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REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

ACKNOWLEDGMENTS

REFERENCES

APPENDIX/ANNEXURE

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- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

SURVEY ON FACTORS INFLUENCING THE PERFORMANCE OF PLM SYSTEM IN AUTO INDUSTRY

M. S. GOPINATHA
SR. EXPERT SPECIALIST, PLM COMPETENCY CENTRE (ASIA PACIFIC), SIEMENS PLM SOFTWARE; &
RESEARCH SCHOLAR
PES INSTITUTE OF TECHNOLOGY (VTU)
BANGALORE

DR. VISHNUKANTH S. CHATPALLI
ADVISOR
KARNATAKA VOCATIONAL TRAINING & SKILL DEVELOPMENT CORPORATION
BANGALORE

DR. K.S. SRIDHAR
PROFESSOR OF MECHANICAL ENGINEERING
PES INSTITUTE OF TECHNOLOGY
BANGALORE

ABSTRACT

Present day automotive industry is global, both in terms of customers spread across multiple regions (from mature and emerging markets) and manufacturers and suppliers scattered around the world. The issue from an original equipment manufacturers' (OEM) perspective is how to respond to and best satisfy complicated demands while at the same time delivering attractive vehicles at higher quality levels, at the right time, and at a reasonable price. Most of the Auto OEMs have an appropriate answer to achieving these goals through product and process innovation enabled by a sound Product Lifecycle Management (PLM) approach and solution. 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. 4 and 5]. Interview based survey is conducted to identify potential areas to optimize product design system performance by Interviewing many practicing managers/engineers from Indian and global automobile companies. A structured questionnaire was administered with the purpose of collecting necessary information regarding potential areas to be focused for optimization of the PLM system performance in automobile industry. This survey results are published in this research paper highlighting the major factors influencing the performance optimization of the PLM system in automobile industries. It provides details about how each factor influences the system performance and its significance in optimizing the overall system performance.

KEYWORDS
system performance, PLM System, performance optimization, automobile industry.

1. INTRODUCTION

Throughout the history of computers, a primary design goal in all systems has been to **achieve maximum performance**. In many real life systems, including PLM systems, the application performance is far from optimal. A lot of improvement can often be achieved by measuring how the system behaves and configuring the system optimally. **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. [Ref. 3]

The performance optimization basically consists of the following steps

1. Define the performance problem and identify the key transactions facing performance issues.
2. Identify the bottlenecks and possible causes.
3. Carryout "**root cause analysis**" using fish bone diagram.
4. Eliminate the root causes one by one using "**cause elimination approach**" to narrow down to specific root causes.
5. Remove the root cause bottlenecks by appropriate performance **optimization methodologies**.
6. Repeat steps 2 to 5, until we have a satisfactory **optimum performance**.

It is important to note here that bottlenecks occur at various points in a product design system. Determining the bottlenecks is a step-by-step procedure of narrowing down the root causes. Root-Cause analysis involves analysis diagrams such as fish bone diagram, including "Cause Elimination Algorithms". Performance optimization is relatively a complex process that requires correlating many types of information, to locate and analyze performance problem bottlenecks.

An attempt is made in this interview based research survey to study the current status of product design systems in automobile industry in detail and **identify the potential areas/topics for optimizing** the product design system performance.

2. SURVEY METHODOLOGY

Interview discussions based survey was conducted with PLM system administrators and IT Managers at different auto industries across Asia-pacific countries. Discussions were held with **pre-defined questionnaire** with the purpose of collecting necessary information reg current status of PLM system performance. The interview discussions were focused on current performance issues and **potential areas to be focused for optimization** of the PLM system performance.

PLM system administrators and IT Managers from following automobile companies were included in the interview discussions:

- **India:**
  TATA Motors Limited
  Maruti Suzuki India Limited
  Mahindra & Mahindra Automobiles Limited
- **Malaysia:**
  Proton Automobiles Company Limited
- **Japan:**
  Nissan Automobiles Company

Toyota Motor Corporation

- **Korea**
  Hyundai Kia Motor Corporation
- **China**
  Cherry Automobiles Company
  Shanghai Automobiles

Total number of respondents were around 96 from all the 9 companies listed above. All the 15 questions from the pre-defined questionnaire were discussed in detail with the respondents on a **face-to-face interview mode**. All the additional details needed were collected post interview from the respondents.

2.1. INTERVIEW SURVEY QUESTIONNAIRE

The **questionnaire** used during the interview consisted of the following questions:

1. Do you feel that the PLM system is running in a healthy condition?
2. Are you facing any specific system performance issue? Please describe the specific issue in terms that describe who experiences the issue, what is experienced, and when and where it happens.
3. What are the **possible root causes** of the performance issue?

a. Insufficient RAM
b. Insufficient CPU capacity
c. Improper deployment architecture
d. Parameters need tuning
e. Insufficient network infrastructure connectivity (Bandwidth/Latency)
f. Bug in software application
g. Software version compatibility
h. Improper storage and distribution architecture of PLM data
i. Change in Business process needed
j. Any other cause

4. Please explain the analysis done to find out the root cause of the issue. Please provide any test data that was generated while previously trying to debug this issue. This may include data from times/locations/client types where performance was bad and times/locations/client types where performance was good. Data may include transaction times, logs, server metrics, etc.
5. Which are the **most effective and contributing areas** of the root cause analysis results, which result in optimizing the system performance. Please rank them in decreasing order of importance/effect.
6. What actions are initiated to resolve the performance issue?
7. Please highlight any additional planned changes/activities that you feel may improve the PLM system performance further.
8. Are there any other **known constraints** that may impact further optimization of PLM system performance? If there are any hardware constraints mandated by corporate procurement policies, please explain and detail how these would impact the PLM system deployment
9. **High Availability**: Is this a design concern at your site? If so, how is it implemented and on which tiers is it implemented?
10. **Disaster Recovery**: Do you have a Disaster Recovery plan? If so, when was the last time the plan was executed / tested?
11. Do you have a **"day in the life" test script** which exercises the actions performed by users during a typical workday?
12. Please provide the current and historical **performance metrics** which you have gathered for your PLM environment. This should include the timing data for your "day in the life" use cases from question11,**Error! Reference source not found.** as well as any corresponding server metrics (CPU, RAM, I/O, Network, etc) or other supporting data gathered from the time of the tests.
13. If one has been maintained, please provide the **list of configuration changes** executed on the production system since the go-live date.
14. If there is a **service level agreement** (SLA) related to PLM system performance between the user community and either your IT organization or an external service provider, please provide the same.
15. Please provide any additional information, issues, requirements or constraints that you feel are relevant and were not covered in the previous questions.

3. SURVEY RESULTS

Answers received from the respondents by the interview survey are compiled in this section. Detailed analysis of these results is presented in the next section along with specific interpretation from this research context.

As per the answer to the **first question** of the questionnaire, only 7 respondents felt that their PLM system is running in a healthy condition. More than 90% of the interviewees (89 out of 96) felt that the PLM system is not healthy enough and there is scope for further optimization of system performance.

Answering the **second question** of the questionnaire, administrators informed that there are many issues un-resolved and many more issues are managed by temporary work-around solutions.

Answering the **third and fourth question** of the questionnaire, many of the respondents highlighted that they are involved with the root cause analysis of the PLM system performance issues. Following are the possible root causes of the performance issues as listed by the respondents.

1. Insufficient RAM
2. Insufficient CPU capacity
3. Improper deployment architecture
4. Software parameters need tuning
5. Insufficient network infrastructure connectivity (Bandwidth/Latency)
6. Bug in software application
7. Software version compatibility issues
8. Improper storage and distribution architecture of PLM data
9. Change in Business process needed

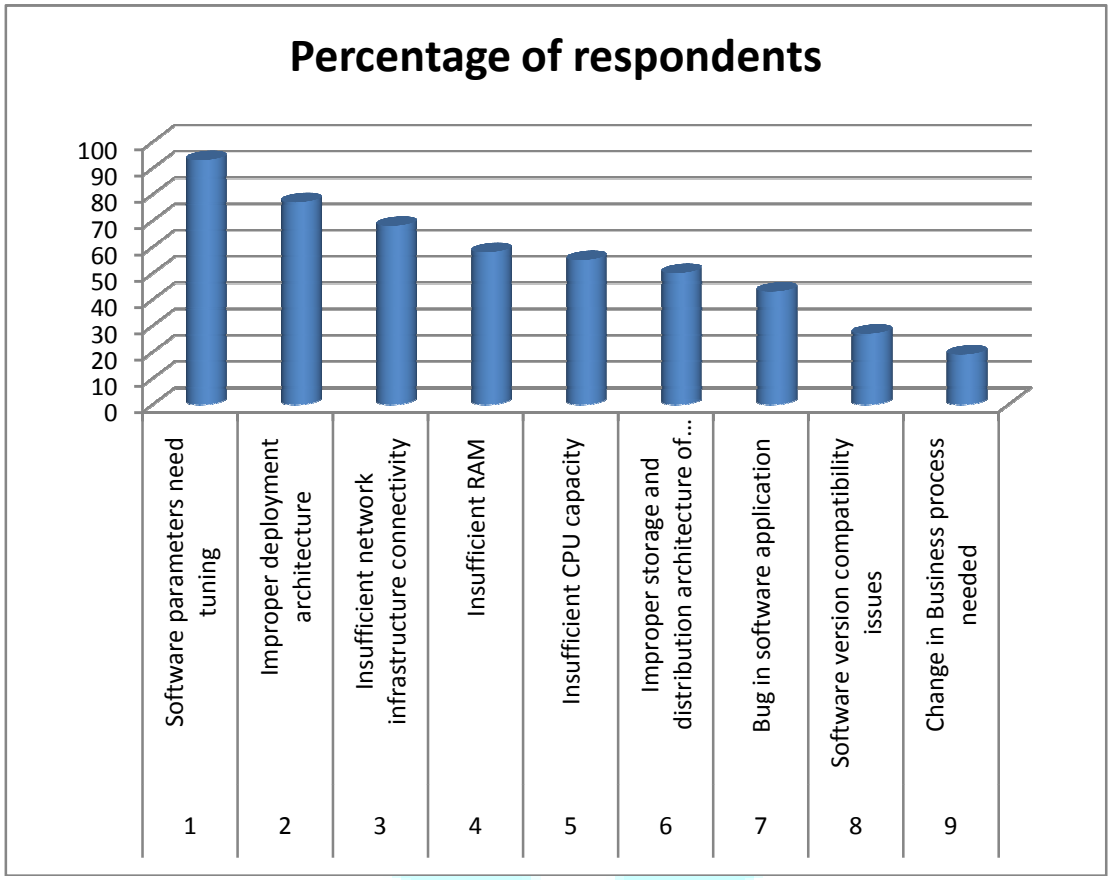
Number of respondents who voted for specific possible root cause to be applicable to their case is listed in Table1 below. Percentage number of respondents who voted for these specific root causes is computed and shown in Table1.

Graphical representation of the percentage number of respondents voted for the possible root causes for PLM performance issue is shown in Figure1 below.

TABLE 1: RESPONSE DETAILS OF INTERVIEW SURVEY ON POSSIBLE ROOT CAUSES

Sl. No.	Possible root causes	No. of respondents	Percentage of respondents
1	Software parameters need tuning	89	93
2	Improper deployment architecture	74	77
3	Insufficient network infrastructure connectivity	65	68
4	Insufficient RAM	56	58
5	Insufficient CPU capacity	53	55
6	Improper storage and distribution architecture of PLM data	48	50
7	Bug in software application	41	43
8	Software version compatibility issues	26	27
9	Change in Business process needed	18	19

FIGURE 1: PERCENTAGE NUMBER OF RESPONDENTS VOTED FOR THE EACH ROOT CAUSE

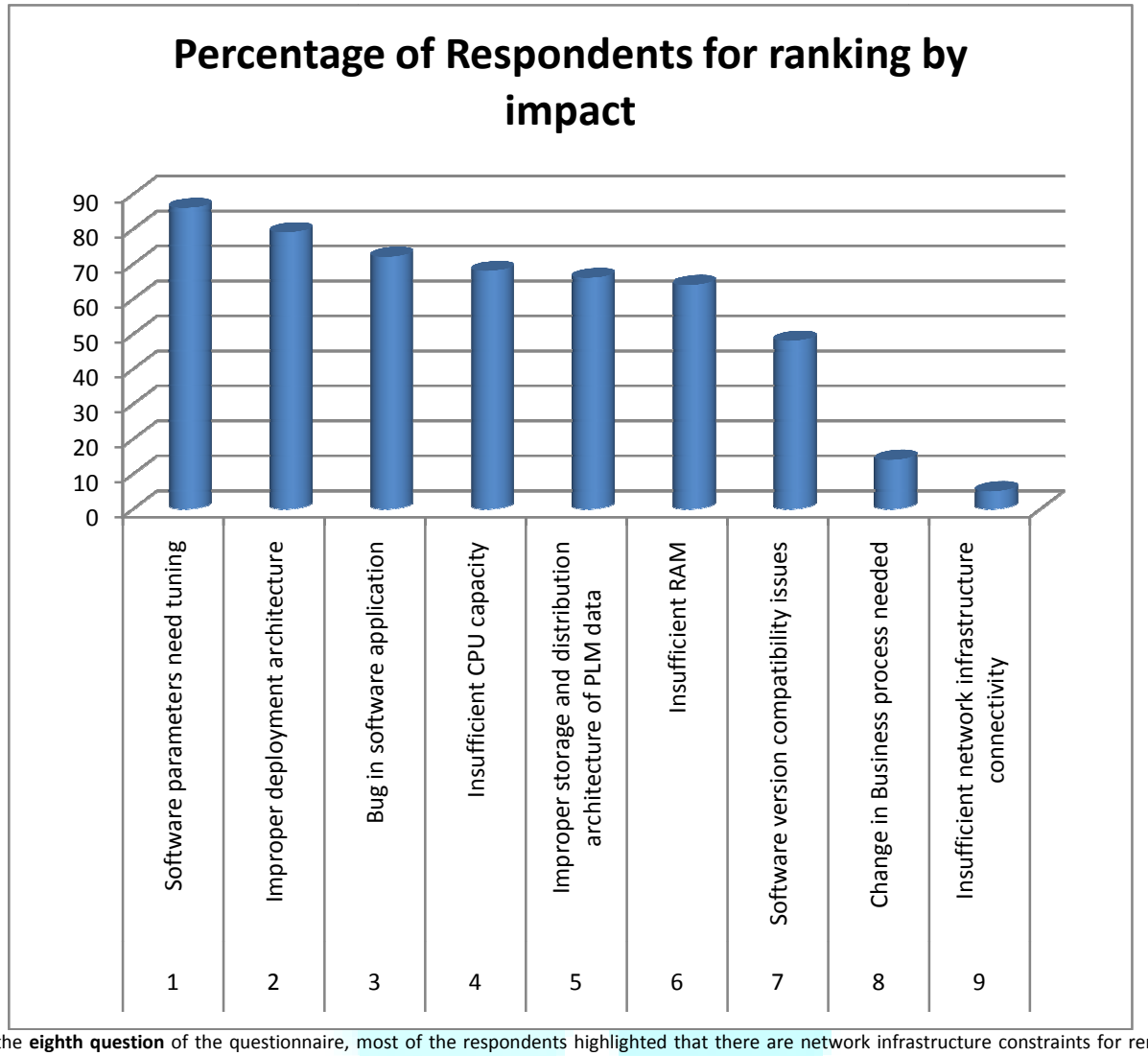


Answering the **fifth question** of the questionnaire, the respondents listed the most effective and contributing areas which will help in optimizing the PLM system performance. The respondents also ranked their list with decreasing order of impact/effect such that the maximum impact area to be rank number 1.
Number of respondents who voted for specific ranking of the possible root cause is listed in Table2 below. Percentage number of respondents who voted for these ranking of the possible root causes is computed and shown in Table2.
Graphical representation of the percentage number of respondents voted for specific ranking of the possible root causes is shown in Figure2 below.

TABLE2: RESPONSE DETAILS REGARDING IMPACT ON PERFORMANCE OPTIMIZATION

Rank No.	Possible root causes	No. of respondents	Percentage of Respondents for ranking by impact
1	Software parameters need tuning	83	86
2	Improper deployment architecture	76	79
3	Bug in software application	69	72
4	Insufficient CPU capacity	65	68
5	Improper storage and distribution architecture of PLM data	63	66
6	Insufficient RAM	61	64
7	Software version compatibility issues	46	48
8	Change in Business process needed	13	14
9	Insufficient network infrastructure connectivity	5	5

FIGURE 2: PERCENTAGE NUMBER OF RESPONDENTS VOTED FOR THE RANK NUMBER

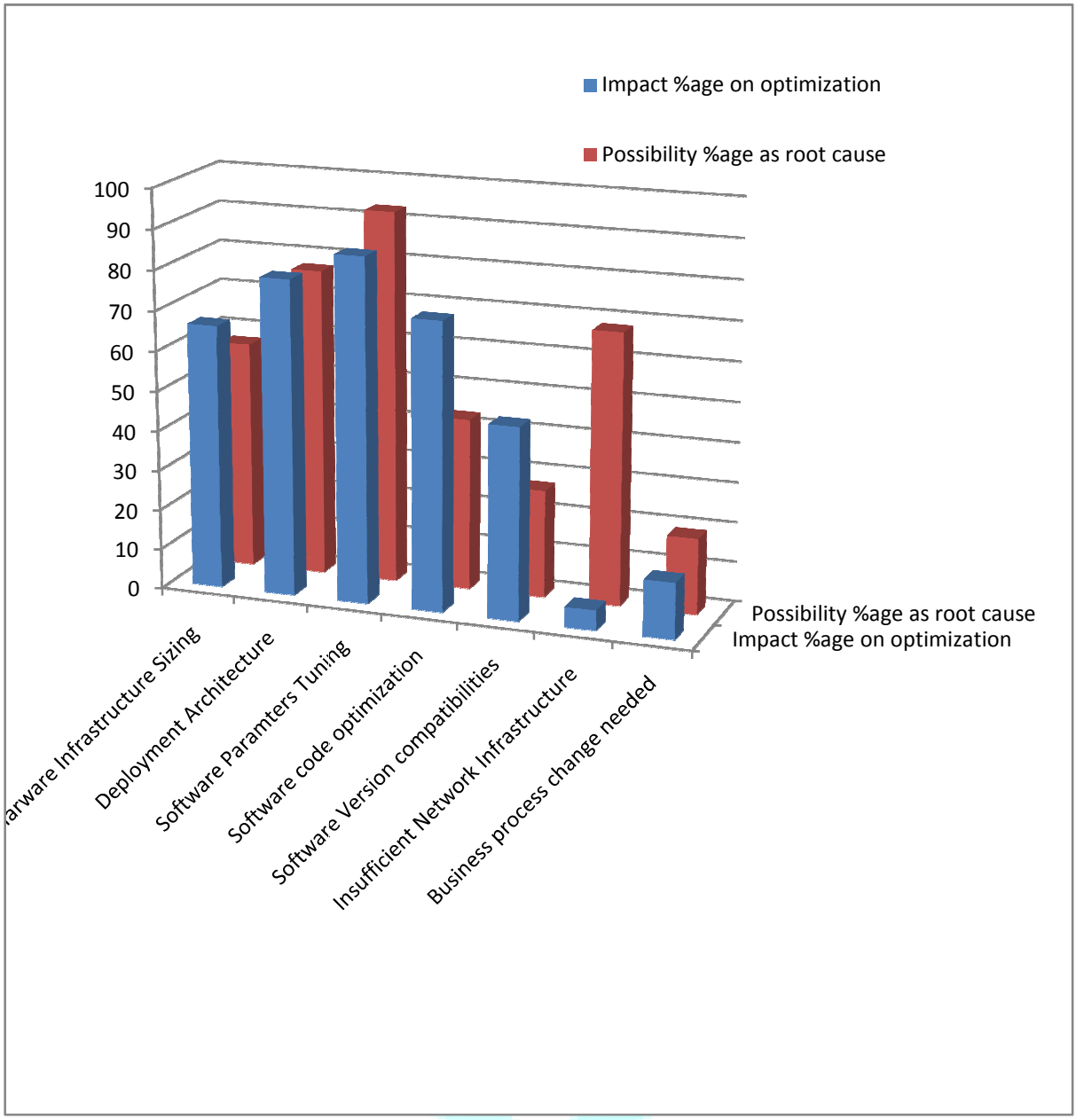


Answering the **eighth question** of the questionnaire, most of the respondents highlighted that there are network infrastructure constraints for remote sites. This is due to the fact that inter-continental network improvement is not in the control of individual companies. This will improve only when the network provider adapts to a new improved networking technology. Hence PLM system deployment team has to mitigate the network issue by designing **proper deployment architecture** and software application architecture.

4. ANALYSIS AND INTERPRETATION OF INTERVIEW SURVEY RESULTS

Figure3 below gives the summary of the **major potential areas** which greatly influence the overall PLM system performance and their possibility as root cause for PLM system performance issues.

FIGURE 3: SUMMARY OF THE MAJOR POTENTIAL AREAS



By reviewing the interview survey results presented in the previous section, the root cause "**Software Parameters need Tuning**" is ranked as the number one area which has maximum potential in optimizing the PLM system performance. This has been voted as the possible root cause for the current performance issues by more than 90% of the respondents.

The number two ranked area which has high impact on system performance optimization is "**Improper Deployment Architecture**". This area has been voted as the possible root cause for the current performance issues by nearly 80% of the respondents. The specific sub-area of the deployment architecture related to data distribution namely, "**Improper storage and distribution architecture of PLM data**" is ranked as number five. Around 50% of the respondents have selected this as one of the possible root causes for their current performance issues.

Two sub-areas in the **Hardware Infrastructure sizing** area are listed by more than 55% of the respondents as possible root causes for the PLM system performance issues. "**Insufficient CPU capacity**" is ranked fourth and "**Insufficient RAM**" is ranked as sixth on their impact on optimization of PLM system performance.

"**Bug in software application**" is ranked third based on its potential in achieving optimized system performance. Around 40% of the respondents voted this area as a possible root cause for their current performance issues.

"**Software Version compatibility issues**" is ranked seventh on its potential in achieving optimized system performance and only around 25% of the respondents voted this area as a possible root cause for their current performance issues.

"**Insufficient Network Infrastructure**" area has been listed as possible root cause by nearly 70% of the respondents. But its impact on optimization of performance has been ranked the lowest. This is due to the fact that improving the network infrastructure is practically very difficult and is not under the control of the auto companies. Network will improve only when the network provider adapts to a new improved networking technology. Hence PLM system deployment team has to mitigate the network issue by designing **proper deployment architecture** and software application architecture.

"**Change in Business needed**" has been ranked very low and less than 15% of the respondents voted this as the possible root cause. This is due to the fact that the necessary business process changes are already taken care of by the PLM implementation team during the "Business Process Re-engineering" step.

5. CONCLUSIONS FROM THE SURVEY

Based on the interview discussions based survey results analysis and interpretation; optimizing the product design IT system performance within the automobile industry, need to deal with optimization of the following **major potential areas** which greatly influence the overall product design system performance:

- **Hardware infrastructure Sizing** – Maximize the usage of available hardware. Most important factors while sizing the hardware infrastructure are:

- It performs the intended function correctly (**correctness**)
- Performs it efficiently (**performance**)
- Does so in a cost-effective manner (**Cost**).

A correct hardware size may not imply that it performs blazingly or is very cost-effective. It is necessary to **trade-off** performance or perfect correctness to save cost. Hence it calls for development of methods in sizing the hardware, where a trade-off between these three conflicting items in some logical manner is established to achieve optimized system performance.

- **Deployment Architecture** – Maximize the usage and architect the deployment within the constraints of network. Upgrading network infrastructure is practically very difficult and expensive. Consider end user's distribution and define the optimal deployment architecture based on available bandwidth and latency of the network. All CAD and other File system items are required to be shared across the all sites. Actual data is stored at Datacenter SAN and is to be shared across the locations.

  Distributed computing is used to increase the performance of operations that can be performed in parallel, by concurrently executing multiple operations. Operations may be distributed across multiple processes on a single CPU, taking advantage of multitasking, multiple processes across multiple CPUs, or across multiple machines. As operations are executed concurrently, ensuring synchronization between processes is essential to ensure correct results.

  As the trend of increasing the potential for parallel execution on modern CPU architectures continues, the use of distributed systems is essential to achieve performance benefits from the available parallelism. High performance **cluster computing** is a well known use of distributed systems for performance improvements.

  Load balancing is often used to achieve further gains from a distributed system by intelligently selecting which machine to run an operation based on how busy all potential candidates are, and how well suited each machine is to the type of operation that needs to be performed.
- **Software system Parameters Tuning** – Application software, Database, Operating system and Web server system parameters: Configure these systems with optimal parameters setting for best performance.
- **Software version compatibilities** – Upgrade to latest version for best performance. Maintaining software version compatibilities is a very challenging task with the fast changing software technology field. **Versions become obsolete very fast** and upgrading to latest will not always justify the costs involved with the upgrade.
- **Software code optimization** – Reduce customization and avoid memory lock-up. Switch to more "open" technologies such as SOA (Service Oriented Architecture), Virtualized platform, Cloud computing, J2EE, etc. Software code optimization is not in the control of auto companies. With multiple software applications deployed in the PLM system, it is **very difficult to optimize and coordinate** with individual software suppliers

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