

COURSE "AUTOMATED PLANNING: THEORY AND PRACTICE"

CHAPTER LAB 02: HIERARCHICAL TASK NETWORKS

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M.S. Course: Artificial Intelligence Systems (LM)
A.A.: 2025-2026
Where: DISI, University of Trento
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Last updated: Sunday 2nd November, 2025

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THE HDDL LANGUAGE

- The *Hierarchical Domain Description Language* (HDDL) Höller et al. [11] is an extension of PDDL 2.1 Fox and Long [4].
- It is the standard language used for the International Planning Competition (IPC) 2020 on Hierarchical Planning.
 - <http://ipc2020.hierarchical-task.net>
<http://gki.informatik.uni-freiburg.de/competition/>
- History
 - SHOP2 Nau et al. [15]
 - ANML Smith et al. [19]
 - HTN-PDDL Gonzalez-Ferrer et al. [8], González-Ferrer et al. [9]
 - HATP de Silva et al. [2], Lallement et al. [12]
 - HPDDL Alford et al. [1]
 - GTOHP Ramoul et al. [17]

HPDDL: TYPES AND PREDICATES

- We use a simple transportation domain
- They are the same as in PDDL

```
(define (domain transport)
  (:types
    package - locatable
    capacity_number - object
    location - object
    target - object
    vehicle - locatable
    locatable - object
  )
  (:predicates
    (road ?arg0 - location ?arg1 - location)
    (at ?arg0 - locatable ?arg1 - location)
    (in ?arg0 - package ?arg1 - vehicle)
    (capacity ?arg0 - vehicle ?arg1 - capacity_number)
    (capacity_pred ?arg0 - capacity_number ?arg1 - capacity_number)
  )
  ...
)
```

HPDDL: PRIMITIVE TASKS (AKA ACTIONS)

- They are the same as in PDDL

```
(:action drive
:parameters (?v - vehicle ?l1 - location ?l2 - location)
:precondition (and (at ?v ?l1) (road ?l1 ?l2) )
:effect (and (not (at ?v ?l1)) (at ?v ?l2) ) )

(:action noop
:parameters (?v - vehicle ?l2 - location)
:precondition (and (at ?v ?l2) ) :effect ( ) )

(:action pick_up
:parameters (?v - vehicle ?l - location ?p - package
             ?s1 - capacity_number ?s2 - capacity_number)
:precondition (and (at ?v ?l) (at ?p ?l)
                  (capacity_pred ?s1 ?s2) (capacity ?v ?s2) )
:effect (and (not (at ?p ?l)) (in ?p ?v) (capacity ?v ?s1)
            (not (capacity ?v ?s2)) ) )

(:action drop
:parameters (?v - vehicle ?l - location ?p - package
             ?s1 - capacity_number ?s2 - capacity_number)
:precondition (and (at ?v ?l) (in ?p ?v)
                  (capacity_pred ?s1 ?s2) (capacity ?v ?s1) )
:effect (and (not (in ?p ?v)) (at ?p ?l) (capacity ?v ?s2)
            (not (capacity ?v ?s1)) ) )
```

HPDDL: (ABSTRACT) TASKS

- In this domain: deliver, get_to, load, unload

```
(:task deliver
:parameters (?p - package ?l - location)
:precondition ()
:effect ()
)

(:task get_to
:parameters (?v - vehicle ?l - location)
:precondition () ; No preconditions, but in principle possible
:effect () ; No effects, but in principle possible to specify them
)

(:task load
:parameters (?v - vehicle ?l - location ?p - package)
:precondition ()
:effect ()
)

(:task unload
:parameters (?v - vehicle ?l - location ?p - package)
:precondition ()
:effect ()
)
```

HPDDL: METHODS

- In this domain: m_unload, m_load, m_i_am_here, m_drive_to, ...

```
(:method m_unload
:parameters (?l - location ?p - package
             ?s1 - capacity_number ?s2 - capacity_number ?v - vehicle)
:task (unload ?v ?l ?p)
:subtasks (and (task0 (drop ?v ?l ?p ?s1 ?s2)) ) )

(:method m_load
:parameters (?l - location ?p - package
             ?s1 - capacity_number ?s2 - capacity_number ?v - vehicle)
:task (load ?v ?l ?p)
:subtasks (and (task0 (pick_up ?v ?l ?p ?s1 ?s2)) ) )

(:method m_i_am_there
:parameters (?l - location ?v - vehicle)
:task (get_to ?v ?l)
:subtasks (and (task0 (noop ?v ?l)) ) )

(:method m_drive_to
:parameters (?l1 - location ?l2 - location ?v - vehicle)
:task (get_to ?v ?l2)
:constraints (not (= ?l1 ?l2)) ; additional to preconditions
:subtasks (and (task0 (drive ?v ?l1 ?l2)) ) )
```

HPDDL: METHODS (CONT.)

- In this domain: ... m_drive_to_via, m_deliver

```
(:method m_drive_to_via
:parameters (?l2 - location ?l3 - location ?v - vehicle)
:task (get_to ?v ?l3)
:subtasks (and (task0 (get_to ?v ?l2))
               (task1 (drive ?v ?l2 ?l3)) )
:ordering (and (task0 < task1) ) )

(:method m_deliver
:parameters (?l1 - location ?l2 - location ?p - package ?v - vehicle)
:task (deliver ?p ?l2)
:subtasks (and (task0 (get_to ?v ?l1))
               (task1 (load ?v ?l1 ?p))
               (task2 (get_to ?v ?l2))
               (task3 (unload ?v ?l2 ?p)) )
:ordering (and (task0 < task1)
               (task1 < task2)
               (task2 < task3) ) )
```


HPDDL: PROBLEM

- Similar to PDDL

```
(define (problem pfile01)
  (:domain transport)
  (:objects
    package_0 package_1 - package
    capacity_0 capacity_1 - capacity_number
    city_loc_0 city_loc_1 city_loc_2 - location
    truck_0 - vehicle )
  (:htn
    :parameters ()
    :subtasks (and (task0 (deliver package_0 city_loc_0))
                   (task1 (deliver package_1 city_loc_2)) )
    :ordering (and (task0 < task1) ) )
  (:init
    (capacity_predecessor capacity_0 capacity_1)
    (road city_loc_0 city_loc_1) (road city_loc_1 city_loc_0)
    (road city_loc_1 city_loc_2) (road city_loc_2 city_loc_1)
    (at package_0 city_loc_1) (at package_1 city_loc_1)
    (at truck_0 city_loc_2) (capacity truck_0 capacity_1)
  )
)
```

THE PANDA HTN PLANNER

- The PANDA planning system allows to solve different kinds of planning problems. In particular hierarchical task network (HTN) problems defined in HDDL.
 - Original web page:
<https://www.uni-ulm.de/en/in/ki/research/software/panda/panda-planning-system/>
 - Download Java JAR file:
https://www.uni-ulm.de/fileadmin/website_uni_ulm/iui.inst.090/panda/PANDA.jar
<https://didatticaonline.unitn.it/dol/course/view.php?id=39242>
- Requirements: Java VM
 - `sudo apt-get install openjdk-14-jre openjdk-14-jre-headless`
- Usage: `java -jar -parser hddl domain-file problem-file`
 - Example:
`java -jar ../PANDA.jar -parser hddl transport-htn.hddl transport-p01.hddl`
 - Full set of options:
`java -jar ../PANDA.jar -help`
`java -jar ../PANDA.jar -help [OPTION or KEY] e.g.`
`java -jar ../PANDA.jar -help -parser for help on the -parser option`

THE TRANSPORTER EXAMPLE

- The Domain:
{ Domains/Transporter/transport-htn.hddl }
- The first problem:
{ Domains/Transporter/p01.hddl }
- The second problem:
{ Domains/Transporter/p02.hddl }
- The third problem:
{ Domains/Transporter/p03.hddl }

THE ROVER EXAMPLE

- The Domain:
{ Domains/Rover/rover-domain.hddl }
- The first problem:
{ Domains/Rover/pfile1.hddl }
- The second problem:
{ Domains/Rover/pfile5.hddl }
- The third problem:
{ Domains/Rover/pfile15.hddl }

THE SATELLITE EXAMPLE

- The Domain:
{ Domains/Satellite/satellite.hddl }
- The first problem:
{ Domains/Satellite/1obs-2sat-1mod.hddl }
- The second problem:
{ Domains/Satellite/2obs-2sat-2mod.hddl }
- The third problem:
{ Domains/Satellite/3obs-3sat-2mod.hddl }

THE WOOD WORKING EXAMPLE

- The Domain:
{ Domains/Woodworking/woodworking.hddl }
- The first problem:
{ Domains/Woodworking/01--p01-complete.hddl }
- The second problem:
{ Domains/Woodworking/05--p02-part4.hddl }
- The third problem:
{ Domains/Woodworking/06--p02-complete.hddl }

OTHER HTN PLANNERS (FROM IPC 2020 ON HTN)

- Tools

- **Name** (hyperlink to singularity image)

- LiloTane by Schreiber [18]
 - SIADEx by Fernandez-Olivares et al. [3]
 - HyperTensioN by Magnaguagno et al. [14]
 - PDDL4J-TO and PDDL4J-PO by Pellier and Fiorino [16]
 - pyHiPOP by Lesire and Albore [13]

- Usage

- `singularity run singularityimage.sif domain.hddl problem.hddl`

- Example (For LiloTane):

- `singularity run IPC2020-competitor-1n.sif domain.hddl problem.hddl`

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