propagation analysis.

Thus in our model an instance of the ensemble planning problem consists of the following items:

- a set S of *services*, where each service $s \in S$ has a positive *bandwidth* μ_s;
- the *area graph* $G = (V, E)$, where V is the set of areas and the edge set E is interpreted as the interference relationship between areas;
- the *requirements* R_v, $v \in V$, which denote, for each area $v \in V$, the set of services to be supplied in that area;
- the maximum *ensemble size* $M > 0$.

We generally assume (w.l.o.g.) that all bandwidths and the ensemble size are positive integers. R and μ are considered as functions $R : V \mapsto 2^S$ and $\mu : S \mapsto \mathbb{N}$. In the following we usually only specify the parameters G, R and M and assume a corresponding service set S with bandwidths μ without further notice.

A solution to the ensemble planning problem consists of two items, an *ensemble assignment* and a corresponding *block assignment.* An *ensemble assignment* is a relation $\mathcal{B} \subseteq V \times 2^S$, which assigns to each $v \in V$ a set $\mathcal{B}_v = \{B : (v, B) \in \mathcal{B}\}$ of *ensembles* (service sets) which are to be transmitted in the corresponding area. For an ensemble assignment $\mathcal{B}$ to be *admissible*, it must satisfy the supply requirements, and the individual ensembles must not exceed the maximum ensemble size:

$$R_v \subseteq \bigcup_{B \in \mathcal{B}_v} B \; \forall\, v \in V, \tag{1}$$

$$\mu_B \leq M \; \forall\, B \in \mathcal{B}_v, v \in V, \tag{2}$$

where the total bandwidth μ_B of an ensemble $B \subseteq S$ is defined by $\mu_B = \sum_{s \in B} \mu_s$.

The second part of the solution is the *block assignment* f, which maps each $(v, B) \in \mathcal{B}$ to a corresponding frequency block or "color" $f(v, B)$. To be *admissible*, the block assignment must not introduce any interferences, i.e., different ensembles in the same or interfering areas must always be assigned different frequency blocks:

$$f(v, B) \neq f(w, C) \; \forall\, (v, B), (w, C) \in \mathcal{B} : B \neq C \wedge (v = w \vee vw \in E). \tag{3}$$

Finally, the *target function* to be minimized is the number of distinct frequency blocks, i.e., $|f(\mathcal{B})| = |\{f(v, B) : (v, B) \in \mathcal{B}\}|$. We can now formulate the ensemble planning problem in the usual decision format as follows:

Problem 1 (Ensemble Planning Problem) Given $G = (V, E)$, $R : V \mapsto 2^S$, $M \in \mathbb{N}$ and $K \in \mathbb{N}$, decide whether there is an admissible ensemble assignment $\mathcal{B}$ and corresponding admissible block assignment f s.t. $|f(\mathcal{B})| \leq K$.