HPC·AI
ADVISORY COUNCIL
NETWORK OF EXPERTISE

Introduction to High-Performance Computing

What is High Performance Computing?

- **There is no clear definition**
  - Computing on high performance computers
  - Solving problems / doing research using computer modeling, simulation and analysis
  - Engineering design using computer modeling, simulation and analysis

- **My understanding**
  - A huge number of computational and memory requirements
  - Cannot be afforded by a PC efficiently
  - Speeds and feeds are the keywords

- **Who uses High-Performance Computing**
  - Research institutes, universities and government labs
    - Weather and climate research, bioscience, energy, military etc.
  - Engineering design: more or less every product we use
    - Automotive, aerospace, oil and gas explorations, digital media, financial simulation
    - Mechanical simulation, package designs, silicon manufacturing etc.

- **Similar concepts**
  - Parallel computing: computing on parallel computers
  - Super computing: computing on world 500 fastest supercomputers

When Do We Need High Performance Computing?

- **Case1: Complete a time-consuming operation in less time**
  - I am an automotive engineer
  - I need to design a new car that consumes less gasoline
  - I'd rather have the design completed in 6 months than in 2 years
  - I want to test my design using computer simulations rather than building very expensive prototypes and crashing them
- **Case 2: Complete an operation under a tight deadline**
  - I work for a weather prediction agency
  - I am getting input from weather stations/sensors
  - I'd like to predict tomorrow's forecast today
- **Case 3: Perform a high number of operations per seconds**
  - I am an engineer at Amazon.com
  - My Web server gets 1,000 hits per seconds
  - I'd like my web server and databases to handle 1,000 transactions per seconds so that customers do not experience bad delays

What Does High Performance Computing Include?

- **High-performance computing is fast computing**
  - Computations in parallel over lots of compute elements (CPU, GPU)
  - Very fast network to connect between the compute elements

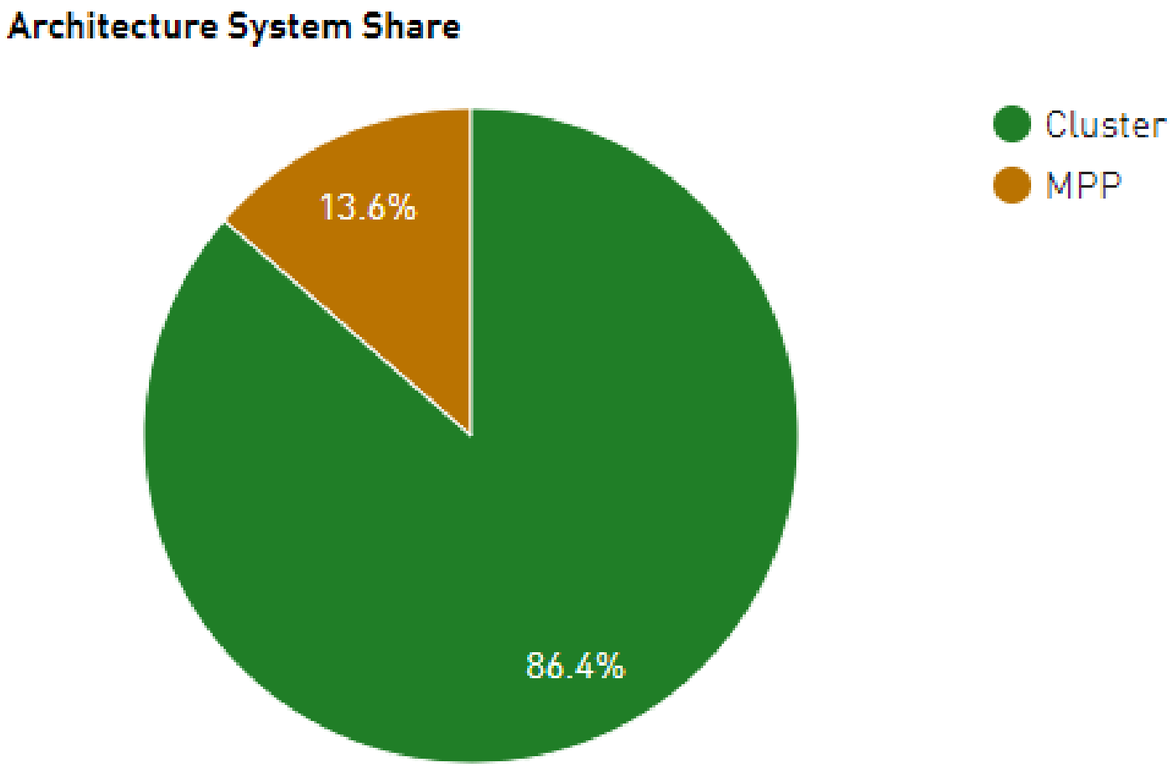
- **Hardware**
  - Computer Architecture
    - Vector Computers, MPP, SMP, Distributed Systems, Clusters
  - Network Connections
    - InfiniBand, Ethernet, Proprietary

- **Software**
  - Programming models
    - MPI (Message Passing Interface), SHMEM (Shared Memory), PGAS, etc.
  - Applications
    - Open source, commercial

Rise and Fall of HPC Computer Architectures

- **Vector Computers (VC) - proprietary system**
  - Provided the breakthrough needed for the emergence of computational science, but they were only a partial answer
- **Massively Parallel Processors (MPP) - proprietary systems**
  - High cost and a low performance/price ratio.
- **Symmetric Multiprocessors (SMP)**
  - Suffers from scalability
- **Distributed Systems**
  - Difficult to use and hard to extract parallel performance
- **Clusters – commodity and highly popular**
  - High Performance Computing - Commodity Supercomputing
  - High Availability Computing - Mission Critical Applications

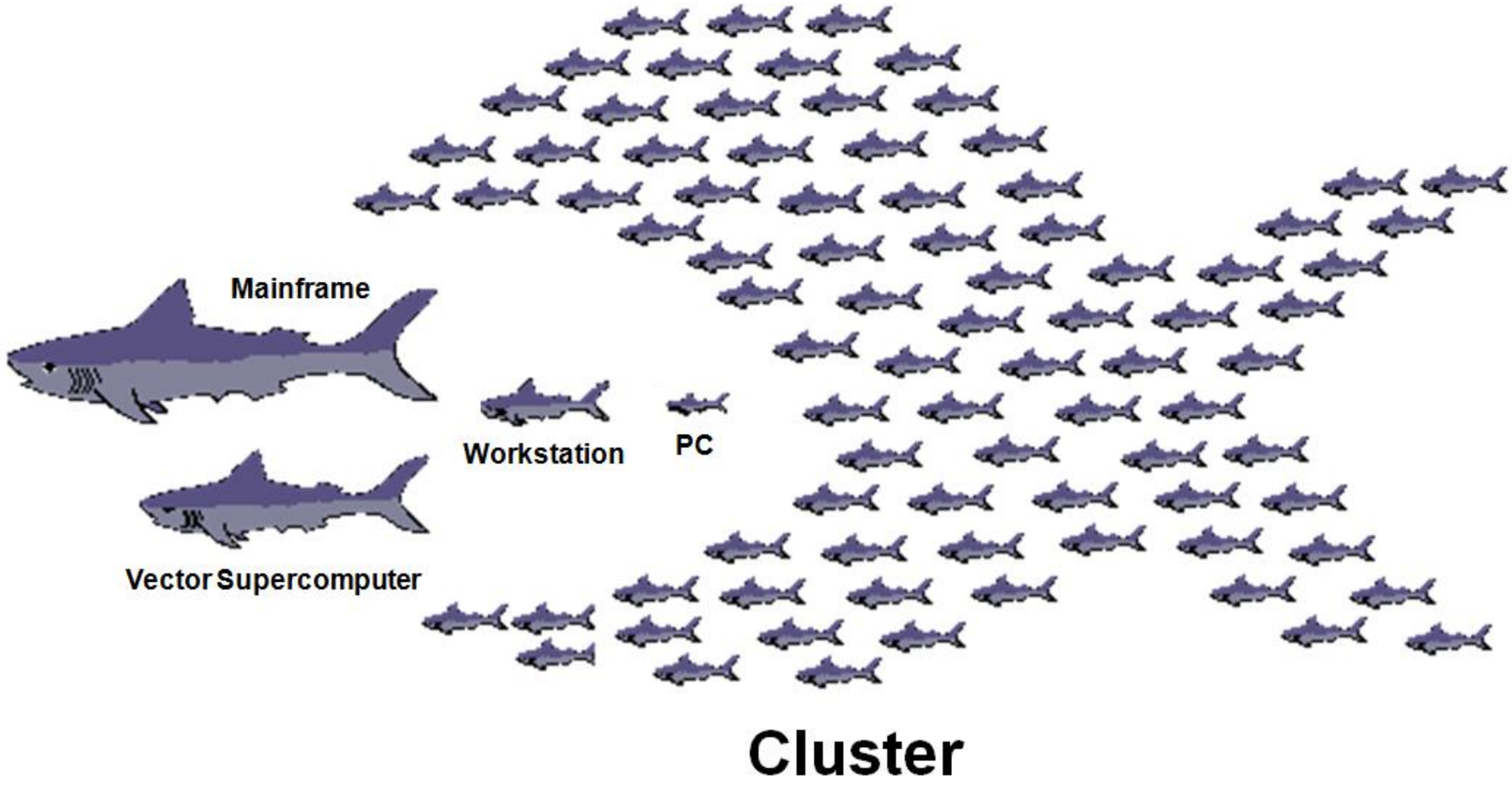
Top500 Supercomputers List – System Architecture (June 2017)



Clusters have become the most used HPC system architecture

More than 86% of Top500 systems are clusters

Computer Food Chain: Causing the Demise of Specialized Systems



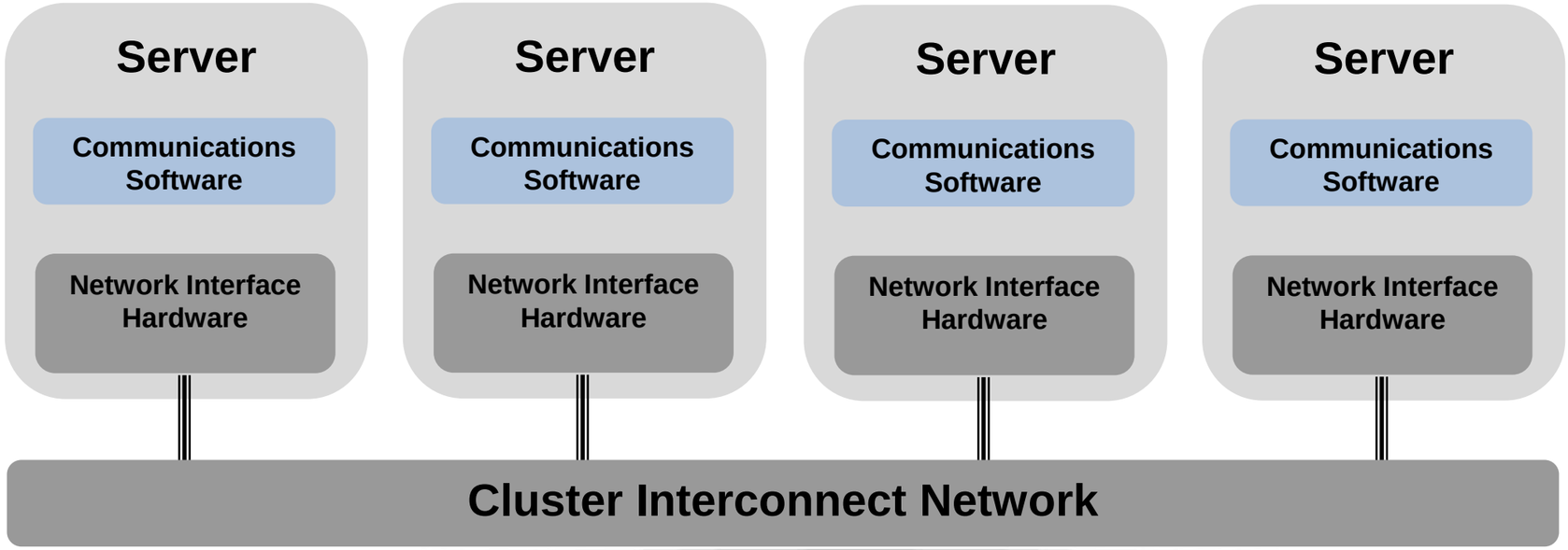
Parallel Computing on a Large Number of Servers is More Efficient than using Specialized Systems

HPC Clusters – Affordable, Efficient and Scalable HPC Solution

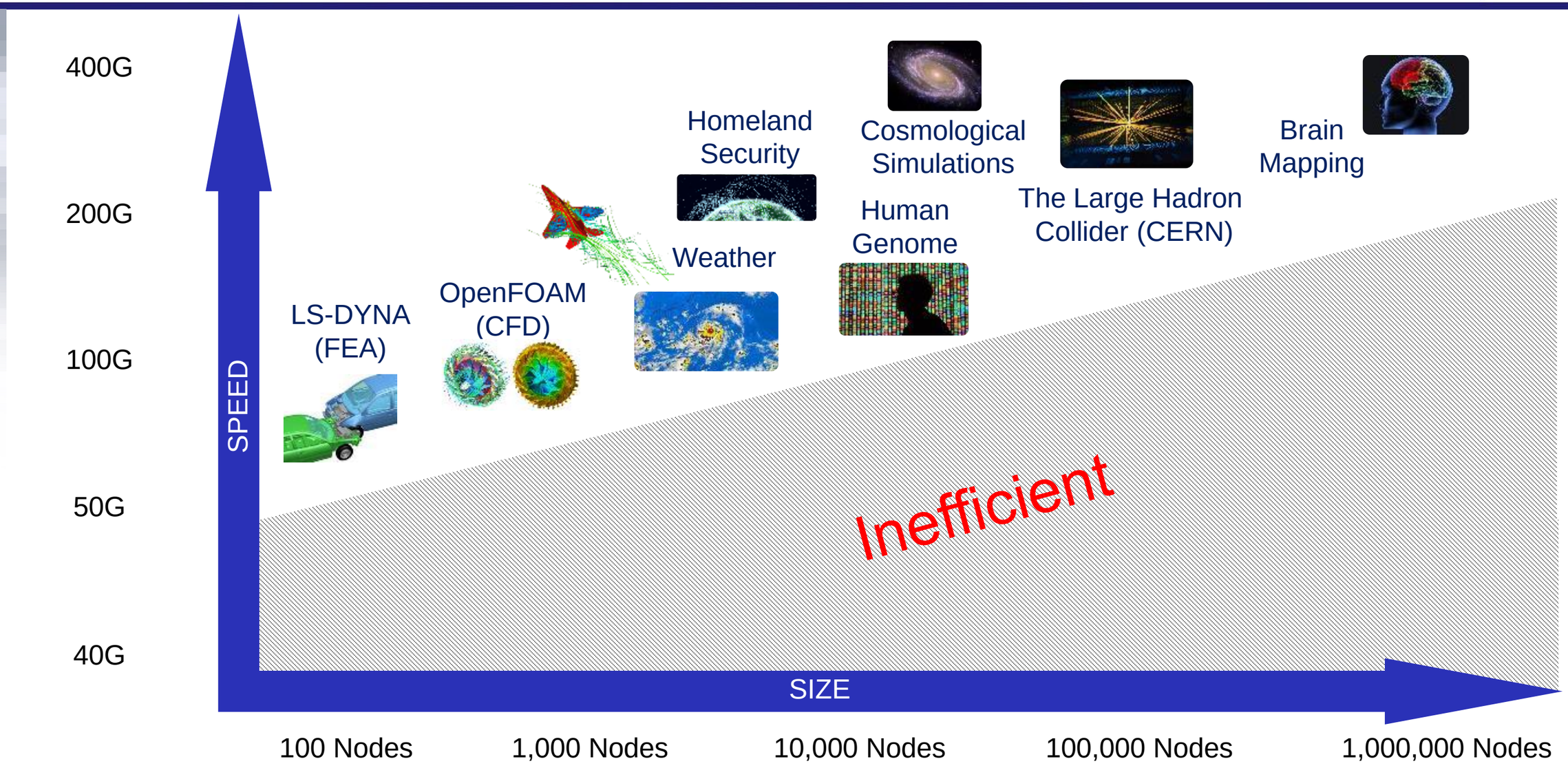
- **Since the 1990s, there has been an increasing trend to move away from expensive /specialized proprietary parallel supercomputers to clusters of computers**
  - From specialized supercomputers to cost effective, general purpose systems

- **So What's So Different about Clusters?**
  - Commodity, standard, affordable, cost effective, scalable and reliable architecture

Cluster Architecture

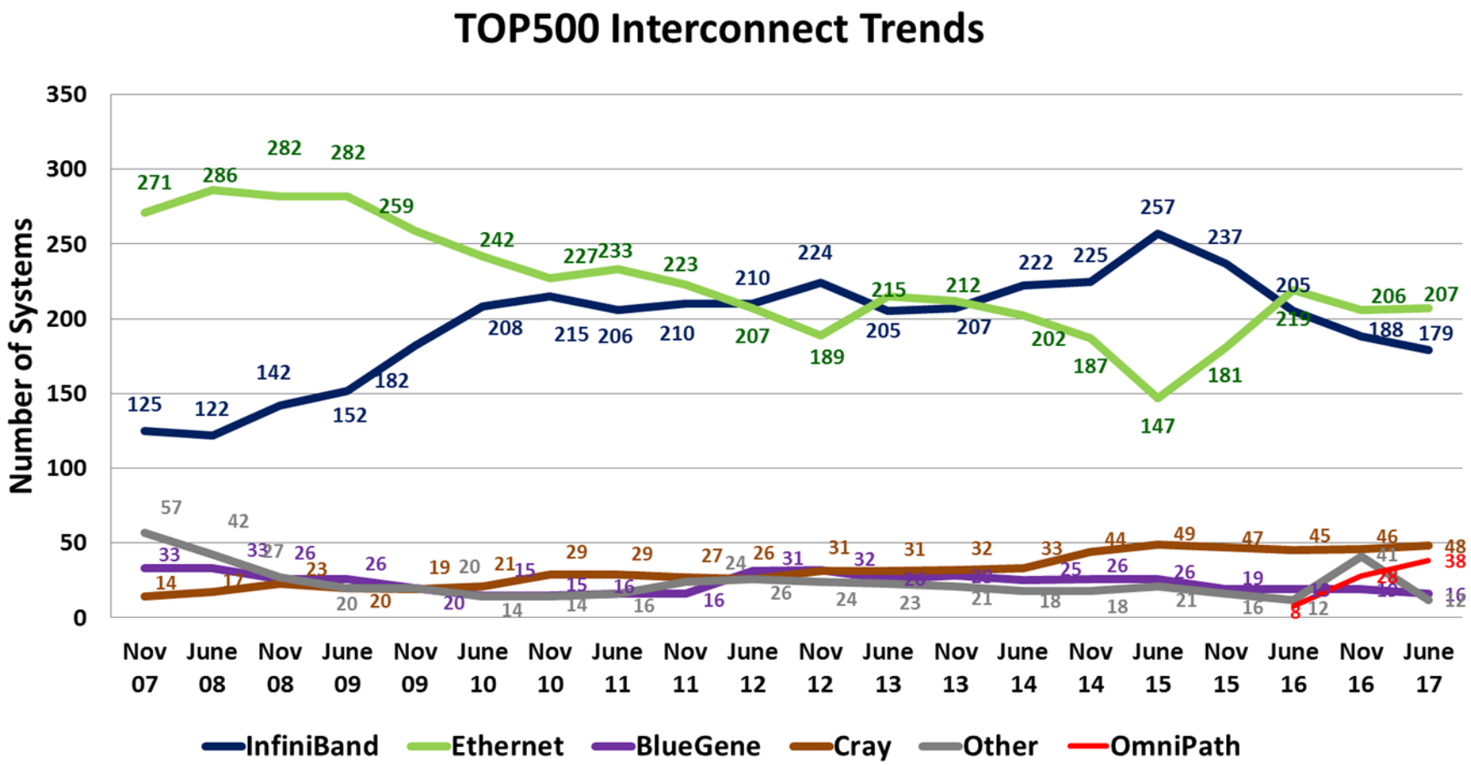


Interconnect Technology: The Need for Speed and Intelligence

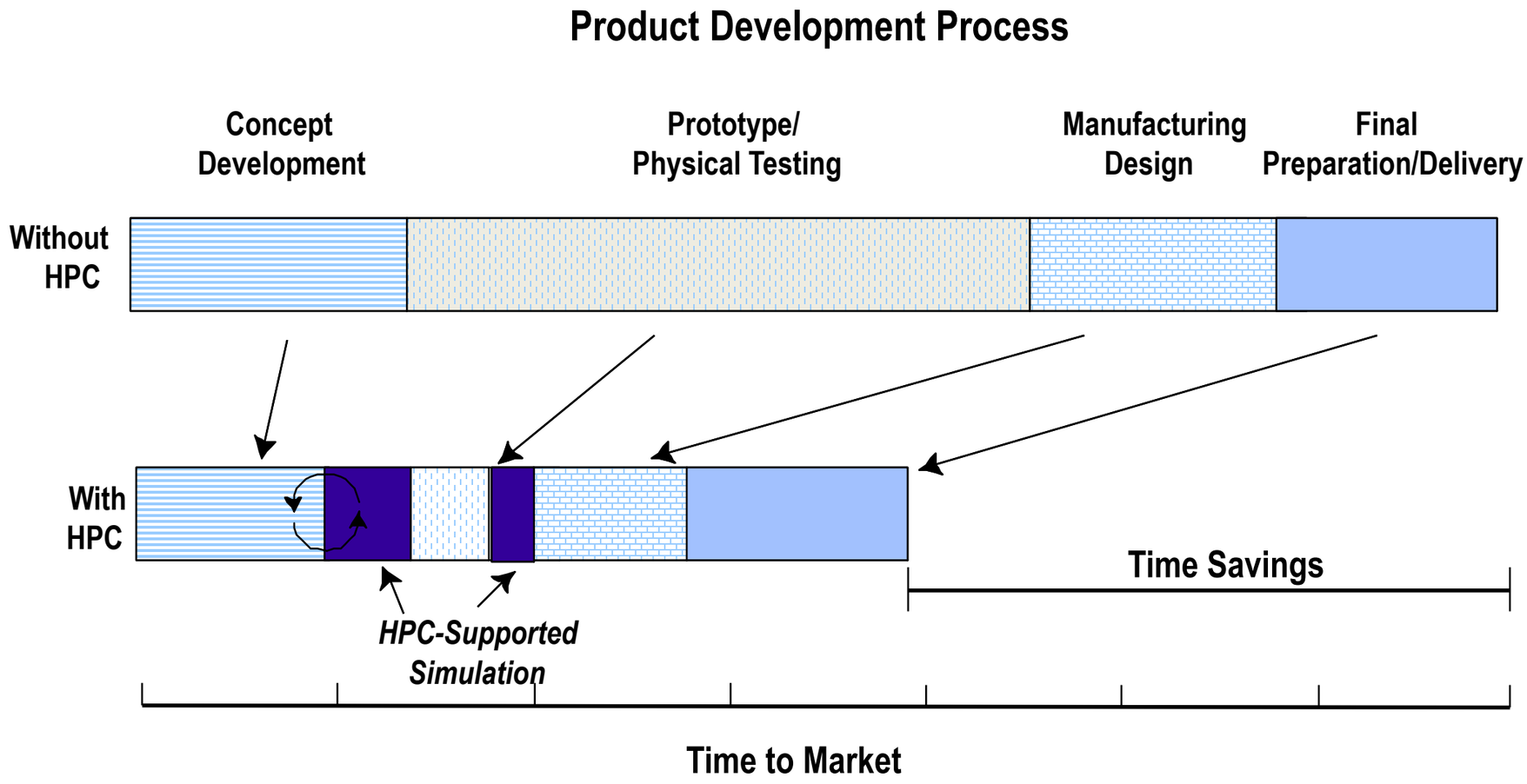


Cluster Interconnect

- Commoditization/standardization are the clustering and interconnect driving forces
- InfiniBand and Ethernet are the most used interconnect solutions for HPC systems



The HPC Advantage: Reduction in Time to Market



Source: IDC

Summary

- **From concept to engineering, from design to test and manufacturing, from weather prediction to medical discoveries, our day to day life depends more and more on HPC simulations**
  - Safer products, accurate predictions, research, etc.

- **High-performance compute clusters provide the most efficient, flexible, cost effective HPC environment for any HPC simulation**

Thank You

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