Building Efficient Virtualization with High Performance Green Memory

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Director, Strategic DRAM Marketing, Samsung

Bob Zuber
WW Marketing Manager, System x Marketing, IBM
Agenda

✓ IT Industry Trends
✓ Environmental Impact
✓ DDR3 Effect on Energy
✓ The IBM eX5 Advantage
✓ Case Study
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Computing Growth Drivers Over Time

Portable Device & Mobile Internet

Back-end Infrastructure: Cloud Computing

Source: Morgan Stanley
An Essential Element: Enterprise Eco-System & Data Centers

- Server Hardware
- Storage Systems
- Networking
- Virtualization
- Operating System
- System Management
- Databases
- Middleware & Tools
- Applications
- Consulting & Services
- Data Center
- IT
Virtualization Trend

WW Spending on Servers, Power and Cooling, and Management/Administration

Customer Spending ($B)

- Physical Server Installed Base (Millions)
- Logical Server Installed Base (Millions)
- Power & Cooling Expense
- Management Cost
- Server Spending

Source: IDC, 2008

Virtualization Management Gap

'96 '97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13
An Essential Element: Enterprise Eco-System & Data Centers

Server Hardware

Storage Systems

Networking

Virtualization

Operating System

System Management

Databases

Middleware & Tools

Consulting & Services

Applications

IT

Data Center
Database Trend: Ex. SAP/HANA In-Memory Application

Maintaining data-intensive applications

<table>
<thead>
<tr>
<th>Density</th>
<th>Product</th>
<th>Speed (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>256Mb</td>
<td>SDRAM</td>
<td>133 - 166</td>
</tr>
<tr>
<td>512Mb</td>
<td>DDR1</td>
<td>266 - 400</td>
</tr>
<tr>
<td>1Gb</td>
<td>DDR2</td>
<td>667 - 1066</td>
</tr>
<tr>
<td>2Gb</td>
<td>DDR3</td>
<td>1066 - 1333</td>
</tr>
<tr>
<td>4Gb</td>
<td>DDR3</td>
<td>1066 - 1333</td>
</tr>
</tbody>
</table>

Density Product Speed (Mbps)

- **Main Memory**: Size: GBs up to TBs Latency: ~100 ns
- **CPU Cache**
  - Size: 64K to 8M Latency: ~1 ns to 20 ns
- **Disk**
  - Size: TBs Latency: >1 Mns
- **SSD**
  - Size: GBs to TBs Latency: 100K ns

**Fast real-time analysis and planning of volume data**
(A couple of seconds for scanning 100GB on New Intel HW)

Source: SAP
An Essential Element: Enterprise Eco-System & Data Centers

- Server Hardware
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- Virtualization
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- IT
Mobile Applications Growing Exponentially

>600% growth

Source: GetJar, 2010
Agenda

- IT Industry Trends
- **Environmental Impact**
- DDR3 Effect on Energy
- The IBM eX5 Advantage
- Case Study
Challenge: Data Center Carbon Footprint

**CO₂ Emissions as % of WW total**

- Data Centers: 0.2
- Airlines: 0.6
- Shipyards: 0.8
- Steel Plants: 1.0

**WW Data Center Emissions, (metric megatons CO₂)**

- 2007: 80
- 2020: 340

CAGR >11%

>4X

Many IT Energy Regulations on the Horizon

Energy Star Server Guidelines for Memory:
2W per GB of Memory

→ 30% more energy efficient than standard servers
→ US Energy savings(*) = $800 million per year
→ US CO2 prevention (*) >1 million vehicle equivalent

Source IDF 2010
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## Importance of Memory in Power

**Image Description:**
- **Diagram:** Shows the relationship between CPU, Memory, Disk, and Network with respect to Power Consumption.
- **Table:** Highlights the importance of Memory with a 26% power consumption compared to other components like Network (52%), Disk (2%), and CPU (20%).
- **Data Points:**
  - Others (Network, AC loss, Main board, Etc.): 52%"
Samsung #1 in DRAM
Innovation and Manufacturing
Confidential

- Considered 8 hours active and 16 hours idle status in server

Measured Power Consumption of Memory in 48GB server

- 86%

<table>
<thead>
<tr>
<th>Type</th>
<th>Density</th>
<th>Speed</th>
<th>Voltage</th>
<th>Power Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDR2 60nm 1Gb</td>
<td>60nm</td>
<td>1Gb</td>
<td>1.8V</td>
<td>102W</td>
</tr>
<tr>
<td>DDR3 50nm 1Gb</td>
<td>50nm</td>
<td>1Gb</td>
<td>1.5V</td>
<td>50W</td>
</tr>
<tr>
<td>DDR3 40nm 2Gb</td>
<td>40nm</td>
<td>2Gb</td>
<td>1.35V</td>
<td>28W</td>
</tr>
<tr>
<td>DDR3 30nm 4Gb</td>
<td>30nm</td>
<td>4Gb</td>
<td>1.35V</td>
<td>14W</td>
</tr>
</tbody>
</table>

- High Density, High Speed, Low Power

- Samsung Memory Offers Lowest Power Consumption

- 2.1W /GB

- 0.29 W /GB

- Considered 8 hours active and 16 hours idle status in server

Samsung Memory
Samsung Memory Offers Lowest Power Consumption

48GB DRAM-Level

102W

86% Savings

Current solution
60nm Class 1Gb 1.8V DDR2

Green solution
30nm Class 4Gb 1.35V DDR3

48GB System-Level

390W

44% Savings

Current solution
60nm Class 1Gb 1.8V DDR2

Green solution
30nm Class 4Gb 1.35V DDR3
## Maximizing Virtualization with Westmere-EX

### 28 Virtual Machines @ 4.5GB

<table>
<thead>
<tr>
<th>Memory</th>
<th>Customer Scenario</th>
<th>Minimum Capacity</th>
<th>Maximum Capacity&lt;sup&gt;1&lt;/sup&gt;</th>
<th>eX5 Memory Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>4Gbit 32GB RDIMM</td>
<td>Server Running 28 Virtual Machines</td>
<td>256GB (8 DIMMs)</td>
<td>Up to 1TB (32 DIMMs)</td>
<td>2TB (64 DIMMs) 454 VMs (+1521%)</td>
</tr>
<tr>
<td>30nm Class (1.35v)</td>
<td></td>
<td>56 VMs (+100%)</td>
<td>227 VMs (+711%)</td>
<td></td>
</tr>
<tr>
<td>2Gbit 16GB RDIMM</td>
<td>Memory Needed: 127 GB*</td>
<td>128 GB (8 DIMMs)</td>
<td>512 GB (32 DIMMs)</td>
<td>1TB (64 DIMMs) 227 VMs (+711%)</td>
</tr>
<tr>
<td>30nm Class (1.35v)</td>
<td></td>
<td>28 VMs</td>
<td>113 VMs (+304%)</td>
<td></td>
</tr>
<tr>
<td>2Gbit 8GB RDIMM</td>
<td>• 2 Socket Westmere-EX</td>
<td></td>
<td>256GB (32 DIMMs)</td>
<td></td>
</tr>
<tr>
<td>40nm Class (1.35v)</td>
<td>• 16 DIMM Slots, 2DPC</td>
<td></td>
<td>56 VMs (+12%)</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>• 1GB Dedicated to vSphere v4.0</td>
<td></td>
<td>128 GB (32 DIMMs)</td>
<td></td>
</tr>
<tr>
<td>1Gbit 4GB RDIMM</td>
<td>• 4.5GB Virtual Machines</td>
<td></td>
<td>256 GB (64 DIMMs)</td>
<td></td>
</tr>
<tr>
<td>50nm Class (1.5v)</td>
<td>• Estimated</td>
<td></td>
<td>56 VMs (+100%)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> with optional memory mezzanine
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The New Thinking of x

5th generation portfolio of IBM innovative technology in enterprise x86 computing.

Expansion of Enterprise X-Architecture to IBM BladeCenter and 2-socket systems.

2X the memory of standard offerings resulting in more workload at lower cost.

Culmination of 10 years and $800M in x86 research and development.

3 systems + 3 innovations

....systems that address your datacenter needs
A portfolio that redefines enterprise x86 computing

**System x3850 X5**

**BladeCenter HX5**

**System x3690 X5**

**MAX5**
- Maximum memory scaling independent of processors

**eXFlash**
- Extreme IOPs
- SSD storage

**FlexNode**
- Scheduled provisioning

- One 4-Socket System
- Two 2-Socket Systems

**IBM** and **BladeCenter®**

[Image of IBM and BladeCenter logos]
MAX5 doubles memory without adding more processors

THE PROBLEM
Industry standard
With embedded memory controllers, memory capacity is tied to processors
✗ More software licenses to purchase
✗ More systems to manage

THE SOLUTION
MAX5
✓ Expand memory capacity without additional CPUs or software licenses
✓ Double the number of memory DIMMs per CPU
✓ 2x memory bandwidth
✓ Maintain full memory performance
✓ 5x the memory capacity in two-sockets vs. today’s leading two-socket systems

Now supporting lower voltage DIMMs and Samsung Green DDR3 32GB RDIMM!
Increased memory performance and capacity

**NEW!** 16GB DIMM support
- 256GB in 2 socket blade
- 640GB in 2 socket + MAX5
- 512GB in 4 socket blade

**NEW!** 1066MHz DIMM speed
- No clock back
- Up from 977MHz

**NEW!** 32GB DIMM support
- 2TB in 4 socket server
- 3TB in 4 socket + MAX5
- 4TB in 8 socket server
- 6TB in 8 socket + MAX5
- Continued 1066MHz support

**NEW!** 32GB DIMM support
- 1TB in 2 socket server
- 2TB in 2 socket + MAX5
- Continued 1066MHz support
MAX5 enables larger, FASTER databases

Have “big data”? Then you also need BIG ANALYTICS
Multiple terabytes of data are useless if you can’t turn them into something useful - QUICKLY
- Answer complex questions
- Glean information from the data

The industry recognizes the “big analytics” challenge…

“(T)he ability to rapidly analyze fresh data from multiple sources, ask creative, complex and iterative questions of that data and get useful answers in a timely fashion are the crux of big analytics, creating new opportunities and giving organizations true competitive advantage.”

Gartner: By 2014, 30% of analytic applications will use in-memory functions to add scale and computational speed

MAX5 is one component that makes eX5 systems the best choice for x86 databases
- 124:1 consolidation, $4M savings for transaction processing workload
- Improves DB throughput by 40% and reduces response time by 88%
- 28% more queries/hour, 39% faster response time for SQL
- 4x more DB transactions, 75% lower cost per transaction with solid DB
28% more queries/hour, 39% faster response time for SQL

**x3850 X5 + MAX5**
4x X7560, 32 cores
1.5TB RAM
5x 320GB SD PCIe adapters
2x 640GB MLC Duo adapters

**x3850 X5**
4x X7560, 32 cores
1TB RAM
5x 320GB SD PCIe adapters
2x 640GB MLC Duo adapters

Increase I/O bandwidth by caching data warehouse in memory using MAX5

154K Queries per hour

120K Queries per hour

Average response time:
57 seconds with MAX5
94 seconds without MAX5

Power Savings
44% less with Samsung Green Memory

IBM's x3850 X5 + MAX5 With Samsungs 32GB RDIMM achieves new World Record TPC-C score

eX5 improves OLTP performance by additional 30%, 66% better than competition’s 2010 score

Samsung’s 32GB Green DDR3 RDIMM

Transactions per minute (tpm-c)

3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0

IBM x3850 X5
Intel Xeon E7-8870 CPU

IBM x3850 X5
Intel Xeon X7560 CPU

Competition

OLTP Throughput

2,308,099
1,807,347
3,014,684

30%
27%

DB2’s TPC-C benchmark was done on an IBM System x x3850 with 4 processors and 32 cores achieving 2,308,099 tpmC at $0.64/tpm (report date 11/16/2010, configuration available 05/20/2011). Full details of the result are available at http://www.tpc.org/results/FDR/TPCC/IBM-x3850X5-DB2-Linux-111610-TPCC-FDR.pdf

Microsoft’s SQL TPC-C benchmark was done on an HP DL580 G7 with 4 processors and 32 cores achieving 1,807,347 tpmC at $0.49/tpm (report date 08/27/2010, configuration available 10/15/2010). Full details of the result are available at http://www.tpc.org/results/FDR/TPCC/Microsoft_SQLServer2008_082710-TPCC-FDR.pdf
MAXIMIZE virtualization efficiency with MAX5

Smaller footprint for mission critical applications

Ready to move beyond virtualization 101? You aren’t alone:

**Gartner:** There will be more virtual machines deployed on servers during 2011 than in 2001 through 2009 combined. 70% of the entire server market will be virtualized by 2014

Publication Date: 29 July 2010/ID Number: G00201551 IBM

Industry experts have noticed that critical workloads are being virtualized... and the importance of MEMORY:

**Gartner:** Database consolidation, through the implementation of server virtualization, can provide considerable costs savings through increased server utilization, the simplification of data center infrastructure, and a reduction in operational costs. Many of the techniques that have been successfully applied in virtualizing non-database environments can be applied in database environments as well. Because databases are characterized by a large memory footprint, high physical I/O, high transaction throughput, a deterministic workload, and a rigorous HA requirement, several key issues that must be addressed when implementing databases in a virtualized environment.

**MAX5 addresses the key issues of virtualization**

- 15% more CPU available for transaction processing
- 28% better SPECvirt throughput
- Advanced memory availability features
- Paired with the Samsung Green DDR3 Technology, reduced power for the memory requirements
MAX5 delivers 28% better virtualization throughput, 24% more VMs

Process more transactions on fewer systems

**x3690 X5 + MAX5**
- 2x X7560, 16 cores
- 1TB RAM
- RHEL 6.0 (KVM)
- **1763** SPECvirt throughput
- **108** virtual machines

**x3690 X5**
- 2x X7560, 16 cores
- 0.5TB RAM
- RHEL 5.5 (KVM)
- **1369** SPECvirt throughput
- **84** virtual machines
IBM System x redefines x86 enterprise server landscape for the next generation datacenter

Clients need solutions that:
• Scale quickly and efficiently
• Remove throughput bottlenecks
• Maximize utilization
• Are optimized for workloads
• Provide rapid access to data
• That are energy efficient as well as resilient

Enterprise X-Architecture
• 5th generation portfolio of IBM industry leading technology
• Expansion of Enterprise X-Architecture to IBM BladeCenter™
• 2x the memory capability of competitive offerings resulting in up to 2/3 software costs

BladeCenter™
• Lowest cost for virtualization on a Blade platform
• Most energy efficient chassis on the planet.
• Only choice for choice in connectivity.
• Most resilient chassis on the planet.
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Data Center Case Study

Data Center “A”
- 25,600 Servers
- 48GB Per Server
- 1.2M GB Total

Current Memory Solution
- DDR2, 60nm, 1Gb, 1.8V

Data Center “B”
- 25,600 Servers
- 48GB Per Server
- 1.2M GB Total

Green DDR3 Solution
- 30nm Class, 4Gb, 1.35V
Data Center Case Study

- Power Consumption

Data Center “A”

Memory Power

22M KW

Data Center Power

174M KW

Cost ($/Year)

$12M

Data Center “B”

3M KW

99M KW

$6.8M

(Source: www.epa.gov)
Data Center Case Study - Cooling

Data Center “A”

Cooling Cost $4M

Data Center “B”

Cooling Cost $2.2M

-45%

(Source: Measured by Samsung Application Engineering Group/Actual measurements of 48GB DDR2 and DDR3 in Server)
Data Center Case Study - Performance

Data Center “A” vs. Data Center “B”

<table>
<thead>
<tr>
<th>Bandwidth (STREAM_Ver5.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>1.95X</td>
</tr>
</tbody>
</table>

(Source: Samsung website / GreenCalculator)
Data Center Case Study - CO₂ Emission

Data Center “A”

- 16K Tons CO₂ (Memory)

Data Center “B”

- 2.2K Tons
- 125.6K Tons CO₂ (Data Center)
- 70K Tons
- 1.4M Ten-year-old Trees

(Source: www.epa.gov)
32M servers in use worldwide...
What if we replaced with Green Memory?

98T WH/year or >$6B Per Year in Energy Costs

Source: IPCC; US Environmental Protection Agency (July, 2010)
Thank You!

Introducing... SAMSUNG Green Memory web site

www.samsung.com/greenmemory

"There's an App for That..."