Departamento de Informática
Universidad Carlos III de Madrid

Grado en Ingeniería en Informática

Artificial Intelligence
Partial exam

March 2014

General indications

- Time assigned to the exam is **2 hours**
- You cannot leave the classroom during the exam, unless you have finished it
- Exams cannot be answered using a pencil

Exercise 1

Given the following rules of a production system:

R1 (priority 9): IF number(X,U), number(Y,V), U > V
THEN number(X+Y,U+1), ¬ number(Y,V)

R2 (priority 5): IF total(X), X > 0
THEN number(0,1)

R3 (priority 5): IF total(X), X > 1
THEN number(1,2)

R4 (priority 2): IF total(X), number(Y,X)
THEN print(Y), stop_exec()

where

- Capital letters represent variables.
- Instantiations with a higher priority are preferred. In case of ties, rules with a smaller index are preferred (i.e. R2 is preferred over R3)
- print(·) and stop_exec() are special directives to print a value and to stop the execution respectively.

Simulate the execution of the production system assuming the initial working memory is:

$$\mathrm{WM}_0 = \{total(5)\}$$

For each cycle, show clearly the conflict set, the selected rule and the resulting working memory.

Exercise 2

For the graph in Figure 1, S is the initial state and G the goal node. Values on arcs represent the cost of each operator. Values denoted by $h(\cdot)$ represent the heuristic function.

Expand the search tree to obtain a path from S to G for the following cases:

1. Uninformed Depth First search assuming unitary costs. Expand successors in alphabetical order.
2. Hill Climbing search.
3. A* search.

For each case, indicate near each node its generation and expansion orders and all the necessary information to interpret correctly your solution. Check for repeated states and prune them whenever possible.

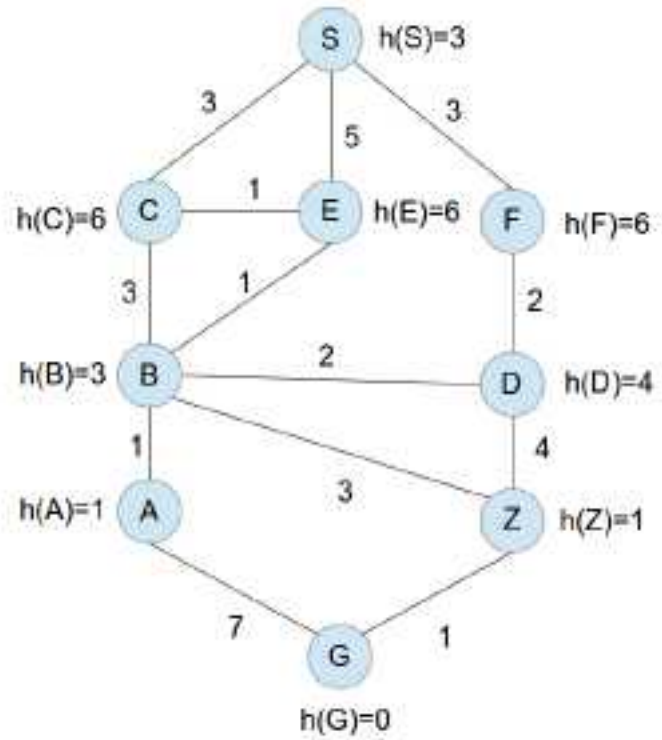


Figura 1: Graph for exercise 2.

Exercise 3

Four persons have to cross a bridge that only support two persons at the same time. The time needed by each person is respectively: 1, 2, 5 and 10 minutes. It is night, and they need to carry a torch while crossing the bridge. There is only one torch. Thus, when two persons cross at the same time they have to be all time together. In this case the crossing time is the maximum of the individual crossing times. The torch is initially at the same side as the persons.

1. Represent the state space for this problem.
2. Represent the initial state and the goal state.
3. Represent the operators of this problem. What is the cost function?
4. What of the studied algorithms will guarantee the optimal solution?
5. Could you propose an admissible heuristic function for this problem?

Exercise 4

Suppose we want to build a production system for the problem in Exercise 3 but ignoring costs.

1. Use predicate logic to represent the information of that problem.
2. Write two rules to model the dynamic of that problem.

1.) FIFO

$WM_0 = \{ total(5) \}$

$CC_0 = \{ R2(x=5), R3(x=5) \}$

$WM_1 = \{ total(5), number(0,1) \}$

$CC_1 = \{ R3(x=5) \}$

$WM_2 = \{ total(5), number(0,1), number(1,2) \}$

$CC_2 = \{ R1(x=1, U=2, Y=0, V=1) \}$

$WM_3 = \{ total(5), number(1,2), number(1,3) \}$

$CC_3 = \{ R1(x=1, U=3, Y=1, V=2) \}$

$WM_4 = \{ total(5), number(1,3), number(2,4) \}$

$CC_4 = \{ R_1(x=2, U=4, Y=1, V=3) \}$

$WM_5 = \{ total(5), number(2,4), number(3,5) \}$

$CC_5 = \{ R_1(x=3, U=5, Y=2, V=4), R4(x=5, Y=3) \}$

$WM_6 = \{ total(5), number(3,5), number(5,6) \}$

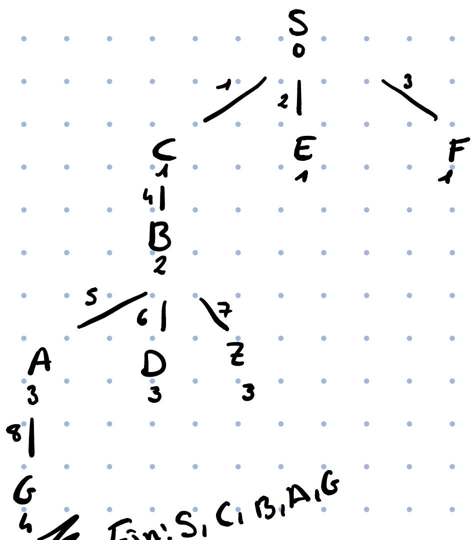
$CC_6 = \{ R4(x=5, Y=3), R_1(x=5, U=6, Y=3, V=5) \}$

$WM_7 = \{ total(5), number(3,5), number(5,6), print(3) \}$

stop-exec()

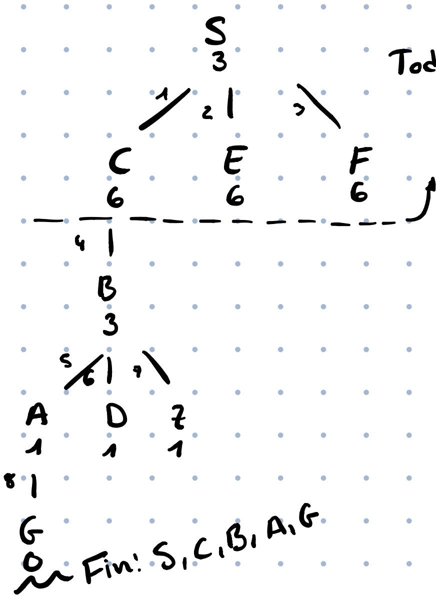
2.)

1. Profundidad: Costes 1 y alfabeticamente.



Fin: S, C, B, A, G

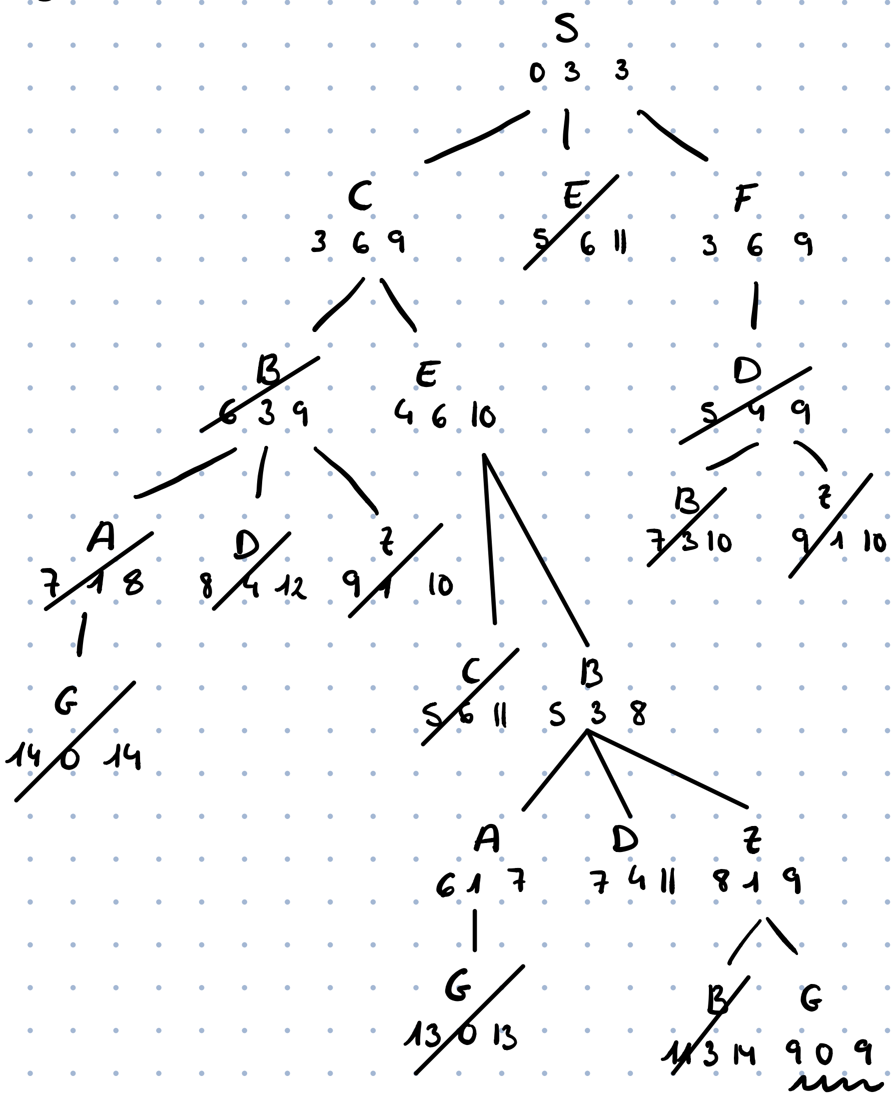
2. Hill Climbing:



Todos los sucesores tienen h(n) mayor

Fin: S, C, B, A, G

3. A*



Fin: S, C, E, B, Z, G

3.) Suponiendo que 1 puede volver

1. person (t, l) t: tiempo que tarda ∈ (1, 2, 5, 10)
l: lado en el que está ∈ (I, D)

cruzan (x, y) x: persona que tarda x
y: persona que tarda y } ∈ (1, 2, 5, 10)

torch (l) l: lado ∈ (I, D)

time (x) x: tiempo acumulado.

2. inicial: person(1, I) person(5, I) torch(I)
person(2, I) person(10, I) time (0)

final: person(1, D) person(5, D) torch(D)
person(2, D) person(10, D) time (x)

3. Cruzar: person(x, I), torch(I)
person(y, I),
x ≠ y
time (T) x>y
→ person (x, D), torch(D) ¬ Precláusulas.
person(y, D), time(T+x)

El coste es el que mayor tiempo tarda

Volver: person (x, D) torch(D)
time(T)
→ person (x, I), time (T+x), ¬ precláusulas
torch (I)

El coste es el tiempo del que vuelve.

4. Amplitud, pero exponencial y no guiada.

Dijkstra, exponencial y no guiada por costes

A*, exponencial y guiada por coste y heurística.

5. h(n): El coste viene dado por el número de personas que quedan por cruzar + el que mayor tiempo tarda y todavía no ha cruzado

10 5 2 1 |	10 5 | 2 1	10 5 1 | 2	1 | 10 5 2	1 2 | 10 5	| 10 5 2 1
14	12	13	2	4	0

$\underbrace{\quad}_{2}$ $\underbrace{\quad}_{1}$ $\underbrace{\quad}_{10}$ $\underbrace{\quad}_{2}$ $\underbrace{\quad}_{2}$ Σ=17