Role of Tuning Parameters in Performance Optimization of PLM systems in Auto Industry

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ABSTRACT

PLM technology has become the backbone of product design and development for many of the auto companies across the globe. System Performance is the "Transaction time as perceived by the end-user - conforming to requirements". Optimized performance of all the IT components of the PLM system will ensure successful product design and development in auto industry. Optimization will generally focus on improving just one or two aspects of performance: execution time, memory usage, disk space, bandwidth, power consumption or some other resource. This will usually require a trade-off - where one factor is optimized at the expense of others.

A typical PLM system in automobile industry consists of the PLM Application server which hosts the PDM system, CAD system, Digital Simulation system, BOM system etc. Database server stores all metadata of PLM system while the bulk data is stored in the file volume server. Web server helps in connecting the PLM Application server with client machines, ERP systems, CRM/SCM systems, legacy systems etc. [Ref. 3 and 4].

Proper tuning and optimal configuration of all the components of the PLM system is very important for better performance across the enterprise. An effort is made in this research paper for analysis of the tuning parameters of the PLM system, which greatly influences the optimization of performance [Ref. 5]. Experimental research was conducted to find out information about the influence of specific parameter settings for a specific sample usage profile using the test labs of Siemens PLM Software and different customer installations across Asia.

This research paper will identify the different Tuning Parameters which affect the overall system performance, for all the layers of PLM deployment such as DB server, PLM Business logic server, Web server and Clients. Optimal values for all these tuning parameters will be highlighted in this paper using experimental analysis methods.

Key Words: PLM, Performance Optimization, Parameters Tuning, Auto Industry, DB Tuning.

1. Introduction

The purpose for parameters tuning is to reduce resource consumption or to reduce the elapsed time for an operation to complete. Either way, the goal is to improve the effective use of a particular resource. Configuration of PLM Application, Database, Operating system and Web server systems with optimal parameters setting is essential for best possible performance of the PLM system.

The PLM Application server provides the bulk of the client processing. It is responsible for communicating with the database server and file systems. Tuning the parameters for optimum performance on this tier plays a major role in optimizing the total PLM system performance.

Operating system performance issues commonly involve process management, memory management, and scheduling. Microsoft Windows manages operating system parameters, as well as numerous application parameters in the *system registry*. The registry can be altered only with the **regedit.exe** tool.

Database server requires a number of operating system kernel parameters be adjusted for proper operation on a server. In order to optimize database performance, care needs to be given to the physical layout of the database. Achieving optimal performance from a database server is an iterative process requiring careful record keeping and patience that involves measuring, making configuration changes, and measuring again. However, there are several options and general practices that can have a significant impact on overall PLM system performance. A missing or out-of-date index can cause an operation to take tens of minutes rather than seconds. A few key parameter settings and maintenance scripts can have dramatic impact on query performance, especially for Oracle [Ref. 1].

The Web Application server performs the function of providing the front end access to the PLM application environment. Its primary function is to manage connections to the Business Logic server pools for various types of clients, and provide protocol translation. Its computing load is dominated by data moving bandwidth. Hence the application should be tuned to optimize network I/O and the JVM should be tuned to optimize Garbage Collection (GC) of very transient memory.

2. Baseline Parameters Tuning

Performance parameters tuning requires a different, although related, method to the initial configuration of a system. Configuring a system involves allocating resources in an ordered manner so that the initial system configuration is functional. Tuning is driven by identifying the most significant bottleneck and making the appropriate changes to reduce or eliminate the effect of that bottleneck [Ref. 2].

The **default installation parameters** setting of most of the applications such as PLM, Database, Web application, OS, etc will not be at the optimum performance level for specific installation of the PLM system. The most effective way to tune the system is to have an established **performance baseline** that can be used for comparison if a performance issue arises.

It is recommended to first apply the baseline tuning parameters on Test and/or Pre-production systems and conduct performance tests iteratively, to decide the final set of parameters to be applied on to the production system. Before applying the parameters on the Test/Pre-production/Production systems, it is recommended to taking proper backup of the system configuration files for restoring back to current setup, if needed.

A common pitfall in performance tuning is to mistake the symptoms of a problem for the actual problem itself. The Parameters recommendation for baseline performance tuning may need further changes based on specific performance tests and detailed root cause analysis.

3. Experimental Research Results and Analysis

Experiments are conducted at different auto companies across Asia and Siemens PLM software company test labs to decide the optimum baseline parameters setting values for different parameters of all layers of PLM deployment. Software applications which are vendor specific are considered based on their popular usage among auto companies. Following subsections will highlight the results of this experimental research and provide specific analysis of the results.

3.1. Performance Tests at a Japanese Auto company

Conducted performance tests for all the baseline test transactions on **pre-production environment** using the 4Tier Rich Client. Test data used is as per Table1 and Test results before and after baseline parameters tuning are shown in Table2 and Figure1 below.

Data size	ItemID	Owner
Small	00007608_Res_S-Size_Top_Ph5_ExpertService-01_20120511	des_0005
	00007608_Res_S-Size_Top_Ph5_ExpertService-02_20120511	des_0005
Medium	00008253_Res_M-Size_Top_Ph5_ExpertService-01_20120511	des_0005
	00008253_Res_M-Size_Top_Ph5_ExpertService-01_20120511	des_0005

Table1: Test Data Used for Baseline Performance Testing

Operation	Response(S) Before tuning	Response(S) After tuning	Response(M) Before Tuning	Response(M) AfterTuning
Login	00:00:24	00:00:22	00:00:25	00:00:24
Launch NX	00:02:27	00:02:22	00:02:35	00:02:22
Load Structure	00:00:33	00:00:27	00:00:19	00:00:18
Load Facet(Volume)	**00:01:02**	**00:00:33**	**00:05:16**	**00:00:47**
Load Facet(Client Cache)	00:00:09	00:00:05	00:00:43	00:00:26
Load Precise	00:00:16	00:00:17	00:01:18	00:00:51
Save	**00:05:14**	**00:03:21**	**00:18:21**	**00:14:20**
Baseline	**00:02:49**	**00:01:19**	**00:15:28**	**00:06:41**
Logout	00:00:01	00:00:01	00:00:01	00:00:01

Table2: Test Results before and after baseline parameters tuning (hh:mm:ss)

The performance test results show that the system performance has improved significantly with tuning of some of the possible recommended parameters on the pre-production system. All the recommended parameters were not tuned on pre-production system due to smaller hardware size available on this environment. **Load Facet (Volume), Save and Baseline transactions has shown significant improvement** in performance as shown above.

3.2. Performance Tests at an Indian Auto company

Conducted performance tests for the baseline test transactions on **production environment** using the 4Tier Rich Client. The table3 below shows performance of baseline test transactions on production environment before the tuning activity.

ItemId: 301-00A00-000	**7000+ Parts**						
	14-03-2013 (11:00 AM)			**14-03-2013 (04:30 PM)**		**15-03-2013 (04:30 PM)**	
User		**2308261 (DBA)**	**2308261 (Axle)**	**2308261 (DBA)**	**2308261 (Axle)**	**2308261 (DBA)**	**2308261 (Axle)**
S.NO	**PROCESS**						
1	LOGIN	25 Sec	25 Sec	30 Sec	32 Sec	30 Sec	31 Sec
2	Part creation	4 Sec	5 Sec	10 Sec	6 Sec	5 Sec	6 Sec
3	Dataset Attachment With Data			3 Sec	2 Sec	3 Sec	3 Sec
4	Project assign	1 Sec	1 Sec	1 Sec	1 Sec	1 Sec	1 Sec
5	BL Release	4 Sec	3 Sec	3 Sec	3 Sec	3 sec	3 Sec
6	Revise	3 Sec	2 Sec	2 Sec	2 Sec	2 Sec	2 Sec
7	**Opening in PSE**	**18 Sec**	**18 Sec**	**27 Sec**	**27 Sec**	**20 Sec**	**18 Sec**
8	**Loading in PSE**	**3 Min 13 Sec**	**2 Min 56 Sec**	**7 Min 33 Sec**	**7 Min 24 Sec**	**3 Min 25 sec**	**3 Min 22 Sec**

Table3: Test Results before baseline parameters tuning

Test results for the baseline transactions on production environment after implementing the baseline database parameter recommendations are shown in Table4 below:

ItemId: 301-00A00-000	**7000+ Parts**						
	22-03-2013 (11:00 AM)			**22-03-2013 (05:00 PM)**		**25-03-2013 (05:00 PM)**	
User		**2310429 (DBA)**	**2310429 (VI)**	**2310429 (DBA)**	**2310429 (VI)**	**2310429 (DBA)**	**2310429 (VI)**
S.NO	**PROCESS**						
1	LOGIN	30 Sec	32 Sec	45 Sec	35 Sec	30 Sec	31 Sec
2	Part creation	5 Sec	5 Sec	6 Sec	6 Sec	5 Sec	6 Sec
3	Dataset Attachment With Data	2 Sec	2 Sec	2 Sec	2 Sec	1 Sec	1 Sec
4	Project assign	< 1 Sec	< 1 Sec	< 1 Sec	< 1 Sec	< 1 Sec	< 1 Sec
5	BL Release	2 Sec	2 Sec	2 Sec	2 Sec	2 Sec	2 Sec
6	Revise	2 Sec	2 Sec	2 Sec	2 Sec	2 Sec	2 Sec
7	**Opening in PSE**	**9 Sec**	**10 Sec**	**10 Sec**	**6 Sec**	**12 Sec**	**11 Sec**
8	**Loading in PSE**	**1 Min 12 Sec**	**1 Min 12 Sec**	**1 Min 12 Sec**	**1 Min 4 Sec**	**1 Min 7 Sec**	**1 Min 1 Sec**

Table4: Test Results after baseline Database parameters tuning

The performance test results show that the system performance has improved significantly with tuning of recommended database parameters on the production system.

- Open in PSE transaction time has improved by 50% (18sec to 9sec) as compared to the baseline results of 14th /15th March 2013.
- Load in PSE transaction time has improved by 60% (3min 13sec to 1min 12sec) on 22nd March, as compared to the baseline results of 14th /15th March 2013.
- Tests were repeated on 25th March also to check for consistency of the system performance improvement.

3.3. Performance Tests at a Chinese Auto company

Performance tests were conducted for the baseline test transactions on the PLM **production environment**. Test data used is as per Table5 and Test results before and after baseline parameters tuning are shown in Table6 below.

Data Type	**Part/Asm No.**	**Size**
Assembly	S22_6101100_200_FR_DR_ASSY_LH_RH_P01_041.CATProduct	59.1 MB
Part	S22_6101_576_FR_DR_BUMP_UPR_RR_BRKT_LH_RH__P01_041112_5701.CATPart	29.4 MB

Table5: Test Data Used for Baseline Performance Testing

User Action	10th Dec Test (Before Parameter Change)	11th Dec Test (After Parameter Change)	% improvement	Usage frequency of the user action
Part Import	29 Sec	4.26 Sec	85%	High
Assembly Import	57 Sec	61 Sec	- 7%	Low
Part Open	49 Sec	13.54 Sec	72%	High
Assembly Open	80 Sec	68 Sec	15%	High
Save Part	11 Sec	1.68 Sec	85%	High
Save Assembly	154 Sec	87 Sec	44%	High
Approve	18 Sec	19.29 Sec	- 7%	High
Archive	36 Sec	45 Sec	- 25%	Low
Login	21 Sec	21.55 Sec	- 3%	Medium

Table6: Test Results before and after baseline parameters tuning

3.4. Performance Tests at a Malaysian Auto company

Stress test was conducted in order to validate the parameter recommendations. This section summarizes a detailed review for final stress testing result. Five Business Processes scenarios (BP01 to 05) were defined as the Table7:

No	Business Process / Function	No of Steps (Transactions)	Virtual User Percentage
BP01	Unique Model BOM Generation	7	10%
BP02	Item Search & Design View (Part)	7	30%
BP03	Item Creation	9	30%
BP04	Structure Manager	9	20%
BP05	PCR work flow	5	10%

Table7: Business Processes Definition

Two Test scenarios were defined as below:

- **Scenario 1**: 100 user login and 20 of them process transaction.
- **Scenario 2**: 300 user login and 50 of them process transaction.

Each scenario was run for 120 minutes. Login was put as virtual user init process and Logout was put into virtual user exit process. Testing results for different scenarios such as CPU and Memory utilization are shown below:

Scenario 1:

- CPU utilization of each server is shown in Table8 and Memory utilization of each server is shown in Table9.

Server	Minimum (%)	Average (%)	Maximum (%)
DB	0	10.9	16
PLM	13	23.4	31
Volume	0	0.3	2
Web	0	4.0	8

Table8: Server CPU Utilization with 100 Concurrent Users

Server	Minimum (%)	Average (%)	Maximum (%)
DB	11	11	11
PLM	3	3	3
Volume	3	3.8	4
Web	15	15	15

Table9: Server Memory Utilization with 100 Concurrent Users after Tuning

Scenario 2:

- CPU utilization of each server is shown in Table10 and Memory utilization of each server is shown in Table11.

Server	Minimum (%)	Average (%)	Maximum (%)
DB	0	19.7	27
PLM	18	34	47
Volume	0	0.3	4
Web	0	7.7	12

Table10: Server CPU Utilization with 300 Concurrent Users after Tuning

Server	Minimum (%)	Average (%)	Maximum (%)
DB	11	11.2	12
PLM	3	3.0	4
Volume	3	4.3	5
Web	15	15.0	16

Tablee11: Server Memory Utilization with 300 Concurrent Users after Tuning

Comparison of test results for before and after applying parameter tuning recommendations are shown as in Table12 and Table13. The system performance has significant improvement referred to green-marked line in the tables below. Some of the transactions performance was degraded due to specific reasons of customization.

Transaction Name	Average Response Time before Tuning (Seconds)	Average Response Time after Tuning (Seconds)	Performance Improvement
BP01			
BP01_01_Login	10.07	13.195	-23.7%
BP01_02_Search_By_*	7.135	2.689	165.3%
BP01_03_Search_Product	5.678	0.524	983.6%
BP01_04_Click_on_UMid	5.766	0.588	880.6%
BP01_05_Click_BOMView Revision_Link	6.201	0.852	627.8%
BP01_06_Expand_EBOM	5.644	7.56	-25.3%
BP01_07_Logout	5.523	0.68	712.2%
BP02			
BP02_01_Login	4.727	4.727	0.0%
BP02_02_Click_Advance_Search	6.29	1.202	423.3%

BP02_03_Search_Part	6.708	1.333	403.2%
BP02_04_Click_on_Part	5.843	0.095	6050.5%
BP02_05_Click_on_Dataset	5.683	0.146	3792.5%
BP02_06_Download CartPart	2.587	0.127	1937.0%
BP02_07_Logout	6.445	1.13	470.4%
BP03			
BP03_01_Login	17.479	5.901	196.2%
BP03_02_Create_Part	17.111	1.202	1323.5%
BP03_03_Create_Dataset	14.895	1.333	1017.4%
BP03_04_Upload_Cart_Part	13.932	0.095	14565.3%
BP03_05_Create_Drawing	20.959	0.146	14255.5%
BP03_06_Create_Drawing_Dataset	10.936	0.127	8511.0%
BP03_07_Upload_Cart_Drawing	13.132	1.13	1062.1%
BP03_08_Attach_Drawing	21.862	1.879	1063.5%
BP03_09_Logout	6.104	1.201	408.2%
BP04			
BP04_01_login	7.961	8.535	-6.7%
BP04_02_Check_Home	9.852	6.861	43.6%
BP04_03_Create_Part	14.802	9.307	59.0%
BP04_04_Submit_Create_Part	9.037	6.642	36.1%
BP04_05_Search_CUPG	9.954	6.904	44.2%
BP04_06_Open_CUPG	10.286	6.732	52.8%
BP04_07_Add_Part	7.28	10.742	-32.2%
BP04_07_Click_on_BOMView Revision	10.42	5.559	87.4%
BP04_08_Update_Quantity	8.514	7.128	19.4%
BP04_09_Logout	9.715	5.91	64.4%
BP05			
BP05_01_Login	45.222	22.266	103.1%
BP05_02_Create_PCR	25.706	18.737	37.2%
BP05_03_MyWorklist	9.831	7.159	37.3%
BP05_04_Home	22.933	1.288	1680.5%
BP05_05_Logout	5.634	5.547	1.6%

Table12: Performance Testing Result Comparison for 100 Concurrent Users

Transaction Name	Average Response Time before Tuning (Seconds)	Average Response Time after Tuning (Seconds)	Performance Improvement
BP01			
BP01_01_Login	12.583	17.084	-26.3%
BP01_02_Search_By_*	10.015	3.089	224.2%
BP01_03_Search_Product	6.608	0.563	1073.7%
BP01_04_Click_on_UMid	6.79	0.661	927.2%
BP01_05_Click_BOMView Revision_Link	8.504	1.003	747.9%

BP01_06_Expand_EBOM	10.085	8.853	13.9%
BP01_07_Logout	5.934	0.709	737.0%
BP02			
BP02_01_Login	5.041	5.041	0.0%
BP02_02_Click_Advance_Search	10.28	3.578	187.3%
BP02_03_Search_Part	12.427	5.083	144.5%
BP02_04_Click_on_Part	8.026	0.847	847.6%
BP02_05_Click_on_Dataset	8.372	1.032	711.2%
BP02_06_Download CartPart	4.668	0.943	395.0%
BP02_07_Logout	7.542	2.411	212.8%
BP03			
BP03_01_Login	20.071	18.448	8.8%
BP03_02_Create_Part	20.617	10.2	102.1%
BP03_03_Create_Dataset	16.661	1.481	1025.0%
BP03_04_Upload_Cart_Part	17.756	3.349	430.2%
BP03_05_Create_Drawing	28.363	12.319	130.2%
BP03_06_Create_Drawing_Dataset	12.456	1.421	776.6%
BP03_07_Upload_Cart_Drawing	15.019	2.356	537.5%
BP03_08_Attach_Drawing	24.715	2.62	843.3%
BP03_09_Logout	6.54	2.1	211.4%
BP04			
BP04_01_login	13.736	13.814	-0.6%
BP04_02_Check_Home	19.08	13.831	38.0%
BP04_03_Create_Part	34.325	22.866	50.1%
BP04_04_Submit_Create_Part	15.069	12.046	25.1%
BP04_05_Search_CUPG	33.651	21.757	54.7%
BP04_06_Open_CUPG	16.147	15.896	1.6%
BP04_07_Add_Part	14.826	14.957	-0.9%
BP04_07_Click_on_BOMView Revision	20.372	11.043	84.5%
BP04_08_Update_Quantity	15.082	15.731	-4.1%
BP04_09_Logout	19.189	10.266	86.9%
BP05			
BP05_01_Login	45.222	32.313	39.9%
BP05_02_Create_PCR	25.706	25.135	2.3%
BP05_03_MyWorklist	9.831	9.766	0.7%
BP05_04_Home	22.933	1.843	1144.3%
BP05_05_Logout	5.634	5.608	0.5%

Table13: Performance Testing Result Comparison for 300 Concurrent Users

4. Conclusions

The experimental results from the tests conducted at various auto companies across Asia have clearly shown that the default installation settings of the different parameters will not be at optimum performance level. Most of the default settings need further tuning specific to the PLM system installation and usage at the specific auto company.

The most effective way to tune the system is to have an established performance baseline that can be used for comparison if a performance issue arises. Baseline parameter settings can be used as a starting point for optimizing the system performance.

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