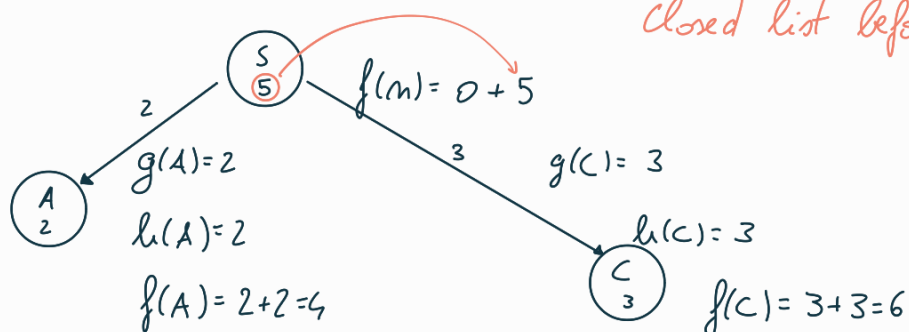Exam 26/01/2015

Consider the search space below, where S is the start node and G1 and G2 are the goal states. Arcs are labelled with the cost of traversing them and the estimated cost to a goal is reported inside nodes.

1 Draw the tree generated by A*
2 List - in order - all the states popped of the OPEN list (mark with increasing natural number the nodes of the tree in the order of their expansion; when values are equal, nodes are expanded in alphabetical order)
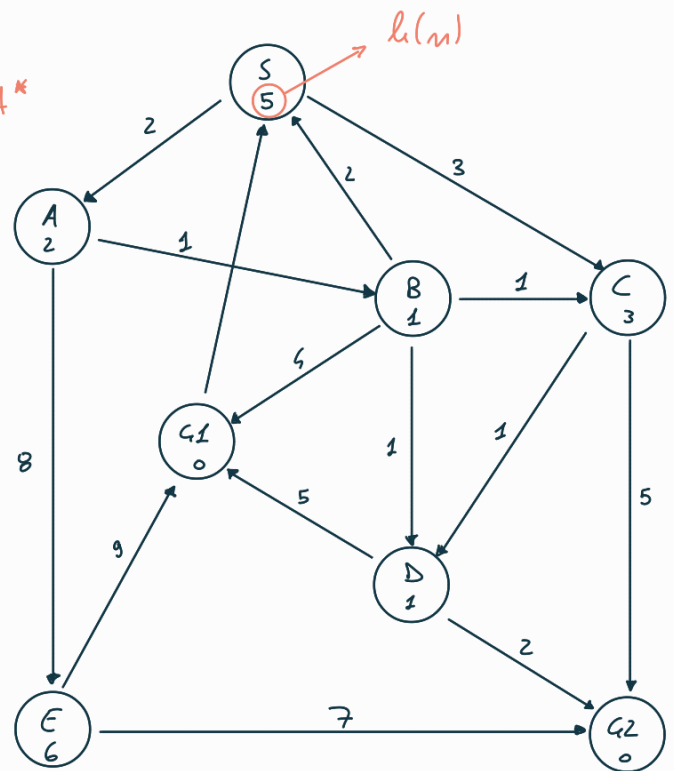
1. Draw the tree generated by A*
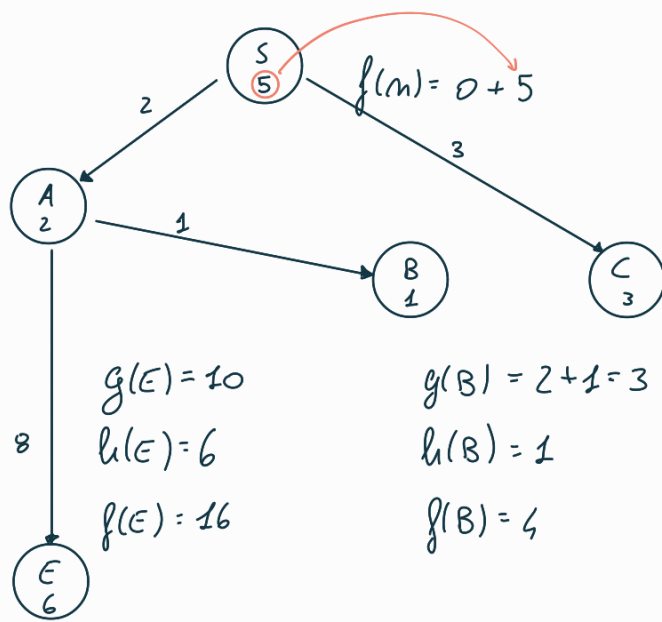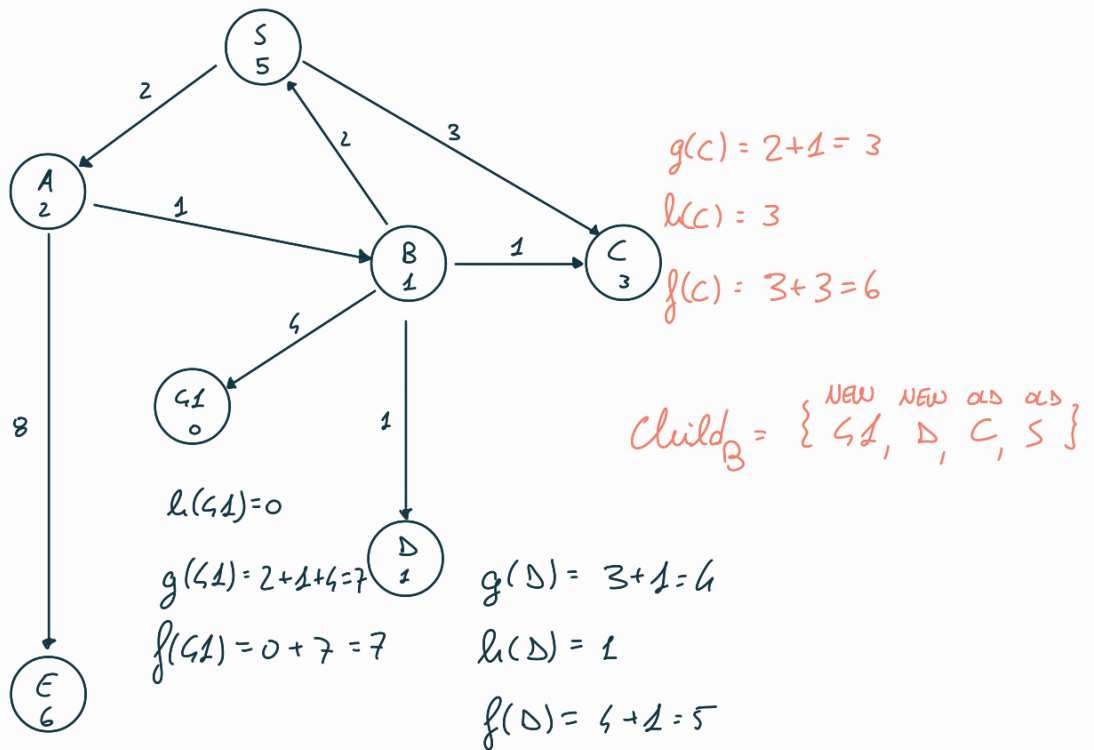
Open list before $\{S\}$
Closed list before $\{\ \}$

$f(m) = 0 + 5$

$g(A) = 2$
$h(A) = 2$
$f(A) = 2 + 2 = 4$

$g(C) = 3$
$h(C) = 3$
$f(C) = 3 + 3 = 6$

$\{A(4), C(6)\} \longrightarrow$ Expand A

O-l $\{A^{S}(4), C^{S}(6)\}$
C-l $\{S^{O}(5)\}$

$f(m) = 0 + 5$

$g(E) = 10$

$h(E) = 6$

$f(E) = 16$

$g(B) = 2 + 1 = 3$

$h(B) = 1$

$f(B) = 4$

$\{ B(4), C(6), E(16) \} \longrightarrow$ Expand B

O-l $\{ B^A(4), C^S(6), E^A(16) \}$

C-l $\{ S^\Omega(5), A^S(4) \}$

$g(C) = 2 + 1 = 3$

$h(C) = 3$

$f(C) = 3 + 3 = 6$

$Child_B = \{ G1, D, C, S \}$ (NEW NEW OLD OLD)

$h(G1) = 0$

$g(G1) = 2 + 1 + 4 = 7$

$f(G1) = 0 + 7 = 7$

$g(D) = 3 + 1 = 4$

$h(D) = 1$

$f(D) = 4 + 1 = 5$

O-l $\{ D^B(5), C^B(6), G1^B(7), E^A(16) \} \longrightarrow$ Expand D

C-l $\{ S^\Omega(5), A^S(4), B^A(4) \}$

Top diagram labels and nodes:

Nodes: S (5), A (2), B (1), C (3), G1 (0), D (1), E (6), G2 (0)

Edges: S–A: 2, S–B: 2, S–C: 3, A–B: 1, A–E: 8, B–C: 1, B–G1: 4, B–D: 1, D–G1: 5, D–G2: 2

$$h(G1) = 0$$
$$g(G1) = 4 + 5 = 9$$
$$f(G1) = 9 + 0 = 9$$
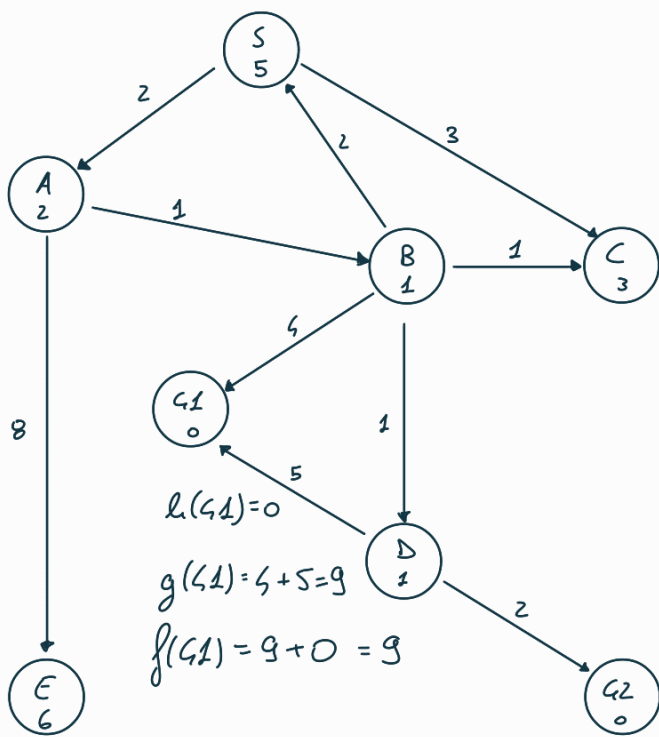
G1 can now be reached from D with cost 9, but it is already in the open list and can be reached with cost 7 from B
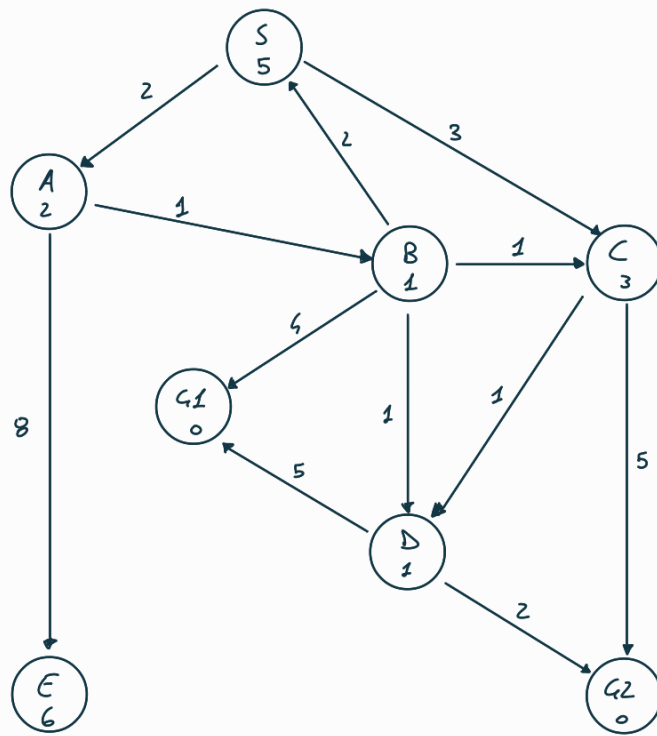
→ no update

O-l { C⁻ᴮ(6), G2⁻ᴰ(6), G1⁻ᴮ(7), E⁻ᴬ(16) } ────→ Expand C

C-l { S⁻ᴼ(5), A⁻ˢ(4), B⁻ᴬ(4), D⁻ᴮ(5) }

Bottom diagram:

Nodes: S (5), A (2), B (1), C (3), G1 (0), D (1), E (6), G2 (0)

Edges: S–A: 2, S–B: 2, S–C: 3, A–B: 1, A–E: 8, B–C: 1, B–G1: 4, B–D: 1, C–D: 1, C–G2: 5, D–G1: 5, D–G2: 2
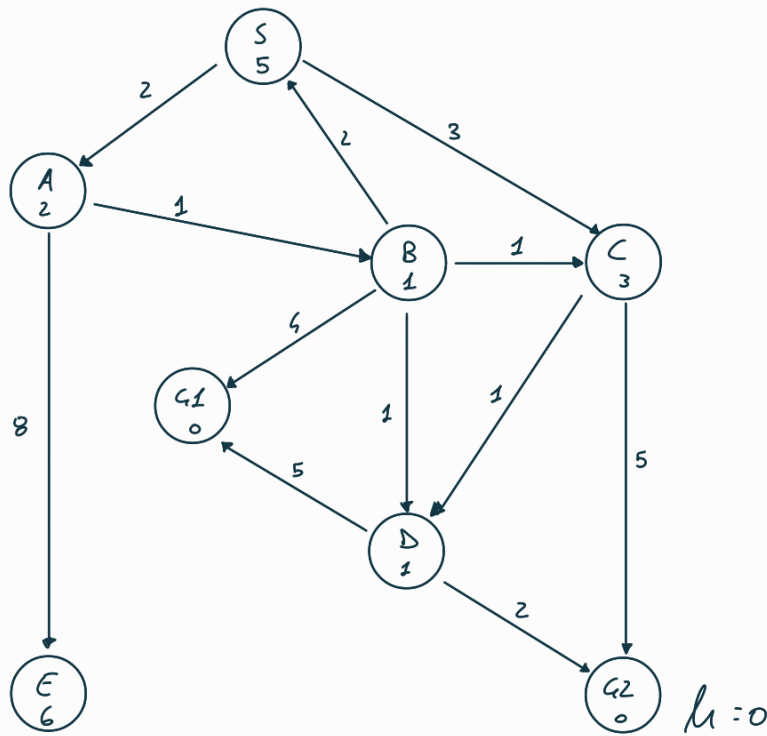
$$h = 0$$
$$g = 3 + 5$$
$$f = (3+5) + 0 = 8 > f(G2)$$
→ no updates

O-l { G2⁻ᴰ(6), G1⁻ᴮ(7), E⁻ᴬ(16) }

C-l { S⁻ᴼ(5), A⁻ˢ(4), B⁻ᴬ(4), D⁻ᴮ(5), C⁻ᴮ(6) }

────→ Expand G2

$$O - \ell \quad \{ G1(7), E(16) \}$$

$$C - \ell \quad \{ S(5), A(4), B(4), D(5), C(6), G2(6) \}$$

Algorithm ends

Graph nodes with heuristic values:
- S: 5 — $l(n)$
- A: 2
- B: 1
- C: 3
- G1: 0
- D: 1
- E: 6
- G2: 0

Edges: S-A: 2, S-B: 2, S-C: 3, A-B: 1, A-E: 8, B-C: 1, B-G1: 4, B-D: 1, C-D: 1, C-G2: 5, G1-D: 5, E-G1: 9, D-G2: 2, E-G2: 7

Search tree:

① S
$$f = 0 + 5 = 5$$

② S-A
$$f = (0+2)+2 = 4$$

⑤ S-C
$$f = (0+3)+3 = 6$$

③ S-A-B
$$f = (2+1)+1 = 4$$

S-A-E
$$f = (2+8)+6 = 16$$

⑥ S-C-D
$$f = (3+1)+1 = 5$$

S-C-G2
$$f = (3+5)+0 = 8$$

S-A-B-C
$$f = (3+1)+3 = 7$$

④ S-A-B-D
$$f = (3+1)+1 = 5$$

S-A-B-G1
$$f = (3+4)+0 = 7$$

S-A-B-S
✗

$$S-A-B-D$$

$$f = (3+1)+1$$
$$= 5$$

$$S-A-B-D -G1$$

$$f = (4+5)+0$$
$$= 9$$

$$S-A-B-D -G2$$

$$f = (4+2)+0$$
$$= 6$$

$$S-C-D$$

$$f = (3+1)+1$$
$$= 5$$

$$S-C-D-G1$$

$$f = (4+5)+0$$
$$= 9$$

$$S-C-D-G2$$

$$f = (4+2)+0$$
$$= 6$$
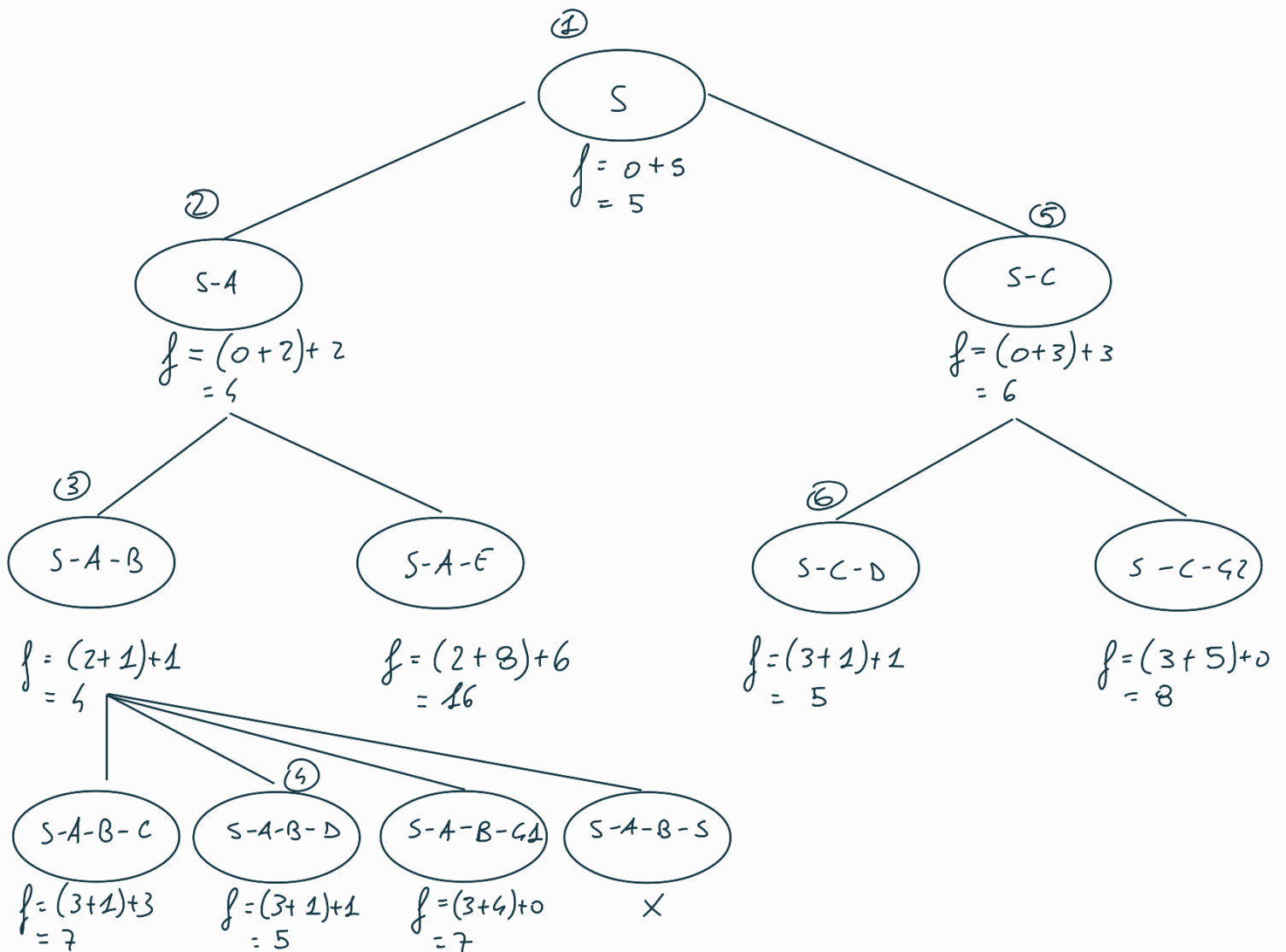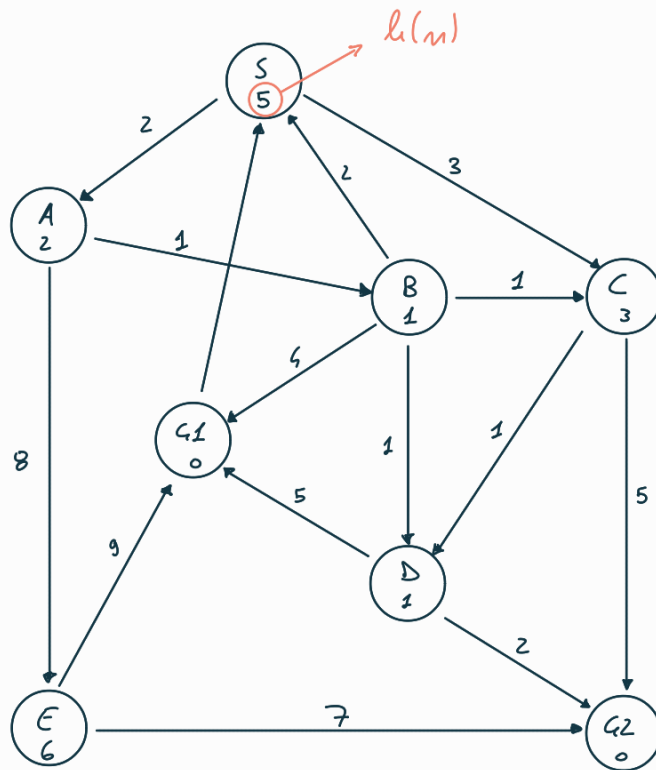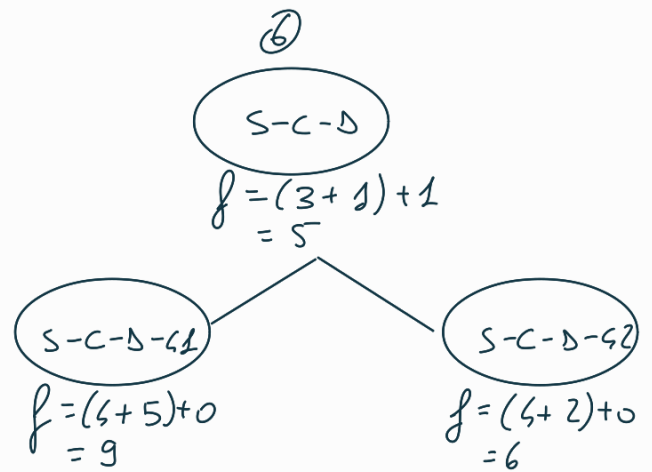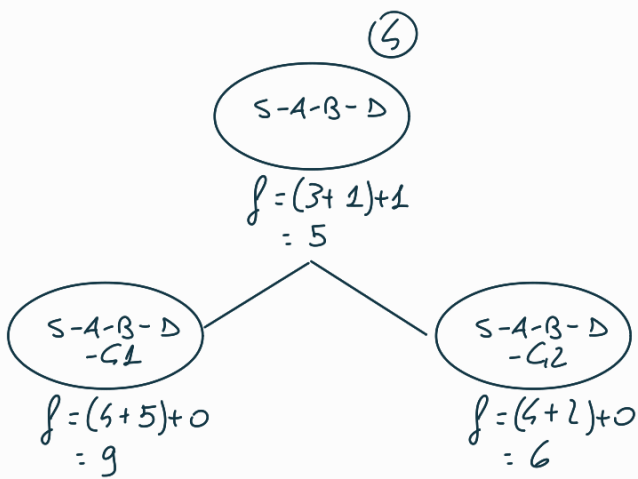
Open set :

contains all the nodes

waiting to be expanded

① $\{ S(5) \}$

② $\{ A(4), C(6) \}$

③ $\{ B(4), C(6), E(16) \}$

④ $\{ D(5), C(6), G1(7), E(16) \}$

④ $\{ C(6), G2(6), G1(7), E(16) \}$

⑤ $\{ D(5), G2(6), G1(7), E(16) \}$

⑥ $\{ G2(6), G1(7), E(16) \}$

Closed set:

contains all the nodes

already expanded

$\{ \}$

$\{ S \}$

$\{ S, A \}$

$\{ S, A, B \}$

$\{ S, A, B, D \}$

$\{ S, A, B, D, C \}$

$\{ S, A, B, D, C, D \}$

$\{ S, A, B, D, C, D, G2 \} \longleftarrow$

2. List - in order - all the states popped of the OPEN list