

Measuring and Improving Process Capabilities – Best Practices

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Abstract:

*This paper discusses how software projects following different processes, which display disparate characteristics, have been categorized and analyzed using statistical techniques to measure and improve process capability. **The analysis shows that language type, size of the application and complexity (represented by ratio of Total Project Effort to Build Phase Effort) are the predominant discriminating factors affecting quality and process parameters.** Categorization done based on this stratification scheme results in minimum variation within the group concerned. Such logical grouping also facilitates meaningful comparison of a project performance with almost similar historical data.*

Key words – Process Capability Baselines, stratification, cluster analysis, rational subgrouping

Authors Biography

Jyoti M Bhat is Bachelor of Engineering in Electronics & Communication from University of Bangalore. She is working with Infosys since August 1993. At present, she is member of SEPG in Quality Department and performs the role of Program Manager, Metrics Management and Technology Change Management. Besides, she is actively involved in CMMI implementation, CMM assessments, internal audits and process training. She has been driving various working groups for process improvement. She also has very rich experience of delivering business critical IT solutions to Fortune 500 organizations.

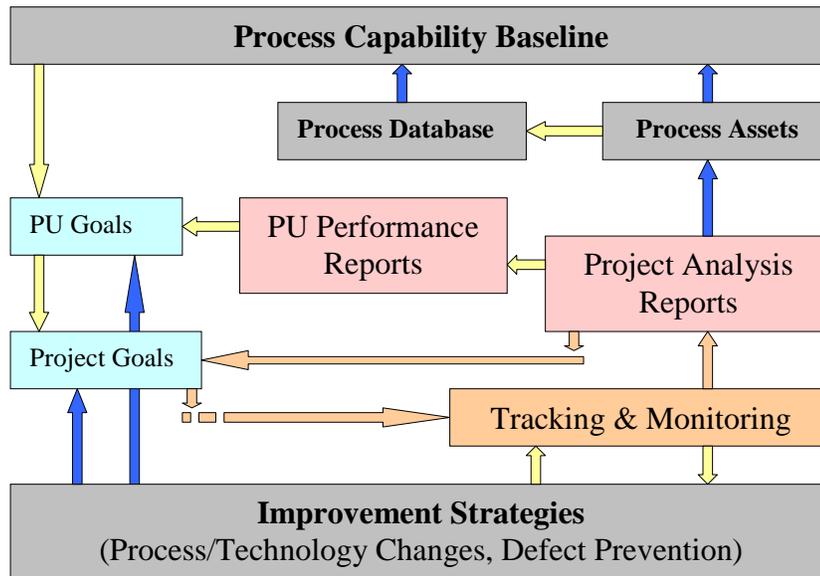
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Brief description of the Organization environment

Infosys (NASDAQ: INFY), a world leader in consulting and information technology services, partners with Global 2000 companies to provide business consulting, system integration, application development and product engineering services. Through these services, Infosys enables its client to fully exploit technology for business transformation. Clients leverage Infosys’ Global Delivery Model to achieve higher quality, rapid time-to-market and cost-effective solutions. Infosys has over 10,000 employees in over 30 offices worldwide. For more information, please visit www.infy.com

Well-defined engineering processes and methodologies are available to execute projects in various domains using various software environments on variety of hardware platforms. Project specific modifications/ variations in the processes/ methodologies are allowed to suit the specific requirements. Such tailoring is done in accordance with properly established guidelines.

Framework of Metrics Program in Infosys



Metrics is extensively used throughout the organization to set goals and monitor performance. Process Capability Baseline (PCB), Process Database (PDB) and Process Asset System are the mainstay of Infosys' metrics program. They contain the historical data of processes and projects in Infosys. PCB contains the actual performance in terms of quality and productivity at the organization level. PDB contains detailed metrics of all projects executed, while Process Assets system contains the work products and other assets developed during the execution of the projects. Every Practice Unit (PU) sets its improvement goals based on the business plans and the historical data. The projects use the PCB, PDB and Process Assets for estimation and deciding improvement strategies. Every project decides upon an improvement target over and above estimated values. These plans are supported by well-laid strategies and form the basis for setting up project level goals in terms of quality, effort, schedule and productivity.

During the project execution progress is tracked on regular basis and stock is taken at predefined milestones. Deviations are analyzed and necessary corrective actions are initiated. This helps to assess the effectiveness of the improvement strategies.

When the project is completed, a thorough analysis of its actual performance is done with respect to the goals set and deviations are analysed. This is stored in the PDB and used for the following:

- Assessing current organization levels of performance in quality, productivity & cycle time
- Assessing current levels of process performance
- Establishing process capability baselines
- Setting process performance improvement goals

The improvement opportunity at hand

At a gross level, major steps involved in delivering IT solution look similar. These are requirements gathering & analysis, design, building and testing the application, verification, validation and installation. However, the processes followed in each project vary significantly owing to a range of factors like nature of service offering, business domain, criticality and complexity of application, technology and so on. Consequently, quality and process performance parameters pertaining to these processes also differ considerably.

Business Impact

Improving the capability of software processes is imperative for achieving organizational business goals. Therefore, the entire gamut of process improvement throws up two major challenges to the practitioners:

- Firstly, how to measure the capability of existing processes right so that it reflects the true picture of different process variants and
- Secondly, how to improve them based on measurement results.

Problem Identification

The methodology of measurement of process capabilities and establishing natural bounds for quality and process performance has evolved over a period of time. During its course, it was observed that variability of some process performance parameters is quite high (standard deviation $\geq 0.3 * \text{mean}$). This led to very wide control limits and changes in quality and productivity were not visible. Shift in mean was not found to be statistically significant due to high variability.

Motivation for improvement

Setting up of clear and achievable productivity & quality goals and their regular monitoring is vital for success of projects. Therefore, it is important to provide the process users with process capability baseline and clear guidelines for estimating & monitoring various quality and process performance parameters. Using the a project can predict, at a gross level, the effort that will be needed for various stages, the defect densities likely to be observed during various defect detection activities and quality and productivity for the project.

Goals set

- Improve estimation, monitoring and control of quality and process parameters by minimizing variation within a rational subgroup
- Ensure visibility of significant changes in quality and process performance parameters
- Identify and correct assignable causes of process variation and provide inputs for process improvements
- Enable meaningful comparison of quality and process performance
- Ensure ease and consistency in usage of capability baselines
- Define a clear methodology for maintenance of capability baselines

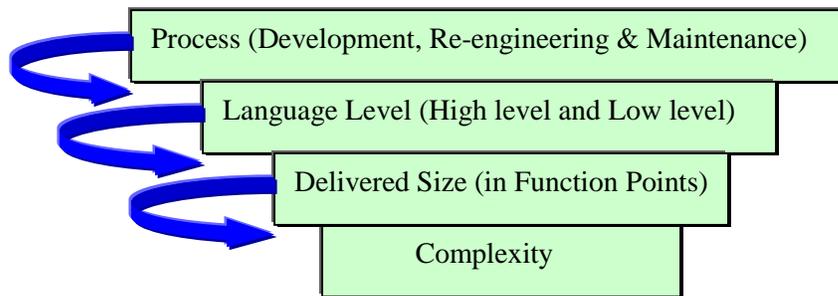
Steps taken to solve the problem and achieve objectives

A) Stratification

In Infosys, projects are executed using Engineering processes. Engineering processes are of two types: Life Cycle Processes and Management Processes. Some of the major Life Cycle Processes are – Development, Re-engineering and Maintenance. Attributes of these processes can be tailored as per predefined guidelines, to suit the project specific requirements. Therefore, steps

followed in different project might vary significantly, leading to dissimilar results. Hence, it is necessary to stratify the projects to gain further insight into their performance.

Statistical analysis is performed to classify the projects into various subgroups so that variation within a subgroup is the least. Stratification and Cluster Analysis revealed that, at present, the following stratification hierarchy provides the optimum results:



Notes:

- If the level of a language is 6 or more as per Capers Jones Table then it is considered as high level, e.g. Visual Basic, JAVA etc.
- Complexity is represented as ratio of Total Project Effort to Build Phase Effort. Build phase consists of Coding and Unit Testing. As project becomes more and more complex due to factors like domain, technology etc., this ratio also increases, since more effort is required in requirement analysis, design and testing stages.

Using this scheme, Development or Reengineering projects can be classified as below:

- Language level (High level and low level).
- Size and Complexity Classification
 1. Type 1 - Small projects, low Total/Build Effort ratio
 2. Type 2 - Small projects, high Total/Build Effort ratio
 3. Type 3 - Large projects, low Total/Build Effort ratio

4. Type 4 - Large projects, high Total/Build Effort ratio

The exact threshold values of size and Total/Build Effort for different processes and language level combinations are provided in the capability baselines.

This stratification scheme is chosen because it provides the clusters of projects having minimum variation within them.

B) Use of appropriate probability distributions

It is extremely important to choose appropriate probability distribution to model the behavior of quality and process performance parameters. Goodness of fit was established for different parameters such as Productivity (Function Points/person month), Cost of Quality (%), Delivered quality (No. of delivered defects/ size of software), Defect Injection Rate (No. of defects/ person hours). Based on this, suitable control charts are selected to establish the control limits. Following table summarizes this analysis:

Parameter	Applicable Probability Distribution
Productivity (Function Points/ Person months)	Normal
Cost of Quality (% of total project effort)	Normal
Effort Distribution (% in different life cycle stages)	Normal
Defect Detection Distribution (% in different life cycle stages)	Normal
Defect Injection Distribution (% in different life cycle stages)	Normal
Delivered quality (No. of delivered defects/ size of software in Function Points),	Poisson
Defect Injection Rate (No. of defect/ person hrs)	Poisson
Defect Removal Effectiveness (%)	Binomial
Failed Serviced Requests (No. of failed requests/ Total no. of serviced requests)	Binomial

This approach yields meaningful process control limits.

C) Use of percentile values for prediction

Owing to inherent variation in the process caused by factors like business domain, technology and service offerings, 15th and 85th percentiles are taken as lower and upper permissible values for productivity and cost of quality. This ensures better predictability and provides opportunity for process improvement.

D) Introduction of scaling factors for attribute charts

Use of 'u' chart may lead to inappropriate control limits where parameter values are small fraction. Therefore, use of scaling factors is introduced to make the control limits meaningful. For example, delivered defects is represented in terms of Delivered defects/ 1000 FP. Similarly, defect injection rate in coding is represented as defects/ 100 person hours. To take care of such situations, 'c' chart can also be used after normalizing the parameter concerned.

E) Baseline Maintenance

Capability baselines are published separately for each life cycle processes. Apart from this, language specific baselines are also provided for commonly used languages e.g. JAVA, VB, COBOL. Changes in capability baseline are incorporated due to:

- Changes in process
- Changes in organizational results
- Changes in business objectives

Well-defined and documented methodology is available for periodic baseline maintenance. It involves deciding sample size, conducting statistical tests for checking significant performance differences, trend analysis, root cause analysis, a mechanism for reporting to senior management and providing feedback for reviewing organizational improvement objectives.

Obstacles encountered and steps taken to overcome them

A) *How to classify project as small and large, or decide upon their type in the initial stage where bottom up estimation is done and size in function points is not known?*

Steps taken:

- ✓ Provide a list of recently completed projects in each category as a reference to capability baseline. People can find the details of such project from organizational process assets repository and use the past results as an aide in project classification
- ✓ Publish the mean values and confidence intervals of typical parameters of completed projects in each categories, such as Total Project Effort, Build Phase Effort, Elapsed days, Peak Team Size etc. These values can provide a guideline for deciding on project type.

B) *How to ensure consistency in understanding and usage of capability baselines?*

Steps taken:

- ✓ Prepare and publish user guidelines with sample illustrative usage of the capability baselines.
- ✓ Provide training to persons responsible for software quality assurance

Results obtained with respect to the goals

A) Improved estimation, monitoring and control of quality and process performance parameters using process capability baselines

B) It was found that if due importance is given to review of early life cycle stages deliverables then defect injection rate in coding reduces to nearly one third. This provided inputs for process improvements such as :

- ❖ Rationalization of reviews
- ❖ Defect Prevention program in Requirements and Design stages

- C) Improvement in Quality and Productivity
- D) Ease of use reported by project managers since it provides more realistic basis for project estimation, monitoring and control
- E) Since capability baselines are generated and published separately, so their maintenance has become easier.
- F) Periodic analysis of process tailoring provides opportunities for new process definitions and improvement. To name few, Production Support, Testing, Parametric Tailoring, Reuse processes have been defined in last one year.
- G) Effort monitoring and control models

Going ahead

- ❑ Regular analysis of process performance to look for identification of more stratifying variables. This will facilitate continuous process improvement.
- ❑ Definition of tailored processes for monitoring and control of critical projects to ensure better customer value.
- ❑ Evolution of estimation methodologies for emerging technologies and new services
- ❑ Defect prediction based on their severity using statistical models and Orthogonal Defect Classification.

Challenges faced

- ❑ Convincing middle management and project managers about changes in methodology
- ❑ Ensuring that capability baselines are used in consistent manner for various aspects of process control

Lessons learnt

- ❑ Provide self-explanatory guidelines with reference illustrations for users to ensure that changes are well understood and uniformly implemented across the organization.
- ❑ Orient people on proposed changes in structured and regular fashion.
- ❑ Involve stakeholders in refining the methodology and implementing associated changes
- ❑ Continuously look for opportunity for fine tuning rational subgrouping
- ❑ Environment scanning and literature survey for validating the proposed changes in methodology