Audit-Staff Scheduling by Column Generation

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1 Introduction

When scheduling its audit-staff, the management of an auditing firm encompasses a number of decisions. These may be grouped into several categories which differ markedly in terms of organizational echelon involved, length of the planning horizon and the planning periods, degree of aggregation of the audit tasks, degree of detail of the required information, and decision objective. However, traditional audit-staff scheduling models (Balachandran and Zoltners 1981, Chan and Dodin 1986, Gardner et al. 1990, Dodin and Chan 1991, Drexl 1991, Dodin and Elimam 1997, Dodin et al. 1998, Brucker and Schumacher 1999, Rolland et al. 2005) are single-level models which try to construct a direct assignment of auditors to tasks and periods. To facilitate algorithmic treatment, all these models are more or less gross simplifications of practical planning situations.

These observations led us to conduct a survey among the 200 biggest certified public accountant (CPA) firms in Germany. Based upon its results we formulated an hierarchical model (Salewski and Drexl 1993, Salewski 1995) comprising three levels: The medium-term planning assigns teams of auditors to the engagements; it constructs a schedule by determining the workload per auditor and week over a planning horizon of between three and twelve months. The medium-to-short-term planning disaggregates the results of the first level for one week and all auditors; the outcome is a schedule for each auditor that covers – on the basis of periods of four hours – all engagements in which he is involved in the considered week. The
short-term planning is based upon the results of the second level for one week and one engagement; it assigns the auditors involved in the auditing of that engagement to the corresponding audit tasks and schedules these tasks to periods of one hour. Here, we will focus on the first, that is, the medium-term level.

The paper is organized as follows: In Section 2 we define the problem formally and investigate where it is positioned in the context of audit-staff/project scheduling. In Section 3 the problem is reformulated as a set partitioning problem with an exponential number of columns. The LP-relaxation of this model can be solved to optimality by column generation. Next we show in Section 4 that the columns of the LP-relaxation can be efficiently computed by means of a shortest path model. The description of the test bed is provided in Section 5. Section 6 presents the results of an in-depth computational study. Finally, Section 7 gives a brief summary, along with our conclusions.

2 Problem Setting

The Medium-Term Audit-Staff Scheduling Problem (MASSP) may be characterized by the following assumptions (cp. Salewski et al. 1997 also):

- A firm employs one or more auditors, who have to audit one or more engagements within a given planning horizon of normally 13, 26, or 52 weeks. A period has a duration of one week.

- Each engagement is made up of one or more phases, e.g. preliminary, intermediate and final audit. The phases of one engagement must be processed in a strictly linear order. This implies that each phase of an engagement, except for the first one, has exactly one predecessor. Work on some phases may not commence before a specific release time, and may have to be completed before a specific deadline.

- Each phase has a specific duration in terms of multiples of periods. In order to allow preemption of phase-processing at the end of some periods each phase is decomposed into as many subphases with one period duration as its processing takes in total. E.g. a phase with a processing time of two periods is splitted into two subphases each having a duration of one period (cp. Figure 1).

Mode-dependent minimum and maximum time-lags are given between subsequent phases of one engagement and between subsequent subphases of one phase, respectively (for details see below).