Sprint Planning and Delivery Optimization Model (SCRUM Domain)

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Contents

1 1. Sets (Entities)

- $\mathcal{P}$ = Projects (Entity: `Project`)
- $\mathcal{T}$ = Teams (Entity: `Team`)
- $\mathcal{W}$ = Workers (Entity: `Worker`)
- $\mathcal{F}$ = Features (Entity: `Feature`)
- $\mathcal{S}$ = Skills (Entity: `Skill`)
- $\mathcal{R}$ = Roles (Entity: `Role`)
- $\mathcal{PO}$ = Product Owners (Entity: `ProductOwner`)
- $\mathcal{SM}$ = Scrum Masters (Entity: `ScrumMaster`)
- $\mathcal{PB}$ = Product Backlogs (Entity: `ProductBacklog`)
- $\mathcal{SP}$ = Sprints (Entity: `Sprint`)
- $\mathcal{SPP}$ = Sprint Plannings (Entity: `SprintPlanning`)
- $\mathcal{DS}$ = Daily Scrums (Entity: `DailyScrum`)
- $\mathcal{SR}$ = Sprint Reviews (Entity: `SprintReview`)
- $\mathcal{SRE}$ = Sprint Retrospectives (Entity: `SprintRetrospective`)
- $\mathcal{SBL}$ = Sprint Backlogs (Entity: `SprintBacklog`)
- $\mathcal{SG}$ = Sprint Goals (Entity: `SprintGoal`)
- $\mathcal{E}$ = Epics (Entity: `Epic`)
- $\mathcal{US}$ = User Stories (Entity: `UserStory`)
- $\mathcal{TSK}$ = Tasks (Entity: `Task`)
- $\mathcal{DEV}$ = Development Snapshots (Entity: `DevelopmentSnapshot`)
- $\mathcal{BL}$ = Blockers (Entity: `Blocker`)
- $\mathcal{SH}$ = Stakeholders (Entity: `Stakeholder`)
- $\mathcal{VEL}$ = Velocities (Entity: `Velocity`)
- $\mathcal{REP}$ = Release Plans (Entity: `ReleasePlan`)
- $\mathcal{RM}$ = Roadmaps (Entity: `Roadmap`)
- $\mathcal{SCB}$ = Scrum Boards (Entity: `ScrumBoard`)
- $\mathcal{FED}$ = Feature Documentations (Entity: `FeatureDocumentation`)

Relationship-induced index maps (from `Relationships.csv`).

- $U(s) \subseteq \mathcal{US}$: user stories contained in epic $s \in \mathcal{E}$ (R9).
- $K(u) \subseteq \mathcal{TSK}$: tasks belonging to user story $u \in \mathcal{US}$ (R10).
- $B(u) \subseteq \mathcal{SBL}$: sprint backlogs that include user story u (R11).
- $S(\text{sp}) \in \mathcal{SBL}$: the sprint backlog of sprint sp (R12).
- $G(\text{sp}) \in \mathcal{SG}$: the goal pursued by sprint sp (R13).
- $L(\text{scb}) \subseteq \mathcal{TSK}$: tasks on scrum board scb (R14).
- $D(\text{sp}) \in \mathcal{DEV}$: snapshot generated by sprint sp (R22).
- $H(\text{rep}) \subseteq \mathcal{F}$: features planned in release plan rep (R20).

2 2. Indices

- $p \in \mathcal{P}$, $t \in \mathcal{T}$, $w \in \mathcal{W}$, $f \in \mathcal{F}$, $s \in \mathcal{S}$, $r \in \mathcal{R}$.
- $po \in \mathcal{PO}$, $sm \in \mathcal{SM}$, $pb \in \mathcal{PB}$, $\text{sp} \in \mathcal{SP}$.
- $\text{spp} \in \mathcal{SPP}$, $ds \in \mathcal{DS}$, $sr \in \mathcal{SR}$, $sre \in \mathcal{SRE}$.
- $\text{sbl} \in \mathcal{SBL}$, $g \in \mathcal{SG}$, $e \in \mathcal{E}$, $u \in \mathcal{US}$, $k \in \mathcal{TSK}$.
- $d \in \mathcal{DEV}$, $b \in \mathcal{BL}$, $sh \in \mathcal{SH}$, $v \in \mathcal{VEL}$, $\text{rep} \in \mathcal{REP}$, $rm \in \mathcal{RM}$, $scb \in \mathcal{SCB}$, $fed \in \mathcal{FED}$.

Data parameters from `Entities.csv` (attributes).

- $\text{sp}(u) \in \mathbb{Z}_{\geq 0}$: story points of user story u (`UserStory.story_points`).
- $\text{stat}^{US}(u) \in \{0, 1\}$: eligibility/status mask for user story u (`UserStory.status`).
- $\text{eff}(k) \in \mathbb{Z}_{\geq 0}$: effort of task k (`Task.effort`); $\text{type}(k)$ is its type.
- $\text{stat}^{TSK}(k) \in \{0, 1\}$: task status mask (1 = allowed).
- $\text{sev}(b) \in \mathbb{Z}_{\geq 0}$: blocker severity (`Blocker.severity`); $\text{act}(b) \in \{0, 1\}$ active mask.
- $\text{prio}(f) \in \mathbb{Z}_{\geq 0}$: feature priority (`Feature.priority`).
- $\text{rel}(sh) \in \mathbb{Z}_{\geq 0}$: stakeholder relevance to feature (`Stakeholder.relevance_to_feature`).
- $\text{infl}(sh) \in \mathbb{Z}_{\geq 0}$: stakeholder influence (`Stakeholder.influence_level`).
- $\text{ach}(g) \in [0, 1]$: sprint goal achievement status (`SprintGoal.achievement_status`).
- $\overline{\text{SP}} \in \mathbb{Z}_{\geq 0}$: reference average story points (`Velocity.avg._story_points`).
- $\text{nb}(pb) \in \mathbb{Z}_{\geq 0}$: number of entries in product backlog (`ProductBacklog.number_of_entries`).
- $\text{bud}(p) \in \mathbb{R}_{\geq 0}$: project budget (`Project.budget`).
- $\text{tst}(d) \in [0, 1]$: snapshot test status (`DevelopmentSnapshot.test_status`).
- $\text{avail}(w) \in \mathbb{R}_{\geq 0}$: worker availability fraction (`Worker.availability`).

3 3. Goals

We aggregate the multiple goals from `Goals.csv` via a weighted-sum objective. Let w_i denote each goal's weight. For goals of type `max`, we minimize the negative of their measure.

Decision variables (used by goals/constraints). See Section 5 for domains; here we recall symbols:

$$x_u \in \{0,1\}\ \forall u \in \mathcal{US};\quad x_k \in \{0,1\}\ \forall k \in \mathcal{TSK};\quad z_f \in \{0,1\}\ \forall f \in \mathcal{F};\quad y_{w,k} \in \{0,1\}\ \forall w \in \mathcal{W}, k \in \mathcal{TSK};$$
$$s^{SP}, s^{CAP}, e^{BUF} \in \mathbb{Z}_{\geq 0};\quad b_b \in \{0,1\}\ \forall b \in \mathcal{BL};\quad v^{TGT}, a^{COV}, r^{RISK} \in [0,1];\quad p^{TH} \in \mathbb{Z}_{\geq 0}.$$

Objective

$$\begin{aligned}\min\ J\ =\ & \underbrace{w_0 \sum_{u\in\mathcal{US}} \mathrm{sp}(u)\, x_u}_{\textbf{G0: minimize\_total\_story\_points}} + \underbrace{w_1 \sum_{k\in\mathcal{TSK}} \mathrm{eff}(k)\, x_k}_{\textbf{G1: minimize\_total\_task\_effort}} - \underbrace{w_2 \sum_{g\in\mathcal{SG}} \mathrm{ach}(g)}_{\textbf{G2: maximize\_sprint\_goal\_achievement}} - \\ & + \underbrace{w_4 \sum_{b\in\mathcal{BL}} \mathrm{sev}(b)\,\mathrm{act}(b)\,(1-b_b)}_{\textbf{G4: minimize\_open\_blocker\_severity}} + \underbrace{w_5 \sum_{pb\in\mathcal{PB}} \mathrm{nb}(pb)}_{\textbf{G5: minimize\_product\_backlog\_size}} - \underbrace{w_6 \sum_{sh\in\mathcal{SH}} \mathrm{rel}(sh)}_{\textbf{G6: maximize\_stakeholder\_relev}} \\ & + \underbrace{w_7 \sum_{p\in\mathcal{P}} \mathrm{bud}(p)}_{\textbf{G7: minimize\_project\_budget}} - \underbrace{w_8 \sum_{d\in\mathcal{DEV}} \mathrm{tst}(d)}_{\textbf{G8: maximize\_test\_status}} - \underbrace{w_9 \sum_{w\in\mathcal{W}} \mathrm{avail}(w)}_{\textbf{G9: maximize\_team\_availability}} \\ & + \underbrace{w_{10} \left(\sum_{\mathrm{sbl}\in\mathcal{SBL}} \mathrm{TotEff}(\mathrm{sbl}) \right)}_{\textbf{G10: minimize\_sprint\_backlog\_total\_effort}} - \underbrace{w_{11} \sum_{f\in\mathcal{F}} \mathrm{prio}(f)\, z_f}_{\textbf{G11: maximize\_feature\_priority\_delivery}}\end{aligned}$$

where $\mathrm{TotEff}(\mathrm{sbl}) := \sum_{k\in L(scb):\, scb\leftrightarrow \mathrm{sbl}} \mathrm{eff}(k)\, x_k$ is the total effort represented for a sprint backlog via its scrum board (R14,R12). Weights (w_i) come from `Goals.csv`.

Goal items (IDs, Names, representations).

- **G0 (minimize_total_story_points):** $\min \sum_u \mathrm{sp}(u)\, x_u$
- **G1 (minimize_total_task_effort):** $\min \sum_k \mathrm{eff}(k)\, x_k$
- **G2 (maximize_sprint_goal_achievement):** $\max \sum_g \mathrm{ach}(g) \equiv \min - \sum_g \mathrm{ach}(g)$
- **G3 (maximize_average_velocity):** $\max \overline{\mathrm{SP}} \equiv \min -\overline{\mathrm{SP}}$
- **G4 (minimize_open_blocker_severity):** $\min \sum_b \mathrm{sev}(b)\,\mathrm{act}(b)\,(1-b_b)$
- **G5 (minimize_product_backlog_size):** $\min \sum_{pb} \mathrm{nb}(pb)$
- **G6 (maximize_stakeholder_relevance):** $\max \sum_{sh} \mathrm{rel}(sh) \equiv \min - \sum_{sh} \mathrm{rel}(sh)$
- **G7 (minimize_project_budget):** $\min \sum_p \mathrm{bud}(p)$
- **G8 (maximize_test_status):** $\max \sum_d \mathrm{tst}(d) \equiv \min - \sum_d \mathrm{tst}(d)$
- **G9 (maximize_team_availability):** $\max \sum_w \mathrm{avail}(w) \equiv \min - \sum_w \mathrm{avail}(w)$
- **G10 (minimize_sprint_backlog_total_effort):** $\min \sum_{\mathrm{sbl}} \mathrm{TotEff}(\mathrm{sbl})$
- **G11 (maximize_feature_priority_delivery):** $\max \sum_f \mathrm{prio}(f)\, z_f \equiv \min - \sum_f \mathrm{prio}(f)\, z_f$

4 4. Conditions

Let M be a sufficiently large constant (Big-M) when needed. The following constraints implement `Conditions.csv` and respect `Relationships.csv`.

Feasibility, selection, and linkage

- **Link tasks to user stories (R10):** $\forall u \in \mathcal{US},\ \forall k \in K(u):\quad x_k \le x_u$.
- **Sprint capacity (definition):**

$$s^{SP} = \sum_{u \in \mathcal{US}} \mathrm{sp}(u)\, x_u, \qquad \sum_{k \in \mathcal{TSK}} \mathrm{eff}(k)\, x_k \le s^{CAP} + e^{BUF}.$$

- **Task assignment feasibility:** $\forall k \in \mathcal{TSK}:\ \sum_{w \in \mathcal{W}} y_{w,k} = x_k$.
- **Worker availability limit:** $\forall w \in \mathcal{W}: \sum_{k \in \mathcal{TSK}} \mathrm{eff}(k)\, y_{w,k} \le \mathrm{AvailEff}(w)$, where $\mathrm{AvailEff}(w)$ is derived from `Worker.availability`.
- **Release-feature link (R20):** $\forall f \in \mathcal{F}:\ z_f \le \mathbf{1}\{f \in H(\mathrm{rep})\}$.

Condition items (IDs, Names, representations)

- **C0 (user_stories_must_be_ready):** $\forall u:\ x_u \le \mathrm{stat}^{US}(u)$ (must-match readiness mask).
- **C1 (tasks_cannot_be_blocked):** $\forall k:\ x_k \le \mathrm{stat}^{TSK}(k)$ (cannot select blocked tasks).
- **C2 (only_available_workers):** $\forall w:\ \sum_k \mathrm{eff}(k)\, y_{w,k} \le \mathrm{AvailEff}(w)$.
- **C3 (sprint_goal_may_match):** prefer higher $\mathrm{ach}(g)$ via objective (soft preference; no hard constraint).
- **C4 (blockers_must_be_low_severity):** $\forall b:\ \mathrm{sev}(b) > \tau^{BL} \Rightarrow b_b = 0$; equivalently $b_b \le \mathbf{1}\{\mathrm{sev}(b) \le \tau^{BL}\}$.
- **C5 (features_may_match_high_priority):** soft preference by objective; optionally enforce $z_f = 0$ if $\mathrm{prio}(f) < p^{TH}$.
- **C6 (product_backlog_status_must_match):** $\forall pb:\ \mathrm{stat}^{PB}(pb) = 1$ required; infeasible otherwise (data pre-filter).
- **C7 (sprint_status_must_match):** $\forall \mathrm{sp}:\ \mathrm{stat}^{SP}(\mathrm{sp}) = 1$ required; else no planning on that sprint.
- **C8 (dev_snapshot_must_match_test_status):** $\forall d:\ \mathrm{tst}(d) \ge a^{COV}$.
- **C9 (stakeholder_may_match_high_influence):** soft preference by objective using $\mathrm{infl}(sh)$.
- **C10 (sprint_backlog_status_must_match):** $\forall \mathrm{sbl}:\ \mathrm{stat}^{SBL}(\mathrm{sbl}) = 1$ precondition to commit tasks.
- **C11 (task_type_cannot_match_excluded):** $\forall k:\ \mathbf{1}\{\mathrm{type}(k) \in \mathcal{X}^{EXCL}\} = 1 \Rightarrow x_k = 0$.

Additional structure from relationships

- **Blockers on tasks (R16):** If task k is blocked by any $b \in \mathcal{BL}$ not resolved in sprint, then $x_k \le b_b$ for each linked blocker; equivalently $x_k \le \min_{b \in \mathcal{B}(k)} b_b$.
- **Sprint backlog linkage (R11,R12):** User stories planned for sprint backlog sbl satisfy $x_u \le \mathbf{1}\{u \in \mathrm{sbl}\}$ and $\mathrm{sbl} = S(\mathrm{sp})$ for the active sprint.

5 5. DecisionVariables

- **DV0 (x_us_selected)**: $x_u \in \{0,1\}$ for $u \in \mathcal{US}$ — select user story in sprint.
- **DV1 (x_task_selected)**: $x_k \in \{0,1\}$ for $k \in \mathcal{TSK}$ — select task in sprint backlog.
- **DV2 (z_feature_in_release)**: $z_f \in \{0,1\}$ for $f \in \mathcal{F}$ — include feature in release plan.
- **DV3 (y_worker_task_assignment)**: $y_{w,k} \in \{0,1\}$ — assign worker w to task k.
- **DV4 (s_story_points_committed)**: $s^{SP} \in \mathbb{Z}_{\geq 0}$ — total committed story points (min 0, max by data).
- **DV5 (s_sprint_capacity)**: $s^{CAP} \in \mathbb{Z}_{\geq 0}$ — estimated capacity in story points (bounded by team velocity).
- **DV6 (e_effort_buffer)**: $e^{BUF} \in \mathbb{Z}_{\geq 0}$ — buffer for unplanned work.
- **DV7 (b_blocker_resolved)**: $b_b \in \{0,1\}$ for $b \in \mathcal{BL}$ — resolve blocker in sprint.
- **DV8 (v_target_velocity)**: $v^{TGT} \in \mathbb{R}_{\geq 0}$ — planning target velocity.
- **DV9 (a_test_coverage_target)**: $a^{COV} \in [0,1]$ — minimum acceptable test/snapshot status.
- **DV10 (p_priority_threshold)**: $p^{TH} \in \mathbb{Z}_{\geq 0}$ — cutoff priority for features/stories.
- **DV11 (r_risk_tolerance)**: $r^{RISK} \in [0,1]$ — allowable normalized risk level.

Model type. With the above binary/integer/continuous variables and linear expressions, the model is a Mixed-Integer Linear Program (MILP). Weighted multi-objective handling is via scalarization in Section 3.