A conceptual framework for an adaptive Internet-Delivered Psychological Treatment (IDPT) system

Suresh Kumar Mukhiya
skmu@hvl.no

Supervisors:
Prof. Yngve Lamo & Assoc. Prof. Violet Ka I Pun & Assoc. Prof. Fazle Rabbi

June 18, 2020

Background

1/4 people in the world will be affected by mental or neurological disorders at some point in their lives. 450 million people are suffering from mental or neurological disorders around the world. [1]

Based on EU Green Papers *1/4* citizens is affected by mental health problems at some point during their lives and has often led to suicide [2, 3].

About half of the Norwegian population may have experience of mental health problems during their life, and about one-third during one year [4].

- According to WHO [1], Less than half of those affected in the world receive such procedures due to long waiting lists, high treatment costs and social stigma [5] associated with the mental disorder.
- Depression can lead to suicide, and close to 800 000 people die due to suicide every year [1].

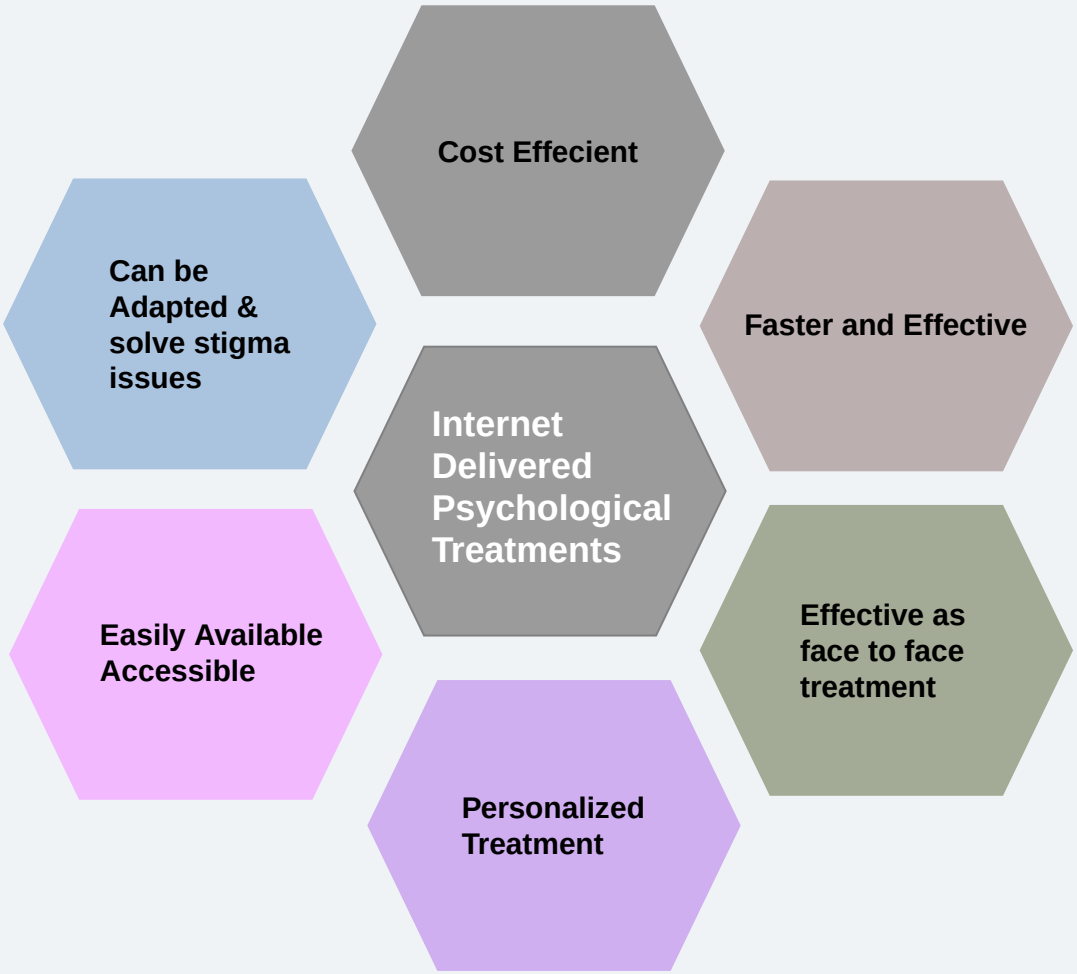
Important question

How can be address the issues of growing mental health disorder and provide healthcare facilities to far-reaching population?

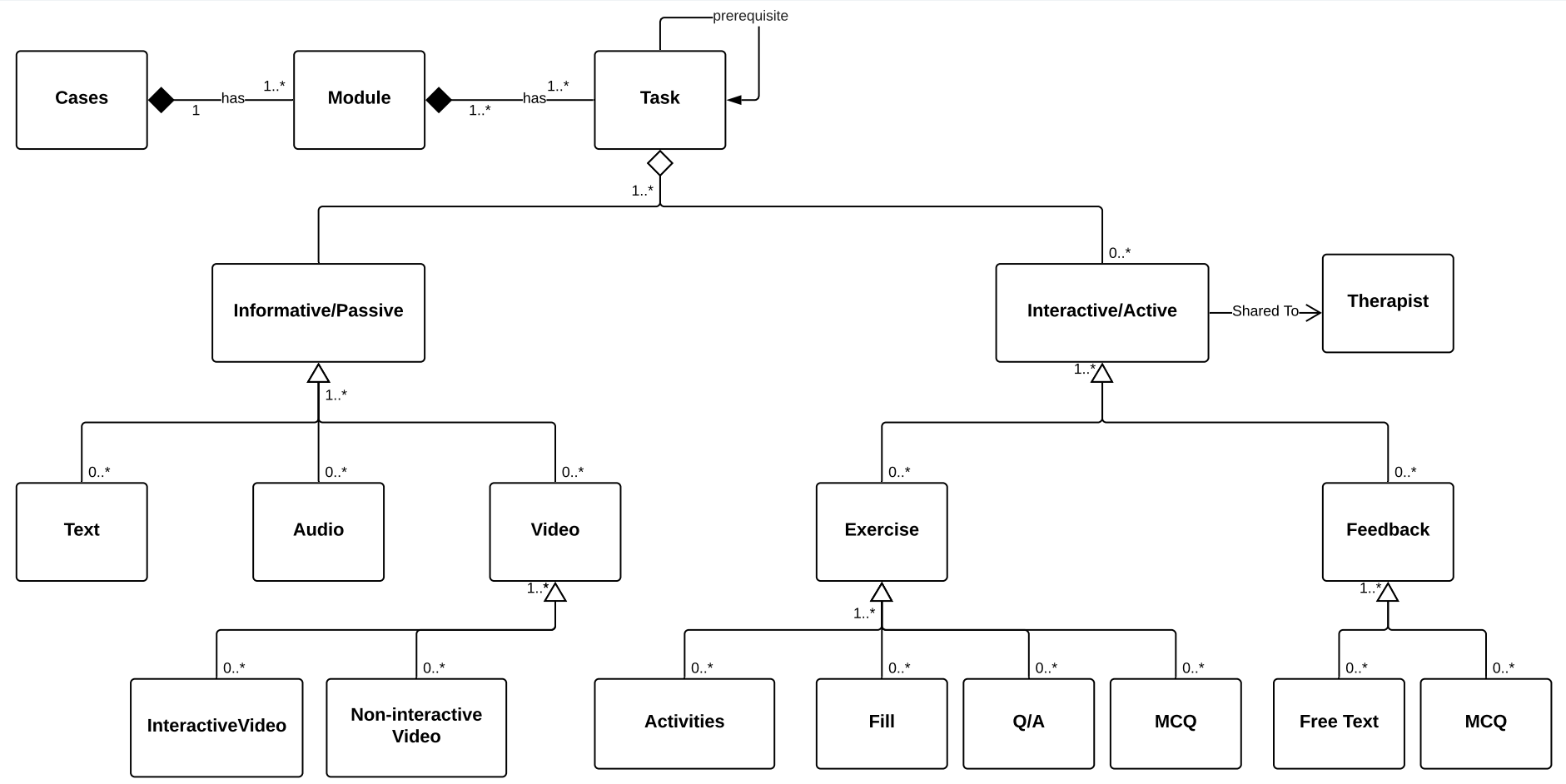
- Internet Delivered Psychological Treatments
- Developed in 1960s [6] and most commonly practiced and extensively researched forms of psychotherapy [7].
- Any form of treatments/therapy delivered through Internet.
- Usually involves web-applications, mobile based or the use of Augmented/Virtual reality environment.

Objectives of IDPT

Goal: provide psycho-education that helps the patients to understand, and manage their illness.



Components of IDPT



Components - ADHD case in INTROMAT

- **Case**: ADHD
- **Modules:** 7 Modules
  1. Start - introduction, symptom description and goal setting
  2. Breathe - inattention and breathing exercises
  3. Stop - awareness and stop exercise
  4. Emotions - description and characteristics of the basic emotions, emotion regulation techniques
  5. Problem solving - identifying problematic behavior and changing this
  6. Planning and organization - using a calendar to plan, to do lists, dividing tasks into subtasks, energy budgeting
  7. Acceptance - self acceptance and self care exercises
- **Tasks**:
  1. Reading/Listening/Watching
  2. Setting personal goal
  3. Self assessment through psychometric test (ASRS V1.1)
  4. Feedback after exercise.

Assumptions

Case

1. **[A1]**: A case contains at least one module.
2. **[A2]** A case can have inclusion and exclusion criteria.
3. **[A3]** A case can have one or more evaluation criteria.

Modules

4. **[A4]**: A module contains at least one task.
5. **[A5]**: Once module can belong to one to many cases.
6. **[A6]**: Modules can have dependencies/criteria between the modules.
7. **[A7]** A module can have one or more evaluation criteria.

Assumptions

Tasks

8. **[A8]**: Task can have sub-tasks. Each task can have an evaluation criteria. The evaluation criteria of a task is the overall evaluation of the sub-tasks.
9. **[A9]**: One task can belong to one to many modules.

An intervention

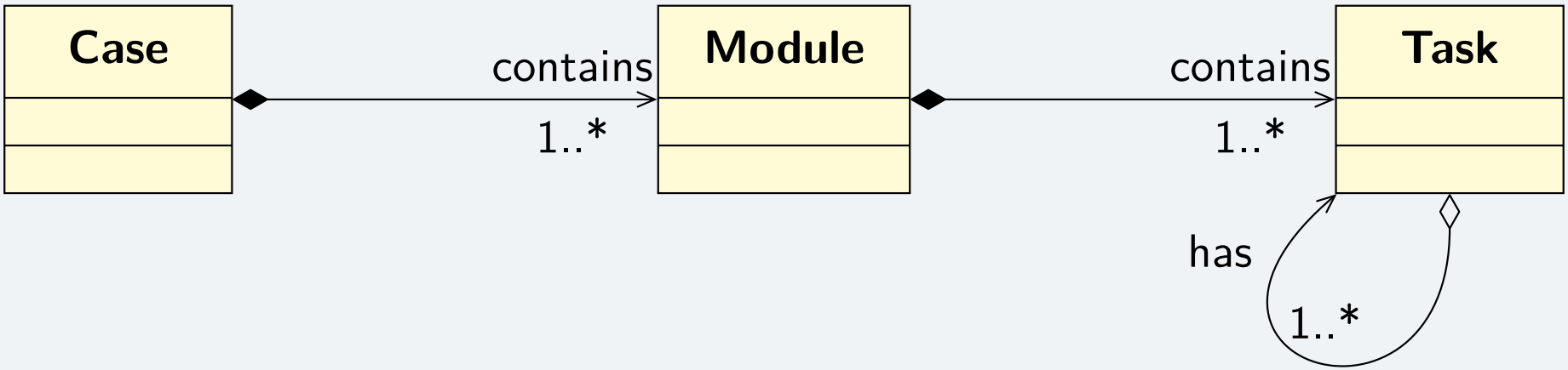
Let C be a case, M be the set of modules inside the case. Each module contains one or more tasks with the evaluation E:

$$C = \{m_1, m_2, m_3, ..., m_n\} \tag{1}$$

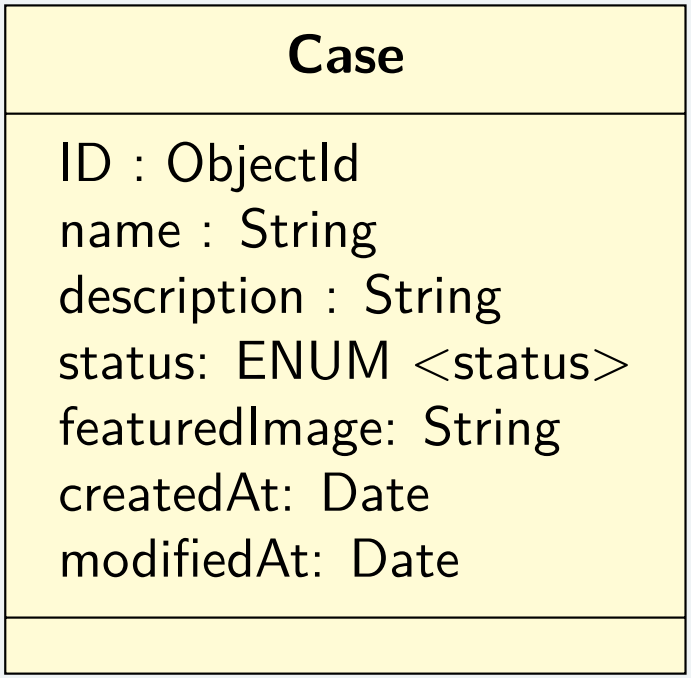
$$M_i = \{t_{i1}, t_{i2}, ..., t_{in}\} \tag{2}$$

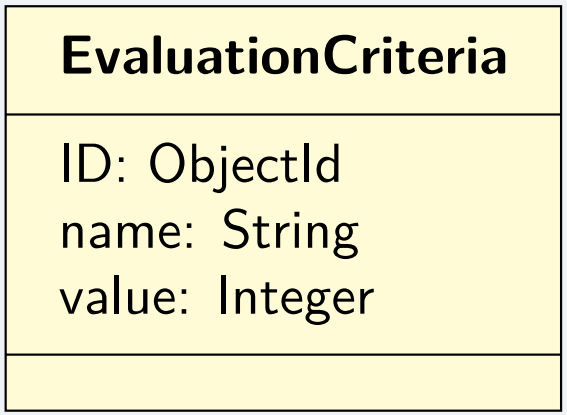
$$E_i = \{e_{i1}, e_{i2}, ..., e_{in}\} \tag{3}$$

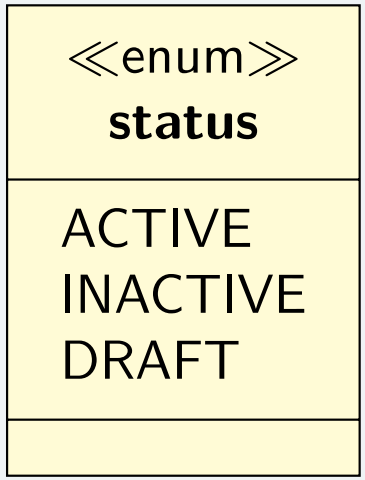
The Model



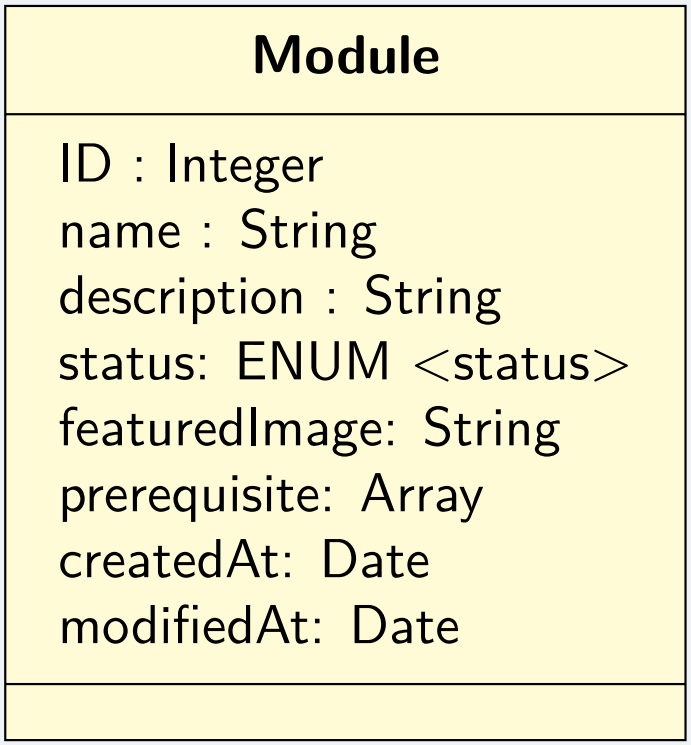
Case

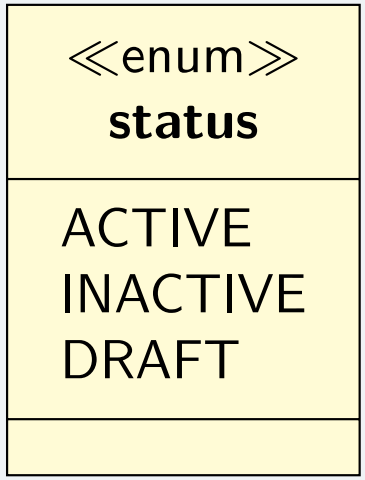

Case
ID : ObjectId
name : String
description : String
status: ENUM <status>
featuredImage: String
createdAt: Date
modifiedAt: Date


EvaluationCriteria
ID: ObjectId
name: String
value: Integer


≪enum≫
status
ACTIVE
INACTIVE
DRAFT

Module



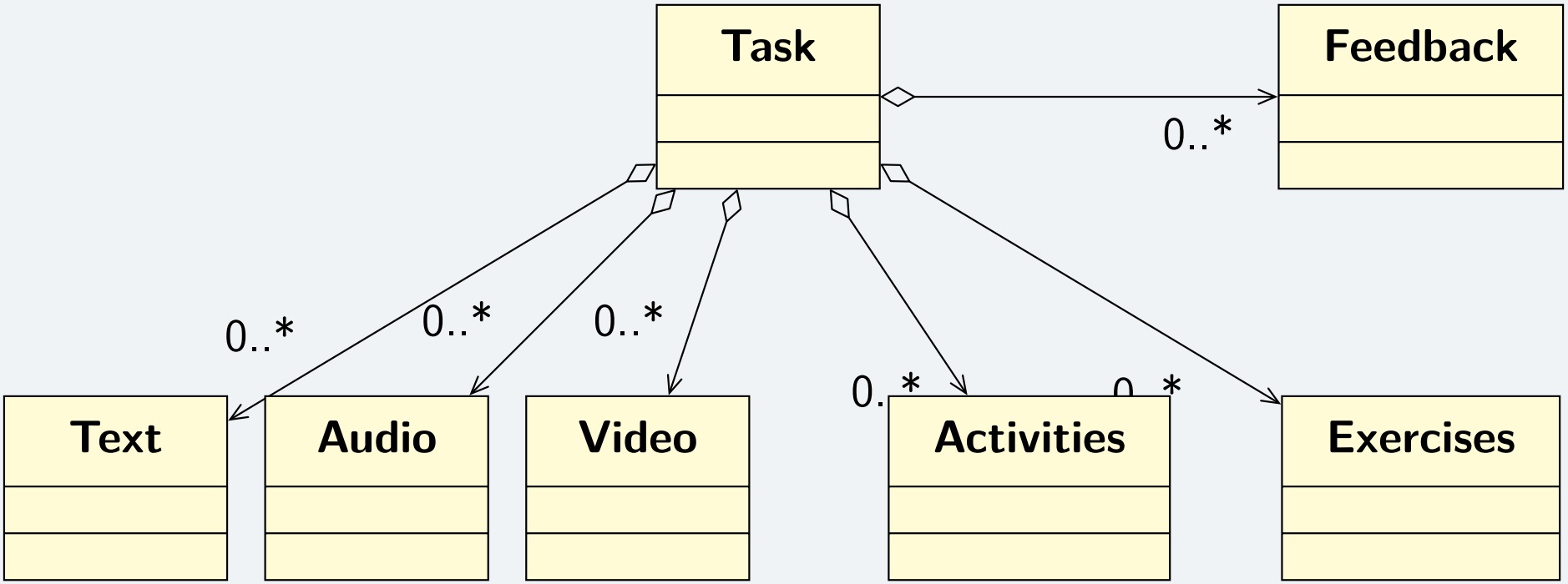


1. `Prerequisite` contains an array of modules that must be completed by an user before it becomes active for any user.

$$\forall m : M \text{ has } \{prerequsites\} \quad (4)$$

$$\text{u} : User | u.m.isComplete = true \iff \forall t : Task \in M | u.t.isComplete = true \quad (5)$$

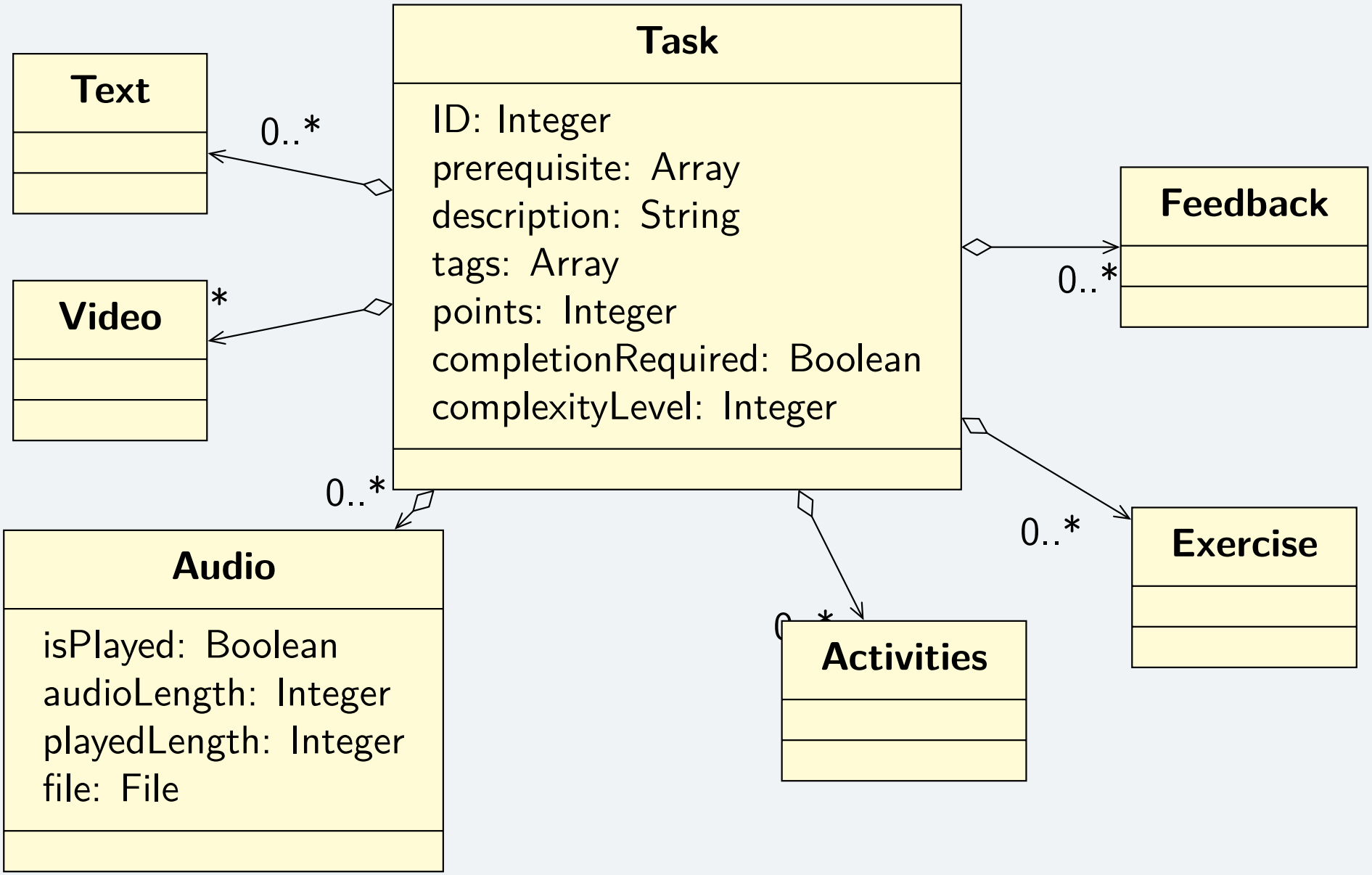
Task



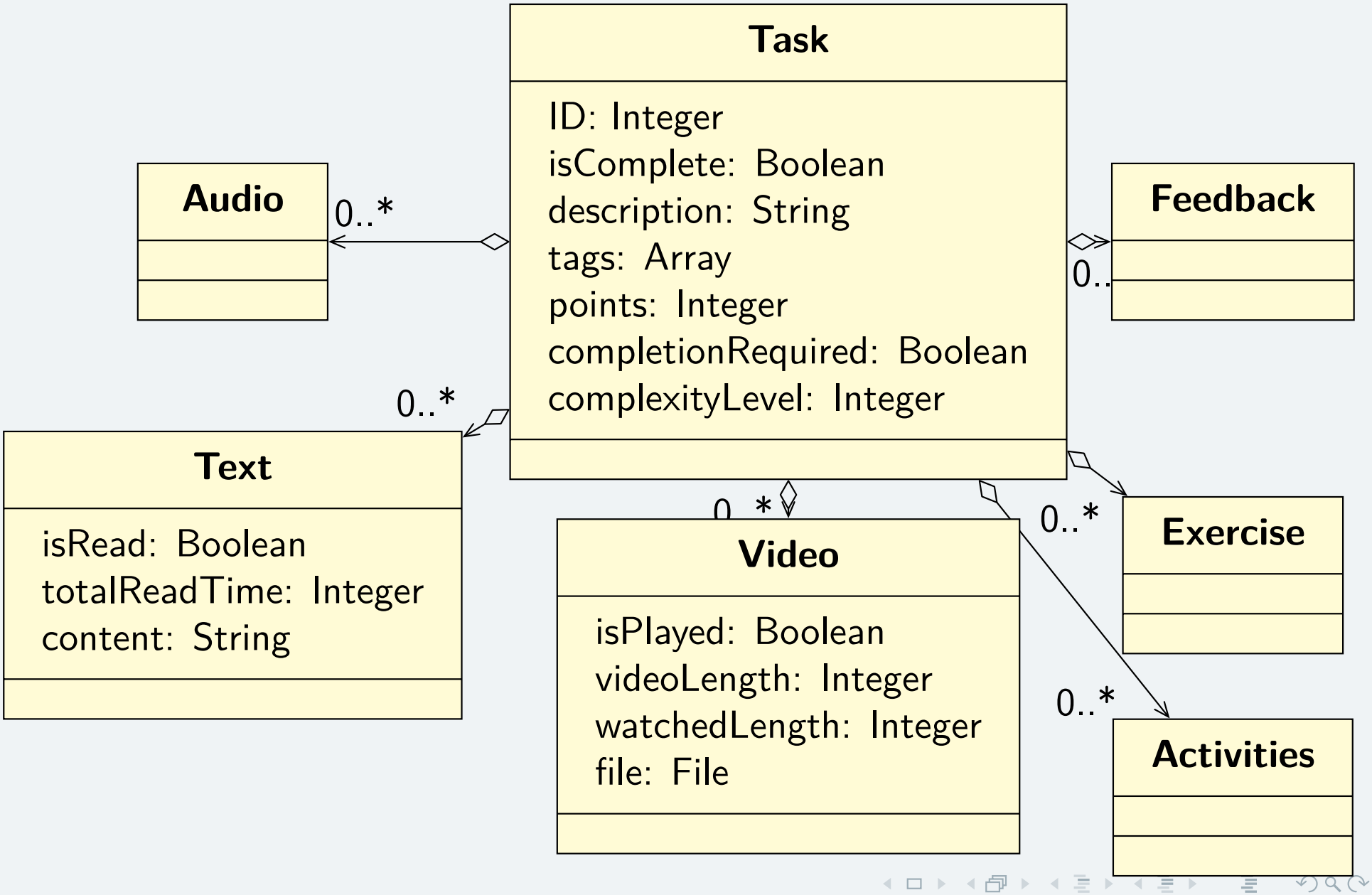
$$\forall t : T \text{ has } \{prerequsites\} \quad (6)$$

$$\text{u} : User | u.t.isComplete = true \iff \forall t : Task \in T | u.t.isComplete = true \quad (7)$$

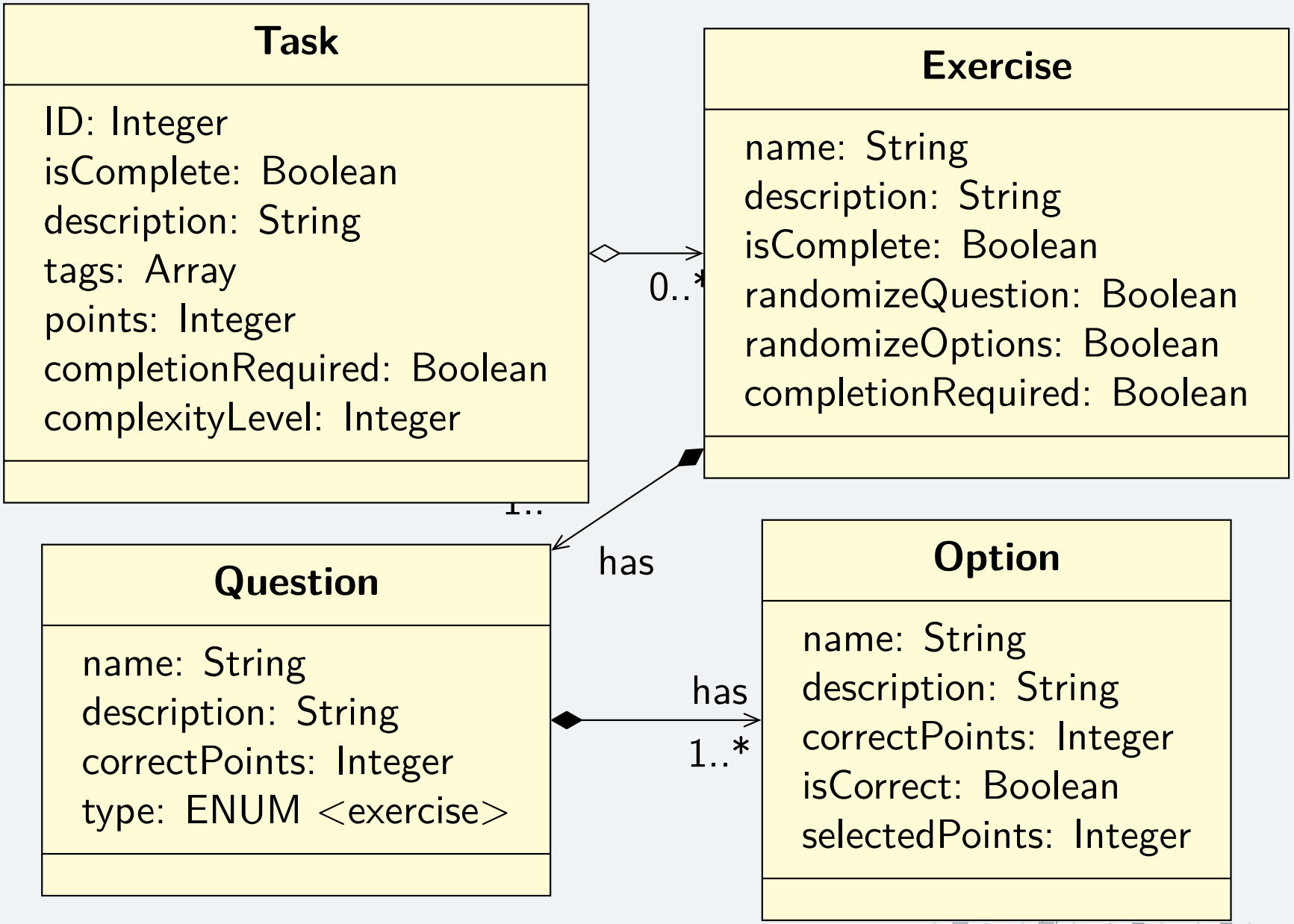
Task - Audio


Task
ID: Integer
prerequisite: Array
description: String
tags: Array
points: Integer
completionRequired: Boolean
complexityLevel: Integer
Text
Video
Feedback
Audio
isPlayed: Boolean
audioLength: Integer
playedLength: Integer
file: File
Activities
Exercise
0..*
*
0..*
0..*
0..*
0..*

Task - [Text, Video]



Task - [Exercise, Feedback]

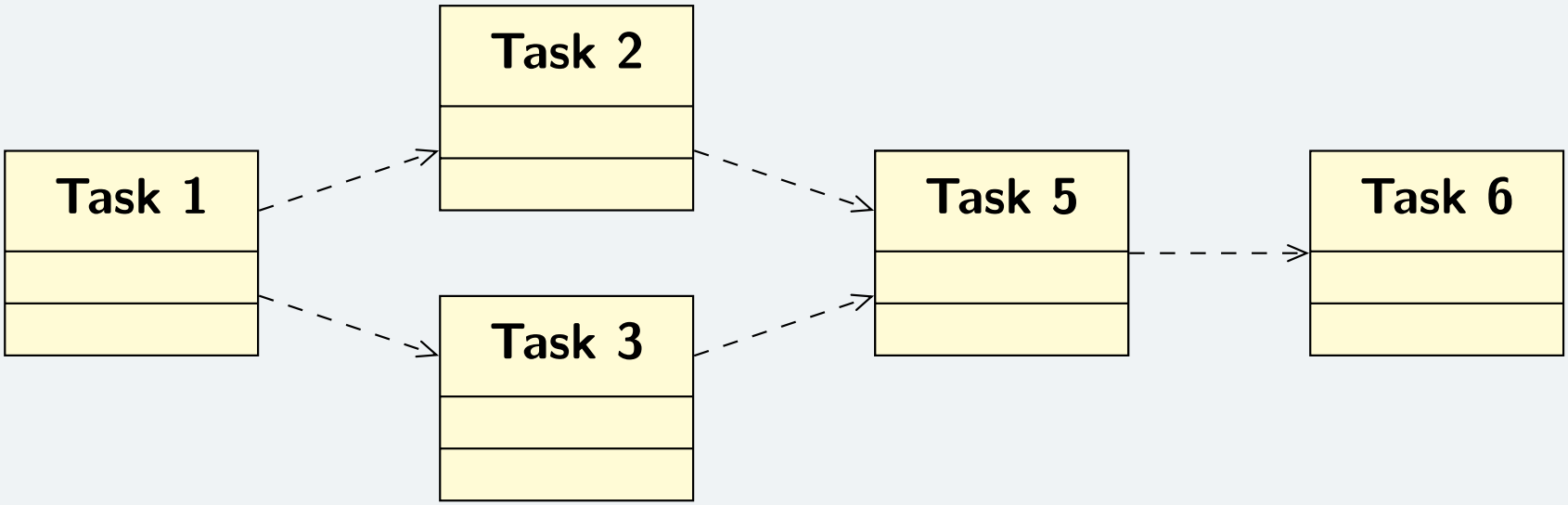


A Module: Content unit

M_k: **Module**	
Tasks	Evaluations
T_1 : Task with label 1	E_1 evaluation with label 1, value 1
T_2 : Task with label 2	E_2 evaluation with label 2, value 2
T_3 : Task with label 3	E_3 evaluation with label 3, value 3
...	...
T_n : Task with label n	E_n evaluation with label m, value m

- Say a task $T1$ of type $< Text >$ has total reading time of 4 minutes. In order to mark this task as `complete` for any user $U1$, the time spent on the task by the particular user must be greater than 3 minutes.

Knowledge map - Task dependencies



Patient profiling - 1/3

Completed Modules

- M1
- M2
- M3
- M5
- M7

Completed Tasks

- T1
- T2
- T3
- T5
- T9

Completed Exercise

- Completed Exercise : E1, E4, E5
- Reading
  - (M1, T1) Time spent reading: 2.9 minutes
- Listening
  - (M2, T3) Time spent listening: 31 minutes
  - (M3, T1) Time spent listening: 3 minutes
- Watching
  - (M6, T1) Time spent watching: 13.9 minutes
  - (M9, T2) Time spent watching: 33 minutes

Patient profiling 2/3

- Lingual preferences (No/En/Ne ...)
- Temporal preferences (Analyzed from login behavior/interaction behavior)
  - Most active days.
  - Most active time of the days.
  - Most active month.
- Platform preferences
  - Device used for intervention (Mobile/Web)
  - Operating system used
- Content/content format preferences
  - Most active content format (Text/Audio/Video/Slides)
  - Most favourites content/modules/tasks
  - Most preferred content category / tags

Patient profiling - user preferences 3/3

- User motivations (M_1, M_2, ... , M_n)
- User history
  - Previous diagnosis/symptoms
  - Previous interventions
- User level
  - Content reading score
  - Video watching score
  - Audio listening score
  - Exercise score
  - Overall score

User model: U

Case
ID: Integer isComplete: Boolean completionDate: Date isActive: Boolean

Module
ID: Integer isComplete: Boolean completionDate: Date isActive: Boolean

Task
ID: Integer isComplete: Boolean completionDate: Date score: Integer isActive: Boolean

Exercise
ID: Integer isComplete: Boolean completionDate: Date score: Integer isActive: Boolean

Motivations
name: String description: String slug: String

Basic
name: String email: String username: String password: String overallScore: Integer

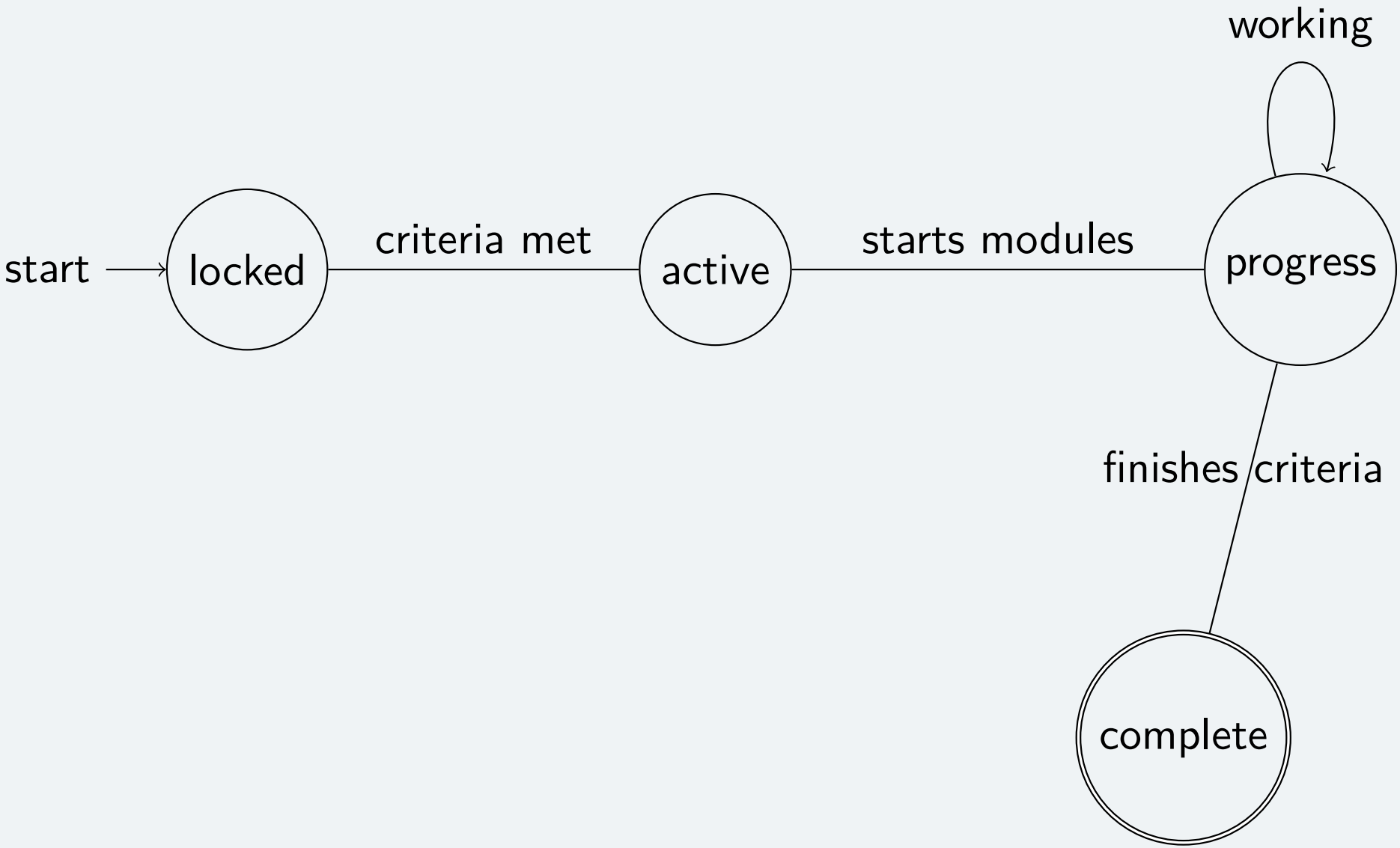
Contextual adaptation rules

1. If user[case, module, task, exercise, motivation] is empty, follow the module dependency learning map. Activate the base (lowest level) modules.
2. For each interaction of the user, store their activities, store cumulative their scores.
3. Create state diagram to activate module based on their scores, motivations, preferences.

States

1. Case [active, progress, complete, locked]
2. Module [active, progress, complete, locked]
3. Task [active, progress, complete, locked]
4. User [active, authenticated, unauthorized, unauthenticated, inactive, dropout]

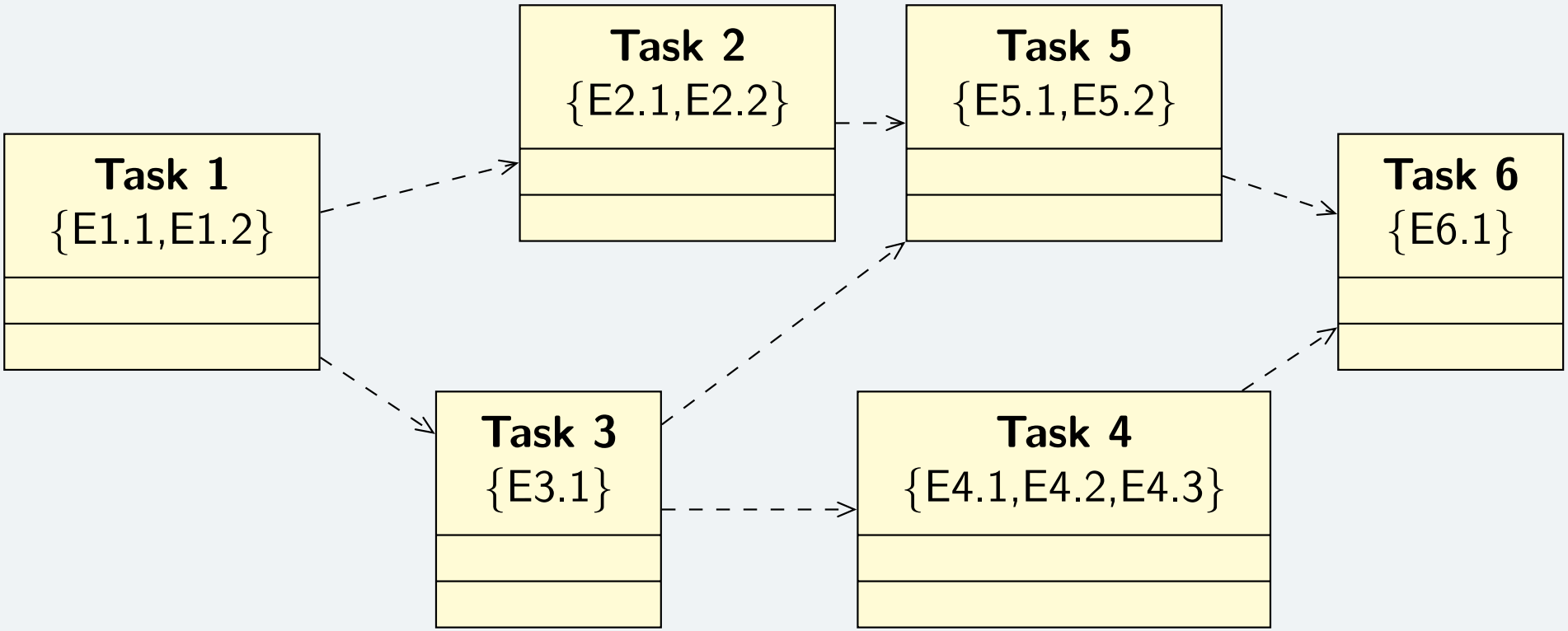
States - [Case, module, Task]



States - [Case, module, Task] - conditions

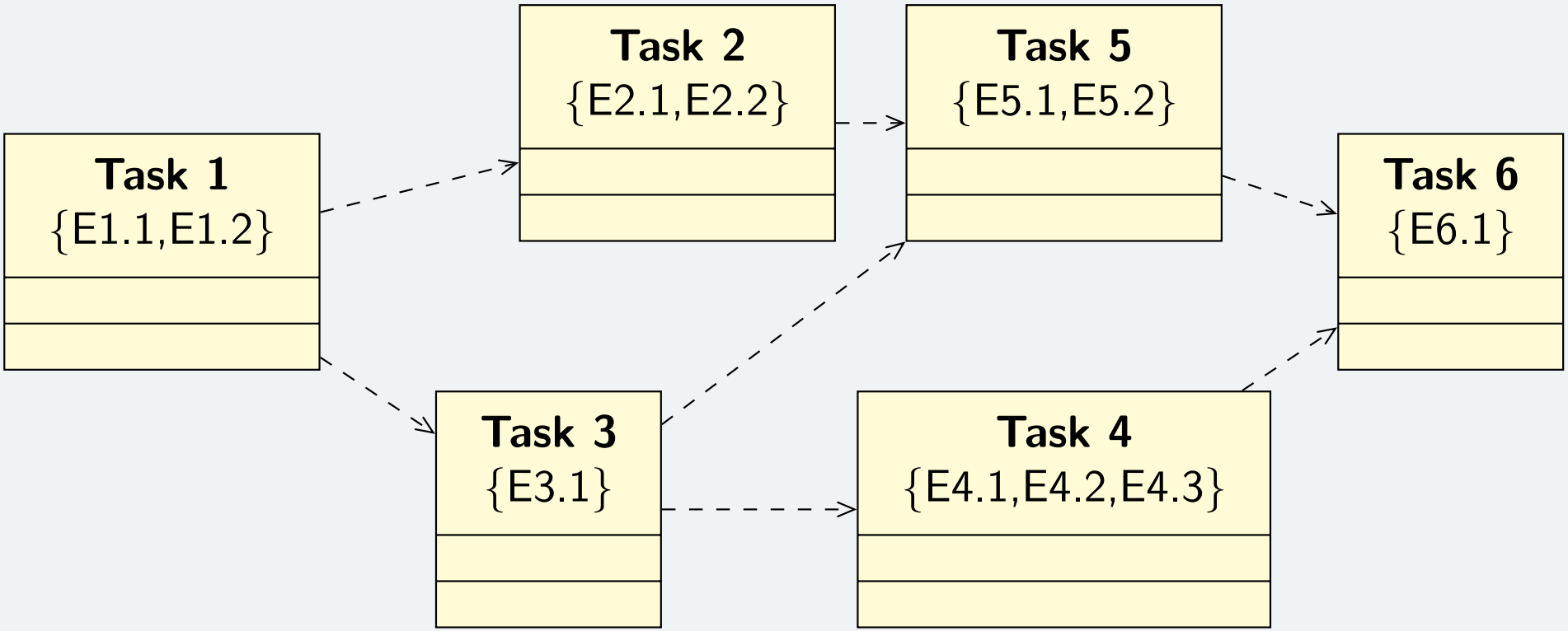
1. **locked**: An entity is locked if its evaluation criteria is not fulfilled or a dependent entity not completed.
2. **active**: An entity is active, as soon as the evaluation criteria is matched or its dependent entity is completed.
3. **progress**: An entity is in progress, if the entity is active but all the evaluation criteria has not completed.
4. **complete**: An active entity is marked complete if, all its evaluation criteria is finished.

Knowledge map - Content adaptation



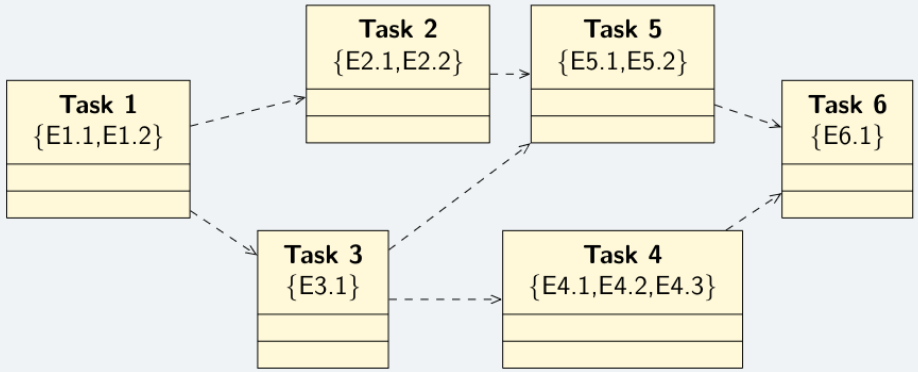
1. Task 1: [active]
2. Say user U: has started or has finished `E1.1`. Then, task 1 is marked [progress] .
3. Tasks [2,3,5,6,4] are [locked].

Knowledge map - - Content adaptation - 2



1. Task 1 $[\ \texttt{E1.1}:\checkmark, \texttt{E1.2}:\checkmark\ ] \Rightarrow Task1 = [complete]$.
2. Then, task [2,3] is marked [active].
3. Tasks [5,6,4] are [locked].

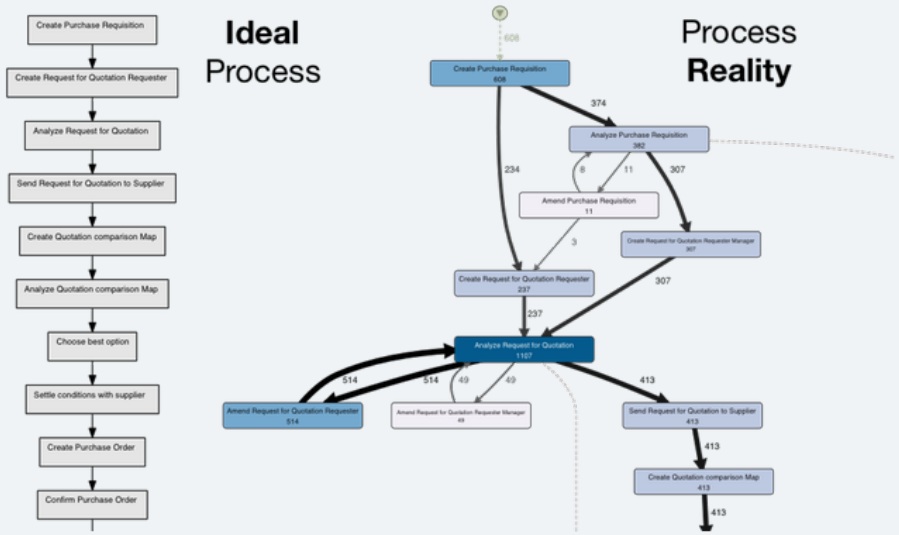
Alert/Notification Adaptation



Task	Evaluation	Completion	Notifications
Task 1	E1.1 E1.2	✓ ✓	▪ Task 1 completion alert & ▪ [T2, T3] is active
Task 2	E2.1 E2.2	✓ ✓	▪ Task 2 completion alert
Task 3	E3.1	✓	▪ Task 3 completion alert & ▪ [T4, T5] is active
...	...	...	...
Task 6	E6.1	✓	▪ Task 6 completion alert ▪ Module 1 completion SMS.

Content format Adaptation

Let us assume a Task $\mathtt{T}$ can be represented by audio $\mathtt{a}$, video $\mathtt{v}$, slides $\mathtt{s}$. Here we assume, each format preserves the semantic meaning of the original format.



- Process mining can reveal which format of content, a particular user interacts the most.
- If a user spends more time, if the content is presented in $\mathtt{v}$: video, then the system tries to present the next task in the video format.

Goal based Adaptation

Let us assume there are two kinds of goals: a) therapists goals $TG_1, TG_2, ..., TG_m$, b) patients goals $PG_1, PG_2, ..., PG_n$. Each type of goals can be specified using pre-defined **keywords**.

- TG_1: Increase the patient's concentration (G_1).
- TG_2: Provide intervention suitable for patient. (G_2).
- ...
- PG_1: Increase my concentration power (G_x).
- PG_2: Better sleeping. (G_{x+1}).

One way to adapt is making particular modules active for user U based on the goal.

$$\forall u : U \text{ has goal } \{G1, G2, G_x\} \implies M1.u.isActive = true \quad (8)$$

Adaptation based on user level

1. Let each Task (T_i) has a complexity level T_{icl} associated with it.
2. Let for any particular user U, the content reading level score is C_{score}, video watching score is V_{score}, audio listening score is A_{score} and exercise score is E_{score}. Then,

$$T_{overall} = C_{score} + V_{score} + A_{score} + E_{score} \tag{9}$$

Then, we can use simple rule engine to adapt content.

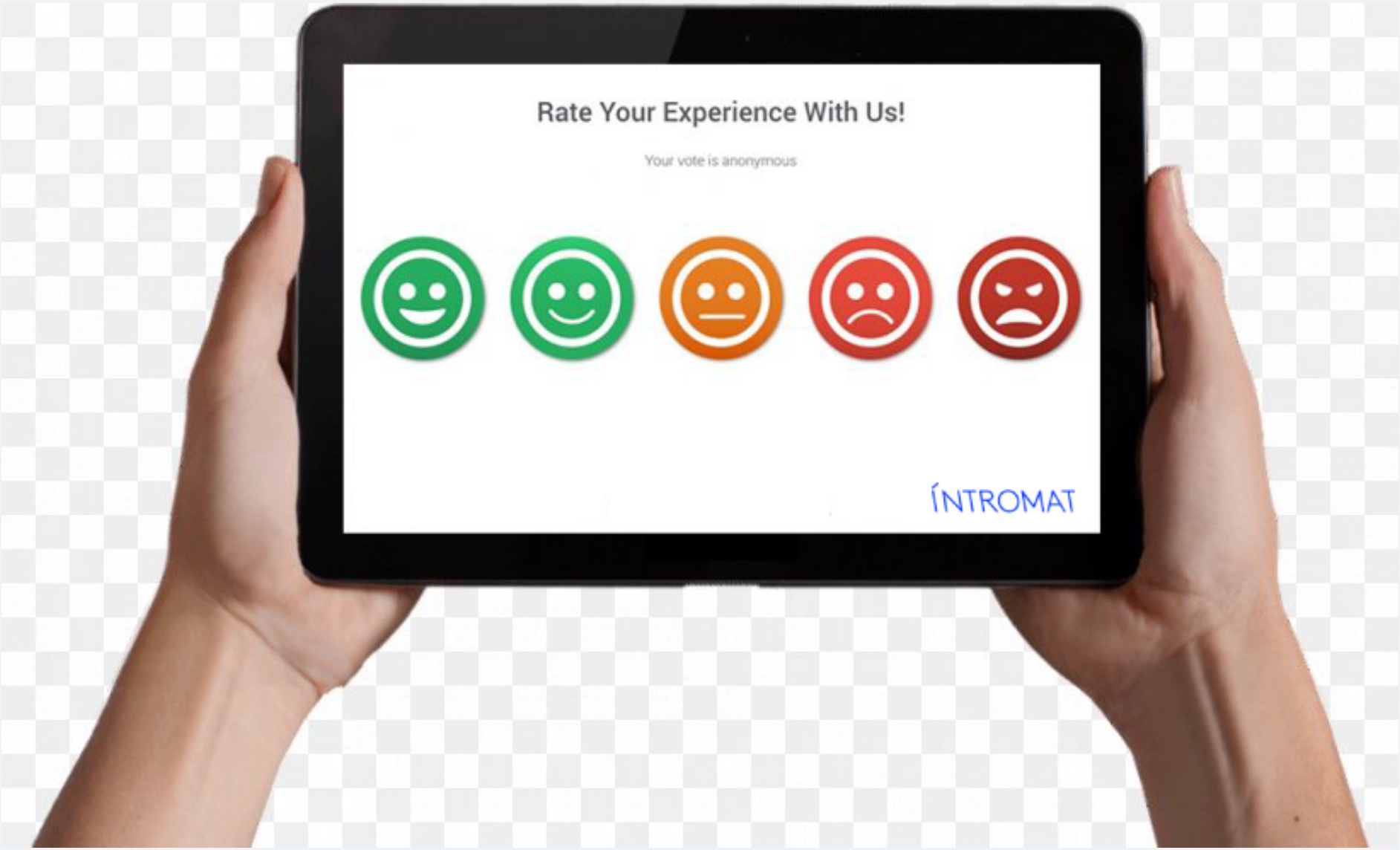
$$T_{overall} \geqslant 0 \wedge T_{overall} \leqslant 40 \Rightarrow T_{1cl} \tag{10}$$
$$T_{overall} \geqslant 41 \wedge T_{overall} \leqslant 80 \Rightarrow T_{2cl} \tag{11}$$
$$T_{overall} \geqslant 81 \wedge T_{overall} \leqslant 120 \Rightarrow T_{3cl} \tag{12}$$
$$\tag{13}$$

Here, we assume the threshold for each score should be decided empirically or determined by the therapists who designs the intervention.

Future work and Summary

1. We need Domain-Specific Language (DSL) for creation of adaptive IDPT system.
2. We also need better dashboard tools that help therapists and other medical practitioners to comprehend the patients status better and adapt their interventions based on their engagement with the interventions.

Thanks!


Rate Your Experience With Us!
Your vote is anonymous
INTROMAT

References I

WHO.
World health report, 2018.

European Union.
Improving the mental health of the population: Towards a strategy on mental health for european Union, Technical report.
Health & Consumer Protection Directorate General, 2005.

European Union.
Improving the mental health of the population: Towards a strategy on mental health for european Union, Technical report.
Health & Consumer Protection Directorate General, 2008.

Mona Sommer.
Mental health among youth in norway.
Norden, 69:7, 06 2016.

Angela Sweeney, Steve Gillard, Til Wykes, and Diana Rose.
The role of fear in mental health service users' experiences: a qualitative exploration.
Social Psychiatry and Psychiatric Epidemiology, 2015.

Aaron T. Beck and Brad A. Alford.
Depression causes and treatment.
University of Pennsylvania, 1967.

Keith S. Dobson.
HANDBOOK OF COGNITIVE- BEHAVIORAL THERAPIES THIRD EDITION.
The Guilford Press, London, 2010.

References II

Colin D. Mathers and Dejan Loncar.

Projections of global mortality and burden of disease from 2002 to 2030.
PLoS Medicine, 2006.

et al Goss, Stephen.

Technology in Mental Health.
Charles C. Thomas, Publisher, Ltd, 2016.

National Health Expenditure Accounts (NHEA).

National health expenditure data, 2017.

David Bloom and et. al.

The global economic burden of noncommunicable diseases.
Pgda working papers, Program on the Global Demography of Aging, 2012.

ISO/IEC 25000, ISO/IEC JTC 1/SC 7.

ISO/IEC 25000:2014 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE, 2014.