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GRANULARITY, AFFORDABILITY AND UTILITY IN BUSINESS PROCESS SIMULATION

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ABSTRACT

This paper seeks modeling guidelines by which project teams may respond confidently to the client's urgency while simultaneously assuring valuable and valid analyses. We conclude that "de-scoping" is the only reliable approach for accelerating a business process simulation project in response to client pressures. A thought experiment supports this conclusion.

1 INTRODUCTION

Recognition of the value of business process simulation has emerged in recent years (Hansen, 1998; Profozich, 1998). However, as appreciation rises, so does urgency. Appalled by the realization of how costly, non-competitive, and otherwise ineffective current processes are, client executives often demand rapid results from business process simulation projects. Time-to-market for business process engineering work is every bit as important as the cycle time of the modeled process.

Drawing on our experience with the "project process" of business process simulation development, we seek modeling guidelines by which the project team can respond confidently to clients' urgency while still assuring valuable, valid analysis results. In the following section, project management and control realities suggest that generally "de-scoping" the simulation is the only reliable approach to accelerating a business process simulation project. We then consider how the process experts on whom the simulation project team must rely also encourage "de-scoping" the process model. We then present our experience-won insights about approximating activity times as a technique to "de-scope" the data collection phase of a business process simulation project. Lastly, we discuss our disappointing thought experiments to infer guidelines about when and how to use "high-level" process modeling (i.e., with few details) while still assuring utility of the simulation results.

2 PROJECT BALANCE

Every project manager confronts a reality packaged neatly in the old saw: "You can have it fast, you can have it good, you can have it cheap—pick two." Figure 1 presents an influence diagram depicting the usually conflicting relationships among cost, quality, and schedule in business process simulation projects. Analysis of this figure exposes complex and unpleasant realities of a balance in simulation project management.

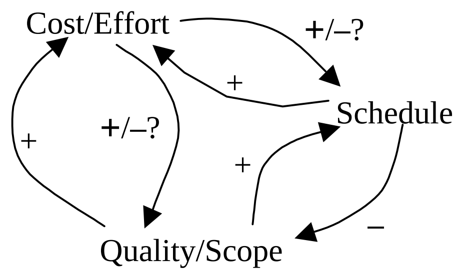

Figure 1: Influence Diagram of Project Balance

As the breadth and depth (i.e., scope) of a business process simulation increase, so will the effort, schedule, and cost of the project. As the schedule extends (e.g., through delays or other difficulties in obtaining needed data), the cost of dedicating the project resources will rise.

The reverse relationships to cost overruns are not always consistent. As the cost or effort alone increase (e.g., due to misestimating the productivity of a simulation staff, or to misestimating the labor or other costs), the project manager may "crash" (accelerate) the schedule (e.g., "I'm spending all this money anyway, so…"), or conversely "stretch" the schedule by assigning less costly, less productive, inexperienced staff. Also, as the perceived cost increases, either the project manager may decide to "de-scope" the project by eliminating features from the business process simulation, or the manager may decide to expand the scope in an attempt to justify the increased project cost by "delivering more value."

Finally, project delays trigger immediate cost increases (project labor tied up unexpectedly longer), which typically provoke a de-scoping response from the project manager or client.

However inconsistent all the cause-effect relationships may be, the balance among cost, schedule, and scope in business simulation projects tends to force a "de-scoping" in reaction to unexpected cost or schedule overruns—or, equivalently, to client urgency. Reducing project scope in business simulation generally takes one or more of the following forms:

- Devote low effort to estimating the activity times and their associated probability distributions
- Model the business process at a "high level," i.e., with little detail
- Simplify the business rules that define jointly the structure of a modeled business process and the conditional flow of work among the resources, queues, and activities of the process

Taking one or more of these actions, the project manager can minimize damage to the cost and schedule of the business process simulation project. However, *the decision-making value of the business process simulation results from accurate estimates of process cycle times and resource bottlenecks.* Can the project manager rely on any of the methods above to control project schedule and cost while assuring the decision-making value of the results?

3 APPROPRIATE EXPECTATIONS

In contrast to most manufacturing and distribution applications, business process simulations rely on human beings to provide nearly all information that could comprise a model. Understanding the unique human constraints of the process experts can help the project team formulate an appropriate perspective on limits to business process simulation quality.

Early in all business process simulation work, the project team will interview process experts who acquaint the simulation modelers with the process subject matter, activities, inputs, outputs, intermediate entities, resources, queues, arriving workload, and governing business rules. Both current process performers ("as-is") and prospective process designers ("to-be") are generally comfortable talking about the "what" of the business process. Difficulties do often arise in identifying queues, which are frequently invisible or physically subtle in business processes (and in contrast to manufacturing). In addition, business rules (especially those regarding queues) are challenging to elicit from the process experts.

The "process immaturity" of the parent organization explains some of these difficulties (Paulk, et al, 1994). With reference to the Software Engineering Institute (SEI) Capability Maturity Model, business process engineering efforts often attempt to assist organizations at "Level 1" and "Level 2" of process maturity. Processes of a Level 1 organization succeed through non-repeatable, heroic performances of individuals. Process communication in a Level 1 organization is ad hoc in the sense that process performers talk to one another about the non-repeatable specifics of their immediate work, and not about the overall process they perform. "How could we make this process better?" is a question that arises only informally and infrequently.

An organization of Level 2 maturity often has defined, repeatable, even documented management processes, but has its core business processes (i.e., those that produce the goods and services of the enterprise) only documented at the task level (e.g., task instructions). Functional departments organize, manage, and reward core business process performers, who lack perspective and real visibility of the end-to-end business process.

Business process simulation projects that address organizations of Level 1 or 2 maturity inevitably encounter process experts who have an incomplete "picture," and who have given little or no thought to a project team's tough questions about queues and business rules. Questions of a quantitative focus, such as activity times or workload arrival rates, are even more vexing—with reference again to the SEI Capability Maturity Model, only an organization of *Level 4* maturity would have institutionalized and managed itself with quantitative measurements across the enterprise.

Thus, the business process simulation project team can almost always expect to encounter individuals who really do not know off-hand the information necessary for modeling a current or future process design. Without question, Level 1 process performers find the typical "data call" a provocative, intimidating experience ("Why don't I know these things? I do this job."), and both Level 1 and 2 performers realize that obtaining answers will take a great deal of time away from very difficult, urgent, essential everyday work. With ineffective leadership, process performers may become extremely reluctant or even intransigent about providing modeling information at a realistic level of detail. Thus, not only cost- and schedule-pressures but also the inherent inertia of process experts favor "de-scoping" measures as a path of least resistance to complete the business process simulation.

The psychological challenge to effective business process information gathering is to prevent "accidental de-scoping" because the process experts' cooperation wanes or dies. Enthusiastic process experts will volunteer vital process information. Checklists can help the simulation project team ask complete questions. However, we have found that business rules can be so process-specific that we have yet to define or discover a perfect checklist or question that guarantees we have properly captured every business rule about resources and queue management.

4 APPROXIMATING ACTIVITY TIMES

Approximating activity times can reduce a simulation project scope. Reduced quantitative data elicitation from process experts will shorten the lead-time to build the model. Simple, approximate probability distributions may shorten simulation run-times over those involving more complex probability distributions (e.g., generating gamma variates). Finally, simple, approximate probability distributions may streamline model validation by process experts who can understand the parameters of the simple probability distributions used, in contrast to the more exotic probability distributions that objective maximum likelihood and goodness-of-fit analyses suggest (e.g., Johnson, gamma, or beta distributions).

In a business process simulation project, activity time data may be available from:

- Extensive interview with process performers, owners, or other experts
- Direct observation via industrial engineering time measurement (e.g., time-and-motion study or work sampling)
- Comparison and construction with standards (e.g., Methods Time Measurement™)
- "Quick-and-dirty," subjective estimates

Subjective activity time estimates require the least effort and time. Consequently, business process simulation projects frequently collect activity time data according to any of the following simple distributions:

- An exponential distribution based only on an estimated "average" activity time
- A uniform distribution based on the lowest and highest possible activity times (or, for example, on subjective estimates of "10-percentile" and "90-percentile" activity times)
- A triangular distribution based on the lowest, most likely (mode), and highest activity times (again, possibly using 10- and 90-percentiles to infer the extremes)

In the authors' (and others') experience, assuming any of these distributions for activity times can yield several project balance and quality impacts on a business process simulation project:

- Exponential distributions for activity time imply a mode at the left. This shape rarely corresponds with a real process, which is likely to exhibit both a left and right tail in its activity times. The simulation will overestimate small activity times.
- In a simulation run, exponential distributions for activity time will occasionally yield high outlier values. The generation of such outlier values create a long, slow warmup period for steady-state simulations, and high variances for performance measures—which require many replications to achieve a target confidence level. In contrast, activity time distributions with finite tails will converge to steady-state relatively quickly.
- To achieve steady-state more quickly, uniform and triangular distributions are preferable to exponential distributions for activity times.
- The uniform distribution is often an accurate reflection of a process expert's uncertainty and ignorance about an activity time. However, the uniform also does not present the simulation a mode, which is likely to exist for the real activity time.
- Irrespective of whether the project team elicits 10/90- or 0/100-percentiles for the extreme activity times, process experts tend to overestimate minimum and underestimate maximum activity times—though the process experts will not reliably offer such restricted ranges.
- Many process experts are uncomfortable about stipulating only a range for a uniform distribution, and would prefer to provide three values for a triangular distribution.
- When the performance criteria for deciding among process designs involve high percentiles (e.g., "99-percentile order cycle time"), the finite uniform and triangular distributions may prevent generation of the extreme activity time values that could be responsible for the extreme end-to-end process performance measures. The difficulty of process experts to estimate extreme values accurately compounds the adverse quality impact of using inappropriate uniform and triangular distributions in such a situation.

Despite these drawbacks, we continue to recommend using the simple, subjective probability distributions for activity times. The positive benefits to business process simulation project schedule and cost overshadow the drawbacks. Moreover, the process experts' limitations with quantitative estimates, and the experts' limited comprehension of other distributions in a model validation, create project uncertainties and delays that destroy any timely decision-making value of more objectively selected distributions. Mindful of the limitations of these distributions and process experts, the business process simulation project team can somewhat mitigate the adverse impacts of using these simple, subjective distributions for activity time.

5 AN AGGREGATION EXPERIMENT

Unfortunately, guidance for effective "high-level" process and simplified business rule modeling is not as straightforward as activity time approximation. To illustrate the difficulty, we hypothesized three descriptions of the same process:

- Case 1: A worker serves a customer who arrives on average every 3.6 minutes. The worker requires an average of 10 minutes to complete his activity. Five identical workers perform this activity.

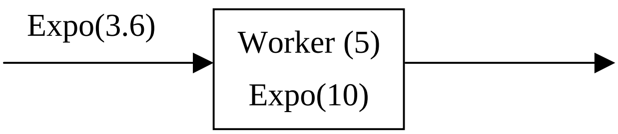

Figure 2: Case 1 High-Level Process Model

- Case 2: In fact, the customers of Case 1 are of two varieties. On average, customers still arrive every 3.6 minutes. An arriving customer has a probability of 1/3 of being Type 1, which one of three identical Worker 1's will serve for the same average of 10 minutes. Either of two identical Worker 2's will serve the other arriving Type 2 customers (probability of 2/3) for an average of 10 minutes.

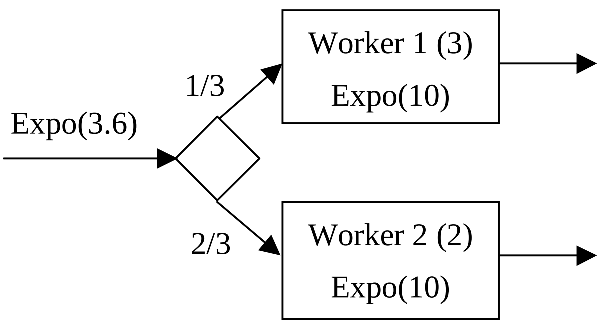

Figure 3: Case 2 Intermediate-Level Process Model

- Case 3: Instead of the simplification of Case 2, the two customer types actually undergo some series and parallel activities. Again, on average customers arrive every 3.6 minutes. Three Worker 1's serve Type 1 customers (probability 1/3 in the arrivals) in two series activities, one for an average of seven minutes followed by another for an average of three minutes. One of the two Worker 2's who process the Type 2 customers (probability 2/3 in the arriving customers) first perform an activity with the customer for an average of seven minutes. However, the Type 2 customers are, in turn, of two types, 2A (probability 0.75) and 2B (probability 0.25). Either Worker 2 is able to process the Type 2A customers in their final activity, which lasts an average of three minutes. However, only one of the Worker 2's is certified to process the Type 2B customers, though that activity also requires an average of three minutes. No special queuing logic pertains to customers competing for the different Worker 2's (i.e., availability is first-come, first-served).

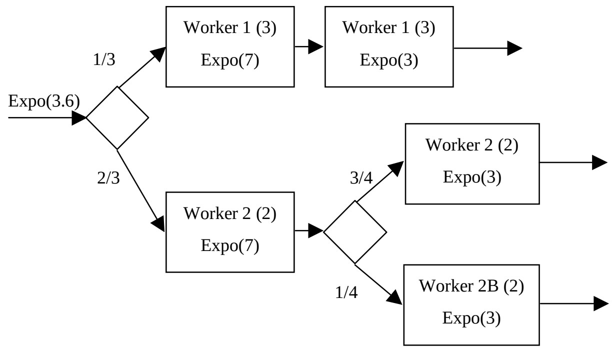

Figure 4: Case 3 Detailed Process Model

From the point-of-view of most process experts typically encountered by the authors, Cases 1, 2, and 3 represent progressively "more detail" describing *the same process*. In each case, the total customer process time averages 10 minutes. Furthermore, the parallel activities in Cases 2 and 3 have the same average activity times. The "level of detail" in Case 3 exposes the business rules of specialized customers, queues, and resources.

Simulations of the three cases provided the following steady-state averages:

Table 1: Simulation Analyses of the Three Process "Modeling Levels"

	Case 1	Case 2	Case 3
Time in Queue at Entry	0.70	43	88
Cycle Time	12.65	40.9	71.8
Throughput	1381	1387	1407
Queue Length at Entry	0.2	8.1	16.6

Expected to the simulation modeler, the differences among these models of the same processes first shock most process experts. In organizations of Level 1 or 2 process maturity, business process experts often do not think about queues and their impacts on cycle time—bottlenecks are an annoying aspect of daily work, not "part of the process." Hence, the process experts find the striking differences in cycle time extremely jarring, and until the project team educates them, the experts tend initially to declare the detailed models invalid.

The throughput numbers are certainly equivalent, so that Case 1 would be a suitable simulation model if process capability is defined only on throughput, *and none of the other measures matters for decision-making about process design*. Thus, if providing space for the queue is a key issue in the facility design, Cases 1 and 2 would severely underestimate the space required, and only the detailed Case 3 would be acceptable.

To date, we have found no satisfactory generalized "rules" for accepting the "high-level" process model with casual or no representation of business rules. To be sure, discovering and modeling the detailed process structure, resources, and business rules hedges all bets. Few real-world business process simulations would be as simple as this example. Suppose this example were part of a larger end-to-end business process, and that a "longer" process activity chain dominated the cycle time of the sub-process in this example. Then, other than possible facility issues of queue length, modeling this example with the detail of Case 3 would add little value to the business process analysis. Yet again, merely shifting the customer arrival pattern and mix (the branching probabilities) could place the sub-process squarely on the critical path. Regrettably, we have consistently observed or contrived plausible counterarguments to every candidate guideline that could justify a "high-level" business process model such as Cases 1 or 2.

6 CONCLUSIONS

Beginning the thought experiments for this paper, we hoped to discover robust, useful guidelines for process simulation that would assure valuable results while minimizing the cost and time of building and using the model. We believe the goal is worthy, and we continue the quest. For the present, we conclude the following:

- Growing client appreciation of the value of business process simulation only increases schedule pressures on the business process simulation project team to yield analysis results.

- Because of inconsistencies in the relationships among schedule, cost, and scope ("project balance") in business process simulation projects, "de-scoping" remains the preferred project management response to client urgency.

- The typical knowledge, ability and psychology of process experts in organizations with low process maturity confounds information gathering about the process. Understanding process experts in a process maturity context helps anticipate information collection problems that could lead to "free-fall de-scoping," and to design risk-mitigating tactics.

- From our experience, we continue to place cautious confidence in approximating activity time as an effective "de-scoping" method.

- Despite "de-scoping" motivations, the best approach for assuring valuable business process simulation results is to model thoroughly all process structure, activities, resources, queues, and business rules.

- To date, we have found no other viable guidelines regarding when and how to model business processes at a "high level" while still confidently assuring valuable analytical results.

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