SCRUM-Based Software Development Optimization Model

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Contents

Introduction

This document formulates a mathematical optimization model using the previously defined domain model (`Entities.csv`, `Relationships.csv`) and the generated artifacts (`Goals.csv`, `Conditions.csv`, `DecisionVariables.csv`). It captures sets (*entities*), indices, objectives, conditions (constraints), and decision variables relevant to planning and operating a SCRUM-driven software development organization. Entity attributes are exposed as parameters; e.g., team_size(t) refers to the `Team.team_size` attribute for team $t \in T$.

1 1. Sets (Entities)

- ▷ **P**: Set of **Projects** (`Project`; attributes: `id, name, project_start, project_end, description, budget, status, target_audience, priority`).
- ▷ **T**: Set of **Teams** (`Team`; attributes: `id, name, team_size, team_start, team_status, location, team_type`).
- ▷ **W**: Set of **Workers** (`Worker`; attributes: `id, name, first_name, email, start_date, status, availability`).
- ▷ **F**: Set of **Features** (`Feature`; attributes: `id, title, description, status, priority, estimated_effort`).
- ▷ **S**: Set of **Skills** (`Skill`; attributes: `id, label, description, level, certified, category`).
- ▷ **R**: Set of **Roles** (`Role`; attributes: `id, role_name, description, area_of_responsibility`).
- ▷ **PO**: Set of **Product Owners** (`ProductOwner`; attributes: `id, name, email, availability`).
- ▷ **SM**: Set of **Scrum Masters** (`ScrumMaster`; attributes: `id, name, email, experience`).
- ▷ **PB**: Set of **Product Backlogs** (`ProductBacklog`; attributes: `id, created_on, last_updated, number_of_entries, status`).
- ▷ **SP**: Set of **Sprints** (`Sprint`; attributes: `id, sprint_number, start_date, end_date, status, achievement_of_goal`).
- ▷ **SPP**: Set of **Sprint Plannings** (`SprintPlanning`; attributes: `id, date, duration_(min), moderation, outcome_documentation`).
- ▷ **DS**: Set of **Daily Scrums** (`DailyScrum`; attributes: `id, date, time, duration, moderation`).
- ▷ **SR**: Set of **Sprint Reviews** (`SprintReview`; attributes: `id, date, duration, feedback_documentatior attendees_count`).
- ▷ **SRE**: Set of **Sprint Retrospectives** (`SprintRetrospective`; attributes: `id, date, duration, improvement_actions, team_satisfaction, moderation`).
- ▷ **SBL**: Set of **Sprint Backlogs** (`SprintBacklog`; attributes: `id, number_of_tasks, last_updated, status, total_effort`).
- ▷ **SG**: Set of **Sprint Goals** (`SprintGoal`; attributes: `id, objective_description, achievement_status, benefit`).
- ▷ **EPC**: Set of **Epics** (`Epic`; attributes: `id, title, description, priority, status, estimated_effort`).

- ▷ **US**: Set of **User Stories** (`UserStory`; attributes: `id, title, description, acceptance_criteria, priority, story_points, status`).
- ▷ **TSK**: Set of **Tasks** (`Task`; attributes: `id, title, description, status, effort, type`).
- ▷ **DEV**: Set of **Development Snapshots** (`DevelopmentSnapshot`; attributes: `id, version_number, creation_date, test_status, deployment_target, documentation`).
- ▷ **BL**: Set of **Blockers** (`Blocker`; attributes: `id, title, description, severity, status, detected_on, resolved_on`).
- ▷ **SH**: Set of **Stakeholders** (`Stakeholder`; attributes: `id, name, organization, role, email, area_of_interest, influence_level, relevance_to_feature`).
- ▷ **VEL**: Set of **Velocities** (`Velocity`; attributes: `id, number_of_sprints_used, avg._story_points, max_velocity, min_velocity, trend`).
- ▷ **REP**: Set of **Release Plans** (`ReleasePlan`; attributes: `id, version, planned_date, included_features, status`).
- ▷ **RM**: Set of **Roadmaps** (`Roadmap`; attributes: `id, start_date, end_date, milestones, objectives, versions`).
- ▷ **SCB**: Set of **Scrum Boards** (`ScrumBoard`; attributes: `id, board_type, columns, number_of_cards, last_updated`).
- ▷ **FED**: Set of **Feature Documentations** (`FeatureDocumentation`; attributes: `id, title, description, creation_date, change_log, linked_requirements, author`).

2 2. Indices

- ▷ $p \in P$, $t \in T$, $w \in W$, $f \in F$, $s \in S$, $r \in R$, $po \in PO$, $sm \in SM$, $pb \in PB$, $sp \in SP$, $spp \in SPP$, $ds \in DS$, $sr \in SR$, $sre \in SRE$, $sbl \in SBL$, $sg \in SG$, $e \in EPC$, $us \in US$, $tsk \in TSK$, $dev \in DEV$, $bl \in BL$, $sh \in SH$, $v \in VEL$, $rep \in REP$, $rm \in RM$, $scb \in SCB$, $fed \in FED$.

Selected Parameters (from attributes and relationships). All attributes are available as parameters named by their attribute; e.g., team_size(t), number_of_entries(pb), story_points(us), effort(tsk), max_velocity(v), min_velocity(v), severity(bl), achievement_of_goal(sp), estimated_effort(f), priority(e), sprint_number(sp), attendees_count(sr), budget(p), etc. We also use indicator parameters derived from statuses or text fields: activeTeam(t), available(w), readyStory(us), blocked(tsk), recentPB(pb), goalDefined(sp), eligibleRelease(f), roadmapAligned(f), docExists(f), velocityBaselineOK(v), actionableEpic(e), each in $\{0, 1\}$. Let $c_{\text{effort}} > 0$ denote cost per effort unit (used where needed).

3 3. Goals

Each goal (ID, Name) is shown with its mathematical form. We combine (as a weighted multi-objective) via scalarization:

$$\max \sum_{g \in \mathcal{G}_{\max}} \omega_g \, Z_g \; - \sum_{h \in \mathcal{G}_{\min}} \omega_h \, Z_h,$$

where $Z_\bullet$ are the expressions below and weights $\omega_\bullet$ are taken from `Goals.csv`.

▷ **G0 maximize_team_capacity** (IsSum=True, GoalType=max):

$$Z_{G0} \;=\; \sum_{t \in T} \text{team\_size}(t).$$

▷ **G1 minimize_product_backlog_size** (IsSum=True, GoalType=min):

$$Z_{G1} \;=\; \sum_{pb \in PB} \text{number\_of\_entries}(pb).$$

▷ **G2 minimize_user_story_effort** (IsSum=True, GoalType=min):

$$Z_{G2} \;=\; \sum_{us \in US} \text{story\_points}(us).$$

▷ **G3 minimize_task_effort** (IsSum=True, GoalType=min):

$$Z_{G3} \;=\; \sum_{tsk \in TSK} \text{effort}(tsk).$$

▷ **G4 maximize_velocity** (IsSum=True, GoalType=max):

$$Z_{G4} \;=\; \sum_{v \in VEL} \text{max\_velocity}(v) \cdot \text{velocityBaselineOK}(v).$$

▷ **G5 minimize_velocity_variance** (IsSum=False, GoalType=min):

$$Z_{G5} \;=\; \sum_{v \in VEL} \big(\text{max\_velocity}(v) - \text{min\_velocity}(v)\big) \cdot \text{velocityBaselineOK}(v).$$

▷ **G6 minimize_blocker_severity** (IsSum=True, GoalType=min):

$$Z_{G6} \;=\; \sum_{bl \in BL} \text{severity}(bl).$$

▷ **G7 maximize_sprint_goal_achievement** (IsSum=False, GoalType=max):

$$Z_{G7} \;=\; \sum_{sp \in SP} \text{achievement\_of\_goal}(sp) \cdot \text{goalDefined}(sp).$$

▷ **G8 minimize_feature_effort** (IsSum=True, GoalType=min):

$$Z_{G8} \;=\; \sum_{f \in F} \text{estimated\_effort}(f).$$

▷ **G9 maximize_epic_priority** (IsSum=True, GoalType=max):

$$Z_{G9} \;=\; \sum_{e \in EPC} \text{priority}(e) \cdot \text{actionableEpic}(e).$$

▷ **G10 minimize_cycle_count** (IsSum=True, GoalType=min):

$$Z_{G10} \;=\; \sum_{sp \in SP} \text{sprint\_number}(sp).$$

▷ **G11 maximize_review_participation** (IsSum=True, GoalType=max):

$$Z_{G11} \;=\; \sum_{sr \in SR} \text{attendees\_count}(sr).$$

4 4. Conditions

Each condition (ID, Name) is shown with its logical intent and mathematical form. CriteriaType = 2 denotes *Must-Match* (hard constraints), = 1 *May-Match* (soft, modeled via penalties/rewards), = 0 *Cannot-Match* (exclusions). We use λ_C to denote the weight of a soft condition from `Conditions.csv`.

▷ **C0 status_must_be_active** (Must-Match):

$$\forall t \in T: \ \text{activeTeam}(t) = 1.$$

(Data filter; only active teams considered in planning.)

▷ **C1 project_within_budget** (Must-Match):

$$\sum_{sbl \in SBL(p)} \text{total\_effort}_{sbl} \cdot c_{\text{effort}} \ \leq \ \text{budget}(p), \quad \forall p \in P,$$

where $SBL(p)$ are sprint backlogs contributing to project p.

▷ **C2 worker_must_be_available** (Must-Match):

$$a_{w,t} \leq \text{available}(w), \quad \forall w \in W,\, t \in T.$$

▷ **C3 user_story_must_be_ready** (Must-Match for inclusion in a sprint):

$$x_{us,sp} \leq \text{readyStory}(us), \quad \forall us \in US,\, sp \in SP.$$

▷ **C4 feature_priority_threshold** (May-Match; encourage high priority):

$$\text{Penalty}_{C4} \ = \ \lambda_{C4} \sum_{f \in F} \big(\pi_{\min} - \text{priority}(f)\big)_+,$$

where $(z)_+ = \max\{0, z\}$ and $\pi_{\min}$ is a chosen threshold. This penalty is subtracted in the objective.

▷ **C5 task_cannot_be_blocked** (Cannot-Match):

$$h_{tsk} \leq M \cdot \big(1 - \text{blocked}(tsk)\big), \quad \forall tsk \in TSK,$$

with a large constant M (e.g., $M = 80$) and also $h_{tsk} = 0$ if $\text{blocked}(tsk) = 1$.

▷ **C6 backlog_recently_updated** (May-Match; prefer recent backlogs):

$$\text{Reward}_{C6} \ = \ \lambda_{C6} \sum_{pb \in PB} \text{recentPB}(pb),$$

added to the objective.

▷ **C7 sprint_with_defined_goal** (Must-Match for any planned capacity):

$$\sum_{t \in T} \text{cap}_{t,sp} \ \leq \ M \cdot \text{goalDefined}(sp), \quad \forall sp \in SP.$$

▷ **C8 release_must_be_planned** (Must-Match):

$$y_f \leq \text{eligibleRelease}(f), \quad \forall f \in F.$$

▷ **C9 roadmap_alignment_preferred** (May-Match):

$$\text{Reward}_{C9} \;=\; \lambda_{C9} \sum_{f \in F} \text{roadmapAligned}(f),$$

added to the objective.

▷ **C10 documentation_required** (May-Match; prefer documented features for release):

$$\text{Penalty}_{C10} \;=\; \lambda_{C10} \sum_{f \in F} y_f \cdot \big(1 - \text{docExists}(f)\big),$$

subtracted in the objective.

▷ **C11 velocity_baseline_sprints** (Must-Match for velocity use):

$$\text{velocityBaselineOK}(v) = 1 \;\Rightarrow\; v \text{ is used in } Z_{G4}, Z_{G5};\ \text{otherwise excluded.}$$

▷ **C12 epic_status_open_or_in_progress** (Must-Match):

$$\text{actionableEpic}(e) = 1, \quad \forall e \in EPC.$$

5 5. DecisionVariables

The following variables (from `DecisionVariables.csv`) define the optimization decisions; bounds reflect the CSV domains.

▷ **DV0 assign_user_story_to_sprint**: $x_{us,sp} \in \{0,1\}$ — whether user story us is scheduled in sprint sp.

▷ **DV1 allocate_worker_to_team**: $a_{w,t} \in \{0,1\}$ — whether worker w is allocated to team t.

▷ **DV2 select_feature_for_release**: $y_f \in \{0,1\}$ — whether feature f is included in a release.

▷ **DV3 task_hours**: $h_{tsk} \in \mathbb{R}_{\geq 0}$, $0 \leq h_{tsk} \leq 80$ — hours assigned to task tsk.

▷ **DV4 set_story_points**: $spAdj_{us} \in \mathbb{Z}$, $1 \leq spAdj_{us} \leq 21$ — planned points for story us.

▷ **DV5 team_capacity**: $\text{cap}_{t,sp} \in \mathbb{Z}_{\geq 0}$, $0 \leq \text{cap}_{t,sp} \leq 200$ — capacity (points) of team t in sprint sp.

▷ **DV6 deploy_increment**: $d_{dev} \in \{0,1\}$ — whether snapshot dev is deployed.

▷ **DV7 prioritize_epic_rank**: $r^E_e \in \mathbb{Z}$, $1 \leq r^E_e \leq 100$ — rank of epic e.

▷ **DV8 feature_priority_rank**: $r^F_f \in \mathbb{Z}$, $1 \leq r^F_f \leq 500$ — rank of feature f.

▷ **DV9 activate_blocker_resolution**: $z_{bl} \in \{0,1\}$ — whether to trigger blocker resolution for blocker bl.

▷ **DV10 set_review_attendees**: $\text{att}_{sr} \in \mathbb{Z}_{\geq 0}$, $0 \leq \text{att}_{sr} \leq 50$ — target attendees for sprint review sr.

▷ **DV11 set_number_of_tasks**: $\text{ntasks}_{sbl} \in \mathbb{Z}_{\geq 0}$, $0 \leq \text{ntasks}_{sbl} \leq 500$ — tasks planned for sprint backlog sbl.

▷ **DV12 set_total_effort**: $\text{total\_effort}_{sbl} \in \mathbb{R}_{\geq 0}$, $0 \leq \text{total\_effort}_{sbl} \leq 1000$ — total planned effort for sprint backlog sbl.

Typical Coupling/Flow Constraints (illustrative). These align decisions with entities/relationships:

(Story effort fits capacity) $\sum_{us \in US} spAdj_{us} \cdot x_{us,sp} \;\le\; \sum_{t \in T} \mathrm{cap}_{t,sp}, \qquad \forall sp \in SP.$

(Team capacity upper bound by size) $\mathrm{cap}_{t,sp} \;\le\; \alpha \cdot \mathrm{team\_size}(t), \qquad \forall t \in T,\ sp \in SP,\ \alpha > 0.$

(Rank uniqueness examples) $\sum_{e \in EPC} \mathbb{1}\{r_e^E = k\} \le 1, \quad \sum_{f \in F} \mathbb{1}\{r_f^F = k\} \le 1, \quad \forall k.$

Final Composite Objective. Combine goals (Section 3) and soft-condition rewards/penalties (Section 4):

$$\max \sum_{g \in \{G0, G4, G7, G9, G11\}} \omega_g Z_g - \sum_{h \in \{G1, G2, G3, G5, G6, G8, G10\}} \omega_h Z_h + \sum_{C \in \{C6, C9\}} \mathrm{Reward}_C - \sum_{C \in \{C4, C10\}} \mathrm{Penalty}_C.$$