Business Process Control-Flow Complexity: Metric, Evaluation, and Validation

Jorge Cardoso, University of Madeira, Portugal and SAP AG Research, Germany

ABSTRACT

Organizations are increasingly faced with the challenge of managing business processes, workflows, and recently, Web processes. One important aspect of business processes that has been overlooked is their complexity. High complexity in processes may result in poor understandability, errors, defects, and exceptions, leading processes to need more time to develop, test, and maintain. Therefore, excessive complexity should be avoided. Business process measurement is the task of empirically and objectively assigning numbers to the properties of business processes in such a way so as to describe them. Desirable attributes to study and measure include complexity, cost, maintainability, and reliability. In our work, we will focus on investigating process complexity. We present and describe a metric to analyze the control-flow complexity of business processes. The metric is evaluated in terms of Weyuker’s properties in order to guarantee that it qualifies as good and comprehensive. To test the validity of the metric, we describe the experiment we have carried out for empirically validating the metric.

Keywords: business processes, complexity metrics, Web processes, workflows, software engineering.

INTRODUCTION

Business process management systems (BPMS) (Smith & Fingar, 2003) provide a fundamental infrastructure to define and manage business processes. BPMS, such as Workflow Management Systems (WfMS) (Cardoso, Bostrom & Sheth, 2004), have become a serious competitive factor for many organizations that are increasingly faced with the challenge of managing e-business applications, workflows, Web services, and Web processes. Business processes, such as Web processes (WS-BEPL, 2005) promise to ease several current infrastructure challenges, such as data, application, and process integration. With the emergence of Web services, a workflow management system becomes essential to support, manage, and enact processes, both among enterprises and within the enterprise (Sheth, van der Aalst & Arpinar, 1999).

A vast amount of work done so far in the business process field has targeted the development of WfMS, including models (e.g., Petri nets), modeling languages (BPML, 2004; BPMN, 2005; Leymann, 2001; Menzel,
Mayer, & Edwards, 1994; Singh, 1995; van der Aalst, 1998; van der Aalst & Hofstede, 2003, and execution environments (Alonso, Mohan, Guenthoer, Agrawal, El Abbadi, & Kamath, 1994; Canós, Penadés, & Carsí, 1999; Jablonski, 1994; Kochut, Sheth, & Miller, 1999; Miller, Palaniswami, Sheth, Kochut, & Singh, 1998; Wodtke, Weissenfels, Weikum, & Dittrich, 1996). Work has also been carried out to develop methods to analyze processes in order to verify their correctness, testing the existence of livelocks and deadlocks (van der Aalst, 1998).

Recently, a new field of research for processes has emerged. This new field—termed process measurement—presents a set of approaches to the quantification of specific properties of processes. Important properties to analyze include the estimation of complexity, defects, process size, effort of testing, effort of maintenance, understandability, time, resources, and quality of service. Process measurement is still in its infancy, and much work has yet to be undertaken.

The effective management of any process requires modeling, measurement, and quantification. Process measurement is concerned with deriving a numeric value for attributes of processes. Measures, such as Quality of Service measures (Cardoso, Miller, Sheth, Arnold, & Kochut, 2004), can be used to improve process productivity and quality.

Designing and improving processes is a key aspect in order for businesses to stay competitive in today’s marketplace. Organizations have been forced to improve their business processes because customers are demanding better products and services. When an organization adopts a process management philosophy, process improvement can take place. Independently of the approach taken, which can be a Continuous Process Improvement (Harrington, 1993), a Business Process Redesign (Wastell, White, & Kawalek, 1994), or a Business Process Reengineering (Ould, 1995) approach, methods need to be available to analyze the processes undergoing improvements. To achieve an effective management, one fundamental area of research that needs to be explored is the complexity analysis of processes.

A business process is composed of a set of activities, tasks, or services put together to achieve a final goal. As the complexity of a process increases, it can lead to poor quality and be difficult to reengineer. High complexity in a process may result in limited understandability and more errors, defects, and exceptions, leading processes to need more time to develop, test, and maintain. For example, in software engineering, it has been found that program modules with high-complexity indices have a higher frequency of failures (Lanning & Khoshgoftaar, 1994). Therefore, excessive complexity should be avoided. For instance, critical processes in which failure can result in the loss of human life require a unique approach to development, implementation, and management. For these types of processes, typically found in healthcare applications (Anyanwu, Sheth, Cardoso, Miller, & Kochut, 2003), the consequences of failure are severe. The ability to produce processes of higher quality and less complexity is a matter of endurance.

Surprisingly, in spite of the fact that there is a vast amount of literature on software measurement of complexity (Zuse, 1997), no significant research on process measurement of complexity has yet been carried out. Analyzing the complexity at all stages of process design and development helps avoid the drawbacks associated with high-complexity processes. Currently, organizations have not adopted complexity metrics as part of their process management projects. As a result, simple processes may be designed in a complex way.

This article integrates and expands our previous work (Cardoso, 2005c; 2005d; 2005f) and discusses the complexity of processes. In the first main section, we present the Control-Flow Complexity (CFC) metric (Cardoso, 2005d) in order to measure the degree of complexity of business processes from a control-flow perspective. As Lord William Thomson Kelvin (1824–1907) said, “If you cannot measure it, you cannot improve it.” The use of the CFC metric allows designers to improve processes,
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