COMP3308
Introduction to Artificial Intelligence

About me

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Graduated Bachelor of Adv. Comp.

Research area: Machine Learning for Healthcare

About You

Introduce yourself:

1. **Name**
2. **Degree, Year**
3. **Do you have a partner for A1 yet?** If not, say **what you’re looking for,** or your **preferred approach.** For examples:
    - Achieving HD / Distinction
    - Complete fast, relax later
    - Go with the flow :)
    - ~~Partner does all the works~~

Content

Uninformed Search Strategies:

- **BFS** (Breadth-First Search)
- **UCS** (Uniform Cost Search)
- **DFS** (Depth-First Search)
- **IDS** (Iterative Deepening Search)

Do not use **heuristic** knowledge

Informed Search Strategies:

- **Greedy**
- **A*** (Next week)

Use **heuristic** knowledge

=> Typically more efficient

Did everyone submit this week homework?

Due on Tuesday 3pm every week!

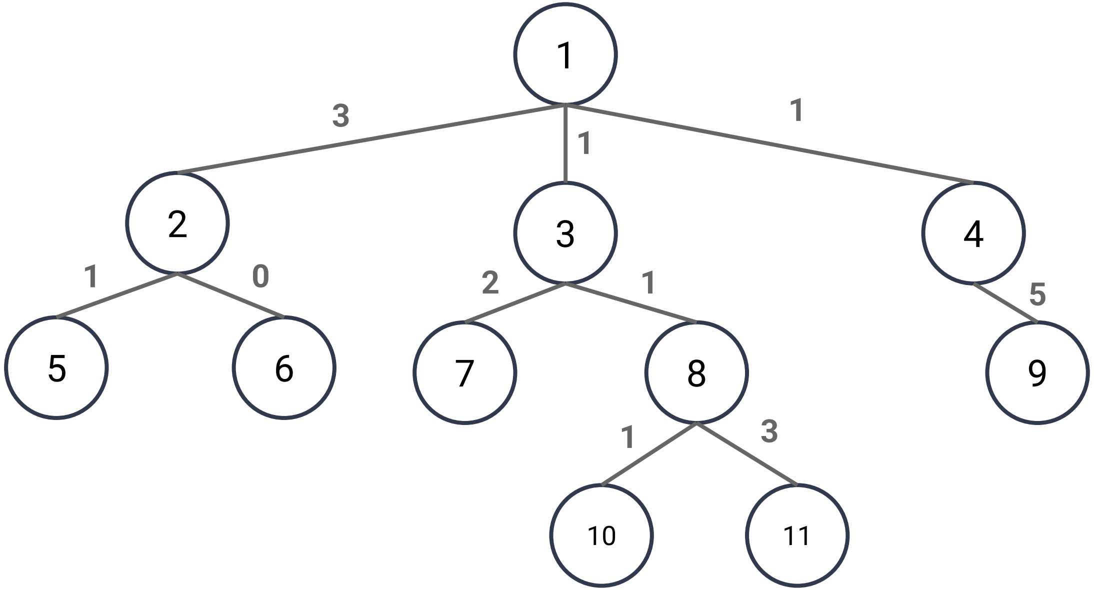
Next: Exercise 1a

Breadth-First Search

- Expands the **shallowest** unexpanded node
- Insert children **at the end** of the **fringe**
- **Complete - Yes**
- **Optimal - No** (only Yes when step cost is the same)

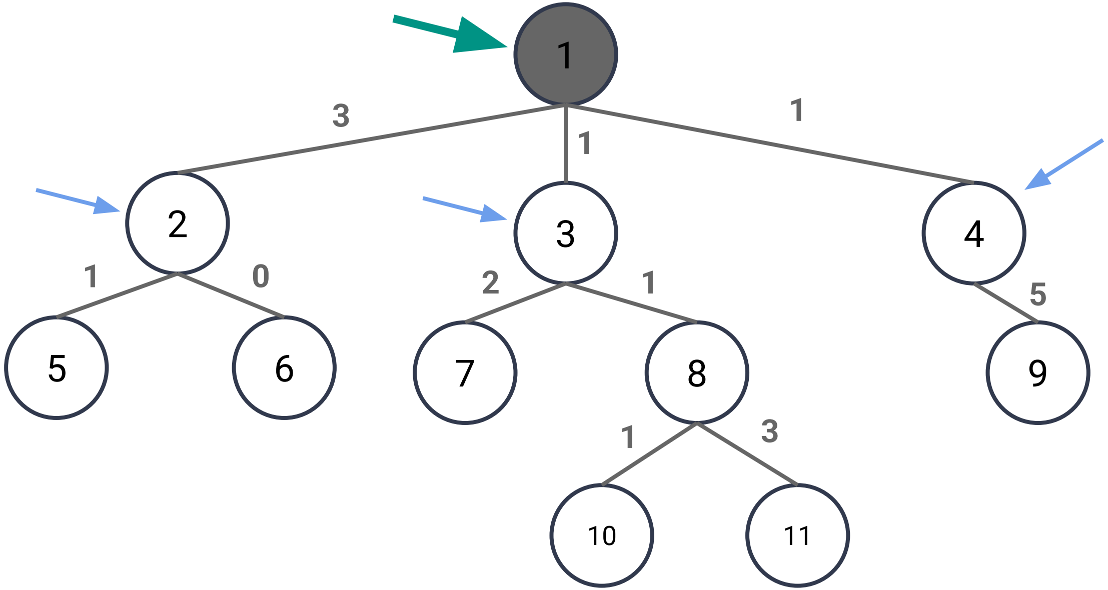
Exercise 1 – a

Fringe: 1
Expanded:



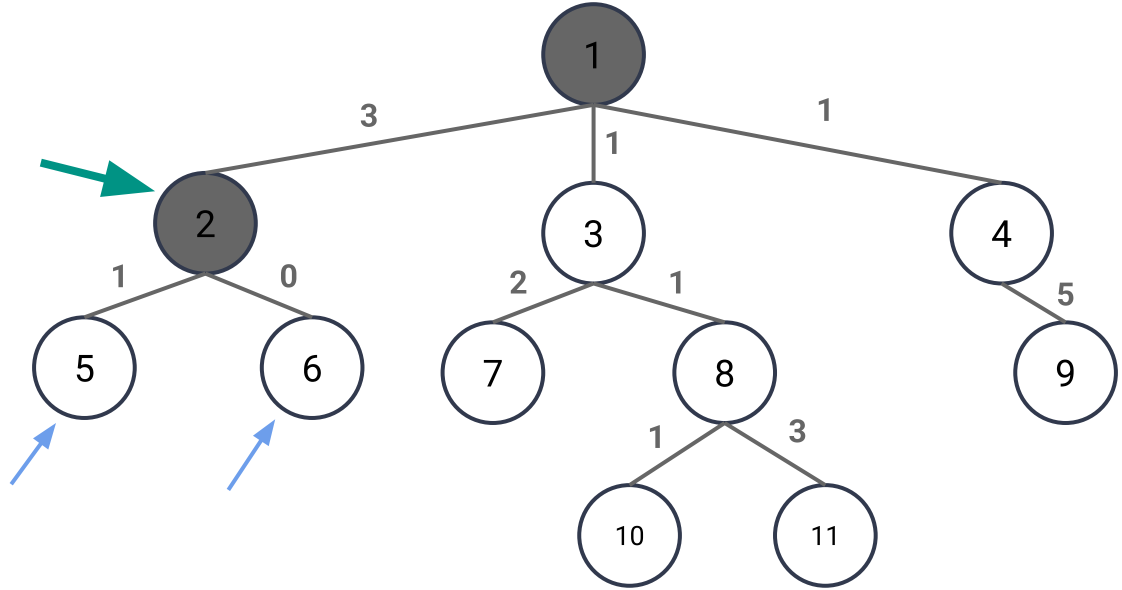
Exercise 1 – a

Fringe: 2, 3, 4
Expanded: 1



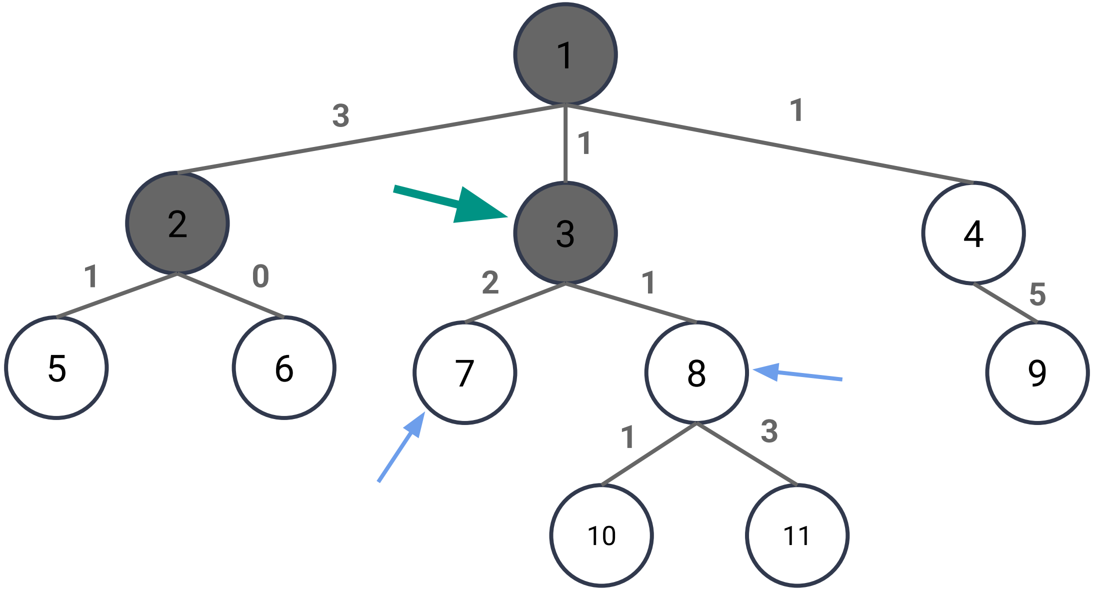
Exercise 1 – a

Fringe: 3, 4, 5, 6
Expanded: 1, 2



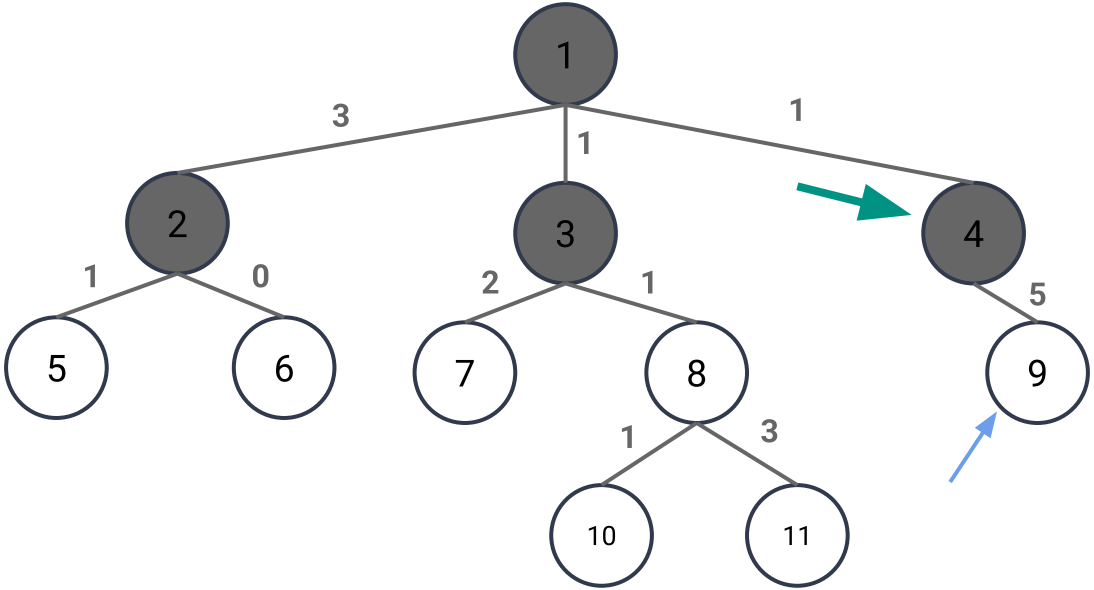
Exercise 1 – a

Fringe: 4, 5, 6, 7, 8
Expanded: 1, 2, 3



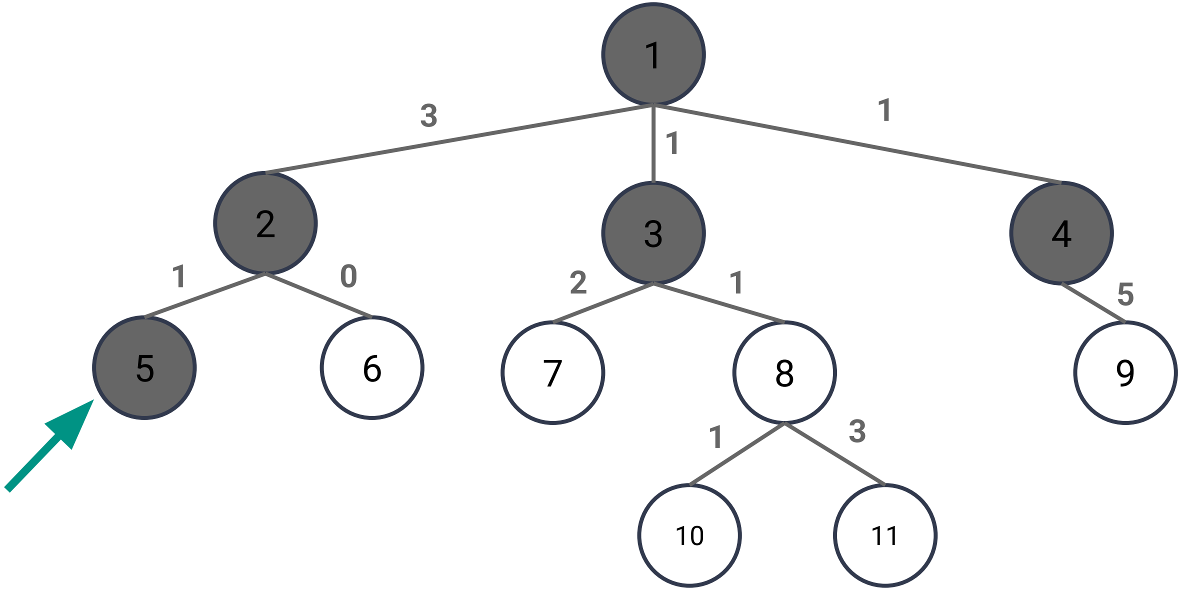
Exercise 1 – a

Fringe: 5, 6, 7, 8, 9
Expanded: 1, 2, 3, 4



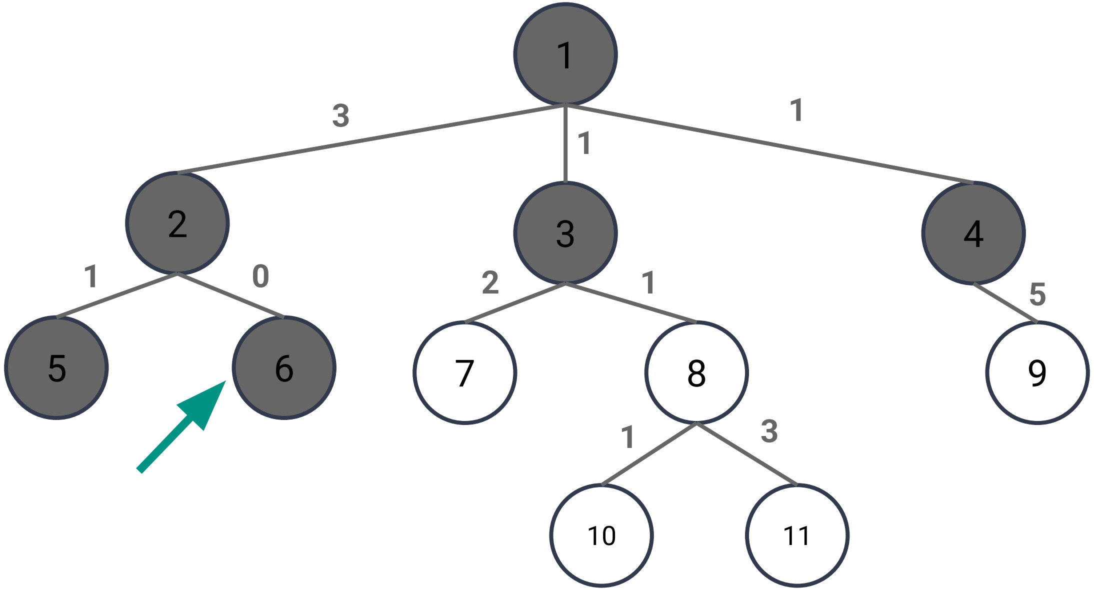
Exercise 1 – a

Fringe: 6, 7, 8, 9
Expanded: 1, 2, 3, 4, 5



Exercise 1 – a

Fringe: 7, 8, 9
Expanded: 1, 2, 3, 4, 5, 6

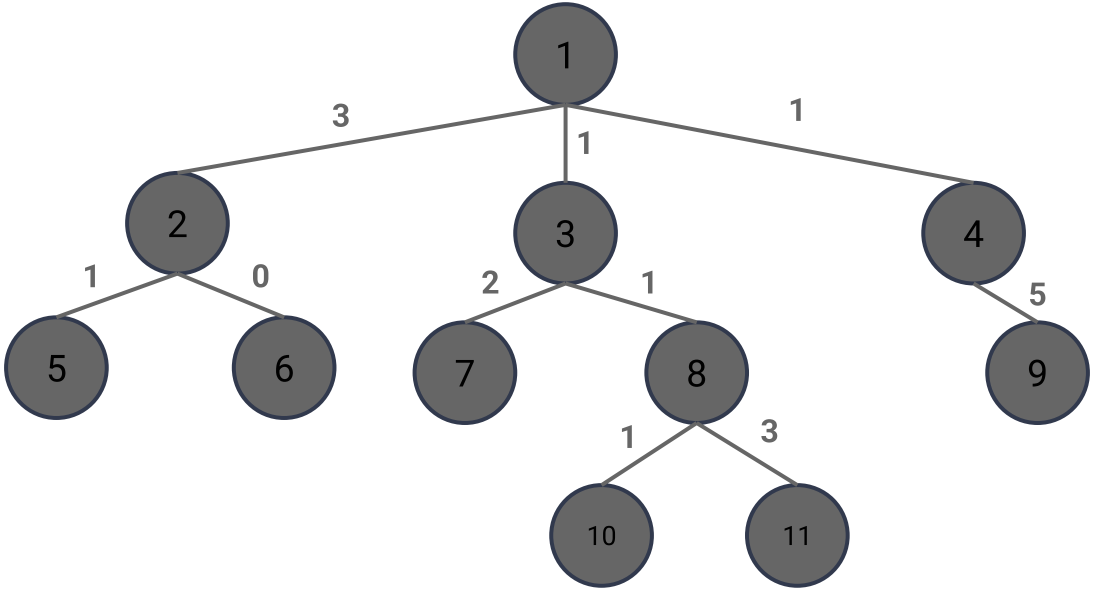


Continue until expanded all nodes

Exercise 1 – a

Solution

Expanded: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11



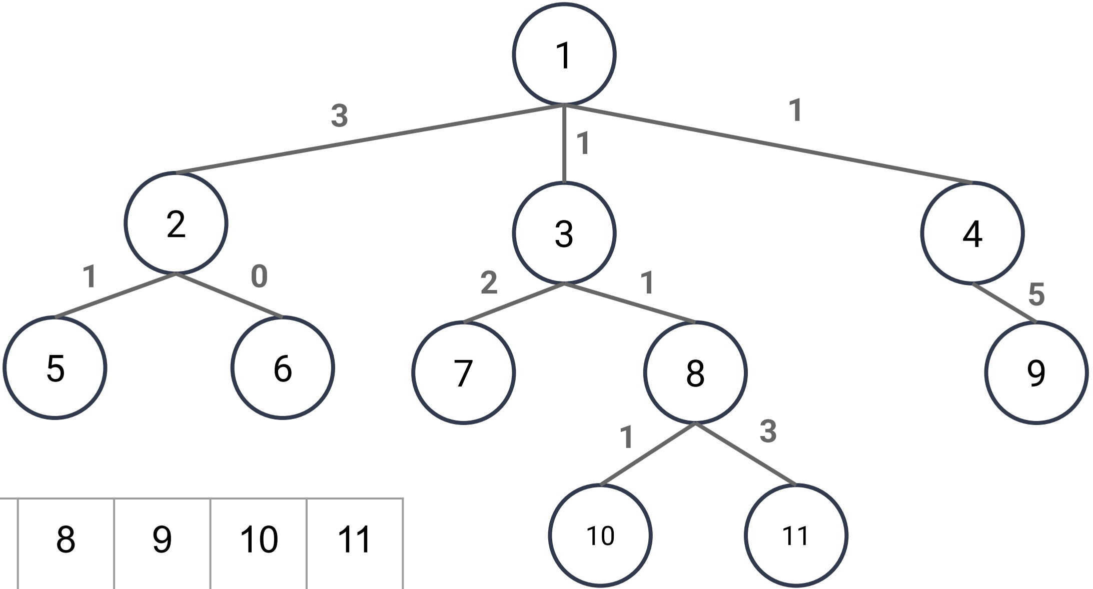
Next: Exercise 1b

Uniform Cost Search

- Expands the **least-cost** (lowest path cost **from root**) unexpanded node
- Insert nodes in the **fringe** in order of increasing path cost **from root**
- **Complete - Yes**
- **Optimal - Yes**

Exercise 1 – b

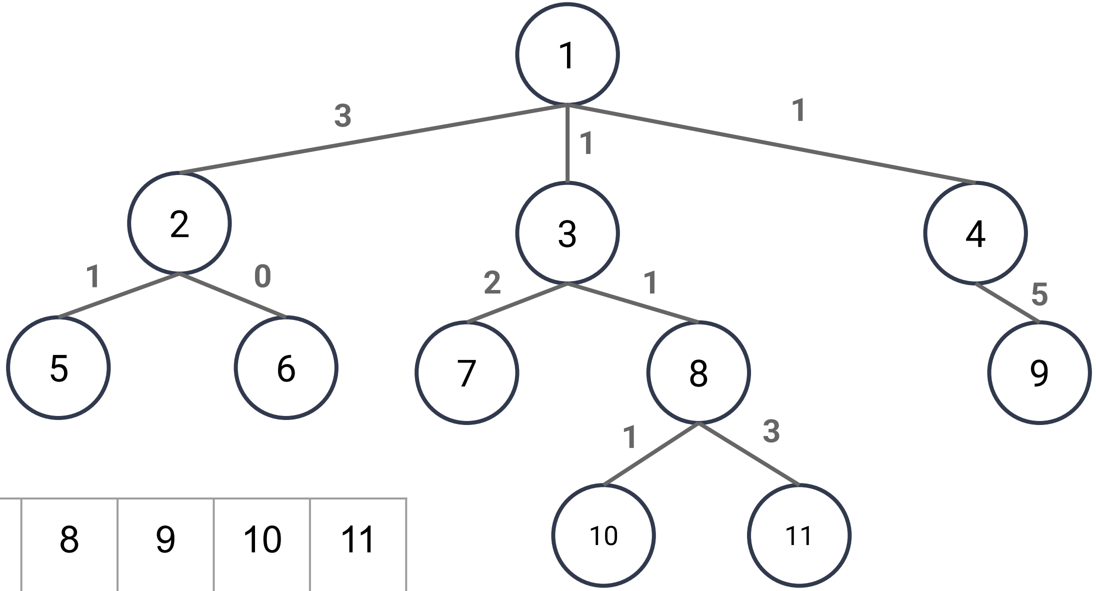
Fringe: 1
Expanded:



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	?						

Exercise 1 – b

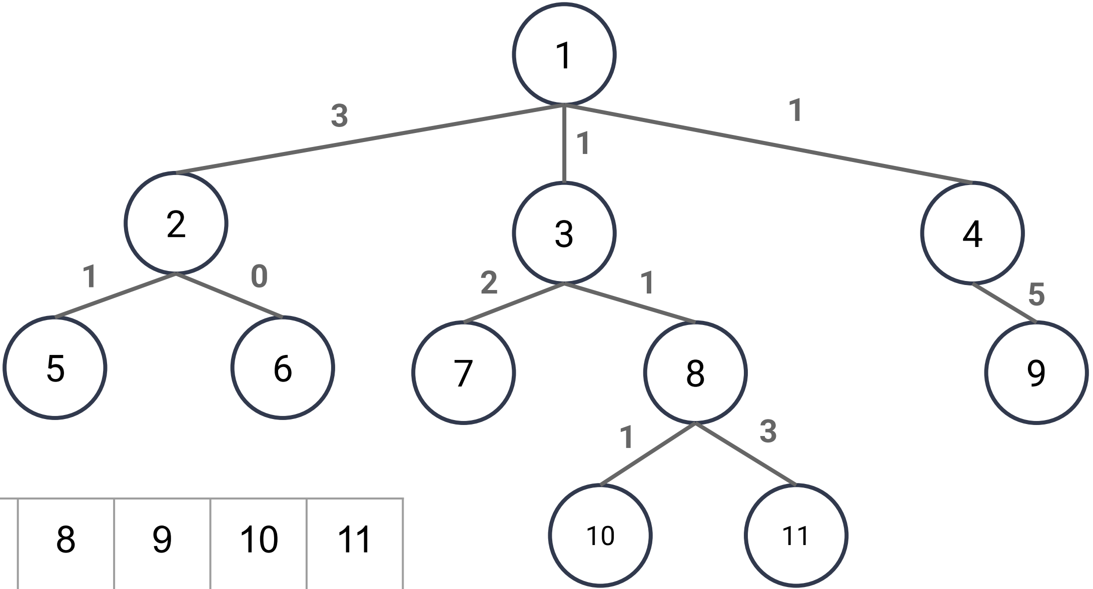
Fringe: 1
Expanded:



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	?					

Exercise 1 – b

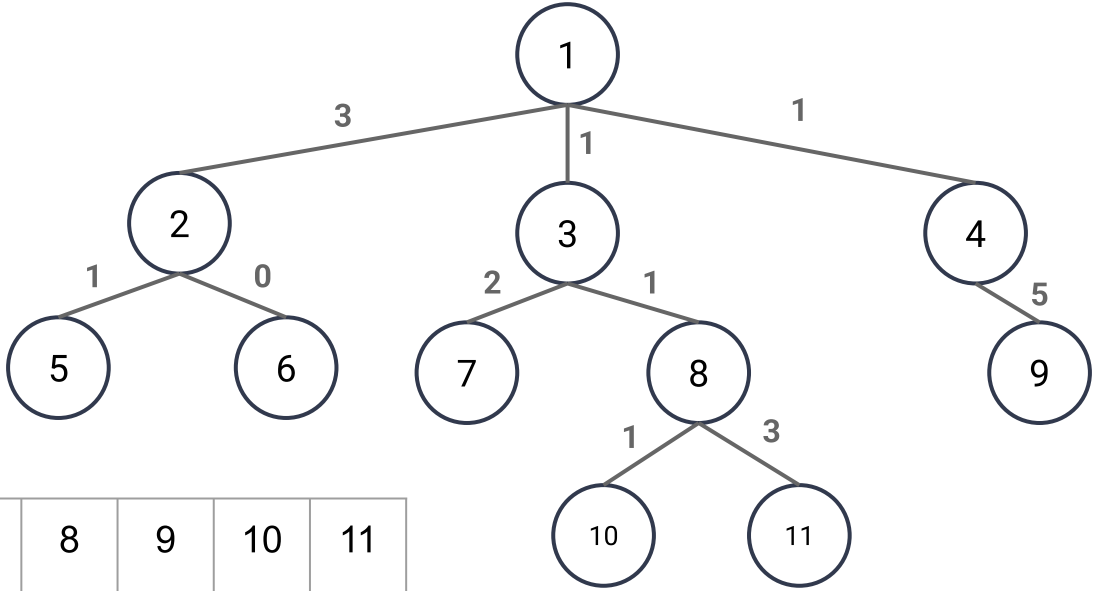
Fringe: 1
Expanded:



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	?				

Exercise 1 – b

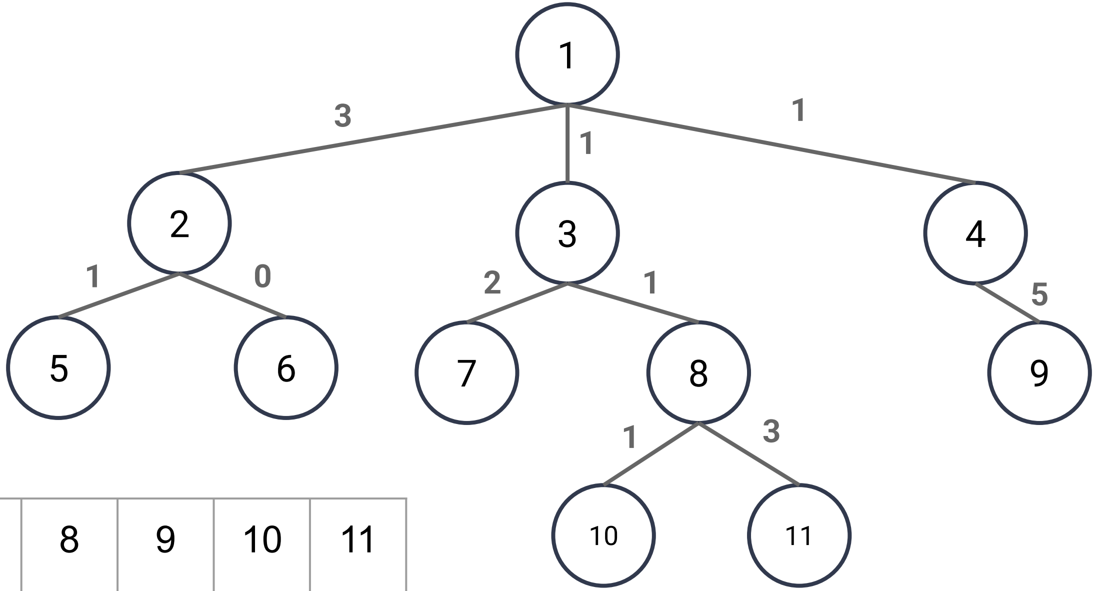
Fringe: 1
Expanded:



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3				

Exercise 1 – b

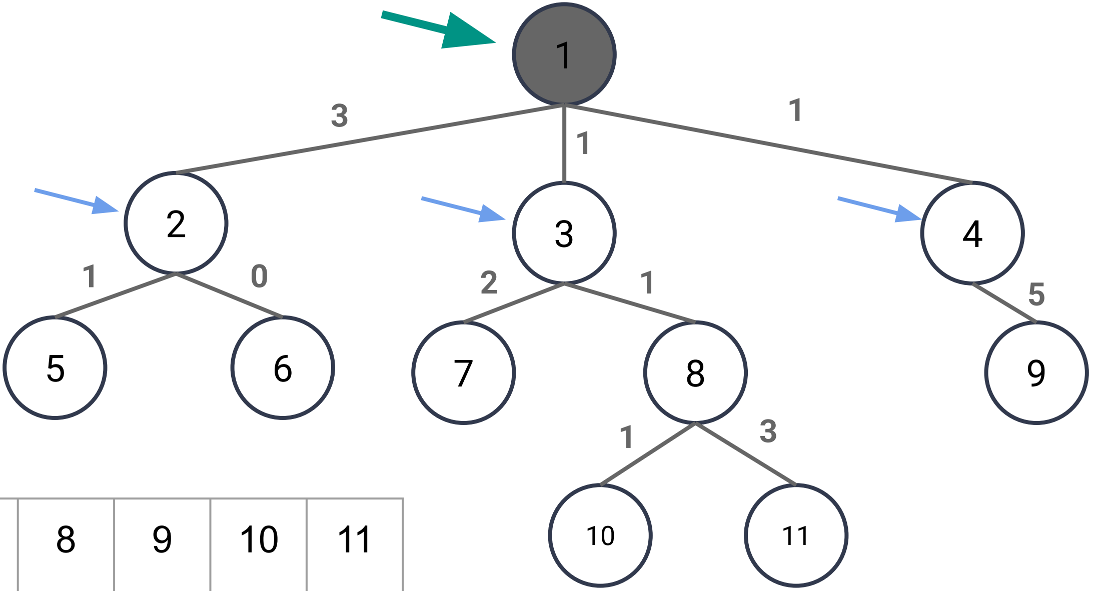
Fringe: 1
Expanded:



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3	2	6	3	5

Exercise 1 – b

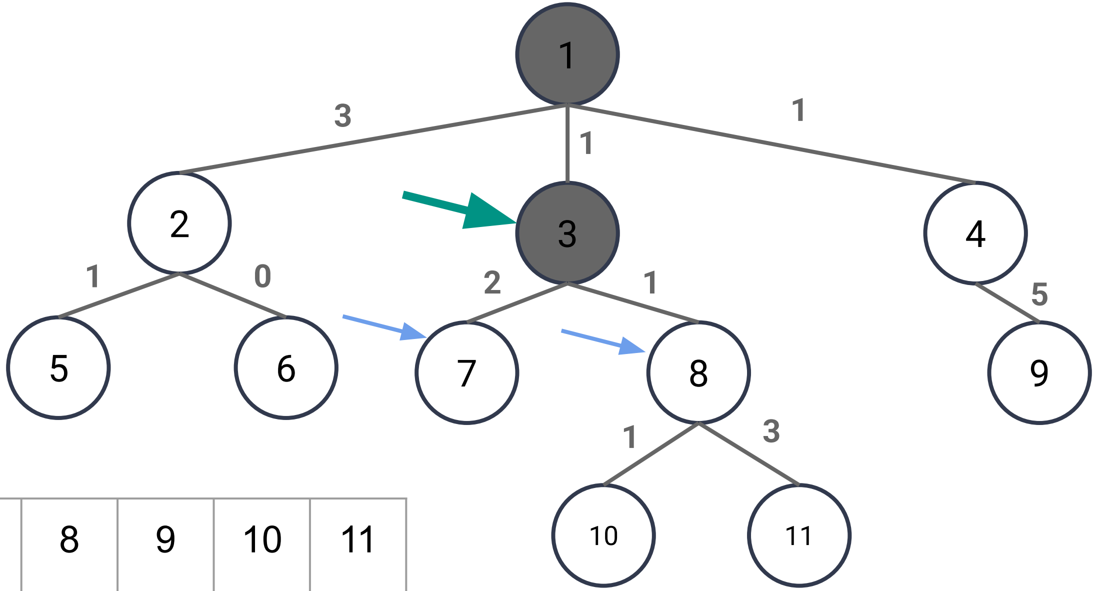
Fringe: (3, 1), (4, 1), (2, 3)
Expanded: 1



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3	2	6	3	5

Exercise 1 – b

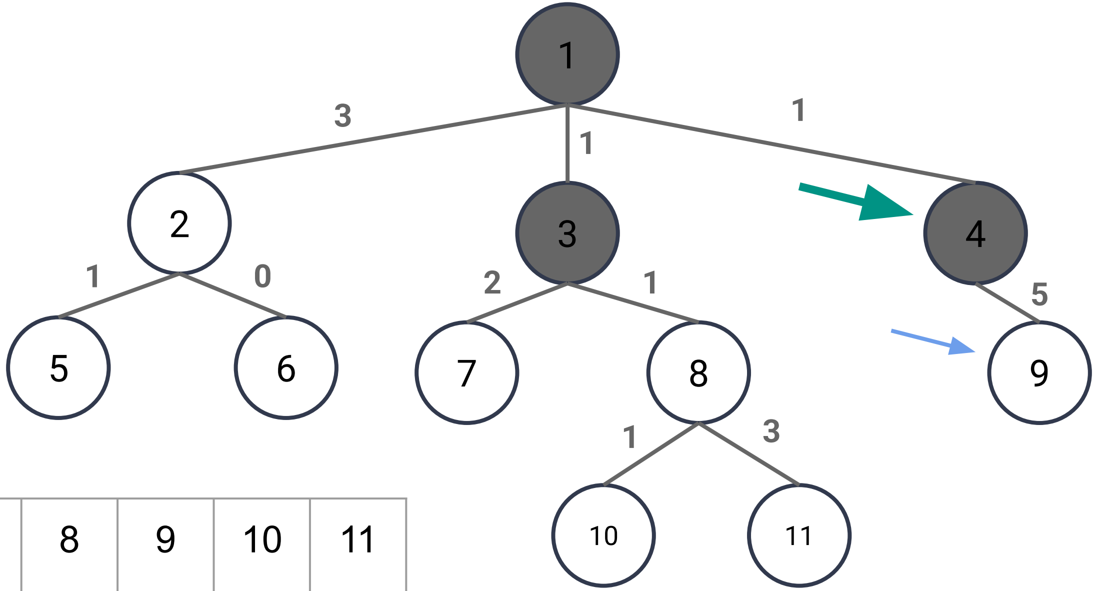
Fringe: (4, 1), **(8, 2)**, (2, 3), **(7, 3)**
Expanded: 1, (3, 1)



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3	2	6	3	5

Exercise 1 – b

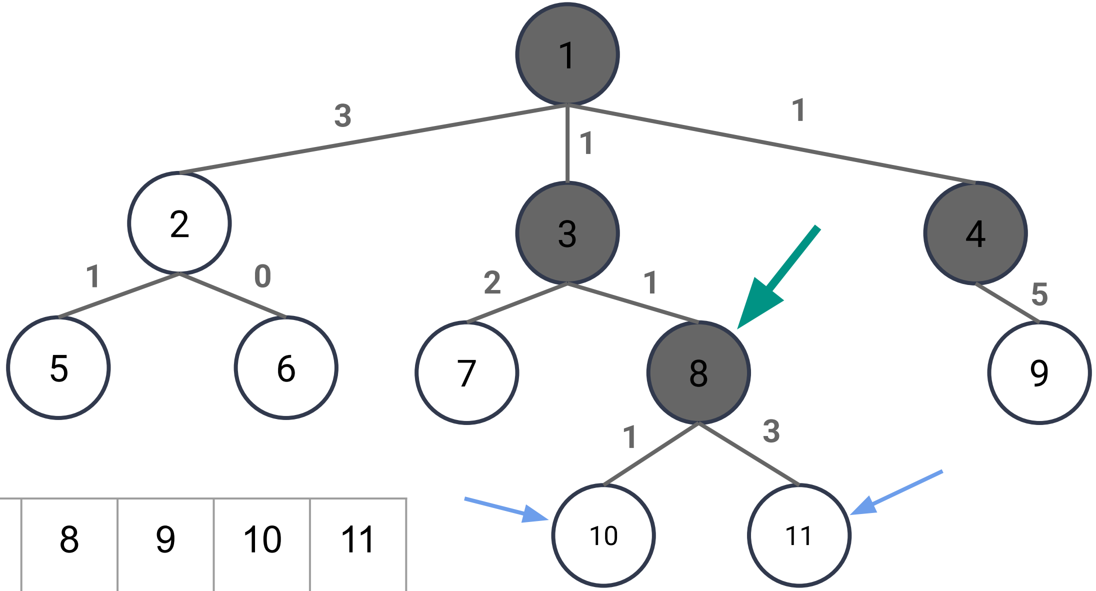
Fringe: (8, 2), (2, 3), (7, 3), **(9, 6)**
Expanded: 1, (3, 1), (4, 1)



node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3	2	6	3	5

Exercise 1 – b

Fringe: (2, 3), **(10, 3)**, (7, 3), **(11, 5)**, (9, 6)
Expanded: 1, (3, 1), (4, 1), (8, 2)

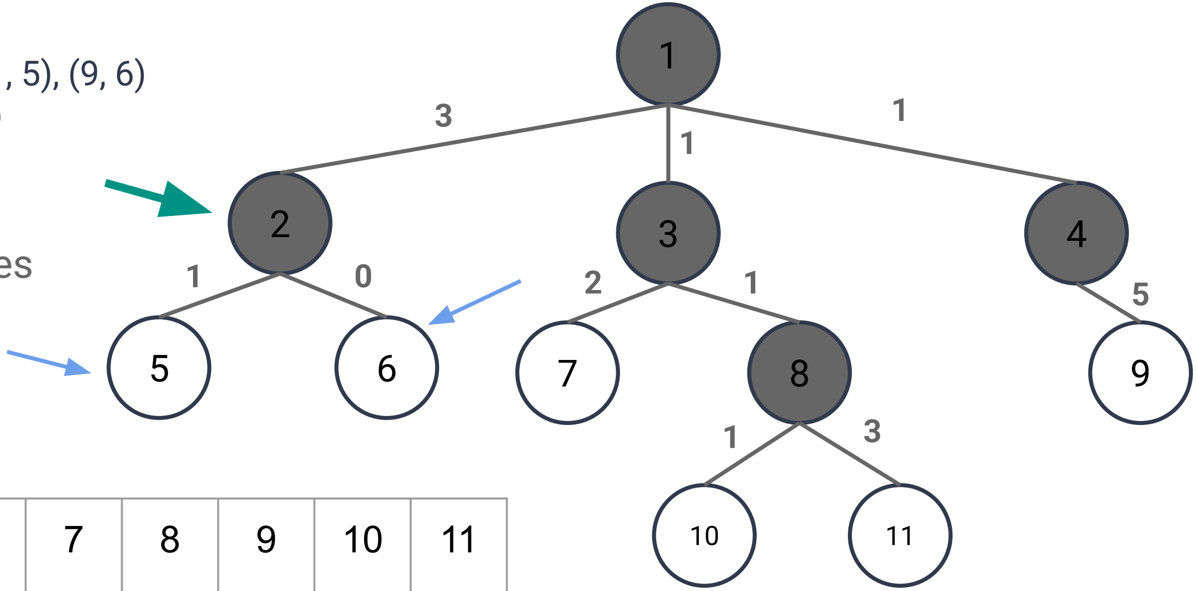


node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3	2	6	3	5

Exercise 1 – b

Fringe: (6, 3), (10, 3), (7, 3), **(5, 4)**, (11, 5), (9, 6)
Expanded: 1, (3, 1), (4, 1), (8, 2), (2, 3)

Continue until expanded all nodes

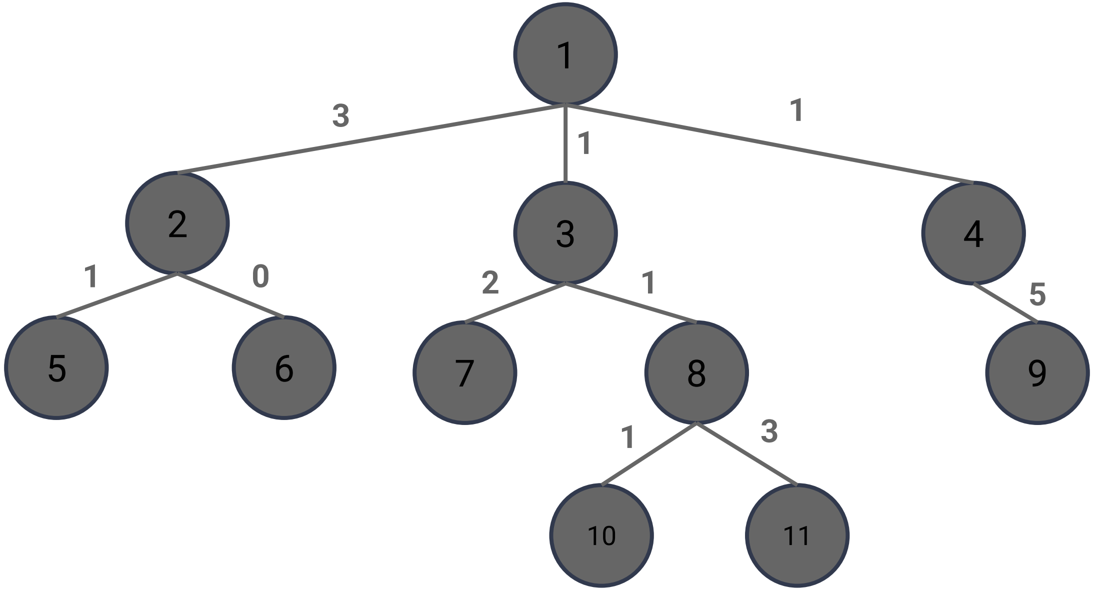


node	2	3	4	5	6	7	8	9	10	11
g(n)	3	1	1	4	3	3	2	6	3	5

Exercise 1 – b

Solution

Expanded: 1, 3, 4, 8, 2, 6, 7, 10, 5, 11, 9



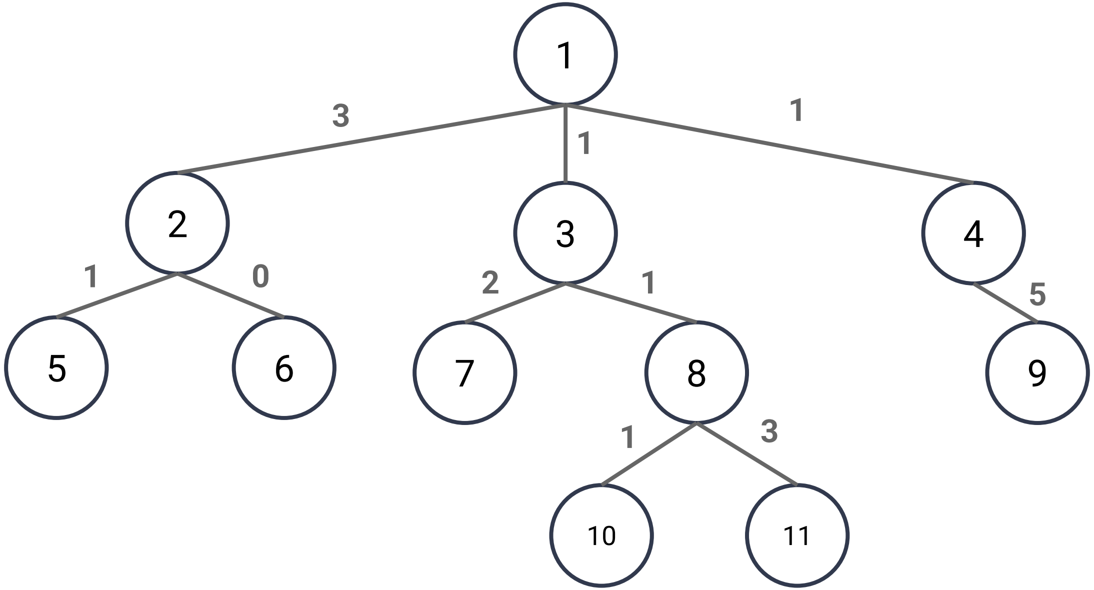
Next: Exercise 1c

Depth-First Search

- Expands the **deepest** unexpanded node
- Insert children **at the front** of the **fringe**
- **Complete - No** (in infinite space), **Yes** (in finite space)
- **Optimal - No**

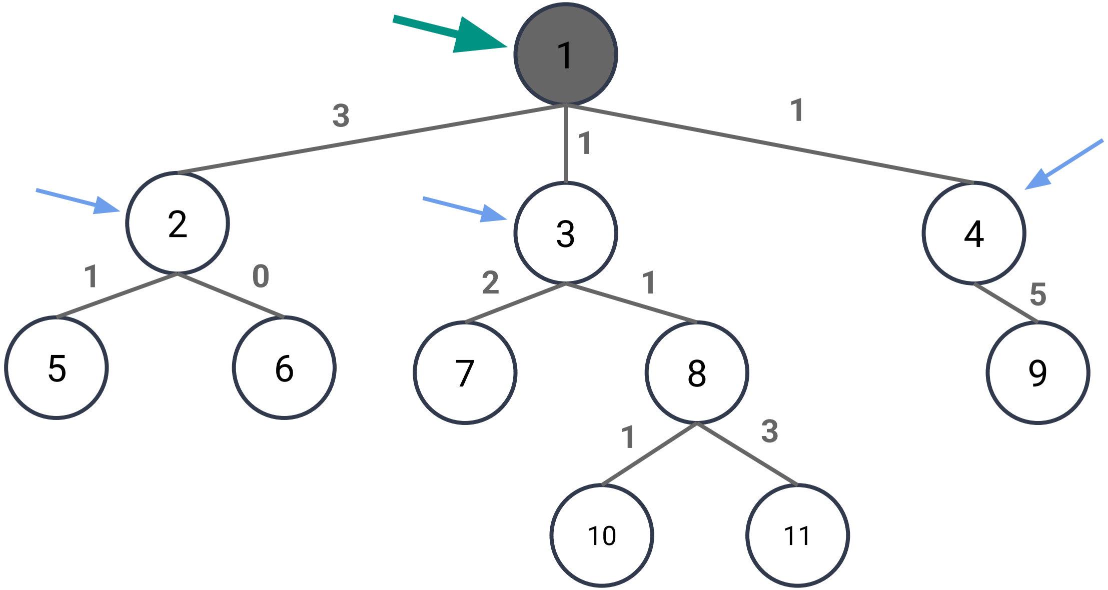
Exercise 1 – c

Fringe: 1
Expanded:



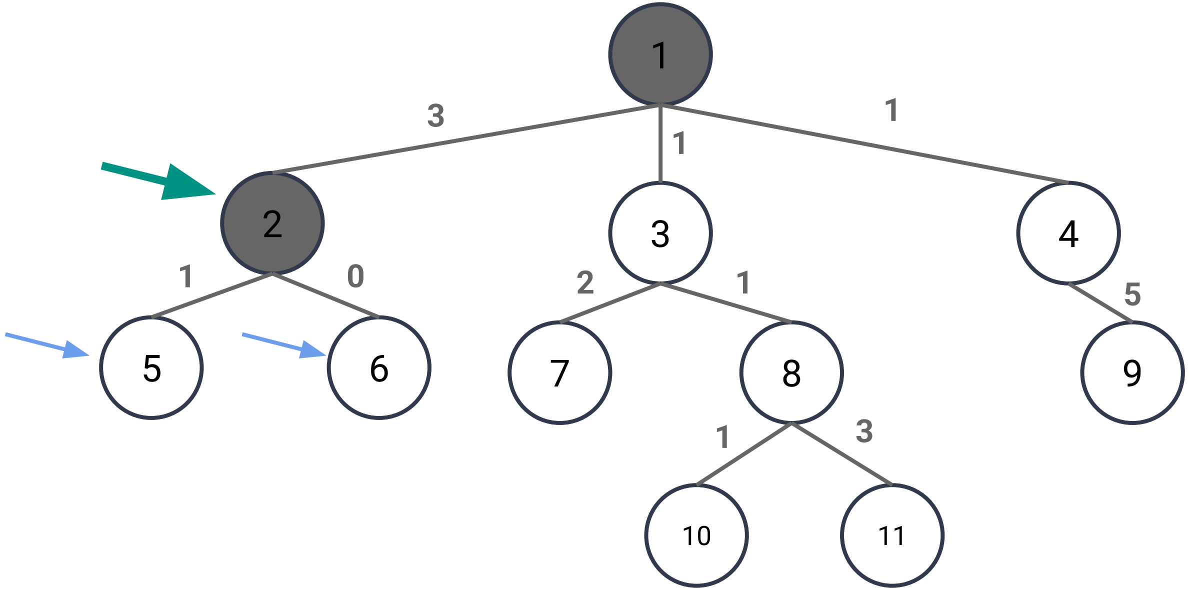
Exercise 1 – c

Fringe: 2, 3, 4
Expanded: 1



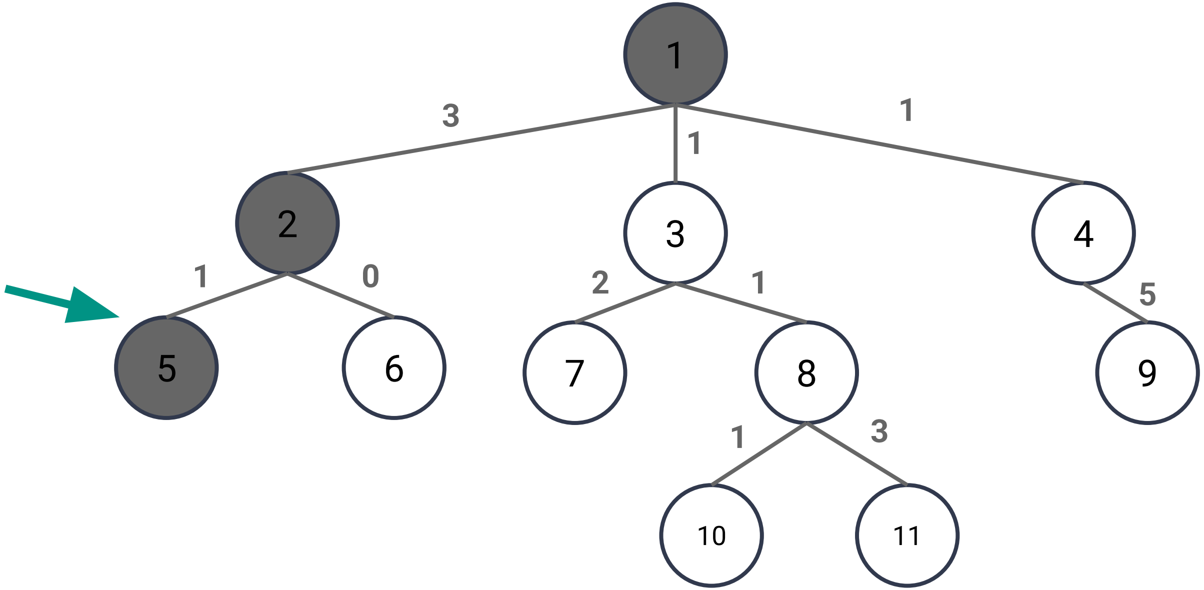
Exercise 1 – c

Fringe: 5, 6, 3, 4
Expanded: 1, 2



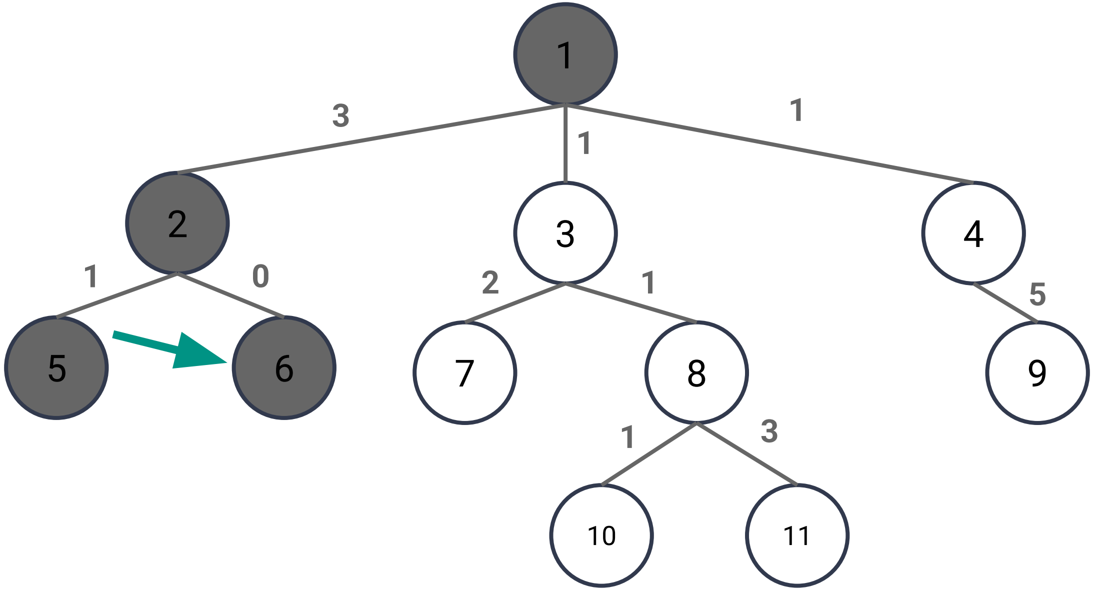
Exercise 1 – c

Fringe: 6, 3, 4
Expanded: 1, 2, 5



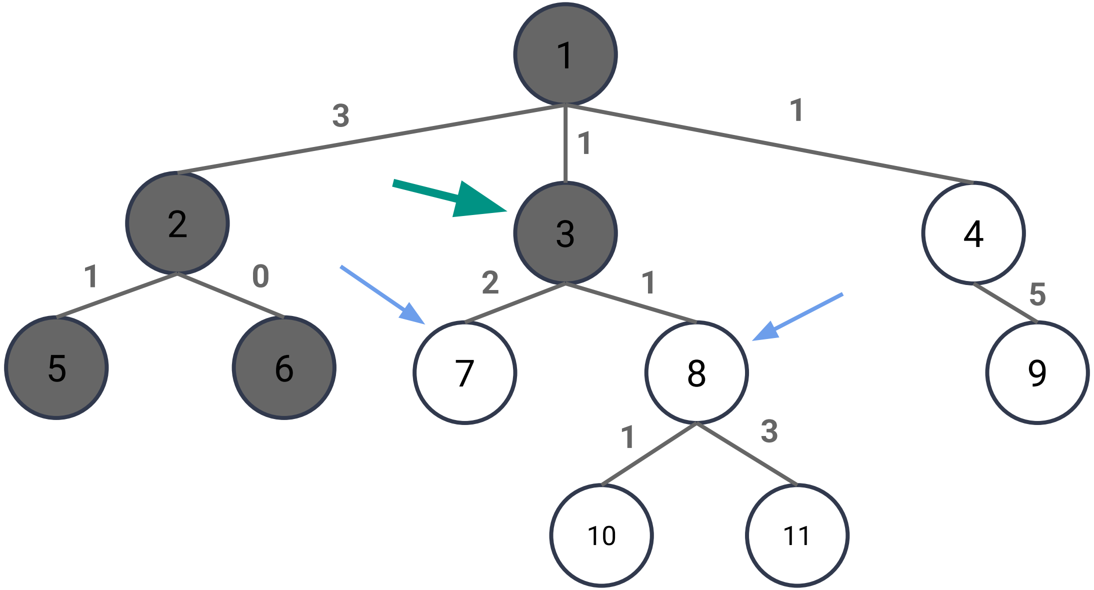
Exercise 1 – c

Fringe: 3, 4
Expanded: 1, 2, 5, 6



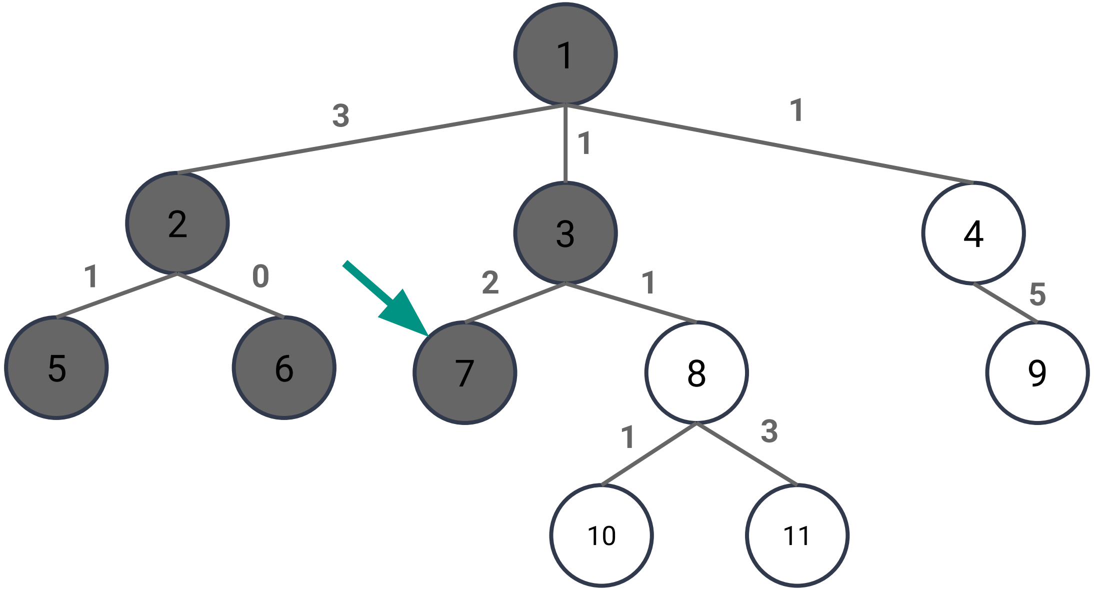
Exercise 1 – c

Fringe: 7, 8, 4
Expanded: 1, 2, 5, 6, 3



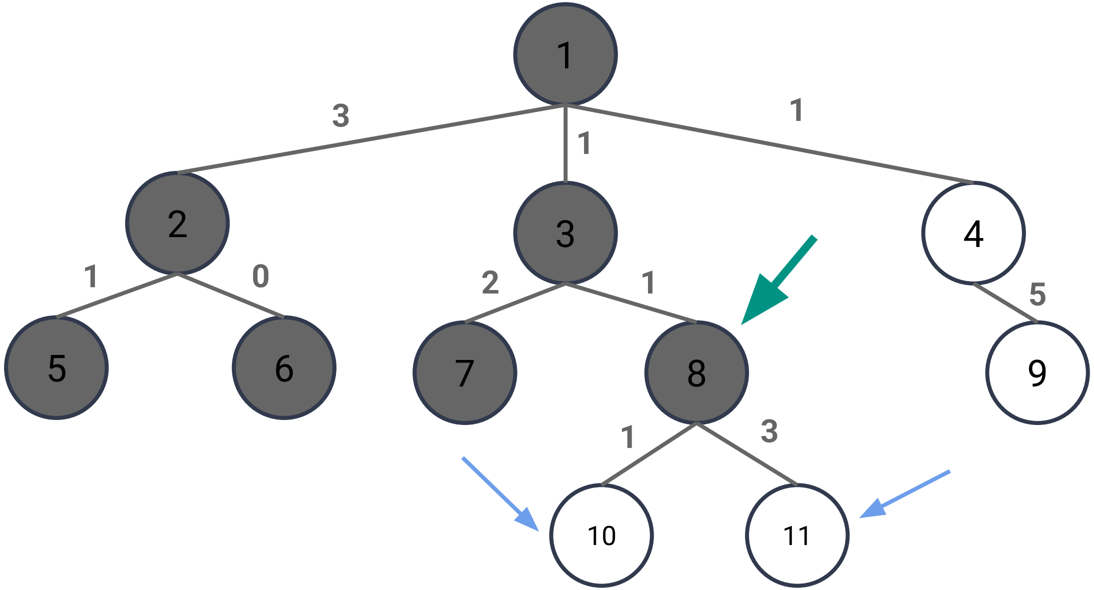
Exercise 1 – c

Fringe: 8, 4
Expanded: 1, 2, 5, 6, 3, 7



Exercise 1 – c

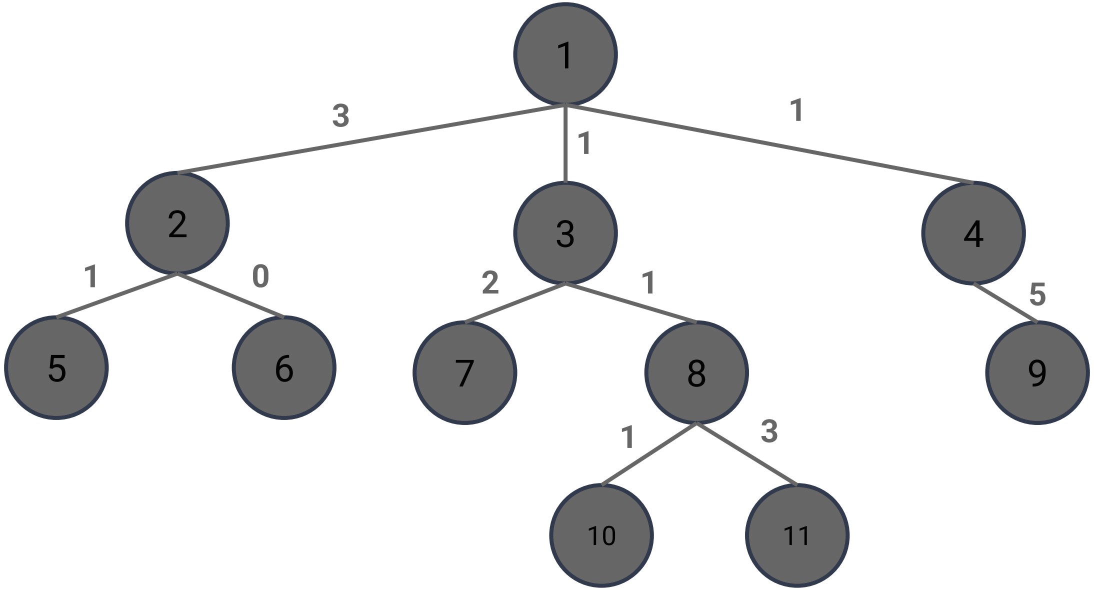
Fringe: 10, 11, 4
Expanded: 1, 2, 5, 6, 3, 7



Exercise 1 – c

Solution

Expanded: 1, 2, 5, 6, 3, 7, 8, 10, 11, 4, 9



Next: Exercise 1d

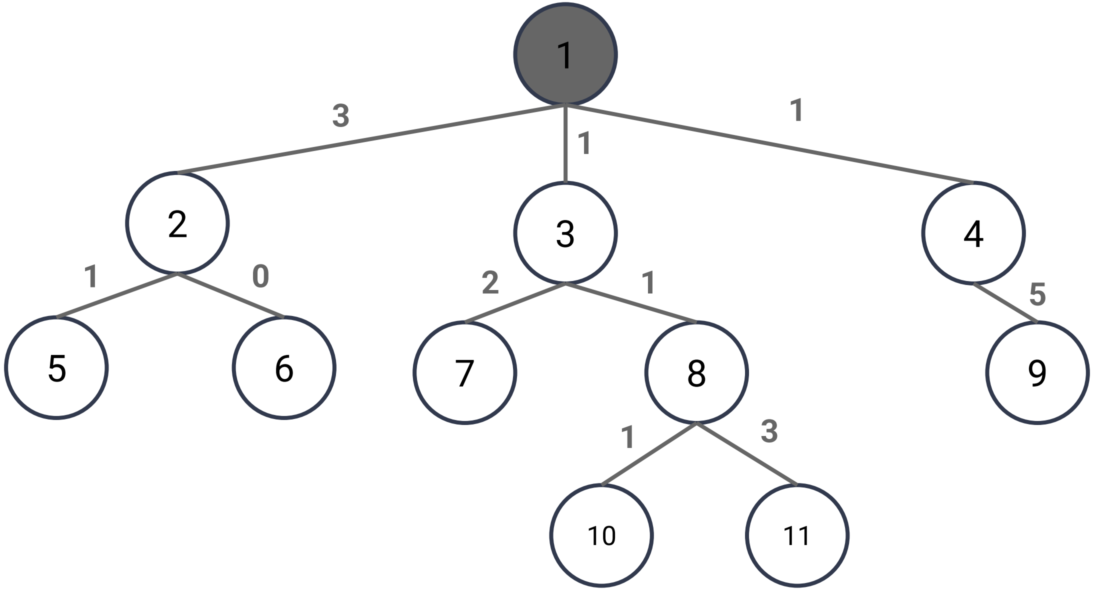
Iterative Deepening Search

- DFS with a depth limit ℓ
- Complete - Yes
- Optimal - No

Exercise 1 – d

- **ℓ = 0**

Expanded: 1



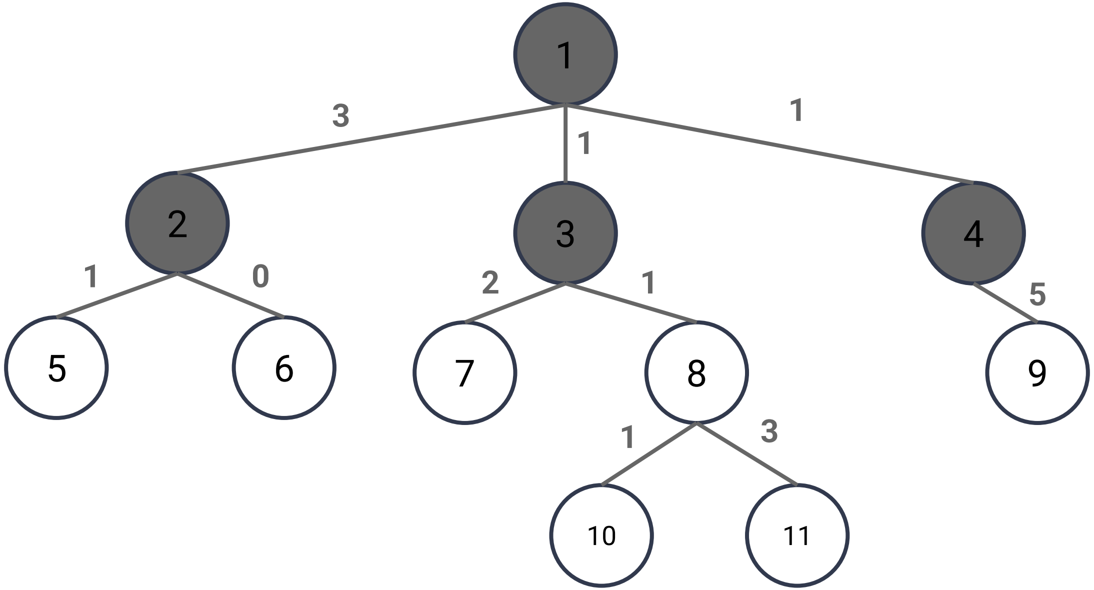
Exercise 1 – d

- ℓ = 0

Expanded: 1

- **ℓ = 1**

Expanded: 1, 2, 3, 4



Exercise 1 – d

- ℓ = 0

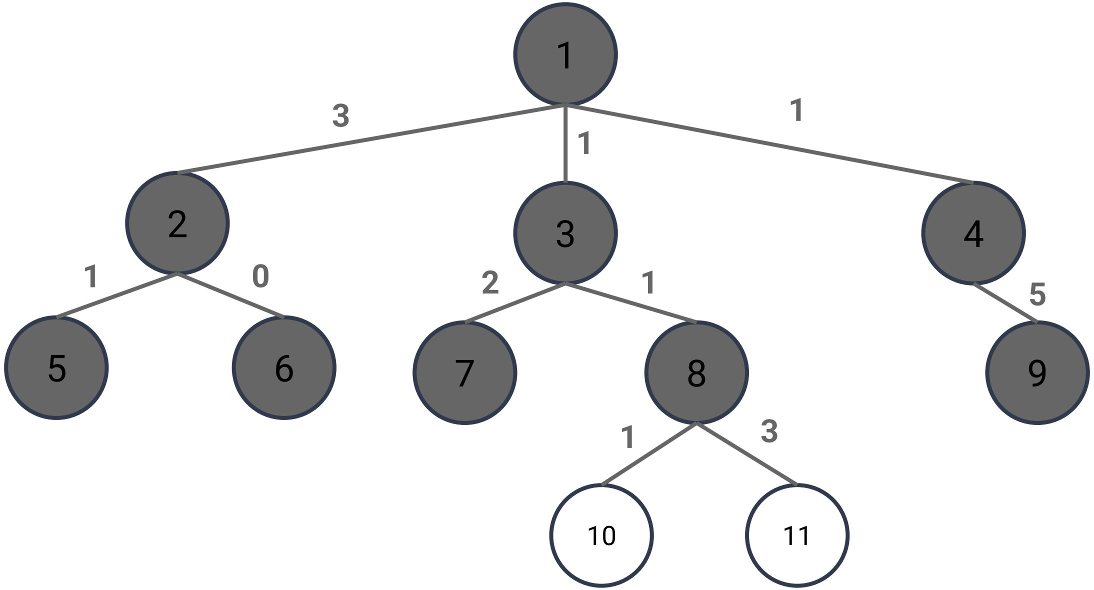
Expanded: 1

- ℓ = 1

Expanded: 1, 2, 3, 4

- **ℓ = 2**

Expanded: 1, 2, 5, 6, 3, 7, 8, 4, 9



Exercise 1 – d

- ℓ = 0

Expanded: 1

- ℓ = 1

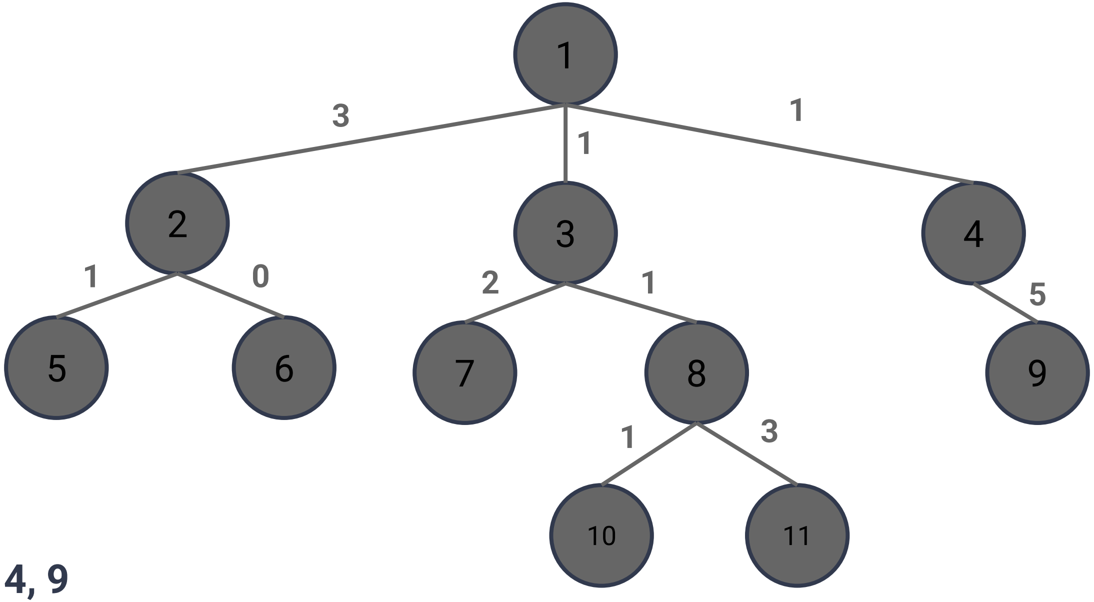
Expanded: 1, 2, 3, 4

- ℓ = 2

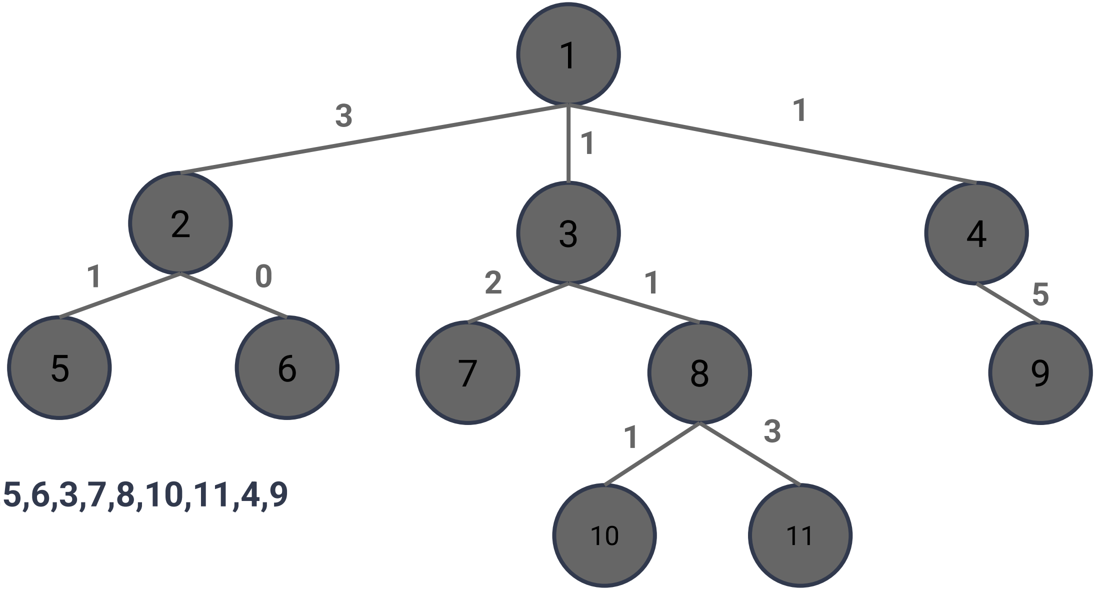
Expanded: 1, 2, 5, 6, 3, 7, 8, 4, 9

- **ℓ = 3**

Expanded: 1, 2, 5, 6, 3, 7, 8, 10, 11, 4, 9



Exercise 1 – d



Solution

Expanded: 1, 1,2,3,4, 1,2,5,6,3,7,8,4,9, 1,2,5,6,3,7,8,10,11,4,9

Next: Exercise 2

Exercise 2

Solution

a) BFS: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

b) UCF: 1, 4, 3, 9, 2, 7, 8, 6, 11, 12, 5, 10, 13

c) DFS: 1, 2, 5, 6, 10, 11, 3, 7, 12, 13, 4, 8, 9

d) IDS: 1,   1, 2, 3, 4,   1, 2, 5, 6, 3, 7, 4, 8, 9   1, 2, 5, 6, 10, 11, 3, 7, 12, 13, 4, 8, 9

Next: Exercise 3

Greedy Search

- Use heuristic value - ***h(n)***
- *h(n)* is the estimated cost from *n* to a goal node
- **Expand node with the smallest *h* value**
- **Optimal - No**
- **Complete - Yes** (in finite space), **No** (in infinite space)

Exercise 3

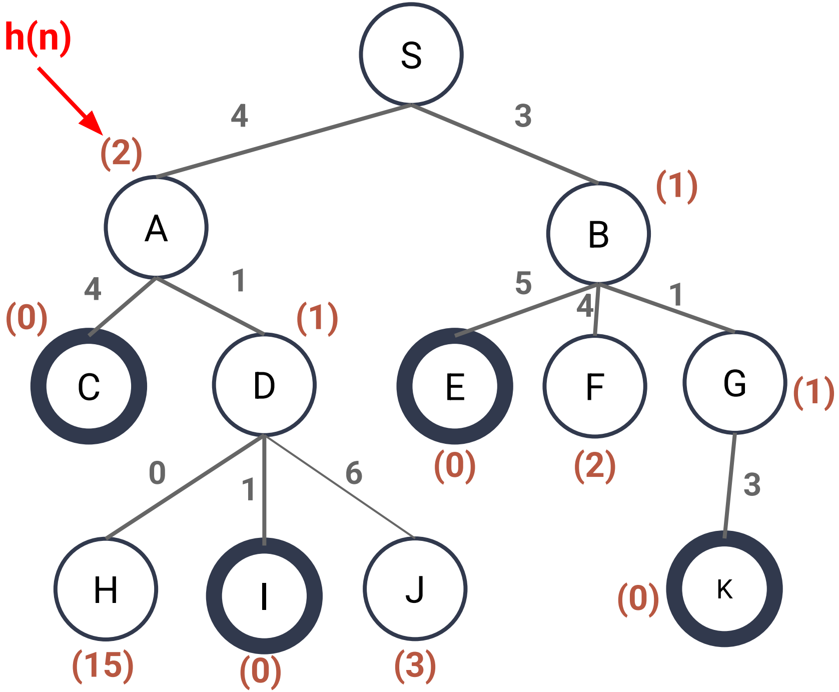
Greedy Search

Show:

1. **List of expanded nodes**
2. **Solution path**
3. **Path Cost**

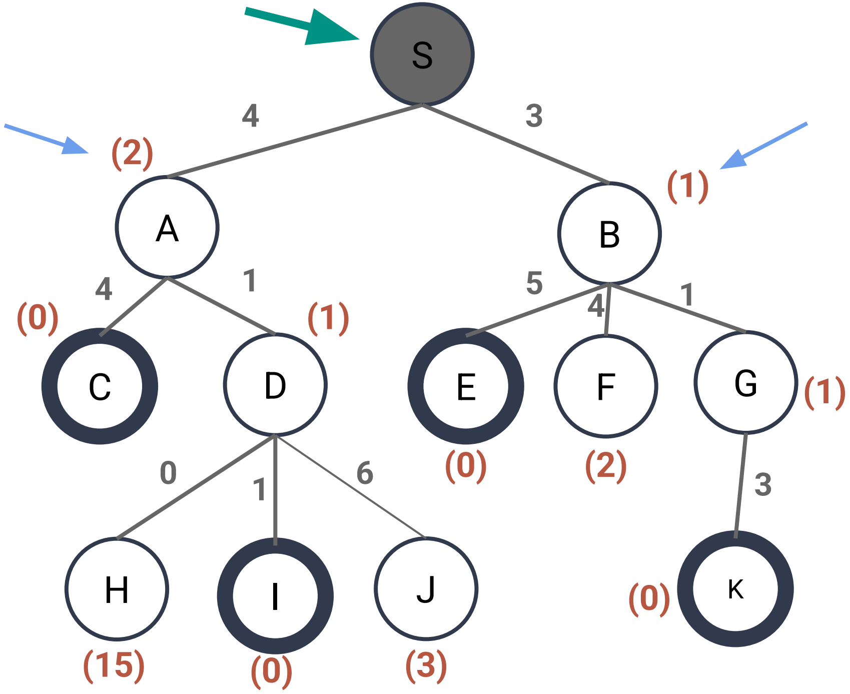
*Same priority -> Expand last added

Fringe: S
Expanded:



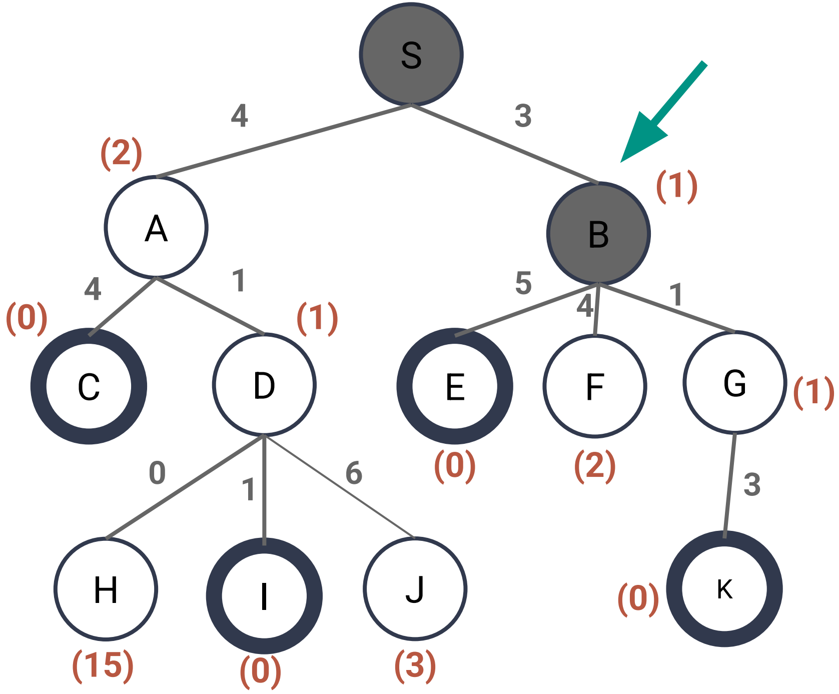
Exercise 3

Fringe: (B, 1), (A, 2)
Expanded: S



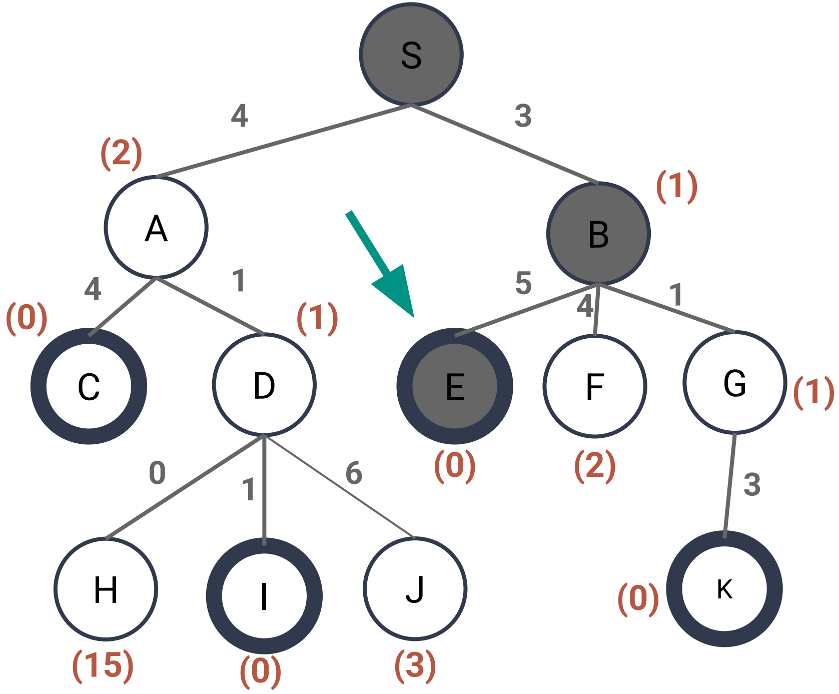
Exercise 3

Fringe: (E, 0), **(G, 1)**, **(F, 2)**, (A, 2)
Expanded: S, (B, 1)



Exercise 3

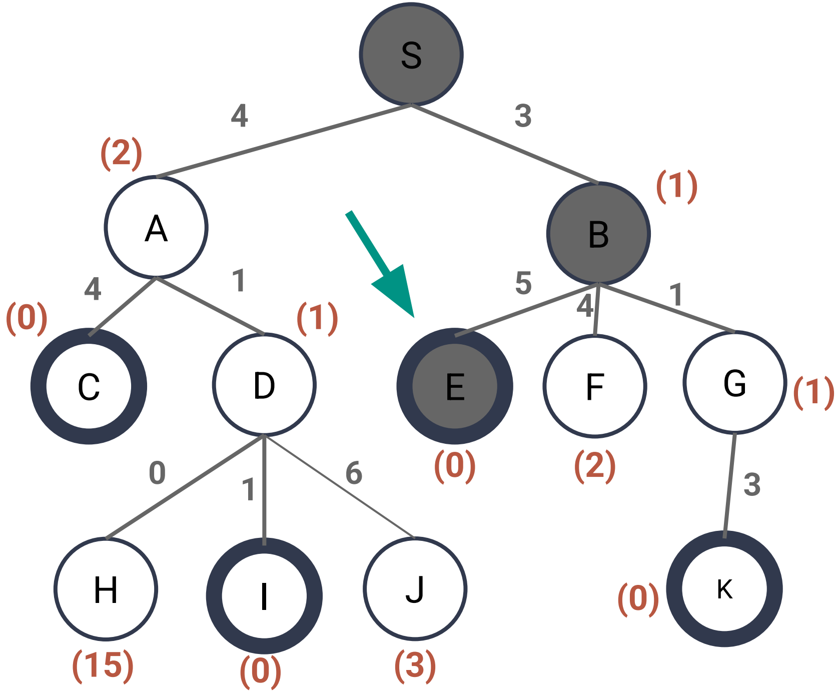
Fringe: (G, 1), (F, 2), (A, 2)
Expanded: S, (B, 1), (E, 0)



Exercise 3

Fringe: (G, 1), (F, 2), (A, 2)
Expanded: S, (B, 1), (E, 0)

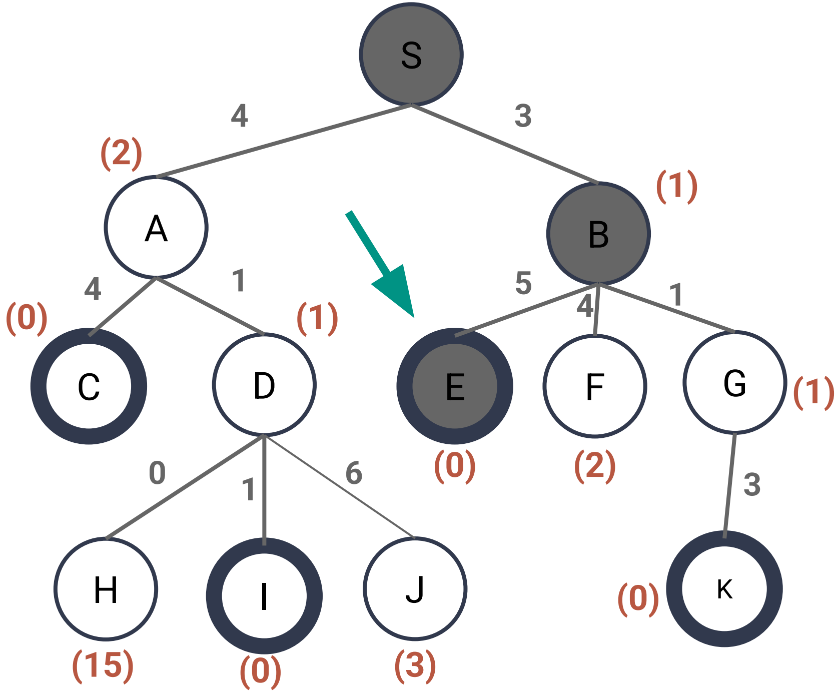
Do we stop?



Exercise 3

Fringe: (G, 1), (F, 2), (A, 2)
Expanded: S, (B, 1), (E, 0)

Do we stop?
YES (because E is a goal node)

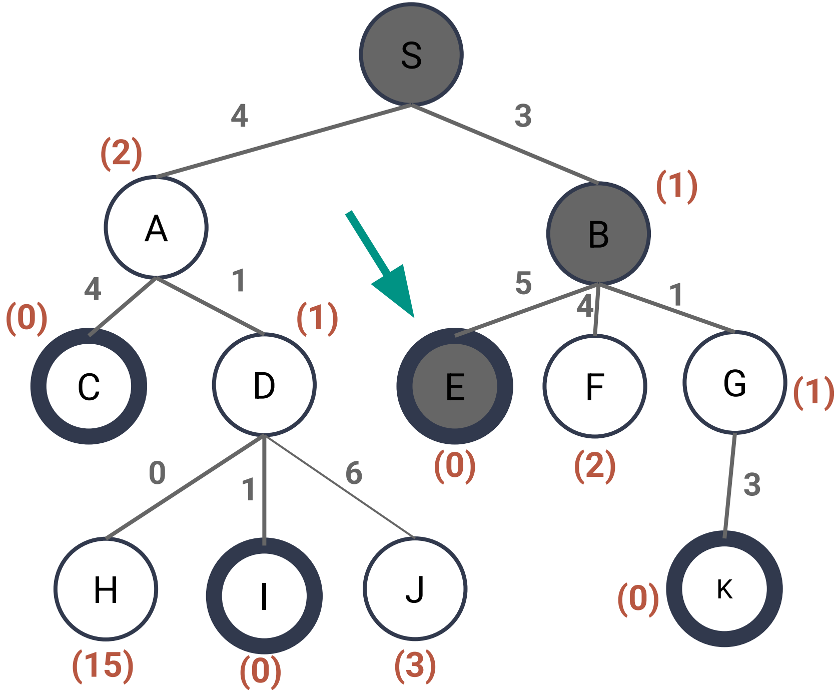


Exercise 3

What nodes were **expanded?**

What is the **path found?**

What is the **cost of the path found?**

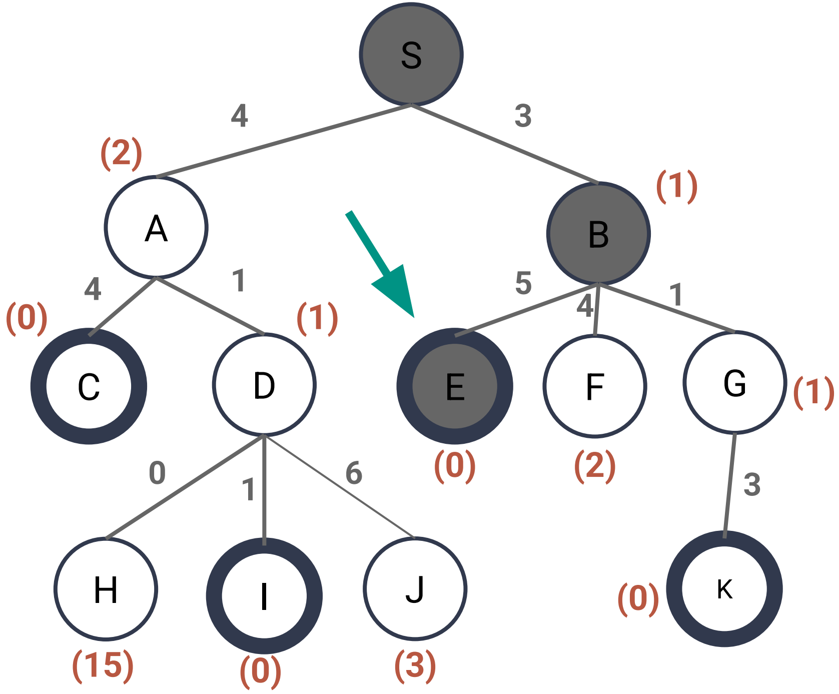


Exercise 3

What nodes were **expanded?**
SBE

What is the **path found?**

What is the **cost of the path found?**

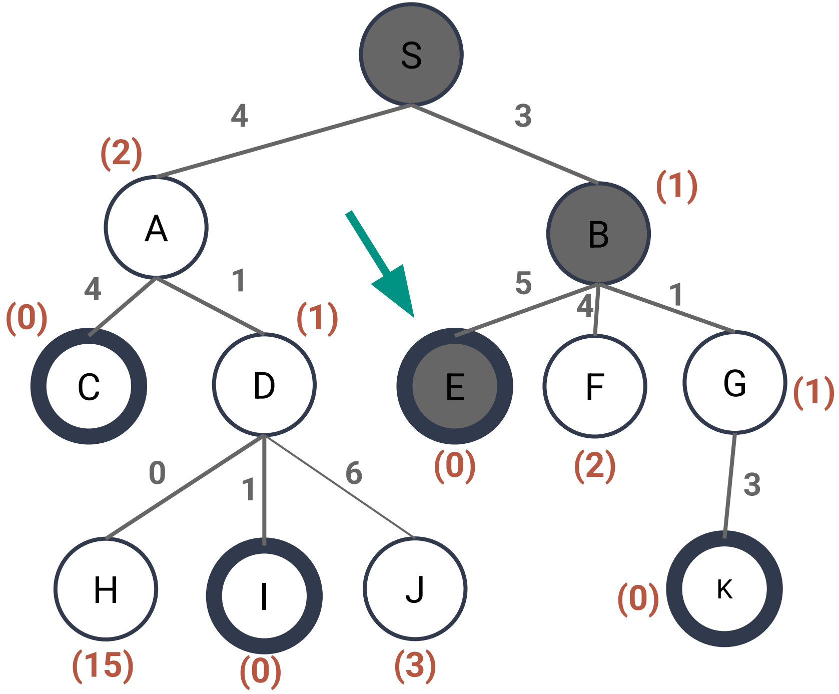


Exercise 3

What nodes were **expanded?**
SBE

What is the **path found?**
SBE

What is the **cost of the path found?**

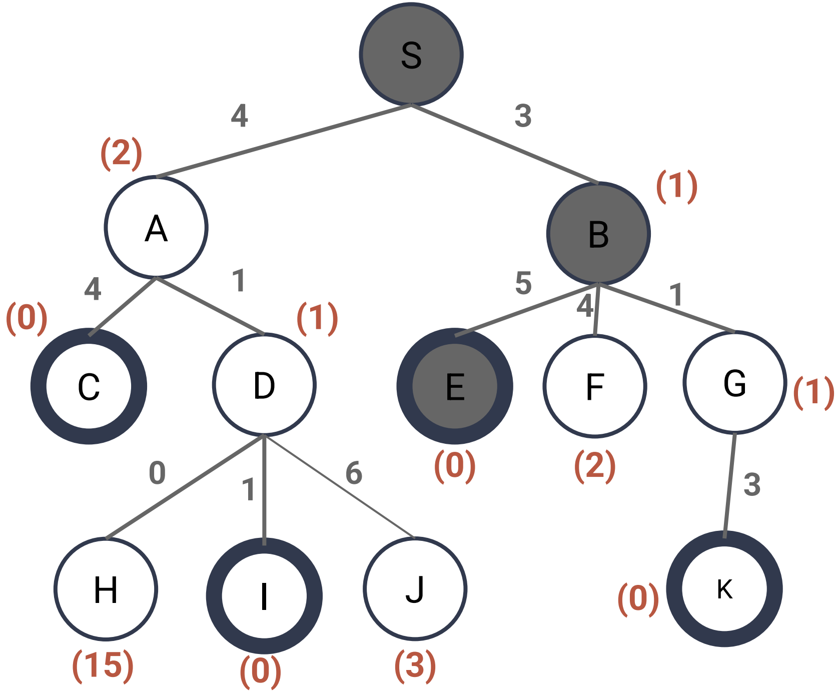


Exercise 3

What nodes were **expanded?**
SBE

What is the **path found?**
SBE

What is the **cost of the path found?**
3 + 5 = 8



Exercise 3

What nodes were expanded?

SBE

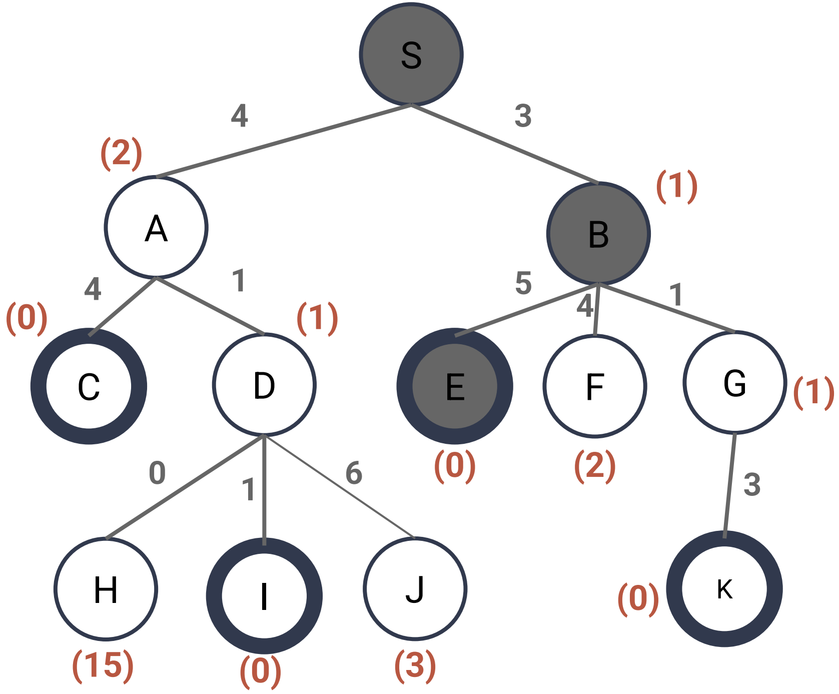
What is the path found?

SBE

What is the cost of the path found?

3 + 5 = 8

Is this solution <u>optimal</u> (lowest path cost)?



Exercise 3

What nodes were expanded?

SBE

What is the path found?

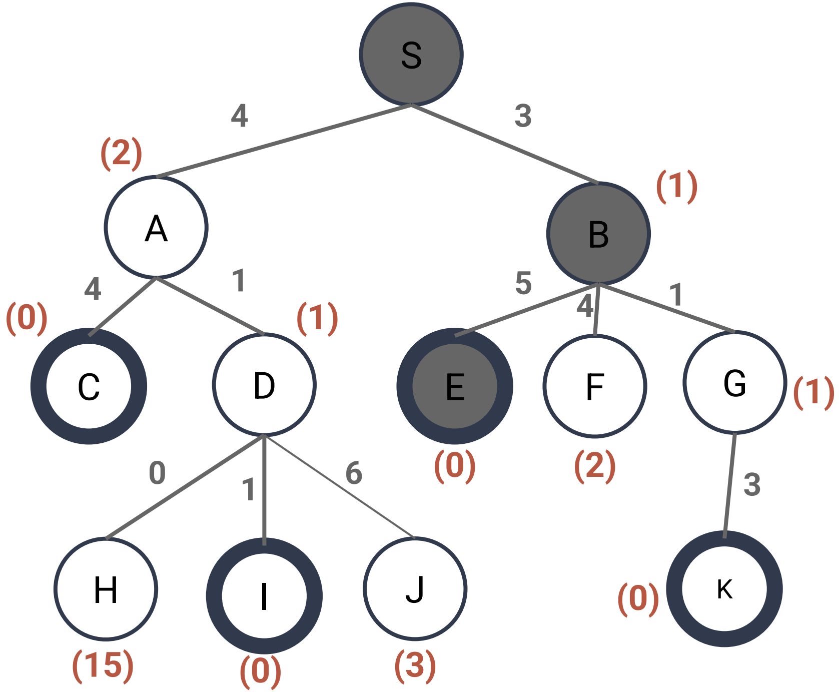
SBE

What is the cost of the path found?

3 + 5 = 8

Is this solution <u>optimal</u> (lowest path cost)?

NO



Exercise 3

What nodes were expanded?

SBE

What is the path found?

SBE

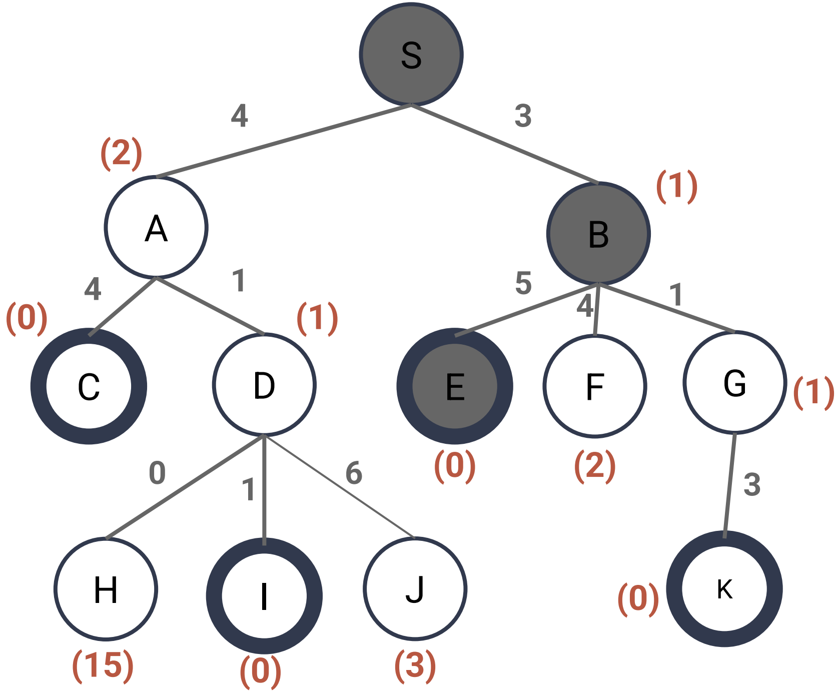
What is the cost of the path found?

3 + 5 = 8

Is this solution <u>optimal</u> (lowest path cost)?

NO

What is the <u>optimal</u> solution?



Exercise 3

What nodes were expanded?

SBE

What is the path found?

SBE

What is the cost of the path found?

3 + 5 = 8

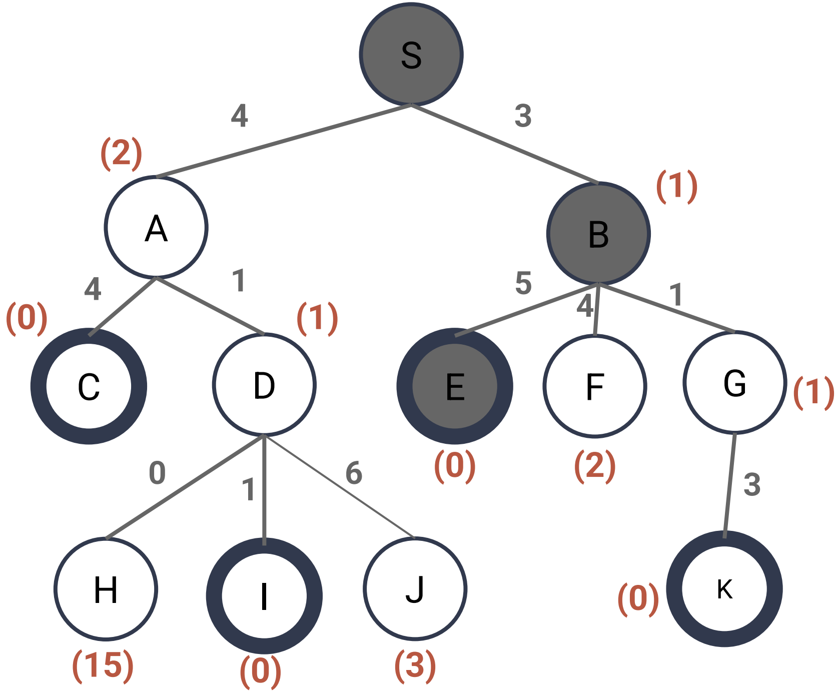
Is this solution optimal (lowest path cost)?

NO

What is the optimal solution?

Path: **SADI**

Cost: **4 + 1 + 1 = 6**



Next: Exercise 4

Hint: Start by listing the expanded nodes

Next: Exercise 5

Rook

Move vertically or horizontally.

N rooks problem

Given a empty n x n board:

1. Place 1 rook at left most column
2. Place 1 rook at the left most **(safe)** column, make sure its is **not attacked** by another rook
3. Repeat step 2 until all columns are filled

Show that there are n! goal state