Optimization Model for SCRUM-Based Software Development

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Contents

1 Sets (Entities)

- Project = $\{p|p$ is a Project$\}$, described by: $id, name, \ldots, priority$
- Team = $\{t|t$ is a Team$\}$, described by: $id, name, \ldots, team\_type$
- Worker = $\{w|w$ is a Worker$\}$, described by: $id, name, \ldots, availability$
- Feature = $\{f|f$ is a Feature$\}$, described by: $id, title, \ldots, estimated\_effort$
- Skill = $\{s|s$ is a Skill$\}$, described by: $id, label, \ldots, category$
- Role = $\{r|r$ is a Role$\}$, described by: $id, role\_name, \ldots, area\_of\_responsibility$
- ProductOwner = $\{po|po$ is a ProductOwner$\}$, described by: $id, name, email, availability$
- ScrumMaster = $\{sm|sm$ is a ScrumMaster$\}$, described by: $id, name, email, experience$
- ProductBacklog = $\{pb|pb$ is a ProductBacklog$\}$, described by: $id, created\_on, \ldots, status$
- Sprint = $\{sp|sp$ is a Sprint$\}$, described by: $id, sprint\_number, \ldots, achievement\_of\_goal$
- SprintBacklog = $\{sbl|sbl$ is a SprintBacklog$\}$, described by: $id, number\_of\_tasks, \ldots, total\_ef$
- UserStory = $\{us|us$ is a UserStory$\}$, described by: $id, title, \ldots, status$
- Task = $\{tsk|tsk$ is a Task$\}$, described by: $id, title, \ldots, type$
- Blocker = $\{bl|bl$ is a Blocker$\}$, described by: $id, title, \ldots, resolved\_on$
- Velocity = $\{vel|vel$ is a Velocity$\}$, described by: $id, number\_of\_sprints\_used, \ldots, trend$

2 Indices

- $p, t, w, f, s, r, po, sm, pb, sp, sbl, us, tsk, bl, vel$: Index over elements in their respective sets.
- i, j, k: General numerical indices.

3 Goals

- **G0: maximize_team_skill_coverage** - Maximize the cumulative skill level of the team for the project's required features.

$$\text{Maximize } Z_0 = \sum_{w} \sum_{s} \text{skill\_level}(w, s) \cdot x_w^{assign}$$

- **G1: minimize_sprint_overcommitment** - Minimize the difference between planned sprint effort and team capacity.

$$\text{Minimize } Z_1 = |\sum_{us \in sp} \text{story\_points}(us) - \text{velocity}(t, sp)|$$

- **G2: maximize_velocity_consistency** - Maximize the team's average velocity to ensure predictable planning.

$$\text{Maximize } Z_2 = \frac{1}{|SP_t|} \sum_{sp \in SP_t} \text{story\_points\_completed}(sp)$$

- **G3: minimize_blocker_resolution_time** - Minimize the average time taken to resolve blockers.

$$\text{Minimize } Z_3 = \frac{1}{|BL_{active}|} \sum_{bl} (\text{resolved\_on}(bl) - \text{detected\_on}(bl))$$

- **G4: maximize_stakeholder_satisfaction** - Maximize the positive feedback from sprint reviews.

$$\text{Maximize } Z_4 = \text{sentiment\_score}(\text{feedback\_documentation}(sr))$$

- **G5: minimize_context_switching** - Minimize the number of different features a developer works on in a single sprint.

$$\text{Minimize } Z_5 = \sum_{w} |\{f : x_{w,f}^{works\_on} = 1\}|$$

- **G6: maximize_feature_completion** - Maximize the number of high-priority features completed per release.

$$\text{Maximize } Z_6 = \sum_{f} \text{priority}(f) \cdot \delta(\text{status}(f), \text{'Done'})$$

- **G7: minimize_technical_debt_growth** - Minimize the introduction of new tasks marked as 'debt' or 'refactoring'.

$$\text{Minimize } Z_7 = \sum_{tsk} \delta(\text{type}(tsk), \text{'debt'})$$

- **G8: maximize_team_availability** - Maximize the cumulative available working hours of the team for the sprint.

$$\text{Maximize } Z_8 = \sum_{w \in t} \text{availability}(w)$$

- **G9: minimize_planning_duration** - Minimize the time spent in sprint planning meetings.

$$\text{Minimize } Z_9 = \text{duration}(\text{spp})$$

4 Conditions

- **C0: mandatory_scrum_master** - The team must have exactly one Scrum Master assigned.

$$\sum_{sm} x_{sm,t}^{assigned} = 1 \quad \forall t \in \text{Team}$$

- **C1: mandatory_product_owner** - The project must have exactly one Product Owner assigned.

$$\sum_{po} x_{po,p}^{assigned} = 1 \quad \forall p \in \text{Project}$$

- **C2: team_capacity_not_exceeded** - The total story points in the sprint backlog must not exceed the team's velocity.

$$\sum_{us \in sbl} \text{story\_points}(us) \leq \text{velocity}(t) \quad \forall sbl, t$$

- **C3: feature_requires_skills** - A feature can only be assigned to a sprint if the team's skill level meets the feature's requirements.

$$\sum_{w \in t} \text{skill\_level}(w, s) \geq \text{required\_skill}(f, s) \quad \forall f, s \text{ if } x_{f,sp}^{selected} = 1$$

- **C4: worker_availability_limit** - No single worker can be assigned more than 40 hours of work in a sprint.

$$\text{assigned\_hours}(w) \leq 40 \quad \forall w \in \text{Worker}, \forall sp \in \text{Sprint}$$

- **C5: unique_worker_assignment** - A worker can only be assigned to one primary team.

$$\sum_{t} x_{w,t}^{assigned} = 1 \quad \forall w \in \text{Worker}$$

- **C6: sprint_goal_must_be_defined** - Every sprint must have exactly one defined sprint goal.

$$\sum_{sg} x_{sg,sp}^{defined} = 1 \quad \forall sp \in \text{Sprint}$$

- **C7: user_story_requires_acceptance_criteria** - No user story can be added to a sprint without defined acceptance criteria.

$$x_{us,sbl}^{added} \leq \delta(\text{acceptance\_criteria}(us) \neq \emptyset) \quad \forall us \in \text{UserStory}$$

- **C8: blocker_severity_high_priority** - Blockers with 'critical' severity must be resolved before any new feature development.

$$\sum_{tsk}^{new\_feature} x_{tsk}^{started} = 0 \quad \text{if } \exists bl \in \text{Blocker} | \text{severity}(bl) = \text{critical} \wedge \text{status}(bl) \neq \text{resolved}$$

- **C9: budget_not_exceeded** - The total cost of the project (based on worker time) must not exceed the project budget.

$$\sum_{w} \sum_{sp} \text{cost}(w) \cdot \text{assigned\_hours}(w, sp) \leq \text{budget}(p)$$

- **C10: task_must_have_owner** - Every task in the sprint backlog must be assigned to a worker.

$$\sum_{w} x_{tsk,w}^{assigned} = 1 \quad \forall tsk \in \text{SprintBacklog}$$

5 Decision Variables

- **DV0:** $x_{w,t}^{assign} \in \{0,1\}$ - Binary assignment of worker w to team t.
- **DV1:** $x_{f,sp}^{select} \in \{0,1\}$ - Binary selection of feature f for sprint sp.
- **DV2:** $x_{tsk,w}^{assign} \in \{0,1\}$ - Binary assignment of task tsk to worker w.
- **DV3:** $a_w \in [0,40]$ - Continuous variable for worker w's available hours in a sprint.
- **DV4:** $p_{us} \in \mathbb{Z}^+, p_{us} \in [1,20]$ - Integer variable for the story points of user story us.
- **DV5:** $d_{sp} \in \mathbb{Z}^+, d_{sp} \in [1,4]$ - Integer variable for the duration of sprint sp in weeks.
- **DV6:** $n_t \in \mathbb{Z}^+, n_t \in [3,9]$ - Integer variable for the size of team t.
- **DV7:** $prio_f \in \{1,2,3\}$ - Integer priority level for feature f.
- **DV8:** $l_{w,s} \in \{1,2,3,4,5\}$ - Integer proficiency level of worker w in skill s.
- **DV9:** $c_t^{blocker} \in [0.0,1.0]$ - Continuous variable for team t's capacity dedicated to resolving blockers.