

# Optimization Model for SCRUM-Based Software Development

## Domain-Driven Mathematical Formulation

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## 1. Sets (Entities)

$\mathcal{P}$ : Set of Projects  $\{p \mid p \in \text{Project}\}$

$\mathcal{T}$ : Set of Teams  $\{t \mid t \in \text{Team}\}$

$\mathcal{W}$ : Set of Workers  $\{w \mid w \in \text{Worker}\}$

$\mathcal{F}$ : Set of Features  $\{f \mid f \in \text{Feature}\}$

$\mathcal{S}$ : Set of Skills  $\{s \mid s \in \text{Skill}\}$

$\mathcal{R}$ : Set of Roles  $\{r \mid r \in \text{Role}\}$

$\mathcal{PO}$ : Set of Product Owners  $\{po \mid po \in \text{ProductOwner}\}$

$\mathcal{SM}$ : Set of Scrum Masters  $\{sm \mid sm \in \text{ScrumMaster}\}$

$\mathcal{PB}$ : Set of Product Backlogs  $\{pb \mid pb \in \text{ProductBacklog}\}$

$\mathcal{SP}$ : Set of Sprints  $\{sp \mid sp \in \text{Sprint}\}$

$\mathcal{SPP}$ : Set of Sprint Plannings  $\{spp \mid spp \in \text{SprintPlanning}\}$

$\mathcal{DS}$ : Set of Daily Scrums  $\{ds \mid ds \in \text{DailyScrum}\}$

$\mathcal{SR}$ : Set of Sprint Reviews  $\{sr \mid sr \in \text{SprintReview}\}$

$\mathcal{SRE}$ : Set of Sprint Retrospectives  $\{sre \mid sre \in \text{SprintRetrospective}\}$

$\mathcal{SBL}$ : Set of Sprint Backlogs  $\{sbl \mid sbl \in \text{SprintBacklog}\}$

$\mathcal{SG}$ : Set of Sprint Goals  $\{sg \mid sg \in \text{SprintGoal}\}$

$\mathcal{E}$ : Set of Epics  $\{e \mid e \in \text{Epic}\}$

$\mathcal{US}$ : Set of User Stories  $\{us \mid us \in \text{UserStory}\}$

$\mathcal{TSK}$ : Set of Tasks  $\{tsk \mid tsk \in \text{Task}\}$

$\mathcal{DEV}$ : Set of Development Snapshots  $\{dev \mid dev \in \text{DevelopmentSnapshot}\}$

$\mathcal{BL}$ : Set of Blockers  $\{bl \mid bl \in \text{Blocker}\}$

$\mathcal{SH}$ : Set of Stakeholders  $\{sh \mid sh \in \text{Stakeholder}\}$

$\mathcal{VEL}$ : Set of Velocity Records  $\{vel \mid vel \in \text{Velocity}\}$

$\mathcal{REP}$ : Set of Release Plans  $\{rep \mid rep \in \text{ReleasePlan}\}$

$\mathcal{RM}$ : Set of Roadmaps  $\{rm \mid rm \in \text{Roadmap}\}$

$\mathcal{SCB}$ : Set of Scrum Boards  $\{scb \mid scb \in \text{ScrumBoard}\}$

$\mathcal{FED}$ : Set of Feature Documentations  $\{fed \mid fed \in \text{FeatureDocumentation}\}$

## 2. Indices

$p \in \mathcal{P}$ : 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

$r \in \mathcal{R}$ : Index for a role  
 $po \in \mathcal{PO}$ : Index for a Product Owner  
 $sm \in \mathcal{SM}$ : Index for a Scrum Master  
 $pb \in \mathcal{PB}$ : Index for a Product Backlog  
 $sp \in \mathcal{SP}$ : Index for a Sprint  
 $sbl \in \mathcal{SBL}$ : Index for a Sprint Backlog  
 $sg \in \mathcal{SG}$ : Index for a Sprint Goal  
 $e \in \mathcal{E}$ : Index for an Epic  
 $us \in \mathcal{US}$ : Index for a User Story  
 $tsk \in \mathcal{TSK}$ : Index for a Task  
 $dev \in \mathcal{DEV}$ : Index for a Development Snapshot  
 $bl \in \mathcal{BL}$ : Index for a Blocker  
 $sh \in \mathcal{SH}$ : Index for a Stakeholder  
 $vel \in \mathcal{VEL}$ : Index for a Velocity record  
 $rep \in \mathcal{REP}$ : Index for a Release Plan  
 $rm \in \mathcal{RM}$ : Index for a Roadmap  
 $scb \in \mathcal{SCB}$ : Index for a Scrum Board  
 $fed \in \mathcal{FED}$ : Index for a Feature Documentation

### 3. Goals

#### **G0: maximize\_project\_budget**

Maximize total project budget:

$$\max \sum_{p \in \mathcal{P}} \text{budget}(p) \quad \text{with weight 1.5}$$

#### **G1: maximize\_team\_size**

Maximize total team size:

$$\max \sum_{t \in \mathcal{T}} \text{team\_size}(t) \quad \text{with weight 1.2}$$

#### **G2: maximize\_worker\_availability**

Maximize sum of worker availability:

$$\max \sum_{w \in \mathcal{W}} \text{availability}(w) \quad \text{with weight 1.3}$$

#### **G3: minimize\_total\_effort**

Minimize total effort of all tasks:

$$\min \sum_{tsk \in \mathcal{TSK}} \text{effort}(tsk) \quad \text{with weight 1.0}$$

**G4: maximize\_story\_points**

Maximize total story points of completed user stories:

$$\max \sum_{us \in \mathcal{US}} \text{story\_points}(us) \cdot \mathbb{I}[\text{status}(us) = \text{done}] \quad \text{with weight 0.9}$$

**G5: minimize\_sprint\_duration**

Minimize average sprint duration:

$$\min \frac{1}{|\mathcal{SP}|} \sum_{sp \in \mathcal{SP}} (\text{end\_date}(sp) - \text{start\_date}(sp)) \quad \text{with weight 1.1}$$

**G6: maximize\_velocity\_trend**

Maximize average velocity trend:

$$\max \sum_{vel \in \mathcal{VEL}} \text{trend}(vel) \quad \text{with weight 1.4}$$

**G7: minimize\_number\_of\_blockers**

Minimize number of active blockers:

$$\min \sum_{bl \in \mathcal{BL}} \mathbb{I}[\text{status}(bl) = \text{open}] \quad \text{with weight 1.6}$$

**G8: maximize\_number\_of\_features**

Maximize count of completed features:

$$\max \sum_{f \in \mathcal{F}} \mathbb{I}[\text{status}(f) = \text{completed}] \quad \text{with weight 0.8}$$

**G9: minimize\_epic\_estimated\_effort**

Minimize total estimated effort of epics:

$$\min \sum_{e \in \mathcal{E}} \text{estimated\_effort}(e) \quad \text{with weight 1.2}$$

**G10: maximize\_satisfaction\_score**

Maximize average team satisfaction:

$$\max \frac{1}{|\mathcal{SRE}|} \sum_{sre \in \mathcal{SRE}} \text{team\_satisfaction}(sre) \quad \text{with weight 1.3}$$

**G11: minimize\_release\_delay**

Minimize delay in release plans:

$$\min \sum_{rep \in \mathcal{REP}} \max(0, \text{actual\_date}(rep) - \text{planned\_date}(rep)) \quad \text{with weight 1.1}$$

**G12: maximize\_documentation\_coverage**

Maximize number of documented features:

$$\max \sum_{fed \in \mathcal{FED}} 1 \quad \text{with weight 0.7}$$

**G13: minimize\_task\_count\_per\_sprint**

Minimize average tasks per sprint:

$$\min \frac{1}{|\mathcal{SP}|} \sum_{sp \in \mathcal{SP}} \text{number\_of\_tasks}(\text{sprint\_backlog}(sp)) \quad \text{with weight 1.0}$$

**G14: maximize\_sprint\_goal\_achievement**

Maximize achieved sprint goals:

$$\max \sum_{sg \in \mathcal{SG}} \mathbb{I}[\text{achievement\_status}(sg) = \text{achieved}] \quad \text{with weight 1.5}$$

**4. Conditions****C0: require\_project\_status\_active**

Only active projects are considered:

$$\forall p \in \mathcal{P} : \text{status}(p) = \text{active}$$

**C1: require\_team\_status\_active**

Only active teams are valid:

$$\forall t \in \mathcal{T} : \text{team\_status}(t) = \text{active}$$

**C2: require\_worker\_status\_active**

Only active workers are assignable:

$$\forall w \in \mathcal{W} : \text{status}(w) = \text{active}$$

**C3: require\_feature\_status\_completed**

Only completed features contribute:

$$\forall f \in \mathcal{F} : \text{status}(f) = \text{completed} \Rightarrow \text{included in goals}$$

**C4: require\_user\_story\_status\_done**

Only done user stories are counted:

$$\forall us \in \mathcal{US} : \text{status}(us) = \text{done}$$

**C5: require\_task\_status\_not\_blocked**

Tasks must not be blocked:

$$\forall tsk \in \mathcal{TSK} : \nexists bl \in \mathcal{BL} \text{ such that } (tsk, bl) \in \text{is\_blocked\_by} \wedge \text{status}(bl) = \text{open}$$

**C6: require\_sprint\_status\_completed**

Only completed sprints are considered:

$$\forall sp \in \mathcal{SP} : \text{status}(sp) = \text{completed}$$

**C7: require\_release\_status\_planned**

Only planned releases are included:

$$\forall rep \in \mathcal{REP} : \text{status}(rep) \in \{\text{planned}, \text{in progress}\}$$

**C8: require\_skill\_certified**

Only certified skills are valid:

$$\forall s \in \mathcal{S} : \text{certified}(s) = \text{true}$$

**C9: require\_role\_area\_defined**

Role must have defined responsibility:

$$\forall r \in \mathcal{R} : \text{area\_of\_responsibility}(r) \neq \emptyset$$

**C10: require\_velocity\_above\_minimum**

Velocity must exceed minimum:

$$\forall vel \in \mathcal{VEL} : \text{avg\_story\_points}(vel) \geq \text{min\_velocity}(vel)$$

**C11: require\_board\_updated\_recently**

Scrum board updated in last 24 hours:

$$\forall scb \in \mathcal{SCB} : \text{last\_updated}(scb) \geq \text{now} - 24\text{h}$$

**C12: require\_stakeholder\_relevance\_high**

Only high-relevance stakeholders:

$$\forall sh \in \mathcal{SH} : \text{relevance\_to\_feature}(sh) \geq 4$$

**C13: require\_snapshot\_test\_passed**

Snapshots must pass tests:

$$\forall dev \in \mathcal{DEV} : \text{test\_status}(dev) = \text{passed}$$

**C14: require\_goal\_achievement\_met**

Sprint goal must be achieved:

$$\forall sg \in \mathcal{SG} : \text{achievement\_status}(sg) = \text{achieved}$$

**5. Decision Variables**

$dv0_p \in \mathbb{Z}$ : Project priority assignment for  $p \in \mathcal{P}$ ,  $dv0_p \in \{1, 2, 3, 4, 5\}$

$dv1_t \in \mathbb{Z}$ : Team size allocation for  $t \in \mathcal{T}$ ,  $2 \leq dv1_t \leq 15$

$dv2_w \in \mathbb{R}$ : Worker availability percentage for  $w \in \mathcal{W}$ ,  $0.0 \leq dv2_w \leq 100.0$

$dv3_{tsk} \in \mathbb{R}$ : Task effort estimate for  $tsk \in \mathcal{TSK}$ ,  $1.0 \leq dv3_{tsk} \leq 40.0$

$dv4_{us} \in \mathbb{Z}$ : User story priority for  $us \in \mathcal{US}$ ,  $dv4_{us} \in \{1, 2, 3\}$

$dv5_f \in \mathbb{Z}$ : Feature priority for  $f \in \mathcal{F}$ ,  $dv5_f \in \{1, 2, 3\}$

$dv6_{sp} \in \mathbb{Z}$ : Sprint duration in days for  $sp \in \mathcal{SP}$ ,  $dv6_{sp} \in \{5, 10, 14, 21\}$

$dv7_{us} \in \mathbb{Z}$ : Story points estimate for  $us \in \mathcal{US}$ ,  $dv7_{us} \in \{1, 2, 3, 5, 8, 13\}$

$dv8_{w,s} \in \mathbb{Z}$ : Skill level rating of worker  $w$  in skill  $s$ ,  $1 \leq dv8_{w,s} \leq 5$

$dv9_{bl} \in \mathbb{Z}$ : Blocker severity level for  $bl \in \mathcal{BL}$ ,  $dv9_{bl} \in \{1, 2, 3\}$

$dv10_{sre} \in \mathbb{Z}$ : Team satisfaction score from retrospective  $sre \in \mathcal{SRE}$ ,  $1 \leq dv10_{sre} \leq 10$

$dv11_{rep} \in \mathbb{R}$ : Release version number for  $rep \in \mathcal{REP}$ ,  $1.0 \leq dv11_{rep} \leq 10.0$

$dv12_{fed} \in \{0, 1\}$ : Documentation completion status,  $dv12_{fed} = 1$  if complete

$dv13_{tsk} \in \{0, 1, 2\}$ : Task status code: 0=todo, 1=doing, 2=done

$dv14_{vel} \in \mathbb{R}$ : Velocity trend value for  $vel \in \mathcal{VEL}$ ,  $-1.0 \leq dv14_{vel} \leq 2.0$