KoI local resource allocation problem

Table 1: ILP input parameters

C	set of available wireless channels
P	set of communication pairs (within the local cell)
$B \in \mathbb{N}_0^{\lvert P\rvert \times \lvert C\rvert}$	CSI matrix indicating how many bits of a packet of $p \in P$ can be transmitted over $c \in C$ per time slot
$\mathrm{N_s}$	amount of available time slots (in the considered time frame)
$\mathrm{T_s}$	size of a time slot
$\mathrm{ps}(p)$	packet size of each packet of communication pair $p \in P$
$\mathrm{per}(p)$	scheduling period of communication pair $p \in P$
$\mathrm{D}(p)$	deadline for each packet of communication pair $p \in P$
$\mathrm{n}(p) = \frac{\lvert T\rvert \cdot \mathrm{T_s}}{\mathrm{per}(p)}$	amount of packets of communication pair $p \in P$ to be considered
$\mathcal{M}$	big-M constant (sufficiently large constant needed for modelling purposes)

Table 2: ILP variables

$x_{p,i,c,k} \in \{0,1\}$	determines whether the i-th packet of $p \in P$ is scheduled on $c \in C$ in time slot k
$z_c \in \{0,1\}$	determines whether channel $c \in C$ is used at all

The objective of this optimization problem is finding the minimum amount of wireless channels that allows scheduling the traffic of all communication pairs within the local cell (1).

$$\min \quad \sum_{c \in C} z_c \tag{1}$$

We need to ensure the validity of the z variables (2).

$$s.t. \quad \sum_{p \in P} \sum_{i=1}^{\mathrm{n}(p)} \sum_{k=1}^{\mathrm{N_s}} x_{p,i,c,k} \leq \mathcal{M} \cdot z_c, \quad \forall c \in C \tag{2}$$

All packets need to be scheduled for a sufficient amount of time slots to be fully transmitted (3).

$$s.t. \quad \sum_{c \in C} \sum_{k=1}^{\mathrm{N_s}} x_{p,i,c,k} \cdot B_{p,c} \geq \mathrm{ps}(p), \quad \forall p \in P, i \in \{1, \ldots, \mathrm{n}(p)\} \tag{3}$$

Of course, each time slot must be scheduled at most once per channel (4).

$$s.t. \quad \sum_{p \in P} \sum_{i=1}^{\mathrm{n}(p)} x_{p,i,c,k} \leq 1, \quad \forall c \in C, k \in \{1, \ldots, \mathrm{N_s}\} \tag{4}$$

At last, each packet must be scheduled between its arrival time (5) and all of its scheduled time slots must end before its deadline is reached (6).

$$\begin{aligned} & \forall p \in P, i \in \{1, \ldots, \mathrm{n}(p)\}, c \in C, k \in \{1, \ldots, \mathrm{N_s}\} : \\ s.t. \quad & (1 - x_{p,i,c,k}) \cdot \mathcal{M} + x_{p,i,c,k} \cdot (k-1) \cdot \mathrm{T_s} \geq (i-1) \cdot \mathrm{per}(p), && (5) \\ s.t. \quad & x_{p,i,c,k} \cdot k \cdot \mathrm{T_s} \leq (i-1) \cdot \mathrm{per}(p) + \mathrm{D}(p). && (6) \end{aligned}$$