

Metric Suite for Assuring the Quality of ERP Implementation and Development

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Abstract— Success of ERP implementation and development relies heavily on careful and accurate measurement of quality goals identified as part of the quality assurance and quality control exercise. A recent report published by Gartner Research revealed that organizations usually measure the effectiveness of ERP implementation and development in terms of time and budget than other factors such as quality of process, quality of product, and stability of requirements. In this paper we provide details of the metric suite designed by the third party Quality Assurance consultant to improve the outcome and help to accomplish successful completion of ERP project launched by the Ministry of Education, Saudi Arabia. The paper provides details of the quality goals, metrics selection criteria and metric suite defined for the purpose of assuring and controlling quality of the ERP implementation and development. This will serve as a source of knowledge for the researchers to refine and practitioners to identify their own quality goals and resulting metric suite based on their business needs and implementation environment.

Key words— ERP, ERP quality goals, metric suite, metric selection criteria

I. INTRODUCTION

The Enterprise Resource Planning (ERP) system is an enterprise wide computer based information system implemented for integrating and optimizing the resources, business processes and transactions in an organization on a common database [9][10]. It is basically a software architecture that facilitates the information flow among all business functions inside the organization boundaries and manages the connections to outside stakeholders [2]. An ERP system is generic in nature and supposed to implement the best business practices, which, as the vendors claim, are the result of painstaking research that reflect the practices followed by successful businesses all over the globe [19]. An ERP system is versatile in nature and supposed to make positive impacts on business, technology, task, people structure, culture, strategy, size and environment of the organization [19]. ERP helps an organization integrate data of all functional units that is used to achieve objectives such as reduce inventory, better human resource management, better supply chain management, better production planning, better resource utilization etc [9][19]. An ERP implementation, depending on size and nature of implementation, time ranges

from 1-3 years and costs 1-3% organization's turnover [19]. However, many ERP implementations failed for various reasons [3][12][13][14][15][20]. Besides this, approximately 75% organizations in US suffer some degree of failure in their ERP implementation [18]. The major symptoms for ERP failure are cost overrun, schedule overrun, system performance deficit or failure to achieve the expected benefits [13][18][19]. According to Panorama's year 2010 study, 57% of ERP implementations take longer than expected and 54% of ERP implementations go over budget [13].

A recent report published by Gartner Research revealed that organizations usually measure the effectiveness of ERP implementation and development in terms of time and budget than other factors such as quality of process, quality of product, and stability of requirements [7]. The result is that although organizations meet deadlines and budgetary requirements but lose what they intended to achieve that can satisfy all business requirements originally envisaged before launching the project. In other words, organizations usually put less focus on quality goals of ERP implementation and consequently this leads to the failure of the ERP system because such system simply fails to achieve envisioned business value. Therefore, in order to get the envisioned business value of the ERP system, it is highly necessary that organizations must clearly identify quality goals along with an accurate metrics suite that can help to achieve those goals.

The successful implementation of ERP system among other factors relies heavily on continuous and careful measurement of both product and process. As Tom DeMarco rightly stated, "You can't control what you can't measure"[1]. Therefore, in order to track the progress and quality of the ERP implementation, the team needs to identify correct suite of metrics along with their attributes that can provide a good picture so that the concerned stakeholders can take decisions based on the situation at hand. There are various methodologies defined for ERP implementation by vendors and consultants e.g., Application Implementation Methodology (AIM) [11], Transform [17]. But, these methodologies do not explicitly identify any metrics and key performance indicators for achieving quality and performance goals. To the best of authors' knowledge no such metric suite is also presented in the literature by researchers and practitioners.

In this paper we provide details of a metric suite that is designed to control and assure the quality of the ERP project's implementation and development launched by the Ministry of Education (MoE), Saudi Arabia. This metric suite is designed for the purpose of quality assurance (QA) to improve the outcome of the project and help to achieve its successful completion. We also provide details on how metrics data is analyzed to get clear insight of the project's progress that helps quality assurance team provide useful suggestions to implementation team throughout project life cycle. This metric suite can help organizations that are planning to implement ERP system to achieve better control of the ERP project implementation.

The rest of the paper is organized as follows: Section II provides a background of the Government Resource Planning (GRP) system launched by the Ministry of Education (MOE), Saudi Arabia. Section III discusses the quality goals defined for GRP project by third party quality assurance consultant. Metrics selection criteria are described in Section IV. Section V highlights various attributes that are identified to define a metric. Section VI provides some metric examples and finally we conclude and provide hints on the future work in Section VII.

II. PROJECT BACKGROUND

The Ministry of Education (MOE), Saudi Arabia, has launched an initiative to implement Government Resource Planning (GRP) in the Ministry. The purpose of the project is to implement a ministry-wide resource planning system to manage, integrate and use all the resources and information in the Ministry and its associated regional departments. This will provide communication channels between MOE's various departments on all levels and in all provinces which will cover 500,000 employees of the ministry. This is a key eGovernment project with the goal of automating the Ministry's operations and building the capability to deliver electronic services. When implemented, the system significantly enhances the infrastructure that supports education in the country, thus positively impacting current and future generations in many ways.

After considering the extent of the project with the goals to improve the outcome and help to accomplish its successful completion, the ministry has launched a separate Quality Assurance (QA) project. The project is carried out by a CMMI level-5 multinational organization. The overall objective is to provide a framework that supports the quickest possible GRP deployment, without sacrificing quality or functionality within allocated budget. That is, the successful implementation of the GRP systems in terms of:

- Functionality
- Quality of Service
- Schedule
- Cost
- Training
- Deployment
- Operation Readiness
- Post-implementation

III. QUALITY GOALS AND METRICS

It is important for the success of any project to define quality goals that can be tracked and monitored using quantitative measures [6]. The appropriate metrics explain how measurement can be applied for process improvement by providing objective ways of characterizing process capability and assessing the impact of process changes [1]. They also serve as the diagnosis tools that help QA team investigate the reasons for anything that goes wrong or that does not follow the predefined goals [16]. The same is true with MOE's GRP project. In order to achieve the aforementioned objectives, the QA project has defined quality goals that can be tracked and measured quantitatively using appropriate metrics, see Figure 1. The defined quality goals are:

A. Improve Delivery Performance

Attaining acceptable delivery performance is the most significant challenge faced by ERP implementation and development. The ERP implementation usually follows a phase-oriented plan-based (waterfall) approach in which each phase produces several deliverables. The decision to move on to the next stage highly depends on the availability of all the deliverables of the current/previous stage. Since implementing ERP system involves huge investment therefore missing even a single deadline may incur huge cost in terms of time, extra investment and loss of business. In order to prevent client from such cost it is essential that QA project must identify effective metrics and collect related data to make sure that all the deliverables are following the deadlines and execute contingency plans in case if missing any deadline is forecast by such measurement.

B. Improve Process Quality

Improving process quality is basically a series of actions taken to identify, analyze and improve existing process to meet quality goals and objectives. In doing so, one needs to keep checking the health of the existing process and take necessary corrective actions when things go awry. This can be achieved through suitable metrics that can give a clear picture of whether the process is adhering to predefined goals and is capable of meeting the client's expectation by delivering high quality ERP system. Metrics can provide good insight of each and every aspect of process and highlight the areas that need improvement. Therefore, appropriate metrics that can guide QA throughout ERP implementation life cycle are essential.

C. Improve Product Quality

Product quality is usually measured by the degree of conformance to predefined specifications, standards and expectation, and deviations from these can lead to poor product quality in terms of loss of functionality, low reliability and reduced availability etc. Improving quality of the ERP system is indispensable for the client organization because all the future business relies on this. The disruption of business due to poor quality may result in grave consequences for the organization. In addition, it is also very essential for the implementer to ensure that the delivered ERP system is of

high quality because failure to achieve so may result in throwing it out of the ERP consultancy in the competitive environment.

D. Improve Productivity (efficiency)

ERP implementation and development productivity can be improved by deploying and utilizing appropriate resources. It is imperative that the resources are utilized such that they are not burnt out and/or get into a race condition. Productivity measurement provides an insight into the causes of high and low productivity. Low productivity may result from inexperienced team, non-availability of proper resources, less control of management over the team members, earlier bad effort estimation etc. Similarly, high productivity may be misleading, for example, it may be because of generous effort estimation at the start of the project or not adhering to product quality goals due to hasty implementation. Therefore, it is highly necessary for the QA team to identify and collect appropriate productivity metrics and investigate the reasons in order to ensure that the ERP implementation is meeting predefined goals with satisfactory productivity and that there are no false positives that may jeopardize the ERP implementation objectives.

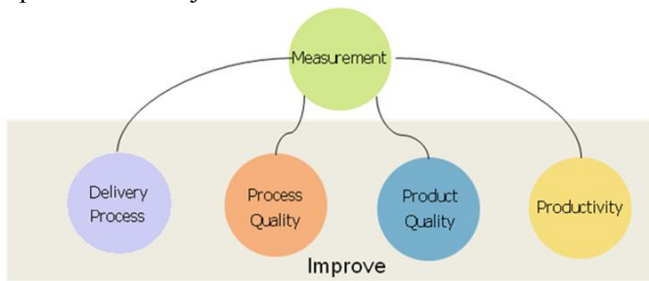


Figure 1. ERP QA measurement encompassing quality goals

IV. METRICS SELECTION CRITERIA

“Tell me how you will measure me and I will tell you how I will behave.” [8]

Identifying appropriate metrics has always been a challenge for any software engineering process [16]. The same is true with ERP implementation and development. There are various methodologies defined for ERP implementation by vendors and consultants e.g., Application Implementation Methodology (AIM) [11], TRANSFORM. But, these methodologies do not explicitly identify any metrics and key performance indicators for achieving quality and performance goals. Therefore, in order to achieve the aforementioned quality goals the QA project has identified various appropriate metrics after outlining selection criteria based on careful examination of defined quality goals. The criteria are:

- Metric should address at least one of the aforementioned quality goals.
- It should provide information that is useful in diagnosing and improving the addressed quality goal(s).
- Data for the metric should be available and can be gathered with relatively little difficulty.

- It should reveal, rather than conceal, the quality goal(s) and related parameters that it addresses.
- It should discourage false assumptions and facilitate improvement wherever possible.
- Metric should provide the basis for meaningful conversation among the stakeholders. It should provide a tangible sense of whether the addressed quality goal(s) can be achieved.
- Metric, wherever applicable, should preferably be available during periodic status update meetings throughout the implementation life cycle. This will amplify learning and quality improvement.
- It should be able to forecast addressed quality trend.

V. METRICS ATTRIBUTES

In order to understand and extract meaningful knowledge, it is beneficial to identify metric's attribute, see TABLE 1. This will help QA team clarify intention for metric usage; analyze metric outcome and provide useful feedback to stakeholders.

TABLE 1. METRIC ATTRIBUTES

Attributes	Explanation
Name	It should be uniquely chosen to avoid ambiguity and oversimplification.
Purpose	It should be very clear and express what aspect of quality it is addressing.
Assumptions and Prerequisites	It should be highlighted to understand data representation and data dependencies.
Measurement Unit	What is being measured should be expressed explicitly.
Frequency	It indicates when the metric will be collected, or collected and analyzed.
Analysis Trigger	It defines the threshold value or extent of deviation that will trigger a root cause analysis.
Analysis Procedure	Mentions the mechanism/system/tool through which data will be collected and analyzed. It also discusses what sort of visualization is used and where it is published. It should also discuss the expected and future trend, wherever applicable.
Source of Data	It should be easily available and regularly updated in order to reflect the intended quality goal(s) status. Also provide formula wherever applicable.
Granularity	It indicates the level at which the metric is collected.

VI. QUALITY GOAL METRICS – EXAMPLES

In the following, we provide details of a couple of metrics along with their attributes that are identified by the QA project [21].

TABLE 2. DEFECT REMOVAL EFFICIENCY (DRE)

Attributes	Explanation
Name	Defect removal efficiency
Purpose	It addresses the product quality improvement goal. The purpose of this metric is to improve the quality of the ERP system and to make sure that technical debt is not piling up that in the end may ensue in low reliability system.
Assumptions and Prerequisites	Defects are resolved on continual basis and with high efficiency. High efficiency ensures that development team is carefully coding the system and is committed to provide as reliable system as possible.
Measurement Unit	Percentage.
Frequency	At the completion of every build iteration.
Analysis Trigger	±5% deviation from the targeted efficiency.
Analysis Procedure	Conduct defect analysis according to work product review defect analysis procedure i.e., investigate the reason for deviation by analyzing defect severity, origin and effort spent.
Source of Data	Work product review reports and test defects log. $DRE = \frac{Defects_Removed}{Defects_Found} \times 100$
Granularity	Project level by each ERP track level.

TABLE 3. REQUIREMENT VOLATILITY INDEX (RVI)

Attributes	Explanation
Name	Requirement Volatility Index
Purpose	It addresses product quality improvement and delivery performance improvement goals.
Assumptions and Prerequisites	The frequent change in requirements leads to unstable architecture which in turn results in defective software that keeps troubling the users during operation. Moreover, the ability to adhere to project schedule is also highly dependent on mature and accurate requirements which prevents rework and saves time.
Measurement Unit	Percentage.
Frequency	Monthly.
Analysis Trigger	If the resulting estimated effort is greater than 10% of overall project effort.
Analysis Procedure	A simple graph displays the monthly status of requirements volatility index. It is expected to have a decreasing graph along the month time line. Investigate reason for change requests. If frequent change requests are taking place then postpone addressing minor requests.
Source of Data	Change request logs and resulting effort estimation.

	$RVI = \frac{Change_Requests}{Total_Requirements} \times 100$
Granularity	Project Level - quantity by type and status by month

Space does not allow explanation of numerous metrics here that are identified by the QA project for ERP implementation and development, so they are simply outlined (further detail may be obtained from the authors). Following are some metrics deemed useful in context of the MoE's ERP project – of course, the reader must judge whether they are also useful in his or her own environment.

- Schedule Variance
- Effort and Effort Variance
- Customer Satisfaction Index
- Number of Issues Pending
- Milestones Completed in Time
- Post-Release Defects
- Major Defects Per Business Process
- Pre-Release Defects
- Risk Mitigated in Time
- Test Coverage

VII. CONCLUSION AND FUTURE WORK

The successful implementation of ERP system among other factors relies heavily on continuous and careful measurement of both product and process. Quality goals need to be defined that help discover appropriate metrics that can be used to gauge the progress of ERP implementation and development. The GRP project at MoE has identified four quality goals and based on predefined metric selection criteria, a metric suite is defined. The selection criteria discussed in Section 4 and attributes table provided in Section V are expected to help practitioners devise their own measurement plan based on the quality goals identified.

The ERP project at MoE is still in the implementation phase. The designed metric suite is operational and being validated. The authors expect to report on the findings and the validation results once the project's implementation phase is over and rolled out for operation.

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REFERENCES

- [1] B. A. Kitchenham, *Software Metrics: Measurement for Software Process Improvement*, Blackwell Publishers, Inc., ISBN:1855547651.
- [2] B. Hossein, *The Internet Encyclopedia*, Volume 1, John Wiley & Sons, Inc., 2004
- [3] S. Buckhout, E. Frey and J. Nemec, "Making ERP Succeed: Turning Fear into Promise, Strategy and Business", 2nd Quarter, 1999.
- [4] D. Hartmann and R. Dymond, "Appropriate Agile Measurement: Using Metrics and Diagnostics to Deliver Business Value", *Agile Conference*, 2006, pp. 134.
- [5] D. Tom, *Controlling Software Projects: Management, Measurement and Estimation*, ISBN 0-13-171711-1.

- [6] N. E. Fenton and S. L. Pfleeger, *Software Metrics: A rigorous and Practical Approach*, Second Edition, PWS Publishing Company, 1997.
- [7] G. V. D. Heiden, "Essential Metrics for Outsourcing ERP Services", *Gartner Research*, ID: G00175075, May 24, 2010.
- [8] E. M. Goldratt, *The Haystack Syndrome-Sifting Information Out of the Data Ocean*, North River Press, 1990.
- [9] V. Kumar, B. Maheshwari, U. Kumar, "Enterprise resource planning systems adoption process: A survey of Canadian organizations," *International Journal of Production Research*, Vol. 40, pp. 509–523, 2002.
- [10] J. Motwani, R. Subramanian and P. Gopalakrishna, "Critical factors for successful ERP implementation: Exploratory findings from four case studies," *Computers in Industry*, Vol. 56(6), pp. 529–544, 2005.
- [11] Oracle Method – AIM for Business Flows Solution Delivery Guide, Oracle, Volume 1, Release 1.4, September 2006.
- [12] P. Iskanius, "The ERP project risk assessment – A case study," *Proceedings of the World Congress on Engineering*, Vol. 1, London, UK, July 1-3, 2009.
- [13] 2010 ERP Report, Panorama Consulting Group. Available: <http://panorama-consulting.com/resource-center/2010-erp-report/>
- [14] G. L. Richard, The 12 Cardinal Sins of ERP Implementation, February 2009. Available: <http://www.articlebase.com>
- [15] C. Stedman, "Failed ERP gamble haunts Hershey," *Computer World* 33(44), pp. 1–2, 1999.
- [16] S. H. Kan, *Metrics and Models in Software Quality Engineering*, 2nd Edition, Addison-Wesley Longman Publishing Co., ISBN: 0201729156.
- [17] Transform, TATA Consultancy Services. Available: <https://knowmax.ultimatix.net/sites/kbank/TechnologyOfferings/TCSOracleEBSOfferingBrochureEnd-to-EndImplementationv1.doc>
- [18] E. J. Umble et al., "Enterprise Resource Planning: Implementation and Critical Success Factors," *European Journal of Operations Research* 146, pp. 241–257, 2003.
- [19] V. Bansal and T. Negi, "A Metric for ERP Complexity," *Springer-Verlag, LNBIP* 7, pp. 369–379, 2008.
- [20] C. Vogt, "Intractable ERP A Comprehensive Analysis of Failed Enterprise Resource Planning Projects", ACM SIGSOFT Software Engineering Notes, pp. 62–67, 2002, Vol. 27(2).
- [21] *Quality Management Plan*, FARIS Project, Ministry of Education, Riyadh, Saudi Arabia, 2010.