Fuzzy COTS Selection for Modular Software Systems Based on Cohesion and Coupling under Multiple Applications Environment

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ABSTRACT

Due to the rapid growth of development of component based software systems, the selection of optimal commercial-off-the-shelf (COTS) components has become the key of optimization techniques used for the purpose. In this paper, the authors use fuzzy mathematical programming (FMP) for developing bi-objective fuzzy optimization models that aims to select the best-fit COTS components for a modular software system under multiple applications development task. The proposed models maximize the functional performance and minimize the total cost of the software system satisfying the constraints of minimum threshold on intra-modular coupling density and reusability of COTS components. The efficiency of the models is illustrated using a real-world scenario of developing two financial applications for two small-scale industries.

Keywords: Cohesion and Coupling, Commercial-Off-the-Shelf (COTS) Component Selection, Fuzzy Optimization, Modular Software System, Reusability

INTRODUCTION

Modern software systems are becoming more and more large-scale, complex and uneasily controlled, resulting in high development cost, low productivity, unmanageable software quality and high risk to move to new technology. Consequently, there is a growing demand of searching for a new, efficient and cost-effective software development paradigm. One of the most promising solutions today is the component-based software development (CBSD) approach. This approach is based on the idea that software systems can be developed...
by selecting appropriate commercial-off-the-shelf (COTS) components and then assemble them to fit a specific architectural style for some application(s) domain. A COTS component can be developed by different developers using different languages and different platforms. In general, a COTS component has three main features: (i) a component is an independent and replaceable part of a system that fulfills a clear function; (ii) a component works in the context of a well-defined architecture; and (iii) a component communicates with other components of the software system through its interfaces (Brown & Wallnau, 1998). In CBSD, the main focus is how to choose the most appropriate and most suited component from COTS components’ market so that it can significantly reduce development cost and time-to-market, and improve maintainability, reliability and overall quality of software system. Several COTS selection methods (Chung, Cooper, & Courtney, 2004; Grau, Carvallo, Franch, & Quer, 2004; Kontonya & Hutchinson, 2004; Leung & Leung, 2002; Rolland, 1999) have been proposed in literature. However, it may be noted that there is no single method which is accepted as a standard COTS selection method. A detailed list of the COTS selection methods has been provided in Mohamed, Ruhe, and Eberlein (2007).


All the previously mentioned optimization models are based on the assumption that in the software development process, the software developer (i.e., decision maker) has complete information. It may be noted that since software development is not an exact science, there are often plenty of indefinite and uncertain factors in the parameter estimation of the COTS selection problem. Hence, the various model parameters are often imprecise or the process of estimation of these input parameters is subjected to uncertainty. In our opinion, the best way to deal with uncertainty in mathematical modelling is to incorporate uncertainty in the model itself. Corresponding to the various possible scenarios of uncertainty in the model parameters, we must explore different possible outcomes and then select the best outcome in a given decision making situation. The optimization models in the software development have benefited greatly from the fuzzy set theory (FST) (Zadeh, 1965) in terms of integrating quantitative and qualitative information, subjective preferences of the decision maker and knowledge of the software experts. Jha, Bali, and Kumar (2011) presented a fuzzy approach for optimal selection of COTS components for modular software system under consensus recovery block scheme incorporating execution time. Gupta, Mehlawat, Mittal, and Verma (2009) formulated fuzzy multiple-objective optimization model for the COTS selection using nonlinear S-shape membership functions describing vague aspiration levels of the decision maker in respect of the weighted quality and cost. Gupta, Verma, and Mehlawat (2011)
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