1 Introduction

This part provides a summary of our theory on DAB ensemble/block assignment planning which the DABTool program is based on. It is intended as a prerequisite to Part II which describes the software itself. Note that this is work in progress and therefore new solution approaches and algorithms are likely to be added in the future.

While channel assignment methods for analog networks, which are usually based on graph coloring techniques (see, e.g., [2, 8, 10, 13, 14]), are also applicable to DAB planning, they are not by themselves sufficient for the effective planning of large DAB networks. This is due to the fact that, in contrast to classical radio networks, the DAB system transmits whole *ensembles* consisting of multiple radio programs and other (data) services, and allows an ensemble to be transmitted on a single channel even if the corresponding transmitters may interfere. Hence it is possible to span large areas with so-called *single frequency networks*, which makes it possible to utilize electromagnetic spectrum much more efficiently. To make the best use of this feature, however, it is necessary to integrate the planning of the ensembles with the frequency assignment step. This is not possible with the techniques currently in use for DAB frequency assignment, which, to our knowledge, are all simply adaptions of known graph coloring techniques that are applied to a prescribed ensemble collection.

In the following we show how to formulate the generalized planning problem sketched out above, which we call the *ensemble planning problem*, as a combined bin packing/graph coloring problem. We also demonstrate how this problem can be solved using heuristics. Furthermore, we point out how to compute lower bounds in order to assess the quality of computed solutions, present some test results obtained using the DABTool program, and discuss some generalizations of the problem statement arising in practice, which will be the subject of future research.

We should point out that while the focus of our work is on DAB planning, the same methods should also apply to other digital broadcast systems using similar technology, like digital video broadcasting (DVB-T).

Mathematical Preliminaries

We assume familiarity with the basic notions of graph theory (see, e.g., [7] or [11]) and NP-completeness [6]. All graphs in this paper are simple undirected and loopless. The subgraph of a graph $G = (V, E)$ *induced* by a subset of vertices $W \subseteq V$ is denoted G_W; it consists of the vertex set W and all edges of G between vertices in W. A *coloring* of a graph $G = (V, E)$ is a function f mapping vertices to "colors" in such a manner that $f(v) \neq f(w)\ \forall\ vw \in E$. If $|f(V)| \leq k$ then f is also called a *k-coloring*. The *chromatic number* $\chi(G)$ of G is defined to be the minimum k for which such a k-coloring exists. The *graph coloring problem* is, given $G = (V, E)$ and integer $k \geq 0$, to decide whether G has a k-coloring. A *clique* of a graph $G = (V, E)$ is a subset W of V s.t. G_W is *complete*, i.e., $vw \in E\ \forall\ v, w \in W : v \neq w$. The *clique number* $\omega(G)$ is the maximum number of vertices in a clique of G, and the *clique problem* is, given G and integer $k \geq 0$, to decide whether