Cost Models for HPC and Supercomputing

Actionable Market Intelligence for High Performance Computing

January 2013
Intersect360 Research

- HPC industry research reports: market sizing, forecasting, and technology trend analysis
- Quarterly surveys of worldwide end users since 2007
- Feature articles in partner publications
- Custom research, consulting, special studies
- Weekly podcast with HPCwire
- “Analyst Crossfire” at HPC conferences
- HPC500 user organization
## Technical vs. Enterprise Computing

<table>
<thead>
<tr>
<th>Technical Computing</th>
<th>Enterprise Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Top-line missions:</td>
<td>• Keeps business running</td>
</tr>
<tr>
<td>– Find the oil</td>
<td>– Communicate/collaborate</td>
</tr>
<tr>
<td>– Design the minivan</td>
<td>– Market and sell the product</td>
</tr>
<tr>
<td>– Cure the disease</td>
<td>– Accounting, HR, finance, …</td>
</tr>
<tr>
<td>• Driven by price/performance</td>
<td>• Driven by RAS: reliability, availability, serviceability</td>
</tr>
<tr>
<td>• Fast adoption of new technologies, algorithms, and approaches</td>
<td>• Slow adoption of new technologies, algorithms, and approaches</td>
</tr>
</tbody>
</table>
Where We Find Technical Computing

High Performance Technical Computing (HPTC)
• Applications in science and engineering
• Top markets: academia, government labs, defense, manufacturing, bio/life science, oil/gas exploration

High Performance Business Computing (HPBC)
• Applications include trading, pricing, risk management, logistics, fraud detection, online games, analytics, …
• Top markets: financial services, ultrascale internet, online games, retail, entertainment
HPTC and HPBC Vertical Markets

- Financial services has overtaken manufacturing as largest commercial vertical
- HPBC is >95% commercial (exceptions: Fannie Mae, Federal Reserve Bank, …)
- Worldwide, private sector is growing faster than public sector
Growth in High Performance Computing

- $27B worldwide in 2011, growing to $38B in 2016
- Servers are the largest individual component, about $10B in 2012
- Storage is fastest-growing component
HPC User Budget Map Survey

• Users describe their HPC budgets
  – Size and projected growth of budget (in ranges)
  – Breakdown by category: hardware, software, staffing, facilities, services, cloud/utility, other
  – Breakdown within category – e.g., Software: operating systems, middleware, developer tools, storage software, application software, transfer costs, …

• Respondents may or may not be in “acquisition years”; therefore budget distribution is a good model basis for total cost of ownership calculation
HPC User Budget Map Survey

The seven top-level spending categories were defined as follows:

- **Hardware purchases and upgrades**, including servers, storage, networks, clients, and other.
- **Software purchases and upgrades**, including O/S and systems software, middleware, applications, tools/libraries/compilers, in-house developed, and other.
- **Facilities spending**, including building/floor space, power consumption, cooling, and other.
- **Staffing**, including system managers, maintenance personnel, systems programmers, application programmers, user services consultants, and others.
- **Services purchases**, including maintenance and repair, external training, programming, and other.
- **Cloud/Utility/Outsource**: Purchases of computational capacity/capability through an external utility-based service, including raw cycles, applications support, and other.
- **Other**: Anything not covered above
HPC Budget Distribution by Year

- ~$29B total market implies ~$44B total budget
- Hardware declined every year until sudden rebound in 2012
- Facilities increased every year until reversing in 2012
- Public cloud is a small part of the market
A Digression on HPC and Public Clouds

• Cost Models
• Barriers
Hardware Increases in All Sectors

<table>
<thead>
<tr>
<th>Hardware by Sector</th>
<th>2007</th>
<th>2008</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>All Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic</td>
<td>45%</td>
<td>41%</td>
<td>39%</td>
<td>39%</td>
<td>47%</td>
<td>42%</td>
</tr>
<tr>
<td>Commercial</td>
<td>44%</td>
<td>41%</td>
<td>36%</td>
<td>32%</td>
<td>44%</td>
<td>38%</td>
</tr>
<tr>
<td>Government</td>
<td>38%</td>
<td>44%</td>
<td>37%</td>
<td>33%</td>
<td>46%</td>
<td>40%</td>
</tr>
</tbody>
</table>

- Hardware increases across all segments indicate a market change, not likely to be sampling error.
- Public sector markets spend a higher proportion of budgets on hardware than commercial markets.
- Academic markets spend much less on software than commercial markets in general; commercial markets vary significantly depending on their usage of licensed software.
Different Software Approaches

Bio
- Public, 25%
- Commercial, 13%
- In-house, 8%
- Open, 55%

Structures (CAE)
- Commercial, 93%
- Open Source, 1%
- Public, 1%

CFD
- Open Source, 12%
- In-house, 11%

Oil
- Open Source, 6%
- Commercial, 29%
- In-house, 66%
# Hardware Distribution

<table>
<thead>
<tr>
<th>Category</th>
<th>2007</th>
<th>2008</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>All Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>65%</td>
<td>50%</td>
<td>48%</td>
<td>45%</td>
<td>50%</td>
<td>49%</td>
</tr>
<tr>
<td>Storage</td>
<td>19%</td>
<td>27%</td>
<td>27%</td>
<td>24%</td>
<td>25%</td>
<td>26%</td>
</tr>
<tr>
<td>Network</td>
<td>10%</td>
<td>13%</td>
<td>13%</td>
<td>14%</td>
<td>12%</td>
<td>13%</td>
</tr>
<tr>
<td>Client</td>
<td>6%</td>
<td>10%</td>
<td>11%</td>
<td>15%</td>
<td>12%</td>
<td>12%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

- Half of hardware spending goes to the compute system
- Half of the rest (one-fourth) is storage (on average)
- Remainder split between networks, clients
### Facilities Distribution

<table>
<thead>
<tr>
<th>Category</th>
<th>2007</th>
<th>2008</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>All Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building/floor space</td>
<td>23%</td>
<td>32%</td>
<td>37%</td>
<td>27%</td>
<td>22%</td>
<td>29%</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>37%</td>
<td>40%</td>
<td>37%</td>
<td>44%</td>
<td>50%</td>
<td>43%</td>
</tr>
<tr>
<td>Cooling</td>
<td>40%</td>
<td>28%</td>
<td>26%</td>
<td>29%</td>
<td>28%</td>
<td>28%</td>
</tr>
<tr>
<td>Other</td>
<td>1%</td>
<td>4%</td>
<td>8%</td>
<td>3%</td>
<td>6%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Building / floor space is often a “step function.” It doesn’t cost much (or anything) as long as I have it. Once I have to knock down a wall, or designate new lab space, or build a new building, it can cost a lot.
### Supercomputing Budgets

<table>
<thead>
<tr>
<th>Budgets over $10M/year</th>
<th>Budgets over $5M/year</th>
<th>All Budget Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>37.5%</td>
<td>41.3%</td>
</tr>
<tr>
<td>Software</td>
<td>10.7%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Facilities</td>
<td>17.3%</td>
<td>11.2%</td>
</tr>
<tr>
<td>Staffing</td>
<td>25.7%</td>
<td>21.9%</td>
</tr>
<tr>
<td>Services</td>
<td>7.9%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Cloud/Utility</td>
<td>0.4%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Others</td>
<td>0.5%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

- Supercomputing sites spend less on hardware, software, cloud
- Supercomputing sites spend more on facilities, staffing

These spending trends make intuitive sense. We can use the > $10M budget data as a proxy for petascale spending distributions.
Planning to Buy a 100M€ Computer?

- Be prepared to also spend (over multiple years):
  - 50M€ on storage
  - 50M€ on other hardware
  - 57M€ on software
  - 46M€ on power consumption
  - 26M€ on cooling
  - 20M€ on a building
  - 137M€ on people
  - 47M€ on other stuff (services, other utilities, etc.)

- Total cost of ownership: **533M€**

All costs vary by site and by installation. These are averages for modeling TCO of a supercomputer. Your mileage may vary.
Future-Looking Trends (tomorrow a.m.)

• Multi-core, and its implications for:
  – Memory usage
  – Power consumption
  – System utilization
• Accelerators (e.g. GPU computing)
  – Programming models
  – System efficiency
• Big Data
• Adoption of HPC
Actionable Market Intelligence for High Productivity Computing