IA-64 for High Performance Technical Computing

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Intel Developer Forum Spring 2000

February 15-17, 2000

Agenda

- The HPTC Market
- Why IA-64 for HPTC ?
- Advantages of a 64-bit OS
- Open Source
- Porting to IA-64
- Scalability and Modularity
- The SGI Strategy

The HPTC Market

What is it ?

- It involves the most powerful computers in existence
- It addresses the most demanding scientific and technical applications
- It includes distinct application areas with specific characteristics and requirements.

Top 500: SGI/CRAY leadership in HPTC

The HPTC Market

Some applications areas

- Computational Fluid Dynamics
- Structural & Crash Analysis
- Computational Chemistry
- Seismic Processing
- Image & Signal Processing
- Weather Simulation

Big compute. Big data. Big visualization

The HPTC Market

What is needed ?

- Faster processing speed
- High memory & I/O bandwidths
- Low memory latencies
- Large memory address space
- Scalability but simple management
- Flexible configurations

Fast enough never is . . .

Why IA-64 for HPTC ?

Outstanding Performance

- **Removes performance bottlenecks**
  - **Large register files**
  - **Parallelism**
  - **Predication (to avoid several branches of execution)**
  - **Memory latency hiding**
- **64-bits allows bigger address space**
- **IEEE-accurate floating point**
- **IA-32 binary compatibility**

Performance.Headroom.Accuracy.Compatibility

Advantages of a 64-bit OS

What do 64 bits allow ?

- Big in-memory data structures
- Large file system and data files
- Efficient large integer calculations
- Ability to run 32-bit apps

64 bits: absolutely essential for HPTC

Advantages of a 64-bit OS

Linux for IA-64

- SGI emphasis is on industry standard solutions for HPTC
- Early and strong emphasis on IA-64
- Migrating IRIX technologies to Linux
  - Scalability (ccNUMA, clusters, CPU & memory)
  - High-bandwidth I/O
  - High-performance file systems
  - High-performance compilers

Open Source

SGI's Commitment

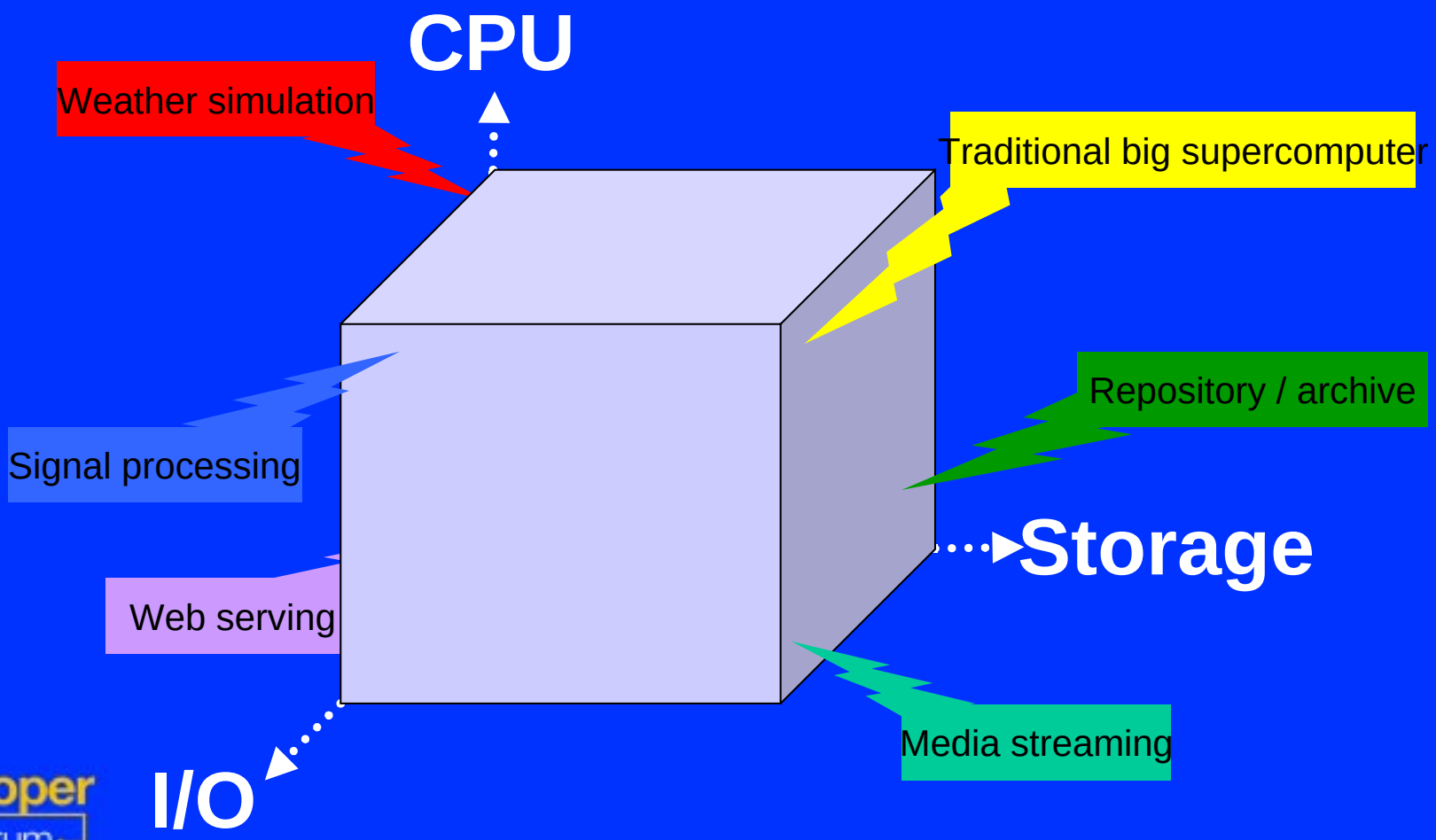
- SGI will contribute kernel enhancements to the Open Source Community

  http://oss.sgi.com

- If the community accepts these changes the code moves to Open Source
- If the community does not accept them, the changes will be discarded
- SGI will develop enhancements above the kernel for customers

Scalability and Modularity

What is Scalability ?



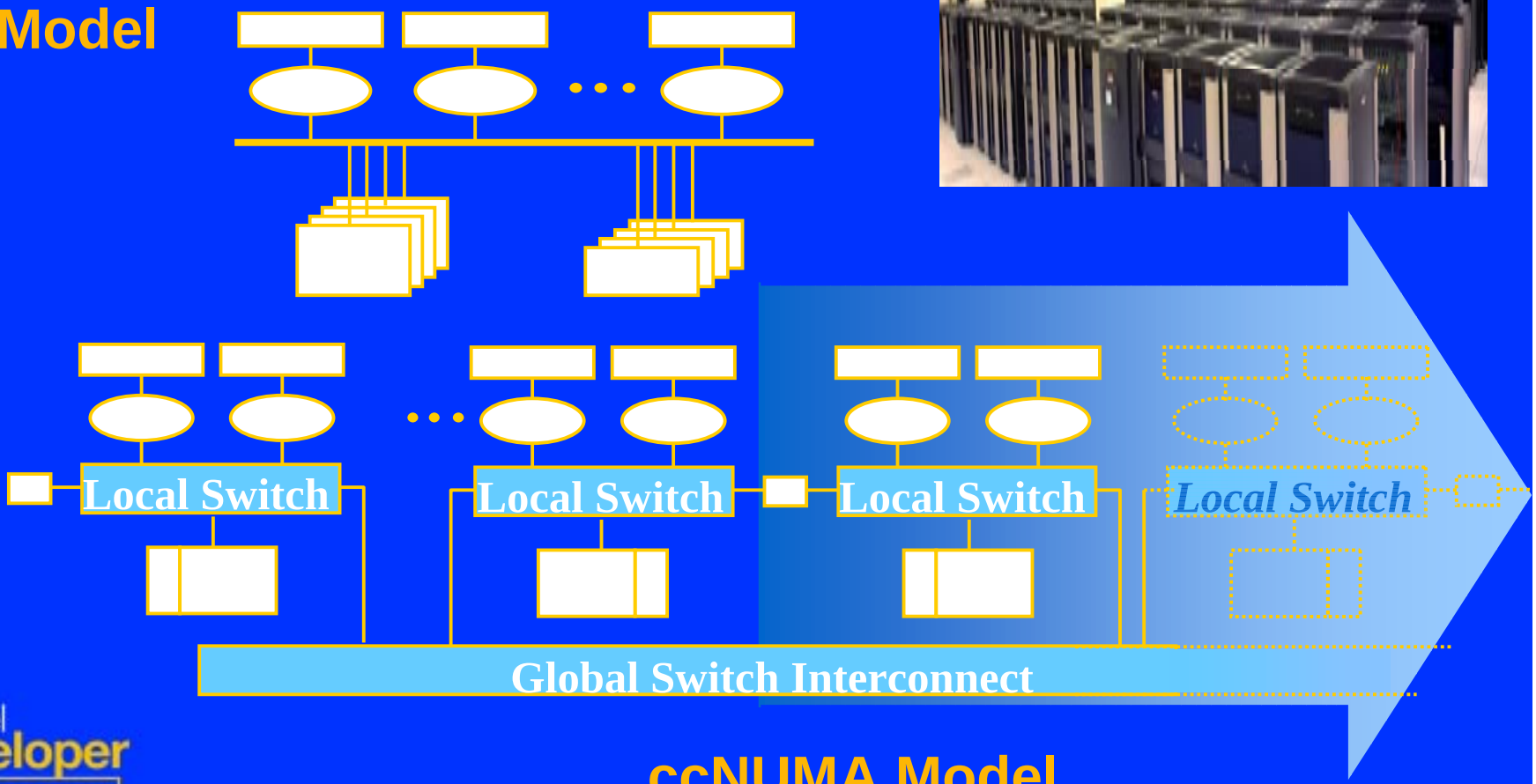
Advantages of modularity

- New technologies can be incorporated as they become available
- Modules can be upgraded separately
- Flexible configurations
- Support diverse customer needs
- Seamless transition between differentiated and off-the-shelf solutions

Scalability and Modularity

Evolution of Modular Architectures...

SMP Model

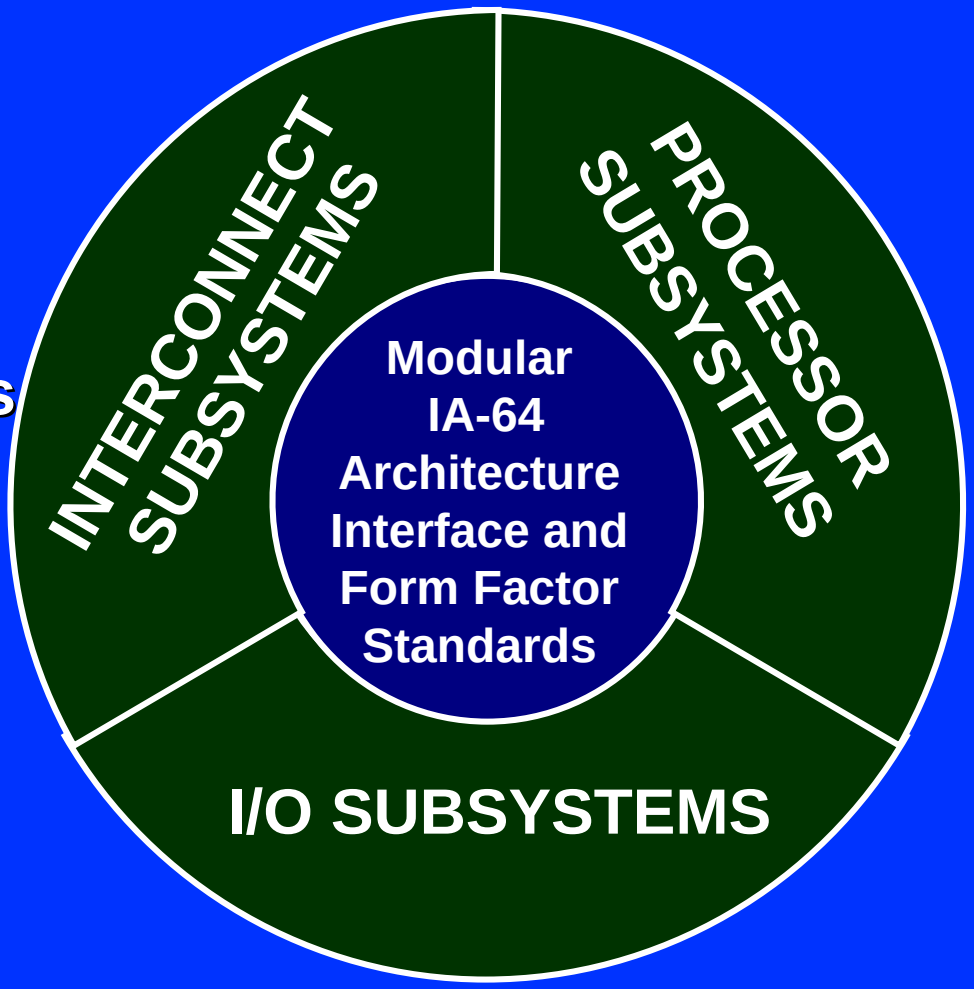


ccNUMA Model

The SGI Strategy

Modular Open Systems

- Ultimate scalability
- Performance & administrative capabilities of shared memory with the price, availability & benefits of clusters
- Tight coupling of scalable memory, processing, high performance I/O & visualization



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The SGI Strategy

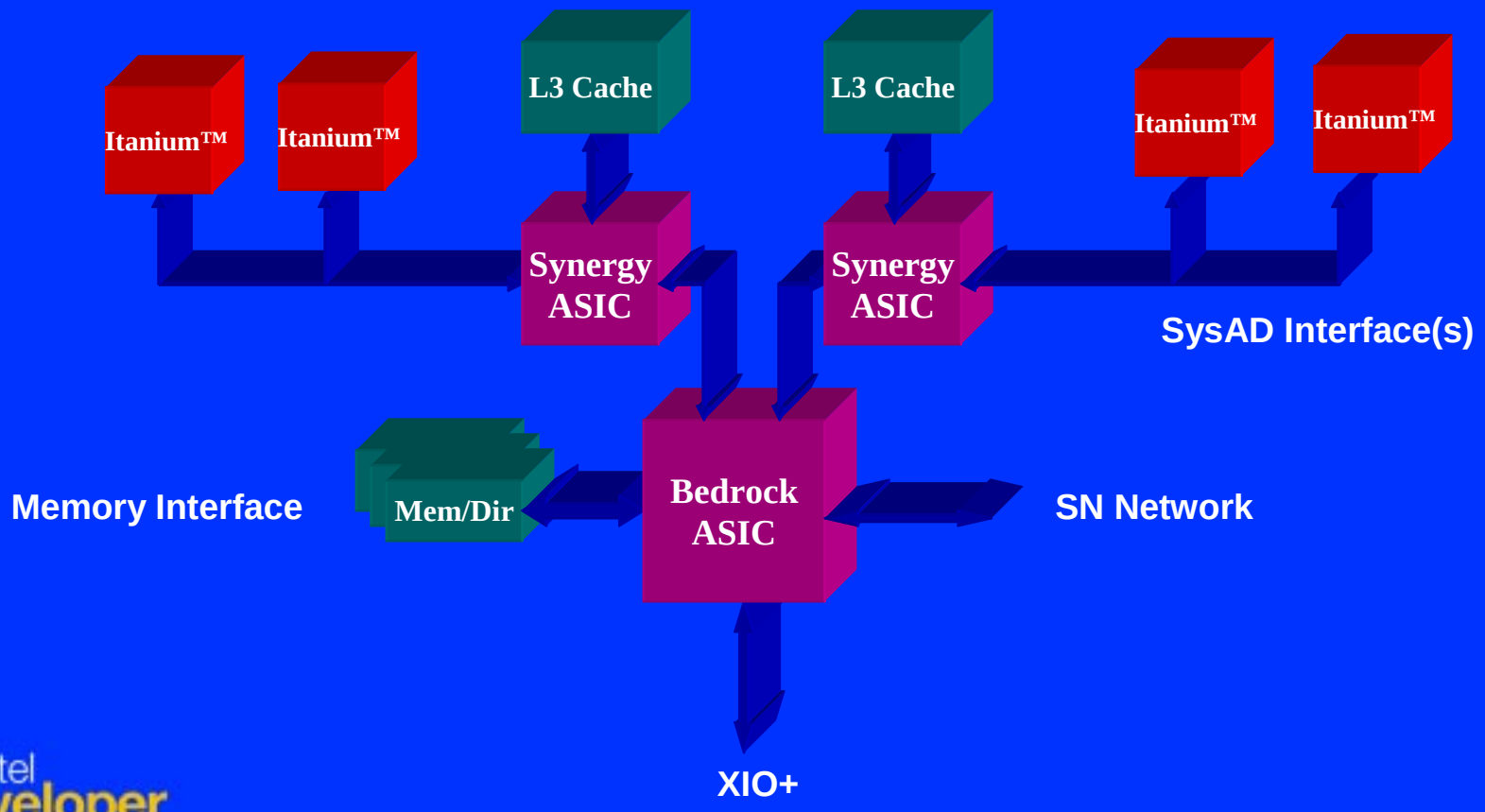
Addressing the needs

- Itanium™ outstanding performance, large memory addressing, IA-32 compatibility
- Open Source leadership with OS, compiler, I/O-related technology from IRIX
- Unmatched high-bandwidth, low latency data movement with cc-NUMA
- Enabling developer efforts with Open IA-64

… by providing superior solutions

The SGI Strategy

SN-Itanium™ Processor Node



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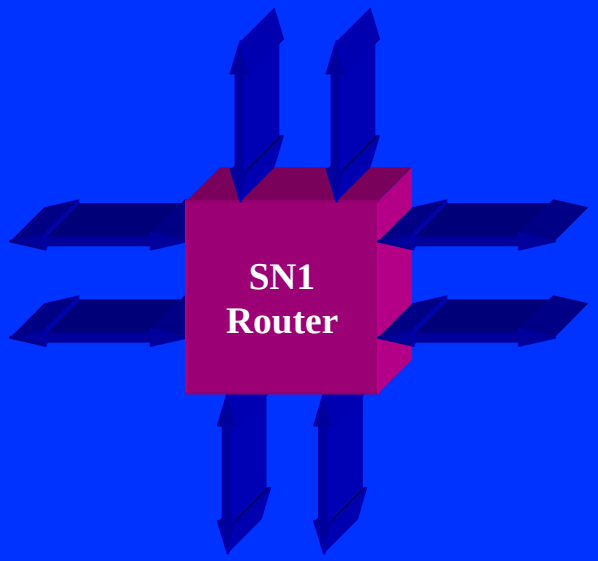
The SGI Strategy

Router Module

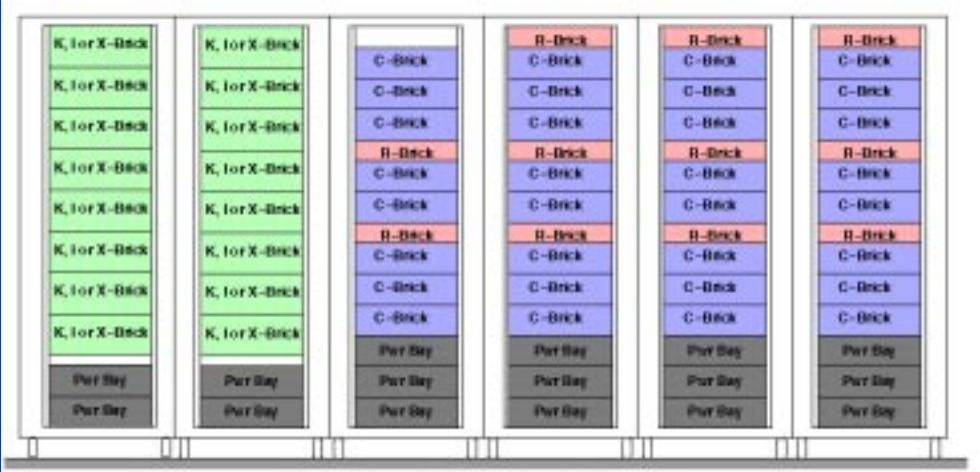


Putting it all together

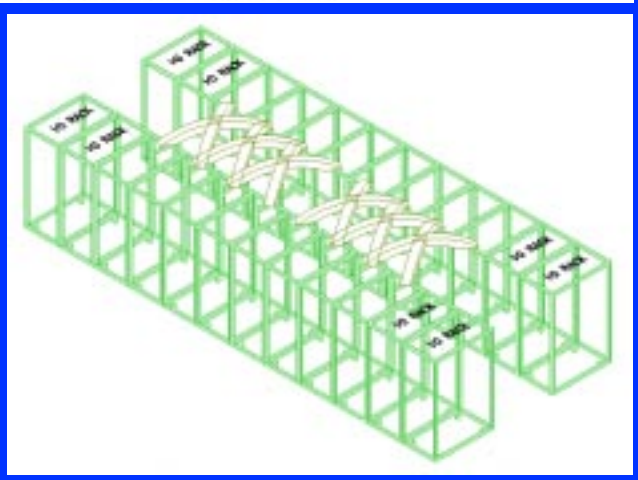
- Use scalable ccNUMA building blocks
- Use modularity at every level
  - Independent scaling/evolution of CPU and I/O
  - Seamless transition from off-the-shelf to high performance solutions
  - “Modular Supercomputers”
  - Leverage infrastructure standards
- Use modularity and redundancy of data paths for improved RAS
- Use state-of-the-art peripherals

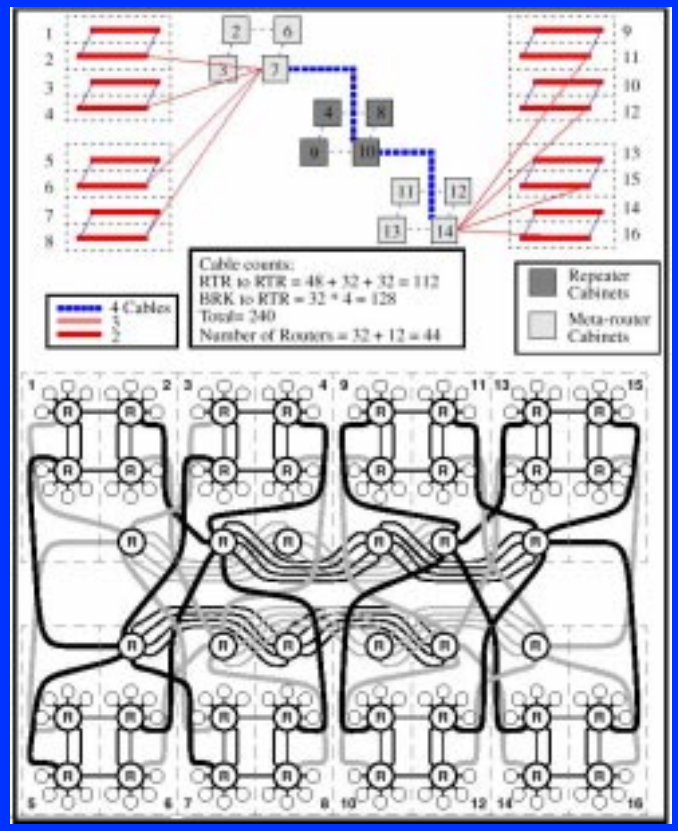
The SGI Strategy

Bricks and Mortar . . .



Quadrant of 512P Single System Image





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Our Experience ...

- It helps to start with an application already ported to a 64-bit environment (most HPTC apps already are).
- Most problems due to: unimplemented API's and incomplete or missing system libraries in Linux
- Good quality generated code. Many inner loops with near 100% utilization of IA-64 functional units !!

Porting to IA-64

CACTUS

- An Astrophysics package for solving Einstein's equations
- Run on very large systems at national laboratories
- Very scalable. Speed-ups of up to 100x on 128 MIPS processor system.
- Expect similar scalability and 3x performance improvement on IA-64 based scalable systems

Porting to IA-64

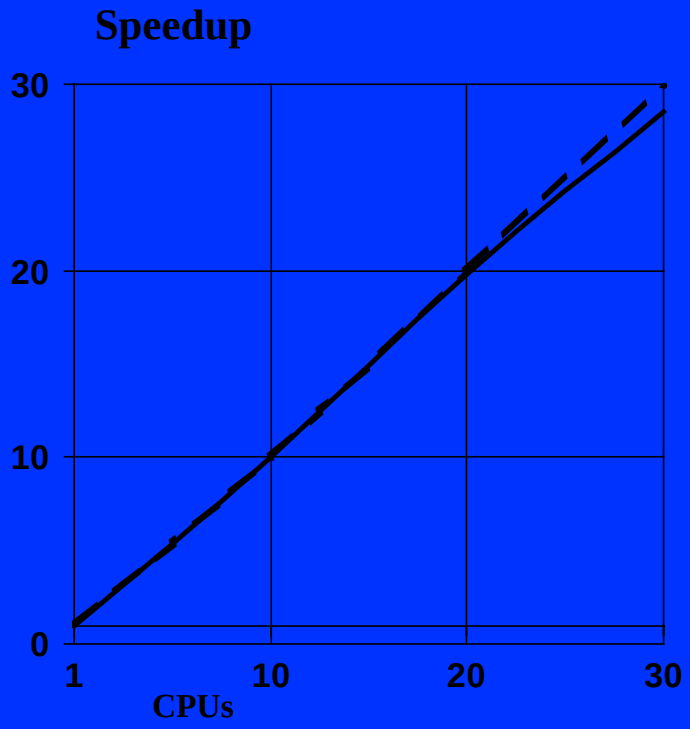
FLUENT

- An industry-grade general-purpose CFD package.
- Speed-ups of up to 114x on a 120 MIPS processor system.
- Expect similar scalability and 3x performance improvement on IA-64 based scalable systems

FLUENT 5.0.2: *External Vehicle Aerodynamics*

Volvo Model 11 Mio. Tetrahedral Fluid Cells, 10 iterations on Origin2000/300MHz, 32 Cpus, 32 GB

Ncpu	Time/Iter 2CPU/node	Speedup	Time/Iter 1CPU/node
1	1017.0*	1.0	
10	101.7	10.0	
20	51.3	19.8	34.9
30	31.1	32.0	18.9
60	16.7	61.0	10.8
90	11.4	89.0	
120	8.9	114.0	



* Estimated

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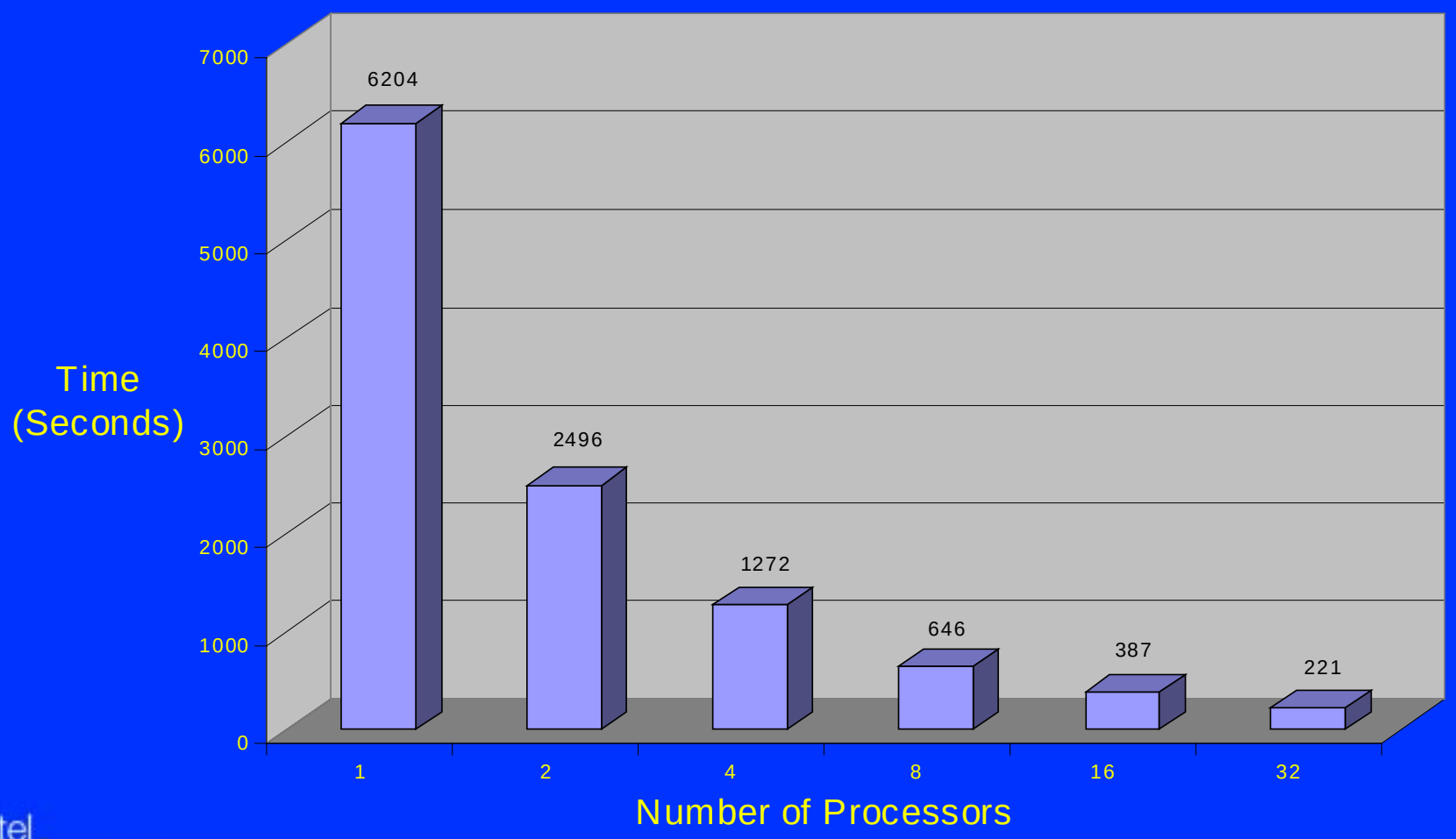
Porting to IA-64

CPLEX

- A widely used Operations Research package. Used to solve from simple to extremely complex optimization and scheduling problems
- Up to 28x speed-up running mixed integer programming (MIP) problem on a 32 MIPS processor system
- Expect similar scalability and 3x improvement on IA-64 based systems

CPLEX

Parallel MIP Times (Single Problem)



SGI 250Mhz Origin 2000

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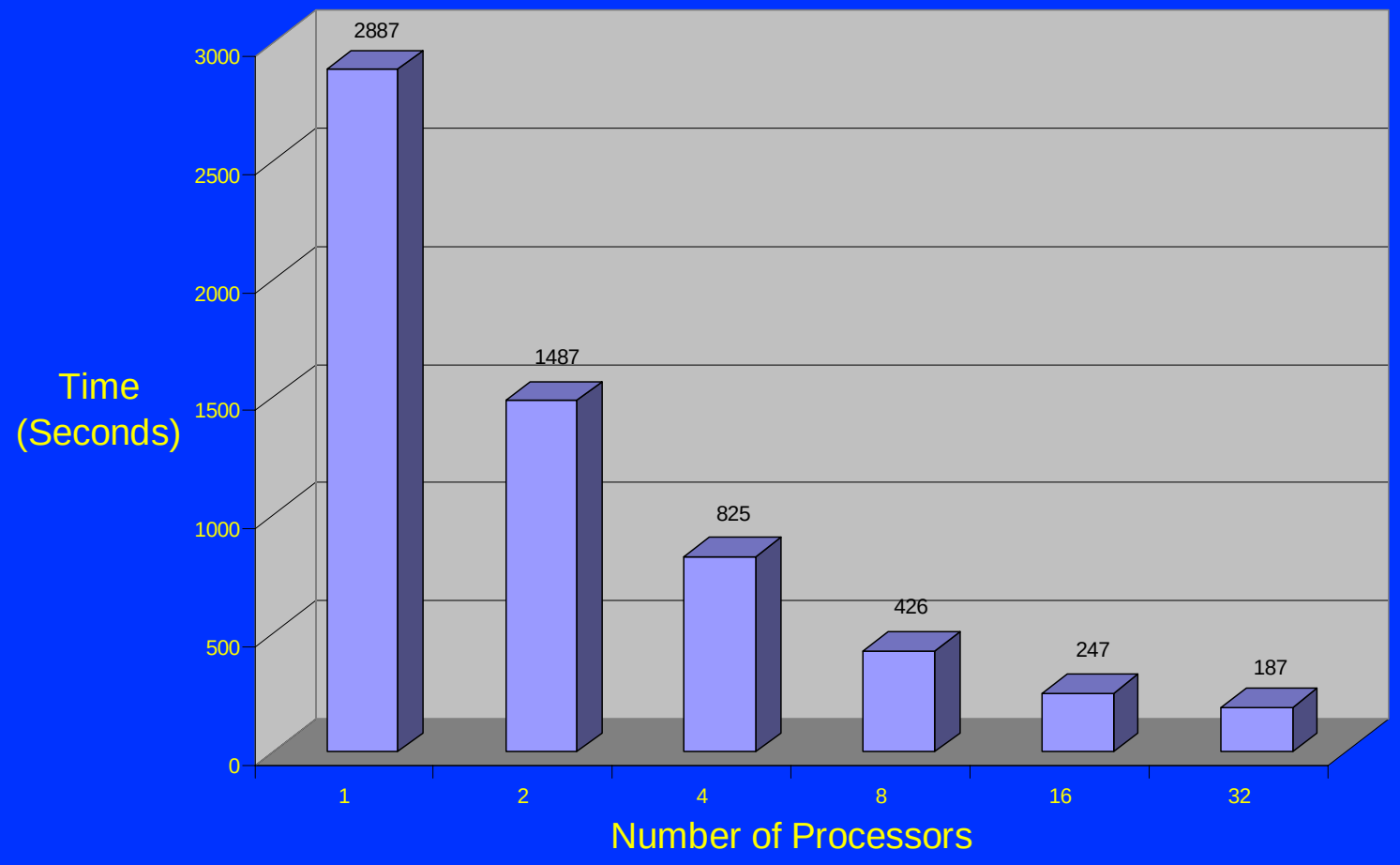
CPLEX

Parallel Barrier Times (Single Problem)



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Summary

- IA-64 is ideally suited for HPTC
- Our strategy is to build scalable, modular systems based on IA-64
- We have started porting significant applications
- Assembler code shows excellent utilization of IA-64 functional units

The solution is in sight.

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