# Part 2

# APPLICATIONS AND FUTURE DIRECTIONS

## INTRODUCTION TO APPLICATIONS CHAPTERS

### Overview

**People** use **processes** to create **products** for **people** to meet **project** and **organization** goals.* This statement positions the application chapters by illustrating the primary dependencies between the taxonomy areas:

- People applications
- Process and product applications
- Project and organization applications.

These aspects are distinct yet an integrated whole with many connections. For instance, there are application examples that are referenced in multiple chapters. Applications that are split across the areas are identified, and pointers given to related sections.

*This statement is a simplification expressing the ideal. For example, some "processes" are debatable, the more ad hoc they appear. With respect to satisfying goals, it must be recognized that goals are not always completely satisfied or even explicitly stated. There may be constraints to deal with that affect goal attainment. Additionally, other goals unrelated to projects or organizations may come into play when it comes to people. Personal win conditions fall in this category (which organizations should explicitly consider and attempt to reconcile for mutual benefit). Additionally, organizations may include informal groups such as open-source communities. Though this statement is a simplification, it does express the basic intent of software development and evolution.

Different classification schemes for the applications are possible, but this one is the most meaningful and feasible division of topics in terms of model state variables. A way to differentiate the areas is by their most important state variables—the levels (accumulations) in the main chains of primary focus. People applications quantify personnel levels and characteristics. Process and product applications are centered around software artifacts, their transformations, and attributes through the process stages. Project and organization applications frequently integrate the other structures to monitor activity status against plans; acquire people and other resources; make policy decisions regarding people, processes, and products; track expenditures and business value measures; and so on. These actions may apply on a single project or a portfolio of projects.

Processes and products are difficult to extricate, considering that software artifact quantities and their attributes are primary state variables for both. Their flow chains are often identical. Project and organization considerations are tightly congruent with each other and their entities are similar in structure and behavior.

The next three chapters include historical overviews of applications and research, more detailed descriptions of selected example implementations with system dynamics, and some critiques of the various works. Each chapter begins with an introduction to the application areas, identifies the major opportunities to improve practices in each area, and briefly overviews the applications to be covered.

Structures called opportunity trees are shown at the beginning of each chapter to help visualize the different ways of improving in the areas. Opportunity trees were first shown in [Boehm 1987] for improving software productivity. They are hierarchical taxonomies of opportunities for achieving objectives. They can serve as a guide to understand the options and can be referred to when traversing through the material. The opportunities also represent potential modeling application areas and, indeed, each chapter addresses some of the important opportunities listed in the trees.

A notional top-level view of the highly connected opportunity trees is shown in Figure 1. The four application areas are starting nodes in their respective trees in each chapter. The multiple leaves from each branch in Figure 1 represent the many subbranches of opportunities. There are many connections between the branches, both within and between areas. Sample overlaps are shown for visual simplicity, but all branches could potentially connect.

A number of opportunities show up more than once on different trees in the chapters. The opportunity trees in Chapters 5 and 6 combine different perspectives and show some major overlaps. Other subtler interconnections can be seen when comparing the end leaves on different trees.

The trees help illustrate the significant overlap and synergies between people, process, product, project, and organization opportunities. For example, better trained and motivated people will tend to create improved processes and better products, process improvement programs will impact product quality, or employing reuse may improve both process performance and product capability simultaneously. Likewise, opportunities may show up more than once on the same tree. The placement depends on the perspective of a tree.

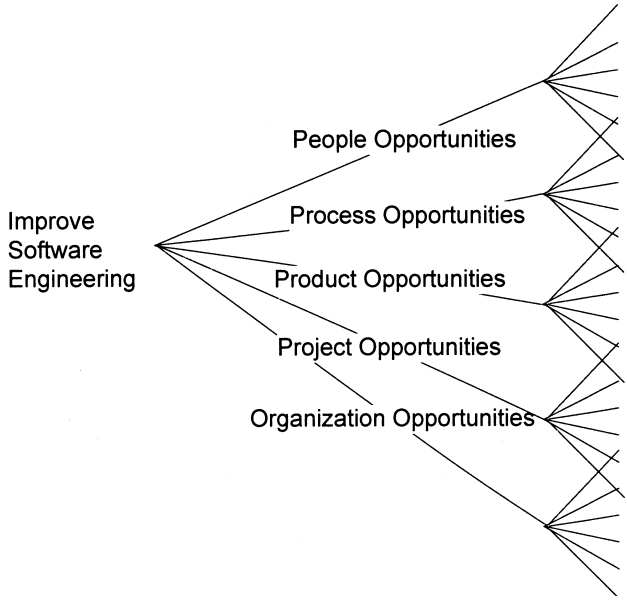


Figure 1. Software engineering opportunity tree (notional top-level view).

## Terminology and Process Performance

Why is this book titled "Software *Process* Dynamics," given the different application areas (people, process, product, project, and organization) and their interactions? Though the title might seem limiting, consider that *process* is central to the other elements when considering process performance. By convention, *process performance* refers to the achieved results from executing a process such as expended effort, schedule, or final product quality. So the performance of a process depends on the interactions between people, processes, products, projects, organizations, and so on. They collectively form the context for *measurable* process performance per Figure 2.

Figure 2 combines the application areas with the control system depicted in Chapter 1, without the feedback connections (it is also a standard Input–Process–Output (IPO) format). The process is the system in the middle with inputs from people, projects, and organizations, and software artifacts as outputs representing the product. All process performance measures are indicators based on the inputs and outputs of the process; therefore, people, project, organization, and product measures are involved in an executed process.

## Organization of Topics

Topical subareas in each chapter begin with a brief review of the phenomenology, then modeling examples are shown with sample insights. Not every past application is covered, and the reader should refer to the annotated bibliography for a complete list of all

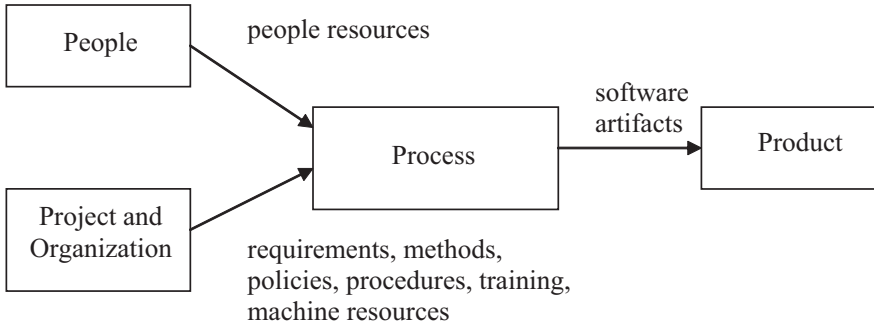


Figure 2. Process performance context.

previous work in the field. Unfortunately, some of the best simulation work occurs in industry behind closed doors. Much of it remains proprietary and, thus, cannot even be published.

Table 1 shows the top-level topics contained in each chapter. The list is not definitive or complete for any given area with respect to all potential applications. The sample topics are those that have been studied and allowed to be published, or, in some cases, important areas already identified for future work. Rigorous studies like Ph.D. dissertations or major funded modeling initiatives are heavily covered. Since there are few people-oriented models in the literature, Chapter 4, People Applications, contains a number of sections for which there are no example models yet.

The degree of detail per topic also varies in order to showcase certain valuable aspects, or it may be a reflection of the available information on a topic. The unique value to the reader is frequently found in the lessons learned and model formulations, but may also be the method of research, data collection and analysis, project management techniques, or other aspects. Substantial space is dedicated to new and previously un-

Table 1. Application topics

| People | Process and Product | Project and Organization |
|---|---|---|
| • Workforce Modeling<br>• Exhaustion and Burnout<br>• Learning<br>• Team Composition<br>• Motivation<br>• Slack Time<br>• Personnel Hiring and Retention<br>• Skills and Capabilities<br>• Communication, Negotiation, and Collaboration<br>• Simulation for Personnel Training | • Peer Reviews<br>• Global Process Feedback<br>• Software Reuse<br>• Commercial Off-The-Shelf Software (COTS)-Based Systems<br>• Software Architecting<br>• Quality and Defects<br>• Requirements Volatility<br>• Software Process Improvement | • Integrated Project Modeling<br>• Software Business Case Analysis<br>• Personnel Resource Allocation<br>• Staffing<br>• Earned Value |

Table 2. Key to model summary tables with examples from Brooks's Law model

**Purpose:** Training and Learning, Planning
**Scope:** Development Project

| Inputs and Parameters | Levels | Major Relationships | Outputs |
|---|---|---|---|
| Inputs that a user changes for each run, plus additional model parameters that may be set. These include constants and functions. Simple conversion factors are not shown, nor level initialization values when zero.<br>• Number of people to add<br>• Pulse time<br>• Nominal productivity<br>• Training overhead portion<br>• Communication overhead multiplier<br>• Planned software<br>• New personnel<br>• Experienced personnel | Levels comprising the system; the stocks or state variables (which could be measured on an actual process). Levels used purely for instrumentation are not shown.<br>• Software<br>Required<br>Developed<br>• Personnel<br>New<br>Experienced | These include important trade-off relationships, multiplier functions, rates, or policy equations germane to the model. Simple linear rates are not listed.<br>• Assimilation delay<br>• Communication overhead<br>• Training losses | Primary outputs or result variables used in the model studies. Many outputs may be available but only the most important ones are shown.<br>• Schedule time<br>• Productivity trend |

published original work. There are undoubtedly more unlisted areas that people will work on, and some of them will be included in the next book version.

The major models are introduced with a standard summary table, as explained in Table 2 with example items listed for the simple Brooks's Law model. First shown are the purpose(s) and scope per the process model characterization matrix in Chapter 1. Then the format follows an IPO convention. The inputs needed for running the model are listed in the left column, then the levels and major relationships used in the model are shown, then the primary outputs. As described, not all elements are shown and sometimes the items are abstractions. Sometimes, the names of model elements are revised for clarity and the naming differences will be evident when the models are studied.