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Resource allocation and planning at a regional Red Cross branch in Austria

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Introduction

The Vienna Red Cross (Wiener Rotes Kreuz - WRK) is one of the nine regional associations of the Austrian Red Cross, which in turn is part of the International Red Cross and Red Crescent Movement. Its role is as for the National Society of the Austrian Red Cross described below. Today, the WRK employs around 2000 people on a full-time basis (all subsidiaries included), and some 2000 volunteers. The Vienna State Association is the WRK's parent organization. This also includes several subsidiaries such as a children's hospital and a training centre as well as trade and service companies.

The National Society of the Austrian Red Cross was founded in 1880 as a national institution of humanitarian aid, has a federal structure and consists of regional associations and 133 district offices with nearly 10,000 full-time and some 75,000 volunteers. From the day of its foundation, it was clear how the organization wanted to work: to help neutrally, independently and altruistically those who need its help. A variety of activities include: rescue services, a blood donation service, health and social services, disaster prevention, relief and development cooperation, dissemination of international humanitarian law, a migration and search service, education and training and youth work in the Youth Red Cross.

The Problem

During the past few years the WRK realised that its software for allocating staff to tasks no longer met its requirements. For example, the old software that has been in use in the area of rescue services provided routines for assigning employees to specific tasks, but was limited and only based on availabilities and affiliations of a maximum of two employees or of one employee to a certain vehicle. Hence, a main drawback of the previous system was that only parts of a schedule were calculated automatically, while the system was not able to take into account the various legal regulations, especially time-related restrictions. The WRK invested a lot of time on formulating their requirements for new software, well before starting the software project itself, and invited the software company Ingentus to assist it. Ingentus was founded in 2012 as a spinoff from the Institute of Production and Logistics of the University of Natural Resources and Life Sciences in Vienna. Its main goal is to develop software for efficient resource planning, based on state-of-the-art optimisation methods. Ingentus' team focuses on solving real-life logistical problems. For this purpose, the company develops web applications that help customers to digitize their business processes, while containing modules based on metaheuristics to enable 'just in time' decision support.

The Resource Planning Software Tool (RPT)

One of the main features of RPT is that it can be used in nearly all the different areas of WRK, thereby eliminating the limitations of the former fragmented software architecture. Dealing with varying planning areas also leads to the requirements of handling different time horizons (from daily to quarterly), some pre-defined shifts, and legal regulations (e.g., due to various terms of employment, like full time or part time employees, volunteers and civil servants). Hence, they can be used as input (e.g., rescue services), while other areas only dictate the weekly regular working hours (e.g. assistance to the homeless), i.e. shifts have to be generated by assigning tasks. As examples, the objectives and some main parameters of the rescue services and assistance to the homeless are described below, as rather heterogeneous representatives of the underlying problems of the different areas:

- **Homeless assistance:** Computation of a quarterly working schedule for each employee of a given facility. The input consists of given regular working hours, favoured working and free times, as well as of the predefined demand of the facility.
- **Rescue services:** Computation of the assignments of the given shifts of the employees as well as the given vehicles to the predefined open positions of the daily demand. Furthermore, these take into account affiliations of employees to vehicles, employees to locations and between employees, and reduce assignments of overqualified staff.
- As a further difference in the approach, it can be stated that in the rescue service "more vehicles with the same available resources" is better, whereas for helping the homeless exactly the required number of positions should be filled.

The project continues to be managed by a close cooperation of the WRK's in-house IT-department and Ingentus. Following an agile software development process, the WRK always has been involved, while the technical work was mainly done by experts of Ingentus. The Project Leader and Senior Developer worked on back end services including Operations Research methods, and the Junior Developer focused on front end programming. The team was completed by its User-Experience Expert, who designed the navigation within the software from a customer's point of view, as well as others who were significantly involved in the design of the software architecture itself, and also during its implementation.

The software is designed as a web service and therefore runs in any web-browser such as Mozilla Firefox, Brave or Google Chrome. It enables a dispatcher to, for example, manually assign resources to given positions, change locations and times or change the composition of required units.

The project of programming the required ERP (*Enterprise Resource Planning*) system was divided into two consecutive stages. The first part focused on the implementation of the data handling software as well as on interface programming to embed RPT in the given system landscape of WRK. The second part focused on the development of the automatic scheduling algorithm.

The latter algorithm starts with a pre-processing phase where the input data is prepared for further calculation. The initial solution is computed by a regret heuristic (*ref 1*). Afterwards, it is iteratively improved by a metaheuristic based on Adaptive Large Neighbourhood Search (ALNS) where different 'destroy and repair' operators (*ref 1*) are used. In each iteration the operators are used on the current solution, which is first 'ruined' by one of the destroy operators and afterwards 'recreated' by one of the repair operators. The thereby newly generated solution's objective value is afterwards compared to the one of the best known solution to see if it should become the new incumbent solution for the next iteration.

The following 'destroy' operators have been implemented: Random Removal, Related Removal and a tailored operator that focuses on destroying non-deployable units. Regret-k-heuristics that differ in the number of candidates considered in computing the regret value ($k = \{1, 2, 3, 4\}$) are used as repair operators.

The objective here is to maximise the fairness for all resources and to assign as many free positions as defined in the demand or where possible if the given demand can't be fulfilled. The fairness score is based on different factors to:

- reduce extra hours,
- consider wishes of employees and volunteers (certain positions, free time, work time),
- consider affiliations between employees, from employees to vehicles and from employees to work locations,
- distribute weekend shifts of the staff equally,
- build blocks of days of vacation or work,
- reduce overqualification,
- minimize the deviation to the specified weekly working hours.

To solve the problem soft and hard constraints are considered. While hard constraints have to be met in order to obtain a feasible solution, the violation of soft constraints is allowed, but tends to be reduced by predefined penalties. The factors that are summed to get the fairness score are typically expressed by soft constraints, while e.g., minimum qualification or legal working time regulations are defined as hard constraints.

After pre-processing and the computation of the initial solution, the metaheuristic typically gets 30 seconds to enhance the given solution. Afterwards the best-known solution is returned and visualized for the user. The user interacts by taking over the suggested assignments, while he/she has the possibility to decide for each assignment individually, if he/she wants to follow the suggestion of the algorithm (Fig. 1).

Figure 1: Screenshot of a result of automatically planning a schedule for rescue services. The dispatcher can assign the suggested 176 positions at once. Note: the names of the used resources (personnel and vehicles) have been blurred to protect data privacy

Results

The results of the software development process were reported to representatives of the different areas of the WRK at three-weekly project meetings, while correspondence with the product owner and the project manager of the Vienna Red Cross (WRK), was exchanged at least weekly. This ensured that the work met the requirements of the WRK, and adaptations could be made quickly and in an early stage of the development. The main part of the Resource Planning Tool, after two years of development, has been used in WRK's daily business by duty planners since April 2023 (Ambulance Service, Social Services, Internal Service Providers, Disaster Relief Service, Medical Service). WRK implemented an internal learning platform for the new software to support employees when working with the new platform. So far, the results of the automatic planning algorithm have their main impact on the area of rescue services of WRK, where it is used daily. In this area it was thereby possible to reduce considerably the number of daily hours spent in the planning process. To exploit the advantages of the automatic planning algorithm for other areas of WRK, the automatic planning algorithm needs to be improved, which will be the main focus of the upcoming months. Some of the biggest challenges will be to include the time-related law regulations as well as to fully implement all factors needed for the fairness score.

▲ Vienna Red Cross, © WRK/Armin Fauland

Statement by David Oberleitner, MSc / Vienna Red Cross

"Introducing "RPT" - our brand-new software designed specifically for the Viennese branch of the Red Cross – a powerful planning tool aiming to significantly improve the organization of personnel and material resources during emergency situations as well as daily operations. We are delighted to say that we were able to renew a significant part of our resource planning tools in collaboration with the project's stakeholders. As requested, duty scheduling can be done in different ways. Employees can either request specific shifts or they can be planned directly by shift scheduling personnel. Additionally, the planning can be done automatically, based on different working-shift-models. The built-in intelligent algorithms help planning personnel and material resources in the most efficient way. By optimizing planning processes, "RPT" aims to reinforce the efforts of our local branch in serving and assisting the community consistently. Together, we can build a more resilient world where effective planning and resource management play a pivotal role in providing aid and support for those who need it most. We are excited to see our software empowers our local branch of the Red Cross and contributes to our humanitarian work."

Reference (1): *Pisinger, D., Ropke, S., 2010. Large neighbourhood search. In: M, G., J-Y, P. (Eds.), Handbook of Metaheuristics. Springer, pp. 399–419*).