

# MitPlan 2.0: Enhanced Support for Multi-Morbid Patient Management Using Planning



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# Outline

- Motivation
- MitPlan 2.0
- Illustrative Example
- Discussion



# Motivation

- Several approaches to the problem of *how to mitigate adverse interactions resulting from application of multiple CPGs* (Bottrighi et al. (2019), Terenziani et al. (2019), Jafarpour et al. (2019), Fdez-Olivarez et al. (2019), Kogan et al. (2020))
- MitPlan 1.0: Michalowski et al. (2021) combined algorithmic and planning approaches
- MitPlan 2.0: a fully planning based framework achieved via an enriched encoding of the problem



# Planning Approach

- Mitigation as a planning problem

Find an optimal sequence of actions from initial to goal state, subject to preconditions and effects, and with respect to relevant metrics

- How to represent and encode the planning problem to find the optimal treatment plan?

- Domain and problem instance, PDDL code, OPTIC planner

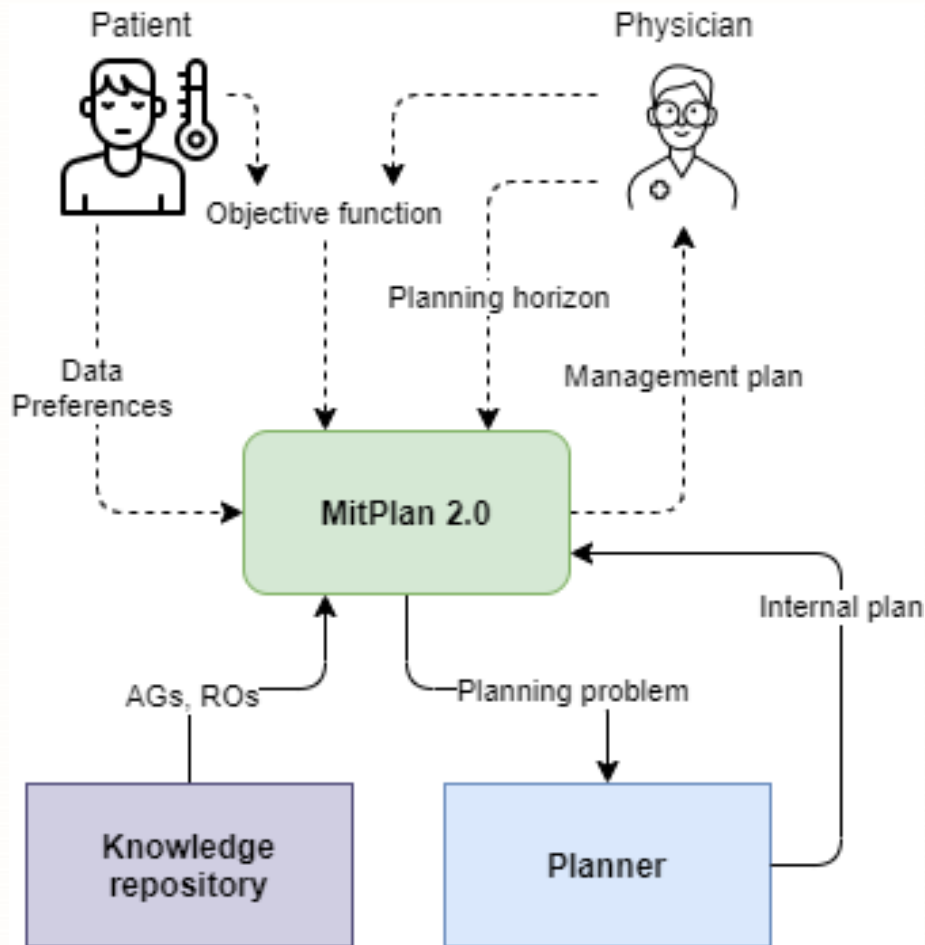


# MitPlan 2.0 Features

- CPGs as actionable graphs (AGs): action, decision, goal nodes
- Patient data, preferences, planning horizon
- Revision operators model adverse interactions
- Extended AG
  - Hybrid model consisting of two components
  - AG expanded to include actions required by revision operators
  - Triggering sequence to identify the presence of adverse interactions
- Objective function
  - Cost/Penalty and other metrics



# MitPlan 2.0 Overview



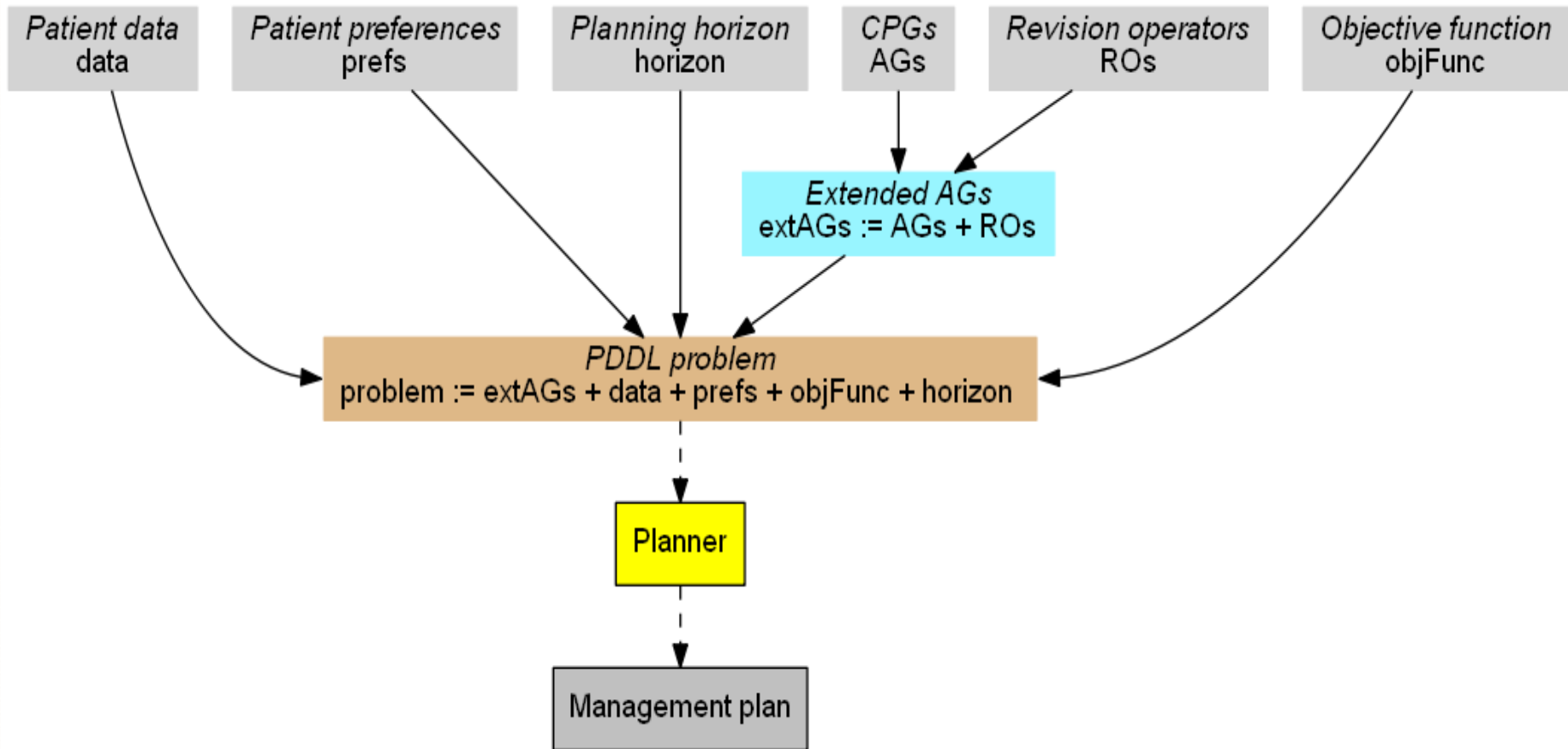
**input** : data: patient data, prefs: patient preferences, horizon: planning horizon, objFunc: objective function for plan optimization

**output**: managementPlan: management plan

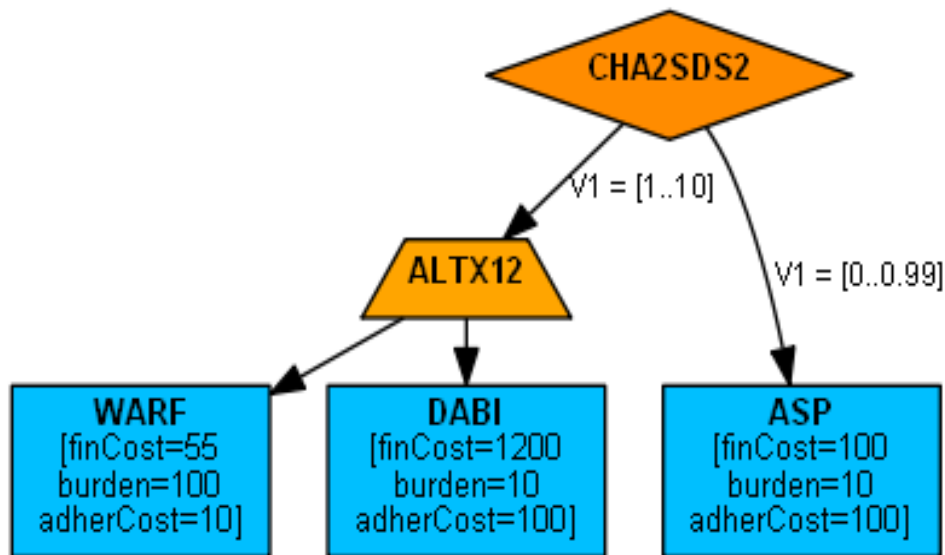
- 1 AGs := select from **knowledge repository** extended AGs representing CPGs used to manage the patient
- 2 ROs := select from **knowledge repository** revision operators possibly applicable to AGs
- 3 problem := create a planning problem using AGs, ROs, data, prefs, horizon and objFunc
- 4 internalPlan := apply **planner** to problem to find an optimal plan
- 5 managementPlan := post-process internalPlan to management plan
- 6 return managementPlan



# MitPlan 2.0 Execution



# Illustrative Example: Using Multiple Metrics



- Metrics used: financial cost, patient's burden, nonadherence likelihood





# Illustrative Example

**Financial cost** only: Warfarin preferred

```
0.000: (makefirstdecision d cha2sds2 altx12) [0.000]
0.001: (makedecisiontonode d altx12 warf) [0.000]
0.002: (takeactiontogoal d warf g) [0.000]
0.003: (finalgoalreached d g) [0.001]
```

**Patient's burden** only: Dabigatram preferred

**Nonadherence likelihood** only: Warfarin preferred

**All the above together:** Dabigatram preferred

Objective function:  $Min [0.2*cost + 0.6*burden + 0.2*nonadherence]$

```
0.000: (makefirstdecision d cha2sds2 altx12) [0.000]
0.001: (makedecisiontonode d altx12 dabi) [0.000]
0.002: (takeactiontogoal d dabi g) [0.000]
0.003: (finalgoalreached d g) [0.001]
```



# Discussion

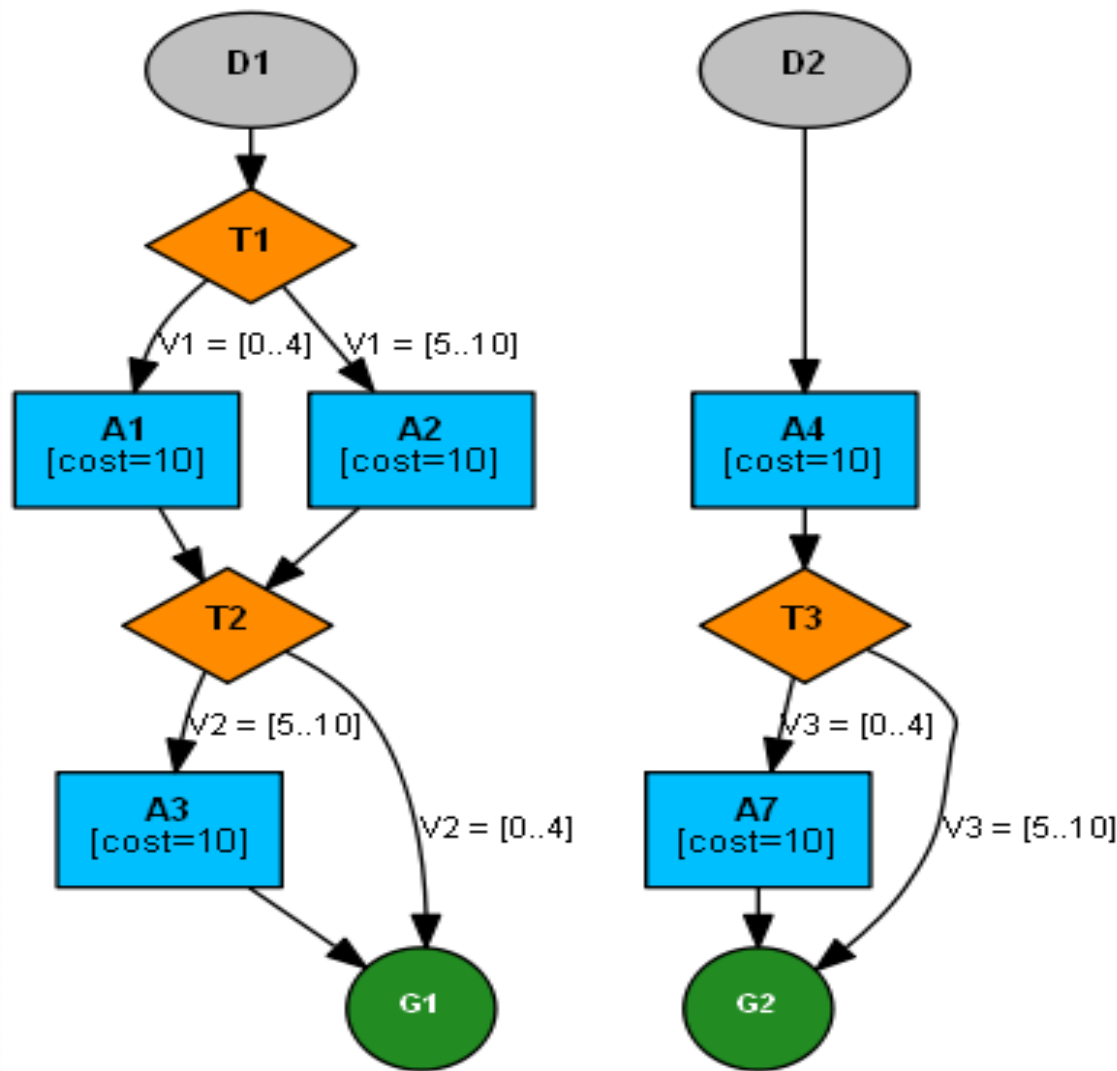
- A fully planning based approach, unified and flexible representation, a disease agnostic approach
- Ongoing and future work to consider the use of hard and soft constraints, partial satisfaction of goals, and stochasticity with respect to test outcomes











<https://www.mobiledss.uottawa.ca>

*Thank you!*

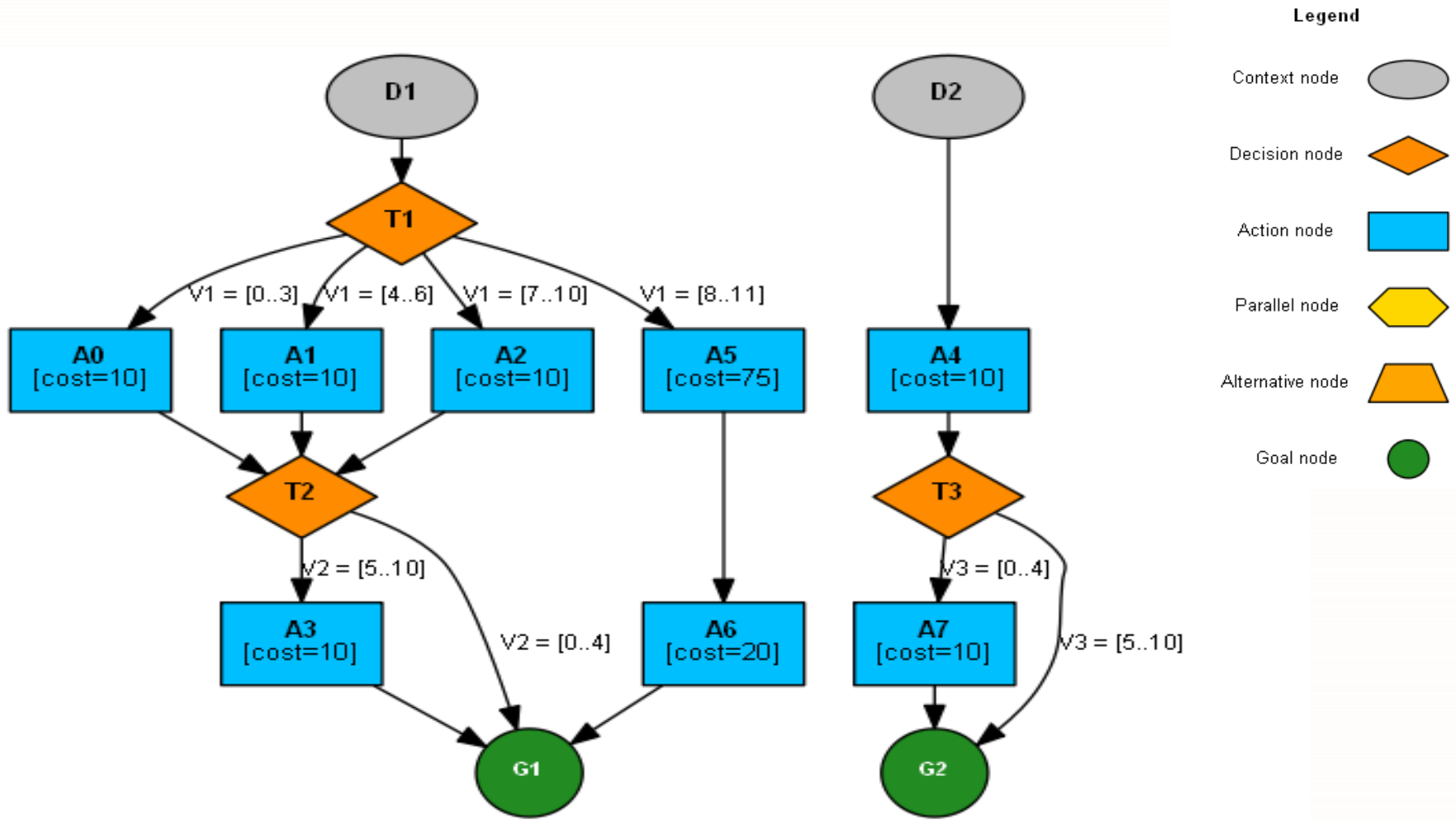


### Legend

Context node	
Decision node	
Action node	
Parallel node	
Alternative node	
Goal node	

### Revision operators:

1. if A2 and A7, then replace A7 with *newAction* [cost=100]
2. if A2 and A7, then replace A7 with *newAction2* [cost=50]



**Revision operators:**

1. if A2 and A7, then replace A7 with *newAction* [cost=100]
2. if A0 and A7, then replace A7 with *newAction0*[cost=100]