CSPE: Cloud Storage Provisioning Decided by Rate of Return and Workload Characteristics

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Motivation
The work introduce a Cloud Storage Provisioning Engine (CSPE) to help users rationally evaluate the benefit of purchasing new disk drives and leasing from remote servers offered by Infrastructure as a service (IaaS) providers. The contributions of CSPE are as follows:
- CSPE evaluates the future storage demand by tracing previous data increment tendency, which is completely customer-made for growth-oriented enterprises.
- CSPE uses the widely-used Internal Rate of Return (IRR) in economics to solve "purchase or not" problem with regard to storage provisioning.
- In regular services stage, we optimize our engine from workload utilization perspective to further complete workload provisioning for the purpose of cost saving.

CSPE Decision Model

<table>
<thead>
<tr>
<th>Notations</th>
<th>Description</th>
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<tbody>
<tr>
<td>C₀</td>
<td>Initial disk drive investment</td>
</tr>
<tr>
<td>Cᵢ</td>
<td>Disk drive investment</td>
</tr>
<tr>
<td>r</td>
<td>Discount rate</td>
</tr>
<tr>
<td>t</td>
<td>Time period (years)</td>
</tr>
<tr>
<td>n</td>
<td>The life cycle of this project (years)</td>
</tr>
</tbody>
</table>

The internal rate of return makes the net present value (NPV) of all cash flows (both positive and negative) from a particular investment equal to zero. The simplified standard NPV equation is shown in Eq (1):

\[
NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}
\]

We can infer that IRR of purchasing new disk drives is given in Eq (2):

\[
NPV_p = \sum_{t=0}^{n} \frac{C_t}{(1+IRR_p)^t}
\]

Similarly the IRR of leasing over the clouds in the right of Eq (3):

\[
NPV_l = \sum_{t=0}^{n} \frac{C_t}{(1+IRR_l)^t}
\]

Using secant method Eq (4), we get IRRᵢ and IRRᵢ respectively, then we could calculate IRR using the equations of next page:

\[
r_{n+1} = (1 + r_{n})\left(\frac{1 + r_{n-1}}{1 + r_{n}}\right)^{p} - 1
\]

\[
\Delta IRR = IRR_p - IRR_l
\]

System Framework of CSPE

CSPE Working Flow

- Firstly, we employ Trace Engine to predict next future years' demand by analyzing previous records of increasing storage in local datacenter, and transport the predicted results to the IRR Module.
- Then, we bring in Internal Rate of Return (IRR) Models to measure and compare the profitability of investments in order to help decide whether companies should purchase new disk drives or lease remote cloud computing service. However, merely a solution to "to purchase or not" problem is not enough for practical applications.
- Lastly, we come up with a module called Burstiness Filter to identify those bursty workloads and then migrate them to the cloud storage service providers for the benefits of cost savings and risks. Because a bursty (i.e. high peak average utilization ratio) workload actually causes a less dense workload placement possible on the server and hence much lower average server utilization, which renders in deployment of more resources and higher cost.

CSPE Model Characterization and Preliminary Evaluation

- The evaluation shows the approximate \( \Delta IRR \) trend in recent 10 years.
- IRR of leasing over the clouds exceeds that of purchasing new disk drives and human capital for operation and monitoring.
- For the large size enterprises with a datacenter of thousands servers, the investment of purchasing new devices becomes more profitable after 8 years, especially for those far-sighted enterprises with servers of long expectancy.

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