Scrum-Based Optimization Model

For Software Development Projects

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September 5, 2025

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1 1. Sets (Entities)

[leftmargin=*]

$\mathcal{P}$: Set of Projects $\{p \mid p \in \text{Project}\}$

$\mathcal{T}$: Set of Teams $\{t \mid t \in \text{Team}\}$

$\mathcal{W}$: Set of Workers $\{w \mid w \in \text{Worker}\}$

$\mathcal{F}$: Set of Features $\{f \mid f \in \text{Feature}\}$

$\mathcal{S}$: Set of Skills $\{s \mid s \in \text{Skill}\}$

$\mathcal{R}$: Set of Roles $\{r \mid r \in \text{Role}\}$

$\mathcal{PO}$: Set of Product Owners $\{po \mid po \in \text{ProductOwner}\}$

$\mathcal{SM}$: Set of Scrum Masters $\{sm \mid sm \in \text{ScrumMaster}\}$

$\mathcal{PB}$: Set of Product Backlogs $\{pb \mid pb \in \text{ProductBacklog}\}$

$\mathcal{SP}$: Set of Sprints $\{sp \mid sp \in \text{Sprint}\}$

$\mathcal{US}$: Set of User Stories $\{us \mid us \in \text{UserStory}\}$

$\mathcal{TSK}$: Set of Tasks $\{tsk \mid tsk \in \text{Task}\}$

$\mathcal{E}$: Set of Epics $\{e \mid e \in \text{Epic}\}$

$\mathcal{DEV}$: Set of Development Snapshots $\{dev \mid dev \in \text{DevelopmentSnapshot}\}$

$\mathcal{BL}$: Set of Blockers $\{bl \mid bl \in \text{Blocker}\}$

$\mathcal{SH}$: Set of Stakeholders $\{sh \mid sh \in \text{Stakeholder}\}$

$\mathcal{VEL}$: Set of Velocity Records $\{vel \mid vel \in \text{Velocity}\}$

$\mathcal{REP}$: Set of Release Plans $\{rep \mid rep \in \text{ReleasePlan}\}$

$\mathcal{RM}$: Set of Roadmaps $\{rm \mid rm \in \text{Roadmap}\}$

$\mathcal{SCB}$: Set of Scrum Boards $\{scb \mid scb \in \text{ScrumBoard}\}$

$\mathcal{FED}$: Set of Feature Documentations $\{fed \mid fed \in \text{FeatureDocumentation}\}$

2 2. Indices

[leftmargin=*]

$p \in \mathcal{P}$: Index for a specific Project

$t \in \mathcal{T}$: Index for a specific Team

$w \in \mathcal{W}$: Index for a specific Worker

$f \in \mathcal{F}$: Index for a specific Feature

$s \in \mathcal{S}$: Index for a specific Skill

$r \in \mathcal{R}$: Index for a specific Role

$po \in \mathcal{PO}$: Index for a specific Product Owner

$sm \in \mathcal{SM}$: Index for a specific Scrum Master

$pb \in \mathcal{PB}$: Index for a specific Product Backlog

$sp \in \mathcal{SP}$: Index for a specific Sprint

$us \in \mathcal{US}$: Index for a specific User Story

$tsk \in \mathcal{TSK}$: Index for a specific Task

$e \in \mathcal{E}$: Index for a specific Epic

$dev \in \mathcal{DEV}$: Index for a specific Development Snapshot

$bl \in \mathcal{BL}$: Index for a specific Blocker

$sh \in \mathcal{SH}$: Index for a specific Stakeholder

$vel \in \mathcal{VEL}$: Index for a specific Velocity record

$rep \in \mathcal{REP}$: Index for a specific Release Plan

$rm \in \mathcal{RM}$: Index for a specific Roadmap

$scb \in \mathcal{SCB}$: Index for a specific Scrum Board

$fed \in \mathcal{FED}$: Index for a specific Feature Documentation

3 3. Goals

The objective function is a weighted sum of selected goals where applicable. Let $\mathcal{G}$ be the set of goals, and z_g the contribution of goal g. The overall objective is:

$$\max \left(\sum_{g \in \mathcal{G}^{\max}} \omega_g \cdot z_g \right) - \left(\sum_{g \in \mathcal{G}^{\min}} \omega_g \cdot z_g \right)$$

where ω_g is the weight of goal g. Each goal is defined as:
[leftmargin=*]

`maximize_project_budget`: Maximize total project budget

$$\max \sum_{p \in \mathcal{P}} \text{budget}_p \quad \text{with weight } 1.5$$

`maximize_team_size`: Maximize total team size

$$\max \sum_{t \in \mathcal{T}} \text{team\_size}_t \quad \text{with weight } 1.0$$

`maximize_story_points`: Maximize sum of story points in completed user stories

$$\max \sum_{us \in \mathcal{US}} \text{story\_points}_{us} \cdot \mathbb{I}(\text{status}_{us} = \text{Done}) \quad \text{with weight } 1.2$$

`minimize_sprint_duration`: Minimize average sprint duration

$$\min \frac{1}{|\mathcal{SP}|} \sum_{sp \in \mathcal{SP}} (\text{end\_date}_{sp} - \text{start\_date}_{sp}) \quad \text{with weight } 1.3$$

`maximize_velocity_trend`: Maximize positive velocity trend

$$\max \sum_{vel \in \mathcal{VEL}} \text{trend}_{vel} \quad \text{with weight } 1.4$$

`maximize_worker_availability`: Maximize sum of worker availability

$$\max \sum_{w \in \mathcal{W}} \text{availability}_{w} \quad \text{with weight } 1.1$$

`minimize_task_effort`: Minimize total task effort

$$\min \sum_{tsk \in \mathcal{TSK}} \text{effort}_{tsk} \quad \text{with weight } 0.9$$

`maximize_feature_priority`: Maximize sum of feature priorities

$$\max \sum_{f \in \mathcal{F}} \text{priority}_{f} \quad \text{with weight } 1.0$$

`minimize_epic_estimated_effort`: Minimize total effort of epics

$$\min \sum_{e \in \mathcal{E}} \text{estimated\_effort}_{e} \quad \text{with weight } 1.2$$

`maximize_stakeholder_influence`: Maximize total influence of engaged stakeholders

$$\max \sum_{sh \in \mathcal{SH}} \text{influence\_level}_{sh} \quad \text{with weight } 1.0$$

`minimize_blocker_severity`: Minimize average blocker severity

$$\min \frac{1}{|\mathcal{BL}|} \sum_{bl \in \mathcal{BL}} \text{severity}_{bl} \quad \text{with weight } 1.3$$

`maximize_sprint_goal_achievement`: Maximize number of achieved sprint goals

$$\max \sum_{sp \in \mathcal{SP}} \mathbb{I}(\text{achievement\_status}_{\text{SG}(sp)} = \text{Achieved}) \quad \text{with weight } 1.4$$

`minimize_daily_scrum_duration`: Minimize average daily scrum duration

$$\min \frac{1}{|\mathcal{DS}|} \sum_{ds \in \mathcal{DS}} \text{duration}_{ds} \quad \text{with weight } 0.8$$

`maximize_release_plan_included_features`: Maximize number of features per release

$$\max \sum_{rep \in \mathcal{REP}} |\text{included\_features}_{rep}| \quad \text{with weight } 1.1$$

`maximize_documentation_linking`: Maximize linked requirements in documentation

$$\max \sum_{fed \in \mathcal{FED}} |\text{linked\_requirements}_{fed}| \quad \text{with weight } 0.9$$

4 4. Conditions

These are constraints that must be satisfied. Let $\mathcal{C}$ be the set of conditions.
[leftmargin=*]

`ensure_product_owner_assigned`: Each project has exactly one Product Owner

$$\forall p \in \mathcal{P},\ \exists! po \in \mathcal{PO} : \text{manages\_backlog}(po, pb) \land \text{has\_backlog}(pb, p)$$

`require_scrum_master_per_team`: Each team has one Scrum Master

$$\forall t \in \mathcal{T},\ \exists! sm \in \mathcal{SM} : \text{is\_supported\_by}(t, sm)$$

`task_must_have_status`: All tasks must have a defined status

$$\forall tsk \in \mathcal{TSK},\ \text{status}_{tsk} \in \{\text{To Do}, \text{In Progress}, \text{Blocked}, \text{Done}\}$$

`user_story_must_have_priority`: All user stories must have priority

$$\forall us \in \mathcal{US},\ \text{priority}_{us} \in \{1, 2, 3, 4, 5\}$$

`project_must_be_active`: Only active projects are considered

$$\forall p \in \mathcal{P},\ \text{status}_p = \text{Active}$$

`worker_must_be_active`: Only active workers are assignable

$$\forall w \in \mathcal{W},\ \text{status}_w = \text{Active}$$

`sprint_must_be_current`: Optimization applies only to current sprint

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

`blocker_must_be_tracked`: All blockers must have detection date

$$\forall bl \in \mathcal{BL},\ \text{detected\_on}_{bl} \neq \emptyset$$

`velocity_based_on_recent_sprints`: Velocity uses at least 3 sprints

$$\forall vel \in \mathcal{VEL},\ \text{number\_of\_sprints\_used}_{vel} \geq 3$$

`feature_must_have_title`: Features must have non-empty title

$$\forall f \in \mathcal{F},\ \text{title}_f \neq \text{""}$$

`documentation_must_have_author`: All docs must have an author

$$\forall fed \in \mathcal{FED},\ \text{author}_{fed} \in \mathcal{W}$$

`release_plan_must_have_date`: Each release plan has a planned date

$$\forall rep \in \mathcal{REP},\ \text{planned\_date}_{rep} \in \mathbb{D}$$

`scrum_board_must_be_updated`: Boards must be updated daily

$$\forall scb \in \mathcal{SCB},\ \text{last\_updated}_{scb} \geq \text{today} - 1$$

`worker_email_required`: All workers must have email

$$\forall w \in \mathcal{W},\ \text{email}_w \neq \text{""} \land \text{valid\_email}(\text{email}_w)$$

`epic_must_have_estimated_effort`: Epics require effort estimate

$$\forall e \in \mathcal{E},\ \text{estimated\_effort}_e > 0$$

5 5. Decision Variables

These are the variables that can be adjusted during optimization.
[leftmargin=*]

$x_{w,tsk} \in \{0, 1\}$: Worker w assigned to task tsk

$e_{tsk} \in \mathbb{R}^+$: Effort (hours) allocated to task tsk, $0 \leq e_{tsk} \leq 40$

$d_{sp} \in \mathbb{Z}^+$: Duration of sprint sp in days, $5 \leq d_{sp} \leq 30$

$s_t \in \mathbb{Z}^+$: Size of team t, $3 \leq s_t \leq 15$

$sp_{us} \in \mathbb{Z}^+$: Story points for user story us, $1 \leq sp_{us} \leq 13$

$a_w \in [0, 100]$: Availability percentage of worker w

$p_f \in \{1, \ldots, 5\}$: Priority level of feature f

$s_{bl} \in \{1, \ldots, 10\}$: Severity level of blocker bl

$v_{vel} \in \mathbb{R}^+$: Average story points in velocity record vel, $0 \leq v_{vel} \leq 50$

$v_{rep} \in [1.0, 5.0]$: Version number in release plan rep

$n_{vel} \in \mathbb{Z}^+$: Number of sprints used in velocity, $3 \leq n_{vel} \leq 10$

$c_{scb} \in \mathbb{Z}^+$: Number of columns on Scrum Board scb, $2 \leq c_{scb} \leq 10$

$ch_{fed} \in \mathbb{Z}^+$: Number of changes in documentation fed, $0 \leq ch_{fed} \leq 100$

$dur_{ds} \in \mathbb{Z}^+$: Duration of daily scrum in minutes, $10 \leq dur_{ds} \leq 30$

$sat_{sre} \in \{1, \ldots, 10\}$: Team satisfaction score from retrospective