Holistic Approach to Optimizing Energy Efficient Storage

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Abstract

A holistic approach to optimizing energy efficient data storage

There is no magic bullet to eliminating the gluttonous power appetite of data centers but there are many technologies that are maturing in data storage that when effectively integrated can optimize power efficiency. This presentation looks holistically at the storage technologies that contribute to data center energy efficiencies and how they balance efficiencies with delivering the necessary QoS.

The discussion starts with a heightened awareness for the growing need for environmentally efficient data storage. The discussion will include device level contributions including lower speed drives, smaller form-factor drives, MAID plus MAID variations, moving to capacity optimization techniques such as thin provisioning, compression, data-dupe and SSD for power efficiency and performance. The story continues beyond physical device boundaries to include data classification, consolidation, virtualization, ILM storage, tiering - all techniques and technologies that can drive energy efficiencies and be positioned as integrated and effective solutions to energy efficiency rather than disparate point solutions.
Learning Objectives

✧ **Lesson 1:**
  › Appreciate that implementing energy efficient data storage starts with understanding the nature of the data. Understand the basic device level technologies and features that should be designed into storage solutions to optimize energy efficiency; know what to look for and what questions to ask.

✧ **Lesson 2:**
  › Take a holistic view to understand how different technologies can be integrated to impact environmental savings and to understand that green storage is not just a power measurement but includes the total of the resources consumed by the product from its inception through end of life.

✧ **Lesson 3:**
  › Be aware of the regulatory agenda energy for energy efficiency and the growth and implications of energy efficiency certificates and utility rebate programs.
Presentation Roadmap

- Introduction
  - Setting the stage.
- Framing the problem
  - The energy challenge
  - Why the status quo is not sustainable.
- Today’s green technology options.
  - Data classification (delete key option)
  - Data footprint reduction
  - Storage optimization
  - Green engineering
- Environmental footprint
  - The disposal dilemma
- Energy efficiency – the regulators are coming
- Final thoughts.
  - Solving for tomorrows problems
Introduction

Holistic Approach to Green Storage

Technology:
How do technology choices help?

Energy Choices:
How green are the sources of energy? Are they renewable?

Environmental footprint
What impact does the manufacturing and delivery have on the environment? What about the impact of disposal?
Framing the Problem
Why should we care about energy efficiency?

- According to the EPA’s Final Report to Congress, August 2007 – U.S. data center energy consumption doubled between 2000 and 2006 and was projected to double again by 2011
  - energy required by data centers grew 13% from 2006 to 2007
    - IDC Report, 2008
- IT runs on electricity - 90% of companies running large data centers need to build more power and cooling in the next 30 months.
  - incremental US demand for data center energy between 2007 and 2010 is equivalent to 10 new power plants.
- National average rate for electricity has jumped 44% since 2004 –
  - only 5% of data center managers actually see the utility bill and few if any are held accountable for energy costs
    - Information Week Analytics Report; Jan 2009
- EPA estimates that electronic components contribute 2% to the solid waste in landfills but 40% of the lead.
  - Sustainable manufacturing; disposal and recyclable fees
- The regulators are coming
  - Cap and Trade, Carbon Tax, Tradable Certificates, etc
Feeling the Budget Pinch

Data Center Budget Allocated to Power & Thermal Management

Source: Wikibon.org
Who are the Culprits?

State of the art data centers have driven the facilities losses close to 20%

IT Equipment Directly Consumes 55% of Data Center Energy Budget

Projected 2008 energy consumption – Data collected from Wikibon end user community

Source: Wikibon.org
Efficiency Metrics

- **PUE = Power Usage Effectiveness**
  \[
  \text{PUE} = \frac{\text{Total Energy Demand}}{\text{Useful Energy Demand}} = \frac{(IT + \text{Mechanical Equipment})}{(IT \text{ Equipment Only})}
  \]

- **DCiE = Datacenter Efficiency**
  \[
  \text{DCiE} = \frac{\text{Useful Energy Demand}}{\text{Total Energy Demand}} = \frac{(IT \text{ Equipment Only})}{(IT + \text{Mechanical Equipment})}
  \]

- **Using the Wikibon Data**
  - PUE = 1.8
  - DCiE = 55%

- **State of the Art Data Center**
  - PUE = 1.25
  - DCiE = 80%
The Blame Pie (Storage Equipment)
Projected 2008 Energy Consumption ($) by Component

- Disk: 80%
- Logic: 10%
- Ports: 4%
- Internal Switching: 2%
- Cache: 1%
- Other (e.g. Svc. Proc.): 3%

Source: Wikibon.org
Explosive Growth – why the status quo is not sustainable

- Growth Factors
  - Internet, e-business, digital media
  - Increasing OLTP
  - Accretive nature of data

- Sustainability Factors
  - Data or use patterns are not homogeneous and drive different storage needs
  - Worthless data has no value only cost and liability

* IDC: The Diverse and Exploding Digital Universe March 2008.*

Data volume is projected to grow by 5.7x between 2007 and 2011 (Exabyte's)

2007: 281
2011: 1,610

* IDC: The Diverse and Exploding Digital Universe March 2008.*
“Green” Innovation

- Data Classification (delete key option)
- Data Footprint Reduction
- Storage Optimization
- Green Engineering
  - Architecture
  - Device Level
  - Removable Media
  - Supporting Ecosystem
  - eWaste
Basic Approach to Data Classification

Transaction Data - this is the traditional view that has molded today's disk storage architecture.

Tends to be data that is being captured or created - highly dynamic - drives high IOPS - random in nature - short shelf life.

Reasons why traditional transaction designs are read-write-modify access model, optimized for "at all times access", cacheable demonstrating temporal and spatial locality, optimized to small grain data.

Persistent Data - data that once created is rarely accessed or modified, does not demand the same response time, tends to have lower IOPS requirements and low temporal access locality, meaning caching is a wasted expense.

Tends to have long term retention requirements, is bandwidth centric and has high data integrity concerns.

Event driven, immutable, reference content is the fastest growing segment of today's enterprise digital footprint.
Matching data needs with storage attributes

Tier 1
- Enterprise disk
- Mission Critical, Transactional Storage

Tier 2
- Modular Array’s
- Repurposed Transactional Storage
- Business critical – Active Archive

Tier 3
- Low-Cost SATA
- Object-Based Storage
- On-line Archive

Tier 4
- Near-online Tape and Optical
- Back-up/recovery

Tier 5
- Off-site Vaulting
- Deep Archive
- Disaster Recovery, Off-Site Data

Intelligent Data Mobility (ILM/HSM)

Transactional data

Persistent data

Deep archive vaulted data
Data Footprint Reduction

- Techniques that take advantage of the fact that data has statistical redundancy
- Compression
  - 2:1 reduction ratio is a good planning number but, it depends!
  - Primary vs. secondary
  - Lossy vs. lossless
  - Compression before encryption
- Data-De-duplication
  - File and block level
  - Replaces duplicate data with pointers to a single shared copy
  - Data reduction – it depends!
- Software vs. Hardware
Storage Optimization

- **Storage Virtualization**
  - Inserts an intelligent layer that abstracts multiple physical storage devices into a single logical storage pool.
    - Flexibility, simplified provisioning, non-disruptive data migrations
    - Block virtualization optimizes block storage devices
    - File virtualization optimizes file-based storage devices

- **Consolidation**
  - Increase utilization

- **Virtual Clone**
  - Space efficiency – minimize PIT copies

- **Thin Provisioning**
  - Avoids over provisioning
  - Resizable volumes
The Effects of Full Block Virtualization, Thin Provisioning & Virtual Copy/Clone on Storage Capacity: Analysis of Data from One Storage Vendor

50% of customers achieved additional capacity benefits of 150% or more from Full Block Virtualization, Thin Provisioning and Virtual Copy/Clone. This means they would have had to install 2.5 times the storage capacity with traditional storage arrays to achieve the same allocated space.

Source: Wikibon 2008
Clusters vs. Monolithic

- Monolithic or Scale-Up - the traditional approach where storage sits behind one or two controllers/servers heads. Standard practice is to buy for future requirements.

- Clustered or Scale-Out - the flexibility to independently scale bandwidth, processing and capacity, non-disruptively and on the fly. Easiest architecture for the incremental introduction of new technologies
Green Engineering

- Component Level
  - Drives;
    - Green, Form factor
  - Power supplies;
  - Variable speed fans,
  - Cache battery options
    (super capacitor + flash)
- Dense Packaging
  - Vibration
    - rigidity and placement
  - Optimize TB/sq ft
- Power Management
  - Policy management
- SSD
  - 1TB stored on SSD consumes 35% to 40% less energy than one 15K drive
  - One SSD can deliver the same performance as approximately 30, 15k drives - a 98% energy savings
    (however beware, as mileage will vary)
Green Drives

- Green drives focus is on energy conservation rather than performance
  - IOPS range from approximately 50 to 180
  - Latency ranges from 5.5ms to 2ms
  - Bandwidth from 50 to 100+ Mb/s

Green features
- Uses less power - Efficiency ranges from 32 to 535 TB/W
- Recyclable components
- Supports spin down or head parking features

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<th>Idle Power Watts</th>
<th>Active Power Watts</th>
<th>Average Power Efficiency GB/watt</th>
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Smaller Form Factor Disk Drives

- **Drive Capacity**
  - 2.5” FF now at 500GB (1TB by 2010)

- **Volumetric Efficiency**
  - 3.7x to 5.8x space utilization advantage

- **Volumetric Density**
  - 1.88 to 2.9 volumetric storage advantage

- **Energy Efficiency**
  - It depends – “consumer” vs. “enterprise” class

- **Double IOPS**

- **Cost is still not there**
Zero Drive Maintenance

- **Fail-in-Place**
  - Sealed storage container
    > greater degrees of design freedom counter vibration and cooling issues
  - Drive population includes operational as well as spare capacity
    > anticipated spare capacity to meet service the life expectations
    > Eliminates hot spare tending
  - Autonomic preventative maintenance
    > Isolation of failed drives
    > Rehabilitation or elimination process

- **Recover usable capacity**
  - Partial capacity drives reintroduced into the storage pool

- **Ongoing spare capacity monitoring**
  - Predicting life of storage container at full capacity
Native MAID

- A storage system that powers down drives individually or in groups when not required.
- Original definition (Univ. of Colorado) specifies that no more than 50% of the maximum installable drives could spin concurrently. Power provisioning advantage (CapEx)
- Very dense packaging
- Power completely removed from drive
- Energy savings claim of up to 85% (OpEx)

Soft MAID

- Drives are spun down but remain “hot”
- Basic implementation is to simply park the actuator
- Reduce energy consumption from 15% to 60% (OpEx)
- However, no data center power provisioning advantage (CapEx)

Drives at reduced speed

- 7200rpm drives spun at 4000 rpm
- Energy savings approximately 20%
Removable media solutions are the most energy efficient – zero energy consumption when on a shelf

- **Tape**
  - Recovery and deep archive

- **Removable disk**
  - The benefits of tape but can deliver the random performance of disk

- **Optical**
  - Blu-ray - not enterprise class
  - Holographic - the future technology that some contend always will be.
“Original Rule of Thumb” - For every kWh consumed by IT equipment a second kWh is consumed by the cooling infrastructure.

- **Vertical Cooling**
  - Cooling at the rack level

- **Sealed Storage Cooling**
  - Cooling at the device level
Innovative “air flow” cooling concepts

Vertical Cooling Technology

Traditional Front to Back Air Flow

Top to Bottom Air Flow

Physical Layout Options To Optimize Storage Shelf Cooling

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eWaste & Sustainable Manufacturing

- **eWaste**
  - electronics in the landfill
    - EPA estimated 2.6M tons of ewaste in 2005 with only 12.5% recycled
    - 133,000 personal computers are discarded daily in the US
  - 3 Billion units will be scrapped this decade

- **RoHS (EU)**
  - Control of hazardous substances

- **WEEE (EU)**
  - imposes the responsibility for disposal of eWaste on the manufacturer
  - US states enacting similar legislation California and Maine have recycling fees

- **Sustainable Manufacturing**
  - use of sustainable components

Source: Garner; International Association of Recyclers
eWaste - Green Packaging Strategy

- Sustainability initiatives reach beyond the technology
- Reusable and increasing sustainable content
  - Elimination of packaging material
  - 2,000,000 recycled milk jugs (HDPE) into protective cushioning
  - Increase % of curbside recyclable materials
- Reduction of 10,000,000 lbs of packaging is equivalent to 150,000 trees – a 2007 vendor achievement

"Excessive packaging is among the most solvable challenges today. Changing packaging paradigm presents an opportunity to increase business and brand value through sustainable innovation, resulting in positive environmental benefits"

Adam Werbach; CEO Saatchi & Saatchi
The Regulators are Coming!

- Background
- Certificates and Rebates
- State Portfolio Standards
Background - a 50,000ft discussion

- Cap and Trade
- Clean Air Act Amendments 1990
- Kyoto Agreement 1997
- Regulation
  - State Level EE Portfolio Standards
  - Certificates & rebates
- Energy generation equates to CO2 emissions
  - “coal power” - generating 1kWh creates 1.725 lb CO2 and 0.00412lb Sulfur Dioxide SO2 – numbers will vary depending on fuel

<table>
<thead>
<tr>
<th>Equipment</th>
<th>CO2 Produced</th>
<th>Trees Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop</td>
<td>1,500 lb</td>
<td>500+ Trees</td>
</tr>
<tr>
<td>Rack of Blade Servers</td>
<td>31,085 lb</td>
<td>2000 to 10,000+ Trees</td>
</tr>
</tbody>
</table>

Equipment powered on 7x24x365. A look at the amount of CO2 produced to generate the power and equivalence in trees to absorb the CO2.
Certificates and Rebates

☀ REC – Green Tags
  ♦ Renewable Energy Certificates – represent electricity generated from a renewable energy facility
  ♦ Purchases mandated by State Renewable Portfolio standards
  ♦ Retail electricity suppliers must meet a percentage of sales in REC’s

☀ Utility Rebates
  ♦ New construction/acquisition
  ♦ Equipment replacement

☀ EEC – White Tags
  ♦ Energy Efficiency Certificates- represents the value of energy conserved
  ♦ Created through the implementation of energy conservation projects
    ↳ Equipment upgrades/replacements/new technologies
    ↳ Operational changes
    ↳ Energy management
Renewable Portfolio Standards (RPS)

- Standards specifying the % of electricity to be generated from renewable sources
- REC purchases mandated by RPS
- Some aggressive state requirements
  - CA 33% by 2020
  - NV 15% by 2013
  - ME 30% by 2000
  - NY 24% by 2013
  - RI 16% by 2019
  - MT 15% by 2016

Source: The Pew Center on Global Climate Change
California Green Solutions
Final thoughts
Final Thoughts

- Green strategies do not necessarily mean additional cost.
  - There are rebates to be had – push your vendors
  - Beware vendors green messaging – tends to be somewhat self serving
  - All wind powered data center (managed services) successfully competing

- Develop a green mentality – good corporate stewardship and readiness for likely legislation.

- In a recent survey 67% of 419 respondents stated that their company does not (or they did not know) have an ewaste policy - do not let ewaste legislation creep up on you

- There is no “Green IT” magic bullet - view the challenge holistically and plan accordingly.
“Certainly, there are environmental reasons for going green, but a green focus can also result in significant savings”

eWEEK.com
Please send any questions or comments on this presentation to SNIA: trackgreenstorage@snia.org

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