Data Flood or Explosion: IT Challenges in the New “Normal”

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Dr. John Pormann, Scalable Compute Support Center
Duke University

INTS001
Agenda

• Environment
  – The New “Normal” – Data Explosion
  – The Internet of Things
  – Context Aware Computing

• IT Challenges
  – Intel’s Data Growth
  – Managing Intel’s Data
  – Event-Driven Data Center Models

• Impact of Research Computing Workloads on Power Consumption – Duke Example

• Summary
The New “Normal” - Data Explosion

• 2010: Crossing zettabyte/year in Data Creation
  – Current estimates are .98 – 1.2 zettabytes in 2010
  – A zettabyte is a trillion gigabytes
  – Growth increasing 60%+ Annually

• Internet of Things
  – Machine to Machine
  – Growing faster than Human to Human

• Unstructured Content Explosion
  – Non-textual Data, Sensor Integration, 3D Content Creation, Efficient Perception, Context Awareness, Access to Databases

Every 2 days the equivalent of all data from the dawn of civilization up to 2003 is being created…
A Day in the Life of Our Data

The Internet of Things

Collect
Compute
Transport
Store & Protect
Consumption And User Experience
The Internet of Things (IoT)

• An ever-growing network of devices (both passive and intelligent) that communicate state or content for global consumption (often advertised as “internet-enabled/ready”)

• Some examples:
  - Passive Devices (RFID) - fixed data when queried
  - Sensing Devices - generate and communicate information about environment or item status when queried
  - Moderate Processing Devices - formatted messaging, with the capability to vary content with respect to time and place
  - Enhanced Processing Devices - enhanced processing capability that facilitate decisions to communicate between devices without human intervention (machine to machine)

• 2015: 15 billion connected devices “real-life” Event-driven
## IT Opportunities Cross All These Areas

*Managing and taking advantage of massive amounts of digital data*

### In my Life
**Terabytes of Photos & Videos**
- Wearable sensors
- Health sensors
- Sensor nets
- Pollution sniffer
- Computer vision
- Speech recognition
- Metadata tagging
- Brainwave sensors
- 3D content creation
- Home energy apps
- Retail preferences
- Research Services

### For my Institution
**Petabytes of business/scientific info**
- Cloud Computing
- Distributed storage
- Security/Trust
- Secure enclaves
- Malware protection
- Embedded Device-Network Security
- In Vehicle Protection
- SSD for datacenters

### On the Internet
**Hundreds of Exabytes per year**
- Silicon photonics
- Fast copper I/O
- Router Bricks
- Networking
- Wireless radios
- Data services
- Connectedness
- Manageability
- Provisioning
- Remote mgmt

### Deriving Value from Data
- Gesture recognition
- Visual computing
- Media mining
- Visual search
- Lifelogging
- Embedded Usage Segments

### Processing Data
- Cloud Computing
- Tera-scale chips
- TPT computing
- Parallel Programming
- Exa-scale systems
- Power Management
- Efficient thermal envelopes

### Collecting & Creating Data
- Cloud Computing

### Storing & Protecting Data
- Cloud Computing

### Sharing & Transporting Data
- Cloud Computing

### Between our Things
**Context Aware, Machine Learning, Predicting and Anticipating, Acting and Making Life Easier**
## IT Context Aware Computing

*Taking action based on physical, logical, temporal and social changes of users and/or their environment*

<table>
<thead>
<tr>
<th>Point Solutions</th>
<th>Loosely Coupled Solutions</th>
<th>Intelligently Coupled Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client based</td>
<td>Client/Server based</td>
<td>Services based</td>
</tr>
</tbody>
</table>

### Timing
- **0-2 years**: Client based
- **2-5 years**: Loosely Coupled Solutions
- **>5 years**: Intelligently Coupled Solutions

### Examples

<table>
<thead>
<tr>
<th>timing</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0-2 years</strong></td>
<td>- Context Aware enabled application</td>
</tr>
<tr>
<td></td>
<td>- Personal/custom UI</td>
</tr>
<tr>
<td></td>
<td>- Democratizing information</td>
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<tr>
<td></td>
<td>- Online Identity (shared trust models)</td>
</tr>
<tr>
<td></td>
<td>- Location context aware services</td>
</tr>
<tr>
<td></td>
<td>- Smart-Call-Center Solution</td>
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<tr>
<td></td>
<td>- Knowledge Worker Productivity</td>
</tr>
<tr>
<td></td>
<td>- Auto locate &amp; configure/secure resources - historical work</td>
</tr>
<tr>
<td></td>
<td>- Mobile Computing</td>
</tr>
<tr>
<td><strong>2-5 years</strong></td>
<td>- Portal Customization experience (user specified- reduce customer effort)</td>
</tr>
<tr>
<td></td>
<td>- Sales Force Automation</td>
</tr>
<tr>
<td></td>
<td>- Intelligent</td>
</tr>
<tr>
<td></td>
<td>- Self-segmentation</td>
</tr>
<tr>
<td></td>
<td>- CRM context rich services</td>
</tr>
<tr>
<td><strong>&gt;5 years</strong></td>
<td>- Portals extends to mobile B2C</td>
</tr>
<tr>
<td></td>
<td>- Hyperpersonalized experiences - context rich services</td>
</tr>
<tr>
<td></td>
<td>- Convergence between fixed and mobile, M2M activities</td>
</tr>
<tr>
<td></td>
<td>- IT Productivity</td>
</tr>
<tr>
<td></td>
<td>- Diversity in the contact center (phone-&gt;web-&gt;video)</td>
</tr>
<tr>
<td></td>
<td>- Knowledge Workers Productivity</td>
</tr>
<tr>
<td></td>
<td>- Ambient Information - push</td>
</tr>
<tr>
<td></td>
<td>- Mobile Enterprise App. Platforms</td>
</tr>
</tbody>
</table>

**Context Aware and Internet of Things improve User Experience by Harnessing the Data Explosion**
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• Summary
Intel IT Compute/Storage Growth

Design
Design Computing

Office
General Purpose

Manufacturing
Factory + Test

Enterprise
E-biz + supply chain

70% of servers in Intel are in D. 30% of servers in Intel are in O, M, and E

Mandate: Enable Efficient Growth

~45% YOY Growth
(Design Compute)

~35% YOY Growth
(Data Storage)

1,2 Source. Intel IT, September 2009. EDA MIPS (Electronic Design Automation - Meaningful Indicator of Performance per System) is a weighted performance measure.
IT Challenges – Managing Data

• Maintaining “state” on our internal cloud of ~100,000 servers
  - Ever-increasing compute and storage needs
  - Continuously adjust use based on compute demand, power, etc
  - Capturing rich state information and acting on it in real time
  - Real-time BI to manipulate our NetBatch workloads more efficiently

• Revolution of In-Memory Analytics and BI Usage
  - Harness very large memory/compute engines for joint BI appliances and Complex Event Processing (CEP)
  - Large models of state for infrastructure (cloud server workloads) or business activities (supply chain details or customer interaction) could establish fluid business rules to respond to state changes

• Energy-Efficient Data Processing

As Data Dramatically Increases in Size and Complexity, new Paradigms of Sensing and Energy Management are Needed to Manage Compute Infrastructure
Analytics on Mass Data

• Goal: Design project execution predictability based on job lifecycle data
  – More than 900 million job records in the Netbatch system now and growing by 20 million per week
  – Mining and analyzing this huge amount of data to discover useful information/knowledge and patterns
  – Research manipulates the huge amount of data and builds predictive models on job run time and wait time to help with decision making on which set of jobs to run where and when

• The resulting workload demand can coupled with the power/thermal demand to maximize efficient usage of the Data Center

Improving NetBatch Scheduling Policy, Resource Utilization as well as the Quality of Services
Creating Event-Driven Data Center Models

Instrument: Performance and Power; Infer: Power and Cooling
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Impact of Research Computing Workloads on Power Consumption

Scalable Computing Support Center  
Duke University  
http://wiki.duke.edu/display/SCSC  
scsc at duke.edu  

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Scalable Computing Support Center at Duke University

- We are a campus-wide service and support center
  - Not an academic center, no academic research aims
  - We are directly tied in to the Provost’s Office and OIT (campus IT)

- Research computing hardware
  - Duke Shared Cluster Resource
  - Condor grid
  - Emerging architectures

- Consulting

- Training
Duke Shared Cluster Resource

- Started in 2003 with 64-machine “seed” from the University
  - “Condo” model

- Currently:
  - ~730 machines, ~4100 CPU-cores
  - 70+ research groups, 650+ users

<table>
<thead>
<tr>
<th>Year Installed</th>
<th>Platform</th>
<th>CPU</th>
<th>CPUs/Cores</th>
<th>CPU TDP</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-2006</td>
<td>Dell 1U (various)</td>
<td>Intel Xeon (various)</td>
<td>dual/dual</td>
<td>(various)</td>
<td>273</td>
</tr>
<tr>
<td>2007</td>
<td>Dell 1950 1U</td>
<td>Intel X5355 (2.65GHz)</td>
<td>dual/quad</td>
<td>120W</td>
<td>11</td>
</tr>
<tr>
<td>2008</td>
<td>Dell M600 Blade</td>
<td>Intel E5420 (2.5GHz)</td>
<td>dual/quad</td>
<td>80W</td>
<td>283</td>
</tr>
<tr>
<td>2009</td>
<td>Dell M610 Blade</td>
<td>Intel E5520 (2.25GHz)</td>
<td>dual/quad</td>
<td>80W</td>
<td>63</td>
</tr>
<tr>
<td>2009</td>
<td>Dell M610 Blade</td>
<td>Intel X5550 (2.65GHz)</td>
<td>dual/quad</td>
<td>95W</td>
<td>99</td>
</tr>
<tr>
<td>2010</td>
<td>Dell M610 Blade</td>
<td>Intel X5650 (2.66GHz)</td>
<td>dual/hex</td>
<td>95W</td>
<td>7</td>
</tr>
</tbody>
</table>

Scalable Computing Support Center
http://wiki.duke.edu/display/scsc
Measurement System

- Oracle/Sun GridEngine batch scheduler
  - Automatically collects CPU, load-average, memory usage, etc.
  - Allows a custom “load sensor” script

- A separate cron job pulled the SGE data and wrote it to a time-stamped file
  - 15 min snapshots

```
% qhost --F
HOSTNAME    ARCH
-------------------------------------
global      -
aeroel-n01  lx26-amd64
  hl:arch=lx26-amd64
  hl:num_proc=2.000000
  hl:cpu=13.500000
  hl:watts=205.000000
...
aeroel-n02  lx26-amd64
  hl:arch=lx26-amd64
  hl:num_proc=2.000000
  ...
```
Dell/IPMI Interface

- All the Dell blades have a separate Blade Management Controller (BMC)

- Dell engineers pointed us at the IPMI interface to pull the power data out of the BMC

```bash
% ipmitool -I open sdr list
Ambient Temp   | 19 degrees C   | ok
Temp           | -69 degrees C  | ok
Temp           | -64 degrees C  | ok
System Level   | 192 Watts      | ok
VTT PG         | 0x01           | ok
...```
WattsUp Meters

For older systems which did not have internal power measurement:

△ https://www.wattsupmeters.com

% ./wattsup -l ttyUSB0
Power Consumption – Raw Data

![Graph showing power consumption vs CPU usage]
Intel® Xeon® Processor X5355 /1U vs. E5420/Blade

130W less power

BUT: 2007-era 1U vs. 2008-era Blade
Intel® Xeon® Processor E5420 vs. E5520

Consistent 30W drop from 0-100% Load
Intel® Xeon® Processor E5520 vs. X5550

15W difference at idle

43W difference at load
Intel® Xeon® Processor X5550 vs. X5650

4W difference at idle

17W difference at load

2x4 vs. 2x6 CPU-Cores
Conclusions

- Under realistic load conditions ...

- From 2007 to present, we’ve seen significant reductions in power per server
  - 1U to blade ... 130W savings
  - Intel® Xeon® Processor E54** to E55** ... 30W savings

- The Intel Xeon processor X-series seem to be efficient in that their idle power is comparable to that of the E-series processors

- (Preliminary Data) The new Intel Xeon Processor X56** seem to have comparable power draw to the Intel Xeon processor X55** .. but with 50% more cores
Future Work

- Tie this power consumption data to real $$$ savings
  - Including A/C savings if possible
  - Automatic power-off of unused machines

- Continue collecting data from older systems

- Head-to-head comparison for 1U and blade
  - (to drive purchase and retirement decisions)
Summary/Call To Action

• Data will continue to grow exponentially as the Internet of Things (IoT) and data complexity accelerates
  – Manage your data before it manages you
  – Invest in understanding workloads to better optimize compute
  – Explore new opportunities to enable Context Aware Computing

• Server refresh enables more energy efficient computing as basis for emerging complex autonomous systems that combine physical data with workload data
  – Implement an active refresh strategy to migrate to the latest Intel® Xeon® processor-based servers
  – Instrument for physical data (power, thermal, etc)
  – Invest in Data Center analytics to improve capacity, performance and health
Additional sources of information on this topic:

• Other Sessions
  – INTS002, DCCS004, DCCL001, SDDS005

• Demos in the showcase
  – Booths 125 and 162 IT Innovation

• IT@Intel white papers at www.intel.com/IT:
  – “An Enterprise Private Cloud Architecture and Implementation Roadmap”
  – “Architecting Software as a Service for the Enterprise”
  – “Intel Cloud Computing Taxonomy and Ecosystem Analysis”

• Contact info:
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  – jbp1@duke.edu
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