From Clustering to **Distributed Resource Computing**

- **Larger Workloads Demand Larger Cluster Platforms**
- **Exponential Power Wall and TCO**
- **Linearly Scalable Cluster**
- **Efficient Network Cost, Power, Performance**
- **Cross-Cluster Resource Virtualization No Node Over-Provisioning**
- **From General-Purpose Nodes to Micro-Nodes**
  - CPUs, Accelerators, Memory, Storage, Special Functions Shared Between Nodes
- **Distributed Resource Computing**
  - No Hardware Overkill, Minimized Cost and Power Consumption, Maximized Efficiency, Scalability, Modularity
- **Efficient Nodes**
  - Cost, Power, Performance
- **100% Cluster Modularity**
- **Good Enough Technology**
From Clustering to Distributed Resource Computing

Scale Down of High-End CPU Power Footprint in Progress

Power-Miser, Low-End, x86 and Non-x86 Processors Vying as Cost- and Power-Conscious CPU Choices for Clusters

Core Proliferation at Threshold of Pain Level for Power Consumption and Performance Bottlenecks
From Clustering to Distributed Resource Computing (cont.)

New-Gen of Ethernet and InfiniBand Switches Deliver Some Form of Power/Cost Reduction

Switched Fabrics Remain Power Hogs

Torus Topologies’ Cost, Power, Performance Efficiency Now Extending from Supercomputers to Commercial Cloud
Fat Tree Network Scalability Limited by Switch Port Capacity – i.e. an Increase in Ports per Switch Increases the Max Node Count Supported. Conversely and in Proportional Measure an Increase in Ports per Switch Decreases Both Cluster Scaling Linearity and Granularity.

Torus Network Scalability Not Limited by Any Hardware Configuration, Scales Linearly and Granularity is Maximized.
Cache Coherent Architectures Deliver Full Cross-Cluster Hardware and Software Virtualization to Small Clusters (10s of Nodes)

Message-Passing Protocols Used with Ethernet and InfiniBand Networks Allow Nodes of Large Clusters to Exchange Data but Do Not Allow them to Efficiently Hardware-Share Resources as if they were a Single Large Node
From Clustering to Distributed Resource Computing (cont.)

Cache Coherent Architectures
Cross-Cluster Resource Virtualization No Node Over-Provisioning
Lowest Power Footprint
Lowest Infrastructure Costs
Lowest Operational Costs

Until Today

but Do not...

as if...
From Clustering to Distributed Resource Computing (cont.)

Best Values Away From Architectural Extremes

High Performance
High Node Scalability
Cross-Cluster Hardware Virtualized Resources

Cache-Coherent Shared Memory

Non-Coherent Global Shared Memory

Lowest Power Footprint
Lowest Infrastructure Costs
Lowest Operational Costs

Typical Choice

Untapped Sweet Spot

Message-Passing Protocols

Any Size Clusters

Any Size Cluster

<= 8 Nodes

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From Clustering to Distributed Resource Computing (cont.)

From General-Purpose Node to Micro-Node
CPU, Acceleration, Memory, Storage, Special Functions Shared Between Nodes

With Cluster Resource Sharing, Nodes Can Go from General Purpose / Multi-Function to Single Function for Lowest TCO

Non-Coherent Global Shared Memory Empowers Mid to Large Size Clusters with Support for Single Function Micro-Nodes and the Ability to Forgo Node Over-Provisioning Typical of Message-Passing-Based Systems
From Clustering to Distributed Resource Computing (cont.)

From General-Purpose Node to Micro-Node
- CPU, Acceleration, Memory, Storage,
- Special Functions Shared Between Nodes

Single Socket CPU Micro-Nodes a Reality and Best Choice for Minimized Hardware, Top Efficiency and Linear, Granular Scaling of Computing Power
From Clustering to Distributed Resource Computing (cont.)

Reflection:
Scaling Down Node Computing Power Allows Efficient Scale Up of Cluster Performance

Single Socket CPU Micro-Nodes a Reality and Best Choice for Minimized Hardware, Top Efficiency and Linear, Granular Scaling of Computing Power
From Clustering to Distributed Resource Computing (cont.)

Single/Multiple GPGPU or Reconfigurable Acceleration Nodes Make Large Clusters Migration from General Purpose to Application-Specific with Off-the-Shelf Technology a Reality
From Clustering to Distributed Resource Computing (cont.)

Memory Nodes Empower Data Base, Data-Intensive Analytics and Informatics Processing with Highly Sought Low Latency Storage Subsystems
From Clustering to Distributed Resource Computing (cont.)

Storage Nodes Enable Localized Back-Up and Permanent Data Storage Subsystems to Serve the Entire Cluster

From General-Purpose Node to Micro-Node
CPU, Acceleration, Memory, Storage
Special Functions Shared Between Nodes
Special Processing Functions, e.g. Deep Packet Inspection, Security, etc., can be Cluster-Centralized to Serve All Nodes in the Cluster.
Leaner, Modular Nodes Deliver Functional and Cost Breakthroughs to Large Scale Clusters

Lower Infrastructure Cost
Greater Power Efficiency
Highly Granular Performance Scalability
Easier to Implement, Less Costly Cooling
Greater Fault-Tolerance
Mission-Critical “Always Up” Capability
Easier System Reconfiguring / Upgrading
Facilitated Servicing and Maintenance
From Clustering to Distributed Resource Computing (cont.)

Distributed Resource Computing
No Hardware Overkill, Minimized Cost and Power Consumption, Maximized Efficiency, Scalability, Modularity

Ultimate Target for Scale-Up Performance and Scaled Down TCO
From Clustering to Distributed Resource Computing

No Hardware Overkill, Minimized Cost and Power Consumption, Maximized Efficiency, Scalability, Modularity

Ultimate Target for Scale-Up Performance and Scaled Down TCO