WORKFORCE PLANNING FOR PROFESSIONAL SERVICE PROJECTS: A BRANCHAND-CUT APPROACH

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Abstract

Workforce planning has long been identified as an opportunity for research by both academicians and industry practitioners. Workforce planning deals with higher level of planning and longer term workforce needs in terms of availability, allocation, and transition. The objective of workforce planning is to provide resources with the right skills for the right job at the right time and at the right cost. The nature of workforce planning varies between different types of industries, mostly differentiated through the varying level of knowledge intensity. Service oriented firms seem to play an increasingly important role in the current global business scenario. According to a study conducted by the US Department of Labor, in the year 2006, in the US, the workforce involved in service oriented jobs constituted approximately83% of total employment, whereas only about 10% of the labor force were involved in manufacturing. Professional service firms (PSF), like engineering, management consulting, as well as architectural firms are examples of those that are highly knowledge-intensive. Hence, they rely heavily on the competence of their human resources. A PSF typically offers a wide range of services (mainly in the form of services development and services maintenance support) over several application areas to their clients. It spends an ample amount of time and effort in recruiting, training, allocating and motivating its human resources. In a PSF, projects are the primary medium through which it (can be identified as project based PSF) aims to deliver high-quality services according to the requirements of its clients. It turns out that obtaining a minimum cost plan to assign resources with diverse skills and delivery roles to several client projects is particularly challenging. Another complicating feature in our study is that the client demand in terms of man-hour needs has to be matched to the availability of workers with the required competence. It could happen that a large number of resources (workers) are idle due to lack of required skills and domain expertise. Potential remedies could be that resources not qualified are sent for training to acquire the required proficiency or that external vendors are temporarily employed so that the projects can be completed by their respective due dates. However, both training activities and employment of vendors significantly affect the delivery schedule and the pre-estimated budget of projects. Thus, poor manpower management, including inappropriate and inefficient allocation mechanism to projects and improper resource utilization, as well as lack of required skills can adversely impact the financial outcome of a PSF. Hence, such organizations are realizing the importance of developing systematic models for planning, scheduling and deploying human resources to projects. To address the above problem, a mathematical programming model is considered. Given a set of projects, a set of resources and a time horizon, the workforce planning problem (WPP) seeks to find the minimum−cost way of allocating resources to projects over time horizon so that the project demands in terms of man-hour are satisfied. The sum of costs for the firm, the resource allocation costs and the project escalation costs need to be minimized while satisfying the constraints imposed by the organization rules and resource work rules. The problem is mathematically formulated as an integer linear program (ILP). In this thesis, we show that this ILP model is NP-hard problem that is computationally hard to solve. Thus, in the worst case, the computational effort increases exponentially with the size of the problem. The generic

algorithmic approach to solve such problems is to use branch-and-bound. One way to reduce the computational effort required to solve this problem is to introduce strong cuts, given that a linear programming relaxation (LPR) is solved at each node of the branch-and-bound tree. When cuts are introduced into a branch-and-bound procedure, it is called a branch−and−cut (B&C) algorithm. The main contribution of this thesis is the development and implementation of a B&C procedure for WPP. To tighten the LPR and therefore to speed up the B&C approach, we have identified several classes of strong valid inequalities that are specific to the ILP formulation. We develop appropriate combinatorial separation algorithms for these in equalities. We also propose two heuristic algorithms that generates upper bounds better than CPLEX. Finally, we validate the effectiveness of our proposed algorithm through extensive computational testing on large test problems. The implementation uses a programming language, C++ and a commercial programming solver, CPLEX to support the effectiveness the proposed solution approaches.