IDF: Multi-Core Processing for HPC
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Computer Science & Engineering
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Embrace digital data-driven society
Empower students to compete in knowledge-based economy
Support research, scholarship, education, and community outreach
Deliver *high-end cyberinfrastructure* to enable efficient
  - Collection of data
  - Management/Organization of data
  - Analysis of data
  - Visualization of data
Center for Computational Research
1999-2005 Snapshot

- High-End Computing, Storage, Networking, and Visualization
  - ~100 Research Groups in 37 Depts
    - Physical Sciences
    - Life Sciences
    - Engineering
    - Scientific Visualization, Medical Imaging, Virtual Reality
  - 13 Local Companies
  - 10 Local Institutions

- External Funding: $300M+
- Total Leveraged WNY: $0.5B
- Deliverables
  - 1100+ Publications
  - Software, Media, Algorithms, Consulting, Training, CPU Cycles…
Major Compute/Storage Resources

- Dell Linux Cluster (2.9TF)
  - 600 P4 Processors (2.4 GHz)
  - 600 GB RAM; 40 TB Disk; Myrinet

- Dell Linux Cluster (6TF)
  - 4036 Processors (PIII 1.2 GHz)
  - 2TB RAM; 160TB Disk; 16TB SAN

- IBM BladeCenter Cluster (3TF)
  - 532 P4 Processors (2.8 GHz)
  - 5TB SAN

- SGI Intel Linux Cluster (0.1TF)
  - 150 PIII Processors (1 GHz)
  - Myrinet

- RFP (10-15TF)
  - Pentium-Based
  - Fast Interconnect
  - Efficient Storage Management

- SGI Altix3700 (0.4TF)
  - 64 Processors (1.3GHz ITF2)
  - 256 GB RAM
  - 2.5 TB Disk

- Apex Bioinformatics System
  - Sun V880 (3), Sun 6800
  - Sun 280R (2)
  - Intel PIIIs
  - Sun 3960: 7 TB Disk Storage

- HP/Compaq SAN
  - 75 TB Disk; 190 TB Tape
  - 64 Alpha Processors (400 MHz)
  - 32 GB RAM; 400 GB Disk
- **Fakespace ImmersaDesk R2**
  - Portable 3D Device
  - Onyx2: 6 R10000 @ 250MHz
  - 2 IR2 Pipes; 3 64MB texture memory mgns.

- **Tiled-Display Wall**
  - 20 NEC projectors: 15.7M pixels
  - Screen is 11’×7’
  - Dell PCs with Myrinet2000

- **Access Grid Nodes (2)**
  - Group-to-Group Communication
  - Commodity components

- **SGI Reality Center 3300W**
  - Dual Barco’s on 8’×4’ screen
  - Onyx300: 10 R14000 @ 500MHz
  - 2 IR4 Pipes; 1 GB texture mem per pipe
Multi-Core Applications

- Application Performance is Key
  - “Moore’s Law of Applications”

- Processor (Socket/Core) Performance Irrelevant

- Balanced System is Critical
  - Memory and Cache Access including SMP
  - System I/O

- Multiprocessing is Critical
  - Human Ingenuity Required/Available to Decompose Algorithms
  - Rededication to the Shared Memory Programming Problem

- Multithreading is Important
  - Difficult Problem in Scientific Computing
  - Tools Required for Multi-Core/Multithreading Environment
Intel Multi-Core Systems

- Pentium Dual Core – 2005
  - Desktop Environment; Serves as Development Platform
- Itanium Dual Core (Montecito) – 2005
  - Multithreading ⇒ Dual Socket System = 8 Processors to OS
  - 12MB L3 Cache
  - Healthy Thermals
- Xeon Dual Core (Dempsey) – 2006
  - Blackford/Greenfield Chipset – Balanced System
    - Dual Independent FSB
    - FB-DIMMs More Efficient for Large Memory Configurations
- Tukwila – 2007/8
  - More than 2 cores
  - Common Chipset and Commodity Components (Memory, Power Supplies, etc) Aimed at Consolidating Xeon and IPF
Benefits of Intel Multi-Core Systems

- Application-Based Moore’s Law requires
  - Parallel (Distributed and/or Shared Memory) and
  - Multithreaded Implementations of Algorithms

- Tools for Multithreading are Critical
  - Hand-Coded Libraries (BLAS, SHMEM, FFT)
  - Posix Threads
  - Compiler Directives (OpenMP)
  - Hybrid MPI-OpenMP

- Balanced Systems are Critical

- Well-funded applications will reap the benefit
More Emphasis on Computational Science & Engineering at all Levels

Black Box Approach is Counter Productive

Programming Skills Must be Improved

Training Required at all Levels
- High School
- Undergraduate
- Graduate
- Post-Doctoral

Better & More Affordable Tools are Required
- Intel Provides Compilers and Libraries Free of Charge (Academic Use/No Support)
- Intel is Major Player in Development Software (Costly)