The challenges of exascale ... technical, geopolitical and social
Technology inflection points ... define our design points
Open source implications .... and the inflection points
Microsoft technical computing ... investments, activities and models
Exascale Challenges

• Recognizing the ecosystem revolution
  • Punctuated change is happening now
• Choosing the right bounding boxes
  • Optimizing the important, not the familiar
• Embracing appropriate cost models
  • OPEX really matters (particularly power)
• Changing the infrastructure culture
  • When discovery is the true goal
• All the usual computing ones
  • Programmability, parallelism, resilience
Disruptive Technologies, Trends and Implications

- **Computing Consumerization**
  - Many device world

- **The Internet of Things (IoT)**
  - Computing everywhere

- **Milliwatts Matter**
  - Not Megahertz

- **Moore’s Law**
  - Multicore parallelism

- **Natural User Interfaces**
  - Moving beyond GUls

- **Holistic Design**
  - Rapidly evolving experiences

- **Software Services**
  - COGS matter

- **Privacy and Security**
  - Social norms, technical capabilities

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**Large Scale Data and Context**
<table>
<thead>
<tr>
<th>Inventory remaining: 22 pints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price reduction: $2.99/pint thru Fri</td>
</tr>
<tr>
<td>New supplier added: World Wide Importers</td>
</tr>
<tr>
<td>Low temps affecting crop yield in Mexico</td>
</tr>
<tr>
<td>Update: Customer loyalty program</td>
</tr>
<tr>
<td>Calories in whole strawberries, per cup: 46</td>
</tr>
<tr>
<td>Customer review: ★★★</td>
</tr>
<tr>
<td>@jenna48: at the grocery store – yum!</td>
</tr>
<tr>
<td>Epicurious mobile app: strawberry recipes</td>
</tr>
<tr>
<td>@john2: Get strawberries for tonight</td>
</tr>
</tbody>
</table>

Computers Mediate Interactions With People and Data

Computing Everywhere – Mobility, Data and Augmented Reality
• 21st century implicit computing
• Increasingly natural interfaces
• Embedded intelligence
• SoCs – *the new motherboard*
  • *Ecosystem diversification*
Exascale Software Leverage

• What made open source attractive in HPC?
  • Standard, commodity hardware ecosystem
  • Web services software ecosystem
  • Software development and reuse amortization
• Do those assumptions still hold?
  • Will exascale hardware be commodity?
    • If so, which commodity?
  • Will there be a non-HPC software ecosystem to leverage?
    • If so, what will it be?
  • Will there be a non-HPC community of developers?
    • If so, what code will be common and reusable?
• Plus IP protection and differentiation for vendors
  • How do they make money?
What’s A Supercomputer? (With Exascale Implications)
Microsoft’s Data Center Evolution And Economics

- **2005-2006**: Data Center Co-Location, Generation 1
- **2007**: Quincy and San Antonio, Generation 2
- **2008**: Chicago and Dublin, Generation 3
- **2009-2010**: Modular Data Center, Generation 4

**Deployment Scale Unit**

- **Server**: Capacity
- **Rack**: Density & Deployment
- **Containers**: Scalability & Sustainability
- **IT PAC**: Time to Market, Lower TCO
Democratizing Computing Mediated Research

Today

Majority of Researchers
- Use laptops and desktop computers
- Overwhelmed by data
- Doing analysis difficult; sharing even harder

Tomorrow

Paradigm Shift
- Powerful tools
  - Building communities around research results
  - The ability to marshal needed resources on demand
    - Without caring or knowing how it gets done...
  - Accelerating discovery

Supercomputing

Users

Those with small clusters or servers

A Unified Research Community

Majority of Researchers

Remember the boxing mantra: If you kill the body, the head will die
Microsoft’s Global Cloud Research Engagement Initiative

**Mission**

- Broaden research capabilities, foster collaborative research communities and accelerate scientific discovery globally
- Provide massively scalable tools and services directly to users (from their desktops) which could transform how research is conducted, accelerating scientific exploration, discovery and results

**Approach**

- Build partnerships with government-sponsored research agencies and university consortia
- Offer cloud services to academic and research communities worldwide supported with a technical engagement team
- Provide code samples and templates for significant cloud application
- Provide tools to access the cloud and important cloud services from the desktop and laptop
Windows HPC Server

- Built on Windows Server 2008 R2
- Scalable for 1000+ nodes
- Customizable management elements
- Evolved SOA support
- Parallel development with VS 2010 & .NET 4.0
- HPC Services for Excel ® 2010
- Expanded capacity through Clusters of Workstations (CoWs)

Provide a complete, integrated, platform, tools and broad ecosystem to reduce the cost and complexity of HPC.
Windows HPC and Cloud

On-premise

[Diagram showing the flow from Desktop User to HPC Head Node to Broker Node(s) to Desktop Compute Cloud via Idle Workstation Cores to HPC Cluster]

Windows Azure

[Diagram showing the flow from Azure Compute Proxies to Azure Compute Instances]

- Desktop User
- HPC Head Node
- Broker Node(s)
- Desktop Compute Cloud via Idle Workstation Cores
- HPC Cluster
- Windows HPC and Cloud
- Azure Compute Proxies
- Azure Compute Instances
Some Concluding Exascale Co-Design Thoughts

- Draw the right bounding box
  - It defines the problem you solve
- Metrics reward and punish
  - Choose carefully what you measure
- Hardware is cheap
  - Optimize for human creativity
- OPEX matters as much (or more) than CAPEX
  - Functional trumps aesthetic
- Engage multidisciplinary solutions
  - Mechanical, electrical, economic, social …
- Culture shapes behavior
  - Implicit versus explicit costs
- Leverage new ecosystems
  - Just as we have in the past