Optimization Model for SCRUM-Based Software Development

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Contents

1 Sets (Entities)

- Project $= \{p_1, p_2, ..., p_n\}$ based on Entity **E0**
- Team $= \{t_1, t_2, ..., t_n\}$ based on Entity **E1**
- Worker $= \{w_1, w_2, ..., w_n\}$ based on Entity **E2**
- Feature $= \{f_1, f_2, ..., f_n\}$ based on Entity **E3**
- Skill $= \{s_1, s_2, ..., s_n\}$ based on Entity **E4**
- Role $= \{r_1, r_2, ..., r_n\}$ based on Entity **E5**
- ProductBacklog $= \{pb_1, pb_2, ..., pb_n\}$ based on Entity **E8**
- Sprint $= \{sp_1, sp_2, ..., sp_n\}$ based on Entity **E9**
- UserStory $= \{us_1, us_2, ..., us_n\}$ based on Entity **E17**
- Task $= \{tsk_1, tsk_2, ..., tsk_n\}$ based on Entity **E18**
- Blocker $= \{bl_1, bl_2, ..., bl_n\}$ based on Entity **E20**
- Stakeholder $= \{sh_1, sh_2, ..., sh_n\}$ based on Entity **E21**
- Velocity $= \{vel_1, vel_2, ..., vel_n\}$ based on Entity **E22**
- SprintGoal $= \{sg_1, sg_2, ..., sg_n\}$ based on Entity **E15**
- SprintBacklog $= \{sbl_1, sbl_2, ..., sbl_n\}$ based on Entity **E14**

2 Indices

- $p, p' \in$ Project
- $t, t' \in$ Team
- $w, w' \in$ Worker
- $f, f' \in$ Feature
- $s \in$ Skill
- $r \in$ Role
- $sp \in$ Sprint

- $us, us' \in$ UserStory

- $tsk \in$ Task

- $bl \in$ Blocker

- $sh \in$ Stakeholder

- $vel \in$ Velocity

- $sg \in$ SprintGoal

- $sbl \in$ SprintBacklog

3 Goals

- **G0: minimize_total_budget** - Minimize the total budget consumed by all projects.

$$\text{Minimize } Z_0 = \sum_{p \in \text{Project}} \text{budget}(p)$$

- **G1: maximize_team_utilization** - Maximize the average utilization of teams.

$$\text{Maximize } Z_1 = \frac{1}{|\text{Team}|} \sum_{t \in \text{Team}} \text{team\_status}(t)$$

- **G2: maximize_feature_completion** - Maximize the number of features with status 'Done'.

$$\text{Maximize } Z_2 = \sum_{f \in \text{Feature}} I(\text{status}(f) = \text{'Done'})$$

- **G3: minimize_blocker_impact** - Minimize the number of unresolved high-severity blockers.

$$\text{Minimize } Z_3 = \sum_{bl \in \text{Blocker}} I(\text{severity}(bl) = \text{'High'} \land \text{status}(bl) \neq \text{'Resolved'})$$

- **G4: maximize_velocity_consistency** - Maximize the team's minimum velocity.

$$\text{Maximize } Z_4 = \min_{t \in \text{Team}} (\text{avg\_story\_points}(vel_t))$$

- **G5: minimize_sprint_overhead** - Minimize the total time spent in ceremonies.

$$\text{Minimize } Z_5 = \sum_{sp \in \text{Sprint}} \text{duration}_{\text{planning}}(sp) + \text{duration}_{\text{review}}(sp) + \text{duration}_{\text{retrospective}}(sp)$$

- **G6: maximize_stakeholder_satisfaction** - Maximize the average influence level of satisfied stakeholders.

$$\text{Maximize } Z_6 = \frac{1}{|\text{Stakeholder}|} \sum_{sh \in \text{Stakeholder}} (\text{influence\_level}(sh) \cdot I(\text{satisfied}(sh)))$$

- **G7: minimize_context_switching** - Minimize the number of different features a team works on in one sprint.

$$\text{Minimize } Z_7 = \sum_{t \in \text{Team}} \sum_{sp \in \text{Sprint}} |\{f : \text{assign}(f, t, sp) = 1\}|$$

- **G8: maximize_skill_application** - Maximize the use of certified skills across the workforce.

$$\text{Maximize } Z_8 = \sum_{w \in \text{Worker}} \sum_{s \in \text{Skill}} I(\text{certified}(w, s) = \text{True})$$

- **G9: minimize_project_delay** - Minimize the delay between planned and actual project end dates.

$$\text{Minimize } Z_9 = \sum_{p \in \text{Project}} \max(0, \text{actual\_end}(p) - \text{planned\_end}(p))$$

4 Conditions

- **C0: team_availability** - A team's status must be 'Available' to be assigned to a new project.

$$\text{team\_status}(t) = \text{'Available'} \quad \forall t \in \text{Team where assign}(t, p) = 1$$

- **C1: sprint_goal_must_be_met** - The Sprint Goal achievement_status must be 'Achieved'.

$$\text{achievement\_status}(sg_{sp}) = \text{'Achieved'} \quad \forall sp \in \text{Sprint}$$

- **C2: worker_availability** - A worker can only be assigned to tasks if their availability > 0.

$$\text{availability}(w) > 0 \quad \forall w \in \text{Worker where assign}(w, tsk) = 1$$

- **C3: budget_not_exceeded** - The total cost of a project must not exceed its allocated budget.

$$\sum_{f \in \text{Feature}_p} \text{cost}(f) \leq \text{budget}(p) \quad \forall p \in \text{Project}$$

- **C4: story_points_per_sprint** - The total story points in a Sprint Backlog must not exceed 1.5x the team's velocity.

$$\sum_{us \in \text{UserStory}_{sbl}} \text{story\_points}(us) \leq 1.5 \cdot \text{avg\_story\_points}(vel_t) \quad \forall sbl \in \text{SprintBacklog}$$

- **C5: cross_functional_team** - Each team must have at least one member with each required role.

$$\sum_{w \in \text{Worker}_t} I(\text{role}(w, r) = 1) \geq 1 \quad \forall t \in \text{Team}, \forall r \in \text{RequiredRoles}$$

- **C6: definition_of_done** - A User Story can only be marked 'Done' if all its acceptance criteria are met.

$$\text{status}(us) = \text{'Done'} \implies \bigwedge_{c \in \text{acceptance\_criteria}(us)} c = \text{True} \quad \forall us \in \text{UserStory}$$

- **C7: no_active_blockers** - A task cannot be marked 'Done' if it has an active blocker.

$$\text{status}(tsk) = \text{'Done'} \implies \nexists bl \in \text{Blocker}_{tsk} : \text{status}(bl) \neq \text{'Resolved'} \quad \forall tsk \in \text{Task}$$

- **C8: feature_dependency** - Feature B cannot start until Feature A is complete.

$$\text{status}(f_B) \neq \text{'In Progress'} \quad \text{until} \quad \text{status}(f_A) = \text{'Done'} \quad \forall (f_A, f_B) \in \text{Dependencies}$$

- **C9: maximum_team_size** - A team cannot have more than 10 members.

$$\sum_{w \in \text{Worker}} \text{assign}(w, t) \leq 10 \quad \forall t \in \text{Team}$$

5 DecisionVariables

- **DV0:** $x_{t,p} \in \{0,1\}$ - Binary assignment of Team t to Project p.

- **DV1:** $x_{w,t} \in \{0,1\}$ - Binary assignment of Worker w to Team t.

- **DV2:** $x_{us,sp} \in \{0,1\}$ - Binary inclusion of UserStory us in Sprint sp.

- **DV3:** $x_{tsk,w} \in \{0,1\}$ - Binary assignment of Task tsk to Worker w.

- **DV4:** $p_{us} \in Z^+$ - Story points for UserStory us, where $1 \leq p_{us} \leq 20$.

- **DV5:** $d_{sp} \in Z^+$ - Duration of Sprint sp in days, where $7 \leq d_{sp} \leq 21$.

- **DV6:** $v_{t,sp} \in Z^+$ - Planned velocity for Team t in Sprint sp, where $0 \leq v_{t,sp} \leq 50$.

- **DV7:** $pri_p \in Z^+$ - Priority level of Project p, where $1 \leq pri_p \leq 10$.

- **DV8:** $pri_f \in Z^+$ - Priority level of Feature f, where $1 \leq pri_f \leq 100$.

- **DV9:** $a_{w,sp} \in R$ - Availability of Worker w in Sprint sp, where $0.0 \leq a_{w,sp} \leq 1.0$.

- **DV10:** $c_{sp,ceremony} \in Z^+$ - Duration of a ceremony in Sprint sp, where $15 \leq c_{sp,ceremony} \leq 240$.

- **DV11:** $l_{w,s} \in Z^+$ - Skill level of Worker w for Skill s, where $1 \leq l_{w,s} \leq 5$.