StaffLogic – workforce scheduling with ants

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Workforce scheduling is a known important issue which is becoming important for increasing the efficiency of enterprises. As with any planning, this procedure draws together enterprise management, human resources and budgeting. StaffLogic [6] is a Workforce Optimization (WFO) software that allows automated shift scheduling, analytics management reporting and payroll system integration. StaffLogic offers corporations of all sizes a streamlined scheduling and reporting procedure. It also consolidates all necessary data for employment planning, scheduling, reporting and analysis.

1. History and development

In 2009 Estonian Air Navigation Services Company asked from Nortal/Webmedia Ltd [4] help for automatization of workforce planning and rostering actions. A working group consisted of several researchers of the University of Tartu and Webmedia was established and by the end of 2010 the first version of StaffLogic was launched.
The complex planning algorithm for creation the best possible work schedule for the customer organisation consists of three stages. At first starts the Ant Colony Optimization (ACO) algorithm [1, 2]. This gives as output a first version of the working schedule according to user-defined Objective Function (see the next section). The ACO methods are based on the behaviour of nature ants and can usually produce a reasonably good feasible solution for a wide range of input data in a limited amount of running time. A metaheuristic is a set of algorithmic concepts that can be used to define heuristic method applicable to the optimization problem under consideration. In StaffLogic the Max-Min version of the ACO is realized. ACO begins with initialization step and continues with algorithmic components, construction of ant solutions, some daemon actions and pheromones updating. The activation of these steps is regulated by the software according to user-defined settings and the construction is repeated until a termination criterion is met. Possible criteria are a maximum number of iterations or a maximum CPU time.
In the second stage, the special part of software adds the individual patterns with individual holiday and hour preferences of workers which are not taken into account yet. Then in the third stage of optimization the local search approach is used.

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The main general features of StaffLogic are automated shift scheduling, human resources analysis, human resources reporting and integration into existind databases and information systems.
Shift scheduling rules realized in the software are scheduling according to business volumes, staff competences and skills. After that law enforced off-time and breaks are included into roster draft. StaffLogic generates optimized shift schedule with one-click after settings are fixed.
StaffLogic allows for better human resources management with employee productivity analysis and activity reporting. Managers have all needed data for decision making. StaffLogic reports include shifts and work hours counts, workforce size and qualifications, human resources costs and salary, absence monitoring and also overview of plan vs real reports.
Existing System Integration feature means that StaffLogic integrates impeccably with existing IT infrastructure. It uses information from human resources, access control or business intelligence systems. Data from StaffLogic can be effectively utilized by payroll and other systems. Benefits for integrated system: no manual data entry; workflow automation and optimization, real-time overview and monitoring.

2. Constraints and Objective Function

Automated shift scheduling is important Operation Research problem, the complexity of which is well known [3]. The high number of constraints that must be satisfied cause large search space. These constraints are often conflicting and because the feasible solution mean something weaker than in other problems of OR. In the final solution, final roster accepted, some of the constraints are allowed to be violated, though it is generally undesirable. These violations of constraints involve the inclusion of penalty terms in the objective function. Often there is a distinction between so called hard and soft constraints. Examples of hard constraints are the demands that a worker cannot attend two shifts simultaneously in the same timeslot and only one event can be assigned per timeslot. In StaffLogic, the constraints are not classified in this way and from the algorithmic point of view are considered as one set. This allows the user to use subjective approach and determine the importance of demands by the balance of penalty weights in initial settings. The constraints, which must be applied independently to each line of work, usually vary significantly between different organisations and these differences give rise to the great variety of rostering problems and models. These individualised problems are set up according to the needs of user and it is appropriate to distinguish the constraints by these penalties or weights in the objective function.
In order to compare two solutions of workforce scheduling and rostering system we have to use an objective or fitness function. This is defined according to constraints for the solutions, which can often be conflicting with each other and because the feasible solution can violate some of them. Mention that the workforce scheduling and rostering problems are overconstrained as a rule, so that to find assignments to decision variables without violating any constraints is usually impossible. The initial specification of the problem has to provide for the relative importance of constraints so that a solution to the problem is allowed to violate a few constraints according to definite priority orders of constraints. The rates of possible

allowed violation in StaffLogic are determined by the user with the sliders in special graphical user interface window.
Let us give an overview also of the input data of StaffLogic. At first mention the statistical data about previous planning periods concerning different working activity needed from workers during the month, week, day or shell. It is possible to use more than one time series on input. The sample data prediction and preprocessing scheme is found at the web page [5]. The data from previous service periods, given in EXCEL worksheet, are extrapolated with statistical methods to the next planning period and the predicted dynamics of working intensity is taken into account for generating new schedule and roster. This tool is a part of the whole software and makes it possible to give also subjective, human-centred data about desires and behaviour peculiarities of clients e.g. Very important data group are the formalizations of law demands with the parameters of calendar (state holidays etc.). Naturally are among the initial data the individual patterns of workers and information about their qualifications and skills.

3. Implementation results

StaffLogic as an applied software product is completely installed on the user's server and completely managed by specialists of the client organisation. In the most importance are skills and knowledge about fixation of weights for violation priorities of constraints. As the constraints vary significantly between different enterprises, there is not possible to give universal hints for all users and because the teaching of clients is strictly individual. The planning and roster management always contains creational moments. Usually there are numerous solutions which are acceptable for real application and to distinguish them is not only the software problem but also the possibility of the user.
In initial specification of StaffLogic, at first the user administrator ha the possibility to determine the requirements to the iteration process at large. The radio buttons are seen to choose the number of general complex planning scheme: ant algorithm – pattern recognition – local search. The choice "Normal" means one loop, "Good" starts this loop three times from the beginning; "Very Good" lets the choice of loops number to the software and "Find Maximum" allows to fix the overall CPU time for looping.
From the points of view of application and implementation, the second stage of the complex planning algorithm is very important. The individual patterns of workers are inserted into the first output version of ACO by special part of the algorithm. This reviews the whole schedule towards the time direction, from the left to the right, excludes contemporarily the main rules and restrictions and fixes the patterns. The coding of patterns is possible using special graphical user interface and the time frameworks have wide variety from hour-based up to the week or month duration. It is possible take into account also statistically predicted patterns obtained with the tool [5].
Final output of the StaffLogic is given to the user as a coloured timetable, the filled shift templates with the names of workers. Also the total account table of all violations of the constraints is computed.
The list of clients and users of the StaffLogic is wide. The Estonian Air Navigation Services Company uses actively this software and is an example of the most complicated clients

because of the very strict demands of scheduling on some important workplaces in the chain of flight control.
In the end of 2009, Securitas Estonia and Webmedia signed a contract to implement StaffLogic. The system is used in live since the end of 2010. The project goal was to create a cost-efficient, automated and end-to-end WFO solution for Securitas Estonia. The proven results of the project are 1,7% savings in labor cost reduction including reduced overtime hours from 6,6% to 4,6% (30,3% reduction), three times faster salary calculation and substantial reduction in time spent on planning and scheduling. This case study was done in May 2011.
Mention also the biggest user of StaffLogic, Estonian Energy Group with more than 7000 employees. The cooperation was introduced in 2010 and the main result to point out is the efficient integration of this new scheduling and rostering complex algorithm with the existing information systems and databases. The same planning procedure, software and approach are in use in all subdivisions of the Estonian Energy Group.

References

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