THE UNIVERSITY OF VERMONT
COLLEGE OF ENGINEERING &
MATHEMATICAL SCIENCES

Representing Trees

CS 124 / Department of Computer Science

How do we represent a tree?

Choosing a data structure

- Adjacency list
- Adjacency matrix
- Incidence matrix
- Simple L/R object-oriented approach

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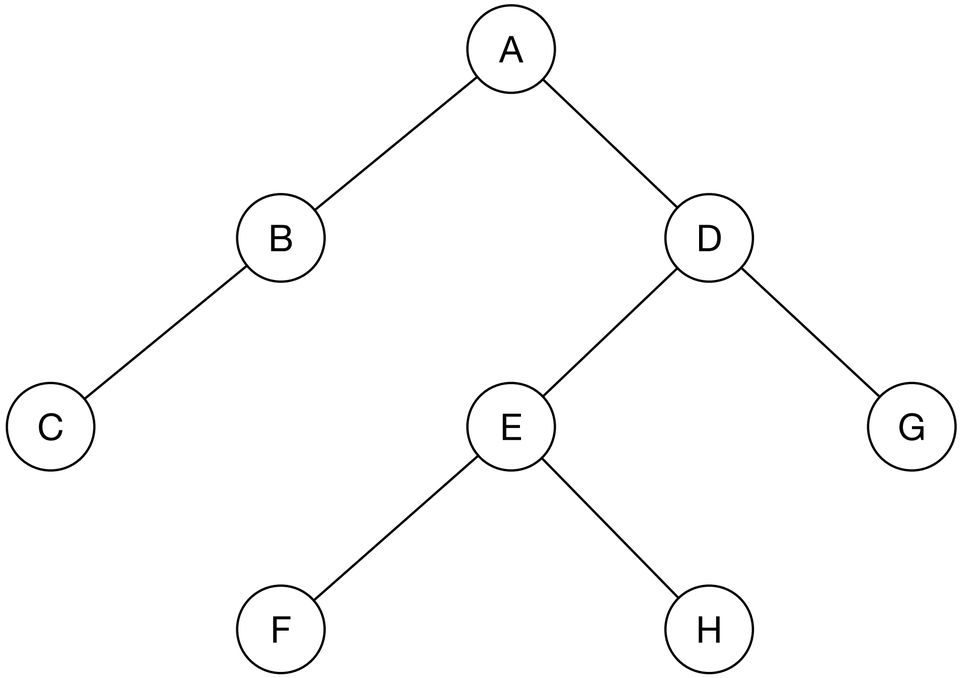
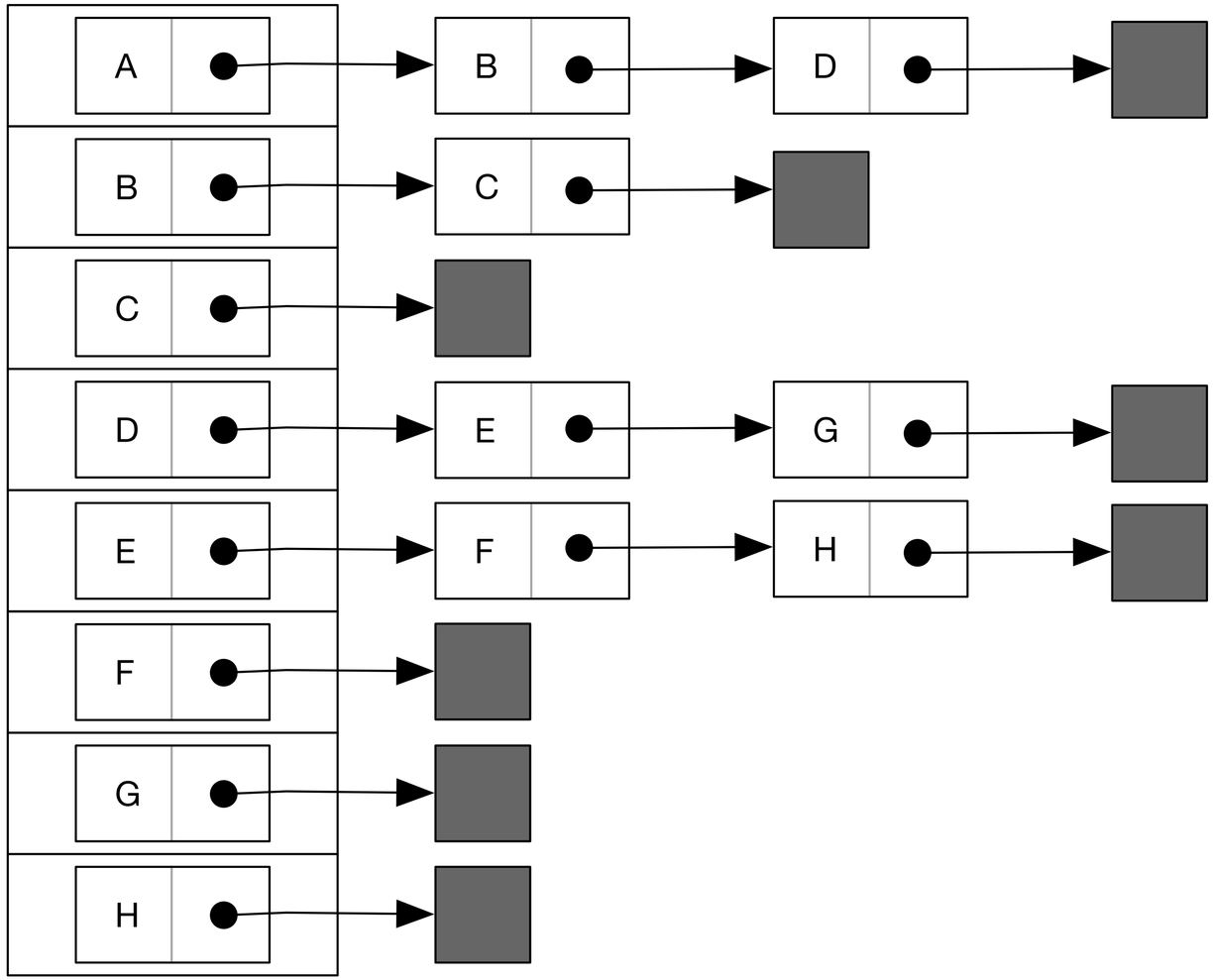
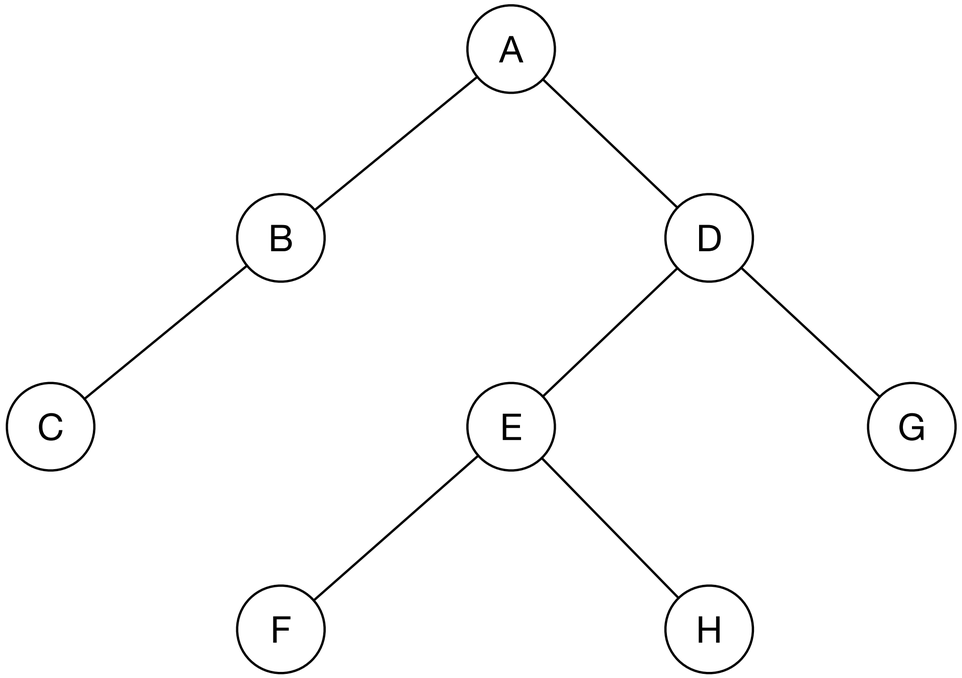
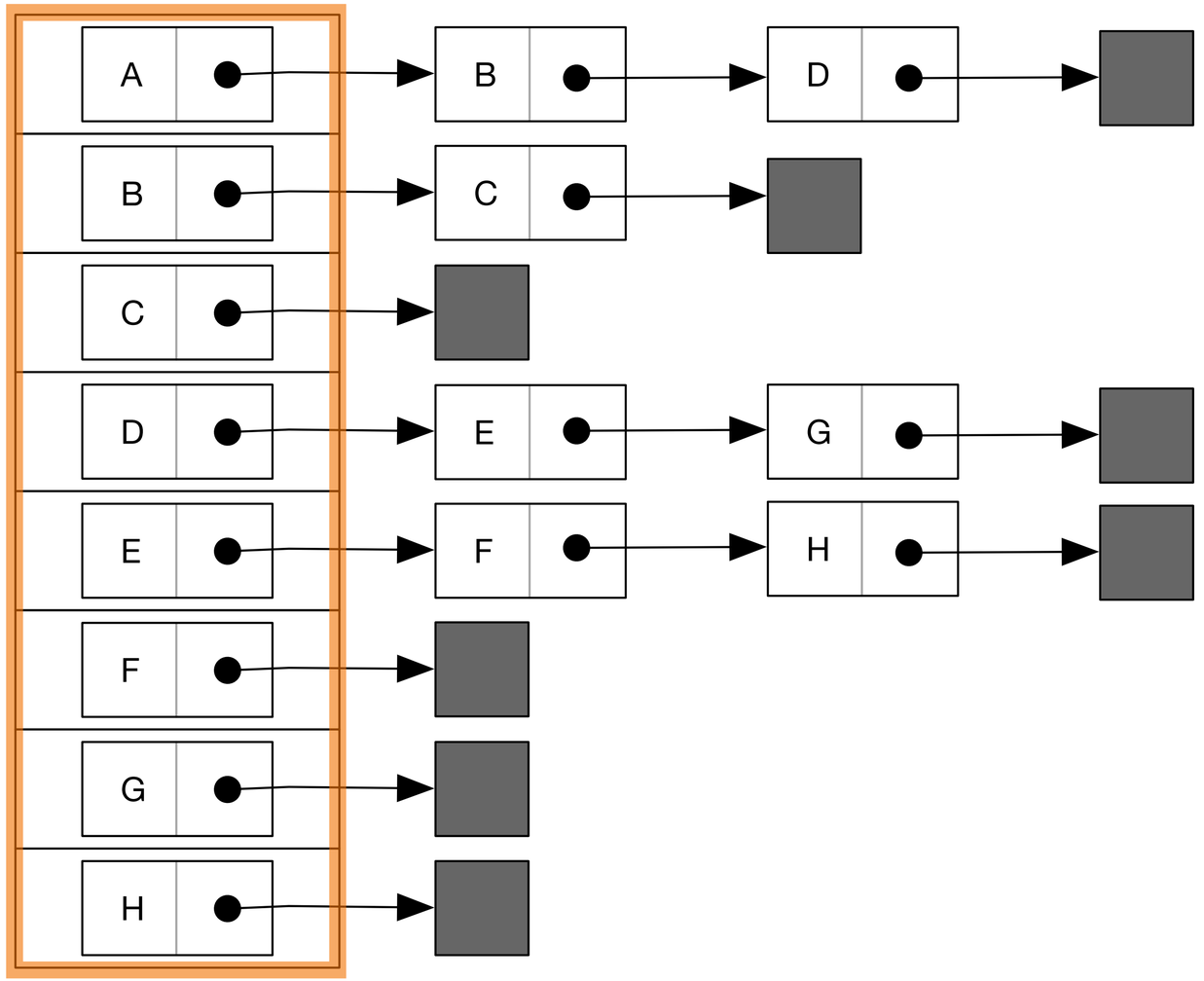
Adjacency list





Adjacency list





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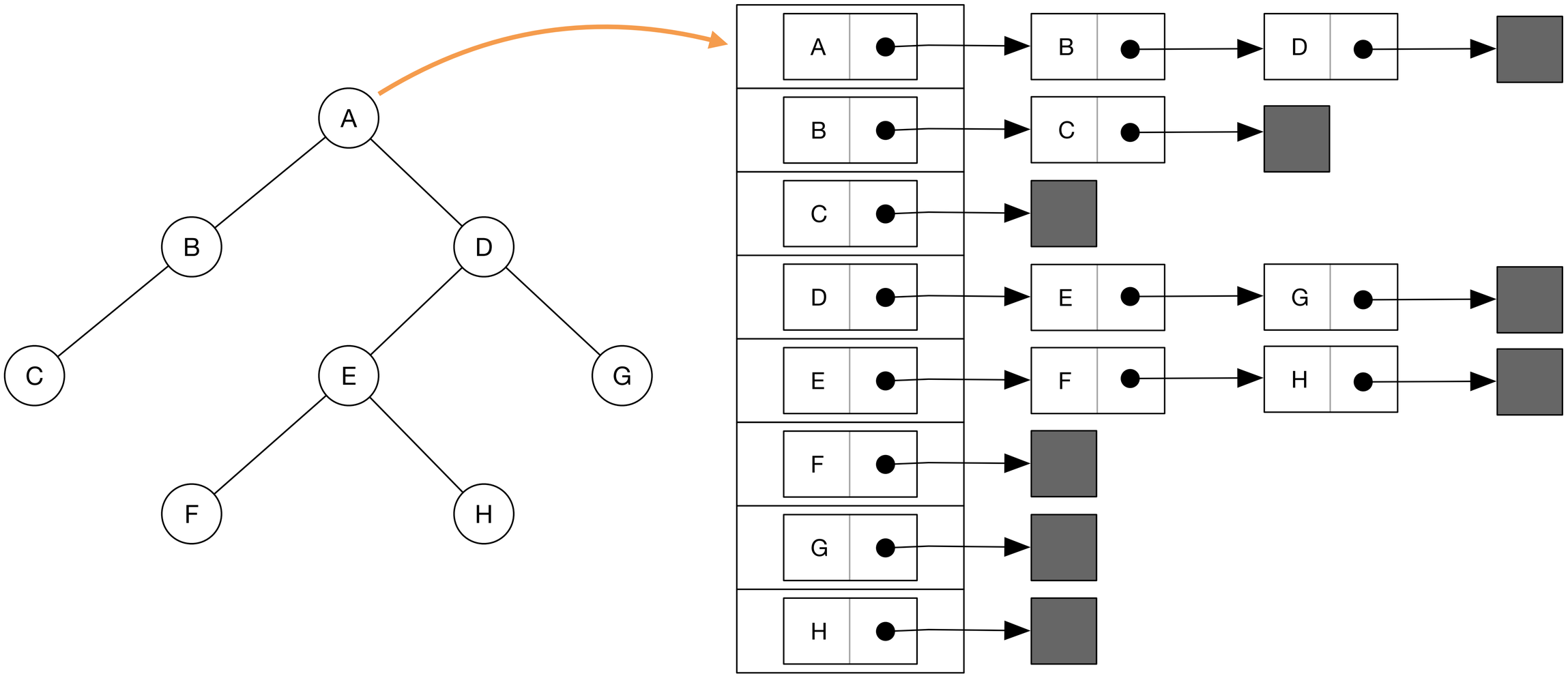

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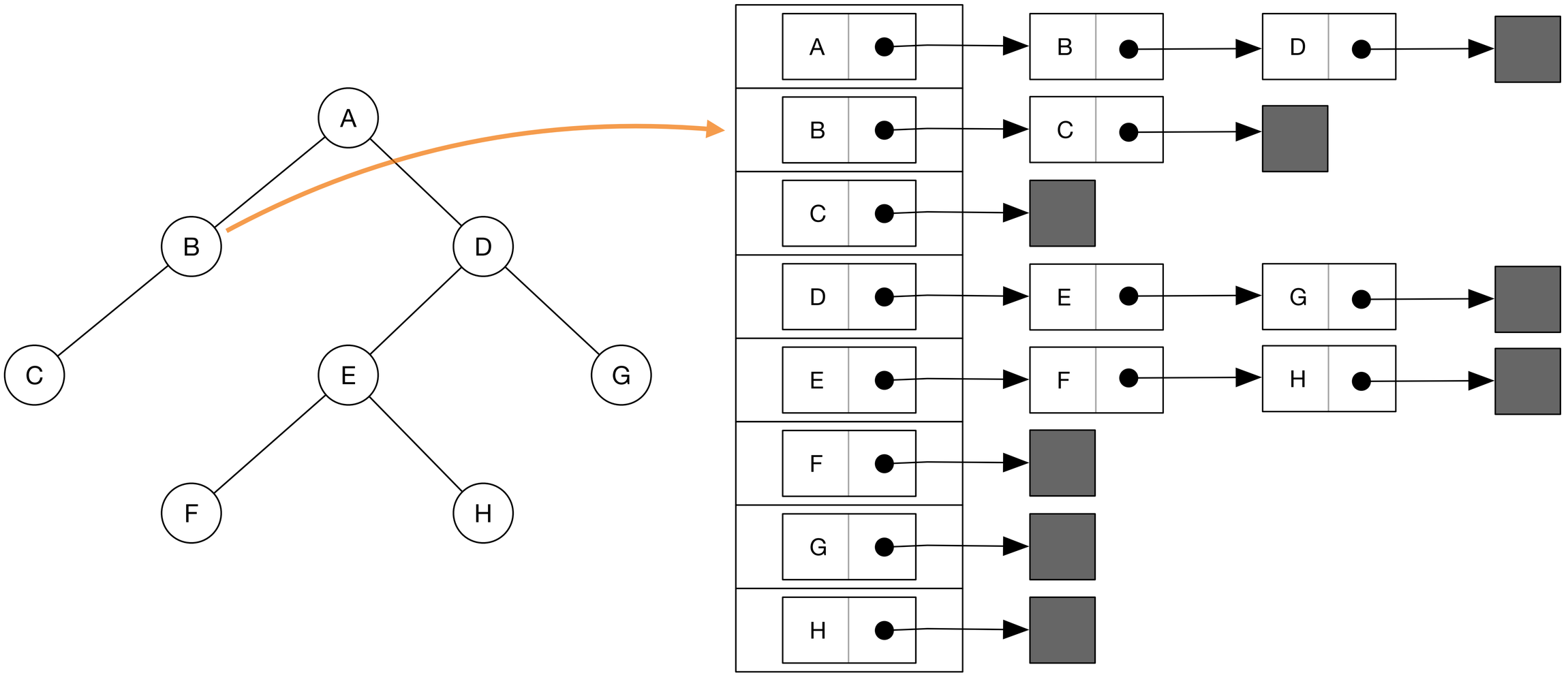

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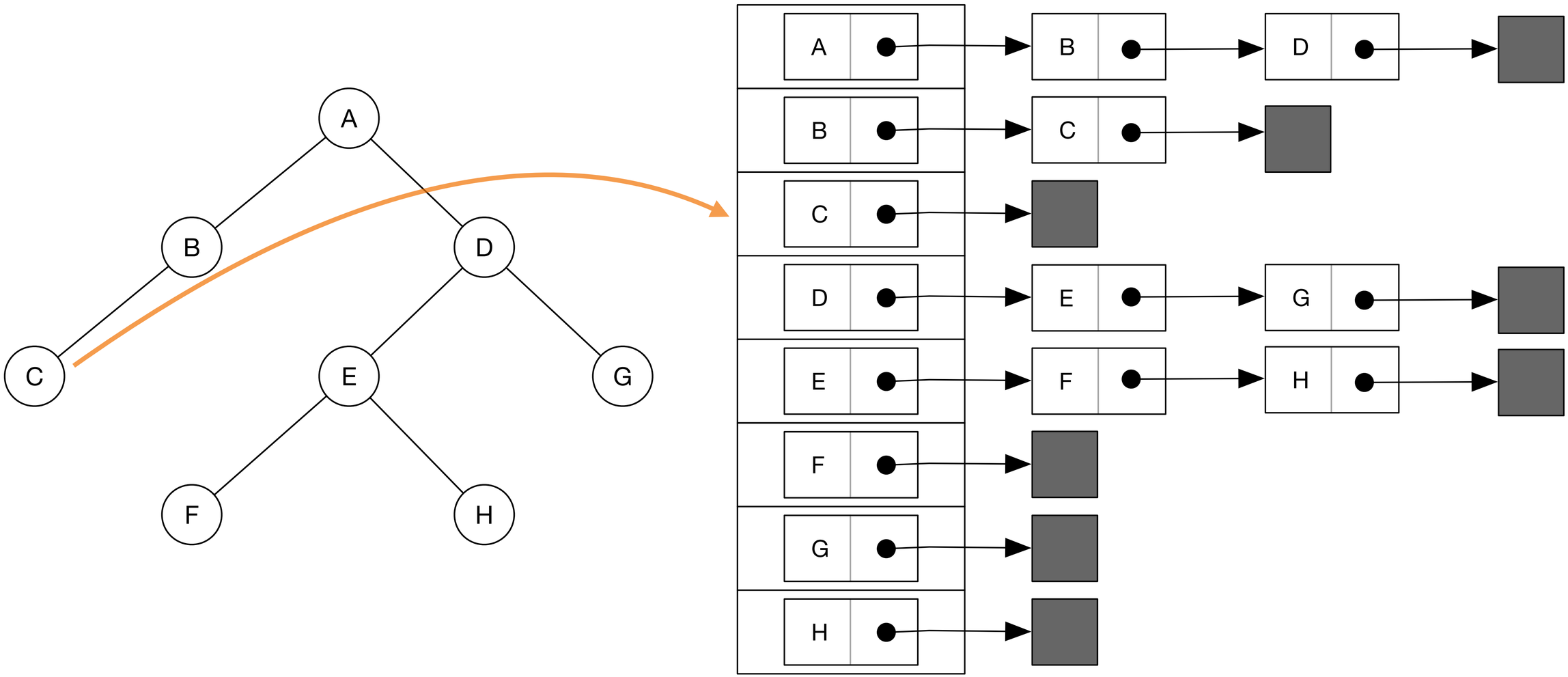

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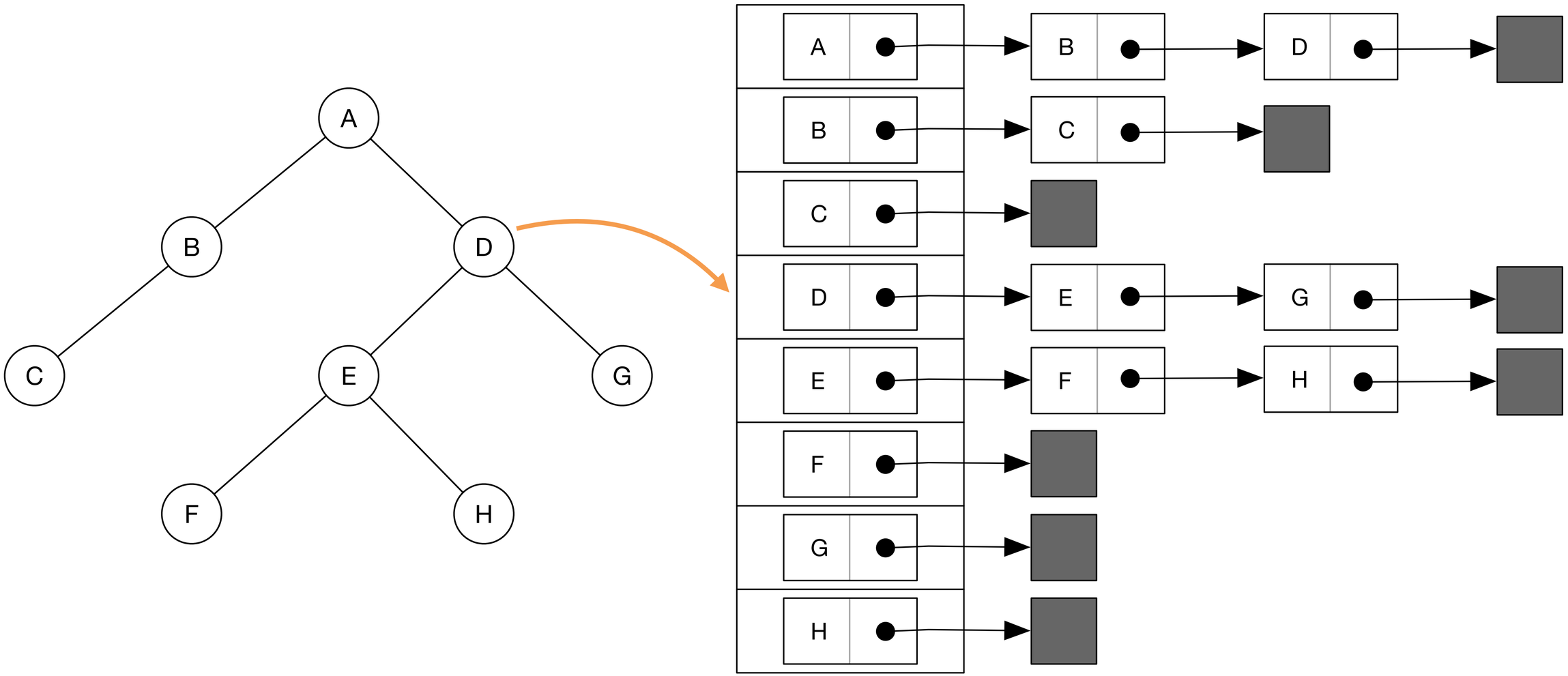

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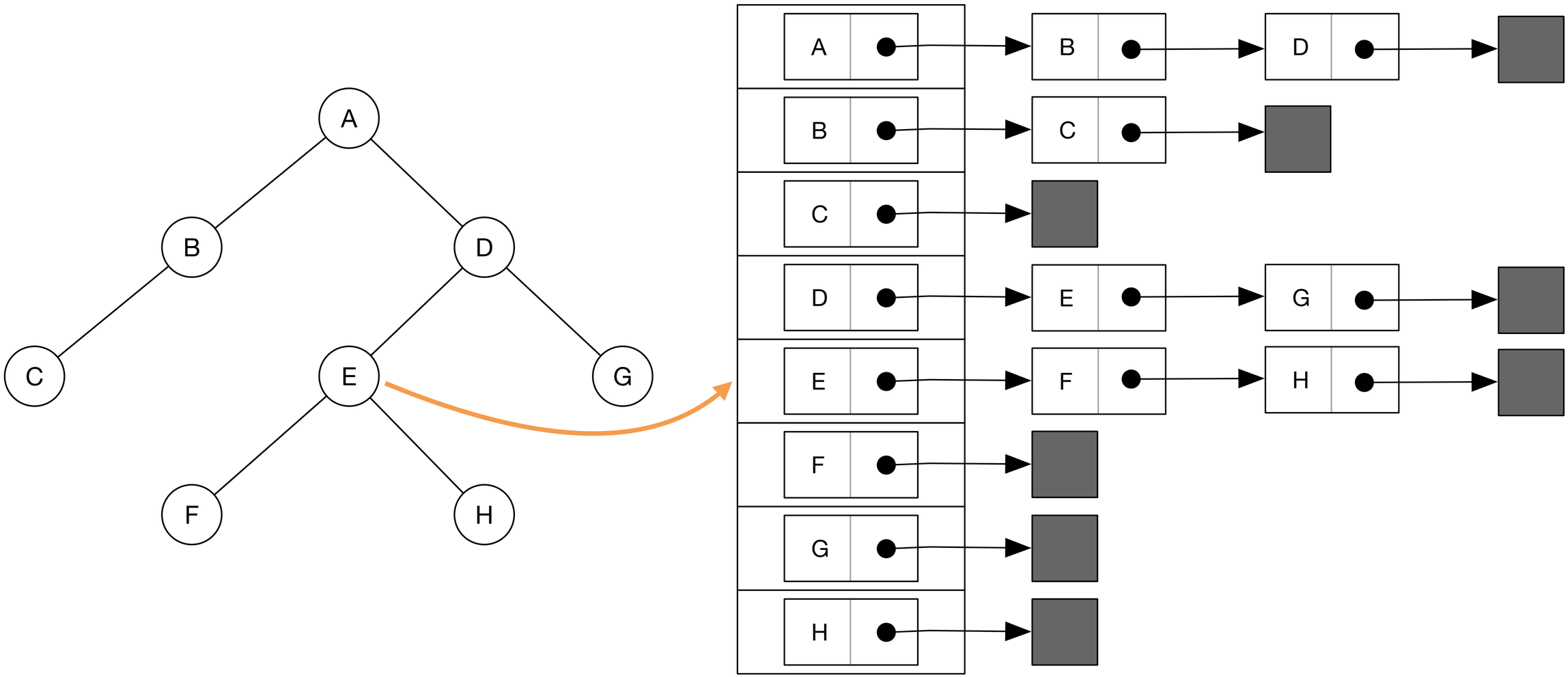

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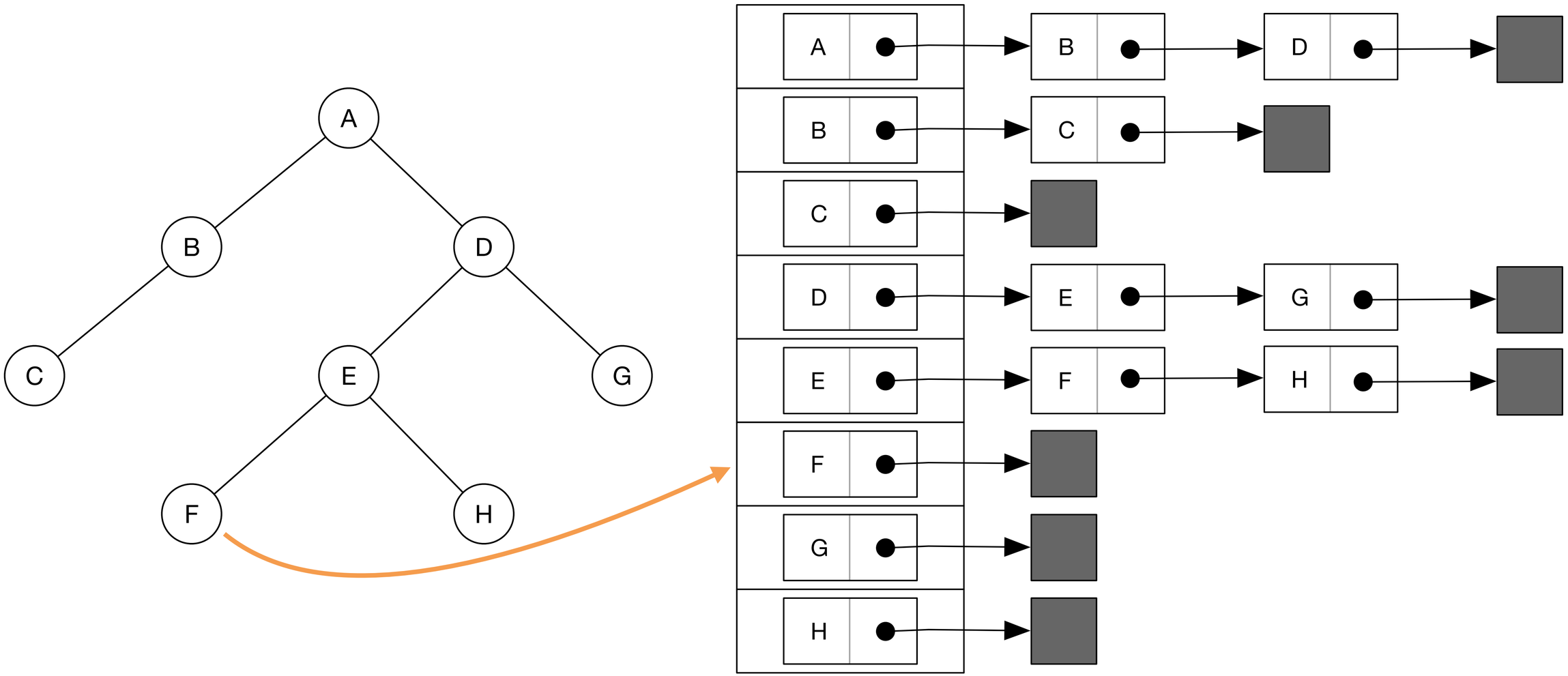

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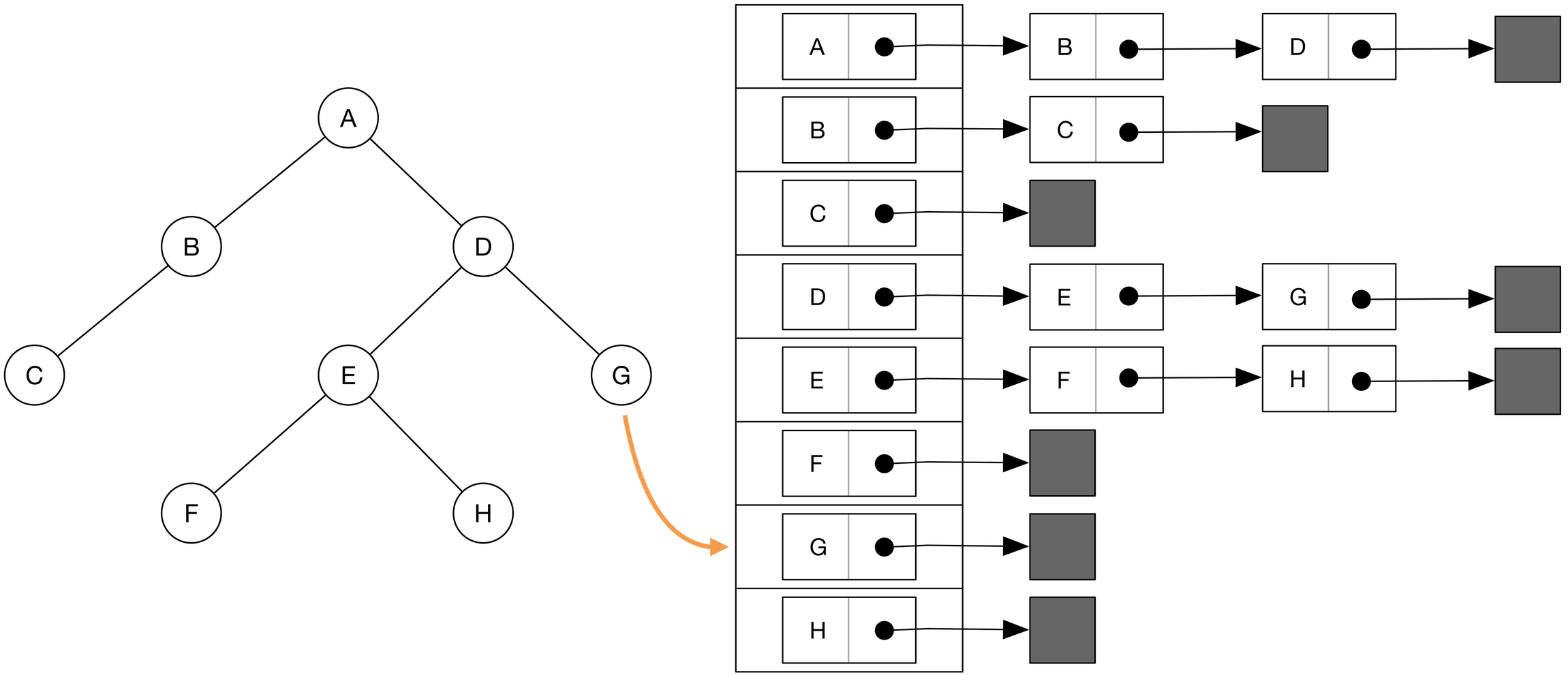

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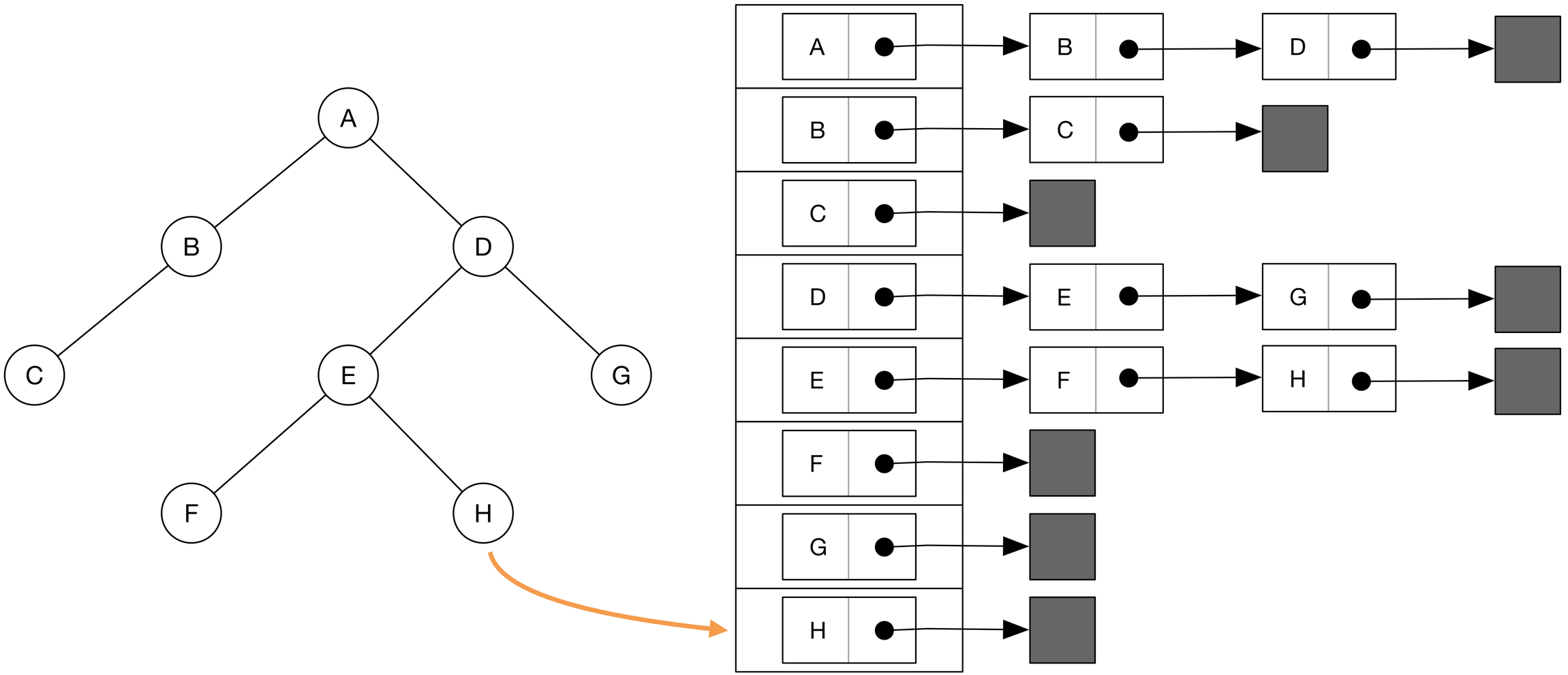

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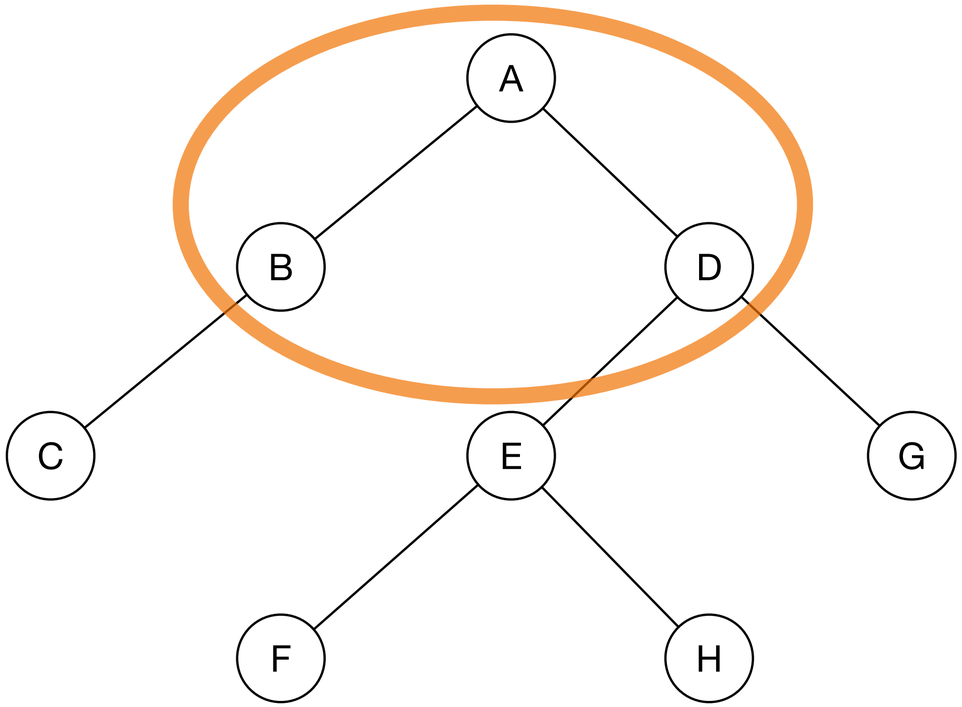

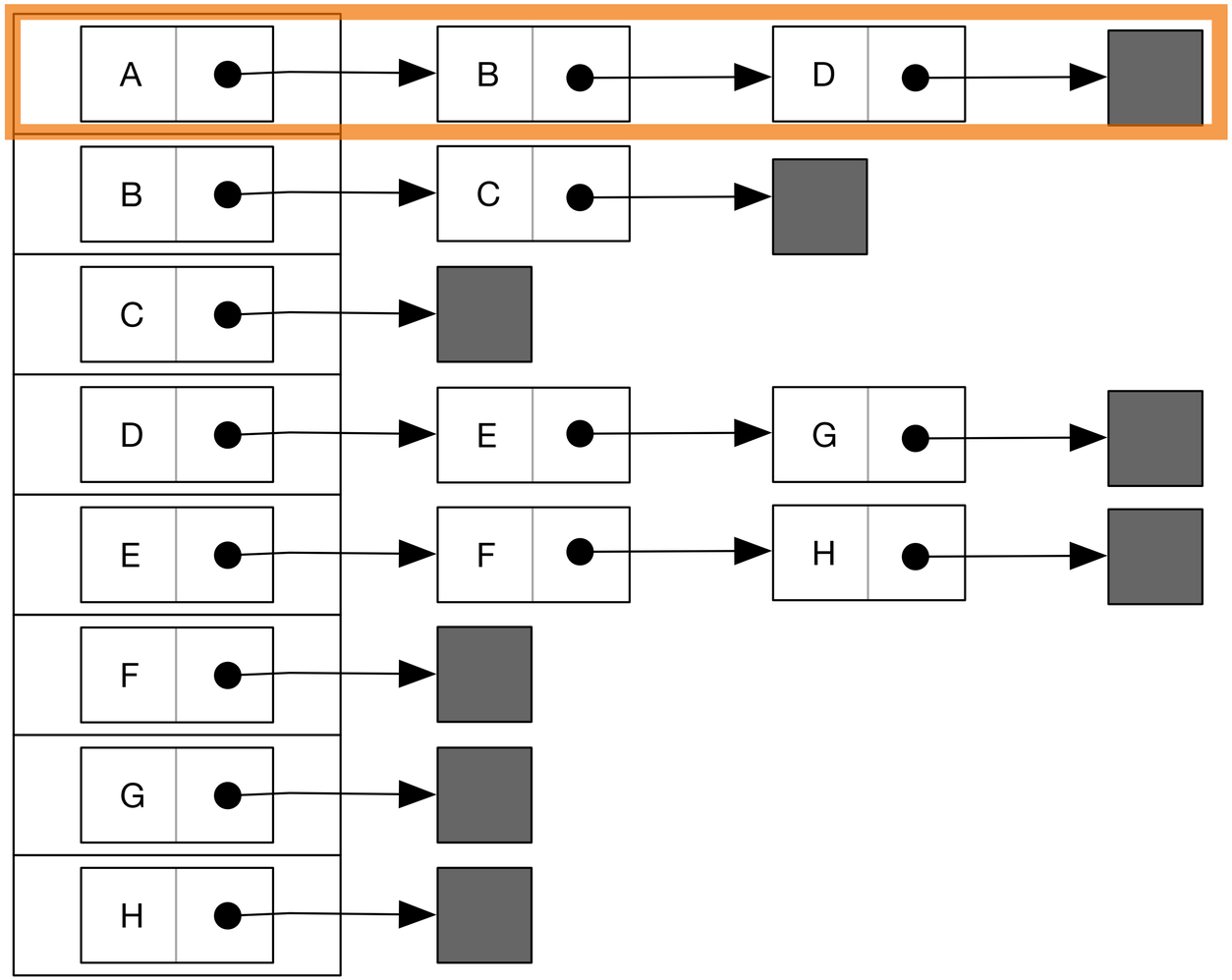

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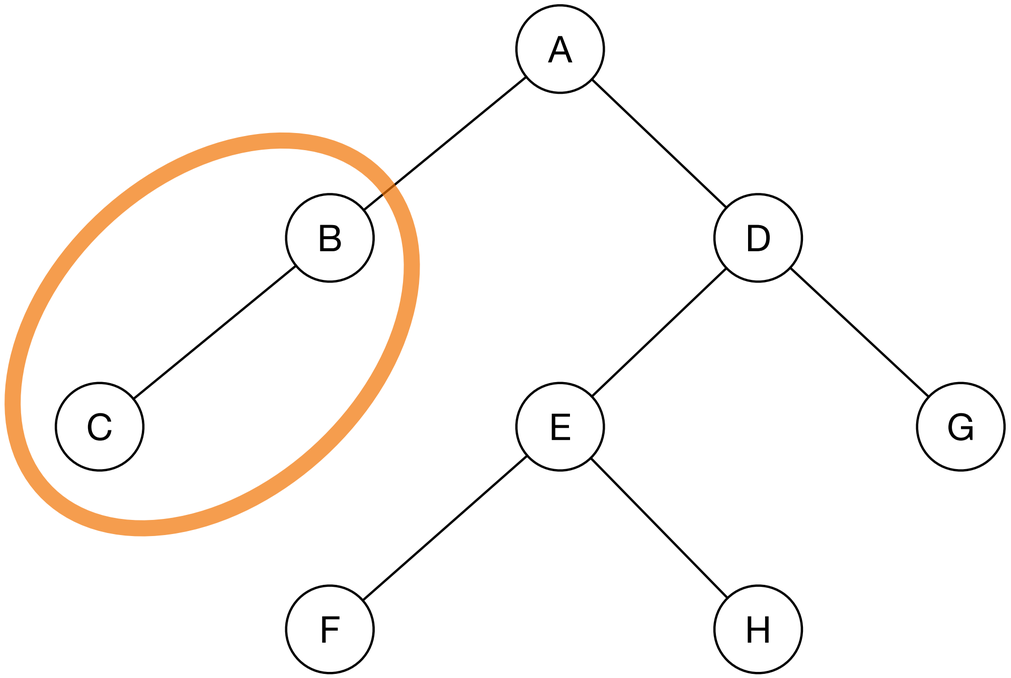

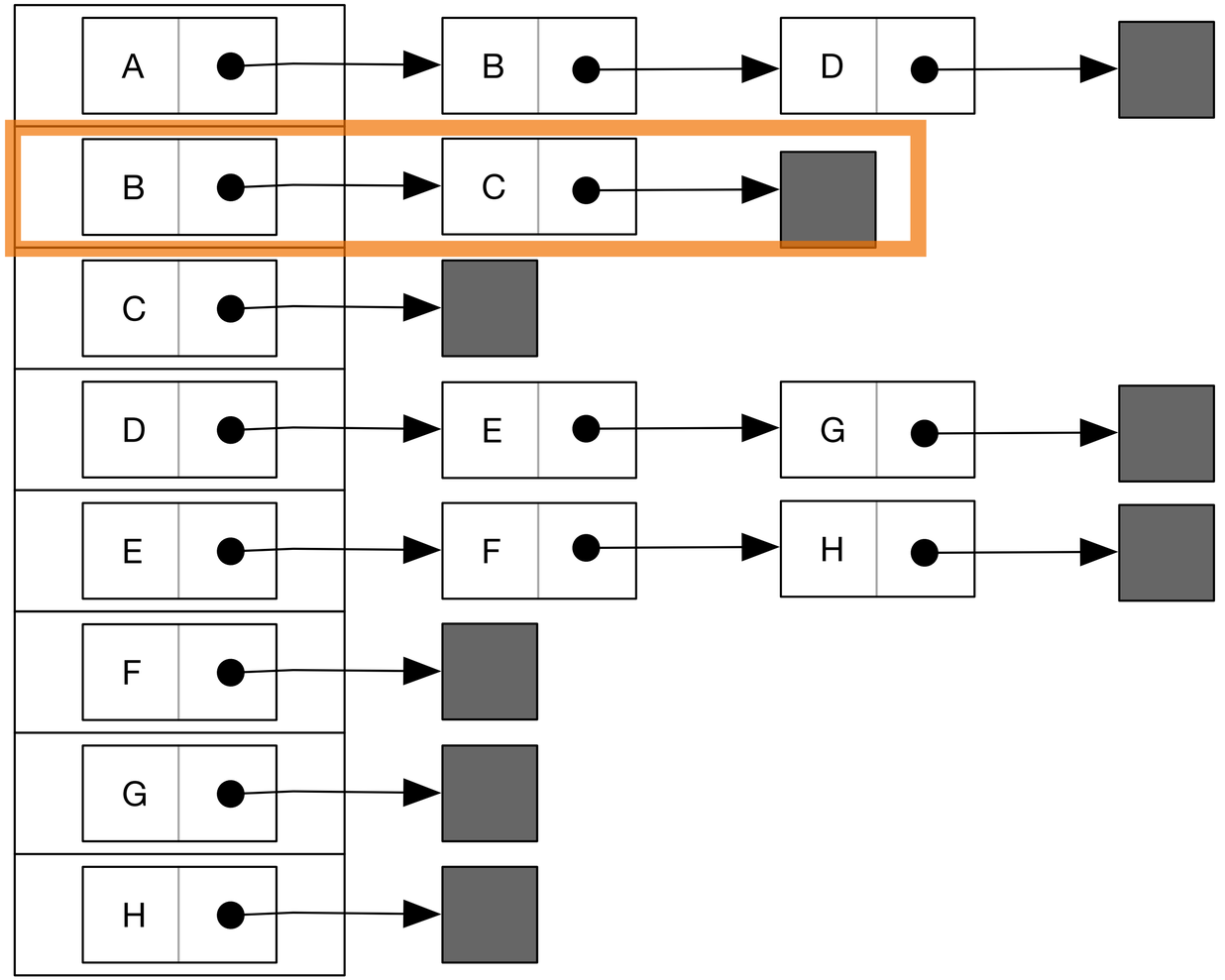

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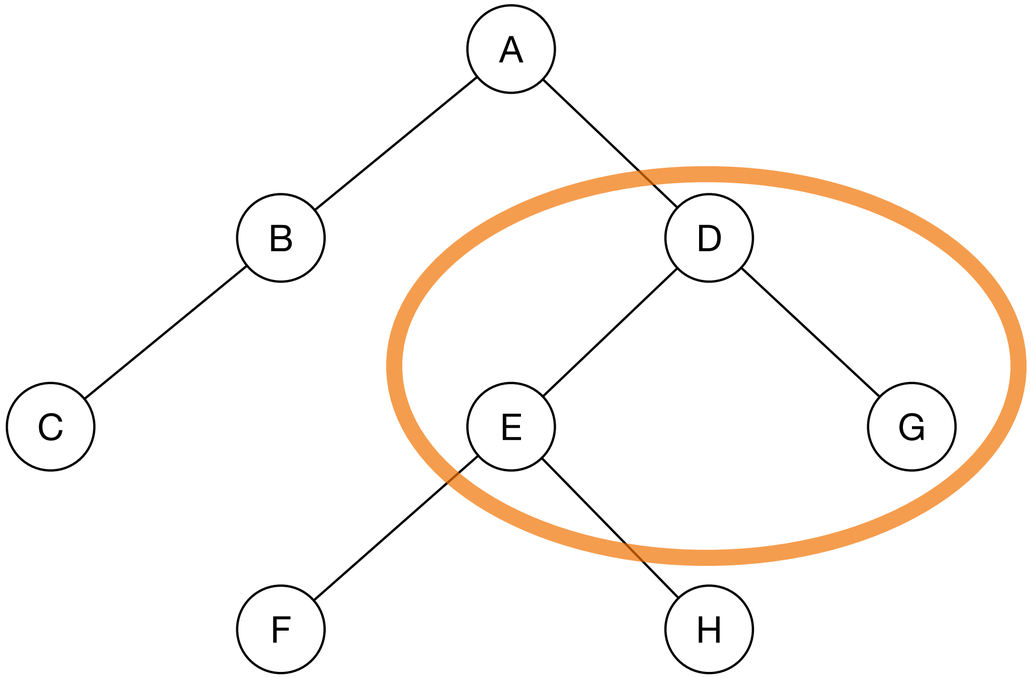

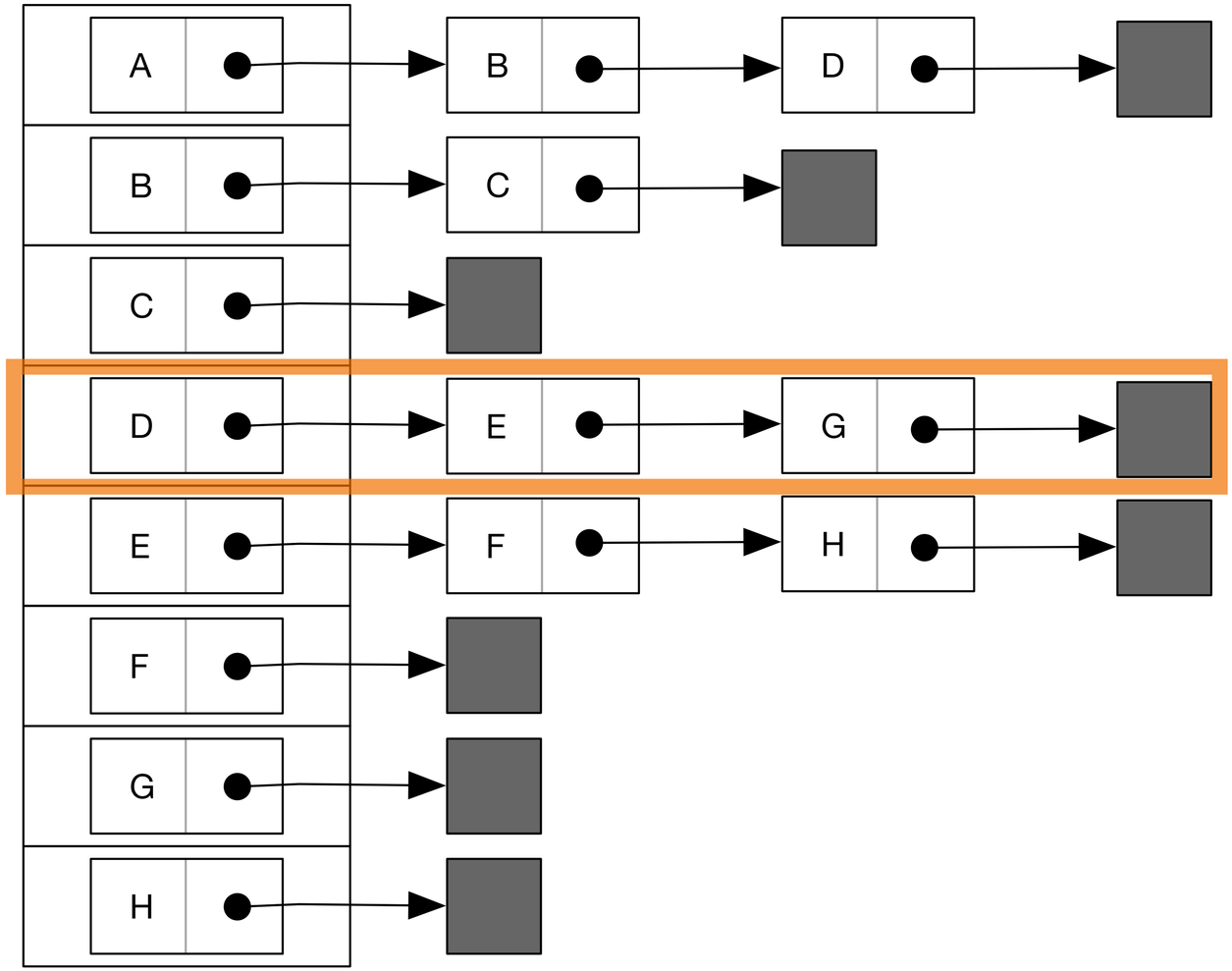

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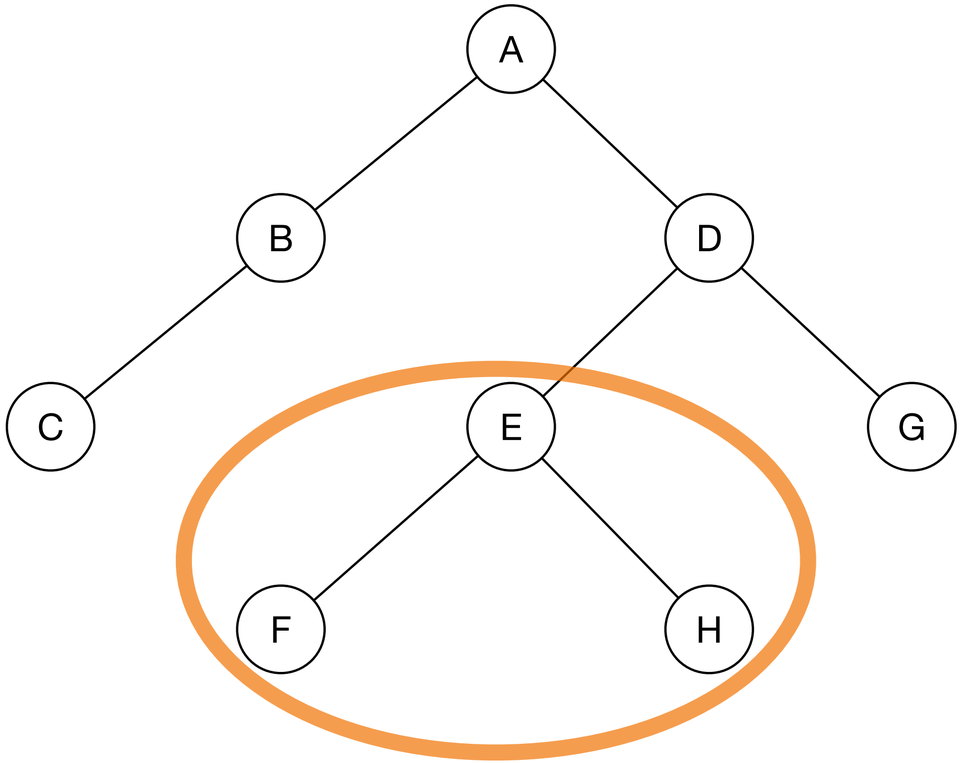

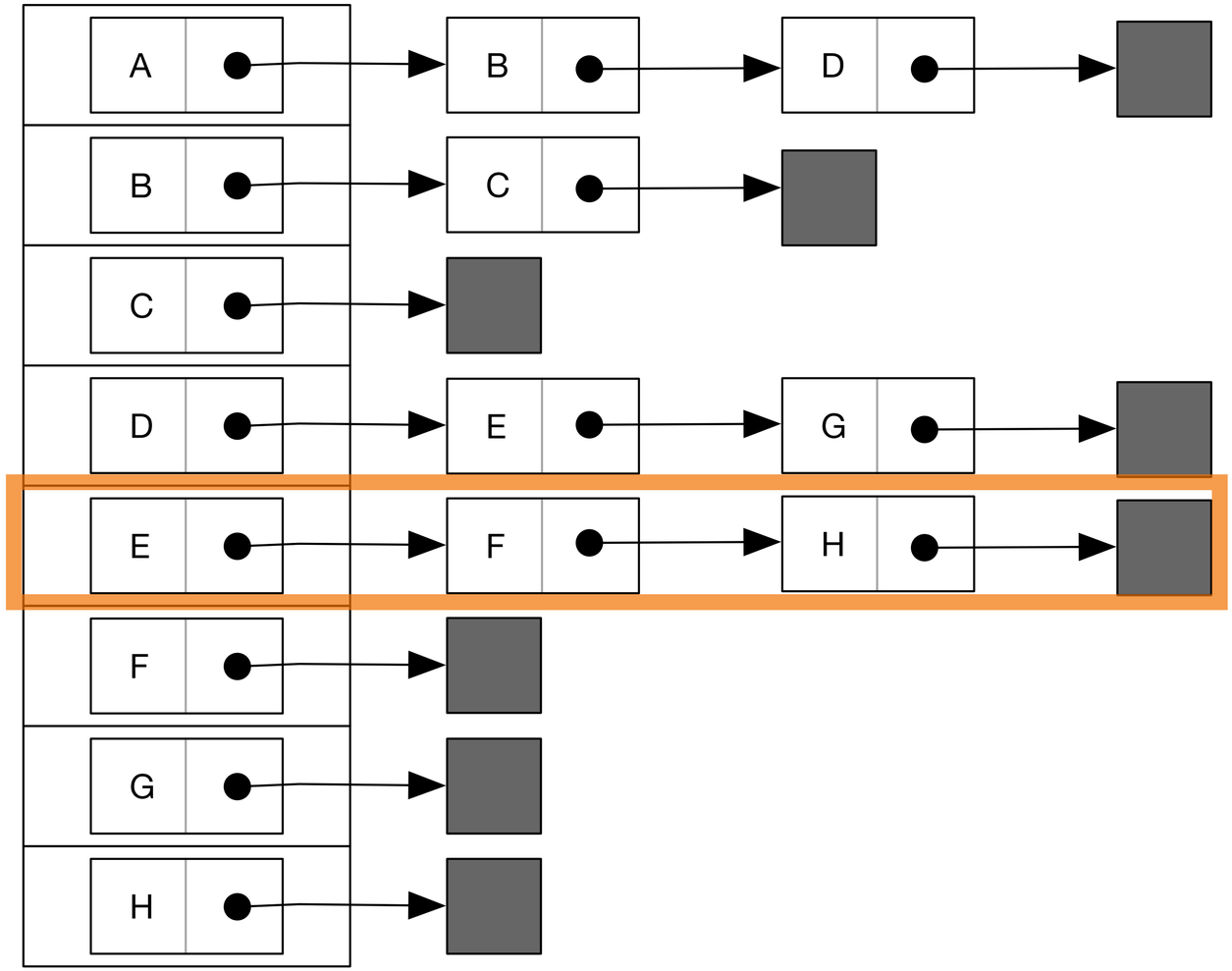

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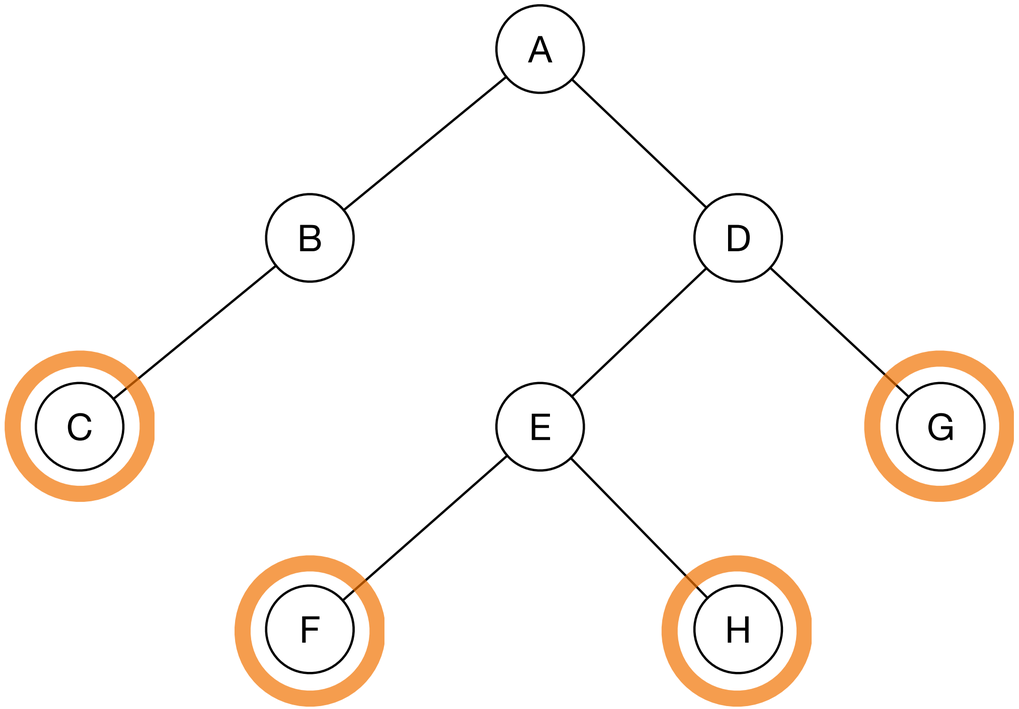

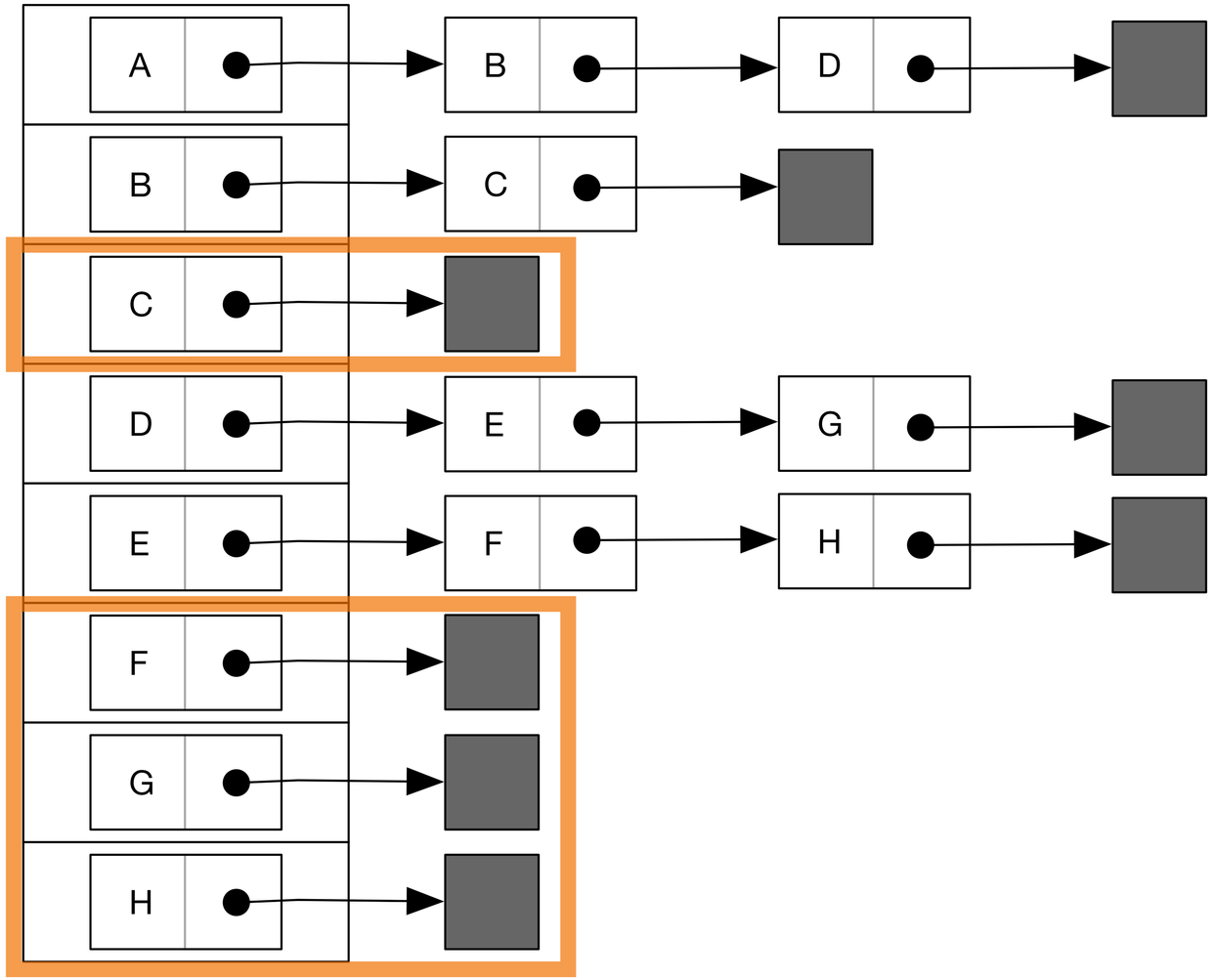

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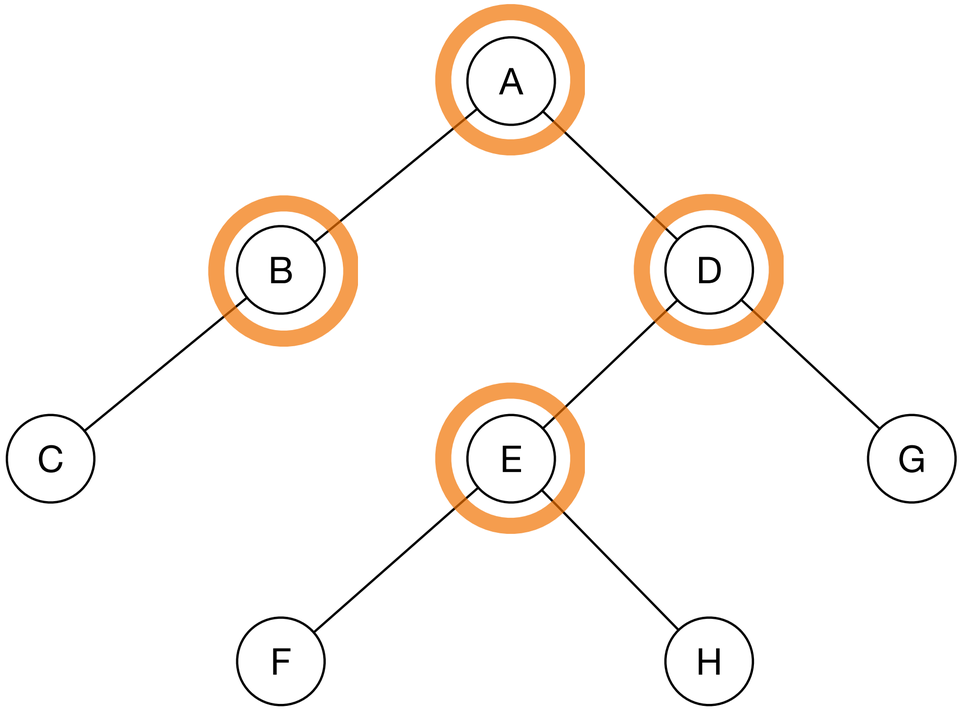

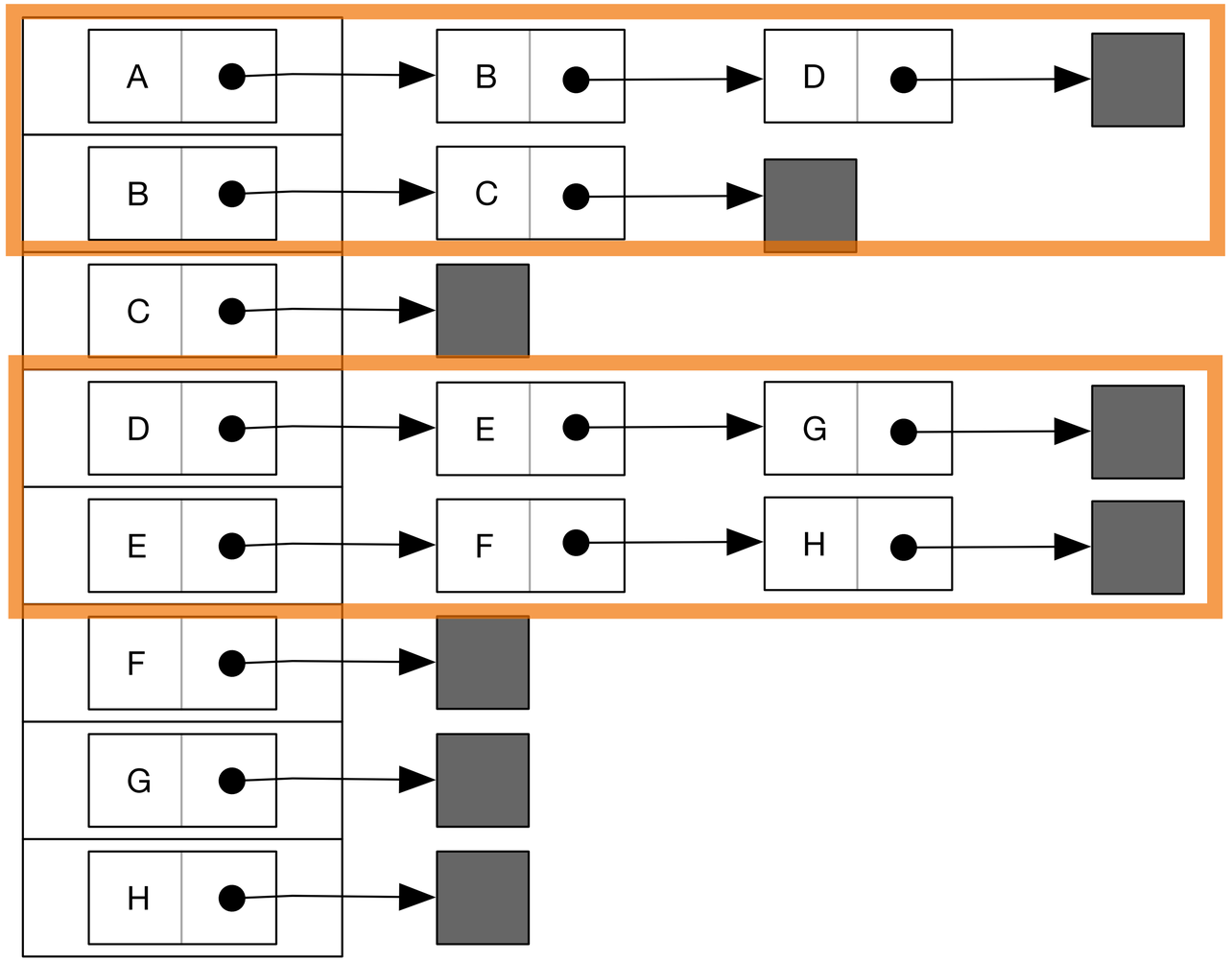

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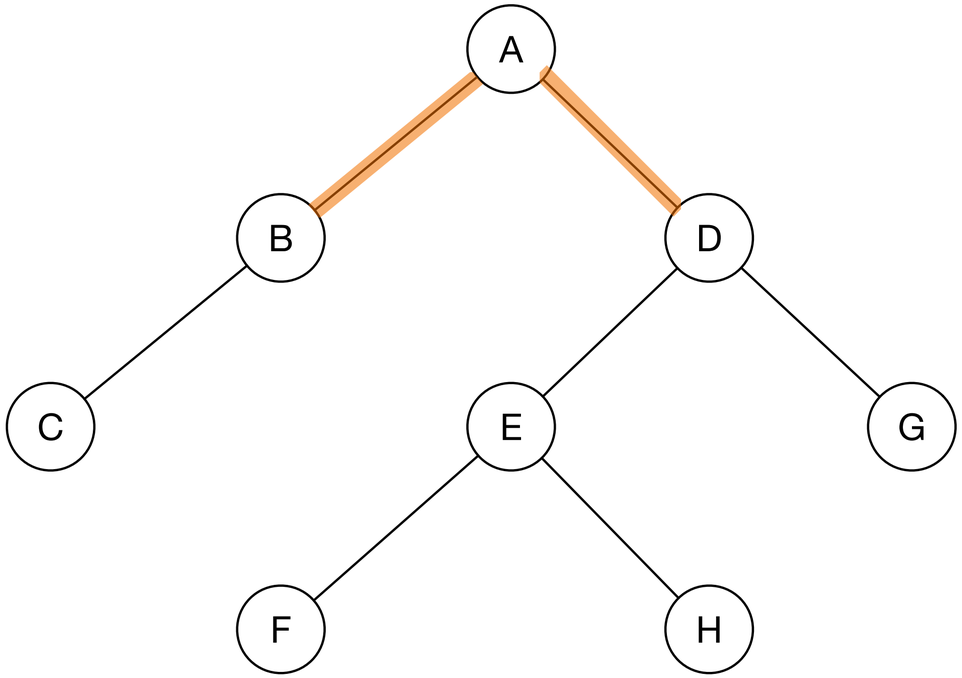

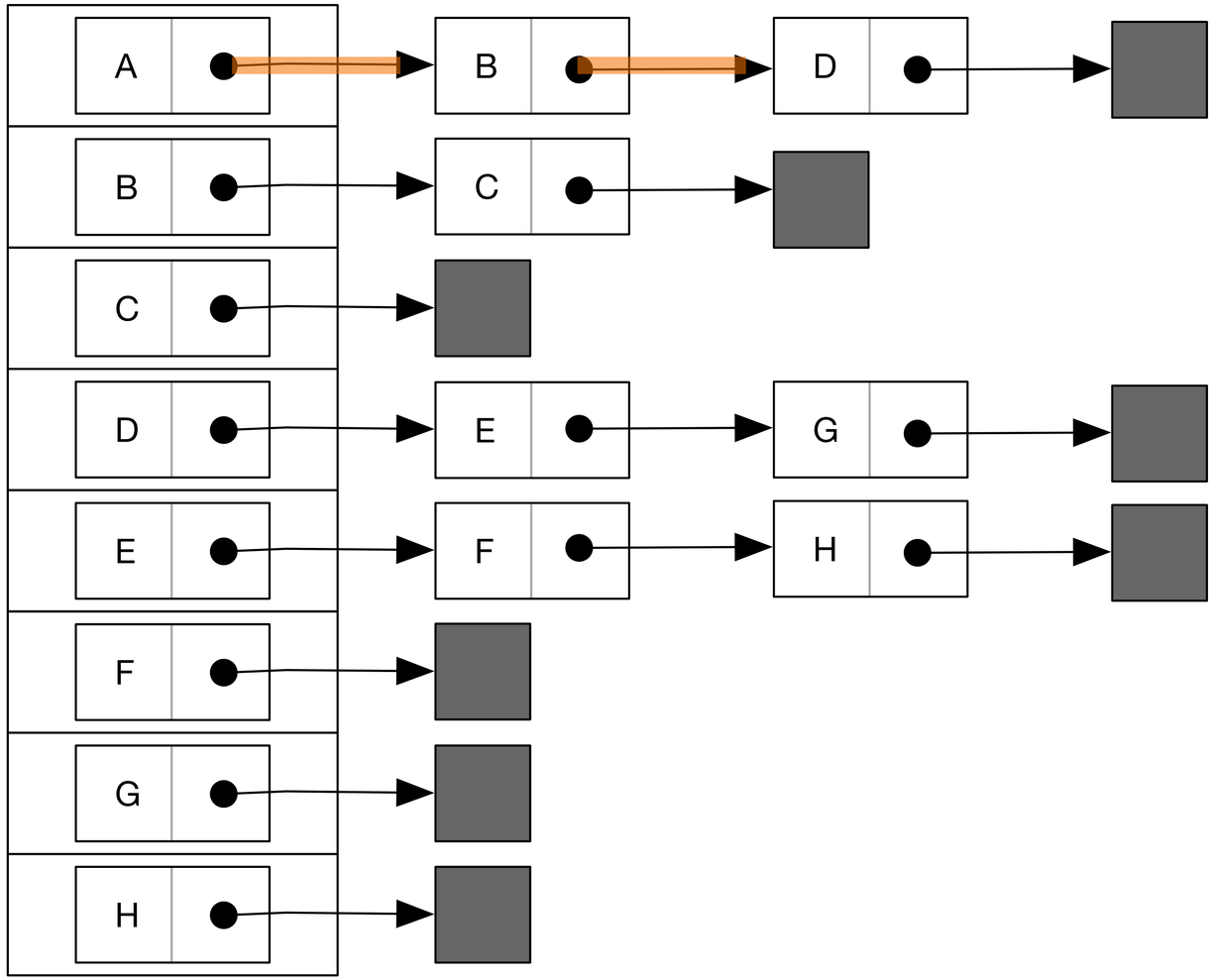

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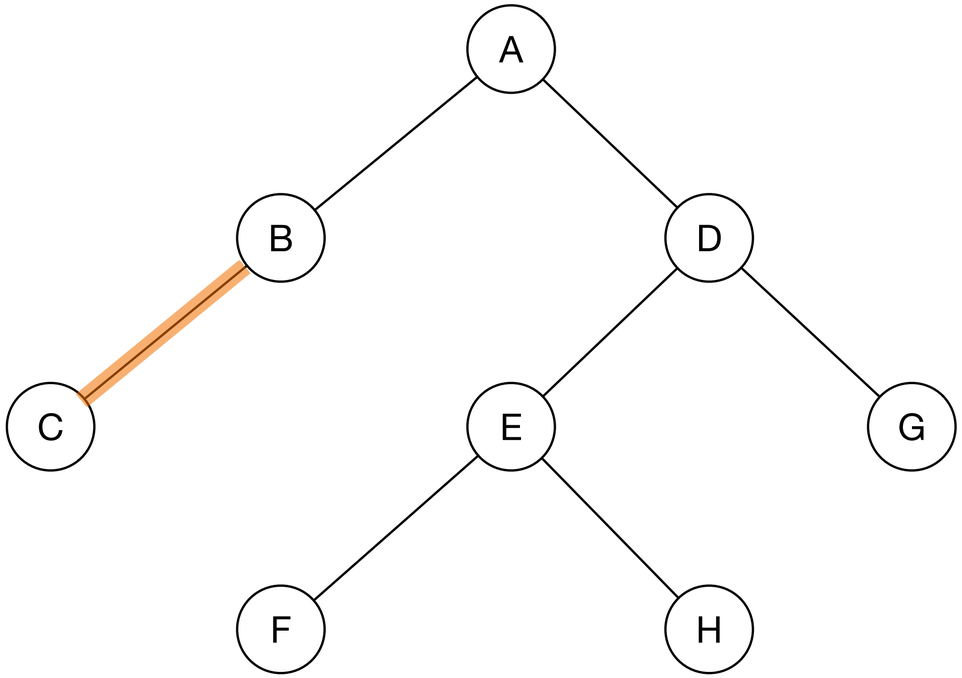

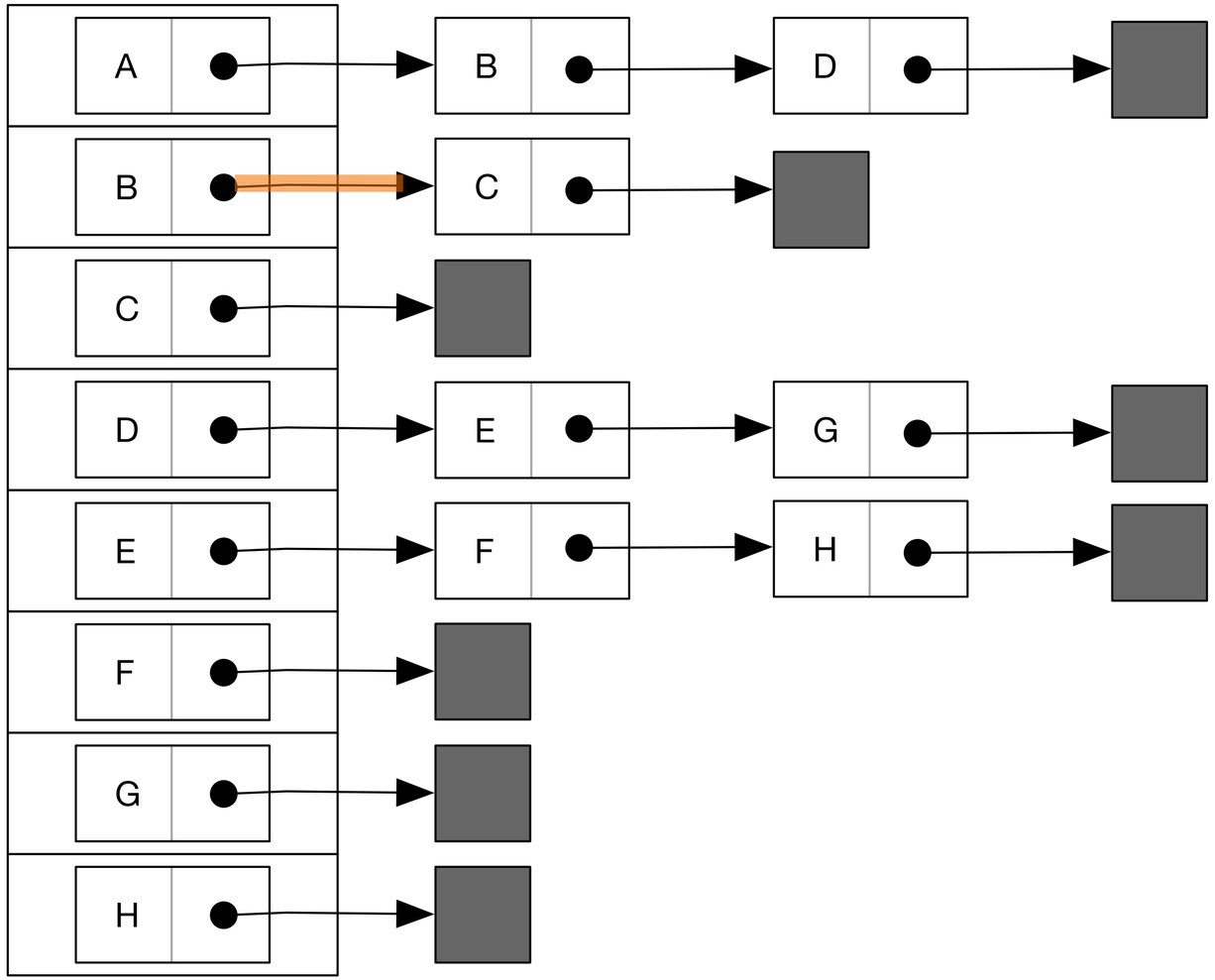

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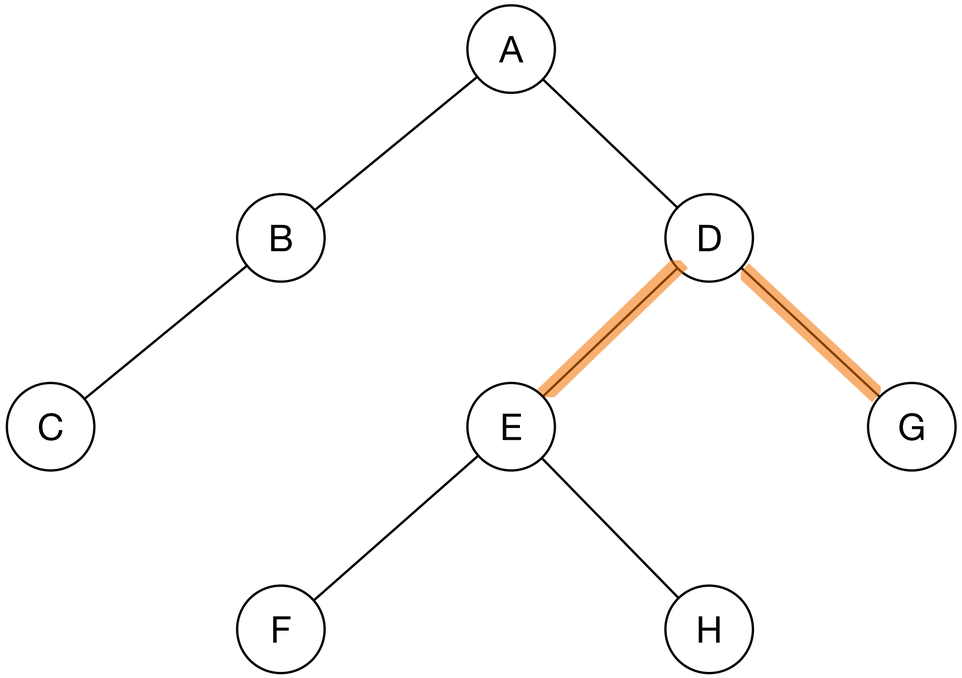

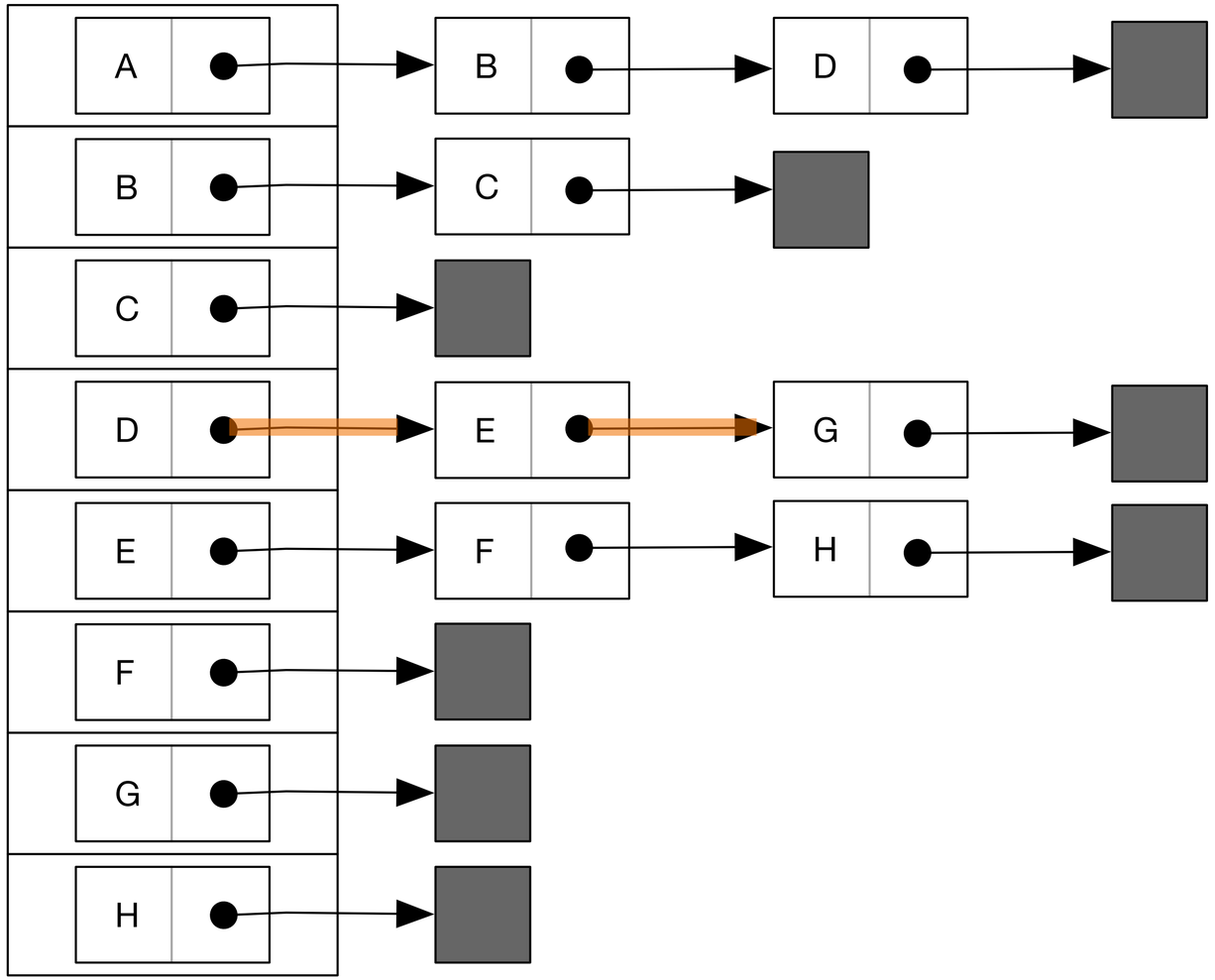

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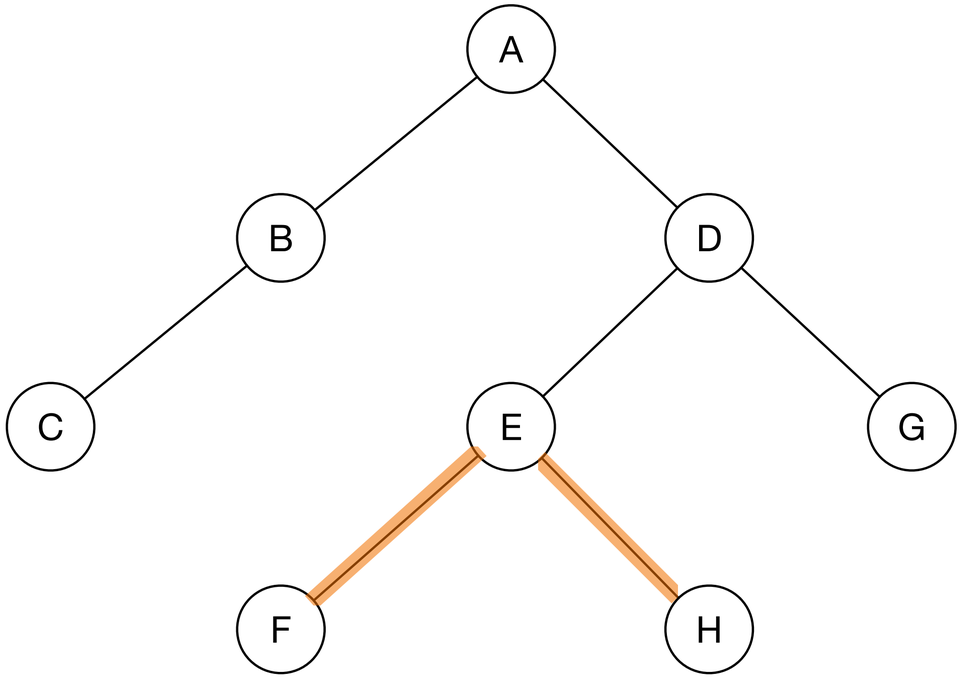

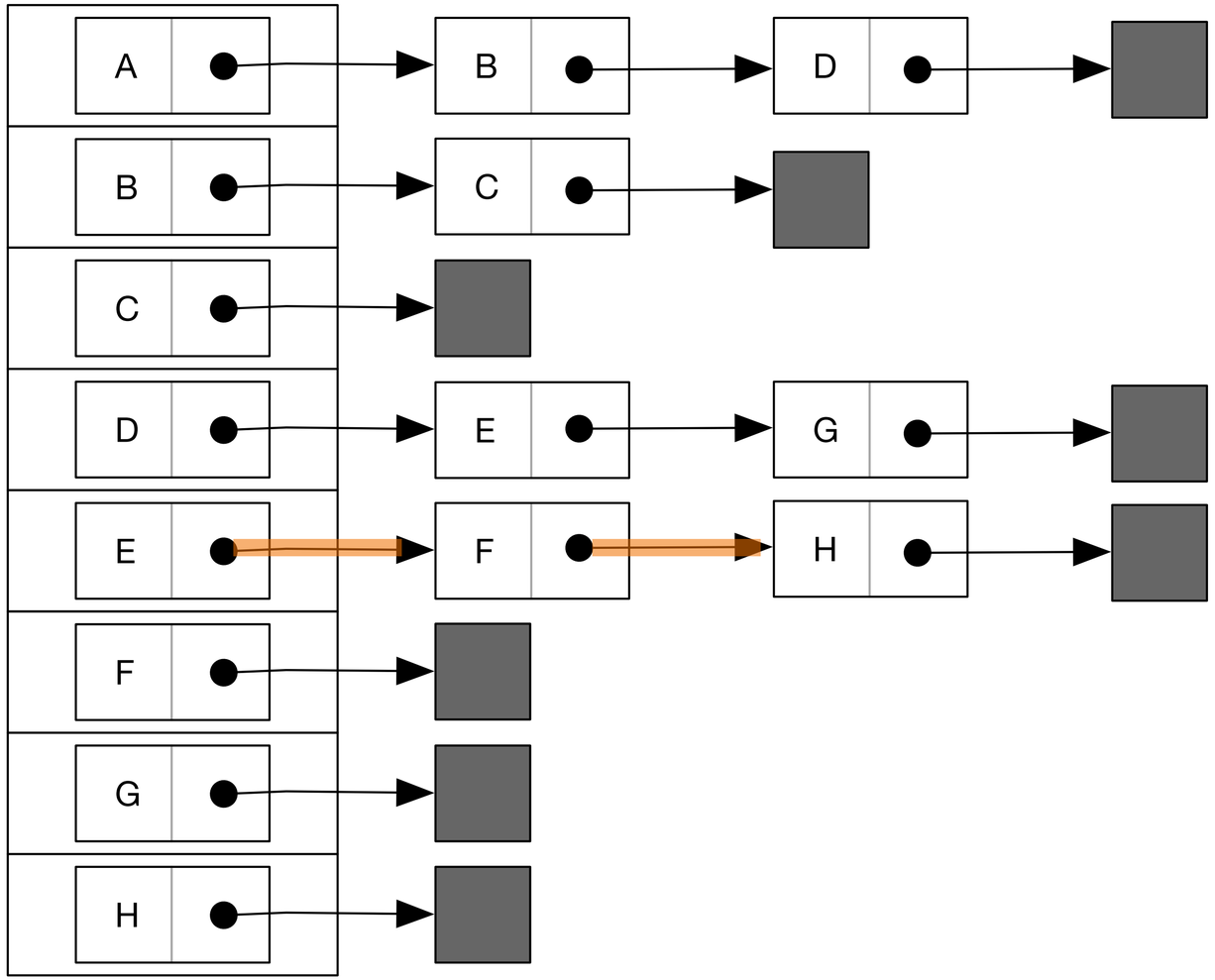

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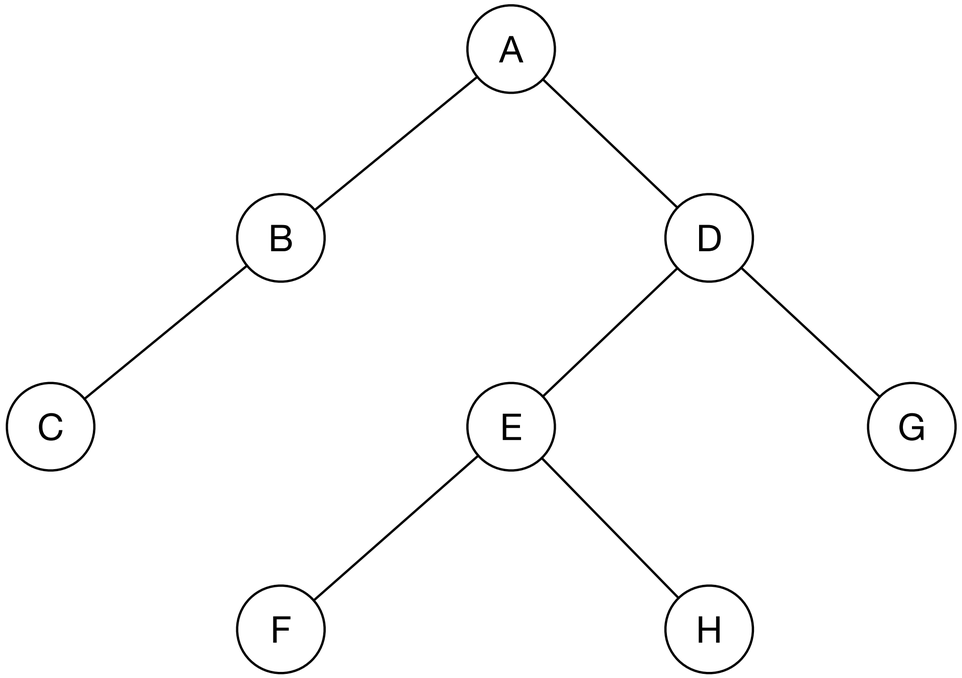
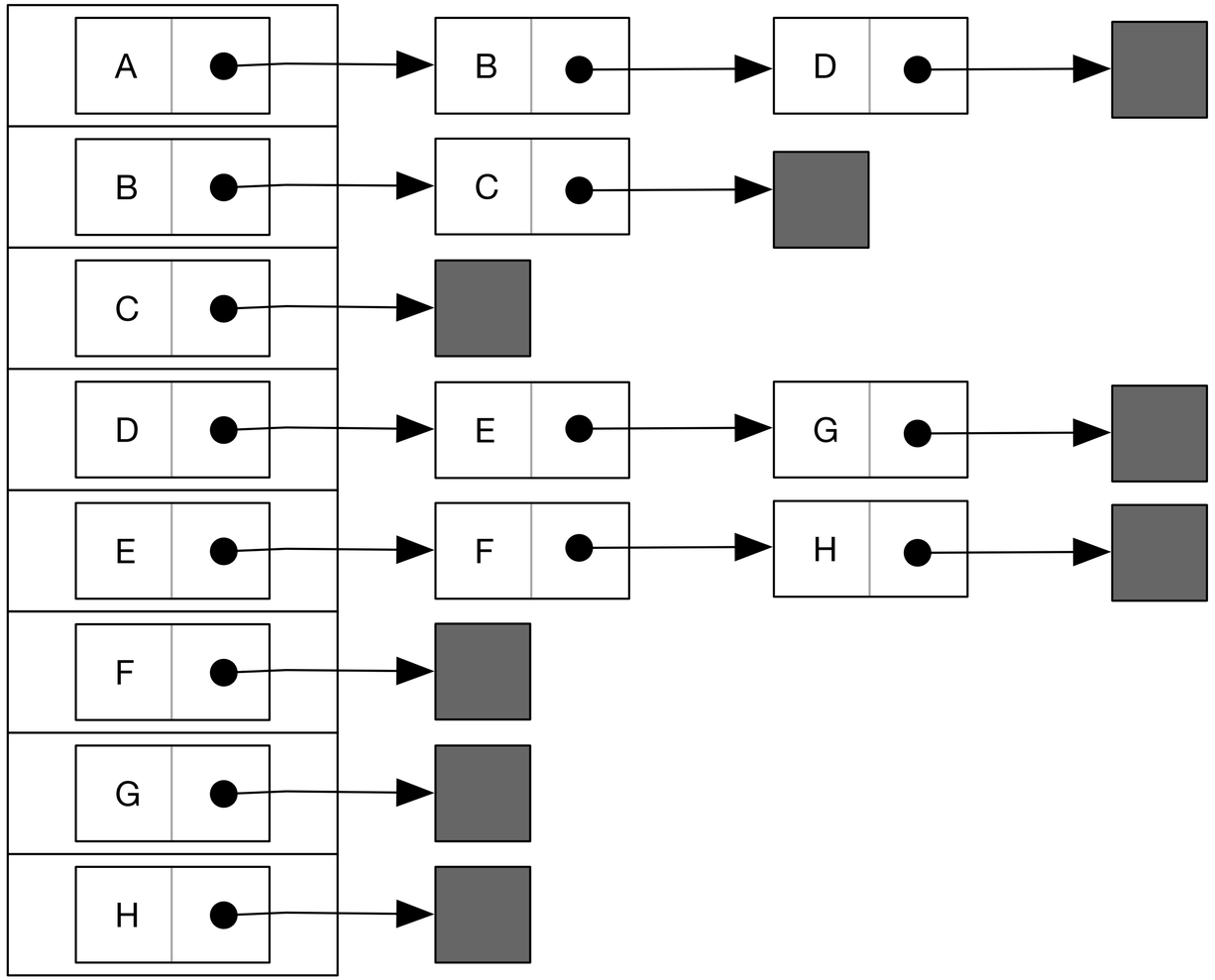
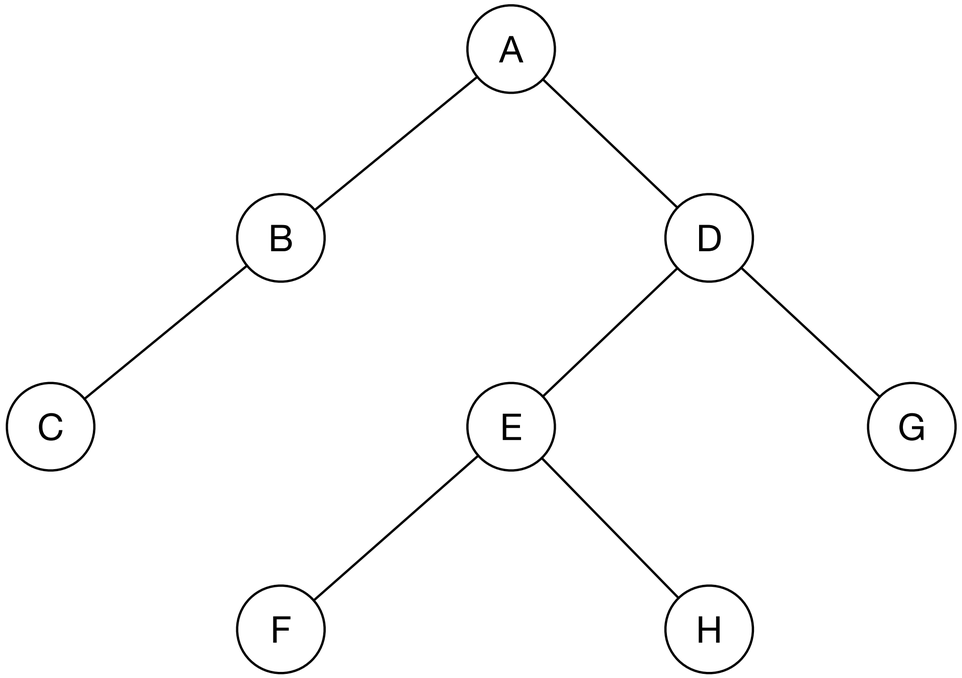


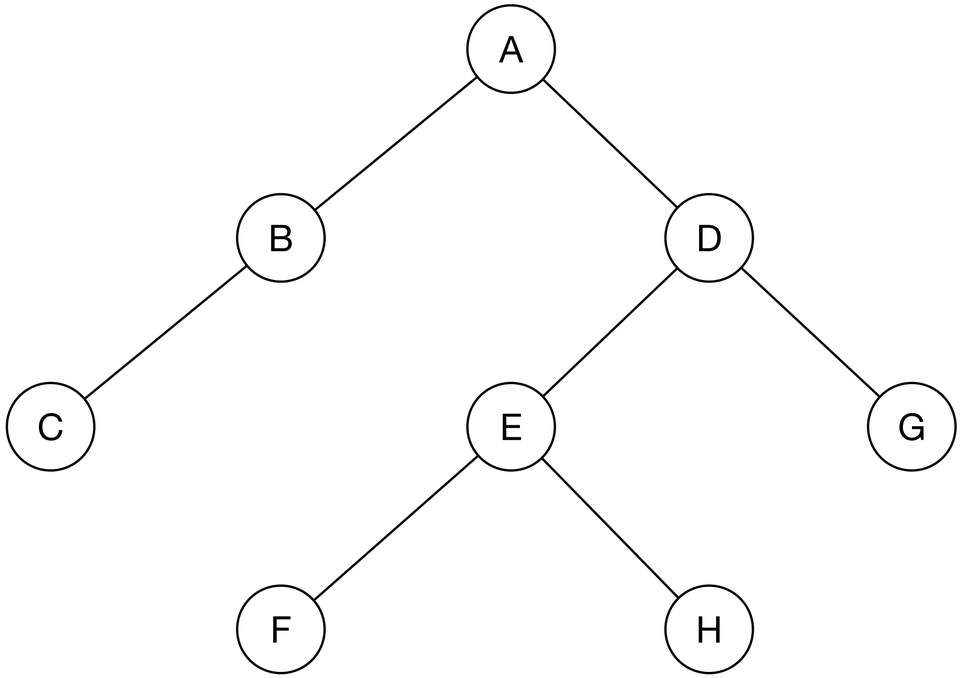


Adjacency matrix



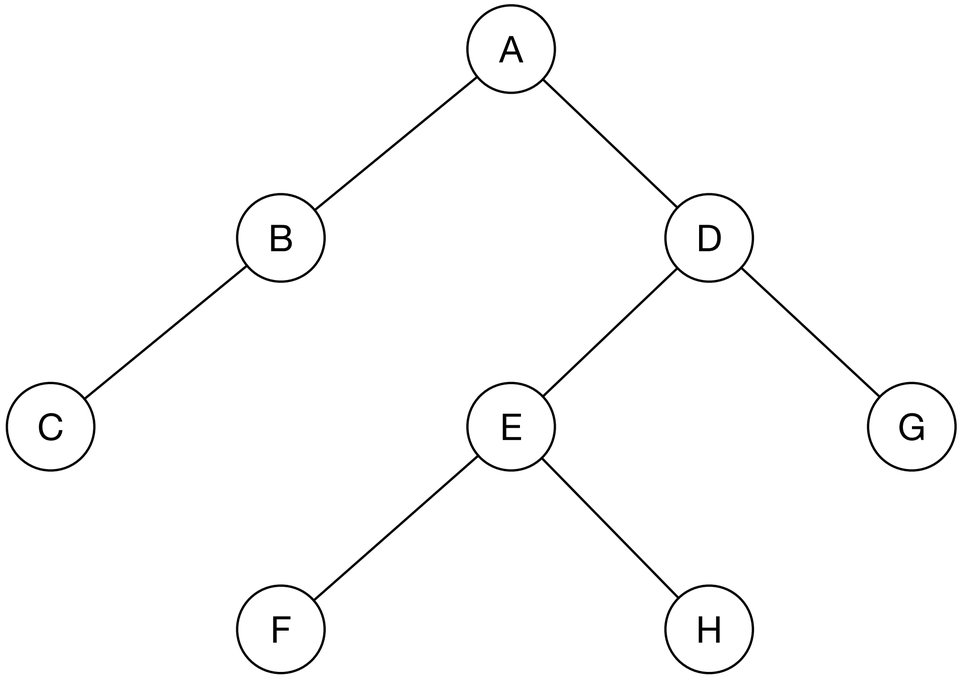
	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
B	1	0	1	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix



	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
B	1	0	1	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix



	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
B	1	0	1	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
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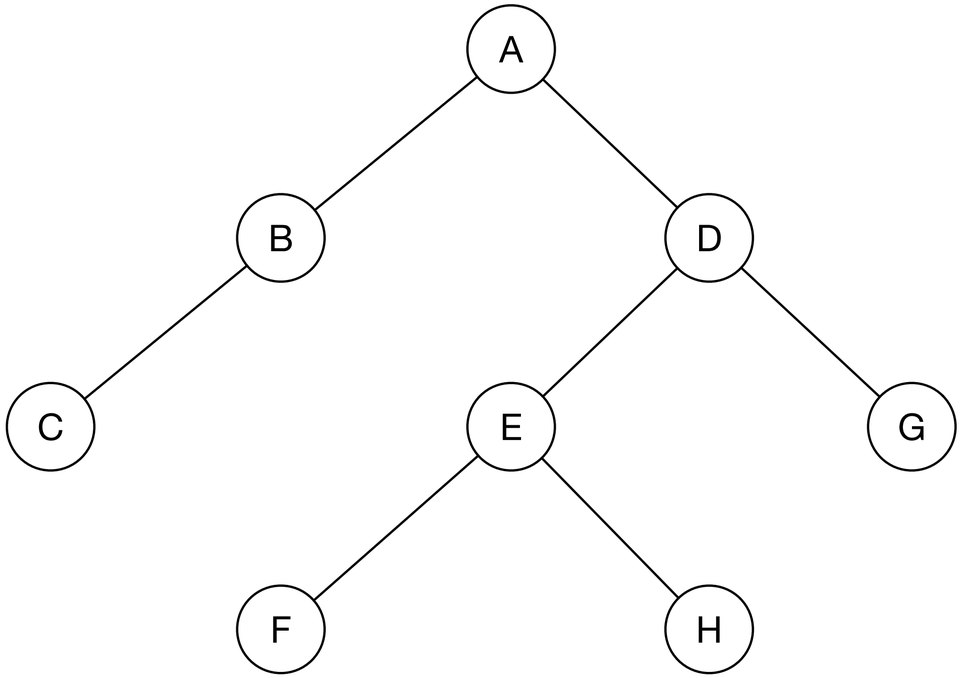
Adjacency matrix



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D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
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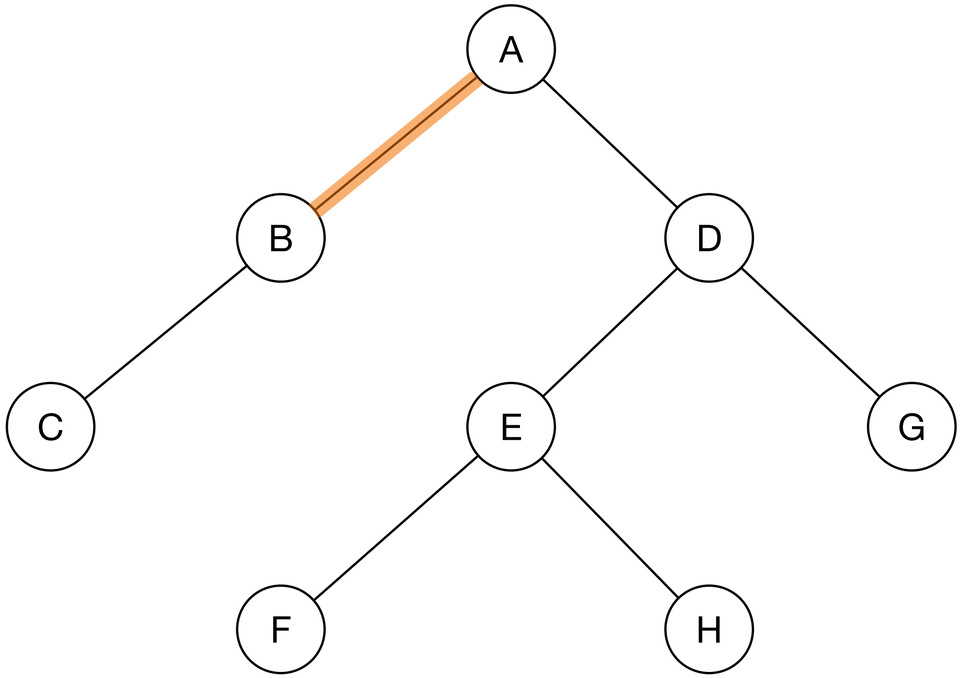
Adjacency matrix



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E	0	0	0	1	0	1	0	1
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G	0	0	0	1	0	0	0	0
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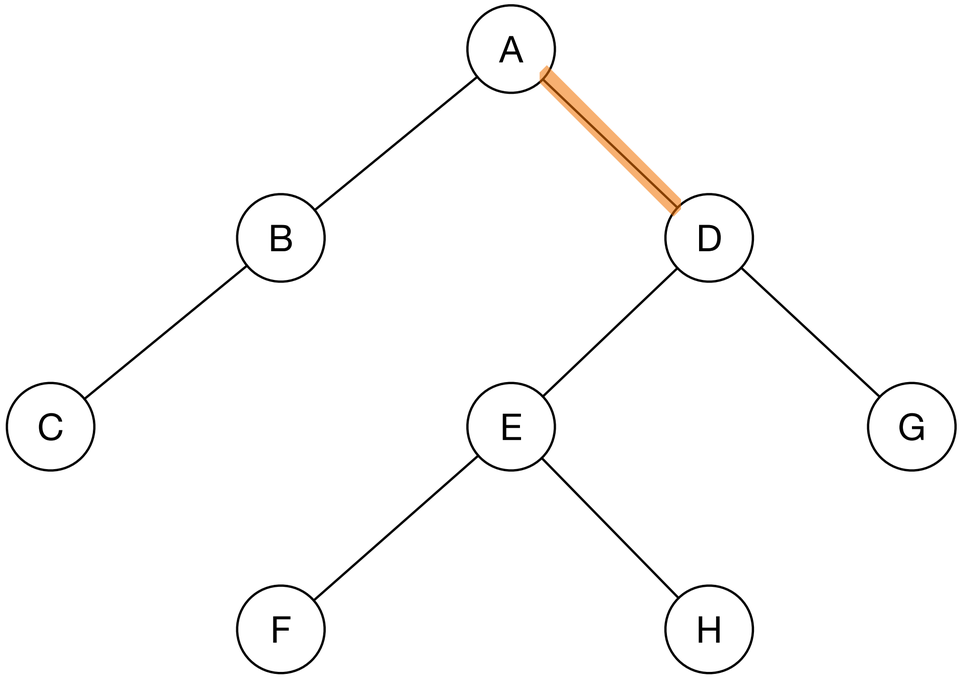
Adjacency matrix



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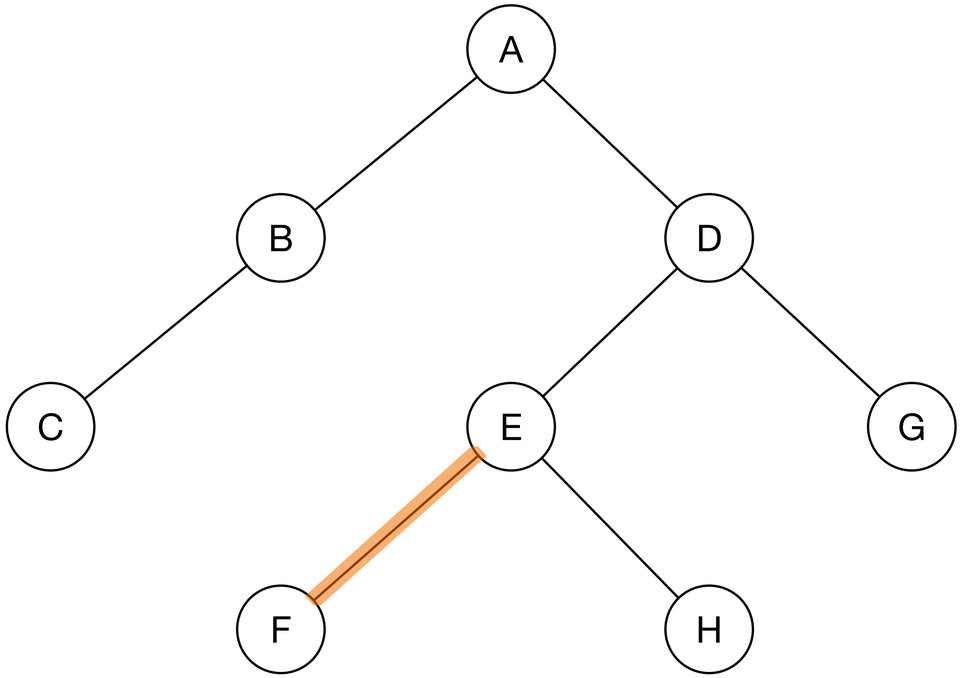
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix



	A	B	C	D	E	F	G	H
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B	1	0	1	0	0	0	0	0
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D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
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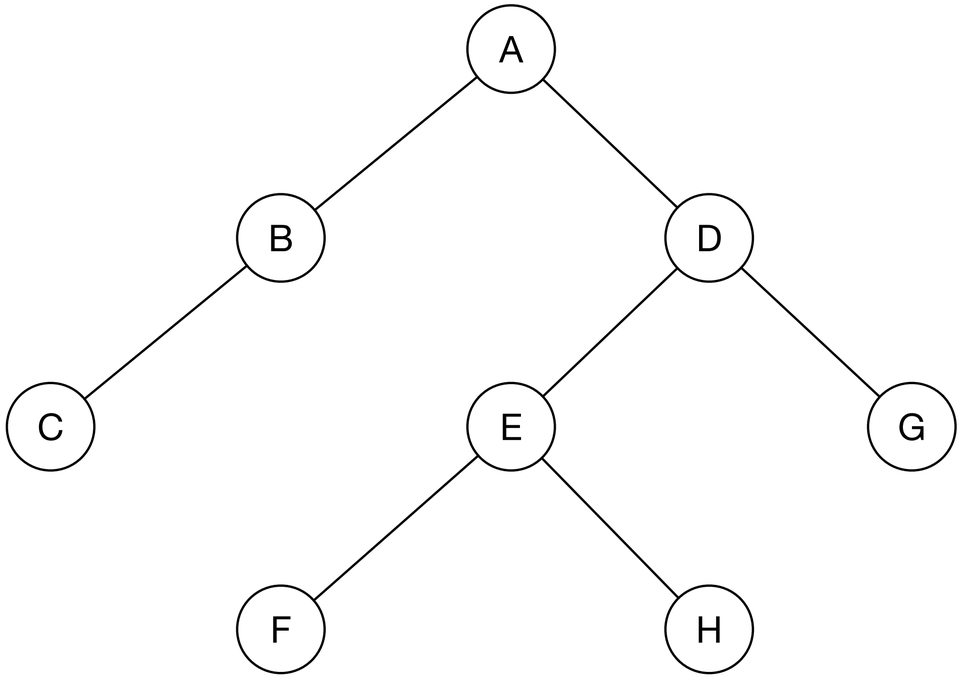
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix



	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
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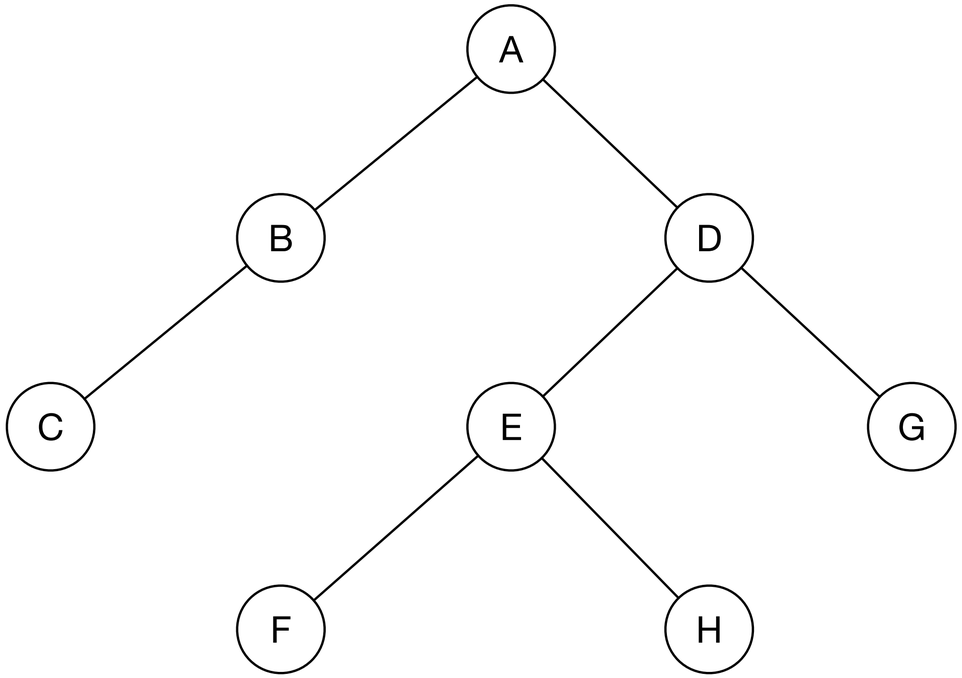
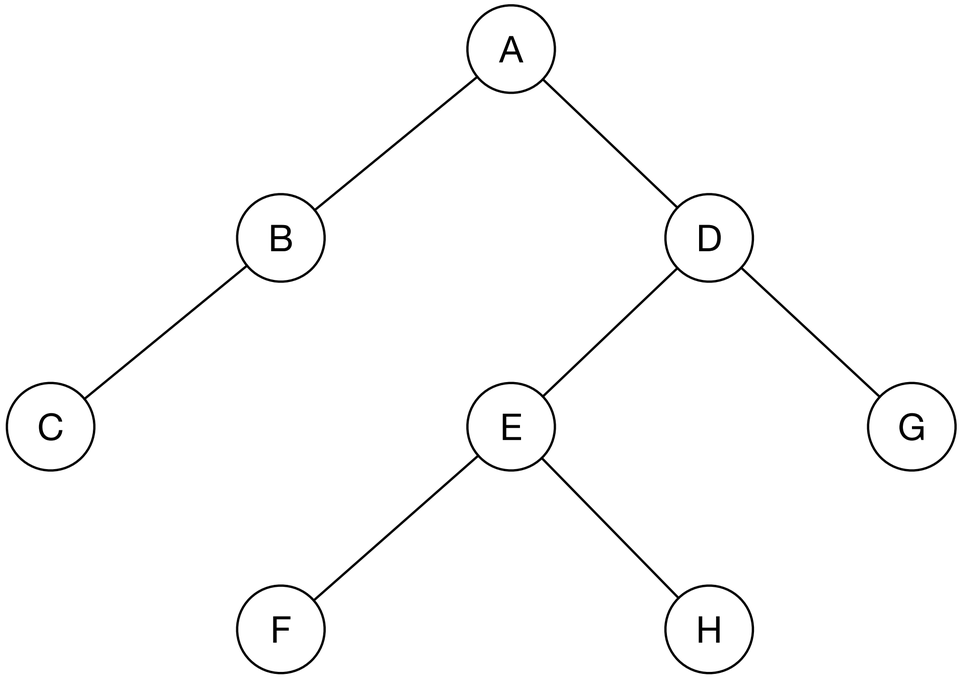
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix



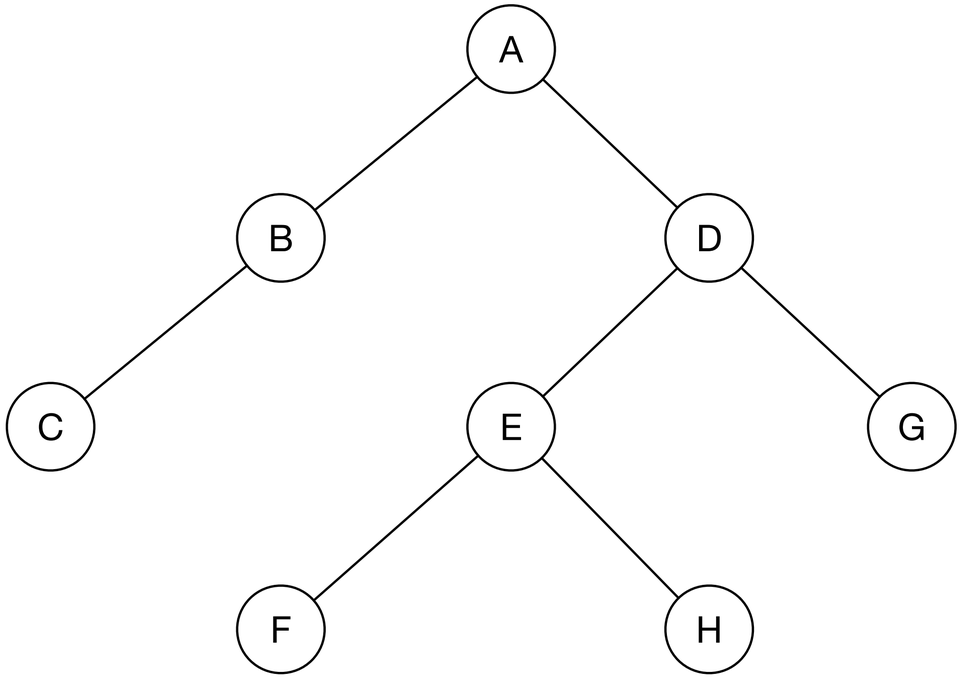
	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
B	1	0	1	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix



	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
B	1	0	1	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency matrix

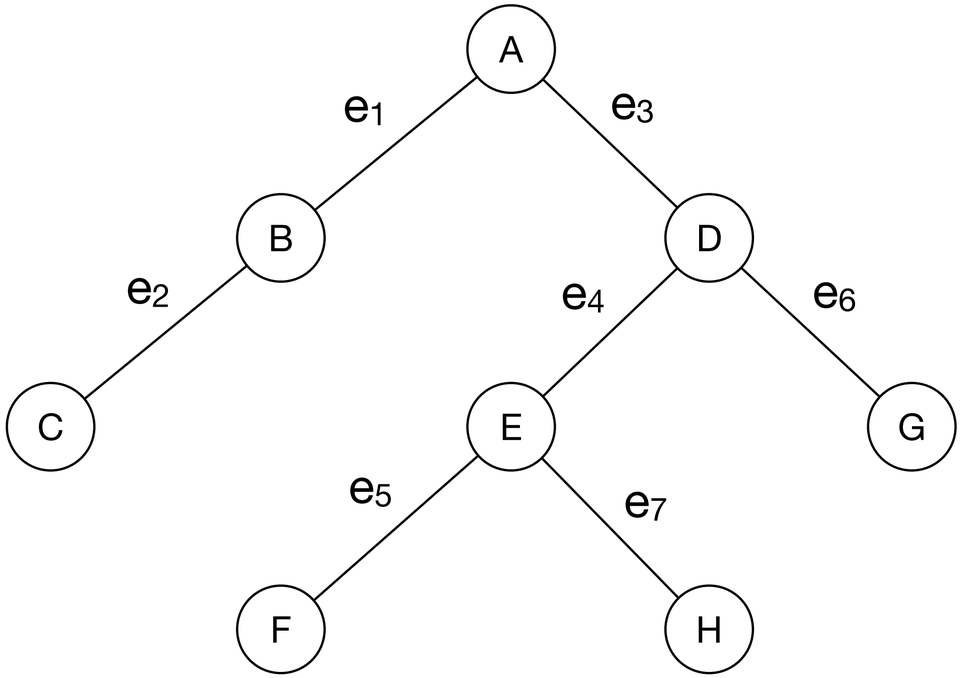


	A	B	C	D	E	F	G	H
A	0	1	0	1	0	0	0	0
B	1	0	1	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1	0
E	0	0	0	1	0	1	0	1
F	0	0	0	0	1	0	0	0
G	0	0	0	1	0	0	0	0
H	0	0	0	0	1	0	0	0

Adjacency List vs Adjacency Matrix

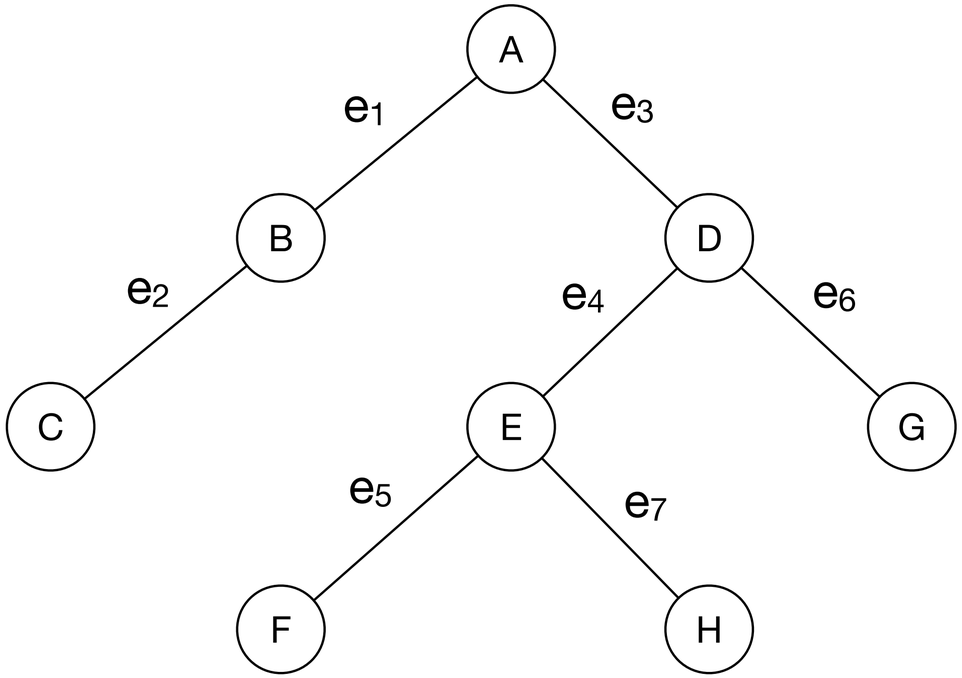
Adjacency list	Adjacency matrix
Good for sparse graphs	Good for dense graphs
Only encodes edges present	Encodes present *and* absent edges
Takes time to traverse list. If d is the degree of a node, this will be $O(d_{\max})$	Can check if two nodes are adjacent in constant time $O(1)$
Easier to find all adjacent nodes	Must scan entire row or column to find all adjacent nodes, $O(N)$
	Can do cool stuff with matrix calculations (spectral graph theory, an advanced topic)

Incidence matrix



	e_1	e_2	e_3	e_4	e_5	e_6	e_7
A	1	0	1	0	0	0	0
B	1	1	0	0	0	0	0
C	0	1	0	0	0	0	0
D	0	0	1	1	0	1	0
E	0	0	0	1	1	0	1
F	0	0	0	0	1	0	0
G	0	0	0	0	0	1	0
H	0	0	0	0	1	0	1

Incidence matrix



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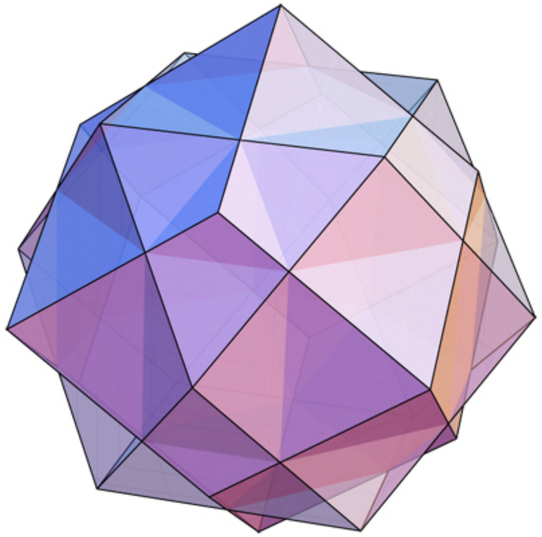
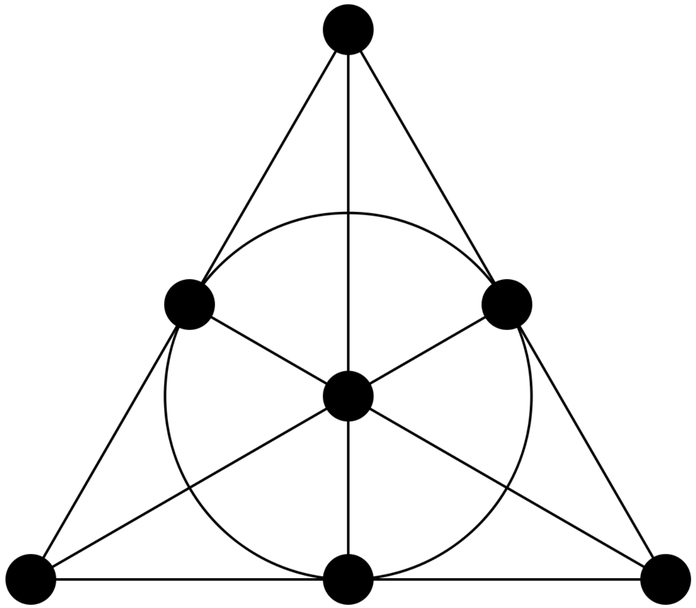
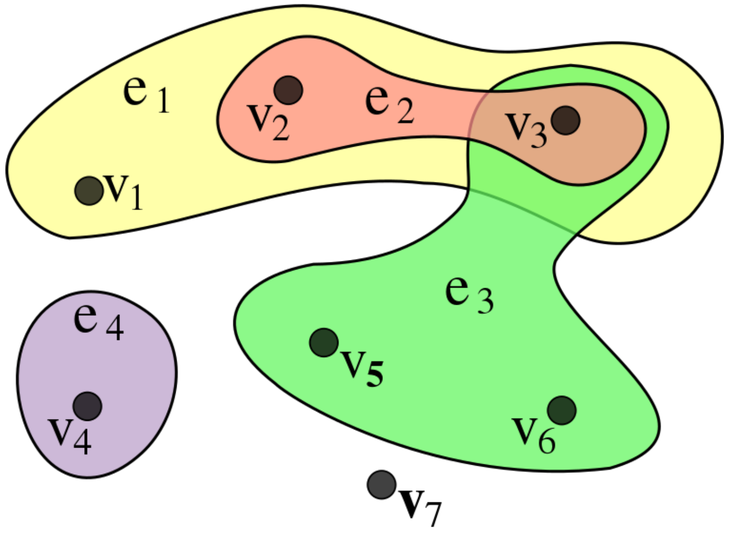
E	0	0	0	1	1	0	1
F	0	0	0	0	1	0	0
G	0	0	0	0	0	1	0
H	0	0	0	0	1	0	1

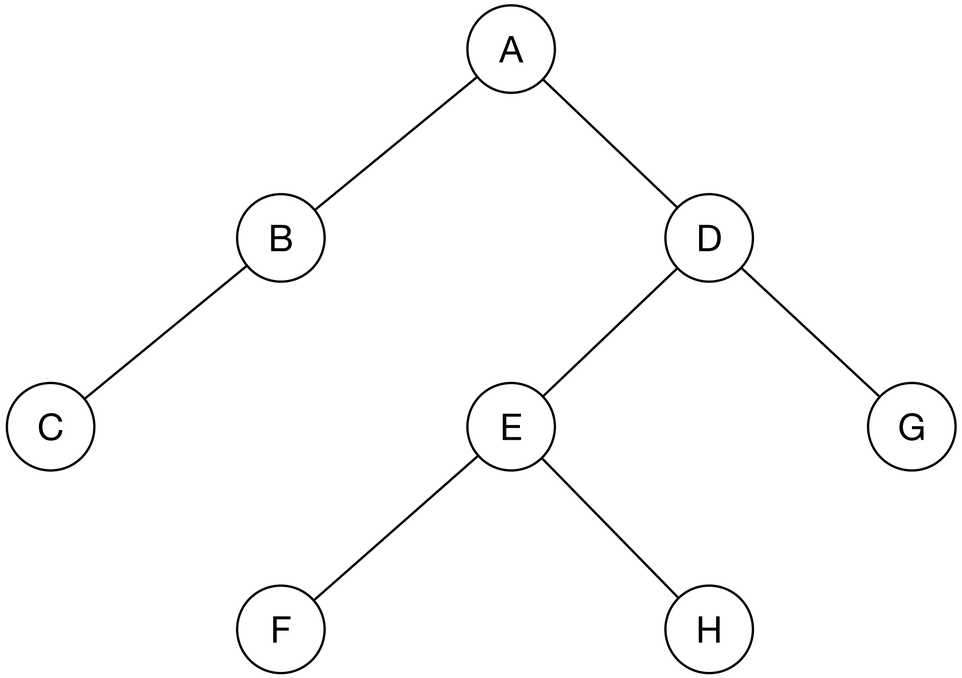
Incidence matrix





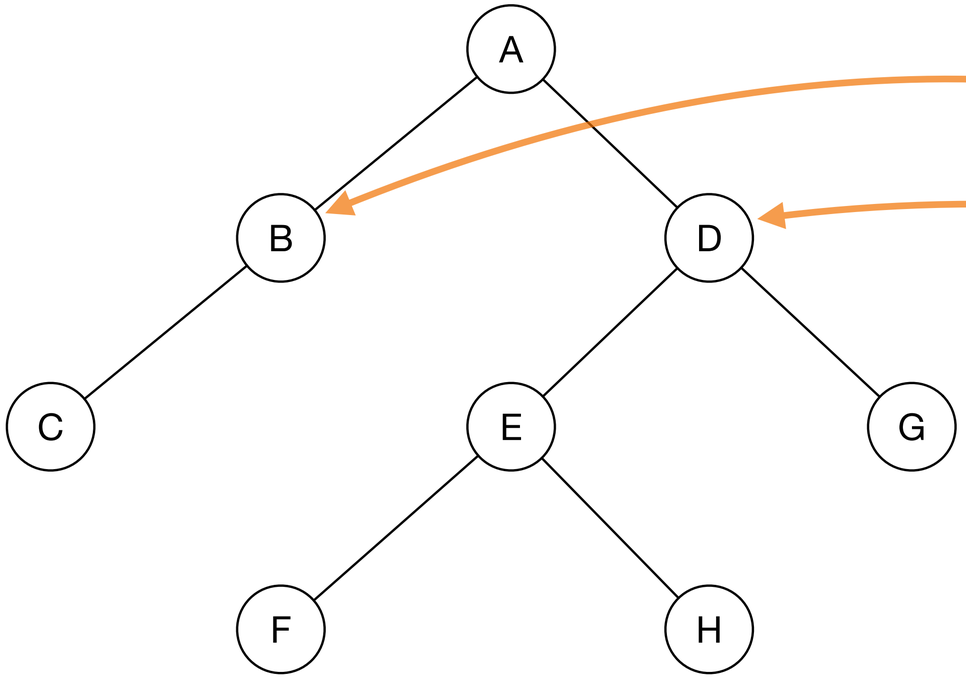


Simple L/R Object-oriented Approach




```
class Node {
private:
    Node *leftChild;
    Node *rightChild;
...
}
```

Simple L/R Object-oriented Approach

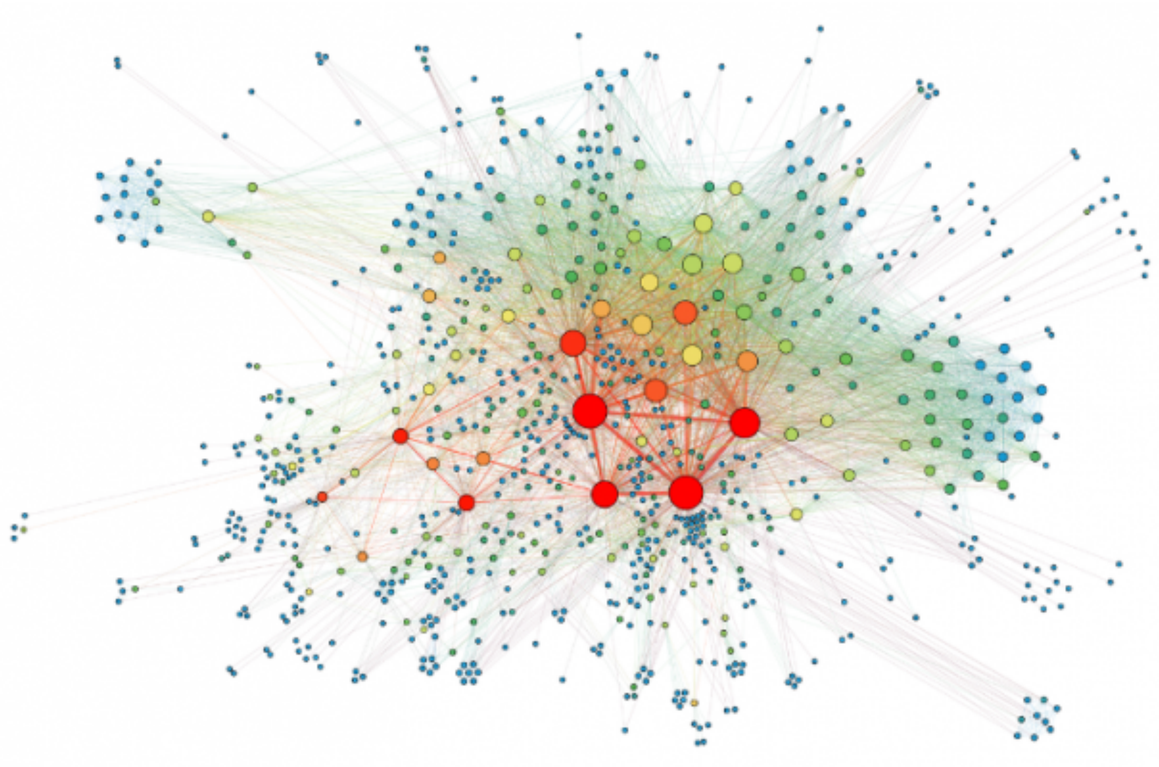


A

```
class Node {
private:
    Node *leftChild;
    Node *rightChild;

...
}
```

Simple L/R Object-oriented Approach



```
class Node {
private
    Node *leftChild;
    Node *rightChild;
...
}
```

How do we represent a tree?

Choosing a data structure

- Adjacency list - sparse objects
- Adjacency matrix - dense objects
- Simple L/R object-oriented approach - binary trees