

Getting the Benefits from Software Process Simulation

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Abstract

Software Process Simulation is directly linked to software process improvement. Organizations can use software process simulation at all levels of maturity to obtain significant benefits. Some of the key benefits of Software Process Modeling include:

- Improved organizational decision making
- Justification for process improvement initiatives
- Predicting the impact of process changes before they are actually implemented

and a number of others. This paper discusses some of the key benefits that can be obtained by companies that engage in software process simulation projects.

Introduction

Being essentially a non-industry forty years ago, software development is now a \$100 billion per year business. Software is replacing hardware as being responsible for much of the functionality provided by systems. With this increased role for software, problems related to the maturity of software development practices are beginning to be recognized. These problems show up as cost and schedule overruns, and a customer perception of low product quality. With the tremendous demand for more complex systems, companies are addressing these problems with an emphasis on software process improvement, improved process performance and increased process maturity.

Software Process Simulation has been used to address a variety of management issues and questions [5]. These include:

- Strategic management
- Planning
- Control and operational management
- Process improvement and technology adoption
- Understanding
- Training and learning

Just as the requirements for a software system drive the system design, implementation strategy, development tools used, and so forth, the questions being asked of a software process simulation model drive the data that needs to be collected and the selection of the modeling paradigm to be used. In this position paper, I will focus on addressing the questions pertaining to process planning, control and operational management, and understanding. The simulation paradigms that I will refer to in this discussion are state-based and discrete event simulations although some of these comments will apply to other paradigms (such as system dynamics) as well.

Major Benefits Provided

Software Process Simulation is directly related to software process improvement. Some of the most important benefits that software process models have been used to provide include:

- Improved organizational decision making
- Justification for process improvement initiatives [8]
- Supporting quantitative prediction of project level performance in terms of cost, quality, and schedule [7, 10]
- Predicting the impact of process changes before they are actually implemented [8]

Paper appeared in: Raffo, "Getting the Benefits from Software Process Simulation", International Conference on Software Engineering and Knowledge Engineering (SEKE'99), Held in Kaiserslautern, Germany, June 1999.

- Establishing a framework for selecting core process and product metrics [9].
- Providing supporting information to determine financial measures of performance such as Return on Investment and Net Present Value and so forth [11].
- Providing a quantitative assessment of the risk or uncertainty associated with various process alternatives [10].
- Providing extensive "what if" analysis capability for assessing multiple process alternatives under probable business conditions and scenarios [8]

Important Benefits for Lower Maturity Organizations as Well

Software process simulation models can provide key benefits for lesser maturity organizations as well. In general, companies wait too long before they attempt software process simulation. They then expect more from these models than can reasonably be provided.

Software process simulation can help companies from early stages of process maturity. First, the graphical capabilities of software process simulation can help companies plan and define their processes and process changes (Capability Maturity Model (CMM)[6, 7] Level 2 Activities). These models can be developed to a fine level of granularity and can provide a great deal of assistance in communicating and understanding a company's software development process. Kellner et al. at the Software Engineering Institute developed a method for graphically encoding process information and applied this to several complex software development processes [3, 4]. This modeling approach captured the four views related to complex business processes (behavioral, functional, organizational, and informational)[2].

In several case studies conducted by the author [8, 10, and other work], process models have been used to define processes and process changes, to revise and sharpen metrics programs and to support process improvement decisions. It has been our experience that the graphical

capabilities of software process simulation can be excellent for providing understandable and usable diagrams of software development processes. These diagrams can then be used as a vehicle for identifying problem areas in a process and facilitating consensus building about processes among developers.

As a company's software processes are defined, the company will collect metrics in order to support their project planning and management goals. These goals may include improved cost estimation, improved cost and schedule tracking and so forth. Software process models can provide a great deal of help in several ways:

- Refining goals for metrics collection, focussed to support the prediction of process performance
- Providing a rationale for retaining or eliminating various metrics
- Identifying points in the process where metrics can be collected
- Defining the mechanism for collecting the metrics

In the above mentioned case studies, the motivation for developing the process models was to quantitatively predict project performance and analyze process alternatives using the simulation models. This goal was used to make decisions regarding what kinds of metrics and data would need to be collected. Questions were also developed using the GQM paradigm [1]. The graphical process models saved time and effort by enabling groups to more quickly and realistically define metrics as well as define how the metrics data would be collected and by whom.

Once a company has well defined processes and a set of core metrics in-place, process models can be applied to provide their full potential to support the planning and process improvement decisions as mentioned above. Moreover, the benefits of predicting project level performance: (i.e. assessing financial measures of performance improvement, quantitatively assessing risk and supporting "what if" analyses) can be achieved. Higher maturity organizations are likely to have more accurate and detailed quantitative information about their processes. This naturally supports better quantitative predictions of project performance. The key point however, is that software process simulation can be used by

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organizations at all levels of maturity to their advantage.

We have worked with companies to develop an integrated modeling and metrics framework to support quantitative project management and control decisions [9]. This framework called the Process Tradeoff Analysis Method uses a "snapshot" concept for developing up-to-date sets of metrics data which are used to create timely model parameters to provide more accurate predictions of process performance. This approach supports several of the more advanced CMM KPAs including the CMM Level 4 key practices related to Quantitative Process Management and Software Quality Management. It also provides a foundation for CMM Level 5 Process and Technology Change Management, and continuous software process improvement.

Companies Sometimes Have Unrealistic Expectations

Software process simulation models are ideal tools for conducting controlled experiments under consistent, quasi-realistic conditions and assumptions. This is something that is very difficult to do in industry due to the expense of conducting multiple replications of the same development activity and variations among developers. Hence, the information provided by simulation models is highly useful and, in some sense, provides one of the most objective standards against which to compare process alternatives. However, given the highly variable nature of software development activities and the low quality and quantity of data that is available in some organizations, it can be very difficult to make exact predictions of project level performance. In short, like any model, the predictions are as accurate as the data used to make them.

Second, when used correctly, software process simulation models can be of an enormous benefit to an organization. However, like any development tool, people need to be trained to use process simulation and a sustained commitment by the organization to develop the model in an iterative fashion are key to getting the maximum benefit. In short, software process simulation models are not "shrink wrapped software".

Summary

Software Process Simulation is directly linked to software process improvement. Organizations can use software process simulation at all levels of maturity to obtain significant benefits. Although benefits such as:

- Improved organizational decision making
- Justification for process improvement initiatives
- Predicting project level performance
- Predicting the impact of process changes before they are actually implemented
- Assessing financial measures of performance improvement
- Quantitatively assessing risk
- Supporting "what if" analyses Predicting project level performance
- Refining metrics programs
- Sharpening software development processes

can be achieved with "full" implementations of simulation models, partial implementations (which can be done by lower maturity organizations) can be highly useful for improving process understanding, communication, and training, and supporting metrics definition and refinement. All of these are vital aspects associated with making sound project management and planning decisions. Software process simulation also supports several of the more advanced CMM KPAs including the CMM Level 4 key practices related to Quantitative Process Management and Software Quality Management. It also provides a foundation for CMM Level 5 Process and Technology Change Management, and continuous software process improvement.

Biographical Information David M. Raffo, Ph.D.

Dr. Raffo received Ph.D. and Masters degrees in Engineering and Business from Carnegie Mellon University. His current research is in the area of strategic software engineering related to software process management, design, and metrics. His dissertation work developed a theoretical framework and quantitative techniques for predicting the performance of software development projects. The concepts and theories have been field tested at leading software development firms. Dr. Raffo has forty refereed

Paper appeared in: Raffo, "Getting the Benefits from Software Process Simulation", International Conference on Software Engineering and Knowledge Engineering (SEKE'99), Held in Kaiserlautern, Germany, June 1999.

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References

- [1] Basili and Weiss, "A Methodology for Collecting Valid Software Engineering Data", IEEE Transactions on Software Engineering, vol. SE-10, no. 6, Nov. 1984, Pgs 728-738.
- [2] Curtis, B., Kellner, M. I., Over, J., "Process Modeling", Communications of the ACM, Vol. 35, No. 9, September, 1992.
- [3] Kellner, M.I., and Hansen, G.A., Software Process Modeling. Technical Report. CMU/SEI-88-TR-9, DTIC: ADA197137, Software Engineering Institute, Carnegie Mellon University, May 1988.
- [4] Kellner, M.I., and Hansen, G.A., Software Process Modeling: A Case Study. *Proceedings of the 22nd Annual Hawaii International Conference on System Sciences - Vol. II - Software Track*, IEEE, 1989, pp. 175 - 188.
- [5] Kellner, Madachy, and Raffo, "Software Process Modeling and Simulation: Why, What, How," Journal of Systems and Software, Number 5, 1999.
- [5] Paulk, M.C., Curtis, W., Chrissis, M.B., Weber, C.V., "Capability Maturity Model for Software, Version 1.1", Technical Report SEI-93-TR-24, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA., February 1993.
- [7] Paulk M.C., Weber C.V., Garcia S.M., Chrissis M.B., and Bush M., "Key Practices of the Capability Maturity Model for Software, Version 1.1", Technical Report SEI-93-TR-25, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA., February 1993.
- [8] Raffo, D., Modeling Software Processes Quantitatively and Assessing the Impact of Potential Process Changes on Process Performance, Ph.D. Dissertation, Graduate School of Industrial Administration, Carnegie Mellon University, Pittsburgh, Pennsylvania, 1996.
- [9] Raffo, Harrison, Keast and Vandeville, "Coordinating Quantitative Software Process Models and Metrics to Manage Software Projects", Proceedings of the Second International Workshop on Software Process Simulation Modeling (ProSim'99), Held in Silver Falls, Oregon, June 27-29, 1999.
- [10] Raffo, Vandeville, and Martin, "Software Process Simulation to Achieve Higher CMM Levels," Journal of Systems and Software, Number 6, 1999.
- [11] Raffo, Settle, and Harrison, "Estimating the Financial Benefit and Risk Associated with Process Changes", First Workshop on Economics-Driven Software Engineering Research, International Conference on Software Engineering (ICSE 99), Los Angeles, California, May 1999.