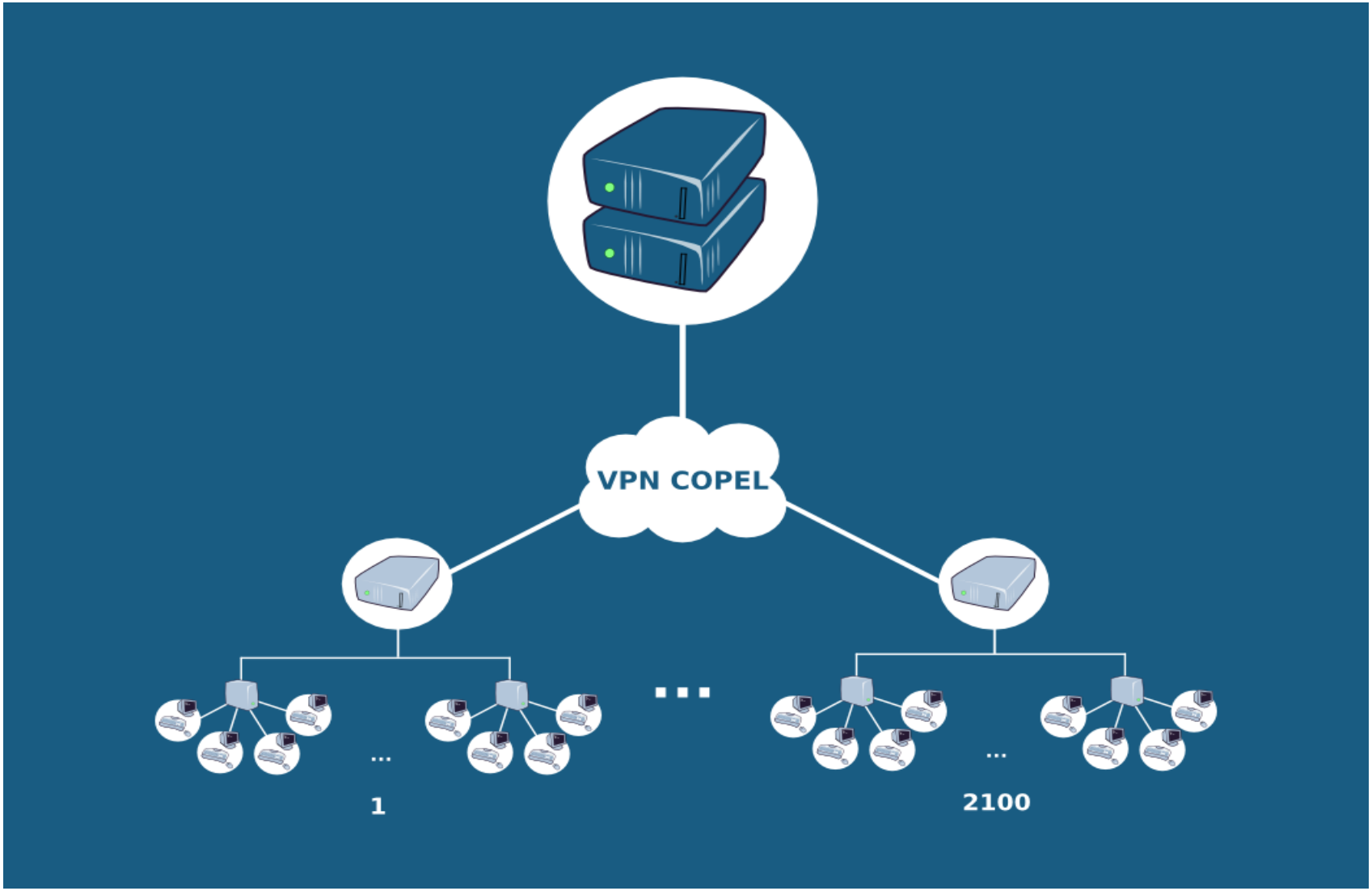
The Paraná Digital Project

- It is a partnership between
  - State Secretary of Education
  - State Computer Company of Paraná State
  - State Secretary of Science and Technology
  - Inter-American Development Bank (IDB)
  - United Nations Development Programme (UNDP)
  - Electric Company of Electricity (COPEL)
  - Universidade Federal do Paraná (C3SL)

View of Paraná State in Brazil

View of Paraná State

PRD's architecture



PRD's architecture

- In each school:
  - a laboratory composed of 20 X-terminals
  - one processing server called *the school server*
- The school server acts simultaneously as
  - processing and storage unit, gateway to the network, firewall and access point to the Core
  - it runs a Debian-based GNU/Linux distribution,
  - all servers have the same software packages installed.
- At the Core, a proxy-controlled connection to the Internet is provided

The grid-based model

- The computer laboratories are interconnected forming a grid
- The hardware, operating system and main applications are fairly homogeneous
- Global tasks: are executed to guarantee the expected services, with maximum performance
- Local tasks: are related to specific aspects of each laboratory and those demanding physical access to the hardware
- Main idea: To implement self-management concepts

The local managers

- They are not computer experts
- They take high level and simple decisions
- They use a user-friendly interface to perform local tasks:
  - User accounts, disk quotas, etc.
  - Initial installation or re-installation procedures
  - Contact the call center in case of problems

Global managers: the Core

- A small group of specialized system managers
- They are able to manage hundreds of laboratories
- They specify what are the system's features, software to be installed, what should be restricted or allowed
- Their decisions are propagated through self-management
  - Self-configuration
  - Self-optimization
  - Self-recuperation
  - Self-protection

Self-configuration

- Concerns the adaptation of new components or new execution environments without a significant human intervention
- Is a continuous process aiming to keep the system configured
- The configuration policies are defined for the entire grid by the Core

Implementing self-configuration

- Users have access to the server through the X-terminals
- The server is the only machine to be configured and maintained
- The software and configuration of the X-terminals are determined at the server
- The servers' self-configuration is based on software package management and unified mirrors

Initial installation

- A CD-ROM containing a standard system image
- The server checks periodically for updates at the central mirror
- X-terminals must automatically recognize and configure hardware
- It allows automated installation and configuration by the local manager
- This automated procedure minimizes service disruption and data loss
- A regular user must have an account created by the local manager.
- The local manager does not have root powers
- This ensures that critical tasks are globally defined on the grid.

Self-optimization

- Allows the configuration of parameters that impact on the overall performance
- Monitoring systems are fundamental in a self-optimized system
- Collected data can be used to optimize system parameters
- New configurations can be automatically applied globally in the grid
- The identification of possible failure points can be used to avoid or to fix bugs

Self-optimization

- The analysis of historical data can also be used to optimize the system
- This helps to scale the hardware in each laboratory or to plan a hardware upgrade
- There is a web page with strategic information from the whole grid

Self-recuperation and Self-protection

- Failures in a system can cost many weeks of work
- It's possible to automatically detect, diagnose, treat and prevent many software and hardware problems
- The downtime can be reduced if some aspects of the hardware and the operating system are tracked
- Examples: Contact the Core depending on memory, hard disk and temperature sensors

Self-recuperation and Self-protection

- Redundant Array of Inexpensive Disks (RAID) prevent loss of data
- Downtime can be minimized by verifying the filesystem's integrity
- The system must automatically recover damaged files
- There must be a recuperation process to reinstall the system without user data loss
- If everything fails, enter in remote assistance mode (ssh from the Core)

System Recovery

- Automatic recovery: it formats only the root filesystem, preserving user data and local information. A collection of scripts saves important files, restoring them after system re-installation.
- The remote help: Live-CD allows the Core to connect to the school server and try to find the problem or to do a backup.

System Upgrade

- Frequent system upgrades are necessary to provide new functionalities, address security problems and propagate new software, tools, or policies from the Core
  - automatic daily upgrades and
  - triggered upgrades

The daily automatic upgrade

- Based on Debian's *apt-get* tools
- Every night, each school server looks for new software packages
- The single mirror ensures that all servers will install exactly the same software
- It is quite simple to propagate a new tool or configuration over the entire network

The triggered upgrade

- The Core can force all school servers to upgrade
- This happens as soon as the network link turns on
- Use cases:
  - the Kernel exploit that allowed an ordinary user to become root
  - the upgrade from *sarge* to *etch* (in February 2008)

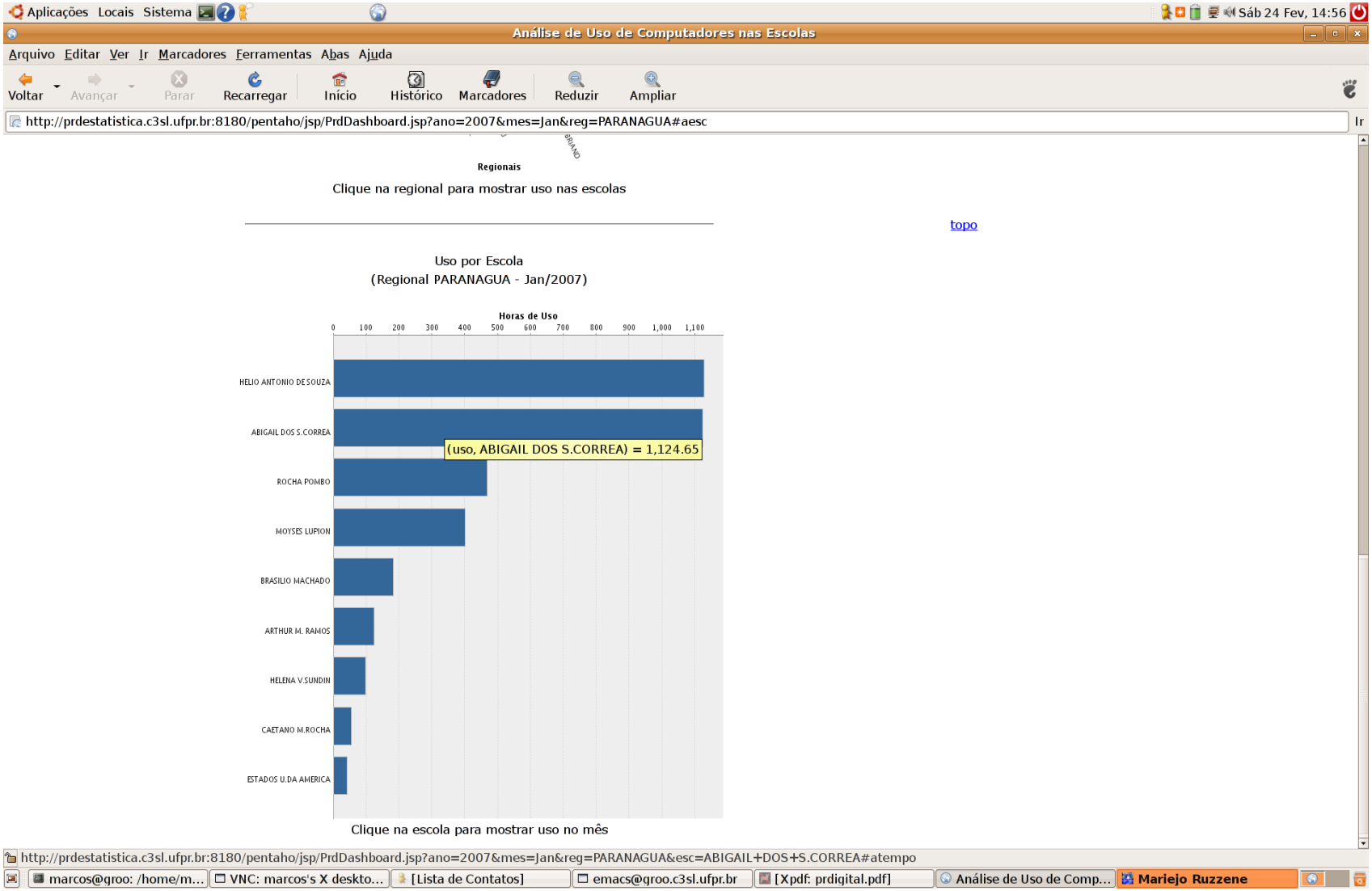
System Monitoring

- Is an essential feature of autonomic systems, and provides information to allow the system's self-optimization and self-recuperation
- It is at the heart of the PRD network, revealing the real state of the whole grid
- In the PRD model, there are two different monitoring systems:
  - the statistics center
  - diagnosis system

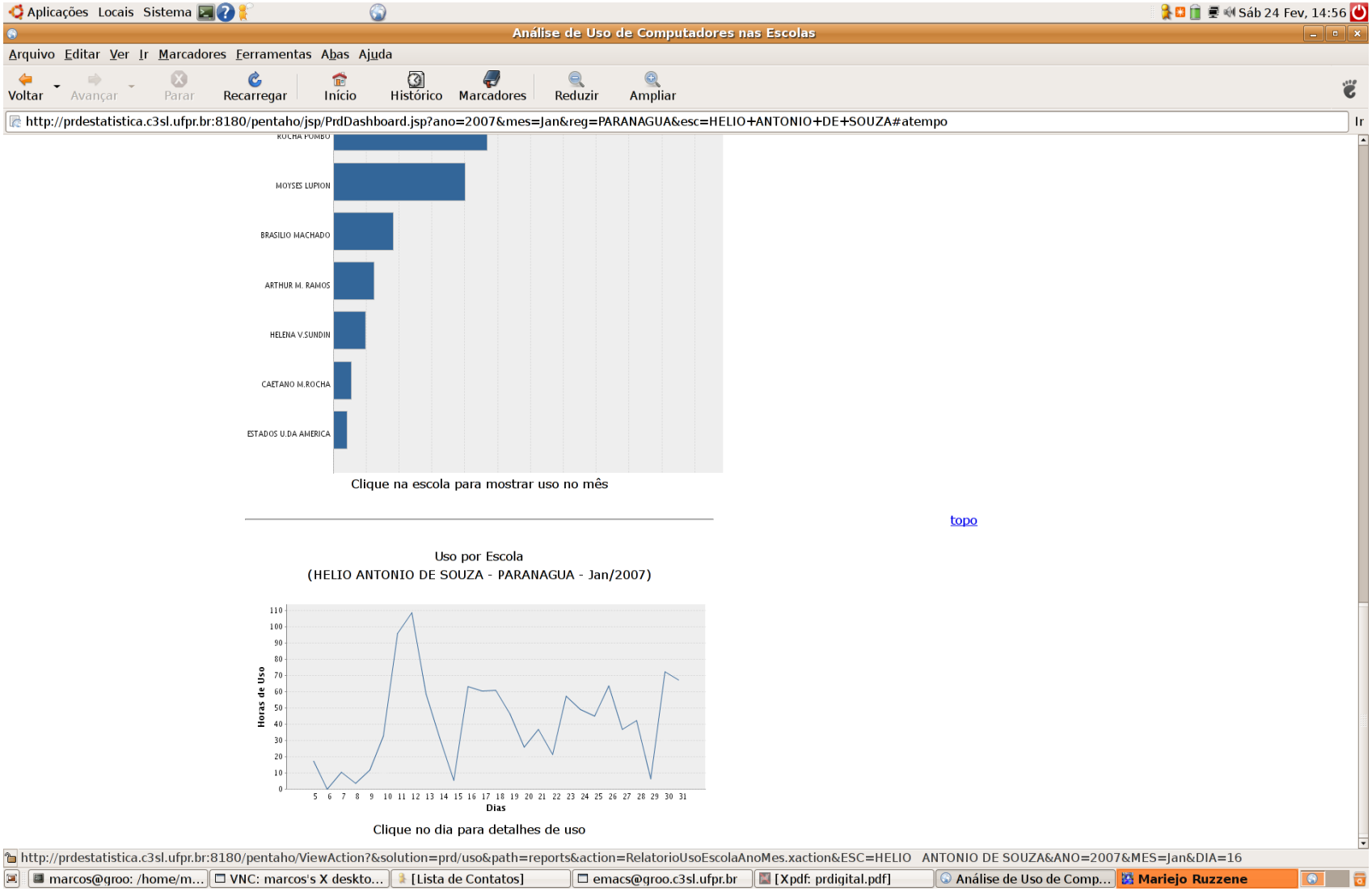
The Statistics Center

- A web site with strategic information
- It allows an overview of the network's growth and provide data concerning the laboratories usage
- This is automatically stored in the central database
- This provides strategic information for decision support

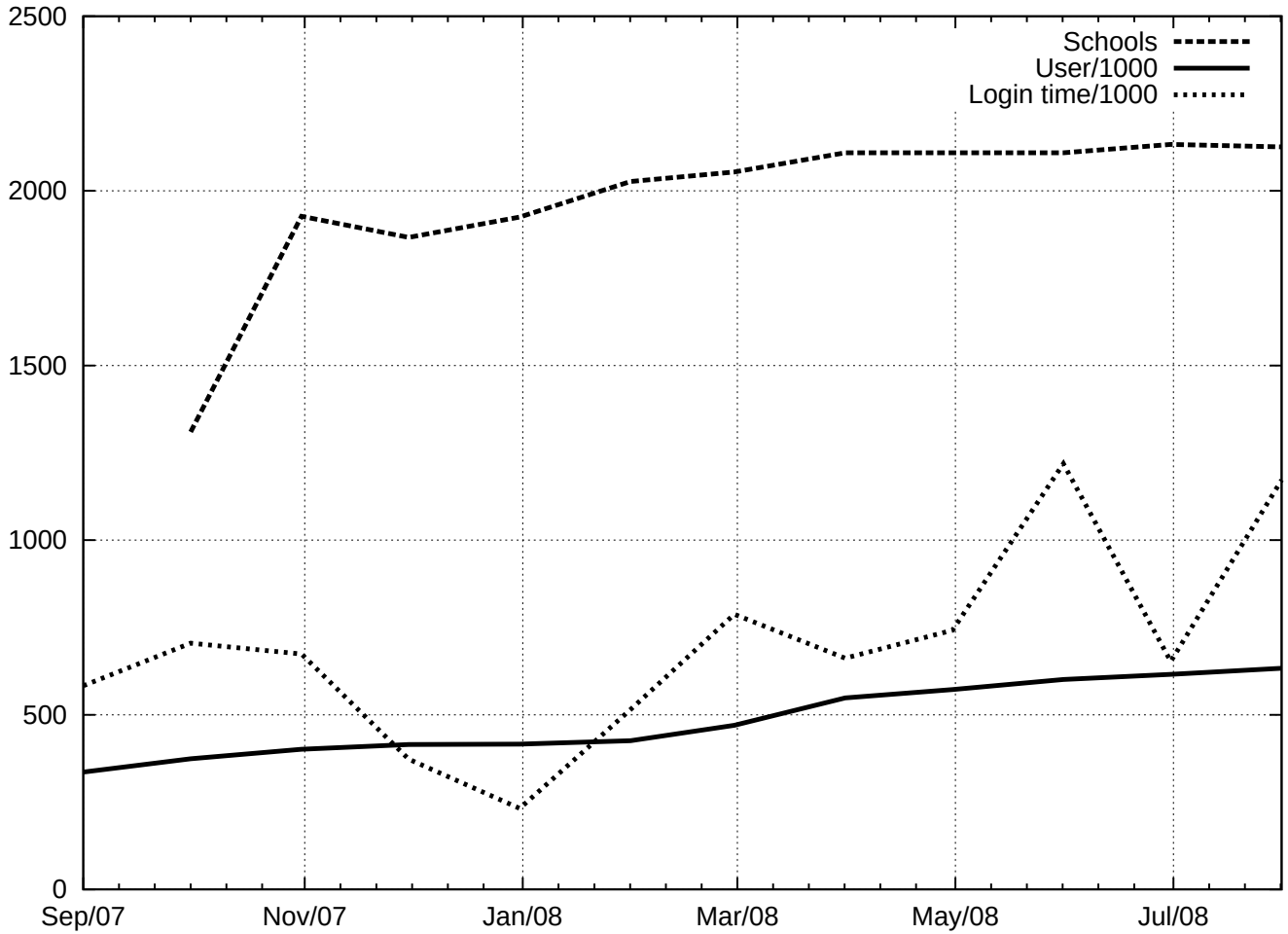
Snapshot of the statistics center web page



Snapshot of the statistics center web page



Examples of collected data giving decision support



The Instant Diagnosis System

- Conceived to provide real time diagnosis of the network's status
- Detects possible faults in the laboratories and triggers alarms at the Core
- Capable to detect whether the schools are online, identify old software, inconsistencies in a filesystem, checksum errors, hard disk problems and so on
- Allows prevention of critical failures, either by acting remotely or by timely providing hardware replacement

Manual System Inspection

- Manual interventions are undesired
- The core can remotely log in a server via SSH
- But just to inspect the server's behavior
- All changes should happen on a global manner in the grid
- This means: global management!

Main contributions

- Software
  - 40 million dollars saved due to free software
  - Software is free and has high quality
  - More than 100 thousand packages are made available
- Hardware
  - Carefully dimensioned hardware configuration
  - "Obsolete" hardware can be reused
- 15 million dollars saved due to the multiseat
- Maximization of hardware lifetime

Conclusion

- This model allows the administration of thousands of computing laboratories with minimum human intervention
- A large scale implementation of this model is provided, in which a management team composed of 12 highly trained Unix managers is able to control all software-related issues from the entire network

Final considerations

- The system works pretty well . . .
- . . . but a working system does not mean it will be used!

Contact and links

- castilho@ufpr.br
- jefferson.s@lactec.org.br
- http://www.c3sl.ufpr.br/prd
- http://yoda.c3sl.ufpr.br/SDI
- http://www.prdestatistica.seed.pr.gov.br