A model for scheduling and staffing multiple projects with a multi-skilled workforce organized in teams

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DEMO TIME!

EXCELLENT!

Motivation

(Business) Motivation

- Current solution is combination of heuristic search an Simplex
- Provide 'better' schedules to our customers
- ... if that is even possible

Problem Decomposition

Scrum Teams Scheduling Problem

Schedule a set of stories for a set of teams working with Scrum sprints leaving out releases and epics.

Kanban Teams Scheduling Problem

As above but with the teams working in Kanban mode.

Sprint Assignment Problem

Assign a set of activities to a set of resource within a single sprint.

Input

Input

We are given the following:

- a set of skills $s \in \mathcal{S}$
- a set of resources $r \in \mathcal{R}$
- resource presence p_r
- a set of skills for every resource $\mathcal{S}_r \subseteq \mathcal{S}$
- a set of activities $a \in \mathcal{A}$
- the activity demands d_{as}
- the resource limitation l_a

Problem Variants

Sprint Assignment Feasiblity Problem

Find a feasible assignment.

Sprint Assignment Overbooking Problem

Allow overbooking resources in order to get all activities done - minimize overbooked work.

Sprint Assignment Selection Problem

Assign a weight to the activities and decide whether or not to implement them - maximize weight of selected activities.

Sprint Assignment Feasibility Problem

$$
\begin{aligned}
\min \quad & C & & \\
\text{s.t.} \quad & \sum_{a \in \mathcal{A}} \sum_{s \in \mathcal{S}} X_{ars} \leq p_r & & r \in \mathcal{R} \\
& \sum_{r \in \mathcal{R}} X_{ars} = d_{as} & & a \in \mathcal{A}, s \in \mathcal{S}_a \\
& \sum_{s \in \mathcal{S}} X_{ars} \leq Y_{ar} \cdot M & & a \in \mathcal{A}, r \in \mathcal{R} \\
& \sum_{r \in \mathcal{R}} Y_{ar} \leq l_a & & a \in \mathcal{A} \\
& Y_{ar} \in \{0, 1\} & & a \in \mathcal{A}, r \in \mathcal{R} \\
& X_{ars} \in \mathbb{R}^+ & & a \in \mathcal{A}, r \in \mathcal{R}, s \in \mathcal{S}
\end{aligned}
\tag{1}
$$

Sprint Assignment Overbooking Problem

$$
\begin{aligned}
\min \quad & \sum_{a\in\mathcal{A}}\sum_{r\in\mathcal{R}}\sum_{s\in\mathcal{S}} X^{+}_{ars} \\
\text{s.t.} \quad & \sum_{a\in\mathcal{A}}\sum_{s\in\mathcal{S}} X_{arst} \le p_r && r\in\mathcal{R} \\
& \sum_{r\in\mathcal{R}} X_{ars} + X^{+}_{ars} = d_{as} && a\in\mathcal{A}, s\in\mathcal{S}_a \\
& \sum_{s\in\mathcal{S}} X_{ars} + X^{+}_{ars} \le Y_{ar}\cdot M && a\in\mathcal{A}, r\in\mathcal{R} \\
& \sum_{r\in\mathcal{R}} Y_{ar} \le l_a && a\in\mathcal{A} \\
& Y_{ar} \in \{0,1\} && a\in\mathcal{A}, r\in\mathcal{R} \\
& X_{ars} \in \mathbb{R}^{+} && a\in\mathcal{A}, r\in\mathcal{R}, s\in\mathcal{S} \\
& X^{+}_{ars} \in \mathbb{R}^{+} && a\in\mathcal{A}, r\in\mathcal{R}, s\in\mathcal{S}
\end{aligned} \tag{2}
$$

Sprint Assignment Selection Problem

$$
\begin{aligned}
\max \quad & \sum_{a \in \mathcal{A}} Y_{ab} \cdot w_a \\
\text{s.t.} \quad & \sum_{a \in \mathcal{A}} \sum_{s \in \mathcal{S}} X_{ars} \leq p_r && r \in \mathcal{R} \\
& \sum_{r \in \mathcal{R}} X_{ars} = Y_{ab} \cdot d_{as} && a \in \mathcal{A}, s \in \mathcal{S}_a \\
& \sum_{s \in \mathcal{S}} X_{ars} \leq Y_{ar} \cdot M && a \in \mathcal{A}, r \in \mathcal{R} \\
& \sum_{r \in \mathcal{R}} Y_{ar} \leq l_a && a \in \mathcal{A} \\
& Y_{ab} \in \{0, 1\} && a \in \mathcal{A} \\
& Y_{ar} \in \{0, 1\} && a \in \mathcal{A}, r \in \mathcal{R} \\
& X_{ars} \in \mathbb{R}^+ && a \in \mathcal{A}, r \in \mathcal{R}, s \in \mathcal{S}
\end{aligned} \tag{3}
$$

Results

Experiment setup

Schedule 1000 activities for 50 resources with 5 skills in 100 randomly generated instances:

- Activity demands: randomly from $[0, \ldots, 5]$
- Resource presences: randomly from $[0, \ldots, 100]$
- Resource skills randomized uniformly

Runtime Results

[ms]	Feasibility	Overbook	Selection
mean	4257	5453	10163
stdDev	540	349	15379
median	4154	5354	5765

Future Work

Next Steps:

- Explain why MILP works so well.
- Compare with heuristic.
- Extend model with sequence of sprints.