Operational Indicators for public transport companies

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SUMMARY

The Operational Indicators Board is a top level oriented module for mass transport companies. The proposal is to collect and to show the planning and control information to support the decision making process. In this extended abstract the authors describe the indicators identification process and discuss the main ideas for the module functionality.

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The GIST system

The GIST system is a computer application for supporting operational planning in public transport companies. It was developed as a decision support system which aims to help transport companies to improve the operation of critical resources, such as vehicles, drivers and planning staff. The system is also an important software tool to support tactical and strategic management studies regarding companies operations. A consortium of 5 leading Portuguese transport companies (CARRIS, STCP, Horários do Funchal, Empresa Barraqueiro and Vimeca) and 2 R&D institutes (INEGI-FEUP and ICAT-FCUL) is responsible for the GIST system. The companies involved in this consortium operate daily about 6000 vehicles, corresponding broadly to half of the road public transport market in Portugal, including Madeira and Azores.

The GIST system was successfully installed in those companies in 1996. Nowadays, the upgrades of this application are being developed under the name of GIST98/EUROBUS. This evolution represents both an improvement to the GIST present functions and an extension of its functionality.

The GIST98/EUROBUS system

The GIST98/EUROBUS system will contain the following modules:

- Network Module, allowing the definition of the transportation network;
- Gist-Line Module, the route information module;
- Trip and Vehicle Scheduling Module, allowing the trip timetable definition and the vehicle scheduling information management and optimisation. This module will have 4 algorithms: the basic algorithm gives the lower cost solution; the fixed algorithm gives the lower cost solution using a given number of vehicles but guaranteeing that all the trips are

affected; the fixed algorithm with penalties does the same as the previous algorithm but does not guarantee that all the trips are affected; finally, the multi-depot algorithm does the same as the basic one but for more than one depot;

- Crew Scheduling Module, the crew scheduling information management and optimisation module. This module will have three families of algorithms: genetic algorithms; columns implicit generation with Branch and Bound, if the solution is not integer; and feasible services generation with lagrangean and linear relaxation;
- Rostering Module, in which is defined who will do each duty each day and in which various optimisation algorithms are applied to the rostering rules. The algorithms use columns implicit generation with Branch and Bound, when the solution is not integer;
- User Information Module, a user-oriented module which provides information to the users of public transports;
- Operational Indicators Board Module, a top level oriented module which gives operational indicators to support the decision making process;
- Hiring Management Module, the module that manages the renting vehicle activity.

The first 4 modules will be upgrades of the present GIST modules. The Crew Scheduling Module, the Rostering Module, the User Information Module and the Operational Indicators Board Module belong to the EUROBUS project that has been financially supported by the Agência de Inovação. All these modules together with the Hiring Management one form the GIST98/EUROBUS system.

The Operational Indicators Board Module (QIO)

The QIO Module filters the information derived from the other modules so that the operational managers can access, in an easy way, the relevant information for the decision making process. The main problem in structuring a QIO Module is to define those indicators, which are significant to the managers and those that are important to the planners but not necessarily to the managers. The QIO Module will just contain the information useful to the operational managers. All the other information is included in the corresponding module. As the GIST98/EUROBUS is a decision support system to the operational planning, the information we can get from it is essentially planning information.

The first questions we tried to answer were: “Which are the big groups of indicators that operational managers need?” and “Which indicators must be included in each group?”.

The results presented in this text are derived from the study accomplished at the STCP Company.

1. “Which are the big groups of indicators that operational managers need?”
   Taking attention to the information GIST98 will have and to the big areas that operational managers work with, we have defined 3 main groups of operational indicators: service indicators, crew indicators and vehicle indicators. The first group gives information about the level of service that the company is offering, which is especially important to the commercial department; the crew indicators give information relevant to the human resource department and, finally, the vehicle indicators are useful to the logistic department.

2. “Which indicators must be included in each group?”
   The answer to this question is not easy. The complexity involved in the definition of those indicators creates problems in a systematic approach. The way we solved this question will be explained in the next section.

The process of defining the service indicators

The first thing to do was to collect information from the companies. It was a long, interactive process between the analysts and the companies’ staff. The service reports produced monthly were another major source of information.

From the information collected it was possible to notice that each potential indicator has no more than 4 parameters. This means that it is possible to identify a specific indicator by answering to 4 questions: “Which is the indicator denomination?”, “Which entity does the indicator refers to?”, “Which is the aggregation level used?” and “Which aggregation function does it represent (in other words, is it an average, a maximum or any other kind of function)?”. As an example: if we want to know the average width of trips per route, the indicator is the width, the entity is the trip, the aggregation level is the route and the aggregation function is the average. Using this methodology it was possible to identify the indicators group, the entities group and the aggregation function group. The aggregation level was more complex to define. In fact, using the example above, the trips can be aggregated by route, by line, by period of the day, by day, by line and by period of the day, at the same time, i.e. they can be aggregated by one entity or by a combination of entities. The first thing we observed was that when an indicator can be aggregated by one entity it can also be aggregated by more generic entities. In the example, if routes can aggregate trips, lines can also aggregate trips (notice that a line is a set of routes). The step forward was to define the different dimensions to be used. Each dimension refers to a sequence of entities. The order by which they appear on the table below is defined by their degree of detail. This means that the first entity of each dimension is the most specific one and the last one is the most generic. In other words, the entity referred at the last column of each dimension is a set of the entities referred at the previous one, and so on.

The tables 1 and 2 present part of the results obtained by this methodological approach (the aggregation functions were ignored just for the sake of simplicity).

Dimensions	Entities					
Space	Segment	Route	Line	Gist-line	Depot	Network
Time	Period	Day type	Week	Month	Quarter	Year
Trips	Trip	Vehicle	Depot	Network		
Rosters	Duty-period	Duty	Duty type	Roster	Depot	Network

Table 1

Service Indicators	Dimensions				
	Space	Time	Trips	Rosters	Planed vs. Real
Extension	x				
Number of routes	x				
Routes width	x				
Number of lines	x				
Lines width	x				
Number of trips	x	x	x	x	x
Number of vehicles used		x	x		x
Number of vehicles used at the same time	x	x	x		x
Total distance	x	x	x	x	x
Commercial distance	x	x	x	x	x
Non commercial distance	x	x	x	x	x
Commercial time	x	x	x	x	x
Non commercial time	x	x	x	x	x
Commercial speed	x	x			x

Table 2

The QIO functionality

The data for QIO will be stored in an appropriate database. This is an important feature for various reasons. Some companies operate in several towns and they may have a GIST98/EUROBUS system working at each town; if the managers want to know indicators concerning all the company, and not just a part of it, the QIO has to work at the same time with information from several databases in order to provide the right indicators. Moreover, the information that is stored is not necessarily the same that is used to support the operational planning. Sometimes, specific statistics based on that information are enough. So, the information will be red from different databases with a given periodicity and only the one that is relevant to the QIO Module will be stored.

The QIO Module will have access permission rules. These rules will allow the definition of permissions by groups of indicators or for each indicator individually considered. The visualisation of the performance indicators and the production of reports according to the company needs are the two main user facilities. The production of reports will also include the possibility of creating documents in a data-sheet format.

Main references

[1] Bertossi, A.A.; P.Carraresi and G. Gallo, “On some Matching Problems Arising in Vehicle Scheduling Models”, Networks 17, 1987, pp. 271-281.

[2] Borges, J.L. and Cunha, J.F., “Sistema de apoio à geração de escalas de pessoal no planeamento operacional de sistemas de transportes colectivos”, In: Investigação Operacional 15, 1, 1995.

[3] Bureau of Transportation Statistics (BTS) of the U.S. Department of Transportation, “National Transportation Statistics 1997”, 1997.

[4] Chu, P.C and Beasley, J.E., “A Genetic Algorithm for the Set Partitioning Problem”, European Journal of Operation Research 94, 1995, pp. 392-404.

[5] Desrochers, M. and Soumis, F., “CREW-OPT: Crew scheduling by column generation”, In: Daduna, J. and Wren, A. (eds.), Computer-Aided Transit Scheduling, North-Holland, Amsterdam, 1995.

[6] Desrochers, M. and Soumis, F., “A Column Generation Approach to the Urban Transit Crew Scheduling Problem”, Transportation Science, Vol.23, nº1, February 1989.

[7] Mesquita, M. and Paixão, J., "Multiple Depot Vehicle Scheduling Problem: A New Heuristic Based on Quasi-Assignment Algorithms", Computer-Aided Transit Scheduling, (M. Desrochers and J.M.Rousseau, eds.), Lecture Notes in Economics and Mathematical Systems 386, Springer Verlag, Berlin, Heidelberg, 1992, pp. 167-180.
[8] Sousa, J.F., "A Computer Based Interactive Approach to Crew Scheduling", European Journal of Operational Research, 55, 1991, pp. 382-393.
[9] Sousa, J.P., Sousa, J.F. and Guimarães, R.C., "Un système informatique d'aide à la génération d'horaires de bus et de chauffeurs", in: Gestion de l'économie et de l'entreprise – l'approche quantitative, Editions CORE, Série Balises, De Boeck, Brussels, 1988, pp. 477-492.
[10] Thomsen, E., "OLAP Solutions: Building Multidimensional Information Systems", John Wiley & Sons, Inc., 1997.