

Optimization Model for Scrum-Based Software Development

Integrating Entities, Goals, Conditions, and Decision Variables

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1. SETS (ENTITIES)

The following sets represent core entities in the Scrum-based software development domain.

\mathcal{P} : Set of Projects, with attributes: id, name, project_start, project_end, description, budget, status, target_audience, priority.

\mathcal{T} : Set of Teams, with attributes: id, name, team_size, team_start, team_status, location, team_type.

\mathcal{W} : Set of Workers, with attributes: id, name, first_name, email, start_date, status, availability.

\mathcal{F} : Set of Features, with attributes: id, title, description, status, priority, estimated_effort.

\mathcal{S} : Set of Skills, with attributes: id, label, description, level, certified, category.

\mathcal{R} : Set of Roles, with attributes: id, role_name, description, area_of_responsibility.

\mathcal{PO} : Set of Product Owners, with attributes: id, name, email, availability.

\mathcal{SM} : Set of Scrum Masters, with attributes: id, name, email, experience.

\mathcal{PB} : Set of Product Backlogs, with attributes: id, created_on, last_updated, number_of_entries, status.

\mathcal{SP} : Set of Sprints, with attributes: id, sprint_number, start_date, end_date, status, achievement_of_goal.

\mathcal{SPP} : Set of Sprint Plannings, with attributes: id, date, duration_(min), moderation, outcome_documentation.

\mathcal{DS} : Set of Daily Scrums, with attributes: id, date, time, duration, moderation.

\mathcal{SR} : Set of Sprint Reviews, with attributes: id, date, duration, feedback_documentation, attendees_count.

\mathcal{SRE} : Set of Sprint Retrospectives, with attributes: id, date, duration, improvement_actions, team_satisfaction, moderation.

\mathcal{SBL} : Set of Sprint Backlogs, with attributes: id, number_of_tasks, last_updated, status, total_effort.

\mathcal{SG} : Set of Sprint Goals, with attributes: id, objective_description, achievement_status, benefit.

\mathcal{E} : Set of Epics, with attributes: id, title, description, priority, status, estimated_effort.

\mathcal{US} : Set of User Stories, with attributes: id, title, description, acceptance_criteria, priority, story_points, status.

\mathcal{TSK} : Set of Tasks, with attributes: id, title, description, status, effort, type.

\mathcal{DEV} : Set of Development Snapshots, with attributes: id, version_number, creation_date, test_status, deployment_target, documentation.

\mathcal{BL} : Set of Blockers, with attributes: id, title, description, severity, status, detected_on, resolved_on.

\mathcal{SH} : Set of Stakeholders, with attributes: id, name, organization, role, email, area_of_interest, influence_level, relevance_to_feature.

\mathcal{VEL} : Set of Velocity records, with attributes: id, number_of_sprints_used, avg_story_points, max_velocity, min_velocity, trend.

\mathcal{REP} : Set of Release Plans, with attributes: id, version, planned_date, included_features, status.

\mathcal{RM} : Set of Roadmaps, with attributes: id, start_date, end_date, milestones, objectives, versions.

\mathcal{SCB} : Set of Scrum Boards, with attributes: id, board_type, columns_(todo/done...), number_of_cards, last_updated.

\mathcal{FED} : Set of Feature Documentations, with attributes: id, title, description, creation_date, change_log, linked_requirements, author.

2. INDICES

Indices are used to reference elements within the defined sets.

$p \in \mathcal{P}$: Index for Projects.

$t \in \mathcal{T}$: Index for Teams.

$w \in \mathcal{W}$: Index for Workers.

$f \in \mathcal{F}$: Index for Features.

$s \in \mathcal{S}$: Index for Skills.

$r \in \mathcal{R}$: Index for Roles.

$po \in \mathcal{PO}$: Index for Product Owners.

$sm \in \mathcal{SM}$: Index for Scrum Masters.

$sp \in \mathcal{SP}$: Index for Sprints.

$us \in \mathcal{US}$: Index for User Stories.

$tk \in \mathcal{TSK}$: Index for Tasks.

$bl \in \mathcal{BL}$: Index for Blockers.

$sh \in \mathcal{SH}$: Index for Stakeholders.

$v \in \mathcal{VEL}$: Index for Velocity records.

$rep \in \mathcal{REP}$: Index for Release Plans.

$rm \in \mathcal{RM}$: Index for Roadmaps.

3. GOALS

Optimization goals aim to maximize or minimize key performance indicators. Each goal is defined with logical intent and mathematical expression.

G0: maximize_project_budget

Maximize total budget across selected projects.

$\max \sum_{p \in \mathcal{P}} x_p \cdot \text{budget}_p$, where $x_p \in \{0, 1\}$ indicates project selection.

G1: maximize_team_size

Maximize the total team size across assigned teams.

$\max \sum_{t \in \mathcal{T}} y_t \cdot \text{team_size}_t$, where $y_t \in \{0, 1\}$ indicates team assignment.

G2: maximize_worker_availability

Maximize total worker availability.

$\max \sum_{w \in \mathcal{W}} z_w \cdot \text{availability}_w$, where $z_w \in \{0, 1\}$ if worker is active.

G3: minimize_feature_estimated_effort

Minimize effort required for all features.

$\min \sum_{f \in \mathcal{F}} \text{estimated_effort}_f$

G4: maximize_sprint_achievement_of_goal

Maximize average sprint goal achievement.

$\max \frac{1}{|\mathcal{SP}|} \sum_{sp \in \mathcal{SP}} \text{achievement_of_goal}_{sp}$

G5: maximize_sprint_velocity

Maximize average velocity of teams.

$\max \sum_{v \in \mathcal{VEL}} \text{avg_story_points}_v$

G6: minimize_sprint_duration

Minimize total sprint duration.

$\min \sum_{sp \in \mathcal{SP}} (\text{end_date}_{sp} - \text{start_date}_{sp})$

G7: maximize_user_story_story_points

Maximize completed story points.

$\max \sum_{us \in \mathcal{US}} \delta_{us} \cdot \text{story_points}_{us}$, where $\delta_{us} = 1$ if story is completed.

G8: minimize_blocker_severity

Minimize average blocker severity.

$\min \frac{1}{|\mathcal{BL}|} \sum_{bl \in \mathcal{BL}} \text{severity}_{bl} \cdot \mathbb{I}(\text{status}_{bl} = \text{open})$

G9: maximize_release_plan_included_features

Maximize number of features in release plans.

$\max \sum_{rep \in \mathcal{REP}} |\text{included_features}_{rep}|$

G10: maximize_documentation_change_log

Maximize documentation update frequency.

$\max \sum_{fed \in \mathcal{FED}} |\text{change_log}_{fed}|$

G11: minimize_worker_start_date

Favor earlier-hired (more experienced) workers.

$\min \sum_{w \in \mathcal{W}} z_w \cdot \text{start_date}_w$

G12: maximize_sprint_retrospective_team_satisfaction

Maximize team morale from retrospectives.

$$\max \sum_{sre \in \mathcal{SRE}} \text{team_satisfaction}_{sre}$$

G13: minimize_task_effort

Minimize total task effort in sprints.

$$\min \sum_{tk \in \mathcal{TSK}} \text{effort}_{tk}$$

G14: maximize_roadmap_milestones

Maximize number of achieved milestones.

$$\max \sum_{rm \in \mathcal{RM}} |\text{milestones}_{rm}|$$

4. CONDITIONS

Constraints enforce mandatory or conditional rules based on entity states.

C0: require_project_status_active

Only active projects are eligible.

$$x_p = 1 \Rightarrow \text{status}_p = \text{active}, \quad \forall p \in \mathcal{P}$$

C1: require_team_status_active

Only active teams can be assigned.

$$y_t = 1 \Rightarrow \text{team_status}_t = \text{active}, \quad \forall t \in \mathcal{T}$$

C2: require_worker_status_active

Only active workers may be assigned.

$$z_w = 1 \Rightarrow \text{status}_w = \text{active}, \quad \forall w \in \mathcal{W}$$

C3: require_feature_status_not_done

Exclude completed features.

$$\text{status}_f \neq \text{done}, \quad \forall f \in \mathcal{F}$$

C4: require_user_story_status_todo

Only user stories not started are assignable.

$$\delta_{us} = 1 \Rightarrow \text{status}_{us} = \text{todo}, \quad \forall us \in \mathcal{US}$$

C5: require_task_status_blocked

Identify blocked tasks.

$$\gamma_{tk} = 1 \text{ if } \text{status}_{tk} = \text{blocked}, \quad \forall tk \in \mathcal{TSK}$$

C6: require_blocker_status_open

Only open blockers are considered.

$$\text{status}_{bl} = \text{open}, \quad \forall bl \in \mathcal{BL}$$

C7: require_sprint_status_active

Only active sprints are valid.

$$\text{status}_{sp} = \text{active}, \quad \forall sp \in \mathcal{SP}$$

C8: require_role_certified

Assigned roles must be formally defined.

$$r \in \mathcal{R} \Rightarrow \text{area_of_responsibility}_r \neq \emptyset$$

C9: require_skill_certified

Only certified skills are valid.

$$s \in \mathcal{S} \Rightarrow \text{certified}_s = \text{true}$$

C10: require_velocity_trend_positive

Only teams with positive trend are selected.

$$\text{trend}_v > 0, \quad \forall v \in \mathcal{VEL}$$

C11: require_release_status_planned

Only planned releases are included.

$$\text{status}_{rep} = \text{planned}, \quad \forall rep \in \mathcal{REP}$$

C12: require_scumb_board_active

Scrum Board must be active.

$$\text{board_type}_{scb} \in \{\text{active}, \text{digital}\}, \quad \forall scb \in \mathcal{SCB}$$

C13: require_epic_status_open

Only open epics are eligible.

$$\text{status}_e = \text{open}, \quad \forall e \in \mathcal{E}$$

C14: require_stakeholder_relevance_high

Only high-relevance stakeholders are considered.

$$\text{relevance_to_feature}_{sh} \geq 4, \quad \forall sh \in \mathcal{SH}$$

5. DECISION VARIABLES

These are the variables optimized in the model.

$x_p \in \{0, 1\}$: Project p is selected.

$y_t \in \{0, 1\}$: Team t is assigned to a project.

$z_w \in \{0, 1\}$: Worker w is assigned to a task.

$slevel_{w,s} \in [1, 5]$: Skill level of worker w in skill s .

$e_{tk} \in [0, 100]$: Effort assigned to task tk .

$d_{sp} \in [5, 30]$: Duration of sprint sp in days.

$prio_{us} \in \{1, 2, 3, 4, 5\}$: Priority of user story us .

$spoints_{us} \in \{1, 2, 3, 5, 8, 13\}$: Story points assigned to user story us .

$sev_{bl} \in \{1, 2, 3, 4, 5\}$: Severity level of blocker bl .

$n_v \in \{3, 4, \dots, 10\}$: Number of sprints used in velocity calculation.

$v_{rep} \in [1.0, 10.0]$: Version number of release plan rep .

$w_{rm} \in [0.1, 5.0]$: Weight of objective in roadmap rm .

$u_{fed} \in \mathbb{Z}^+ \cup \{0\}$: Number of updates to feature documentation fed .

$a_{sre} \in \{0, 1, \dots, 20\}$: Number of improvement actions from retrospective sre .

$c_{scb} \in \{3, 4, 5, 6, 7\}$: Number of columns on Scrum Board scb .