Multi-Objective Planning Model for a Scrum-based Software Organization

Generated from Entities & Relations & CSV Specifications

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Contents

1 1. Sets (Entities)

- P – set of **Projects** (Entity: Project).
- T – set of **Teams** (Entity: Team).
- W – set of **Workers** (Entity: Worker).
- F – set of **Features** (Entity: Feature).
- SK – set of **Skills** (Entity: Skill).
- R – set of **Roles** (Entity: Role).
- PO – set of **Product Owners** (Entity: ProductOwner).
- SM – set of **Scrum Masters** (Entity: ScrumMaster).
- PB – set of **Product Backlogs** (Entity: ProductBacklog).
- $\mathcal{S}$ – set of **Sprints** (Entity: Sprint).
- SPP – set of **Sprint Plannings** (Entity: SprintPlanning).
- DS – set of **Daily Scrums** (Entity: DailyScrum).
- SR – set of **Sprint Reviews** (Entity: SprintReview).
- SRE – set of **Sprint Retrospectives** (Entity: SprintRetrospective).
- SBL – set of **Sprint Backlogs** (Entity: SprintBacklog).
- SG – set of **Sprint Goals** (Entity: SprintGoal).
- E – set of **Epics** (Entity: Epic).
- US – set of **User Stories** (Entity: UserStory).
- K – set of **Tasks** (Entity: Task).
- DEV – set of **Development Snapshots** (Entity: DevelopmentSnapshot).
- BL – set of **Blockers** (Entity: Blocker).
- SH – set of **Stakeholders** (Entity: Stakeholder).
- VEL – set of **Velocity records** (Entity: Velocity).
- REP – set of **Release Plans** (Entity: ReleasePlan).
- RM – set of **Roadmaps** (Entity: Roadmap).
- SCB – set of **Scrum Boards** (Entity: ScrumBoard).
- FED – set of **Feature Documentations** (Entity: FeatureDocumentation).

Relation-incidence sets (from Relationships.csv):

- $R1 \subseteq T \times P$ (is_assigned_to_project).
- $R2 \subseteq W \times T$ (belongs_to_team). *Note: "Employee" interpreted as* ***Worker****.*

- $R3 \subseteq W \times SK$ (has_skill).
- $R4 \subseteq W \times R$ (takes_on_role).
- $R5 \subseteq PO \times PB$ (manages_backlog).
- $R6 \subseteq T \times SM$ (is_supported_by).
- $R7 \subseteq PB \times F$ (contains_feature).
- $R8 \subseteq PB \times E$ (contains_epic).
- $R9 \subseteq E \times US$ (contains_user_story).
- $R10 \subseteq US \times K$ (consists_of_tasks).
- $R11 \subseteq US \times SBL$ (is_in_sprint_backlog).
- $R12 \subseteq SBL \times \mathcal{S}$ (belongs_to_sprint).
- $R13 \subseteq \mathcal{S} \times SG$ (pursues_goal).
- $R14 \subseteq SCB \times K$ (contains_tasks).
- $R15 \subseteq FED \times F$ (documents_feature).
- $R16 \subseteq K \times BL$ (is_blocked_by).
- $R17 \subseteq SH \times SR$ (participates_in). *Note: "Sprint Review"* $\rightarrow$ ***SprintReview***.
- $R18 \subseteq SM \times SRE$ (moderates_retrospective).
- $R19 \subseteq VEL \times T$ (refers_to_team).
- $R20 \subseteq REP \times F$ (plans_release).
- $R21 \subseteq REP \times RM$ (is_part_of_roadmap).
- $R22 \subseteq \mathcal{S} \times DEV$ (generates_snapshot).

2 2. Indices

- $p \in P,\ t \in T,\ w \in W,\ f \in F,\ sk \in SK,\ r \in R,\ po \in PO,\ sm \in SM,\ pb \in PB,$
- $s \in \mathcal{S},\ spp \in SPP,\ ds \in DS,\ sr \in SR,\ sre \in SRE,\ sbl \in SBL,\ sg \in SG,$
- $e \in E,\ u \in US,\ k \in K,\ dev \in DEV,\ bl \in BL,\ sh \in SH,\ v \in VEL,\ rep \in REP,\ rm \in RM,\ scb \in SCB,\ fed \in FED.$

Attributes as parameters (examples aligned to Entities.csv):

- Project: budget_p, priority_p (if used), etc.
- Feature: priority_f, $\widehat{effort}_f$ (estimated_effort).
- UserStory: sp_u (story_points), priority_u.
- Task: eff_k.
- Blocker: sev_{bl}.

- SprintBacklog: totEff_{sbl}, numTasks_{sbl}.
- SprintGoal: benefit_{sg}.
- SprintReview: attend_{sr}.
- Velocity: for each t, define avgSP_t, maxVel_t, minVel_t via $R19$ mapping from VEL to T.
- ProductBacklog: incidence $\text{inPB}_{pb,f}$ and $\text{inPB}^{E}_{pb,e}$ from $R7, R8$.
- Epic & UserStory: incidence $\text{inEpic}_{e,u}$ from $R9$.
- UserStory & Task: incidence $\text{inUS}_{u,k}$ from $R10$.
- Task & Blocker: incidence $\text{blocked}_{k,bl}$ from $R16$.
- SprintBacklog $\rightarrow$ Sprint: unique mapping $s = \text{sOfSBL}(sbl)$ from $R12$.
- Sprint $\rightarrow$ SprintGoal: unique mapping $sg = \text{sgOfS}(s)$ from $R13$.

Decision variables (DecisionVariables.csv):

- $x^{F}_{f} \in \{0,1\}$ (DV0) – select feature f for next release.
- $x^{US}_{u,s} \in \{0,1\}$ (DV1) – assign user story u to sprint s.
- $x^{K}_{k,t} \in \{0,1\}$ (DV2) – assign task k to team t.
- $x^{WT}_{w,t} \in \{0,1\}$ (DV3) – assign worker w to team t.
- $x^{WR}_{w,r} \in \{0,1\}$ (DV4) – worker w takes role r.
- $x^{RES}_{k,bl} \in \{0,1\}$ (DV5) – resolve blocker bl for task k.
- $B_p \geq 0$ (DV6) – allocated budget to project p.
- $x^{SG}_{s} \in \{0,1\}$ (DV7) – plan to achieve sprint s's goal.
- $x^{TP}_{t,p} \in \{0,1\}$ (DV8) – assign team t to project p.
- $x^{SA}_{s} \in \{0,1\}$ (DV9) – sprint s active.
- $x^{FED}_{fed} \in \{0,1\}$ (DV10) – use/link feature documentation fed.
- $x^{SM}_{sm,t} \in \{0,1\}$ (DV11) – Scrum Master sm supports team t.
- $x^{PO}_{po,pb} \in \{0,1\}$ (DV12) – Product Owner po manages backlog pb.
- $x^{TS}_{t,s} \in \{0,1\}$ (DV13) – team t works on sprint s.
- $x^{SR}_{sr} \in \{0,1\}$ (DV14) – sprint review sr scheduled.

3 3. Goals

All goals are handled in a weighted multi-objective sense; each can be optimized separately or combined (e.g., via scalarization). For each goal we show **(ID)** Name and its mathematical form.

- **(G0) maximize_feature_priority:** $\max \sum_{f \in F} \text{priority}_f \, x_f^F$.
- **(G1) minimize_feature_estimated_effort:** $\min \sum_{f \in F} \widehat{effort}_f \, x_f^F$.
- **(G2) maximize_user_story_points:** $\max \sum_{u \in US} \sum_{s \in \mathcal{S}} \text{sp}_u \, x_{u,s}^{US}$.
- **(G3) minimize_task_effort:** $\min \sum_{k \in K} \sum_{t \in T} \text{eff}_k \, x_{k,t}^K$.
- **(G4) minimize_blocker_severity_unresolved:** $\min \sum_{k \in K} \sum_{bl \in BL} \mathbf{1}[\text{blocked}_{k,bl}=1] \, \text{sev}_{bl} \, (1 - x_{k,bl}^{RES})$.
- **(G5) minimize_project_budget_allocation:** $\min \sum_{p \in P} B_p \quad \text{with } 0 \le B_p \le \text{budget}_p$.
- **(G6) maximize_team_velocity:** $\max \sum_{t \in T} \sum_{s \in \mathcal{S}} \text{avgSP}_t \, x_{t,s}^{TS}$.
- **(G7) maximize_sprint_goal_benefit:** $\max \sum_{s \in \mathcal{S}} \text{benefit}_{\text{sgOfS}(s)} \, x_s^{SG}$.
- **(G8) minimize_sprint_total_effort:** $\min \sum_{sbl \in SBL} \text{totEff}_{sbl} \, x_{\text{sOfSBL}(sbl)}^{SA}$.
- **(G9) maximize_stakeholder_attendance:** $\max \sum_{sr \in SR} \text{attend}_{sr} \, x_{sr}^{SR}$.
- **(G10) minimize_number_of_tasks:** $\min \sum_{sbl \in SBL} \text{numTasks}_{sbl} \, x_{\text{sOfSBL}(sbl)}^{SA}$.
- **(G11) maximize_documented_features:** $\max \sum_{fed \in FED} \text{linkedReq}_{fed} \, x_{fed}^{FED}$.

4 4. Conditions

Below, we formalize each condition (constraint). IDs match Conditions.csv.

- **(C0) assign_user_story_to_one_sprint:** $\sum_{s \in \mathcal{S}} x_{u,s}^{US} \le 1 \quad \forall u \in US$.
- **(C1) limit_sprint_capacity_by_velocity:** $\sum_{u \in US} \text{sp}_u \, x_{u,s}^{US} \le \sum_{t \in T} \text{maxVel}_t \, x_{t,s}^{TS} \quad \forall s \in \mathcal{S}$.
- **(C2) team_to_one_project:** $\sum_{p \in P} x_{t,p}^{TP} = 1 \quad \forall t \in T$.
- **(C3) worker_to_at_most_one_team:** $\sum_{t \in T} x_{w,t}^{WT} \le 1 \quad \forall w \in W$.

- **(C4) each_team_has_one_scrum_master:** $\sum_{sm \in SM} x^{SM}_{sm,t} = 1 \quad \forall t \in T.$
- **(C5) po_manages_one_backlog:** $\sum_{pb \in PB} x^{PO}_{po,pb} = 1 \quad \forall po \in PO.$
- **(C6) feature_in_backlog_if_in_release:** $x^F_f \leq \sum_{pb \in PB} \text{inPB}_{pb,f} \quad \forall f \in F.$
- **(C7) epic_in_backlog_for_user_story:** $\sum_{s \in \mathcal{S}} x^{US}_{u,s} \leq \sum_{e \in E} \text{inEpic}_{e,u} \cdot \sum_{pb \in PB} \text{inPB}^E_{pb,e} \quad \forall u \in US.$
- **(C8) task_only_if_user_story_in_sprint:** For $U(k) = \{u \in US : \text{inUS}_{u,k} = 1\}$, $\sum_{t \in T} x^K_{k,t} \leq \sum_{u \in U(k)} \sum_{s \in \mathcal{S}} x^{US}_{u,s} \quad \forall k \in K.$
- **(C9) resolve_blocker_if_task_selected:** $\sum_{bl \in BL} \mathbf{1}[\text{blocked}_{k,bl}=1]\, x^{RES}_{k,bl} \geq \sum_{t \in T} x^K_{k,t} \quad \forall k \in K.$
- **(C10) budget_allocation_within_limit:** $0 \leq B_p \leq \text{budget}_p \quad \forall p \in P.$
- **(C11) activate_sprint_if_has_user_stories:** Let $M = |US|$. $\frac{1}{M} \sum_{u \in US} x^{US}_{u,s} \leq x^{SA}_s \leq \sum_{u \in US} x^{US}_{u,s} \quad \forall s \in \mathcal{S}.$

5 5. DecisionVariables

- (DV0) $x^F_f \in \{0,1\}$, (DV1) $x^{US}_{u,s} \in \{0,1\}$, (DV2) $x^K_{k,t} \in \{0,1\}$, (DV3) $x^{WT}_{w,t} \in \{0,1\}$,
- (DV4) $x^{WR}_{w,r} \in \{0,1\}$, (DV5) $x^{RES}_{k,bl} \in \{0,1\}$, (DV6) $B_p \in \mathbb{R}_{\geq 0}$,
- (DV7) $x^{SG}_s \in \{0,1\}$, (DV8) $x^{TP}_{t,p} \in \{0,1\}$, (DV9) $x^{SA}_s \in \{0,1\}$,
- (DV10) $x^{FED}_{fed} \in \{0,1\}$, (DV11) $x^{SM}_{sm,t} \in \{0,1\}$, (DV12) $x^{PO}_{po,pb} \in \{0,1\}$,
- (DV13) $x^{TS}_{t,s} \in \{0,1\}$, (DV14) $x^{SR}_{sr} \in \{0,1\}$.