

# РОССИЙСКИЙ УНИВЕРСИТЕТ ДРУЖБЫ НАРОДОВ

Факультет физико-математических и естественных наук

Кафедра прикладной информатики и теории вероятностей

## ОТЧЕТ

### ПО ЛАБОРАТОРНОЙ РАБОТЕ № 2

дисциплина: *Интеллектуальные системы*

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Группа: НПИбд-01-21

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МОСКВА

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## **Введение.**

### **Цель работы.**

Изучение основ работы со стандартным языком планирования PDDL (Planning Domain Definition Language) и выполнение практического задания с его применением.

### **Задачи.**

1. Описать домен, который должен в себя включать:
  - 6 типов объектов;
  - 6 предикатов;
  - 6 действий.
2. Составить описание каждого предиката и действия.
3. Придумать 3 задачи(проблемы) для данного домена.
4. Протестировать работу домена с каждой задачей.

## 1 задание.

Опишем домен для решения будущих задач(рис.1):

```
1 (define (domain Nenuphars)
2
3   (:requirements :strips :typing)
4
5   (:types
6     place physobj player - object
7     obstacle equipable - physobj
8     nenuphar - place
9     bonus swampflower - equipable
10    thorns - obstacle
11    scissors fishrod - bonus
12  )
13
14  (:predicates
15    (in-pl ?pl - player ?loc - nenuphar)
16    (is-obs ?obs - obstacle ?loc - nenuphar)
17    (at ?eq - equipable ?loc - nenuphar)
18    (keep-flower)
19    (keep-scissors)
20    (keep-fishrod)
21    (connected ?con1 - nenuphar ?con2 - nenuphar)
22  )
23
24  (:action CutThorns
25    :parameters (?pl - player ?loc-from - nenuphar ?loc-to - nenuphar ?obs - thorns)
26    :precondition (and (or (connected ?loc-from ?loc-to) (connected ?loc-to ?loc-from)) (in-pl ?pl ?loc-from) (is-obs ?obs ?loc-to) (keep-scissors))
27    :effect (not (is-obs ?obs ?loc-to))
28  )
29
30  (:action MakeASuperJump
31    :parameters (?pl - player ?loc-from - nenuphar ?loc-to - nenuphar ?obs - thorns)
32    :precondition (and (in-pl ?pl ?loc-from) (not (is-obs ?obs ?loc-to)) (keep-fishrod))
33    :effect (and (not (in-pl ?pl ?loc-from)) (in-pl ?pl ?loc-to))
34  )
35
36  (:action JumpToAnotherNenuphar
37    :parameters (?pl - player ?loc-from - nenuphar ?loc-to - nenuphar ?obs - thorns)
38    :precondition (and (or (connected ?loc-from ?loc-to) (connected ?loc-to ?loc-from)) (in-pl ?pl ?loc-from) (not (is-obs ?obs ?loc-to)))
39    :effect (and (not (in-pl ?pl ?loc-from)) (in-pl ?pl ?loc-to))
40  )
41
42  (:action TakesWampFlower
43    :parameters (?pl - player ?loc - nenuphar ?eq - swampflower ?obs - thorns)
44    :precondition (and (in-pl ?pl ?loc) (not (keep-flower)) (at ?eq ?loc) (not (is-obs ?obs ?loc)))
45    :effect (and (keep-flower) (not (at ?eq ?loc)))
46  )
47
48  (:action PutSwampFlower
49    :parameters (?pl - player ?loc - nenuphar ?eq - swampflower ?obs - thorns)
50    :precondition (and (in-pl ?pl ?loc) (keep-flower) (not (at ?eq ?loc)) (not (is-obs ?obs ?loc)))
51    :effect (and (not (keep-flower)) (at ?eq ?loc))
52  )
53
54  (:action EquipScissors
55    :parameters (?pl - player ?loc - nenuphar ?eq - scissors)
56    :precondition (and (in-pl ?pl ?loc) (at ?eq ?loc))
57    :effect (and (not (at ?eq ?loc)) (keep-scissors) (not (keep-fishrod)))
58  )
59
60  (:action EquipFishrod
61    :parameters (?pl - player ?loc - nenuphar ?eq - fishrod)
62    :precondition (and (in-pl ?pl ?loc) (at ?eq ?loc))
63    :effect (and (not (at ?eq ?loc)) (keep-fishrod) (not (keep-scissors)))
64  )
65 )
66
```

РИС.1

## 2 задание.

Составим описание для каждого предиката и действия в домене:

(1):**CutThorns (pl, loc-from, loc-to, obs)** – срезание шипов, находящихся на кувшинке **loc-to**, когда игрок **pl** находится на **loc-from**, т.е. собирается совершить переход на **loc-to**. Если на **loc-to** есть шипы **obs**, у игрока есть ножницы (**keep-scissors**) и кувшинки **loc-from** и **loc-to** связаны, то переход на **loc-to** с ЭТОГО момента ВОЗМОЖЕН.

Preconditions: (connected(loc-from, loc-to)∨connected(loc-to, loc-from))∧in-pl(pl, loc-from)∧is-obs(obs, loc-to)∧(keep-scissors)

Effects: NOT is-obs(obs, loc-to)

**(2):MakeASuperJump (pl, loc-from, loc-to, obs)** – совершение супер-прыжка игроком **pl** с кувшинки **loc-from** на любую кувшинку **loc-to** без шипов **obs** при наличии удочки (**keep-fishrod**).

Preconditions:  $\text{in-pl}(\text{pl}, \text{loc-from}) \wedge \text{NOT is-obs}(\text{obs}, \text{loc-to}) \wedge (\text{keep-fishrod})$

Effects:  $\text{NOT in-pl}(\text{pl}, \text{loc-from}) \wedge \text{in-pl}(\text{pl}, \text{loc-to})$

**(3):JumpToAnotherNenuphar (pl, loc-from, loc-to, obs)** – совершение прыжка игроком **pl** с кувшинки **loc-from** на кувшинку **loc-to** без шипов **obs** при условии, что **loc-from** и **loc-to** связаны.

Preconditions:  $(\text{connected}(\text{loc-from}, \text{loc-to}) \vee \text{connected}(\text{loc-to}, \text{loc-from})) \wedge \text{in-pl}(\text{pl}, \text{loc-from}) \wedge \text{NOT is-obs}(\text{obs}, \text{loc-to})$

Effects:  $\text{NOT in-pl}(\text{pl}, \text{loc-from}) \wedge \text{in-pl}(\text{pl}, \text{loc-to})$

**(4):TakeSwampFlower (pl, loc, eq, obs)** – подборание цветка **eq** игроком **pl** с кувшинки **loc** при условии, что на ней нет шипов **obs** и игрок **pl** уже не несёт цветок (**keep-flower**).

Preconditions:  $\text{in-pl}(\text{pl}, \text{loc}) \wedge \text{NOT}(\text{keep-flower}) \wedge \text{at}(\text{eq}, \text{loc}) \wedge \text{NOT is-obs}(\text{obs}, \text{loc-to})$

Effects:  $(\text{keep-flower}) \wedge \text{NOT at}(\text{eq}, \text{loc})$

**(5):PutSwampFlower (pl, loc, eq, obs)** – сохранение цветка **eq** игроком **pl** на кувшинке **loc** при условии, что на ней нет шипов **obs** и игрок **pl** уже несёт цветок (**keep-flower**).

Preconditions:  $\text{in-pl}(\text{pl}, \text{loc}) \wedge (\text{keep-flower}) \wedge \text{NOT at}(\text{eq}, \text{loc}) \wedge \text{NOT is-obs}(\text{obs}, \text{loc-to})$

Effects:  $\text{NOT}(\text{keep-flower}) \wedge \text{at}(\text{eq}, \text{loc})$

**(6):EquipScissors (pl, loc, eq)** – взятие подбираемого предмета **eq**, ножниц (**keep-scissors**), на кувшинке **loc** игроком **pl**. Если у игрока **pl** уже есть удочка (**keep-fishrod**), то он её утрачивает.

Preconditions:  $\text{in-pl}(\text{pl}, \text{loc}) \wedge \text{at}(\text{eq}, \text{loc})$

Effects:  $\text{NOT at}(\text{eq}, \text{loc}) \wedge (\text{keep-scissors}) \wedge \text{NOT}(\text{keep-fishrod})$

**(7):EquipFishrod (pl, loc, eq)** – взятие подбираемого предмета **eq** удочки (**keep-fishrod**) на кувшинке **loc** игроком **pl**. Если у игрока **pl** уже есть ножницы (**keep-scissors**), то он их утрачивает.

Preconditions:  $\text{in-pl}(\text{pl}, \text{loc}) \wedge \text{at}(\text{eq}, \text{loc})$

Effects:  $\text{NOT at}(\text{eq}, \text{loc}) \wedge (\text{keep-fishrod}) \wedge \text{NOT}(\text{keep-scissors})$

### 3 задание.

Разработаем 3 задачи для данного домена (рис.2.1, рис.2.2, рис.3.1, рис.3.2, рис.4.1, рис.4.2):

```
1 (define (problem p01)
2   (:domain Nenuphars)
3
4   (:objects
5     player1 - player
6     n1 n2 n3 n4 n5 n6 n7 n8 n9 n10 n11 n12 n13 n14 n15 n16 n17 n18 n19 n20 n21 n22 n23 n24 n25 n26 n27 n28 n29 n30 n31 n32 n33 n34 n35 n36 - nenuphar
7     scissorsbonus - scissors
8     fishrodbonus - fishrod
9     thorns - thorns
10    flower1 flower2 flower3 flower4 - swampflower
11  )
12
13  (:init
14    (connected n1 n2)
15    (connected n1 n7)
16    (connected n2 n3)
17    (connected n2 n8)
18    (connected n3 n4)
19    (connected n3 n9)
20    (connected n4 n5)
21    (connected n4 n10)
22    (connected n5 n6)
23    (connected n5 n11)
24    (connected n6 n12)
25    (connected n7 n8)
26    (connected n7 n13)
27    (connected n8 n9)
28    (connected n8 n14)
29    (connected n9 n10)
30    (connected n9 n15)
31    (connected n10 n11)
32    (connected n10 n16)
33    (connected n11 n12)
34    (connected n11 n17)
35    (connected n12 n18)
36    (connected n13 n14)
37    (connected n13 n19)
38    (connected n14 n15)
39    (connected n14 n20)
40    (connected n15 n16)
41    (connected n15 n21)
42    (connected n16 n17)
43    (connected n16 n22)
44    (connected n17 n18)
45    (connected n17 n23)
46    (connected n18 n24)
47    (connected n19 n20)
48    (connected n19 n25)
49    (connected n20 n21)
```

**РИС.2.1**(1-ая задача)

```

50 (connected n20 n26)
51 (connected n21 n22)
52 (connected n21 n27)
53 (connected n22 n23)
54 (connected n22 n28)
55 (connected n23 n24)
56 (connected n23 n29)
57 (connected n24 n30)
58 (connected n25 n26)
59 (connected n25 n31)
60 (connected n26 n27)
61 (connected n26 n32)
62 (connected n27 n28)
63 (connected n27 n33)
64 (connected n28 n29)
65 (connected n28 n34)
66 (connected n29 n30)
67 (connected n29 n35)
68 (connected n30 n36)
69 (connected n31 n32)
70 (connected n32 n33)
71 (connected n33 n34)
72 (connected n34 n35)
73 (connected n35 n36)
74
75
76 (in-pl player1 n2)
77
78 (at flower1 n5)
79 (at flower2 n27)
80 (at flower3 n15)
81 (at flower4 n9)
82
83 (at scissorsbonus n16)
84 (at scissorsbonus n29)
85 (at fishrodbonus n5)
86
87
88 (is-obs thorns n4)
89 (is-obs thorns n25)
90 (is-obs thorns n14)
91 (is-obs thorns n26)
92 (is-obs thorns n30)
93 (is-obs thorns n12)
94
95 )
96
97 (:goal (and (at flower1 n26) (at flower2 n35) (at flower3 n2) (at flower4 n17)))
98 )

```

## РИС.2.2(1-ая задача)

```

1 (define (problem p01)
2   (:domain Nenuphars)
3
4 ~ (:objects
5   player1 - player
6   n1 n2 n3 n4 n5 n6 n7 n8 n9 n10 n11 n12 n13 n14 n15 n16 n17 n18 n19 n20 n21 n22 n23 n24 n25 n26 n27 n28 n29 n30 n31 n32 n33 n34 n35 n36 - nenuphar
7   scissorsbonus - scissors
8   fishrodbonus - fishrod
9   thorns - thorns
10  flower1 flower2 flower3 flower4 - swampflower
11 )
12
13 ~ (:init
14   (connected n1 n2)
15   (connected n1 n7)
16   (connected n2 n3)
17   (connected n2 n8)
18   (connected n3 n4)
19   (connected n3 n9)
20   (connected n4 n5)
21   (connected n4 n10)
22   (connected n5 n6)
23   (connected n5 n11)
24   (connected n6 n12)
25   (connected n7 n8)
26   (connected n7 n13)
27   (connected n8 n9)
28   (connected n8 n14)
29   (connected n9 n10)
30   (connected n9 n15)
31   (connected n10 n11)
32   (connected n10 n16)
33   (connected n11 n12)
34   (connected n11 n17)
35   (connected n12 n18)
36   (connected n13 n14)
37   (connected n13 n19)
38   (connected n14 n15)
39   (connected n14 n20)
40   (connected n15 n16)
41   (connected n15 n21)
42   (connected n16 n17)
43   (connected n16 n22)
44   (connected n17 n18)
45   (connected n17 n23)
46   (connected n18 n24)
47   (connected n19 n20)
48   (connected n19 n25)
49   (connected n20 n21)

```

## РИС.3.1(2-ая задача)

```

50 (connected n20 n26)
51 (connected n21 n22)
52 (connected n21 n27)
53 (connected n22 n23)
54 (connected n22 n28)
55 (connected n23 n24)
56 (connected n23 n29)
57 (connected n24 n30)
58 (connected n25 n26)
59 (connected n25 n31)
60 (connected n26 n27)
61 (connected n26 n32)
62 (connected n27 n28)
63 (connected n27 n33)
64 (connected n28 n29)
65 (connected n28 n34)
66 (connected n29 n30)
67 (connected n29 n35)
68 (connected n30 n36)
69 (connected n31 n32)
70 (connected n32 n33)
71 (connected n33 n34)
72 (connected n34 n35)
73 (connected n35 n36)
74
75
76 (in-pl player1 n15)
77
78 (at flower1 n5)
79 (at flower2 n27)
80 (at flower3 n11)
81
82 (keep-scissors)
83 (at fishrodbonus n5)
84
85
86 (is-obs thorns n4)
87 (is-obs thorns n25)
88 (is-obs thorns n14)
89 (is-obs thorns n26)
90 (is-obs thorns n30)
91 (is-obs thorns n12)
92
93 )
94
95 (:goal (and (at flower1 n26) (at flower2 n35) (at flower3 n2)))
96 )

```

## РИС.3.2(2-ая задача)

```

1 (define (problem p01)
2   (:domain Nenuphars)
3
4   (:objects
5     player1 - player
6     n1 n2 n3 n4 n5 n6 n7 n8 n9 n10 n11 n12 n13 n14 n15 n16 n17 n18 n19 n20 n21 n22 n23 n24 n25 n26 n27 n28 n29 n30 n31 n32 n33 n34 n35 n36 - nenuphar
7     scissorsbonus - scissors
8     fishrodbonus - fishrod
9     thorns - thorns
10    flower1 flower2 flower3 flower4 - swampflower
11  )
12
13  (:init
14    (connected n1 n2)
15    (connected n1 n7)
16    (connected n2 n3)
17    (connected n2 n8)
18    (connected n3 n4)
19    (connected n3 n9)
20    (connected n4 n5)
21    (connected n4 n10)
22    (connected n5 n6)
23    (connected n5 n11)
24    (connected n6 n12)
25    (connected n7 n8)
26    (connected n7 n13)
27    (connected n8 n9)
28    (connected n8 n14)
29    (connected n9 n10)
30    (connected n9 n15)
31    (connected n10 n11)
32    (connected n10 n16)
33    (connected n11 n12)
34    (connected n11 n17)
35    (connected n12 n18)
36    (connected n13 n14)
37    (connected n13 n19)
38    (connected n14 n15)
39    (connected n14 n20)
40    (connected n15 n16)
41    (connected n15 n21)
42    (connected n16 n17)
43    (connected n16 n22)
44    (connected n17 n18)
45    (connected n17 n23)
46    (connected n18 n24)
47    (connected n19 n20)
48    (connected n19 n25)
49    (connected n20 n21)

```

## РИС.4.1(3-ая задача)

```

50      (connected n20 n26)
51      (connected n21 n22)
52      (connected n21 n27)
53      (connected n22 n23)
54      (connected n22 n28)
55      (connected n23 n24)
56      (connected n23 n29)
57      (connected n24 n30)
58      (connected n25 n26)
59      (connected n25 n31)
60      (connected n26 n27)
61      (connected n26 n32)
62      (connected n27 n28)
63      (connected n27 n33)
64      (connected n28 n29)
65      (connected n28 n34)
66      (connected n29 n30)
67      (connected n29 n35)
68      (connected n30 n36)
69      (connected n31 n32)
70      (connected n32 n33)
71      (connected n33 n34)
72      (connected n34 n35)
73      (connected n35 n36)
74
75
76      (in-pl player1 n2)
77
78      (at flower1 n5)
79      (at flower2 n27)
80      (at flower3 n15)
81      (at flower4 n9)
82
83      (keep-fishrod)
84      (at scissorsbonus n16)
85
86      (is-obs thorns n4)
87      (is-obs thorns n25)
88      (is-obs thorns n14)
89      (is-obs thorns n26)
90      (is-obs thorns n30)
91      (is-obs thorns n12)
92
93    )
94
95    (:goal (and (at flower1 n26) (at flower2 n35) (at flower3 n2) (at flower4 n17)))
96  )

```

## РИС.4.2(3-ая задача)

### 4 задание.

Протестируем работу домена с каждой задачей:

```

(jumptoanotherthenuphar player1 n2 n8 thorns)
(jumptoanotherthenuphar player1 n8 n9 thorns)
(jumptoanotherthenuphar player1 n9 n15 thorns)
(takeswampflower player1 n15 flower3 thorns)
(jumptoanotherthenuphar player1 n15 n21 thorns)
(jumptoanotherthenuphar player1 n21 n27 thorns)
(jumptoanotherthenuphar player1 n27 n28 thorns)
(jumptoanotherthenuphar player1 n28 n29 thorns)
(equipscissors player1 n29 scissorsbonus)
(jumptoanotherthenuphar player1 n29 n28 thorns)
(jumptoanotherthenuphar player1 n28 n27 thorns)
(cutthorns player1 n27 n26 thorns)
(jumptoanotherthenuphar player1 n27 n28 thorns)
(jumptoanotherthenuphar player1 n28 n29 thorns)
(jumptoanotherthenuphar player1 n29 n23 thorns)
(jumptoanotherthenuphar player1 n23 n17 thorns)
(putswampflower player1 n17 flower4 thorns)
(jumptoanotherthenuphar player1 n17 n11 thorns)
(jumptoanotherthenuphar player1 n11 n5 thorns)
(takeswampflower player1 n5 flower1 thorns)
(equipfishrod player1 n5 fishrodbonus)
(makeasuperjump player1 n5 n35 thorns)
(putswampflower player1 n35 flower2 thorns)
(makeasuperjump player1 n35 n9 thorns)
(takeswampflower player1 n9 flower4 thorns)
(makeasuperjump player1 n9 n2 thorns)
(putswampflower player1 n2 flower3 thorns)
(makeasuperjump player1 n2 n27 thorns)
(takeswampflower player1 n27 flower2 thorns)
(makeasuperjump player1 n27 n26 thorns)
(putswampflower player1 n26 flower1 thorns)

```

(План для 1-ой задачи)



(jumptoanothernenuphar player1 n15 n21 thorns)  
(jumptoanothernenuphar player1 n21 n27 thorns)  
(takeswampflower player1 n27 flower2 thorns)  
(cutthorns player1 n27 n26 thorns)  
(jumptoanothernenuphar player1 n27 n26 thorns)  
(putswampflower player1 n26 flower1 thorns)  
(jumptoanothernenuphar player1 n26 n20 thorns)  
(cutthorns player1 n20 n14 thorns)  
(jumptoanothernenuphar player1 n20 n14 thorns)  
(jumptoanothernenuphar player1 n14 n8 thorns)  
(jumptoanothernenuphar player1 n8 n9 thorns)  
(jumptoanothernenuphar player1 n9 n10 thorns)  
(jumptoanothernenuphar player1 n10 n11 thorns)  
(takeswampflower player1 n11 flower3 thorns)  
(jumptoanothernenuphar player1 n11 n5 thorns)  
(equipfishrod player1 n5 fishrodbonus)  
(makeasuperjump player1 n5 n35 thorns)  
(putswampflower player1 n35 flower2 thorns)  
(makeasuperjump player1 n35 n5 thorns)  
(takeswampflower player1 n5 flower1 thorns)  
(makeasuperjump player1 n5 n2 thorns)  
(putswampflower player1 n2 flower3 thorns)

(План для 2-ой задачи)

(makeasuperjump player1 n2 n27 thorns)  
(takeswampflower player1 n27 flower2 thorns)  
(makeasuperjump player1 n27 n35 thorns)  
(putswampflower player1 n35 flower2 thorns)  
(makeasuperjump player1 n35 n16 thorns)  
(equipscissors player1 n16 scissorsbonus)  
(jumptoanothernenuphar player1 n16 n15 thorns)  
(takeswampflower player1 n15 flower3 thorns)  
(jumptoanothernenuphar player1 n15 n21 thorns)  
(jumptoanothernenuphar player1 n21 n20 thorns)  
(cutthorns player1 n20 n26 thorns)  
(cutthorns player1 n20 n14 thorns)  
(jumptoanothernenuphar player1 n20 n26 thorns)  
(putswampflower player1 n26 flower1 thorns)  
(jumptoanothernenuphar player1 n26 n20 thorns)  
(jumptoanothernenuphar player1 n20 n14 thorns)  
(jumptoanothernenuphar player1 n14 n15 thorns)  
(jumptoanothernenuphar player1 n15 n9 thorns)  
(takeswampflower player1 n9 flower4 thorns)  
(jumptoanothernenuphar player1 n9 n8 thorns)  
(jumptoanothernenuphar player1 n8 n2 thorns)  
(putswampflower player1 n2 flower3 thorns)  
(jumptoanothernenuphar player1 n2 n8 thorns)  
(jumptoanothernenuphar player1 n8 n14 thorns)  
(jumptoanothernenuphar player1 n14 n15 thorns)  
(jumptoanothernenuphar player1 n15 n16 thorns)  
(jumptoanothernenuphar player1 n16 n17 thorns)  
(jumptoanothernenuphar player1 n17 n11 thorns)  
(jumptoanothernenuphar player1 n11 n5 thorns)  
(takeswampflower player1 n5 flower1 thorns)  
(jumptoanothernenuphar player1 n5 n11 thorns)  
(jumptoanothernenuphar player1 n11 n17 thorns)  
(putswampflower player1 n17 flower4 thorns)

(План для 3-ей задачи)

### **Заключение.**

В ходе проделанной лабораторной работы, мной были усвоены основные навыки работы со стандартным языком планирования PDDL.