Oracle Database Capacity Planning

How to Scientifically start doing Capacity Planning for an Oracle Database
About Me

- 8 years of experience in Oracle Database Performance Optimization and IT Services/Infrastructure Capacity Planning.
- Certified Oracle DBA – OCP 9i, 10g, 11g, RAC Expert
- Other Certifications – ISO/20000 Certified Auditor, ITIL Practitioner V3, Base SAS
- Currently working with Barclays Bank PLC as a Capacity Manager
- When time allows I blog at http://neerajbhatia.wordpress.com/
What is Capacity Planning

“Capacity Planning is the process of predicting when future load levels will saturate the system and determining the most cost-effecting way of delaying system saturation as much as possible”

- by Daniel A. Menasce and Virgilio A.F. Almeida
(Authors of Capacity Planning for Web Services: Metrics, Models & Methods)
Systematic Approach to Capacity Planning

1. State Goals
2. Define the System Configuration
3. List Database Services
4. Identify Right Metrics
5. Collect Data
6. Analyze and Model Data
7. Interpret the Data and Results
8. Present Results
Identifying Application Metrics

Users of Business Services

Business Transactions
(ATM Cash withdrawal etc)

IT Service
(ATM Service)

IT Service Components
(Application server, Database Application)

IT Infrastructure
(Server, Network components etc)

- Talk with Business and application teams to identify good set of metrics by which growth and workload of business is measured.

- Examples – Total ATM transactions, Active Users, total login on an online bookstore etc

- Underlying Database workload metrics – transactions/sec, user calls/sec etc

- CPU Utilization, Memory Utilization
"I have seen the future and it is very much like the present, only longer."
--Kehlog Albran, The Profit

This philosophy is actually a concise description of statistical forecasting. We search for statistical properties of a time series that are constant in time - trends, seasonal patterns, correlations etc. We then predict that these properties will also describe the future.
Data History, History, History!!!

- The precision of forecasted results lies in quantity of historical data; longer the data more the chances of precise results.

- In small shops AWR schema is the best place to keep the data. Big enterprises generally upload the data to CMIS.

- Data retention value should be large enough to keep seasonal trend, periodic activities. Retention value of 13 months is recommended in most of the cases.

Other data in CMIS

- Database metrics pertaining to Capacity and Performance from AWR Schema and v$sysstat etc
- Business Metrics
- Future Business Demand
- Resource Utilization Data
- Capacity Plans and Reports
Time for some Statistics recap ...

- Most of the times data show a tendency to group around a central point and this single typical value can be used to describe the entire data set. These measures are Arithmetic Mean and the Median.
- The Arithmetic Mean (aka Average) is most commonly used metric to summarize the numeric data. It is calculated by summing all the values and then dividing the total number of observations involved.
- Arithmetic Mean are vulnerable to the extreme points, which are known as Outliers.
- Let’s take an example of hourly CPU Utilization for 6-hours window as:
  - 28%, 31%, 30%, 32%, 95% and 29%
  - Mean CPU Utilization = 41%
  - Eliminating 95% as an Outlier, Mean CPU Utilization = 30%
- Because it is based on every observation, the arithmetic mean is significantly affected by Outliers. In such cases, only reporting the arithmetic mean may present a distorted representation of what the data are conveying.
Median & Percentile

- The Median is the middle value in the ordered set of data. In case of even number of observations, the Median is calculated by taking the average of two middle observations.
- Consider our previous example of hourly CPU Utilization,
  
  28%, 29%, 30%, 31%, 32%, 95% (Data sorted in ascending order)

  \[ \text{Median} = \text{Average (30%, 31%)} = 30.5\% \]

- The Median is unaffected by any extreme observations.
- When summarizing a set of data that has Outliers, you should report the median or better both the mean and median.
- A Percentile is the value below which a certain percent of observations fall. For example, the 70th percentile is the value below which 70 percent of the observations may be found.
- Percentile in Oracle Database environment can be used to set Adaptive thresholds for Performance/Workload metrics, analyze and summarize database performance data.
- MS Excel has inbuilt formula \( \text{PERCENTILE(Data Array, k)} \) to calculate \( k^{\text{th}} \) percentile of values. For example to calculate 90\(^{\text{th}}\) percentile, use \( \text{PERCENTILE(Data Array, 0.9)} \)
Standard Deviation and Empirical Rule

- Although the arithmetic Mean give a central point around which all the values tend to cluster, but it doesn’t give us a clue about the variation in the data around the mean.
- To evaluate the fluctuation around the mean a statistic measure called Standard Deviation is used.
- MS Excel has inbuilt formula STDEV(data array) to quickly calculate the Standard deviation for a given set of numbers.
- The Standard Deviation measure the “average” scatter around the mean – some observations are larger than the mean while some of them can be lower.
- The Empirical Rule of statistics states that:
  - About 68.27% of the values lie within 1 standard deviation of the mean.
  - Similarly, 90% of the values lie within 1.645 standard deviations of the mean.
  - Nearly all (95%) of the values lie within 1.960 standard deviations of the mean.
- Thus the arithmetic mean and the standard deviation usually helps define where majority of the data values are clustering.
Little Law’s Formulas

\[ U = \frac{S \times \lambda}{M} \]

- **Utilization of a server**
- **Arrival Rate**
- **Service Time**
- **Number of CPUs**

Can also re-written as:

\[ M = \frac{S \times \lambda}{U} \]
Case Study: DB Capacity Planning

Problem Statement: You are an Oracle DBA. The Business wants to know how much additional workload current database can support AND how much additional capacity (if any) would be required to support double the workload (around 10% per month).

**Step-1 State Goal:**

- How much load of some particular business activity database can support, before running “out of gas”?

- If the workload grows by 100% (around 10% every month), when we will need to add more capacity to the system?

**Step-2: Define the System Configuration**

Oracle Database 11.2 running with 8 CPUs and 16 Gigs memory

**Step-3: List Database Services**

Database is primarily part of an Order management system in an OLTP environment.
Case Study: DB Capacity Planning

Step-4 Identify Right Metrics

You had discussion with Business to understand how they measure business growth and came to know that #orders and #order lines give a clear picture to them. Then you discuss with application team to understand which columns in the application tables hold this data.

Step-5: Collect Data

Further you have agreed with relevant application teams to have these metrics on an hourly basis. You collect CPU utilization data from any monitoring tool installed on the server, native OS tool or from AWR tables (Host CPU utilization in DBA_HIST_SYSMETRIC_SUMMARY).

Step-6: Analyze and Model Data

You correlate #Order and #Order lines with the host CPU utilization to see which Application metric is driving the CPU utilization on underlying database.

<table>
<thead>
<tr>
<th>Application metric</th>
<th>Correlation Coefficient</th>
<th>SQL (CC) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total order/hr</td>
<td>0.5862</td>
<td>34.36</td>
</tr>
<tr>
<td>Total Order lines/hr</td>
<td>0.7662</td>
<td>58.71</td>
</tr>
</tbody>
</table>

Avg CPU can be explained by the Order Lines/hour 58.71 % of the time.
Case Study: DB Capacity Planning

For example -
Service Time = (68.37% * 8) / 976 = 0.00560369
Case Study: DB Capacity Planning

70th Percentile Arrival Rate

<table>
<thead>
<tr>
<th>Arrival Rate Increase (%)</th>
<th>Arrival Rate (Order lines/hour)</th>
<th>Avg Busy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>941.60</td>
<td>52.19</td>
</tr>
<tr>
<td>5%</td>
<td>988.68</td>
<td>54.80</td>
</tr>
<tr>
<td>10%</td>
<td>1035.76</td>
<td>57.41</td>
</tr>
<tr>
<td>15%</td>
<td>1082.84</td>
<td>60.02</td>
</tr>
<tr>
<td>20%</td>
<td>1129.92</td>
<td>62.63</td>
</tr>
<tr>
<td>25%</td>
<td>1177.00</td>
<td>65.24</td>
</tr>
<tr>
<td>30%</td>
<td>1224.08</td>
<td>67.85</td>
</tr>
<tr>
<td>35%</td>
<td>1271.16</td>
<td>70.46</td>
</tr>
<tr>
<td>40%</td>
<td>1318.24</td>
<td>73.07</td>
</tr>
<tr>
<td>45%</td>
<td>1365.32</td>
<td>75.68</td>
</tr>
<tr>
<td>50%</td>
<td>1412.40</td>
<td>78.29</td>
</tr>
<tr>
<td>55%</td>
<td>1459.48</td>
<td>80.90</td>
</tr>
<tr>
<td>60%</td>
<td>1506.56</td>
<td>83.51</td>
</tr>
<tr>
<td>65%</td>
<td>1553.64</td>
<td>86.12</td>
</tr>
<tr>
<td>70%</td>
<td>1600.72</td>
<td>88.73</td>
</tr>
<tr>
<td>75%</td>
<td>1647.80</td>
<td>91.34</td>
</tr>
<tr>
<td>80%</td>
<td>1694.88</td>
<td>93.95</td>
</tr>
<tr>
<td>85%</td>
<td>1741.96</td>
<td>96.56</td>
</tr>
<tr>
<td>90%</td>
<td>1789.04</td>
<td>99.17</td>
</tr>
<tr>
<td>95%</td>
<td>1836.12</td>
<td>101.78</td>
</tr>
<tr>
<td>100%</td>
<td>1883.20</td>
<td>104.39</td>
</tr>
</tbody>
</table>

Table: Predicted CPU Utilization

<table>
<thead>
<tr>
<th>Number of CPUs</th>
<th>Predicted CPU Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>104.39%</td>
</tr>
<tr>
<td>9</td>
<td>92.79%</td>
</tr>
<tr>
<td>10</td>
<td>83.51%</td>
</tr>
<tr>
<td>11</td>
<td>75.92%</td>
</tr>
<tr>
<td>12</td>
<td>69.59%</td>
</tr>
<tr>
<td>13</td>
<td>64.24%</td>
</tr>
<tr>
<td>14</td>
<td>59.65%</td>
</tr>
<tr>
<td>15</td>
<td>55.67%</td>
</tr>
<tr>
<td>16</td>
<td>52.19%</td>
</tr>
</tbody>
</table>

Neeraj Bhatia | Oracle Database Capacity Planning: How to Start?
Effecting Capacity Planning involves not only analyzing the data but also summarizing the key findings and presenting it to the relevant people.

**Step-8: Present Results**

- Current Database Capacity can support 35% additional order lines workload which means around we are safe for next 3 - 4 months.

- We would need 4 additional CPUs to support double Order lines workload.
Capacity Planning Tools

✓ A tool can help you but that's not the end of the world.

✓ For big enterprise environment a sophisticated tool is recommended, which can ease your life.

✓ For small shops, MS Excel is a low-cost solution for Performance Visualization, Capacity Planning and Data Analysis.
"I hear and I forget. I see and I remember. I do and I understand."
-- Chinese Proverb

The best way to learn a subject is to apply the concepts to a real system. The techniques presented in this presentation may appear simple on the surface, their applications to real world may offer a different experience.
References

Additional Resources:

- Email - neeraj.dba@gmail.com