Does a new chip in and of itself drive innovation?
Or do the delivery vehicles of this new technology spark the **imagination** of the industry?
Cell is at its very cores a unique opportunity for highly scalable performance ...
... and the powerful engine inside one of the industry's most exciting consumer products.
Cell-ebration
Commercial Solutions
for Low Cost Cell/B.E. Clusters
Terra Soft Solutions

Founded in 1999, Terra Soft Solutions maintains 3 core elements to its business:

• Terra Soft develops Yellow Dog Linux, an operating system for the Power architecture.
• Terra Soft offers integrated, turn-key solutions built upon industry leading Power systems.
• Terra Soft provides Linux consulting services.
Yellow Dog Linux

YDL has maintained a 100% dedication to the Power architecture since 1999:

- Built upon CentOS, an open version of Red Hat Enterprise Linux.
- Includes industry standard desktop, development, and server applications.
- First commercial Linux OS to support the Cell B.E., November 2005.
- First to market with PS3 sound, WiFi support, and a single kernel which resolved both the 'CPU load average' and 'reboot' bugs.
- The only Linux OS, community or open, to support every Cell based computer on the market.
- The only Linux OS to include the IBM Cell SDK, installed by default.
Yellow Dog Linux

YDL has maintained a 100% dedication to the Power architecture since 1999:

- E17 & Gnome installed by default, KDE included.
- Gnash, the Flash work-alike. Ekiga VoIP, Pidgin IM/IRC, and Fluendo codec installer.
- kernel v2.6.23, gcc v4.1.1, gblic v2.5, and Eclipse v3.2.2.
- IBM iRT (interactive raytrace) demo available via YDL.net Enhanced.
- The PS3 Grid “BOINC” software package coming soon! More than 2400 packages in all ...
Yellow Dog Linux

Yellow Dog supports a rich diversity of Power systems and devices:

- IBM System p (JS2x, 510, 520, 540).
- 802.11b Airport auto-config; Extreme with configuration.
- 802.11b through PCMCIA and USB WiFi cards.
- Cell phone modem wireless connectivity.
- Audio on all tested machines.
- Sony PS3 Sixaxis game controller.
How far would you go to be the first?
Cell Hack-a-thon I
Cell Hack-a-thon I

In January of 2007, in just one week, IBM, Sony, Mercury, and RapidMind sponsored Terra Soft's Hack-a-thon to help produce the world's first optimized Cell code for real-world use:

- BLAST
- ClustalW
- Dot Product
- Kernel Probe
- Life Sciences
- Mesa, VR, Visualization, Games
- A Windows cross development environment for Cell

The Mesa project in particular stands out as a success with an increase in performance:

- Speed ratio in frames/s 7 : 1
- Speed ratio in million fragments/s 80 : 1
Cell Hack-a-thon I
Cell Hack-a-thon I

“The hack-a-thon is an interesting exercise in social & commercial collaboration ... the breakdown of day-to-day barriers that otherwise interfere with open collaboration and research, while fostering and building relationships between individuals of cross disciplines and industries that might not have occurred on their own. To my taste, the working server lab designed to house a powerful cluster is a wonderful backdrop, underscoring the stated mission and target outputs.” --Michael Paolini, IBM Master Inventor
Cell Hack-a-thon I
Cell Hack-a-thon II
The Yellow Dog Learns to Drive
In November 2007, Victorville, California, Terra Soft Solutions lent an innovative hand to the Axion Racing team with a Sony PS3 running Yellow Dog Linux to assist with on-board, realtime image processing system.

DARP Autonomous Vehicle Challenge 2007
DARP Autonomous Vehicle Challenge 2007

- In 10 days, Terra Soft ported, wrote, and optimized code for a Yellow Dog Linux PS3 connected to an RGB camera.

- This realtime image processing system enabled the robot vehicle to “see” the street terrain and avoid obstacles.

- The RGB camera is tied into the Axion arbitrator and other computerized sensors to help determine the best path for the 3/4 ton Jeep.

- All sensors vote and then send commands to actuators that control steering, gas, and brakes for the vehicle.
Two Logitech Quickcam Pro 5000's are connected via USB to the PS3 running YDL 5.0.2. The PS3 is connected to Spirit's Dell server rack over 100Mb ethernet. The PS3 captures the images, processes the data, and sends a message to Spirit indicating the presence, distance, and general direction of obstacle.
The two cameras are placed side by side. Pictures from the right and left cameras are taken simultaneously. This data is fed into an algorithm that detects apparent shift of objects in the images which generates a disparity map. The greater the shift, the higher the value in the disparity map.

DARP Autonomous Vehicle Challenge 2007
How did we do?
We were the first ...
... to collide with a human driven vehicle :(
Introduction to Yellow Dog Enterprise Linux

Yellow Dog Enterprise Linux, like Red Hat's RHEL, is a product and service bundle. YDEL combines the world renowned Yellow Dog Linux with support services from Terra Soft's engineering staff.

- YDEL is immediately available for the IBM QS22 from either Terra Soft.
- YDEL is available from Mercury Computer Cell systems.
- Japan's Argo Graphics last week announced a partnership with Terra Soft to provide YDEL as the preferred OS and support package for turn-key QS22 Cell solutions.
- A second Japanese firm will soon announce provision of YDEL in association with its OEM'd PXCAB Cell solutions.
- At SIGGRAPH 2008, a new Cell-based hardware solution will be announced with YDEL as the sole OS offering.
YDEL for the IBM QS22

In October of 2007 Terra Soft was contracted by IBM to prepare a version of Yellow Dog Linux for the IBM QS21 Cell blade. The result is an operating system that may be installed on an entire chassis of 14 QS22s in just 2 hours, saving time and money over the industry alternatives.

- YDEL may be installed from an x86 or Power architecture head node.
- YDEL uses an optimized Anaconda graphical installer.
- YDEL may be installed on 14 blades in less than 2 hours.
- At just $400 USD per annual board license, Yellow Dog Enterprise Linux offers a significant cost savings over other licensed OS packages.
Y-HPC Cluster Construction Suite

- World’s only commercial, cross arch (x86, ppc) cluster construction suite.
- World’s first Cell cluster construction suite.
- Rapid, image-based compute node build-out.
- Readily create custom node images.
- “Node Personality”, template machine configuration.
- Local disk and diskless, multiple file system support.
- Support for Mercury, IBM, and Sony Cell products.
Y-HPC Cluster Construction Suite

- Rapid, image-based cluster construction.
- A simple, effective and intuitive interface.
- Support for Power 32/64-bit and x86_64 architecture head and compute nodes.
- Support for Yellow Dog Linux, RHEL, and CentOS.
- Use of Ganglia and the Y-HPC communications daemon to manage nodes.
- Designed to work with Cluster Resources' TORQUE and Moab for a cluster management.
- NFS, OpenMPI, IB, and PVFS2 tested with Yellow Dog Linux. Support for other operating systems according to customer needs.
Y-HPC Cluster Construction Workflow

1. Build your head node and install Y-HPC.

2. From the Y-HPC GUI, select the preferred node image for your target, compute node.

3. Customize one or more templates to form unique node personalities.

4. Netbuild each compute node.

5. The compute nodes reformat, receive the node image, reboot per template instructions.

6. Configure NFS, NIS, TORQUE and/or MPI as required by your needs.

7. Execute your code across the cluster.
Y-HPC Cluster Construction Value-Add

- Ease of initial node imaging.
- Ease of node reconstruction and re-purpose.
- Simplification of node maintenance and updates.
- Simple visualization of cluster.
- Node image snap-shot, copy, management, and storage.
- Support for heterogeneous (x86, Power, others) architectures in same cluster.
Commercial Tools for Cell

The Cell development ecosystem is growing, with new products from both open source and commercial sources.

- IBM Cell SDK (complete tool suite).
- IBM XL C/C++ and Fortran compilers.
- Allinea parallel debuggers DDT and OPT.
- CMPWare development environment.
- Gedae development environment.
- Mercury MCF optimized libraries.
- RapidMind compiler.

More information on each of these at:
Open Tools for Cell

The number of open source applications and tools is growing steadily, with the open portion of the IBM Cell SDK as the standard foundation:

- Georgia Tech's “Cell Buzz” optimized libraries and educational material.
- MIT's educational material.
- Eclipse IDE which is enjoying growing Cell support.

More information on each of these at:
Sony PlayStation3 Clustering Benefits

- Low cost, truly commodity cluster.
- High performance through optimization for the Cell SPEs and vector engine (AltiVec).
- Seamless code migration to/from Mercury & IBM Cell blades.
- Binary compatibility with prior, current, and future Power architecture systems.
- Same/Same desktop-to-cluster user interface and back-end OS (no cross compilation).
- Same/Same headnode to compute node OS (IBM p Series to Sony PS3).
- Relatively low power consumption.
- A true desk-side cluster (very, very quiet + low, low price).
- When bored (and no one is watching), engage in wicked multi-player gaming.
Sony PlayStation3 Clustering Challenges

- Getting through GameOS the first time (simple once the Linux bootloader is installed).
- Low memory (192MB effective RAM).
- Single gigabit interconnect.
- Relatively slow internal drives (resolved with external SATA TB storage).
- 6 of the 8 SPUs available (not a power of 2).
- Optimization for Cell SPEs (not all code lends itself to this function).
PS3 Cluster Case Scenario - Overview

- University Massachusetts, Dartmouth, Gaurav Khanna.
- Remotely used 20 PS3s managed by Terra Soft's Y-HPC.
- Currently working with EMRI code written in Fortran.
- No SPE Fortran compilers forced Gaurav to write a "bridging" routine that maps the relevant arrays from Fortran to C and back again. While a bit messy, the code's overall performance on the Cell is excellent, even in double-precision.
- Seeing 5x over the PPU-only version with double precision (Cell is optimized for single).
- MPI parallelization with nearly linear scalability.
PS3 Cluster Case Scenario – Approach

“Multi-dimensional hyperbolic PDE solvers ... wave-equation solvers with fairly complicated 'right-hand-sides' ... a fairly generic type of computation commonly seen in many many scientific and engineering disciplines.”

“In my approach to optimization on the Cell, I typically farm-out the computation of this complicated 'right-hand-side' to the Cell's SPEs.” “In some cases, ie: modeling the in-spiral of a small star into a supermassive black hole, the 'right-hand-side' is so computationally intense (computing the effect of the of small star's present location on the entire black hole space-time!), it strongly dominates the entire computation.”

Gaurav drastically reduces the time it would take to compute the right-hand-side by running this portion of the equation on the PPE, typically yielding “an awesome speed-up in most cases, from 2x to 6x over a PPE-only computation in double-precision accuracy [for] which the Cell is actually not that great. The speed-up can be much higher in single-precision, easily over 10x.”
PS3 Cluster Case Scenario – Performance

“There is still plenty of room for more performance. We're just scratching the surface.

“To compare with a known system, this performance compares very well with that from a high-end Mac Pro, with Intel multi-core technology based Xeon processors. Again, note that this is in double-precision. The overall performance would be much higher in single-precision accuracy. Another comparison is that each PS3 yields a performance on my codes comparable to 25 nodes of an IBM Blue Gene supercomputer.

“For distributing tasks over several PS3s I just use the conventional domain decomposition approach based on MPI (message-passing) parallelization. This works independently with the parallelization of the right-hand-side on the SPEs of each Cell. So, overall I have parallelization at two levels (Cell's SPEs and MPI). This approach yields near perfect scaling with the number of PS3 used. Therefore, your 20 PS3 cluster yields a performance on my codes comparable to over 500 nodes of a Blue Gene supercomputer! Really.”
Sony PlayStation3 Customers, March - December 2007

Atmospheric Sciences Research Center
Aerospace Corp
Argonne National Lab
Astek Corp
Columbia University
Computational Research Labs, India
Digital Video S.p.A
Dream Works
Florida Institute for Human & Machine Cognition
General Dynamics Robotic Systems
Georgia Institute of Tech, College of Computing
Georgia Southern University
Honeywell-Defense Avionics Systems
Isilon Systems
Los Alamos National Lab
Lawrence Berkeley National Lab
LG Electronics
MIT Lincoln Lab
Naval Post Grad School
Naval Underseas Warfare Center
Oak Ridge National Lab, DOE
Purdue University

SAIC
Sodankyla Geophysical Observatory
Stanford University
University of Alaska
University of Akron, Ohio
University of Buffalo, New York
University of California, CalTech
University of California Davis, CS Department
University of Delaware
University of Kentucky, Center for Visualization
University of Maryland, Lab for Physical Science
University of Minnesota
University of North Carolina, Charlotte
University of Utah
Uppsala University, D.t. of Cell & Molecular Biology
U.S. Army Research Lab
U.S. Airforce Research Lab (AFRL)
U.S. Food & Drug Administration
U.S. Naval Air Warfare Center
U.S. Naval Post Grad School
Wright Patterson Airforce Base
IBM QS22 Clustering

- Native 32- and 64-bit precision.
- Up to 32GB RAM per blade.
- Dual Cell processors per blade.
- High-speed I/O via backplane PCIe bus.
- Optional gigabit, 10Gb, and Infiniband interconnect.
- Redundant power and cooling.
- IBM's signature support.
- Full Cell seamless code migration from PS3s.
- PPU binary compatibility with IBM Power systems: JS21, POWER5/6, PowerStation.
PowerStation Workstation & Headnode

Terra Soft recently launched the PowerStation, a deskside tower which readily provides a solid, scalable, reliable workstation and cluster headnode for Power architecture clusters.

- Quad-core 2.5GHz 970MP processors and up to 32GB RAM.
- On-board 4 hot-swap capable SAS drive bays, 1 SAS drive included.
- Support for x86 graphics cards with PCIe expansion slots.
- Seamless code migration to POWER and Cell based clusters.
- Inexpensive at just $1890 USD.
PlayStation3 Internal Drive Expansion

Terra Soft has partnered with an industry leading RAID storage device manufacturer to provide an adapter plate which replaces the internal drive on the bottom of a PS3.

- Up to 4TB 7200 RPM SATA storage (currently limited by the GameOS to 1.2TB).
- Support for RAID0, RAID5.
- Starting at just $450 USD for the adapter plate and chassis, drives sold separately.
- Coming soon!
This is the end of my presentation,

but not of the Cell-ebration.
This presentation was prepared entirely with Yellow Dog Linux and open source tools.