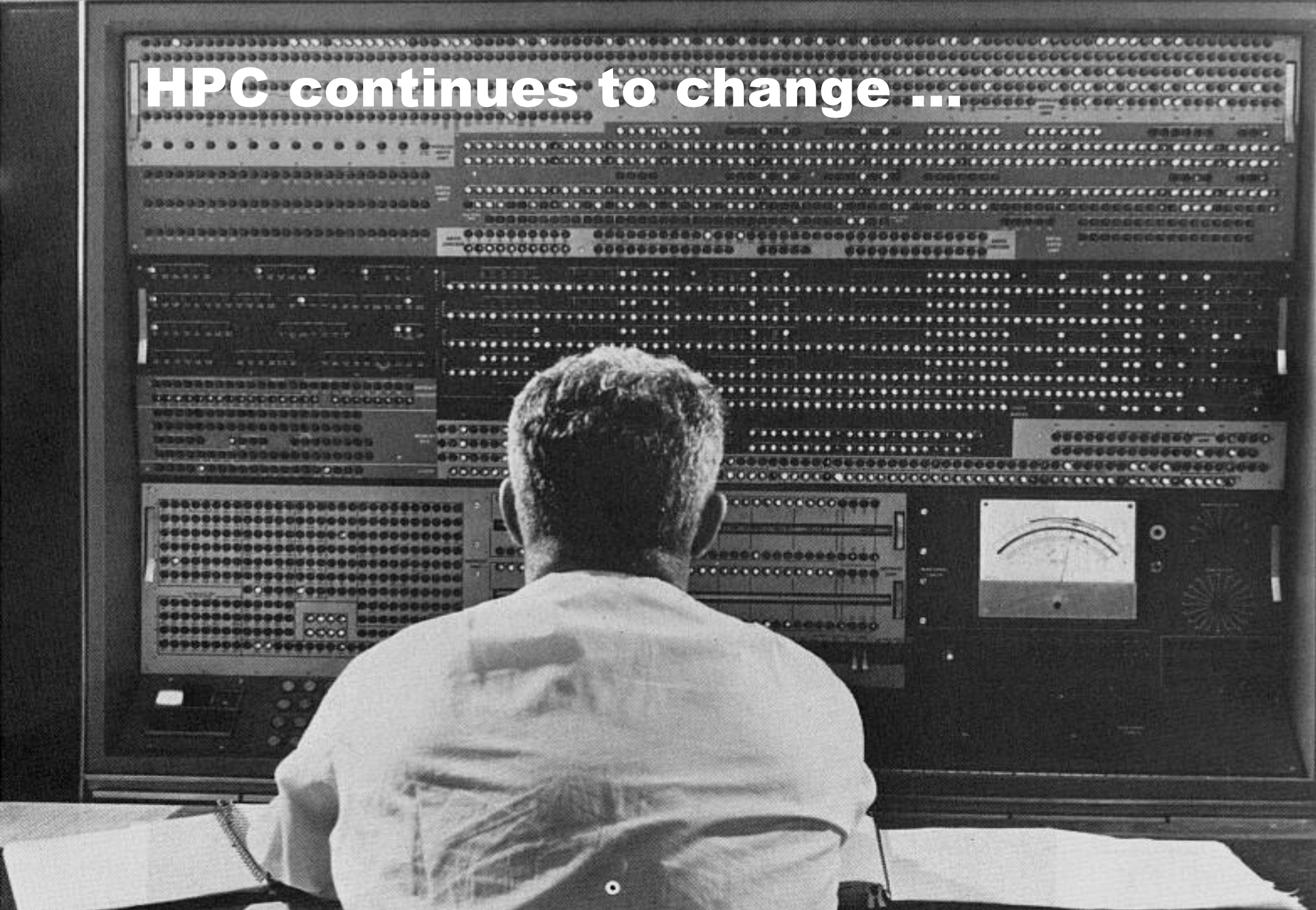


Intel's High-Performance Computing Technologies

11th ECMWF Workshop
Use of High Performance Computing in Meteorology
Reading, UK
26-Oct-2004

Dr. Herbert Cornelius
Advanced Computing Center
Intel EMEA

HPC continues to change...



Some HPC History



1960s



1970s



1980s



1990s



2000s

HPC Systems	1970s	1980s	1990s	2000s
Processor	<i>proprietary</i>	<i>proprietary</i>	COTS	COTS
Memory	<i>proprietary</i>	<i>proprietary</i>	COTS	COTS
Motherboard	<i>proprietary</i>	<i>proprietary</i>	<i>proprietary</i>	COTS
Interconnect	<i>proprietary</i>	<i>proprietary</i>	<i>proprietary</i>	COTS
OS, SW Tools	<i>proprietary</i>	<i>proprietary</i>	<i>proprietary</i>	<i>mixed</i>

COTS: Commercial off the Shelf (industry standard)



High-Performance Computing with IA



2

Thunder
LLNL
Livermore, USA
Intel Tiger4/Quadrics
Rmax: 19.94 TFlops



© SUPERMIA DIGITAL www.cofferedigital.com
Lawrence Livermore National Laboratory - Thunder April 2004

Source: <http://www.top500.org/lists/2004/06/2/>

5

Tungsten
NCSA
Urbana-Champaign, USA
Dell PowerEdge 1750/Myrinet
Rmax: 9.819 TFlops



Source: <http://www.top500.org/lists/2004/06/5/>

**4096 (1024x4) Intel® Itanium® 2 processor based system
22.9 TFLOPS peak performance**

**2500 (1250x2) Intel® Xeon™ processor based system
15.3 TFLOPS peak performance**

9

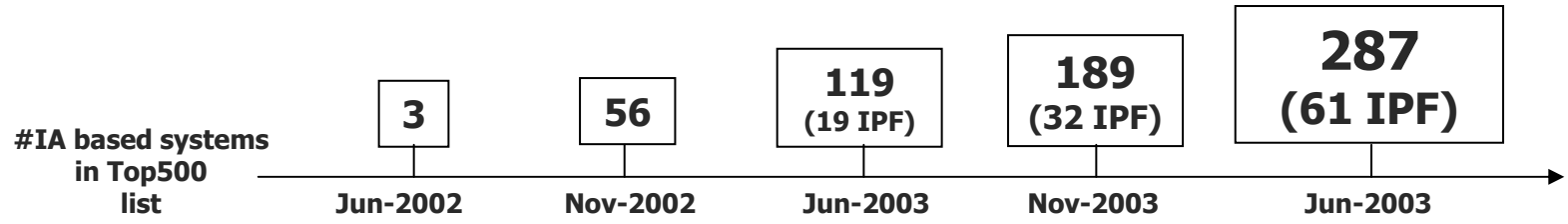
PNNL
1936 Intel® Itanium® 2 processor cluster
11.6 / 8.6 TFLOPS Rpeak/Rmax

7

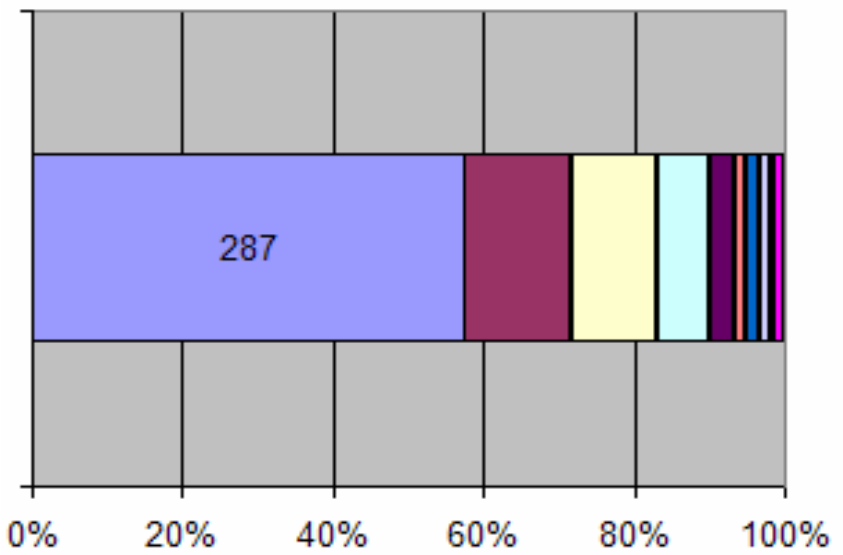
RIKEN
2048 Intel® Xeon™ processor cluster
12.5 / 8.7 TFLOPS Rpeak/Rmax



Intel in Top500* List (6/2004)



TOP500 Processor Architectures



- INTEL
- IBM POWER
- HP PA-RISC
- AMD
- ALPHA
- CRAY
- NEC
- HITACHI
- SPARC
- Others

Architecture	#Systems	%
INTEL	287	57.4
IBM POWER	72	14.4
HP PA-RISC	57	11.4
AMD	34	6.8
ALPHA	16	3.2
CRAY	9	1.8
NEC	9	1.8
HITACHI	6	1.2
SPARC	3	0.6
Others	7	1.4

ITANIUM®

Source: www.top500.org



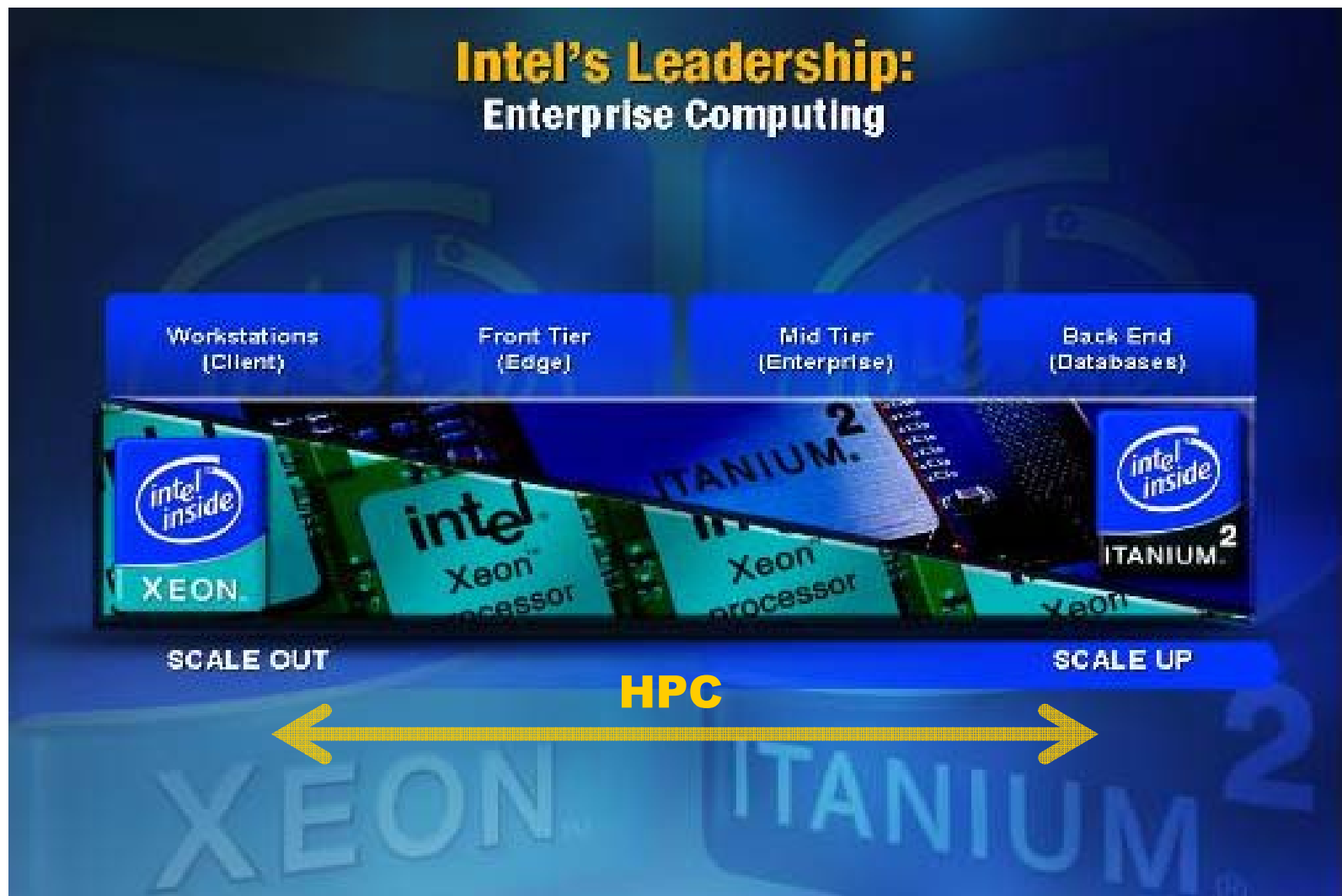
The next Step ...



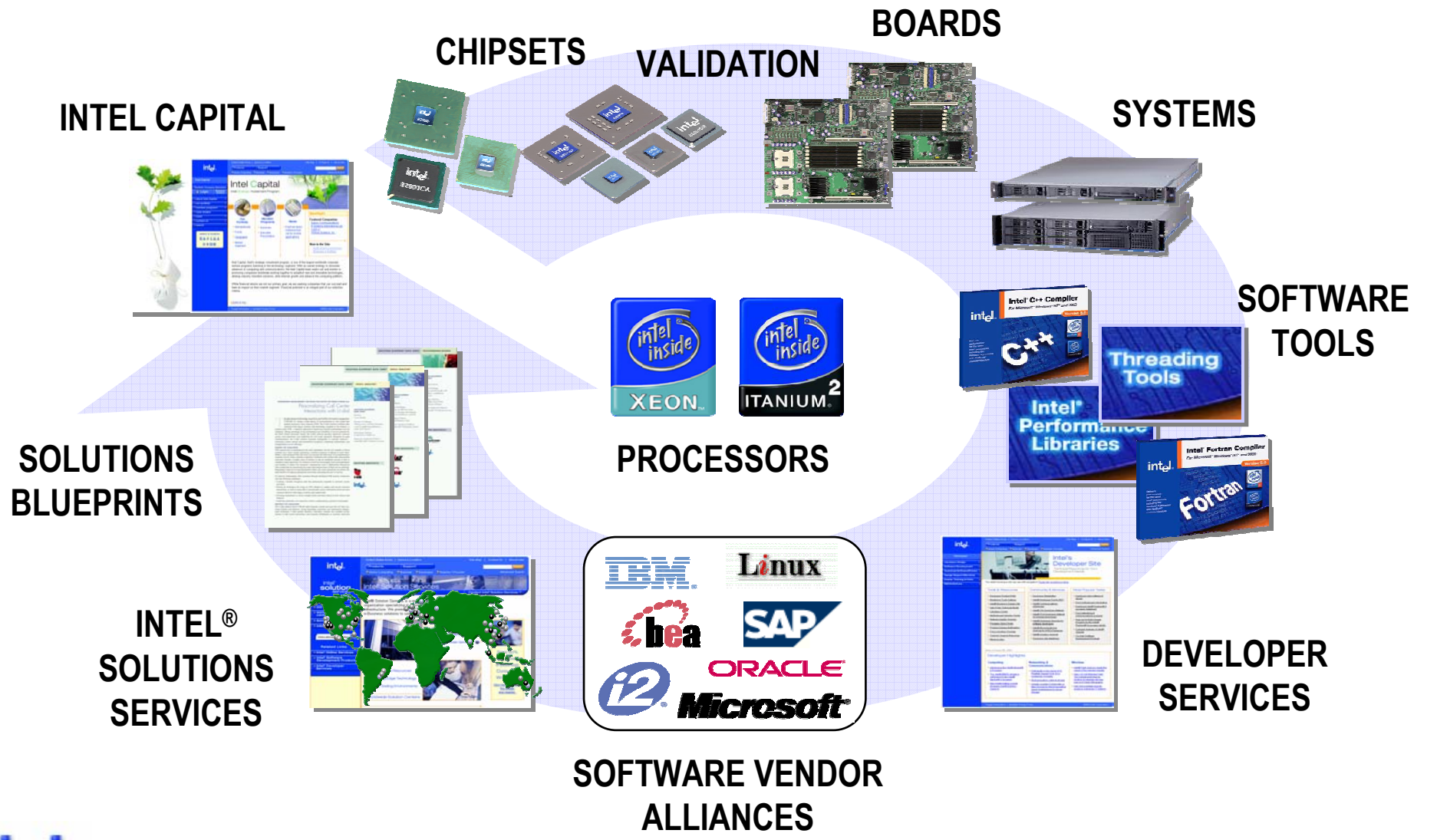
Image Credit: NASA and Thomas N. Trower

60 TFLOPS peak performance
10240 Intel® Itanium® 2 processors
20x 512-processor SGI Altix nodes
400 terabytes of RAID storage capacity
2.5 petabytes tape silo farm capacity

http://www.nas.nasa.gov/About/Media/Releases/07_27_04_innovative.html



Beyond Enterprise Processors



HPC Focused Activities at Intel

▶ Continuing HPC Product Focus

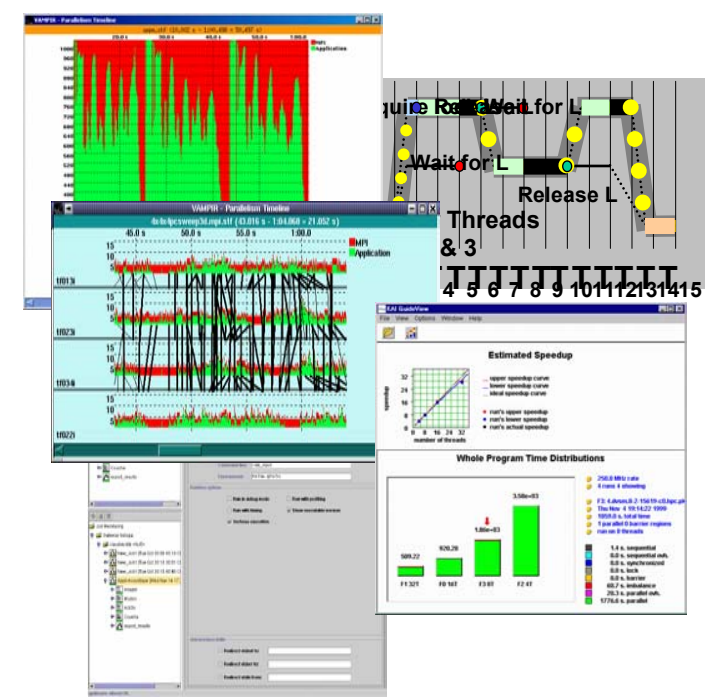
- New Intel® Itanium® Processor - 1.6 GHz with 3MB cache
- New Intel® Xeon™ processor platforms – 3.6GHz
 - EM64T, PCI Express*, DDR-2 memory

▶ HPC Focused SW Group – Parallel & Distributed Solutions Division

- ISV Software porting efforts for HPC
- Expansion of Parallel Application Centers
- Improved Ease of Use with Cluster Toolkit

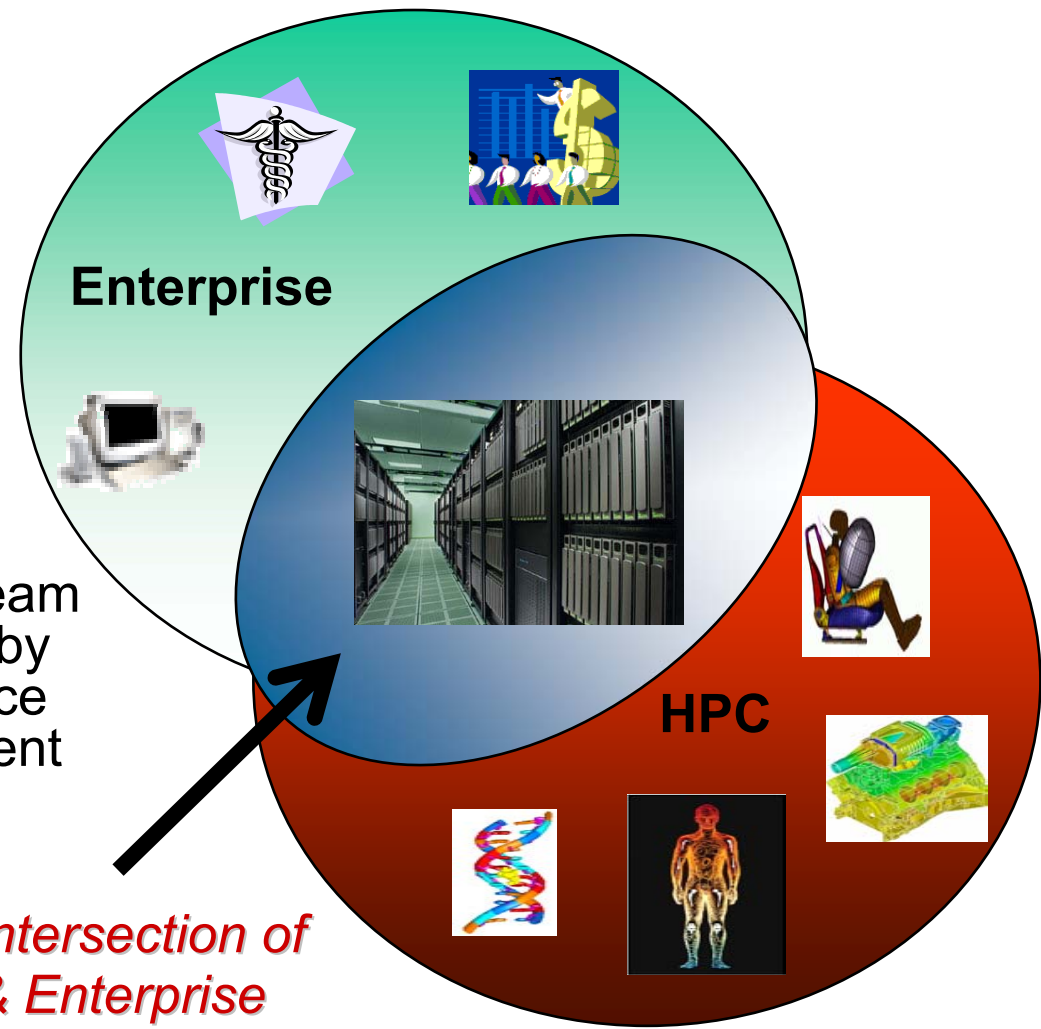
▶ Intel Advanced Computing Center

- Focused on advancing HPC with COTS
- Projects to improve
 - Performance
 - Scalability
 - Ease of use
 - System Management



Intel's "Advanced Computing Center"

- ▶ **HPC**
 - Leading edge technology
 - Niche market segment
- ▶ **Enterprise**
 - Risk adverse philosophy
 - Large market segment
- ▶ **IACC**
 - Accelerate innovation in mainstream (volume) computer technologies by working with the High Performance Computing community, government agencies and industry



Target intersection of HPC & Enterprise

Driving Performance Vectors

Intel Research & Development

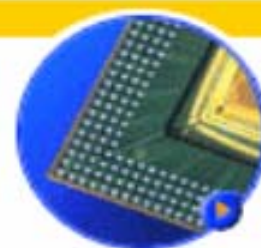
Pioneering Innovation Through Technology Leadership



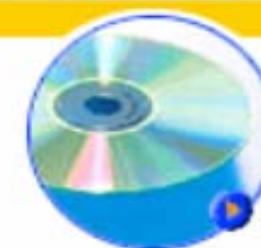
Silicon
Technology &
Manufacturing



Microarchitecture
& Circuits



Computing
Platforms



Software
Technology

- **Silicon Process**
- **Density**
- **Frequency**
- **Manufacturing**

- **Micro-Architecture**
- **Execution Units, Caches**
- **Threading**
- **Memory Subsystem**
- **I/O-Subsystem**
- **System Architecture**

- **Compilers**
- **Libraries**
- **Tools**
- **ISVs**

Technology Leadership

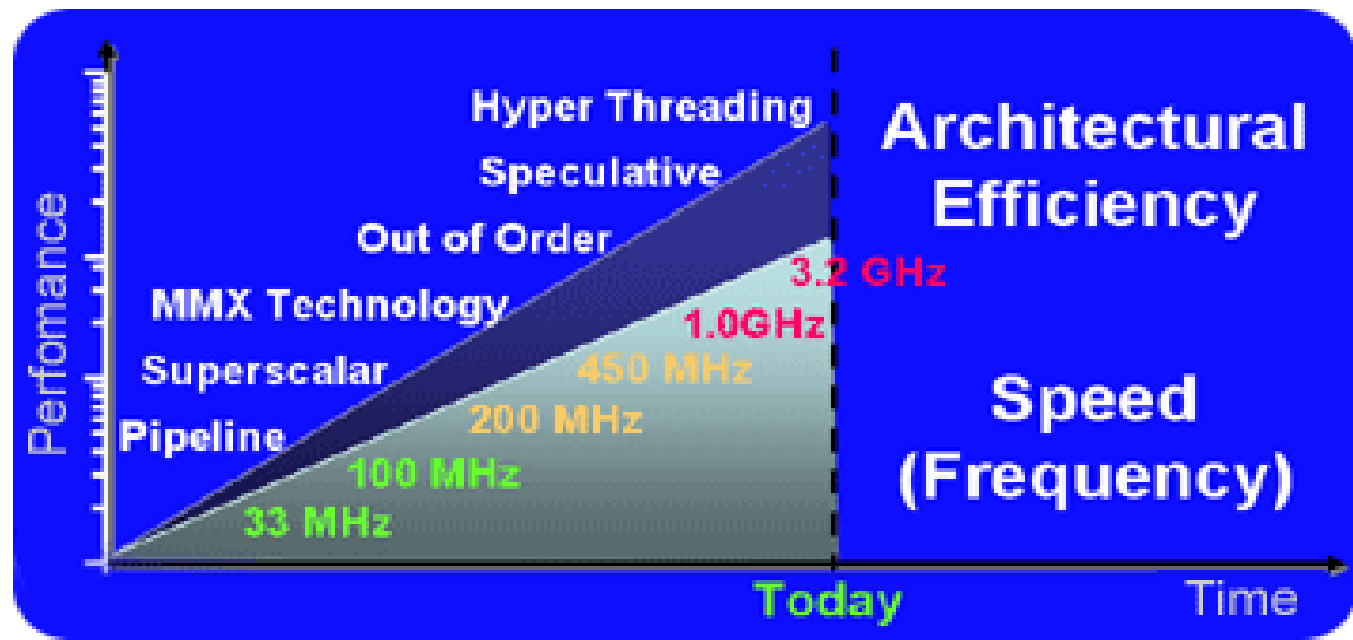
Driving Volume Economics



- ▶ 90NM PROCESS PRODUCTION, 65NM PROTOTYPE
- ▶ 300MM WAFERS PRODUCTION
- ▶ TERAHERTZ TRANSISTOR
- ▶ TRI-GATE TRANSISTOR
- ▶ HIGH-K GATE DIELECTRIC

All features and dates specified are targets provided for planning purposes only and are subject to change without notice.

Performance = Architectural Innovation + Speed

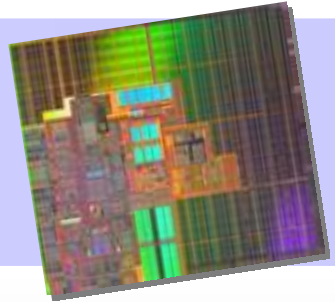


Enable more capabilities, performance, and flexibility to end users beyond processor speed.

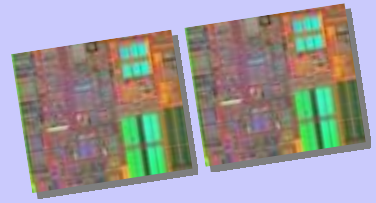


Multi-Core Transition

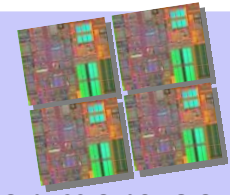
...dual core a natural evolution



TODAY
Single Core

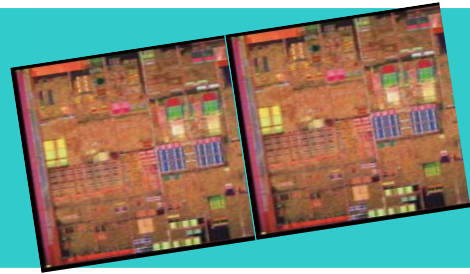
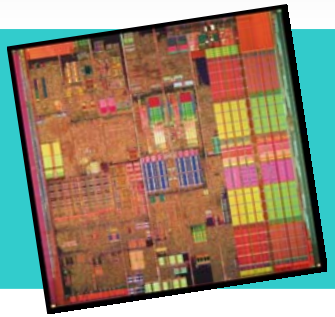


2005-2006
Dual Core



4 or more cores
+ cache

Future
Multi-Core



2 or more cores
+ cache

Intel's manufacturing leadership (90nm, 65nm) enables leading multi-core. Intel® Itanium® 2 architecture has smaller core size – enabling up to 2x more cores per die than IA-32 for higher performance at same cost



Intel® Itanium® Architecture

Leading the way

“ Eventually one billion transistors, or electronic switches, may crowd a single chip, 1,000 times more than possible today.”

National Geographic, 1982



**codename

▶ NEXT GENERATION: MONTECITO

- DUAL-CORE & MULTI-THREADING
- PERFORMANCE INCREASE
- 90NM PROCESS
- HIGHER FREQUENCY, LOWER POWER
- 2005 INTRODUCTION

Available Itanium® Architecture Systems

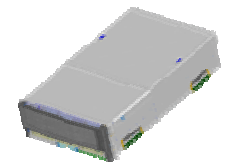
A wide range of solutions from many vendors ...



1-2P/1U



2P/2U



4P/4U



4P/8P/16P



8-16P



32-64P



64-512P



(not drawn to scale)



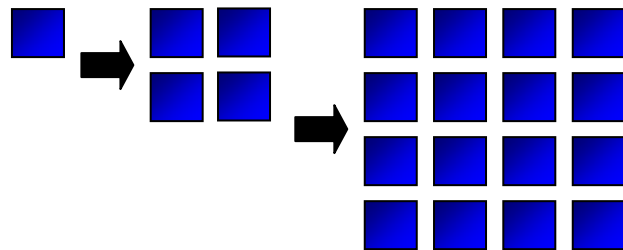
Performance Scaling



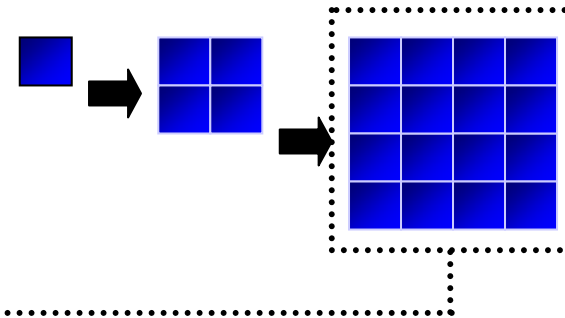
Scale Right



**Scale-Out
(Cluster)**



**Scale-Up
(SMP/ccNUMA)**



Visualization with Itanium® Architecture

Silicon Graphics Prism



<http://www.sgi.com/products/visualization/prism/overview.html>

Technology Trends in Memory & I/O

- ▶ Multi-channel DDR2 Memory
- ▶ Fully-Buffered DIMMs (FB-DIMM) are coming
- ▶ **PCI-Express*** (4x, 8x, 16x)
- ▶ PCI-Express based Graphics (16x: 8GB/s)
- ▶ **InfiniBand*** on PCI-Express (3x faster than PCI-X)
- ▶ 10GbE is going into volume
- ▶ SATA and SAS is taking off



www.intel.com/software/products/

Intel® Software Development Products Tools for improving application performance



Performance, Compatibility, Support, Productivity



3 Levels of Development Tools

←Level of Parallelism →

		Serial/Node Level (Fine Grain)	SMP/Cluster Level (Medium Grain)	Job Parallel/Grid Level (Coarse Grain)
Development Tools	Programming Model	Compilers	OpenMP MPI-2.0 Cluster OMP	UNICORE DRMAA G-API
	Performance Libraries	MKL,IPP	Cluster MKL	GPE
	Performance Analysis	VTune	Thread Profiler Trace Analyzer Trace Collector	
	Debugging	IDB	Thread checker IDB-MPP	
		Continue	Enhancing	Engaging



Summary

The Economics of High-Performance Computing have changed.

High-Performance Computing solutions must track Moore's law to be viable.

Intel is playing a key role in accelerating HPC solutions for science, engineering and business with open commercial off the shelf technology leadership and working with the industry and end-users.

High-Performance Computing with Intel® Architecture

GFLOPS



yesterday ...

TFLOPS



today ...

PFLOPS



tomorrow ...



Thank You !



www.intel.com/go/hpc