

Optimization Model for Agile Software Development using SCRUM

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1 Sets (Entities)

This section defines the fundamental sets of objects in the domain model, derived from `Entities.csv`.

- \mathcal{P} : Set of all Projects (E0)
- \mathcal{T} : Set of all Teams (E1)
- \mathcal{W} : Set of all Workers (E2)
- \mathcal{F} : Set of all Features (E3)
- \mathcal{S} : Set of all Skills (E4)
- \mathcal{R} : Set of all Roles (E5)
- \mathcal{PO} : Set of all Product Owners (E6)
- \mathcal{SM} : Set of all Scrum Masters (E7)
- \mathcal{PB} : Set of all Product Backlogs (E8)
- \mathcal{SP} : Set of all Sprints (E9)
- \mathcal{SPP} : Set of all Sprint Plannings (E10)
- \mathcal{DS} : Set of all Daily Scrums (E11)
- \mathcal{SR} : Set of all Sprint Reviews (E12)
- \mathcal{SRE} : Set of all Sprint Retrospectives (E13)
- \mathcal{SBL} : Set of all Sprint Backlogs (E14)
- \mathcal{SG} : Set of all Sprint Goals (E15)
- \mathcal{E} : Set of all Epics (E16)
- \mathcal{US} : Set of all User Stories (E17)
- \mathcal{TSK} : Set of all Tasks (E18)
- \mathcal{DEV} : Set of all Development Snapshots (E19)
- \mathcal{BL} : Set of all Blockers (E20)
- \mathcal{SH} : Set of all Stakeholders (E21)
- \mathcal{VEL} : Set of all Velocity metrics (E22)
- \mathcal{REP} : Set of all Release Plans (E23)
- \mathcal{RM} : Set of all Roadmaps (E24)
- \mathcal{SCB} : Set of all Scrum Boards (E25)
- \mathcal{FED} : Set of all Feature Documentations (E26)

2 Indices

This section defines the indices used to iterate over the sets defined above.

- $p \in \mathcal{P}$: Index for a Project
- $t \in \mathcal{T}$: Index for a Team
- $w \in \mathcal{W}$: Index for a Worker
- $f \in \mathcal{F}$: Index for a Feature
- $s \in \mathcal{S}$: Index for a Skill
- $us \in \mathcal{US}$: Index for a User Story
- $tsk \in \mathcal{TSK}$: Index for a Task
- $sp \in \mathcal{SP}$: Index for a Sprint
- $rep \in \mathcal{REP}$: Index for a Release Plan

3 Decision Variables

This section defines the variables that the optimization model will solve for, derived from `DecisionVariables.csv`.

- **DV0** ($X_{us,sp}$): Binary variable, 1 if User Story us is assigned to Sprint sp , 0 otherwise.
- **DV1** ($Y_{w,tsk}$): Binary variable, 1 if Worker w is assigned to Task tsk , 0 otherwise.
- **DV2** ($A_{t,p}$): Binary variable, 1 if Team t is assigned to Project p , 0 otherwise.
- **DV3** ($I_{f,rep}$): Binary variable, 1 if Feature f is included in Release Plan rep , 0 otherwise.
- **DV4** ($M_{w,t}$): Binary variable, 1 if Worker w is a member of Team t , 0 otherwise.
- **DV5** (S_{sp}): Integer variable representing the start day of Sprint sp .
- **DV6** (N_t): Integer variable representing the number of members in Team t .
- **DV7** (P_{us}): Integer variable representing the assigned priority of User Story us .
- **DV8** (C_w): Continuous variable $[0,1]$ representing the capacity allocation of Worker w .
- **DV9** (B_p): Binary variable, 1 if Project p is active, 0 if on hold.
- **DV10** (D_{sp}): Integer variable representing the duration in days of Sprint sp .

4 Goals (Objective Functions)

This section translates the goals from `Goals.csv` into mathematical objective functions. We define parameters where necessary (e.g., $StoryPoints_{us}$ is the given story points value for User Story us).

- **G0: maximize_story_points_in_sprint**

$$\text{Maximize } \sum_{us \in \mathcal{US}} StoryPoints_{us} \cdot X_{us,sp} \quad \forall sp \in \mathcal{SP}$$

- **G1: minimize_effort_for_features**

$$\text{Minimize } \sum_{f \in \mathcal{F}} \text{EstimatedEffort}_f \cdot I_{f,rep} \quad \forall rep \in \mathcal{REP}$$

- **G2: maximize_priority_of_user_stories**

$$\text{Maximize } \sum_{us \in \mathcal{US}} \sum_{sp \in \mathcal{SP}} \text{Priority}_{us} \cdot X_{us,sp}$$

- **G3: minimize_number_of_blockers**

$$\text{Minimize } \sum_{bl \in \mathcal{BL}} \text{ActiveStatus}_{bl}$$

- **G4: maximize_team_satisfaction**

$$\text{Maximize } \text{TeamSatisfaction}_{sre} \quad \forall sre \in \mathcal{SRE}$$

- **G5: maximize_sprint_goal_achievement**

$$\text{Maximize } \text{AchievementStatus}_{sg} \quad \forall sg \in \mathcal{SG}$$

- **G6: minimize_project_timeline_slippage**

$$\text{Minimize } (\text{ActualEndDate}_p - \text{PlannedEndDate}_p) \quad \forall p \in \mathcal{P}$$

- **G7: maximize_feature_stakeholder_relevance**

$$\text{Maximize } \sum_{f \in \mathcal{F}} \sum_{sh \in \mathcal{SH}} \text{Relevance}_{f,sh} \cdot \text{Influence}_{sh} \cdot I_{f,rep}$$

- **G8: minimize_task_effort_variance**

$$\text{Minimize } \sum_{tsk \in \mathcal{TSK}} |\text{ActualEffort}_{tsk} - \text{EstimatedEffort}_{tsk}|$$

- **G9: maximize_velocity_trend**

$$\text{Maximize } \text{Trend}_{vel} \quad \forall vel \in \mathcal{VEL}$$

- **G10: maximize_skill_level_on_tasks**

$$\text{Maximize } \sum_{w \in \mathcal{W}} \sum_{tsk \in \mathcal{TSK}} \sum_{s \in \mathcal{S}} \text{SkillLevel}_{w,s} \cdot \text{TaskRequiresSkill}_{tsk,s} \cdot Y_{w,tsk}$$

5 Conditions (Constraints)

This section translates the conditions from `Conditions.csv` into mathematical constraints.

- **C0: constrain_sprint_capacity_by_velocity**

$$\sum_{us \in \mathcal{US}} \text{StoryPoints}_{us} \cdot X_{us,sp} \leq \text{Velocity}_t \quad \forall sp \in \mathcal{SP} \text{ (where Team } t \text{ runs Sprint } sp)$$

- **C1: constrain_worker_availability**

$$\sum_{tsk \in \mathcal{TSK}} TaskEffort_{tsk} \cdot Y_{w,tsk} \leq Availability_w \quad \forall w \in \mathcal{W}$$

- **C2: enforce_minimum_team_size**

$$N_t \geq 3 \quad \forall t \in \mathcal{T}$$

- **C3: enforce_maximum_team_size**

$$N_t \leq 9 \quad \forall t \in \mathcal{T}$$

- **C4: require_mandatory_product_owner**

$$\sum_{w \in \mathcal{PO}} M_{w,t} = 1 \quad \forall t \in \mathcal{T}$$

- **C5: require_mandatory_scrum_master**

$$\sum_{w \in \mathcal{SM}} M_{w,t} = 1 \quad \forall t \in \mathcal{T}$$

- **C6: prevent_assignment_of_inactive_workers** Let $\mathcal{W}_{inactive} = \{w \in \mathcal{W} \mid Status_w = \text{'inactive'}\}$

$$\sum_{tsk \in \mathcal{TSK}} Y_{w,tsk} = 0 \quad \forall w \in \mathcal{W}_{inactive}$$

- **C7: require_sprint_goal**

$$\sum_{sg \in \mathcal{SG}} BelongsToSprint_{sg,sp} = 1 \quad \forall sp \in \mathcal{SP}$$

- **C8: task_must_belong_to_sprint_user_story**

$$Y_{w,tsk} \leq X_{us,sp} \quad \forall w, tsk, us, sp \text{ (where Task } tsk \text{ belongs to US } us)$$

- **C9: budget_must_not_be_exceeded**

$$\sum_{t \in \mathcal{T}} Cost_t + \sum_{other} OtherCosts \leq Budget_p \quad \forall p \in \mathcal{P}$$

- **C10: epic_cannot_be_in_sprint_backlog** No decision variable exists for assigning epics to sprints, enforcing this implicitly.

$$X_{e,sp} \text{ is undefined and assumed to be } 0 \quad \forall e \in \mathcal{E}, sp \in \mathcal{SP}$$

- **C11: certified_skill_for_critical_tasks** Let $\mathcal{TSK}_{crit} = \{tsk \in \mathcal{TSK} \mid Type_{tsk} = \text{'critical'}\}$

$$Y_{w,tsk} \cdot (1 - IsCertified_{w,s}) = 0 \quad \forall w \in \mathcal{W}, tsk \in \mathcal{TSK}_{crit}, s \in \mathcal{S}$$

- **C12: feature_must_have_documentation**

$$I_{f,rep} \leq \exists fed \in \mathcal{FED} \text{ s.t. } Documents_{fed,f} \quad \forall f \in \mathcal{F}, rep \in \mathcal{REP}$$