Optimality aspects with assigning of Magistrates to Sessions and Teams of the Amsterdam Criminal Court

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1 Overview

In the criminal court (Arrondissements rechtbank, sector strafrecht) of Amsterdam the assignment of magistrates (judges, officers, etc) to sessions needed to handle the cases presented, has become a problem last years mainly caused by the increase of so called mega-sessions. One complicating factor is that there are specialisations amongst the magistrates for sessions at different levels. Another one is that for some (severe) cases a team of three magistrates or judges are required (MK). The assignment takes a period of 4 weeks at a time in which each week up to 100 magistrates and 150 sessions have to be scheduled.

The objective of this research is to develop an optimal decision support system for personnel [1] to work in teams with different functions, organised in different groups. With such a system, a scheduler could make assignments in a shorter time period, more reliable and at least with the same quality. In order to reach for an optimal mix of support and user friendliness against minimal construction time/costs, we used EXCEL (with Visual Basic) for the administration-input-report data representation orientated parts and FORTRAN for the combinatorial assignment parts. CPLEX was used to obtain optimal solutions.

In general the problem described here can be characterized as a problem with a multiple conflicting objective function under overdetermined requirements with both qualitative and quantitative data [2].

The overall optimal assignment approach followed in this applied research is based on three main steps after the input of the relevant data, which is quite a problem in itself. Firstly, a so-called Availability Matrix is developed, which indicates which personnel can be assigned to which tasks, on an individual basis. In former presentations at PATAT conferences [3] the whole administrative system was explained in order to arrive at relevant, robust and reliable data. Database management is crucial here. Pre-processing and reduction rules were applied which reduced the solution space considerably without deleteting possible assignments. Next, in order to take into account the team assignments and the working conditions [4], a Combination Matrix is constructed indicating which tasks in the week the personnel can be assigned to. This assignment is still individually based. Finally, the Overall Schedule for the teams is constructed, giving a minimal difference between

E. K. Burke, H. Rudová (Eds.): PATAT 2006, pp. 492–495. ISBN 80-210-3726-1.

the total available working hours and the assigned ones: the objective function. The approach is demonstrated with a (small!) example in Tables 1..4, see Appendix.
The general approach used is to generate a number of possible alternatives and pick the optimal one. In order to arrive always at a solution within a restricted time period we used a crash approach, a Greedy algorithm, a version of the Marriage Problem and an heuristic based on the Branch-And-Bound principle with integer linear programming [5]. The paradox here is that approaches easy to apply give in general solutions far from the optimal one. The more complex the approach the better the solution possibilities will be against a more time consuming character. Another question which is dealt with is the use of commercial available Integer-Linear-Programming packages in parts of the approach.
The optimization part is still in a development stage, but a lot of experiments were executed and the results are promising. The administration part is already in use for some years.

2 Statements

The problem could be characterized using as keywords assignment, timetabling, personnel, magistrates and Decision Support Systems.
The mathematical model is a multiple-conflicting-subjective objective function under overdetermined requirements with both qualitative and quantitative data.
Always it is basic to separate data – model – solvers.
The paradox: the more constraints are added, the faster a (better) solution can be found, however, the bigger the chance on infeasibilities.
You can built in the rules, but you have to check the exceptions.
Better restrict/reduce the solution space than look for better search techniques: use the knowledge on the problem structure. Crash solution?
Collecting robust, reliable and relevant data is hard: 'You get the data you structure'.
You should not solve those problems which you can solve in view of theoretical limitations, but adept to tackle the real world requirements.

References

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Appendix: Overall optimal assignment approach

Table 1. Step 1. Availability Matrix: Possible assignments (preprocessing/reduction rules), 0: no assignment possible, 1: possible assignment, 2: specialization.

					Judges								
					AAA	BBB	CCC	DDD	EEE	FFF	PV1		
					1	2	2	1	2	1	5	Group	
					1.7	3.5	5.0	4.5	5.0	5.0	0	Pt (C)	24.9
Sessions					0	0	0	0	0	0	2.5	Pt (E)	2.5
Name F	nr	MK	Pt	Gr	0.7	2.5	4.0	4.5	4.0	5.0	0	Pt (F)	20.7
madMK4A OR	1	2	2.5		0	2	0	0	1	0	0		
madMK4A JR	2	1	2.5		0	0	2	0	1	0	0		
maoSR1	3		1.3		1	1	1	1	1	0	0		
mamPR1	4		1.6		0	1	1	1	1	1	0		
wodMK7A VZ	5	6,7	3.3		0	0	0	2	0	0	0		
wodMK7A OR	6	5,7	2.5		0	0	0	0	0	2	0		
wodMK7A JR	7	5,6	2.5	1	0	0	0	0	0	0	1		
wooSR1	8		1.3		1	0	1	1	0	1	0		
wooPR1	9		1.6		1	0	1	1	0	1	0		
womPR2	10		1.6		1	0	1	1	0	1	0		
dooPREC	11		1.4	2	2	0	0	0	0	0	0		
domPR1	12		1.6		0	1	0	0	1	0	0		
vrmPR1	13		1.6		1	1	1	1	1	1	0		
		∑	25.3										
					0.4	1.5	3.0	3.5	3.0	4.0		Pt min	
					1.7	3.5	5.0	5.5	5.0	6.0		Ptmax	

Table 2. Step 2. Combinations per person. Need to know about restrictions in assigning points and distance sessions: absmin, absmax, relmax, relmin, ddMK, ddEK (=0.4 6.0 1.0 1.0 2 1).

Fortran output

```
  8 UITVOEREN ALTERNATIEVEN
 AAA 0.70 1 1.40 dooPREC VZ +
 BBB 2.50 1 2.50 madMK4A OR +
 CCC 4.00 3 3.80 madMK4A JR + wooSR1  VZ +
            4.10 madMK4A JR + wooPR1  VZ +
            4.10 madMK4A JR + womPR2  VZ +
 DDD 4.50 3 4.60 wodMK7A VZ + maoSR1  VZ +
            4.90 wodMK7A VZ + mamPR1  VZ +
            4.90 wodMK7A VZ + vrmPR1  VZ +
 EEE 4.00 3 4.10 madMK4A OR + domPR1  VZ +
            4.10 madMK4A OR + vrmPR1  VZ +
            4.10 madMK4A JR + domPR1  VZ +
 FFF 5.00 3 4.10 wodMK7A OR + mamPR1  VZ +
            4.10 wodMK7A OR + vrmPR1  VZ +
            5.70 wodMK7A OR + mamPR1  VZ + vrmPR1  VZ +
 PV1 0.00 1 2.50 wodMK7A JR +
 XXX 0.00 0 0.00 +
```

Table 3. Combination matrix: possible assignment for magistrates. Pt: points available against points required

		judges		AAA	BBB	CCC			DDD			EEE			FFF			PV1
sessions			Pt	0.7	2.5		4.0			4.5			4.0			5.0		0
madMK4A OR	1	2	2.5		2							1	1					
madMK4A JR	2	1	2.5			2	2	2						1				
maoSR1	3		1.3						1						1			
mamPR1	4		1.6							1							1	
wodMK7A VZ	5	6,7	3.3						2	2	2							
wodMK7A OR	6	5,7	2.5												2	2	2	
wodMK7A JR	7	5,6	2.5															1
wooSR1	8		1.3			1												
wooPR1	9		1.6				1											
womPR2	10		1.6					1										
dooPREC	11		1.4	2														
domPR1	12		1.6									1		1				
vrmPR1	13		1.6								1		1			1	1	
				0.7	2.5	3.8	4.1	4.1	4.6	4.9	4.9	4.1	4.1	4.1	4.1	4.1	5.7	0

Table 4. Step 3 Construction Overall Schedule

Crash: only special: first still available
Greedy: use combinations, see Table 2
Marriage Problem: ordering assignments, see Table 1, forbidden combinations are needed
Optimisation: as much as possible combinations (ILP)
Always assign just one of the alternative combinations or a part of one combination.

				Crash	Greedy	Marriage	Optimize
				2		1	
madMK4A OR	1	2	2.5	BBB	BBB	BBB	BBB
madMK4A JR	2	1	2.5	CCC	CCC	CCC	CCC
maoSR1	3		1.3		DDD	DDD	EEE
mamPR1	4		1.6		FFF	FFF	FFF
wodMK7A VZ	5	6,7	3.3	DDD	DDD	DDD	DDD
wodMK7A OR	6	5,7	2.5	FFF	FFF	FFF	FFF
wodMK7A JR	7	5,6	2.5	PV1	PV1	PV1	PV1
wooSR1	8		1.3		CCC		EEE
wooPR1	9		1.6			CCC	CCC
womPR2	10		1.6				
dooPREC	11		1.4	AAA	AAA	AAA	AAA
domPR1	12		1.6		EEE	EEE	DDD
vrmPR1	13		1.6		FFF	FFF	FFF
points assigned		∑PtG	20.7	12.2	19.6	19.9	21.2
% from optimal		ObjF	100	41	5	4	1