Optimizing the Cloud Infrastructure: Tool Design and a Case Study

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IBM Software
Problem

With cloud computing:

- Workloads move at the click of a mouse
- Capacity can change dynamically
- Resources can cloudburst to a public cloud

Cloud tenants want to understand and optimize performance of the services being delivered

Cloud provider needs to understand workload usage characteristics, policies, and optimize the infrastructure use across tenants.
Use Cases

- **Consolidation**
  - Consolidate the workloads on minimum set of resources to either re-purpose or power-down additional hardware or reduce software license costs or add more workloads.

- **Bottleneck removal**
  - Spread incompatible workloads across clusters and remove a resource bottleneck in a cluster.

- **Growth planning**
  - What-if analysis by adding new workloads, projecting usage of existing workloads
  - Experiment with new hardware, cluster reorganizations

- **Policy compliance**
  - Ensure that the environment is in compliance with business policies and technical best practices.
Benefits

- **Cost reduction**
  - Consolidation may help to reduce hardware, labor, and other costs associated with hardware.
  - Software consolidation may reduce license cost.
  - The increase in VM density may also increase Cloud ROI

- **Risk reduction**
  - The analysis can determine which resources are overloaded and how close we are to the resource limits of the physical infrastructure.
  - One can determine if there have been any significant changes in the environment recently or identify trends to predict bottlenecks or free space and balance workloads.
  - One can ensure that the resource supply can meet the demand to avoid any performance risk.
  - The technical and business policies are checked to reduce risk.

- **Plan for the future**
  - The what-if capabilities enable users to size workloads based on usage and best practices, project to future demand levels, experiment with over-commit levels, and generate optimization plans for the future environment.
Assures that health of cloud environment meets customer needs (reduces MTTR, lower operations cost, etc)

Helps to consolidate and reduce IT footprint (reduces TCO, optimizes resource usage, etc)
Planning Tool

- Benchmarking data
- Business and Technical policies

Optimization Engine to size and place VMs

Plan Recommendation (minimize systems, license, balance)

Usage profiles, workload relationships

Workload Characterization
- Establish patterns using historical data
- Capture workload attributes to enable optimization policies

Custom Tags enhance Config Profiles and workload relationships

Data Mart

Copy, Federate

Hypervisors
Storage
Network
Servers
Platforms
PlanningCenter – Steps 1-2

1. Load the latest configuration data for what-if changes

2. Set the time period to analyze measurement data in Warehouse
PlanningCenter – Step 3

1. Click opens a new tab

2. Choose servers in Austin Prod to analyze

3. Optionally add new attributes to be used in analysis, e.g. for defining policies

Create custom column views, sort, filter by any attribute. Edit/clean data.
PlanningCenter – Step 4

1. Auto-sized VMs

2. Advanced option: Get into expert mode to create custom usage profile of VMs, e.g. based on peak periods.

3. Apply growth profile

Can also specify a time limit to trend usage data.
PlanningCenter – Step 5

### Generate Optimization Plan

- Generate Plan
- Recommendation Topology
- Recommendation Report

#### Capacity Planner Optimized Environment Plan

**Report As Of:** Oct 3, 2011 4:49:22 PM

<table>
<thead>
<tr>
<th>Physical Servers</th>
<th>Current</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU (GHz)</td>
<td>132.42</td>
<td>74.30</td>
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<tr>
<td>Memory (GB)</td>
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<tr>
<td>Total Capacity</td>
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<tr>
<td>Total Reservation</td>
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<td>Total Unused Capacity</td>
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<tr>
<td>Capacity Efficiency Index</td>
<td>95.12</td>
<td>91.78</td>
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</table>

**Data Center:** Austin

#### CPU Details (GHz)

- Expected Utilization Before Optimization
- Expected Utilization After Optimization
- Total Capacity
- Headroom
- Unused Capacity

#### Memory Details (GB)

- Expected Utilization Before Optimization
- Expected Utilization After Optimization
- Total Capacity
- Headroom
- Unused Capacity

Accommodated growth and consolidated further

Growth in Austin Prod
Co-location or anti-colocation: Help to specify how workloads running in VMs can be put together or separated on hosts, clusters, data centers. For example, Windows VMs should be collocated for memory sharing and license cost reduction as a technical best practice. Competitive customer VMs in a shared Cloud may be anti-colocated at host level as a business policy.

Sizing: Help to determine sizing of VMs running specific types of workloads based on usage and other attributes. For example, there may be a best practice recommendation of sizing WebSphere VMs based on version, number of users and expected transactions per sec it needs to support.

Overhead: Helps to specify headroom for platforms based on various attributes.

Scaling: Helps to automatically create new VMs to scale out an application during what-if simulations using various usage attributes.
Case Study Scenario 1: ROI for Increasing VM Density

- An IBM Internal Dev/Test Cloud with multiple geographically distributed Data Centers, consisting of multiple clusters.
- Scenario 1 considers VMWare ESX Cluster in Raleigh with 18 hosts, 1802 VMs
- Cloud admins carefully optimize the placement and allocations but no usage-driven optimization
- Cloud admins have ROI methodology to track how they are utilizing their physical resources
- We applied SCM Planning tool to determine how to increase the VM density or re-purpose hardware

Studied 3 months usage data to understand how geographically distributed users are using the VMs, is there any temporal behavior, which VMs are inactive etc.

20% VMs are inactive

<table>
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<th>Physical Servers</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Virtual Machines</td>
<td>1,802</td>
<td>1,426</td>
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<td>CPU (GHz) Memory (GB)</td>
<td>1,124.30 4,607.96</td>
<td>1,124.30 4,607.96</td>
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<td>Total Reservation</td>
<td>58.74</td>
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<tr>
<td>Total Unused Capacity (excluding headroom)</td>
<td>959.37 4,119.30</td>
<td>396.62 763.57</td>
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<tr>
<td>Capacity Efficiency Index</td>
<td>89.40</td>
<td>35.28</td>
</tr>
</tbody>
</table>

Memory is the bottleneck. Given various hypervisor level memory optimization techniques and complementary usage behavior, one can aggressively over-commit memory.

10% CPU headroom, 10% memory over-commit
ROI for consolidation in Scenario 1

### ROI Method: Increase VM density

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost / Year (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>12,900.00</td>
</tr>
<tr>
<td>Average VM Cost</td>
<td>1,500.00</td>
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<tr>
<td>Administration Cost / Server</td>
<td>20,000.00</td>
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<tr>
<td>Administration Cost / VM</td>
<td>228.00</td>
</tr>
<tr>
<td>Energy Cost / Server</td>
<td>730.00</td>
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<tr>
<td>Energy Cost / VM</td>
<td>9.00</td>
</tr>
<tr>
<td>Floor Space</td>
<td>125.00</td>
</tr>
<tr>
<td>Virtualization License</td>
<td>4740.00</td>
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<tr>
<td>Storage and Management Systems</td>
<td>500,000.00</td>
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**ROI with different What-ifs**

- ROI of Current Environment: $2,152,500.00
- ROI of more Optimized Environment with no Memory headroom: $2,332,000.00
- ROI of more Optimized Environment with 10% Memory over commit: $2,491,500.00

### ROI Method: Reduce hosts

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Current Environment (16 Servers, 1 Year, USD)</th>
<th>Optimized Environment, No memory headroom/over-commit (17 Servers, 1 Year, USD)</th>
<th>Optimized Environment, 10% memory over-commit (16 Servers, 1 Year, USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server Cost</td>
<td>232,200.00</td>
<td>219,300.00</td>
<td>206,400.00</td>
</tr>
<tr>
<td>Storage and Management Systems</td>
<td>500,000.00</td>
<td>500,000.00</td>
<td>500,000.00</td>
</tr>
<tr>
<td>Administrator / Support</td>
<td>360,000.00</td>
<td>340,000.00</td>
<td>320,000.00</td>
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<tr>
<td>Energy</td>
<td>13,140.00</td>
<td>12,410.00</td>
<td>11,660.00</td>
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<tr>
<td>Floor Space</td>
<td>2,260.00</td>
<td>2,125.00</td>
<td>2,000.00</td>
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<tr>
<td>Virtualization License</td>
<td>89,320.00</td>
<td>80,590.00</td>
<td>75,840</td>
</tr>
<tr>
<td>Total</td>
<td>1,192,910.00</td>
<td>1,154,415.00</td>
<td>1,115,920.00</td>
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<tr>
<td>Savings</td>
<td>38,495.00</td>
<td></td>
<td>76,990.00</td>
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</table>

**ROI of Current Environment (1435 active VMs, 1 Year)**
- USD 2,152.5K or 80.4%

**ROI of Optimized Environment, no memory headroom/over-commit (1548 VMs, 1 Year)**
- USD 2,332K or 94.6% (i.e. additional 14.2%)

**ROI of Optimized Environment, 10% memory over-commit (1661 VMs, 1 Year)**
- USD 2,491.5K or 108.8% (i.e. additional 28.4%)
Scenario 2: Cross-cluster optimization

Austin Cluster:
18 hosts, 1339 VMs (1266 active)

890MHz, 2GB VMs
Need 5 more servers for 362 VMs

Pick a cluster in scope to optimize
Scenario 2: Cross-cluster optimization

Pune Cluster: 9 hosts, 159 VMs (149 active)

120MHz, 3GB VMs
Expecting ~640 more VMs
Reserve 4 hosts

Fits all workloads without getting new servers and leaves 2 spare
ROI = Capital avoidance of 5 Austin cluster servers

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<td>Virtual Machines</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>159</td>
<td>419</td>
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<tr>
<td>Total Capacity (GHz)</td>
<td>430.66</td>
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<tr>
<td>Total Reservation</td>
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<tr>
<td>Total Unused Capacity</td>
<td>411.31</td>
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<tr>
<td>(excluding headroom)</td>
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</tr>
<tr>
<td>Capacity Efficiency Index</td>
<td>97.76</td>
<td>73.60</td>
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</tbody>
</table>

VMware VI Resources Needed for Additional Workloads on Clusters

Reserve 4 hosts
Spare 7 hosts
Fits all workloads without getting new servers and leaves 2 spare
ROI = Capital avoidance of 5 Austin cluster servers
Summary

- Capacity management in virtual environments
  - Consolidation to reduce cost
  - Reduce risk
  - Plan for growth

- 5 step easy to use planning tool
  - Can be driven through UI for what-if analysis or scripted through APIs

- Applied in IBM internal dev/test cloud
  - Inter and cross-cluster optimization scenarios
  - Applied what-if on various overhead and over-commit policies
  - Demonstrated ROI by increasing VM density further or through capital avoidance