Data Centre Server Efficiency Metric - A Simplified Effective Approach

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Agenda

- The Elephant in your Data Center
- Calculating Server Utilization Effectiveness (SUE)
- Using SUE to manage Server Refresh
- Looking Ahead
The Elephant in your Data Center
The Elephant in the Data Center

- The Data Center is an Information Factory
- It uses energy to process information
- Energy is used by the IT equipment & the factory
- ... but how efficient is the equipment?
Spotting the Elephant

- How **efficient** is my data center?

Inefficient IT equipment can be the Elephant in your Data Center
PUE is Part A of the Answer

• PUE* measures the efficiency of data center infrastructure (UPS, CRACs, etc.)

\[
PUE = \frac{\text{Energy Consumed by the Data Center}}{\text{Energy Consumed by IT equipment}} = \frac{\text{IT Energy + nonIT Energy}}{\text{IT Energy}}
\]

Efficient Data Center Energy Usage (PUE)

* PUE: Power Usage Effectiveness
SUE is Part B of the Answer

- SUE measures the Effectiveness of Data Center Performance (Work Output)
- Uses “Moore’s Law” as a proxy for performance metrics & efficiency
- SUE is a ratio of ACTUAL to IDEAL

\[
\text{Current Performance} \approx \sum_{\text{servers}} 0.707^{\text{Age}} \\
\text{Ideal Performance} \approx \sum_{\text{servers}} 0.707^{\text{Age}=0} = N_{\text{servers}}
\]
SUE: Server Utilization Effectiveness

- Formula balances ease of use and precision
  - Not a substitute for actual measure of business metrics
- Consistent with the Green Grid PUE metric
  - \((1.0 = \text{ideal}, \text{larger number worse})\)
- Simple to calculate
- Results are actionable and interpretable

\[
SUE = \frac{N}{\sum_{\text{Servers}} 0.707^{\text{Age}}}
\]

Higher SUE (less effective) is using more Servers to deliver the same work output
SUE Tracks Actual Benchmark Results

- All data from SPEC.ORG published performance results of 2S systems
- Dashed curve is an average of 5 benchmarks

\[
\text{SUE} = \frac{1}{0.707^{\text{AGE}}}
\]

SUE is Easy & Accurate metric of compute efficiency

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark* and MobileMark*, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. Configurations: [describe basic config]. For full configuration information, please see backup. For more information go to [http://www.intel.com/performance](http://www.intel.com/performance)
Practical Example

**Age Distribution**
- 64%
- 32%
- 4%

**Energy Consumption**
- 60%
- 35%
- 5%

**Performance Capability**
- 93%
- 4%
- 3%

*Older Server population consumed 60% of the energy, delivered only 4% Relative Performance Capability*

Data collected in 2011 at a Fortune 100 company;
courtesy of William Carter & John Kuzma Intel
Calculating Server Utilization Effectiveness (SUE)
Calculating SUE of the IT Inventory

<table>
<thead>
<tr>
<th>Purchase Timeframe</th>
<th>Age</th>
<th>$0.707^{Age}$</th>
<th>Population</th>
<th>$\Sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0</td>
<td>1.0</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>2010</td>
<td>1</td>
<td>0.71</td>
<td>200</td>
<td>142</td>
</tr>
<tr>
<td>2009</td>
<td>2</td>
<td>0.50</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>0.35</td>
<td>200</td>
<td>70</td>
</tr>
<tr>
<td>2007</td>
<td>4</td>
<td>0.25</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td><strong>$N_{\text{servers}}$</strong></td>
<td></td>
<td></td>
<td><strong>1000</strong></td>
<td><strong>562</strong></td>
</tr>
</tbody>
</table>

\[
SUE = \frac{\sum_{\text{servers}} N_{\text{Servers}}}{\sum_{\text{servers}} 0.707^{\text{Age}}} = \frac{1000}{562} = 1.78
\]

Actual : Ideal Ratio of Capability is 1.78
To understand how many NEW servers are required to replace old servers, set SUE = 1, and solve for N

\[ N_{\text{New Servers}} \approx \sum \text{Servers to be replaced} \times 0.707^{\text{Age}} \]

Back to our example:

<table>
<thead>
<tr>
<th>Purchase Timeframe</th>
<th>Age</th>
<th>$0.707^{\text{Age}}$</th>
<th>Servers to be replaced</th>
<th>New Servers Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>2011</td>
<td>1</td>
<td>0.71</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>2</td>
<td>0.5</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>2009</td>
<td>3</td>
<td>0.35</td>
<td>200</td>
<td>70</td>
</tr>
<tr>
<td>2008</td>
<td>4</td>
<td>0.25</td>
<td>200</td>
<td>50</td>
</tr>
</tbody>
</table>
## Applying SUE to the IT Inventory

To understand how many NEW servers are required to replace old servers, set $SUE = 1$, and solve for $N$

$$SUE = \frac{N_{Servers}}{\sum_{Servers} 0.707^{Age}}$$

<table>
<thead>
<tr>
<th>Purchase Timeframe</th>
<th>Age</th>
<th>$0.707^{Age}$</th>
<th>Baseline Population</th>
<th>Refreshed Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>0</td>
<td>1</td>
<td>200 (200)</td>
<td>420 (420)</td>
</tr>
<tr>
<td>2011</td>
<td>1</td>
<td>0.71</td>
<td>200 (142)</td>
<td>200 (142)</td>
</tr>
<tr>
<td>2010</td>
<td>2</td>
<td>0.5</td>
<td>200 (100)</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>3</td>
<td>0.35</td>
<td>200 (70)</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>4</td>
<td>0.25</td>
<td>200 (50)</td>
<td>0</td>
</tr>
<tr>
<td>$N_{servers}$</td>
<td></td>
<td></td>
<td>1000 (562)</td>
<td>620 (562)</td>
</tr>
<tr>
<td><strong>SUE</strong></td>
<td></td>
<td></td>
<td><strong>1.78</strong></td>
<td><strong>1.10</strong></td>
</tr>
</tbody>
</table>

SUE calculation shows ability to reduce this IT population by **38%**
Total Efficiency* is a function of the efficiency of Servers (SUE) in transforming energy into processed information, AND the efficiency of the infrastructure (PUE) to delivery the energy and remove the heat byproduct.

\[
\text{Overall Efficiency} = f(\text{PartA, PartB}) = SUE \times PUE
\]

* Efficiency through provisioning does not include utilization
Using SUE to Manage Refresh
# Using SUE in Project Comparisons

<table>
<thead>
<tr>
<th>Current Facility</th>
<th>Scenario - Improve PUE</th>
<th>Scenario - Improve SUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing DC with 500KW critical load. Raised Floor area utilizes hot and cold aisle layout, perimeter CRAC units</td>
<td>Facility upgrade with added air containment, ducting, VFD air movers &amp; instrumentation</td>
<td>Same as Current</td>
</tr>
<tr>
<td>1000 Servers, 0 to 8 yrs old, Avg age of equipment is 4 yrs old</td>
<td>1000 Servers, 0 to 8 yrs old, Avg age of equipment is 4 yrs old</td>
<td>50 new servers @ $8,000 ea;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PUE</th>
<th>SUE</th>
<th>PUE x SUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>1.6</td>
<td>2.5</td>
<td>4.25</td>
</tr>
<tr>
<td>1.8</td>
<td>1.78</td>
<td>3.2</td>
</tr>
</tbody>
</table>

- **Baseline**
  - 11% Energy Reduction ($88K annual savings) ($2M investment)
  - 29% Energy Reduction ($144K net cost in YR 1 and $80K savings annually)

SUE provides data driven investment decisions; Compares Infrastructure & IT improvements

**Assumptions:**
- $2M project cost is not based on actual project costs
- Energy calculations assumed $0.10 KW-Hr
- Energy reduction estimates based on qty of servers
- 8yr to 5 yr policy change requires 22 add’l servers in yr 2-5
Using SUE to Project IT Efficiency

- March 2010: 7272 servers, SUE at 2.1, & IT growth of 45% projected
- Refresh accelerated with removal of systems > 5 yrs old
- UPS load decreases, extends UPS capacity through 2014

SUE calculation projects the required refresh and server population necessary to meet demand
Using SUE for Refresh Policy Comparisons

Impact of One Year Policy Change
- $4.2M CapEx avoidance
- $90K OpEx savings
- 12% less
  - floor space
  - Servers
  - Racks
  - NW routers

Assumptions:
Baseline is 7500 Servers following a 5 year refresh policy
$14/watt for new construction, 2.0 PUE, $.08 KW-hr, 6% interest on capital, 10 yr facility amortization, 6 yr network equip amortization, $3500/server avg. purchase price, 285 watts avg. energy per server, 30sq ft per rack, server population normalized based on SUE calculation.
Looking Ahead
SUE and benchmark correlation error is higher for shorter periods that span new processor & technology introductions:

SUE change over 8 months is $= \frac{1}{0.707^{0.66}} = 1.26$

Avg. Benchmark change between Apr’11 and Dec’11 = 1.73

SUE is best used for longer term trends
**SUE a look ahead ....**

\[ SUE \equiv \frac{Ideal \ Server \ Performance}{Actual \ Server \ Performance} \]

<table>
<thead>
<tr>
<th>Maturity Levels</th>
<th>Performance Measure</th>
<th>Investment</th>
<th>Requires</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance Measure</strong></td>
<td>Moore’s Law proxy</td>
<td>Benchmark Data</td>
<td>Productivity Proxy</td>
<td>Actual Workload</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td>A few hours</td>
<td>Days</td>
<td>Weeks</td>
<td>Months to years</td>
</tr>
<tr>
<td><strong>Requires</strong></td>
<td>Server Inventory</td>
<td>Server Performance</td>
<td>Specialized Software</td>
<td>Software development</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Simplified assessment</td>
<td>Config &amp; BM dependent</td>
<td>Very accurate assessment</td>
<td>Most accurate assessment</td>
</tr>
</tbody>
</table>

*Increasing Efforts will Improve Accuracy*
Wrap Up

• The Modern Data Center is an Information Factory
• The infrastructure and IT Equipment affect Efficiency
• SUE recognizes Moore’s Law as a proxy for performance metrics in the absence of your own business metrics
• Formula balances ease of use and precision
• SUE is a ratio of ACTUAL to IDEAL performance; no Units

• Overall Efficiency = \( f (\text{PartA, PartB}) = \text{SUE} \times \text{PUE} \)

What’s YOUR Number?
Thank You

Henry.L.Wong@intel.com
Q&A
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