Available online at www.sciencedirect.com
ScienceDirect
European Journal of Operational Research 176 (2007) 1371–1386
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

Discrete Optimization

The TV-Break Packing Problem

Thierry Benoist [a,*], Eric Bourreau [b], Benoît Rottembourg [c]

[a] *Bouygues e-lab, 1 av. Eugène Freyssinet, 78061 St. Quentin en Yvelines Cedex, France*
[b] *LIRMM, 161 rue Ada, 34392 Montpellier Cedex 5, France*
[c] *TF1, 1 quai Point du Jour, 92100 Boulogne Billancourt, France*

Received 29 July 2004; accepted 16 September 2005
Available online 6 December 2005

Abstract

Instead of selling advertisement spots one by one, some French satellite channels decided in 2002 to modify their commercial offer in order to sell packages of spots. These new general conditions of sale lead to an interesting optimization problem that we named the TV-Break Packing Problem (TVBP). We establish its NP-hardness and study various resolutions approaches including linear programming (LP), Lagrangian relaxation (LR), constraint programming (CP) and local search (LS). Finally we propose a generic CP/LS hybridization scheme (branch and move) whose application to the TVBP obtained the best results in our experiments. Dual upper bounds of the maximal revenue are also computed.

Keywords: Combinatorial optimization; Constraint programming; Linear programming; Local search

1. Introduction

Satellite TV channels draw an increasing audience in France (from 1 million to 12 millions viewers in 2002). In addition to subscription fees, a large percentage of their revenues comes from broadcasted advertisements. Since 2001, accurate audience measurements are available for these thematic channels. Share of markets are generally smaller than those of hertzian general interest channels, but target groups (housewives, upper class, 15–24 year old people...) are precisely identified what is an interesting feature from an advertiser point of view since it helps designing sharp marketing strategies.

* Corresponding author. Tel.: +33 130 602835; fax: +33 130 602115.
E-mail addresses: tbenoist@bouygues.com (T. Benoist), eric.bourreau@lirmm.fr (E. Bourreau), brottembourg@tf1.fr (B. Rottembourg).

0377-2217/$ - see front matter
doi:10.1016/j.ejor.2005.09.027

Instead of selling advertisement "spots" (a slot of 30s during a TV break) one by one, the marketing department of a bundle of satellite channels decided to modify its commercial offer in order to sell *packages* of spots. Several types of packages are proposed, characterized by their *price*, *size* (number of spots) and *shape* (approximate dispatching of spots into keys zones of the week like prime time, week-end, night...). The most innovative aspect of this offer lies in an audience guarantee attached to each type of package, namely a lower bound on the total number of (forecasted) spectators collected by spots constituting the package. This feature allows advertisers saving time (no need to select each TV-break) without loss of efficiency for the media plan (audience is guaranteed).

For a TV-channel, these packages have to be designed in order to fit the demands of the advertising market. Besides, interaction between these packages must also be taken into account because of the limited capacity of each TV-break: for instance selling too many week-end specific packages can prevent selling packages spanning the whole week. Due to such interactions, packages need to be prepared beforehand. In the above example, building packages on demand may lead to inextricable situations if the first clients all choose packages of the "week-end" family.

The problem considered in this paper takes as input a list of packages (price, size, shape and audience requirement) that the marketing department would like to build for a given week. The objective is to build all these packages, maximizing the total value of those fulfilling their audience constraint. We name it the TV-Break Packing Problem (TVBP). We shall point out in Section 2.2 that it can be seen a generalization of the NP-hard 3-Partition problem.

The problem is defined in Section 2 and its NP-hardness is proven. Section 3 is devoted to mathematical programming approaches (linear programming and lagrangian relaxation) essentially providing upper bounds of the maximal revenue. In Section 5 a constraint programming (CP) model of the problem is designed and a local search (LS) improvement process applicable to a solution is introduced. Finally, an original CP/LS hybrid algorithm (*Branch* and *Move*) is defined and applied to the TVBP, yielding high-quality solutions. After a presentation of computational results we conclude on real-world variants of the TVBP.

2. The TV-Break Packing Problem

In this section we give a formal (linear) description of the TV-Break Packing Problem and we establish it NP-hardness. Its underlying flow structure is also emphasized.

2.1. Description

In a TV channel week there is a fixed number of commercial breaks. The TV-Break Packing Problem described below essentially consists in partitioning this limited resource into packages, subject to audience collecting constraints.

Each TV-break is characterized by its forecasted audience and by the number of advertisement messages it can contain (all messages having equal duration). Instead of selling these spots[1] one by one, the marketing department of the TV channel wants to prepare several packages of spots. For each package they define its price, size (number of spots) and "shape". This shape is a hierarchical time-zones decomposition of the week (week-end, prime-time, etc....) with minimum and maximum number of spots on each zone. Each package is also assigned an audience *requirement* i.e. a minimum total number of spectators (sum of forecasted audiences). Finally no package can have two spots in the same TV-break.

[1] What we call "spot" is a slot of 30 seconds during which an advertisement can be broadcasted.