Linux® and the Intel® Itanium® Processor: A Road Map

Hewlett-Packard

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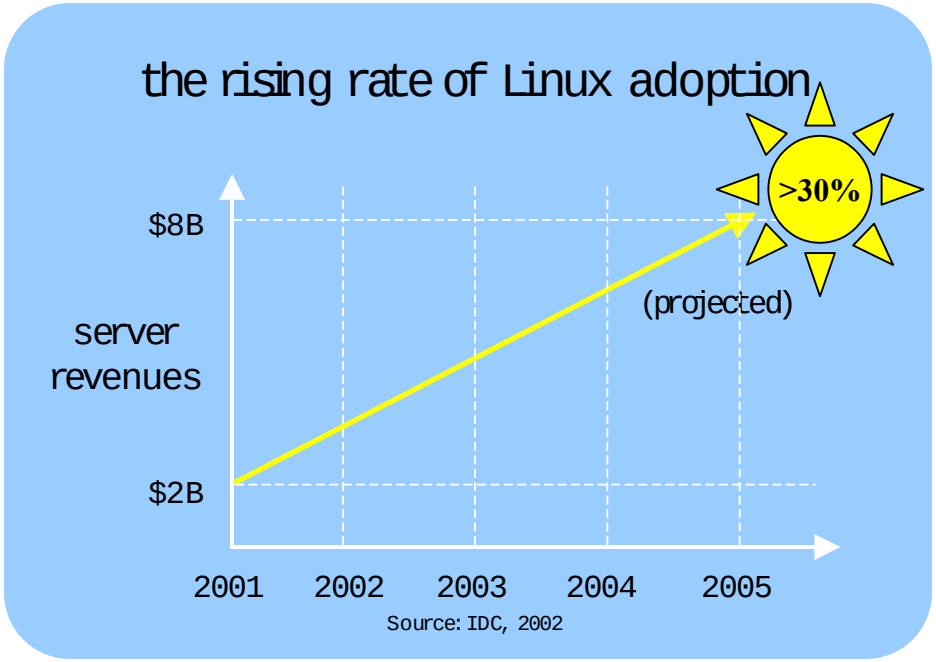
Conference & Expo

Agenda

- Is Linux® ready?
- HP's Linux® strategy
- The Intel® Itanium® Processor Family
- Linux® and Itanium® – a bit of history
- Linux® and Itanium® – how is it being used?
- Conclusion

Is Linux Ready?

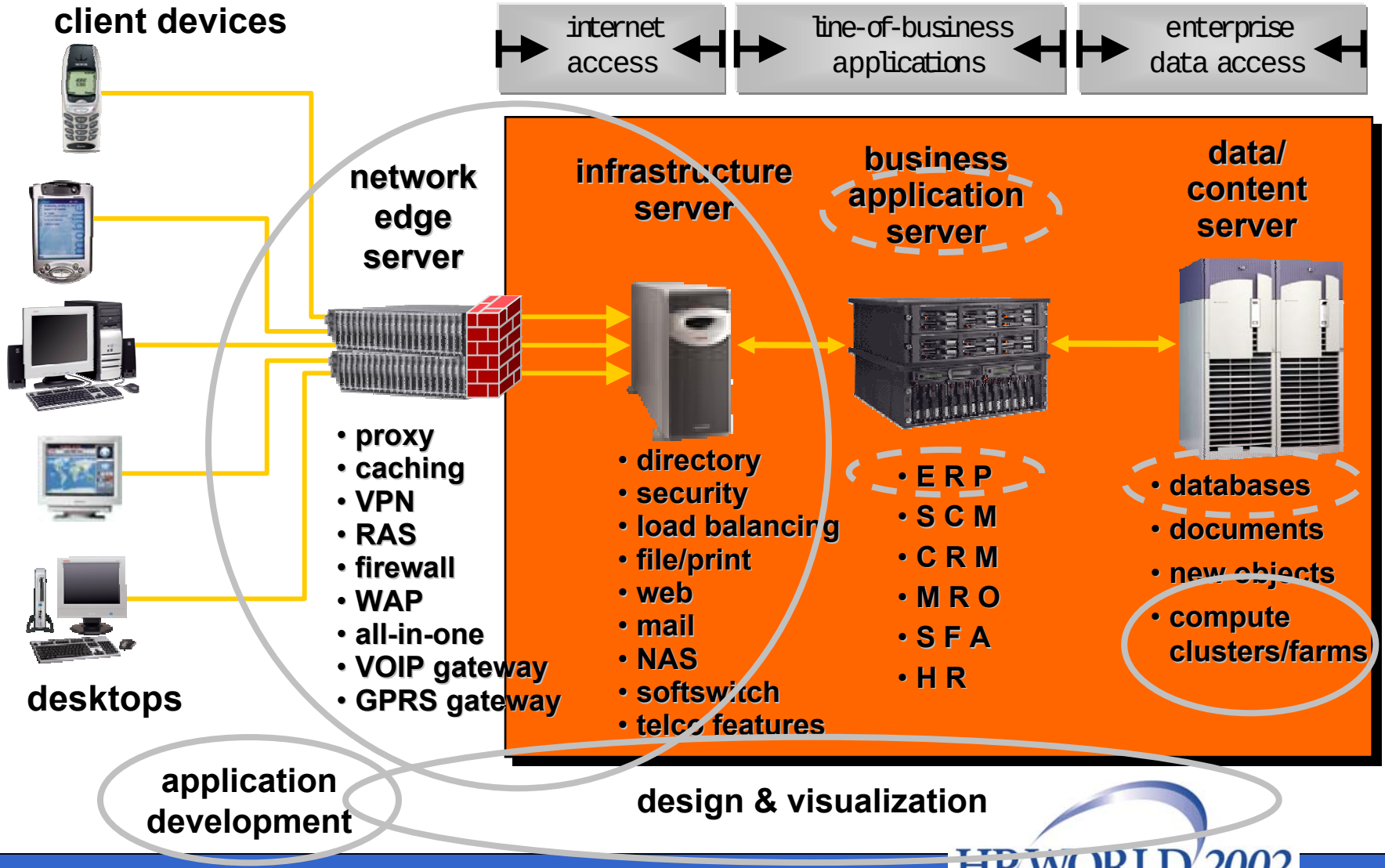


Linux-based products and solutions are:

- delivering improved time-to-market
- reducing IT costs
- transforming IT strategy
- yielding competitive advantage
- fastest growing @ > 30% CAGR

Linux solution workloads

- where Linux products and solutions are making significant in-roads -



why Linux?

- lower IT cost of ownership:
  - runs on industry standard Intel architectures: IA-32 & Itanium
  - makes the HW platform readily substitutable, decreasing dependency on proprietary platforms
- shrinks IT footprint
- single, stable, modular kernel
- flexibility to customize the OS
- leverage of the world's largest OS development environment
- ISVs motivated: shift to Linux is gaining momentum
- provides alternative to legacy UNIX® or Windows operating systems

HP's Linux Strategy

bringing the best of hp and compaq to Linux

hp Linux strategy

To facilitate enterprise success with Linux via:

- commitment to open source and Linux
- enabling enterprise software functionality
- driving Linux / UNIX® affinity
- best-in-class Linux partnerships
- innovative and industry-leading platforms
- comprehensive and proven services
- end-to-end solution definition & delivery

"The question for us isn't, '*Will Linux dominate the world?*', but '*What part of the world will Linux dominate?*'"

Carly Fiorina
CEO, Hewlett Packard Company
Linuxworld 2002

hp strategic Linux platforms

IA-32

Industry-leading ProLiant, blade and carrier grade servers

Intel® Itanium® architecture

Leading server platform performance and compatible with IA-32

Desktops

Business and Technical systems for client needs

Storage

Heterogeneous Direct and Network attached storage solutions

The Intel® Itanium® Processor

Why the Itanium architecture?

- to go beyond the 4GB limit of today's volume systems
- even if extended to 64-bits, out of order, superscalar performance gradient is a gentle and predictable one
- current architectures are delivering limited performance gains per year
- the Intel® Itanium® processor is a radical move:
  - breaks superscalar brick wall
  - major performance gains are achievable through compiler and application optimizations, as well as through hardware and manufacturing process optimizations

The Itanium Processor Architecture

- High-performance, 64-bit architecture, co-developed by HP and Intel
- New Explicitly Parallel Instruction Computing (EPIC) paradigm
- Predication (avoid costly branches)
- Speculation (hide memory latency)
- Large register sets and register stack engine
- Performance Monitor Units (PMUs)
- IA-32 hardware emulation

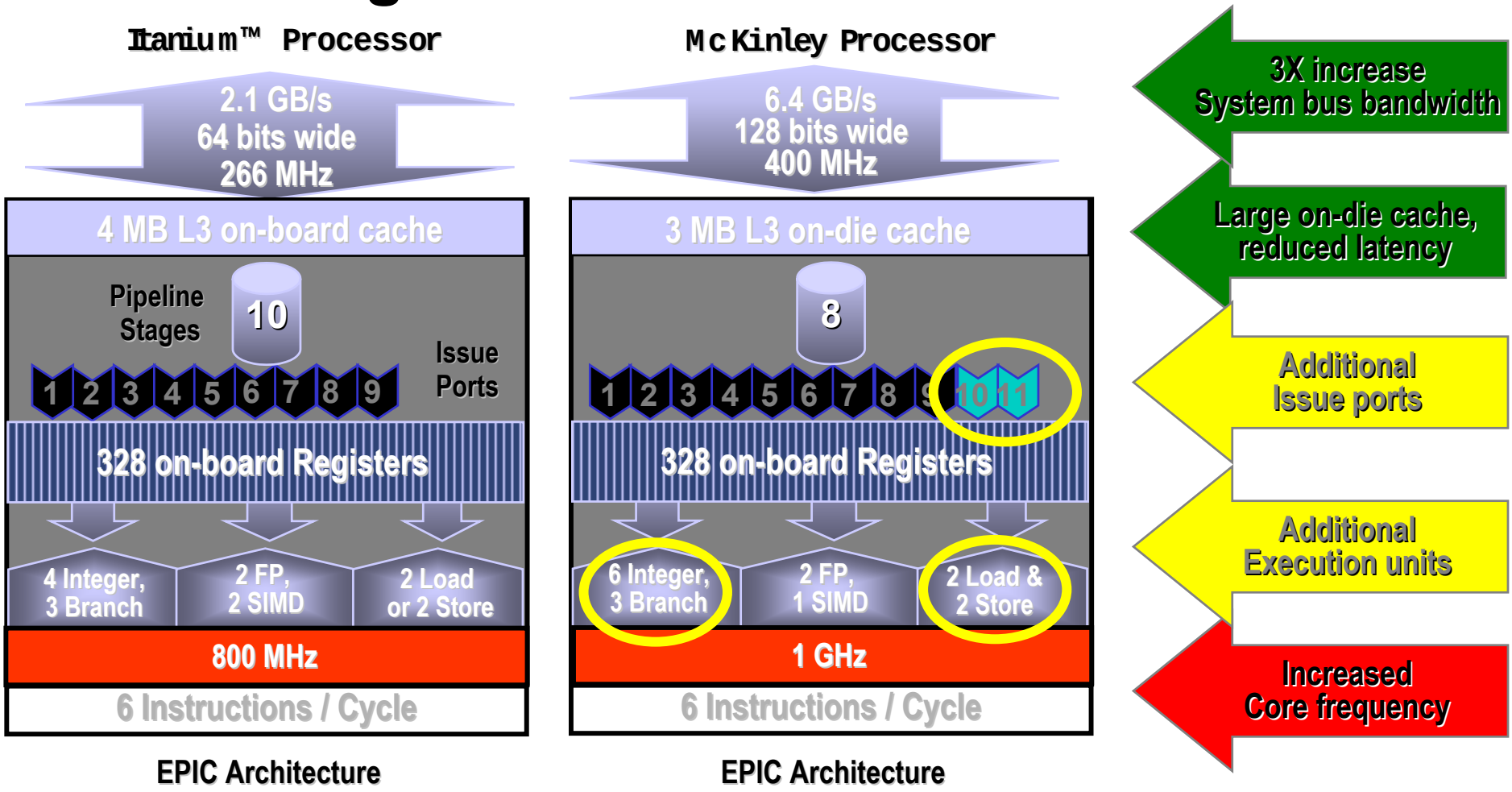
- First implementation: Itanium® (aka Merced)
- Second implementation: Itanium® 2 (aka McKinley)
- Next implementation: Madison

The Benefits of Itanium 2 – Available Now

why is now the time to move to the Itanium architecture?

- more bandwidth
  - 3x FSB
- more cache on chip
  - ½ the latency
  - 3x bandwidth
- 1.5 – 2x performance over Itanium™- based systems
- HP provides added performance differentiation with its chipset

building out the Itanium® architecture



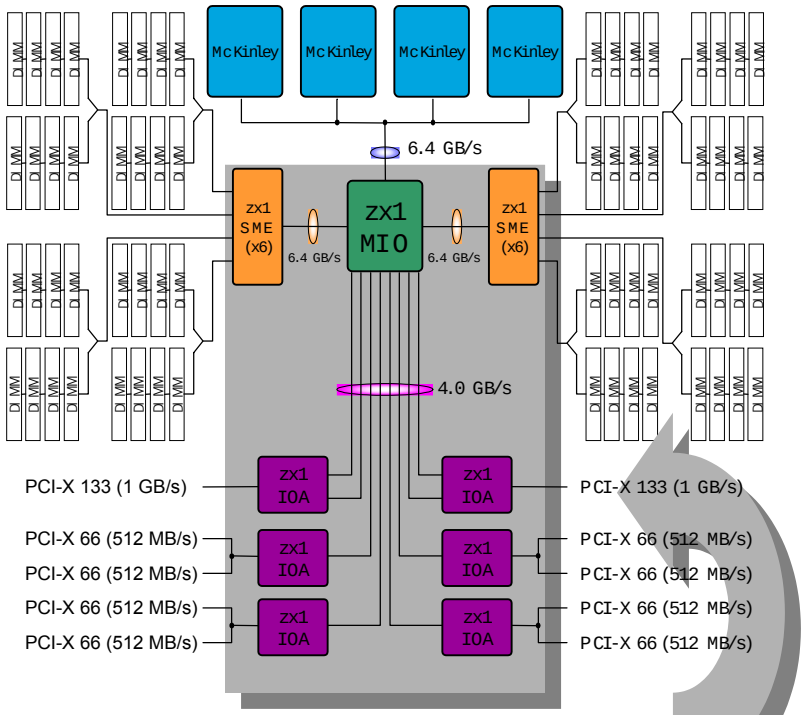
McKinley systems will deliver performance improvements through:

- **Bandwidth and cache improvements**
- **Micro-architecture enhancements**
- **Increased frequency**

Estimate
McKinley performance
1.5-2X = Itanium processor

hp's chipset zx1 unleashes the full power of Intel Itanium 2 processor

- high memory bandwidth, low memory latency
  - enables top application performance through consistent response times
  - supports more users / processes
- high memory capacity supports DDR RAM
  - enables optimum performance for large models/databases
- high I/O bandwidth and capacity
  - consolidate applications to reduce # of servers
  - very large databases or multiple large databases
  - eight high-speed channels provide ~4 GB/s available bandwidth
- scalability
  - enables a family of systems tuned to meet a variety of needs



hp's chipset zx1 unique value-add drives the fastest Intel Itanium 2 processor platforms on the planet

hp chipset zx1 components

zx1 MIO

- hp zx1 memory and I/O controller
  - connects to processor bus
  - contains memory controller
  - contains I/O cache controller

zx1 IOA

- hp zx1 I/O adapter
  - single I/O adapter that supports:
    - PCI
    - PCI-X
    - AGP

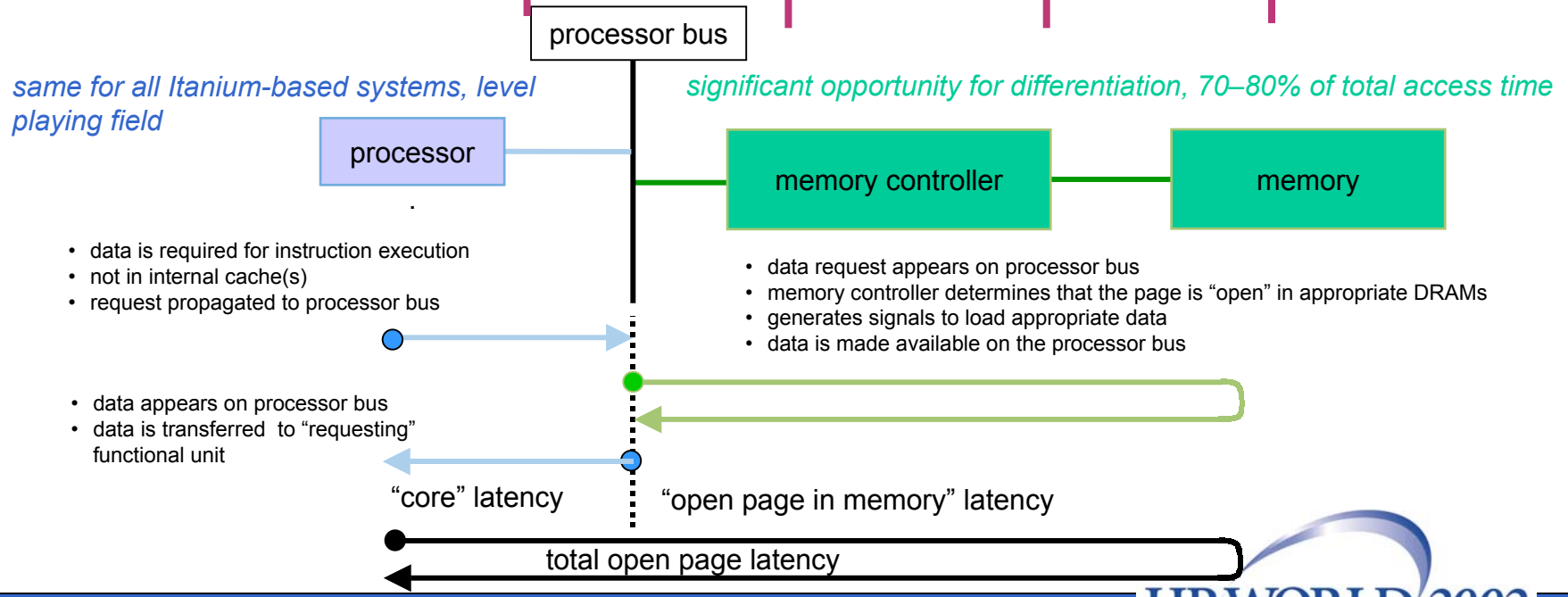
zx1 SME

- hp zx1 scalable memory expander
  - optional component used to:
    - increase memory capacity
    - increase memory bandwidth

1–4 CPU memory latencies

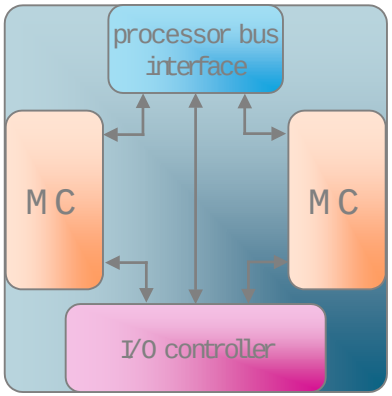
Itanium Processor Family–based Systems

	PA-RISC	1/2 CPUs	4 CPUs	competitors
core	58ns	32ns	32ns	32ns
open page in memory	108ns	80ns	105ns	150–200ns
total open page	166ns	112ns	137ns	182–232ns



hp zx1 internal I/O busses

- The HP chipset zx1 uses internal data buses between the I/O and memory controllers to minimize the amount of I/O traffic on the processor bus.
  - only data transfers from processor caches to I/O will appear on the processor bus
  - all other DMA data transfers are kept off of the processor bus



hp zx1 memory and I/O controller

Linux and Itanium:

A bit of history

Trillian Project Overview: Milestones

- Linux/Itanium project started at HP in Mar 1998
  - No compilers, libraries, or hardware
  - Develop initial toolchain, simulation envioronment & kernel port
  - CERN (birthplace of WWW) contributed work on glibc
  - HP boots first OS (Linux) on early Itanium hardware
- Trillian project founded in May 1999
  - Founding members: HP, Intel, Cygnus, IBM, SGI, VA
- All source code public since Feb 2000
- Multiple distributions available:
  - Redhat, Debian, SuSE, …

Trillian Project Goals

- Optimized 64-bit Linux for Itanium
- Release early and often
  - Functionally complete & ready for Itanium launch
  - easy-to-install distributions
  - SMP support (scalable to 4-way or better)
- Backwards compatibility
  - support for running existing Linux/x86 apps
- Joint effort ("Open Source in a box")
  - Apply open source model within pre-release, NDA environment
  - Contributions from multiple vendors
  - single Linux/Itanium version
  - best code wins

Design Goals & Approach

- Pure 64-bit design for Itanium
  - 64-bit kernel
  - 64-bit user-space/applications
- Compatibility with Linux/x86 wherever possible
- Minimize changes to platform-independent code
  (started with 2.1.126, now at 2.4.8)
- Follow standards: EFI, SAL/PAL, DIG, …

Trillian Consortium Members

source code made public on 2/2/2000

- The code is now fully integrated into Linux sources
- Trillian project is now defunct

HP – Leadership in Linux on Itanium

- Itanium port started in HP
  - HP engineers first to boot Linux on Itanium
- Itanium Linux maintainer is an HP employee
  - David Mosberger's book is now available
    - *IA-64 Linux Kernel: Design and Implementation*
- HP aggressively extending this work to future systems
- HP running Linux on McKinley since Feb 2001
  - Running Linux on 1-4 way McKinley hardware prototypes
  - Running Linux on high-end McKinley simulators
  - Driven McKinley support into kernel.org
- HP running Linux on PA/SuperDome as research "sandbox" for high-end IA-64 work
- HP established the Gelato Federation
  - A worldwide consortium focused on enabling open source Linux-based Itanium solutions in academic, government, and industrial research

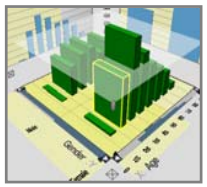
Linux and Itanium:

How is it being used?

Linux and Itanium® 2 for technical computing: the ideal engine for power users

large memory addressing and data bandwidth, leading
floating-point performance, excellent visualization and clustering capability

scientific research & life sciences



- faster molecular modeling and simulations, protein folding, semi-empirical quantum mechanics

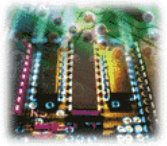
computer-aided engineering

- fast design, prototyping, simulation, finite element analysis, computational fluid dynamics
- memory headroom for larger data set analysis

digital content creation

- digital rendering
- 3D work for feature film, HDTV, and IMAX

electronic design automation



- ideal for complex verification, analysis, and simulation

Linux and Itanium® 2 for enterprise IT: the ideal engine for power users

large memory addressing and data bandwidth, world's best de-/encryption computing, leading edge parallel instruction processing for complex transactions

SSL secure web serving

- accelerates protocol for managing the security of a message transmission on the internet for such usages as retrieval of private records and online financial transactions
- Zeus web server 4.0

business processing

- speeds software that helps an enterprise optimize customer, supply chain, personnel and sales relationships
- Oracle 9i by late 02 – early 03
- SAP by late 02 – early 03

application server

- quicker application development, integration, and deployment using open industry standards
- BEA WebLogic by late 02 – early 03

financial services

- ideal for complex economic and financial modeling

What about Application Development?

Intel Toolchain:

- Maximum Itanium 2 optimization will be provided by version 7.0 of the Intel compilers when they become available. Until then, version 6.0 is recommended.
- If upgrading from Intel compiler versions prior to 6.0, any shared library files and object code that references them must also be upgraded for binary compatibility.
- Version 6.0 of Intel's C/C++ compiler claims to have sufficient gcc extension compatibility to compile the Linux kernel.

Gnu Toolchain:

- The currently-recommended version (2.96) of gcc provides good object code compatibility with older versions. However, C++ applications compiled with it are not binary compatible with subsequent versions of gcc, nor with the IPF C++ ABI.
- If C++ application compatibility with the IPF C++ ABI is important, gcc version 3.1 or later (available on the Gnu web site www.gnu.org) is expected to provide it. However, it has not yet been tested by HP at the time of this publication.
- Some Linux distributions include gcc version 3.0.1. which provides most of the IPF C++ ABI functionality. However, the C++ object code it generates is incompatible with other versions of gcc.

University of Tennessee

Grid Computing Research

Business Needs

- Develop software for grid management
- High performance technologies
- Scientific research on Intel architectures

Solution

- A cluster of four HP i2000 Itanium-based workstations:
  - 2 dual processor 800MHz Intel Itanium processors with 2GB of RAM each
  - 2 uniprocessor 733MHz Intel Itanium processors with 1GB of RAM each
- A cluster of four Itanium-based (HP i2000) workstations
- Each node running Red Hat Linux 7.1 and application-accessible libraries such as BLAS, LAPACK, and ScaLAPACK

"Early performance testing on our HP workstation i2000 indicates that its performance in carrying out floating point operations was very impressive. It's a fresh architecture and it's already performing strongly."

-- Dr. Jack Dongarra
Director, Innovative Computing Laboratory

Benefits

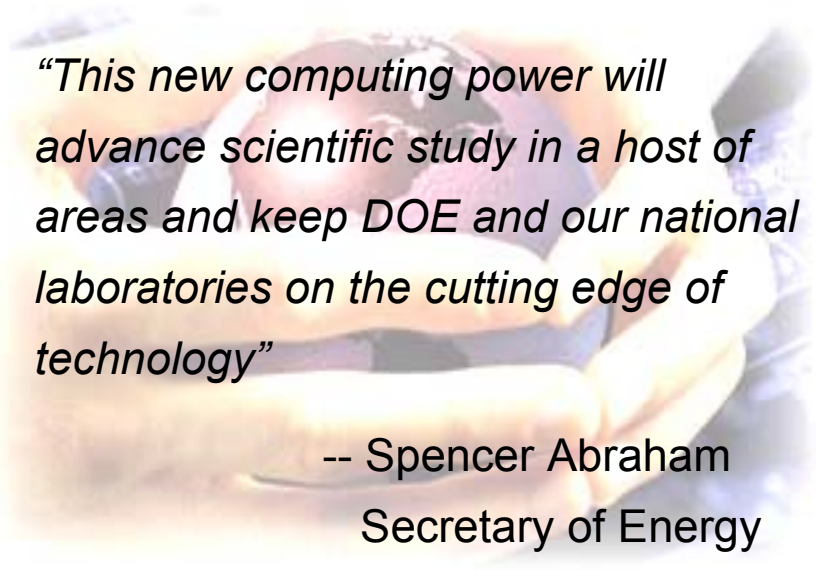
- ✓ Impressive performance in floating point intensive benchmarks starting with the first generation Itanium processors
- ✓ Improved ability to solve problems in computationally intensive scientific computing areas such as computational ecology, medical imaging, interactive molecular design, and advanced machine design
- ✓ Fast compile times when compared with their former IA-32 and RISC systems

Pacific Northwest National Laboratories

Biological & Environmental Research

Business Needs

- Increased computational power
- Sustained performance
- Superior support services
- Improve cost efficiencies



"This new computing power will advance scientific study in a host of areas and keep DOE and our national laboratories on the cutting edge of technology"

-- Spencer Abraham
Secretary of Energy

Solution

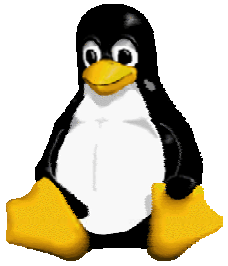
- 8.3 Teraflop HP Supercomputer based on:
  - 700 dual-CPU Itanium 2-based compute nodes = 1400 total processors
- Compute cluster-tuned MSC.Linux distribution and services
- Quadrics high-performance Network Fabric
- HP Storage
- HP Professional & Support Services

Benefits

- ✓ World's most powerful Linux based supercomputer. Calculations that currently take a month to complete can be done in one day
- ✓ Improved ability to solve critical energy and national security problems
- ✓ Price/performance
- ✓ Extensive support services including on-site engineer and global deployment ensure system is up and running from day one

Conclusion

hp is the Linux leader for Itanium® 2-based systems



For openness, flexibility, and the low-cost of Linux with the performance advantages of the HP systems

Target applications

- most compute-intensive workloads
- internet infrastructure where demanding encryption needs exist

The power of HP with Linux® and Itanium® 2 - based systems

- HP offers workstations and servers with Linux preloaded and optimized for hp's zx1 chip set
- HP offers a broad range of award winning Linux support and services
- HP is building one of the worlds fastest Linux supercomputers for DOE
- HP collaborating with leading Linux distributors
  - Red Hat Linux Advanced Server – preloaded
  - MSC.Linux – for high performance compute clusters
  - UnitedLinux-based distributions – SuSe in November

HP leadership in the open source community for Itanium® 2 drives innovation and improves support

HP led the way in bringing Itanium® kernel enhancements to the Linux community

David Mosberger in HP Labs is the maintainer of the Linux Itanium® kernel

HP established the Gelato Federation for advancement of Linux on Itanium® – based systems

www.hp.com/linux