Optimization Model for SCRUM-Based Software Development

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Contents

1 Sets (Entities)

- P: Set of all Projects
- T: Set of all Teams
- W: Set of all Workers
- F: Set of all Features
- S: Set of all Skills
- R: Set of all Roles
- PO: Set of all ProductOwners
- SM: Set of all ScrumMasters
- PB: Set of all ProductBacklogs
- SP: Set of all Sprints
- SPP: Set of all SprintPlannings
- DS: Set of all DailyScrums
- SR: Set of all SprintReviews
- SRE: Set of all SprintRetrospectives
- SBL: Set of all SprintBacklogs
- SG: Set of all SprintGoals
- E: Set of all Epics
- US: Set of all UserStories
- TSK: Set of all Tasks
- DEV: Set of all DevelopmentSnapshots
- BL: Set of all Blockers
- SH: Set of all Stakeholders
- VEL: Set of all Velocities
- REP: Set of all ReleasePlans
- RM: Set of all Roadmaps
- SCB: Set of all ScrumBoards
- FED: Set of all FeatureDocumentations

2   Indices

- $p \in P$: Index for a Project
- $t \in T$: Index for a Team
- $w \in W$: Index for a Worker
- $f \in F$: Index for a Feature
- $s \in S$: Index for a Skill
- $r \in R$: Index for a Role
- $us \in US$: Index for a UserStory
- $tsk \in TSK$: Index for a Task
- $bl \in BL$: Index for a Blocker
- $sp \in SP$: Index for a Sprint
- $sbl \in SBL$: Index for a SprintBacklog
- $vel \in VEL$: Index for a Velocity
- $rep \in REP$: Index for a ReleasePlan
- $sg \in SG$: Index for a SprintGoal
- $sr \in SR$: Index for a SprintReview

3   Goals

- **G0: minimize_total_effort** - Minimize the total estimated effort of all tasks in the active sprint backlog.

$$\text{minimize} \quad \sum_{tsk \in TSK} \text{effort}(tsk) \cdot x_{tsk}^{sbl}$$

Where x_{tsk}^{sbl} is a binary variable indicating if task tsk is in the active sprint backlog.

- **G1: maximize_team_velocity** - Maximize the average velocity of the team to improve throughput.

$$\text{maximize} \quad \text{avg\_story\_points}(vel_t)$$

Where vel_t is the velocity entity associated with team t.

- **G2: minimize_blocker_severity** - Minimize the maximum severity of any active blocker in the sprint.

$$\text{minimize} \quad \max_{bl \in BL} \left(\text{severity}(bl) \cdot (1 - \text{resolved\_on}(bl))\right)$$

- **G3: maximize_feature_priority** - Maximize the total priority score of features included in the release plan.

$$\text{maximize} \quad \sum_{f \in F} \text{priority}(f) \cdot x_f^{rep}$$

Where x_f^{rep} is a binary decision variable (DV3) indicating if feature f is included in the release plan.

- **G4: minimize_sprint_duration** - Minimize the duration of sprints to increase feedback frequency.
$$\text{minimize} \quad (\text{end\_date}(sp) - \text{start\_date}(sp))$$

- **G5: maximize_skill_match** - Maximize the alignment between task requirements and worker skills.
$$\text{maximize} \quad \sum_{w \in W} \sum_{tsk \in TSK} \text{skill\_match}(w, tsk) \cdot x_{w,tsk}^{assign}$$

Where $x_{w,tsk}^{assign}$ is the assignment decision variable (DV0).

- **G6: minimize_budget_deviation** - Minimize the deviation of the actual spend from the project budget.
$$\text{minimize} \quad |\text{budget}(p) - \text{actual\_cost}(p)|$$

- **G7: maximize_stakeholder_satisfaction** - Maximize the satisfaction level of stakeholders from the sprint review.
$$\text{maximize} \quad \text{sentiment\_score}(\text{feedback\_documentation}(sr))$$

- **G8: minimize_context_switching** - Minimize the number of different story types a single worker is assigned to.
$$\text{minimize} \quad \sum_{w \in W} \text{num\_unique\_story\_types}(w)$$

- **G9: maximize_sprint_goal_achievement** - Maximize the rate of successfully achieved sprint goals.
$$\text{maximize} \quad \frac{1}{|SG|} \sum_{sg \in SG} \text{achievement\_status}(sg)$$

4 Conditions

- **C0: team_availability** - The total assigned effort for a team member cannot exceed their availability.
$$\sum_{tsk \in TSK} \text{effort}(tsk) \cdot x_{w,tsk}^{assign} \leq \text{availability}(w) \cdot \text{capacity}, \quad \forall w \in W$$

- **C1: sprint_capacity** - The total story points in a sprint backlog must not exceed the team's velocity.
$$\sum_{us \in US} \text{story\_points}(us) \cdot x_{us}^{sbl} \leq \text{avg\_story\_points}(vel_t), \quad \forall sbl \in SBL$$

- **C2: critical_blocker** - No task with a 'Critical' severity blocker can be in status 'In Progress'.
$$\text{status}(tsk) \neq \text{'In Progress'}, \quad \forall tsk \in TSK \text{ where } \exists bl \in BL : \text{severity}(bl) = \text{Critical} \wedge \text{is\_blocked\_by}(tsk, bl)$$

- **C3: role_requirement** - Every user story must have at least one team member assigned with a required role.
$$\sum_{w \in W} x_{w,tsk}^{assign} \cdot \Vdash[\text{has\_role}(w, r_{req})] \geq 1, \quad \forall us \in US, \forall tsk \in TSK(us)$$

- **C4: budget_constraint** - The total cost of the project must not exceed the allocated budget.
$$\text{actual\_cost}(p) \leq \text{budget}(p), \quad \forall p \in P$$

- **C5: sprint_duration** - Sprint length must be between 1 and 4 weeks.
$$7 \leq (\text{end\_date}(sp) - \text{start\_date}(sp)) \leq 28, \quad \forall sp \in SP$$

- **C6: definition_of_done** - All tasks for a user story must be 'Done' for the story to be 'Done'.
$$\text{status}(us) = \text{'Done'} \iff \text{status}(tsk) = \text{'Done'}, \quad \forall tsk \in TSK(us), \forall us \in US$$

- **C7: product_owner_approval** - No feature can be added to a release plan without Product Owner approval.
$$x_f^{rep} \leq \nVdash[\text{status}(f) = \text{'PO Approved'}], \quad \forall f \in F$$

- **C8: skill_requirement** - A task requiring a certified skill can only be assigned to a worker with that certification.
$$x_{w,tsk}^{assign} \leq \nVdash[\text{certified}(s,w) = True], \quad \forall w \in W, \forall tsk \in TSK \text{ requiring certified skill } s$$

- **C9: min_velocity** - The team's calculated velocity must be greater than a minimum threshold.
$$\text{avg\_story\_points}(vel_t) \geq \text{min\_velocity}(vel_t), \quad \forall vel_t \in VEL$$

5 Decision Variables

- **DV0:** $x_{w,tsk}^{assign} \in \{0,1\}$ - Binary assignment of worker w to task tsk.

- **DV1:** $\text{story\_points}(us) \in \mathbb{Z}^+$ - Story points for user story us, bounded $[1, 20]$.

- **DV2:** $\text{duration}(sp) \in \mathbb{Z}^+$ - Duration of sprint sp in days, bounded $[7, 28]$.

- **DV3:** $x_f^{rep} \in \{0,1\}$ - Binary inclusion of feature f in the release plan.

- **DV4:** $\text{start\_day}(tsk) \in \mathbb{Z}^+$ - Start day of task tsk within its sprint, bounded $[1, 28]$.

- **DV5:** $\text{size}(t) \in \mathbb{Z}^+$ - Size of team t, bounded $[3, 9]$.

- **DV6:** $\text{availability}(w) \in \mathbb{R}$ - Availability of worker w, bounded $[0.0, 1.0]$.

- **DV7:** $x_{bl}^{resolve} \in \{0,1\}$ - Binary resolution status of blocker bl.

- **DV8:** $\text{level}(s,w) \in \mathbb{Z}^+$ - Skill level of worker w for skill s, bounded $[1, 5]$.

- **DV9:** $x_{sg}^{achieved} \in \{0,1\}$ - Binary achievement status of sprint goal sg.