Oracle Database Capacity Analysis Using Statistical Methods

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Who Am I?

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- Member:- IOUG, OAUG & AIOUG

Agenda

Why system capacity? Are you being served properly?

- ✓ What Are The Different Statistical Methods Of Analyzing The System Capacity Of Database Tier
- ✓ Simple Math – CPU Analysis.
- ✓ Linear Regression Model for CPU.
- ✓ Queuing Theory – CPU or I/O Subsystems.

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Why System Capacity? Are You Being Served Properly?

How long can you wait to have your favorite dish at your favorite restaurant ? Waiter says you will have to wait for another 1 hour to be served.

Imagine a angry waiter on your table, refusing to serve you. (No Service)

Obviously, you are not happy !!

Any computer system serves you in similar fashion if not properly sized.

Capacity Planning plays a vital role in such situations.

Proper capacity analysis done by restaurant owner could have helped the waiter serve you your favorite dish faster .

What are the different statistical methods of analyzing the system capacity a database server?

Introduction of Capacity Analysis Methods

- **Simple Math -** This model can take single component inputs either application or technical metrics. This method is usually involved with short-duration projects, The precision is usually low, but sufficient when used appropriately.
- **Linear Regression Analysis –** This method is typically used to determine how much of some business activity can occur before the system runs out of gas.
- **Queuing Theory –** This method uses Queuing theory used in telecom networks for high precision capacity base lining & forecasting.

SIMPLE MATH


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Simple Math - CPU

Scenario:- The customer wants to downsize the infrastructure and check the CPU requirements for a 4-node 16 CPU Database tier.

On Host1 , during peak utilization timings (1/5/09 3:00 AM- 4:00 AM), CPU utilization was 39.27%.
CPU consumption = 0.3927 X 14,400 s (per hour available capacity) = 5654.88s

Similarly, on Host2, Host3, Host4 observed Peak CPU consumption were 43.87% (Avg) 6173.28 s, 41.22 %(Avg) 5935.68 s and 53.11% (Avg) 7503.84s respectively.

Total CPU requirement = 25267.68 s/Hour

Calculate Utilization with 16 CPU's

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Considering 10% overhead for OS, estimated CPU utilization on 8-core (Dell 1950 QC)
Physical Server = (25267.68 + 25267.68 *10%) / (16*60*60) = 0.4825425 = **48.25%**

Calculate Utilization with 12 CPU's

~~~~~~~~~~~~~~~~~~~~~~~~~

Considering 10% overhead for OS , estimated CPU utilization on 4-core (Dell 1950 QC)
Physical Server = (25267.68 + 25267.68 *10%)/ (12*60*60) = 0.64339 = **64.33%**

Calculate Utilization with 8 CPU's

~~~~~~~~~~~~~~~~~~~~~~~~~

Considering 10% overhead for OS , estimated CPU utilization on 4-core (Dell 1950 QC)
Physical Server = (25267.68 + 25267.68 *10%)/ (8*60*60) = 0.87735 = **87.73%**
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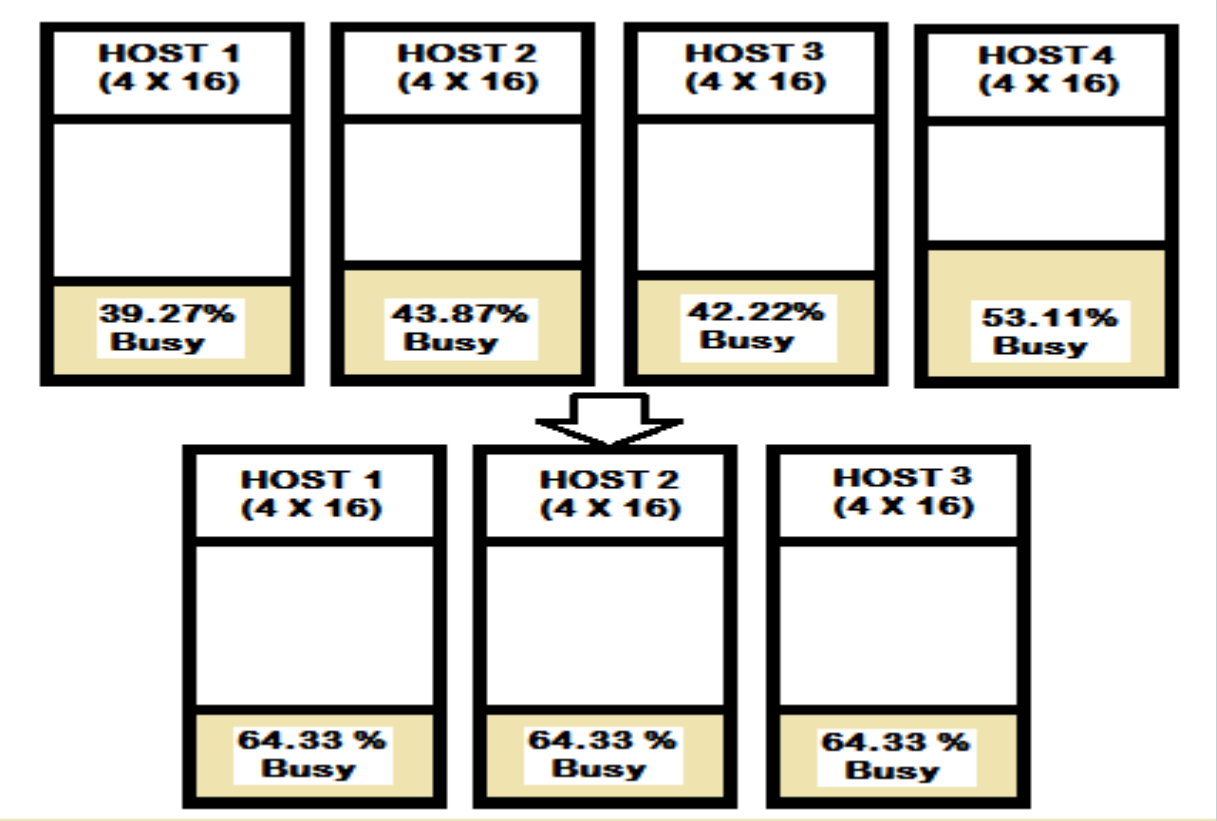
Simple Math - CPU



LINEAR REGRESSION

LIO is Expensive?

- How many of you think RAM access is 10,000 times faster than Physical disk access?

- In real world, LIO is only 25-100 times cheaper than PIO

  - ...not 1,000s or 10,000s

  Reason – Internal locks & latch serialization mechanisms involved.

- Targeting only PIO counts(or high cache hit ratios) during SQL optimization is an important pitfall to avoid.

- Even with no PIOs, a query can still be outrageously inefficient
  - -LIO are a critical component of query cost

Definitions: LIO and PIO

- Oracle Logical I/O (LIO)
  - - Oracle requests a block from the database buffer cache
  - -LIO statistics are captured in db block gets, consistent gets, session logical reads & buffer is pinned count statistics
  - - In raw trace data, It's cr + cu
- Oracle physical I/O (PIO)
  - Oracle requests one or more blocks from the operating system
  - Might be "physical," might not be
  - PIO statistics are captured in the physical reads statistics
  - In raw trace data, it's p or pr
- Note:- There are occasions were Oracle manipulates database blocks without using the database buffer cache (e.g. blocks read by PQO access paths, and blocks read from temporary segments)

Linear Regression Analysis

WHAT IS LINEAR REGRESSION
==========

- ✓ Linear regression analysis is a method for investigating relationships among variables.
  eg. Logical Rds Vs CPU utilization

- ✓ Relation is y=mx +c (equation of straight line), Here c represents the y-intercept of the line and m represents the slope.

- ✓ Here the variable “LIO" is used to predict the value of CPU Utilization .So, “LIO" becomes the explanatory variable. On the other hand, the variable whose value is to be predicted is known as response or dependent variable

- ✓ Generally response variable is denoted as Y & predicted variable denoted as X

CPU utilization = user calls * m + c

Corr coeff r = $\Sigma (y_i - y)(x_i - x) / SQRT (\Sigma (x_i - y)^2 (x_i - x)^2)$

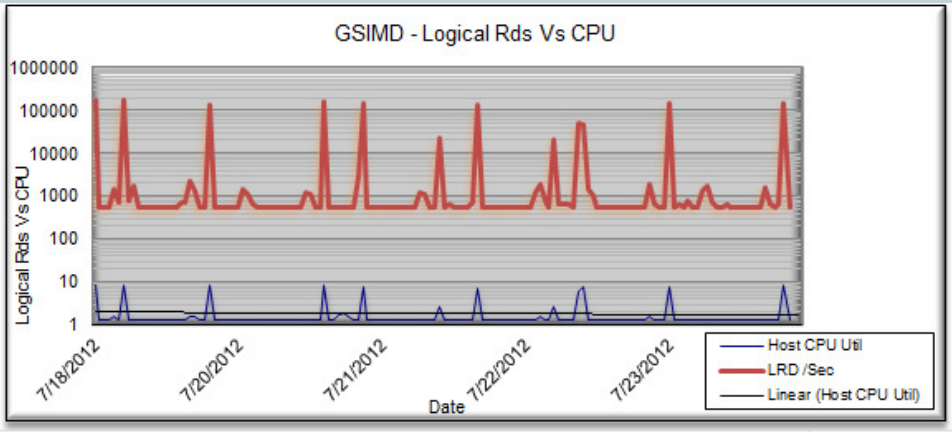
Again there is no need to solve this complex mathematical equation; Excel’s predefined function CORREL () is available for us (Good news!).

Correlation Coefficient (r)	Practical Meaning
0.0 to 0.2	Very week
0.2 to 0.4	Week
0.4 to 0.7	Moderate
0.7 to 0.9	Strong
0.9 to 1.0	Very strong

Linear Regression Analysis

Scenario:- Database capacity forecasting

Co-relation table	Host CPU Util
LRD /Sec	0.98
PRD/Sec	0.56
User Calls/Sec	0.48
Commits/Sec	0.44



Capacity Forecasting for DB Node GSIMD

Metric Name	Business Hours
Avg Logical Rds per sec	10110
Avg CPU utilization	1.84

Analysis: Impact of Workload Increase on CPU utilization

Inputs	Number of CPUs	8			
	Arrival Rate	10110	Avg Logical Rds per sec		
	CPU Utilization	1.84%			
	Arrival Rate	185971.809	Max Logical Rds per sec is	1739.485252	% Of Avg workload 10110 Avg Logical Rds /Sec
Output	Service Time	0.00001455			

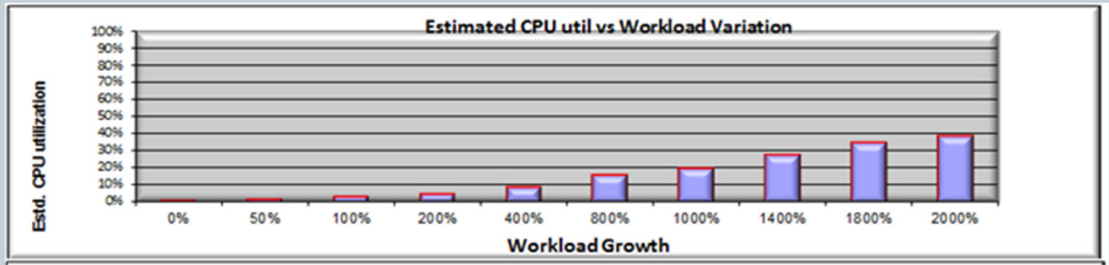
Observations:

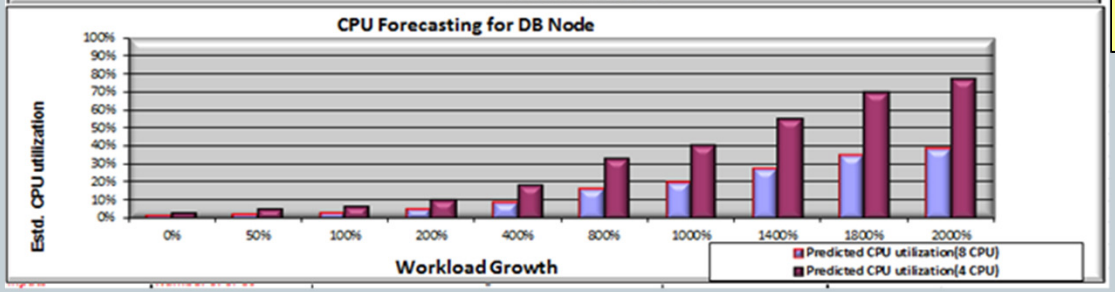
- **CPU utilization is highly correlated with Logical Reads. Correlation coefficient 0.98 in (ideal 1.0) . Both the CPU usage & Logical Reads trend line are similar. (Spikes are matching 98%)**

Linear Regression Analysis

Scenario:- Database capacity forecasting

Workload variation	Arrival rate	Avg Busy	RT	RT Change (%)	Utilization with 4 CPU's
0%	10110	1.84%	0.00001455	0.00%	3.68%
50%	15165	2.76%	0.00001455	0.00%	5.52%
100%	20220	3.68%	0.00001455	0.00%	7.36%
200%	30330	5.52%	0.00001455	0.00%	11.04%
400%	50550	9.20%	0.00001455	0.00%	18.39%
800%	90990	16.55%	0.00001455	0.00%	33.11%
1000%	111210	20.23%	0.00001455	0.00%	40.46%
1400%	151650	27.59%	0.00001455	0.00%	55.18%
1800%	192090	34.94%	0.00001456	0.02%	69.89%
2000%	212310	38.62%	0.00001456	0.03%	77.25%



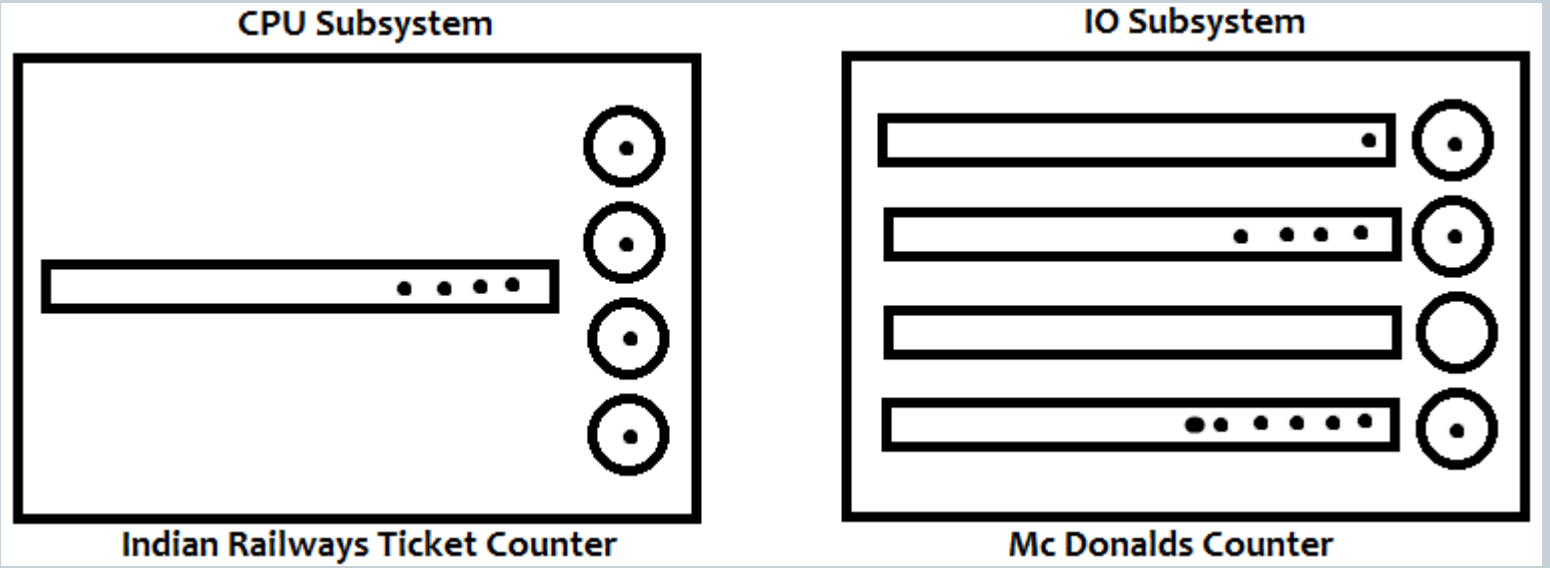


Observations:

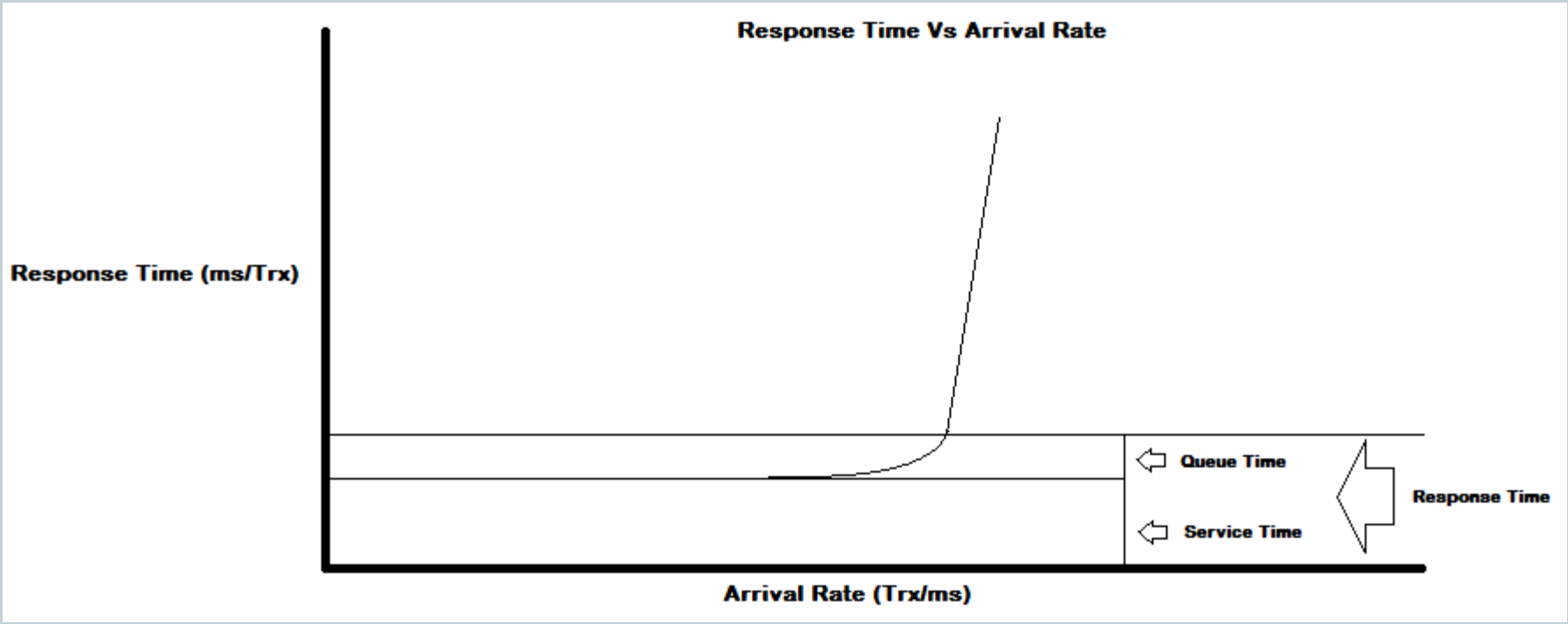
- **Current Capacity can handle additional 2000% workload by maintaining CPU utilization at 38.62% (Considering additional OS overhead etc.)**
- **Moreover, there is a downsizing possibility seen for reducing the box capacity from 8 CPU to 4 CPU (As indicated by rightmost column)**

QUEUING THEORY

Queuing Structure of CPU & IO Subsystems



Queuing Theory



Queuing Theory

Queuing Theory is basically an upgrade to essential forecasting mathematics. This method can do a baseline of the current capacity along with its forecasting(Scalability/Downgrading possibility)

Erlang C Forecasting

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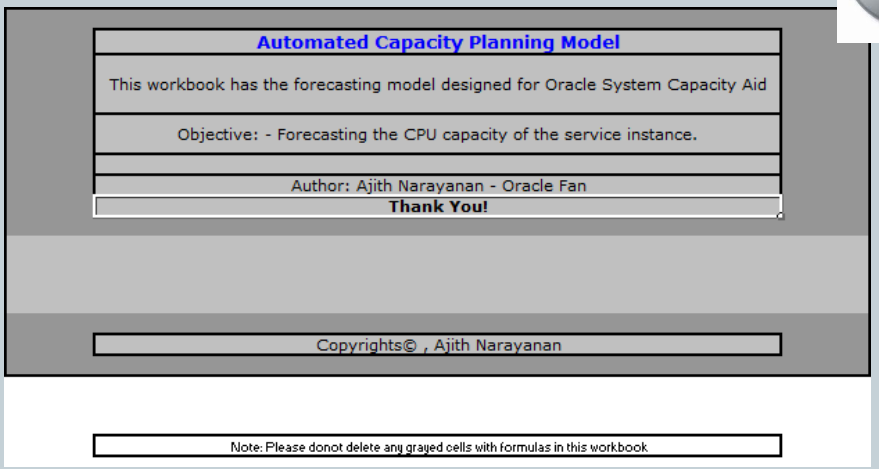
Agner Krarup Erlang(1878-1929) is the man behind this math. He studied the performance of telephone networks.

When Erlang C function is used, we do not apply the essential forecasting response time formulas, Instead, we have a single new queue time formula that can be applied to both CPU & I/O subsystem.

For CPU subsystems, there is only one queue, So the entire system arrival rate is (λ_{sys}), But for IO subsystems, the arrival rate at each queue (λ_q) is the system arrival rate(λ_{sys}) divided by the number of I/O devices.

$$U = \frac{S_t \lambda_q}{m} \qquad Q = \lambda_q Q_t \qquad E_c = \text{Erlang}(m, S_t, \lambda_q) \qquad Q_t = \frac{E_c S_t}{m(1-U)}$$

Queuing Theory



Automated Capacity Planning Model

This workbook has the forecasting model designed for Oracle System Capacity Aid

Objective: - Forecasting the CPU capacity of the service instance.

Author: Ajith Narayanan - Oracle Fan

Thank You!

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Note: Please donot delete any grayed cells with formulas in this workbook

(1)RAWDATA:
Dump your raw data in this worksheet. You'll have atleast 120 rows after the data gathering for 1 hr steady state duration; The first 60 rows of data is used to develop the forecast model and the next 60 rows for model validation.

Workload Baseline	
Peak workload (90%)	71214.3
Peak workload (95%)	71496.45

Gathered Workload Data

Date	Time	System Arrival Rate (sys_lambda)	Queue Arrival Rate (lambda)	Service Time (Ts)	Queue Time (Tw)	Utilization % (Util)	Response Time (Tq)	Servers	ErlangC	Random#
6/11/2012	6:30:15 AM	2.176966667	2.176966667	6.291322789	1.23041	0.856	7.521728	16	0.450597414	0.6750285
6/11/2012	6:30:45 AM	2.178566667	2.178566667	6.272748137	1.19589	0.8541	7.468634	16	0.445048296	0.2761636
6/11/2012	6:31:15 AM	0.000266667	0.000266667	51402	10148	0.8567	61549.97	16	0.452652745	0.8039326

Conversions

Actual Workload UserCalls/30Secs
65309
65357
8

(3)AnalysisModel:
This page computes the weighted average of service time and queue time and gives the residual error by comparing it with actual service time and queue time.

Metrices	Weighted Avg	Average	Std Dev
Service Time	0.06839203	25.61587	78.61618
Queue Time	1.304223405	485.547	1345.278

Gathered Workload Data

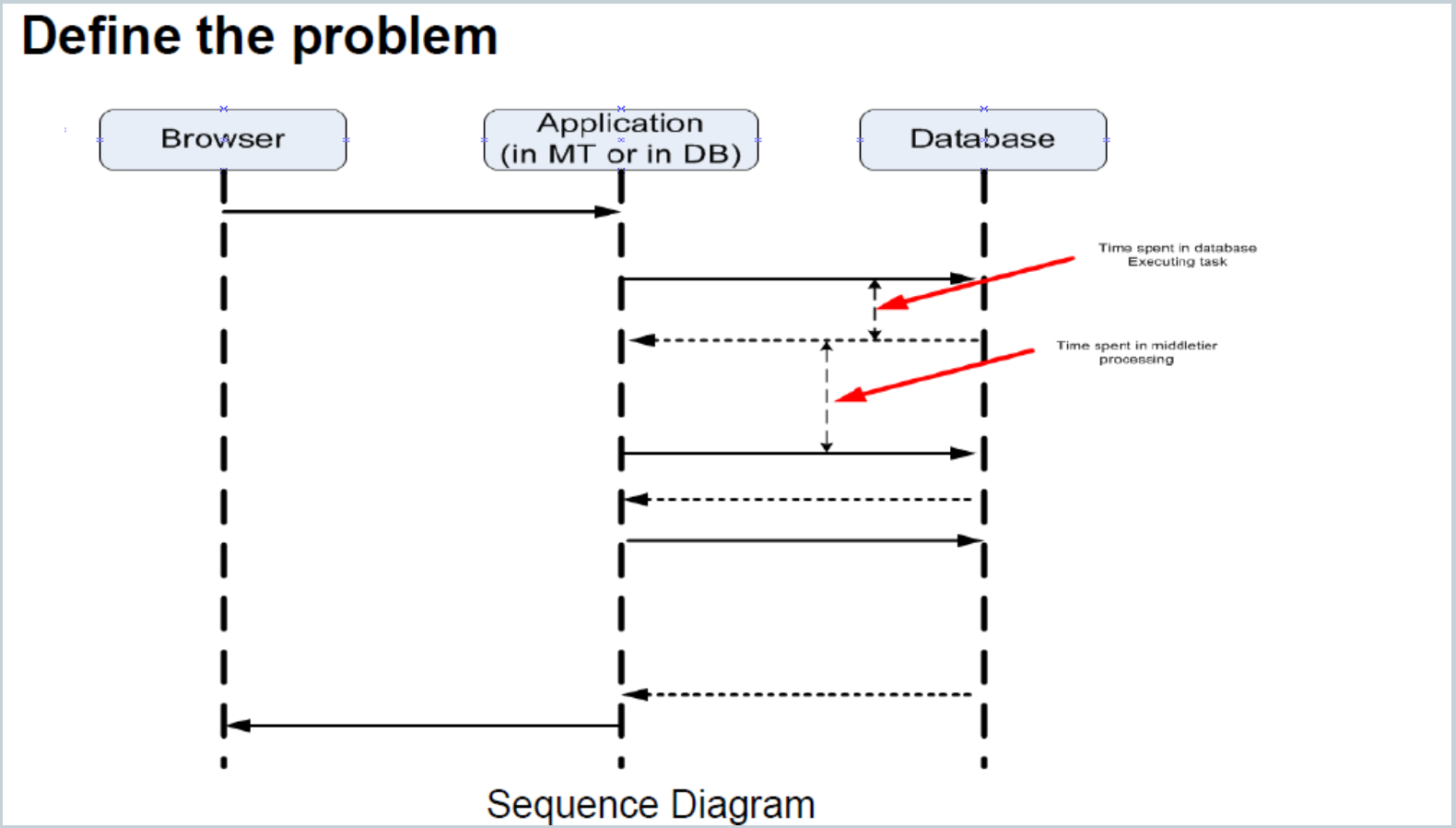
Date	Time	System Arrival Rate (sys_lambda)	Server Arrival Rate (lambda)	Service Time (Ts)	Queue Time (Tw)	Utilization % (Util)	Response Time (Tq)	Servers
6/11/2012	7:19:16 AM	0.001033	0.001033	133.8735484	2943.051321	0.86	16330.41	16
6/11/2012	6:38:45 AM	2.204533	2.204533	0.062779727	1.387759108	0.87	7.665732	16
6/11/2012	6:43:16 AM	0.000967	0.000967	141.897931	2824.156269	0.86	17013.95	16
6/11/2012	7:10:46 AM	2.330567	2.330567	0.059460217	1.334480847	0.87	7.280503	16

Residual Error Finding

Residual (Derived Ts)	Residual^2(Ts)	Residual (Derived Tw)	Residual^2(Tw)
133.8051564	17903.81987	2941.747098	8653875.989
-0.005612304	3.1498E-05	0.083535703	0.006978214
141.829539	20115.61813	2822.852046	7968493.674
-0.008931813	7.97773E-05	0.030257442	0.000915513

- Example CPU Subsystem Modelling
- Example IO Subsystem Modelling

Wider Approach of Analysis



Create An Impact With Capacity Analysis

So let's see an example of 4-cpu Intel boxes and put them together in a cluster with Oracle11G and RAC on top:

Price for the hardware: About US$15,000 or so.

Price for the OS (Linux): About US$ 0.5- or thereabout (it depends!)

Price for Oracle w/ RAC: US$480,000,-

So that's half a million to Oracle. Put another way: It's 1 dollar to the box movers for every 32 dollars paid for Oracle RAC.

Psychologically it's hard for the customers to understand that they have to buy something that expensive to run on such cheap hardware. The gap is too big, and Oracle will need to address it soon.

There's nothing like RAC on the market, but that doesn't mean you have to buy RAC. A usual joke exists that it's like buying a car for US$10,000,- that has all the facilities you need from a good and stable car.

Airbags and ABS brakes are US$500,000,- extra, by the way. Well, airbags and ABS are wonderful to have and they increase your security. But it's a lot of money compared to the basic car price.

Q&A

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1. Forecasting Oracle Performance by Craig Shallahamer (Apress, 2007)

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