SWOPS (Shift Work Optimized Planning and Scheduling)

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1 The Challenges of Modern Shift Work Scheduling

Assigning workers to shifts is one of the most challenging operational problems in workforce management. The problem is complex, versatile and rich in mathematical, algorithmic and performance challenges. Listed down are some of the major challenges:

1.1 Demand Forecast and Analysis

Demand forecast must take a lot of variables into account – the day of week, the hour of day, the date in the month, special events like holidays and so on. Then there is the analytic part of converting the load volumes into number of agents needed to handle them. The problem get more and more complex when each agent have several skills and the traditional demand graph approach breaks down. Some of the service center, e.g. delivery centers work in a way that is not supported by any clear mathematical model.

1.2 Complex Business Rules

The set of possible business rules is extremely versatile and almost endless. It almost rules out any heuristic approach because of the complex coding effort.

Here is a small sample of rules:

- Pregnant women should not work after 22:00
- Agents that are less than 6 month in the job, should not do night shifts.
- Mr. X should work every day on the 07:30 shift.
- All senior employess should start every day in the same hour, not including weekend days.
- Group X should not do more than two evening shifts per week. (An evening shift is a shift that starts between 14:30 and 20:00).
- Mr. A has a special schedule of 3 hours and 25 minutes, starting at 13:00 every day.
- The night, early morning and weekend shifts should be distributed evenly among all the agents in Group X.
- Nobody should work two nights in a row.
- No more (or no less or exactly) than 10 sales agents should start working between 09:00 and 10:00.

E. K. Burke, H. Rudová (Eds.): PATAT 2006, pp. 518–523. ISBN 80-210-3726-1.

- No more than (or no less than or exactly) 10 agents of group X should be at work at any moment between 20:00 and 22:00.
- The schedule of an agent and his team leader should overlap in at least 80%.
- The 7.5-hour shift should be effective only on Mondays and start only in 08:00 10:00 and 10:30. Only mothers to small children are allowed to do it.
- The first break in the 10 hours shift should start between 120 to 150 minutes from shift start and last 30 minutes. The second break should start between 120 to 140 minutes from the end of the first break.
- Lunch break should be of one hour always between 11:30 and 13:30 and equaly spaced among the other breaks.
- There should be at least 2 Russian speakers and 3 Italian speakers between 10:00 and 17:00.
- There should be at least 5% of the marketing agents on-site who speak Spannish at every moment Mon-Fri between 08:00 and 21:00.
- An agent can do 2 shifts in one day only if the first is in the morning (until 08:00) and the second is after 21:00. In any case, he\she should be free for the next day.
- An agent should work between 4 to 5 days a week, with total of at least 38 hours where weekend duties are not included. Weekend limits are open to the user to define.
- If an agent works in weekend they should work in both Saturday and Sunday. They will be compensated in the next week at Thusrday and Friday.
- No more than two agents can stay in a break at the same time in Team A, between hours 08:00 and 11:00.
- The sum of all overtime hours per day should not exceed 20, from Monday to Friday, and 10 on weekends and holidays.

1.3 Intra-day Schedule

The traditional schedule requirement was to assign an agent to a shift and tell him what will be their activity during that shift. Now there is a growing request for intra-day scheduling drilled down to one hour resolution. Many centers have a lot of off-line activity that has to be addressed during the shift. Requirements for off-line activity are in terms of total number of hours per week or month. In intra-day planning an agent can do on-line and off-line work in the same shift. Another type of intra-day scheduling is breaks scheduling with the rules that accompany break assignments. Obviously, intra-day scheduling increases the problems size very much and poses performance challenges.

1.4 Workforce Management Analytic Tool

Service centers are not just interested in scheduling. They would also like to regard scheduling tools as decision support systems in more long-term aspects. They would like to be aided in deciding on their shift length and start hours, the combination of skills they need, whether they can save in headcount, how to solve their transportation problems etc.

There is also a growing demand to the ability to run different 'what if' scenarios and get some machine generated explanations on questionable results.

1.5 On-Line Crisis Management

Users would like the tool to advice them in case of no-show, sudden rise in demand and other on-line crisis situations. They would like to run a corrective program that solves the problem with minimal changes.

1.6 Complex Working Environment

Large service centers has many independent teams to schedule. They would like the tool to handle several users concurrently and also provide access to the agents themselves to enter their personal preferences. Some of the centers are world wide dispersed and time difference issues must be taken into account. Some of them have huge transportation problems. These problems connect several teams that otherwise can be solved independently.

2 *SWOPS* as a Workforce Management Solution

2.1 Background

SWOPS is being developed at IBM Haifa Research Lab (HRL) as an on demand service-based system for the shift work optimized planning and scheduling. ***SWOPS*** is a work force management tool, specifically designed for shift work, supporting multi-service queue, multi-skill environments. It is currently deployed in two very large IBM service centers in Germany and India and going to be deployed in two delivery centers in India as well. ***SWOPS*** is a follow on to CCS (Call Center Scheduler) which is in production in several directory assistance and banking call centers for more than 10 years.

2.2 *SWOPS* Technology Aspects

2.2.1 MIP Modeling with Flexibility and Calibration features

The scheduling problem is modeled into a 0-1 assignment problem of agents to scheduling slots. Penalty variables (variables that appear in the objective function) relax the business rules equations and enable the implementation of rule preference and system calibration. In some coverage equations there is also a need to model a non linear behavior of rule violation. It is done by the introduction of several layers of penalty variables to the same equation with increasing penalty values. In fact *SWOPS* uses two calibration mechanisms. The first is controlled by system administrator and

the second is user controlled. The first calibration is among different business rules and the second is between different records of the same business rule.

2.2.2 Business Rules Modeling

Scheduling problems are notorious for their rich diversity and complexity of business rules, varying considerably from one user to another. ***SWOPS*** offers an extensive 'library' of implemented business rules that cover all our current customers' needs. A lot of experience has been accumulated in modeling business rules and internal modeling tools have been developed. The result is that the implementation of new rules, even the most bizarre ones, becomes quite a simple task.

2.2.3 Flexible Scheduling Environment

A schedule run is characterized by the scheduling time range, a set of active business rules (called '*profile'*), group of agents to be scheduled and solver parameters (max. running time, search parameters, node selection etc.). In many cases the full schedule is done by running a sequence of several individual runs, each of them with its unique profile. This is called a '*phased run*' which is a powerful tool for achieving high quality schedules and fast performance.

2.2.4 Advanced Demand Graphs Coverage and Intra-day Scheduling

Usual service queue demand graph coverage assumes that an agent is assigned to a single service queue during the entire shift. ***SWOPS*** advanced coverage scheme models a business environment in which an agent can handle different service queues at the same shift and even at the same time interval. The new approach to service queue coverage addresses three very interesting problems:

1. The set of skills is large and each agent has a 'random' subset of skills (which often occurs in language skills).
2. Each queue has a very small number of incoming calls and requires a small number of agents. If they are devoted to that queue only, they are idle for most of the time.
3. The model enables the breakup of a shift into basic (30 minutes or so) time intervals. An agent may be assigned into several on-line and off-line assignments within the same shift. In fact there is a special assignment variable to each time interval.

This new coverage approach and off-line intra-day scheduling increases the problem size significantly. A considerable reduction in the solving time is achieved by integer variable prioritization that exploits the semantics of the variables.

2.2.5 Delivery Center Modeling

Delivery center deals with off line customer problems rather than phone calls. Handling time is measured in hours or days rather than seconds. The same customer problem can be handled by several people and not continuously and therefore switching times have to be taken into account. There are deadlines and periods of time where the problem is transferred to external bodies and then returns back and so on. The model is too complex for mathematical analysis and therefore there is no form of demand graph to follow. *SWOPS* applies simulation techniques to handle such cases.

2.2.6 Optimized Break Assignment

SWOPS handles timed breaks (that are limited by absolute time end-points such as lunch) as well as ordinary breaks with various spacing rules within each shift. Breaks computations must also take the coverage requirements into account. Since there are quite complicated breaks rules, the implementation uses column generation.

2.2.7 Performance Issues

Performance is a great issue in scheduling. As demands grow, the processing time increases accordingly. Our main accelerators are problem phasing, variable prioritization, and an efficient local improvement phase called ‘cleanup’.

2.2.8 Explainer

The explainer is a tool to answer user questions like: Why such a schedule was computed when they can easily point out a local improvement. The explainer enforces the user proposal and compares it to the computed schedule. If it is cheaper then a bug was found, otherwise (most of the cases) the difference in penalties is displayed to the user in a way they that can immediately recognize. Another use is to find out why a certain business rule has been violated while there seems to be some work around that does violate it.

2.3 Other Tool Features

2.3.1 Demand Forecast and Demand Graph Generation

The demand forecast takes all the day, hour, week month parameters into account + calendar special dates. The demand graph generation uses Erlang C queues model. When there are several activities, a demand graph each generated for each one.

2.3.2 Input of Personal Availability Constraints

Call center agents have their own short and long term availability constraints. They can be inserted via web interface by the agents themselves. The scheduler just has to review and approve or decline them but the input time is saved, (quite significant when you have several hundreds of agents).

2.3.3 Multi-User Environment

Current call centers consist of several independent scheduling units. Each schedule unit (or 'team') has its own agents. ***SWOPS*** is designed as a multi-user system. Just one installation is required for the whole call center. Different teams can work concurrently. The GUI is web based.

2.3.4 Security and Roles

SWOPS provide security facilities according to predefined roles. The typical roles are: Developer, system administrator (one for whole call center), scheduler (one per each schedule unit, in charge of producing weekly or monthly schedules) and agent.

2.4 Future Developments

- Delivery Center Full Solution
- Intra-day Planning - Full solution
- Transportation Solutions.
- Crisis Management.
- Shift Structure Planning