Workforce Scheduling and Planning Limited Resources: Algorithms and Complexity

(Thesis summary of Murat Fırat)

Nowadays, as specialization in production and maintenance increases, the importance of skill management in employee scheduling grows significantly. The companies having operations like maintenance, construction, and installation face multi-skill workforce planning problems that are hard to solve optimally in acceptable times. Especially, when activities require skills from several specialization fields at different levels, skill management becomes more challenging. Another important emerging topic is the development of faster algorithms for the easy problems which appear as sub-routines of heuristics solving complex problems. These faster algorithms improve the efficiency of the heuristics using the easy problems in their sub-routines. In this thesis, there are three main parts relevant to the above mentioned topics;

- Building schedules of multi-skill workforce,
- Stability analysis of multi-skill workforce assignments,
- Developing algorithms for planning of limited resources.

The first problem considered is to build schedules in which groups of technicians are assigned to sequences of tasks provided that the required skills of tasks are met by the assigned technicians. Mixed Integer Linear Programming (MILP) models with high flexibility are developed to construct efficient schedules in terms of task completion times. The flexibility of the MILP models makes it possible to revise technician-task allocations easily while constructing the schedules. The computational results included in this thesis are promising and superior to the ones reported in the literature.

The second problem studied in this thesis is the stability of multi-skill workforce assignments. Inspired by the Gale-Shapley paper, the stability is defined in the workforce scheduling framework. A technician-job assignment is said to be stable if and only if there exists no technician-job pair both liking each other to their current matches. A polynomial-time algorithm for a special case is reduced to the well-known University Admissions Problem and NP-Hardness of the general problem is proved. As an important result, the set all stable assignments is expressed by a set of linear inequalities. Furthermore, an approach to find technician-optimal assignments is developed.

In the third part of the thesis, algorithms for planning limited resources are developed. It is shown the feasibility testing for a dial-a-ride problem under maximum wait time and maximum ride time constraints can be done in linear time using interval graphs. Moreover, a polynomial-time algorithm for a vehicle refueling problem is developed using its network representation. The network representation of the vehicle refueling problem enabled us to develop a deep understanding of the dual problem with respect to its linear programming formulation.