

# Fundamentals of Artificial Intelligence

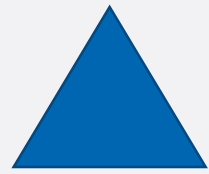
## Laboratory

Dr. Mauro Dragoni

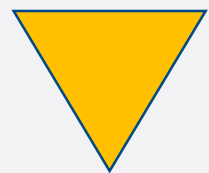
Department of Information Engineering and Computer Science  
Academic Year 2020/2021

## Exercise 5.1

- Minimax with alpha-beta pruning



- MAX nodes. The goal at a MAX node is to maximize the value of the subtree rooted at that node. To do this, a MAX node chooses the child with the greatest value, and that becomes the value of the MAX node.

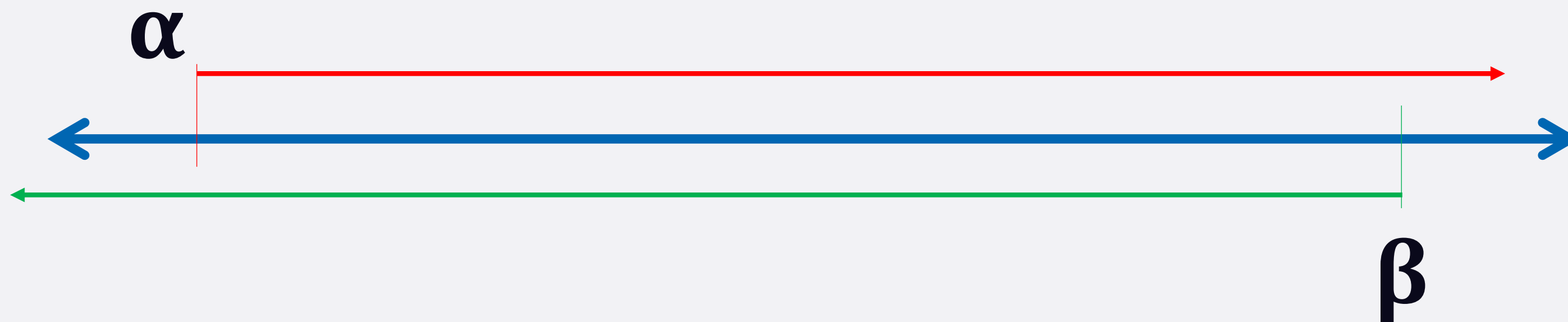


- MIN nodes. The goal at a MIN node is to minimize the value of the subtree rooted at that node. To do this, a MIN node chooses the child with the least (smallest) value, and that becomes the value of the MIN node.
- $\alpha$ : Alpha is the maximum lower bound of possible solutions. It is equivalent to  $\geq -\infty$
- $\beta$ : Beta is the minimum upper bound of possible solutions. It is equivalent to  $\leq \infty$ .

## Exercise 5.1

- Minimax with alpha-beta pruning, tips:
  - When any new node is being considered as a possible path to the solution, it can only work if:

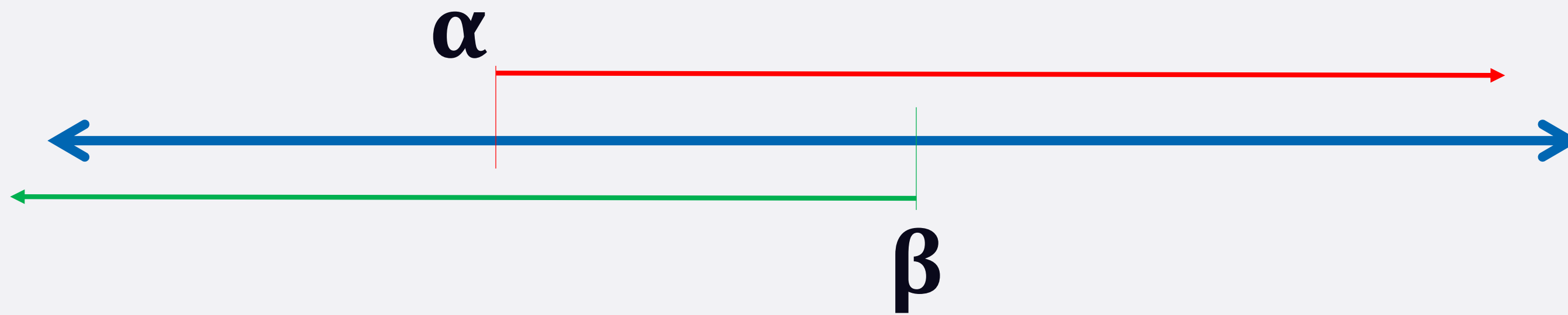
$$\alpha \leq \mathbf{N} \leq \beta$$



## Exercise 5.1

- Minimax with alpha-beta pruning, tips:
  - When any new node is being considered as a possible path to the solution, it can only work if:

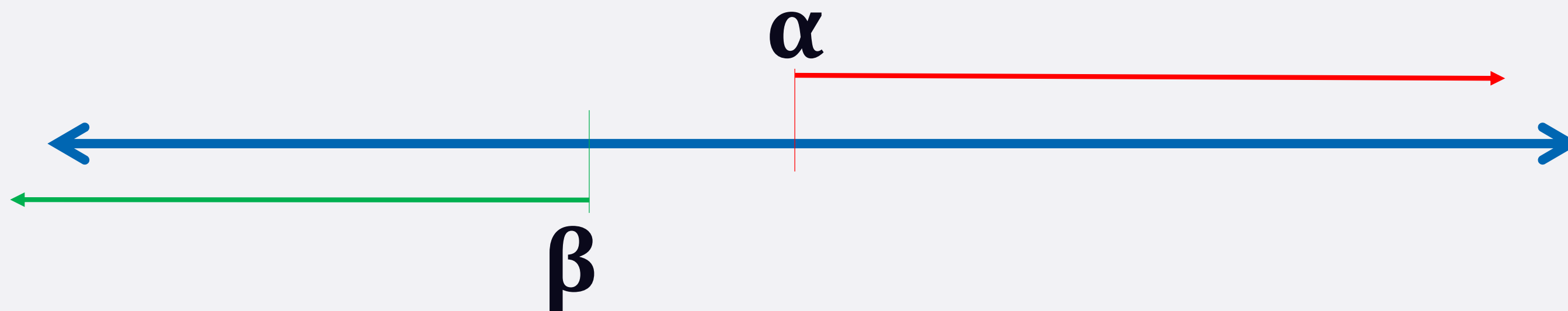
$$\alpha \leq \mathbf{N} \leq \beta$$



## Exercise 5.1

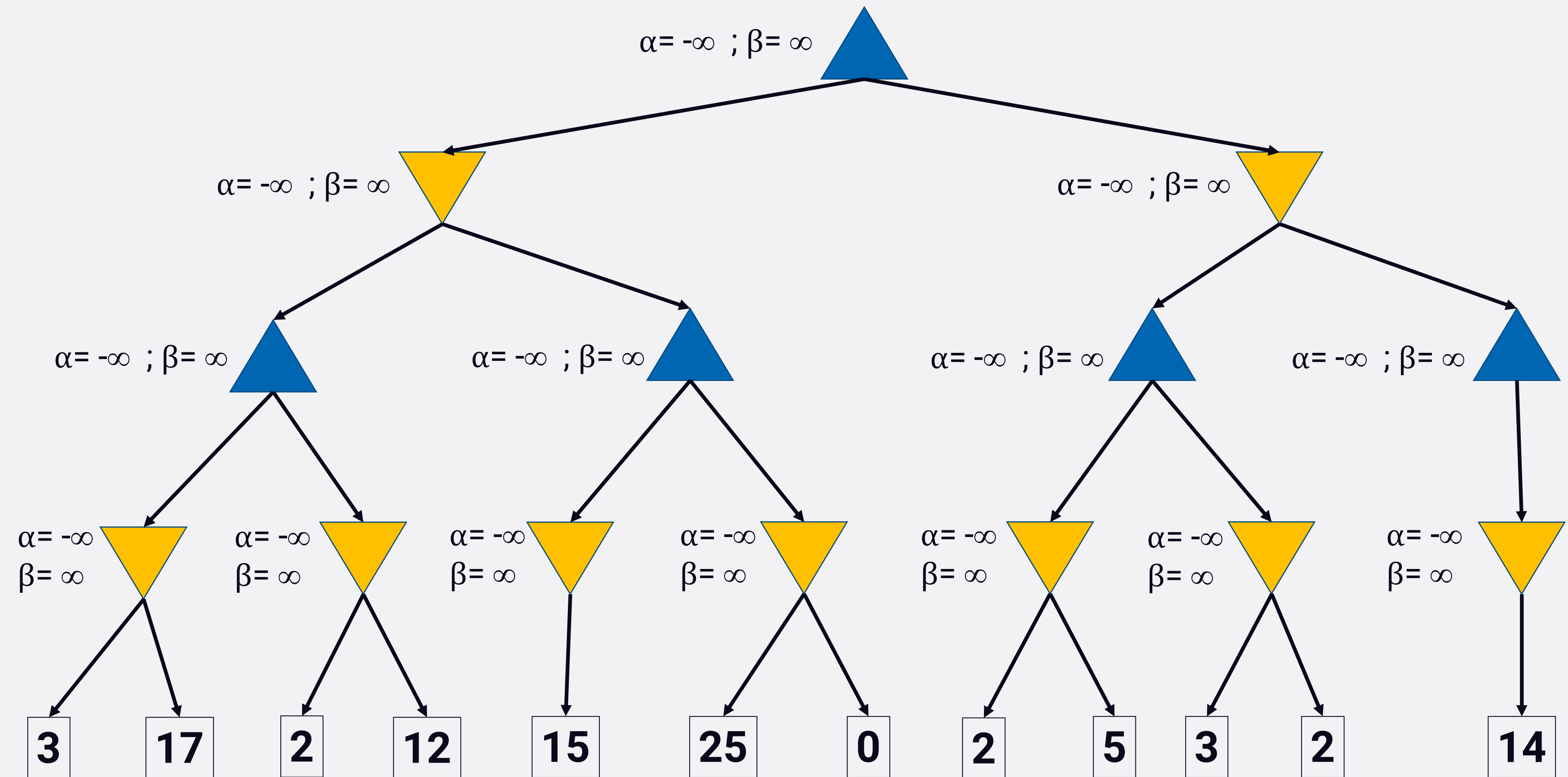
- Minimax with alpha-beta pruning, tips:
  - When any new node is being considered as a possible path to the solution, it can only work if:

$$\alpha \leq \mathbf{N} \leq \beta$$



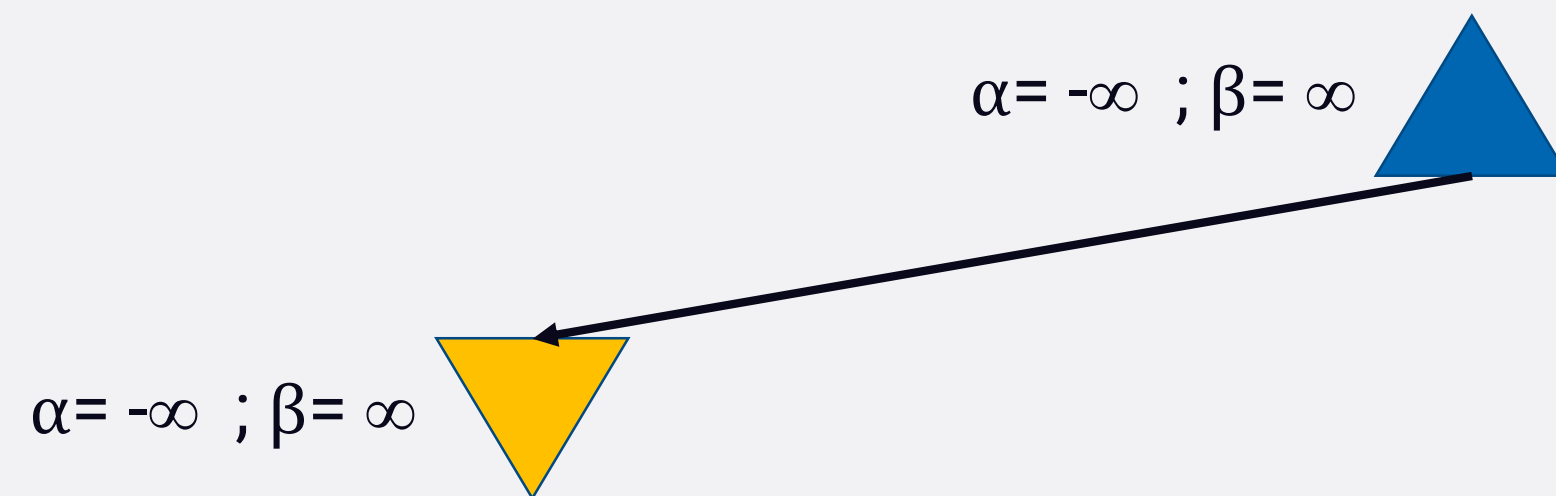
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- Minimax with alpha-beta pruning



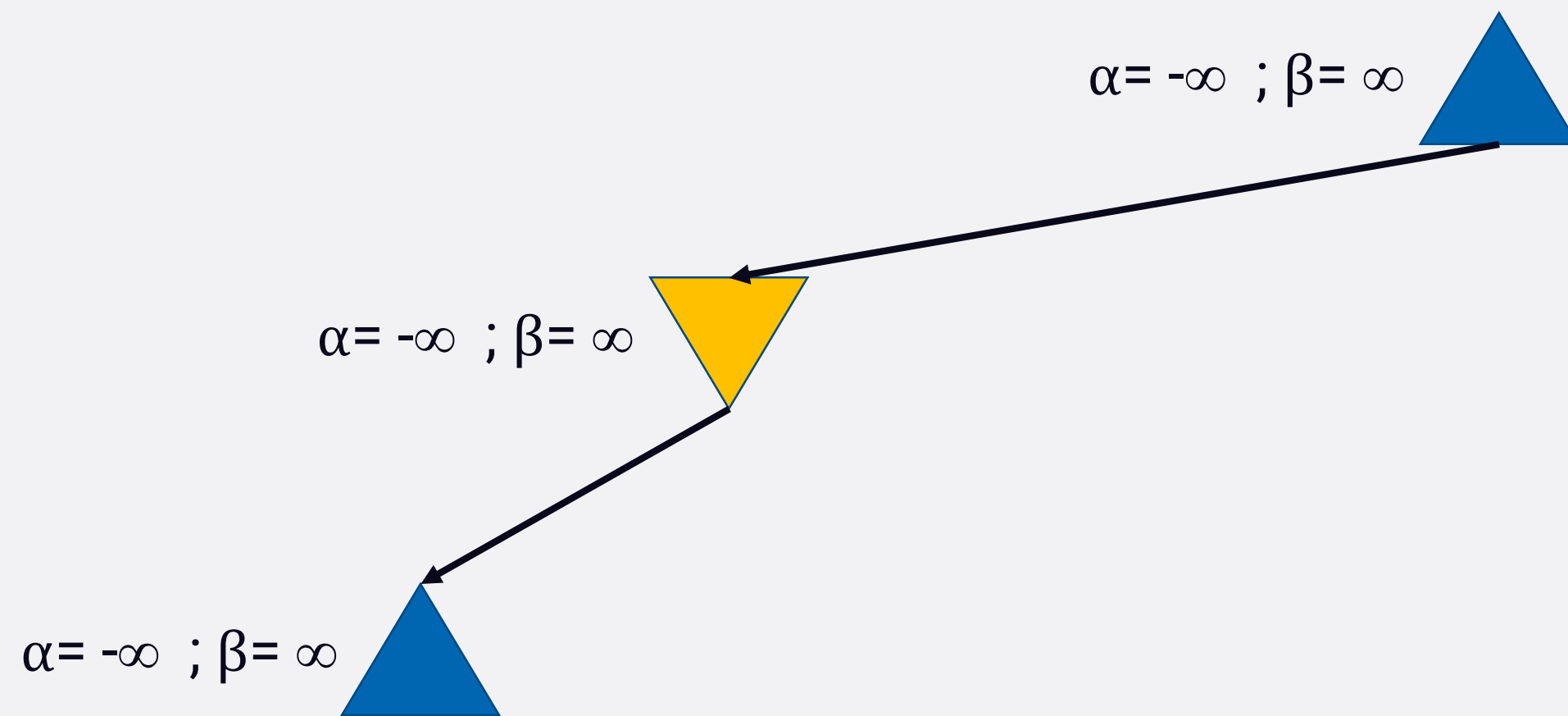
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- Minimax with alpha-beta pruning



# Exercise 5.1

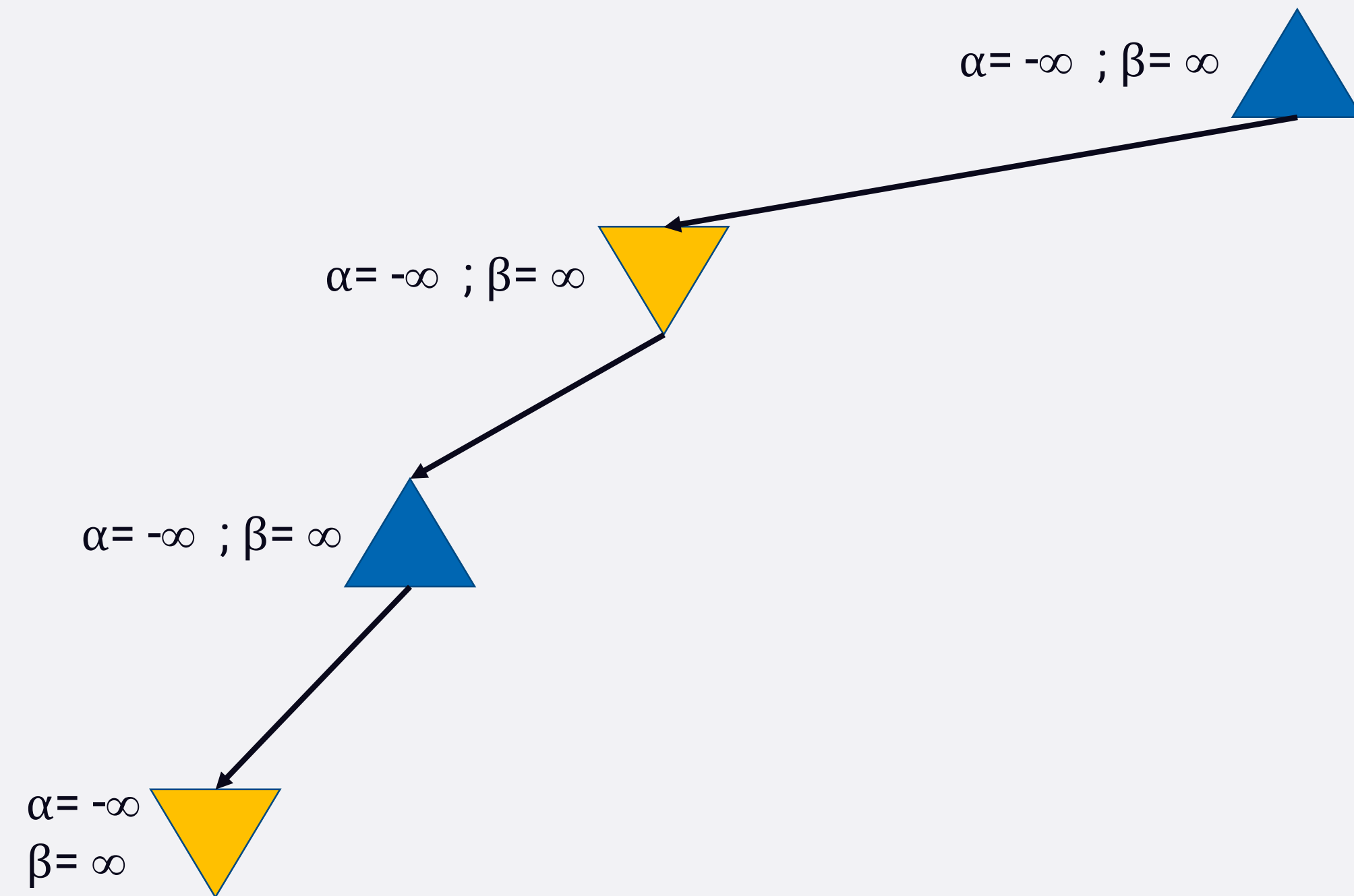
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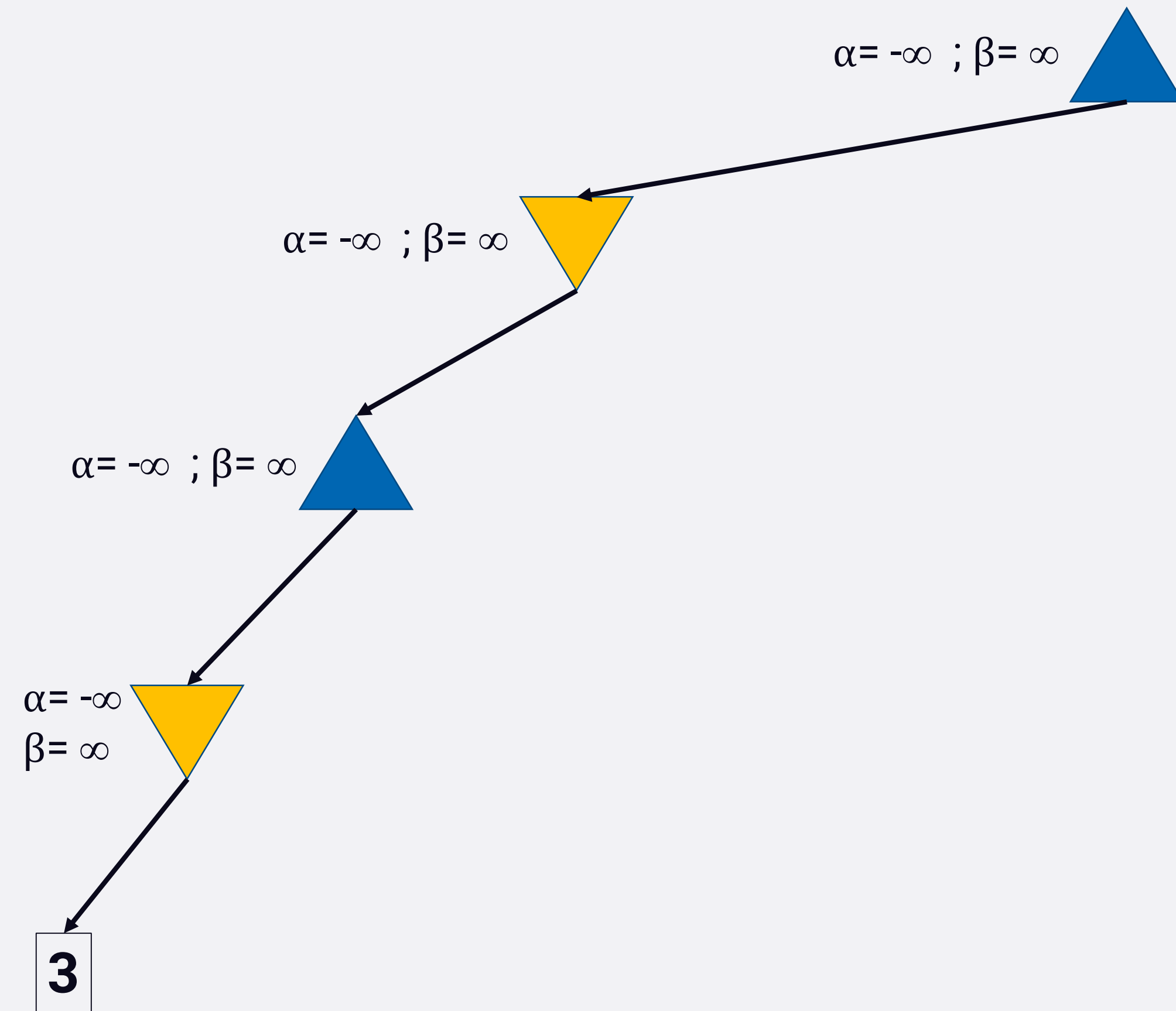
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- Minimax with alpha-beta pruning



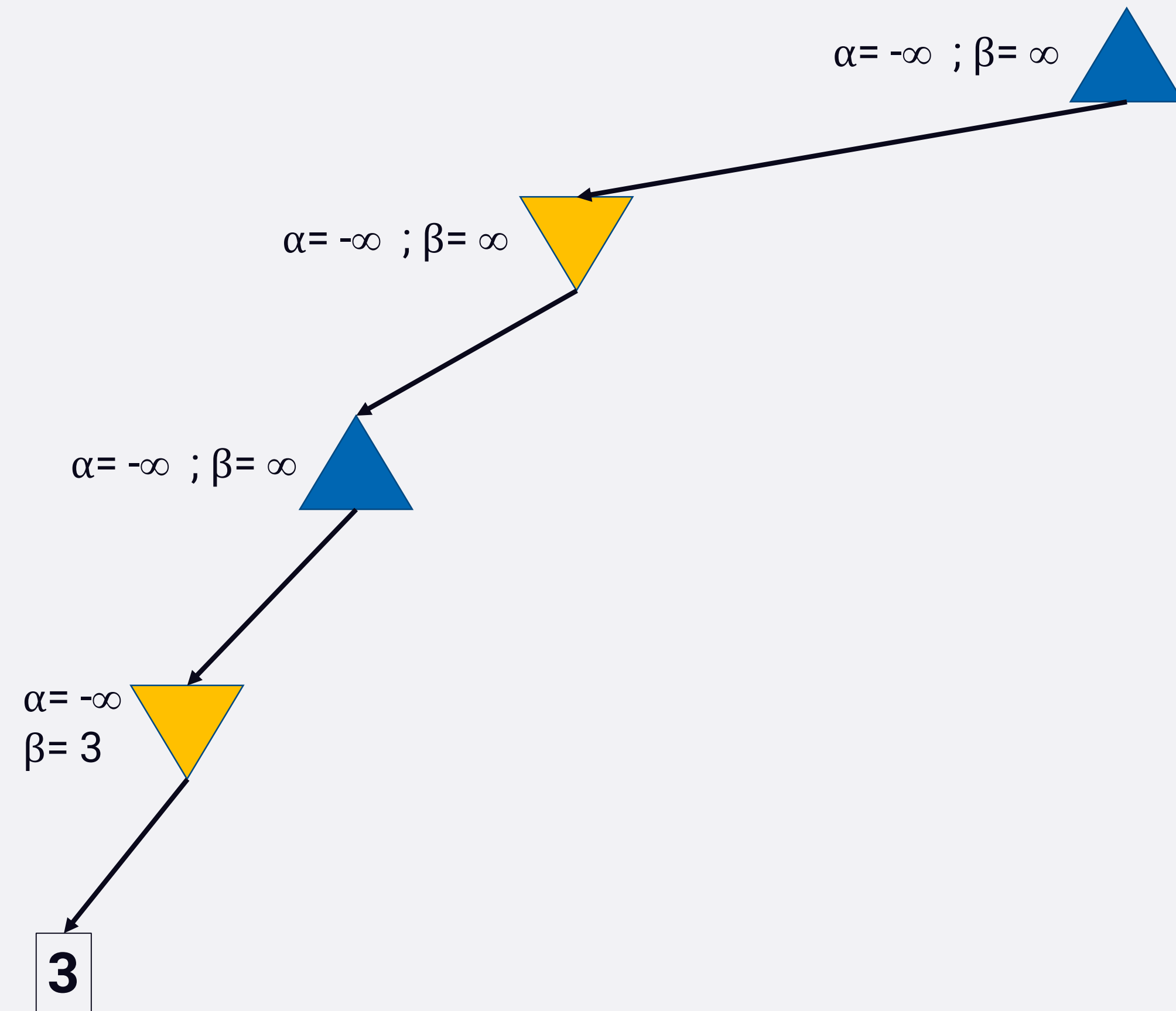
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- Minimax with alpha-beta pruning



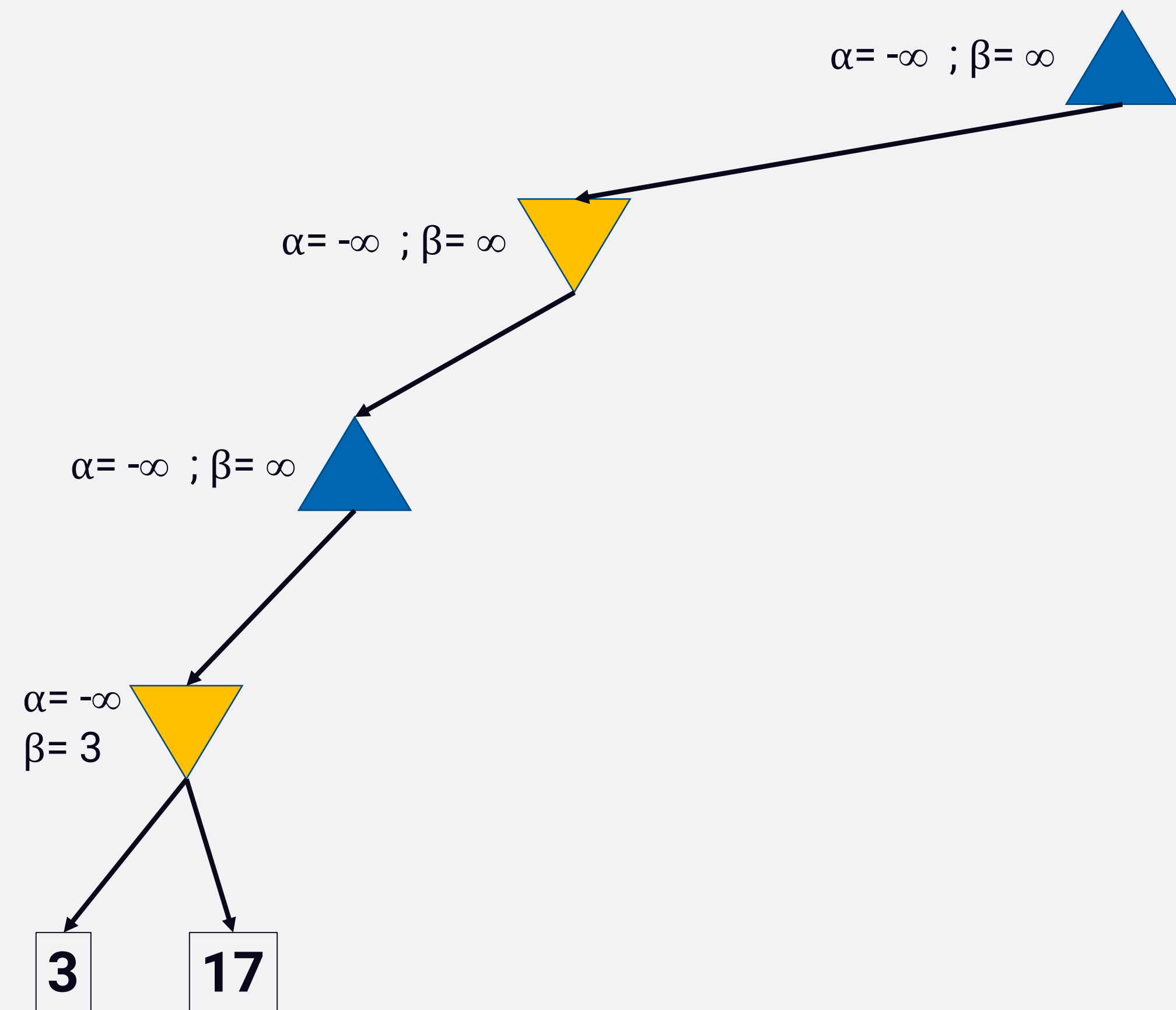
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- Minimax with alpha-beta pruning



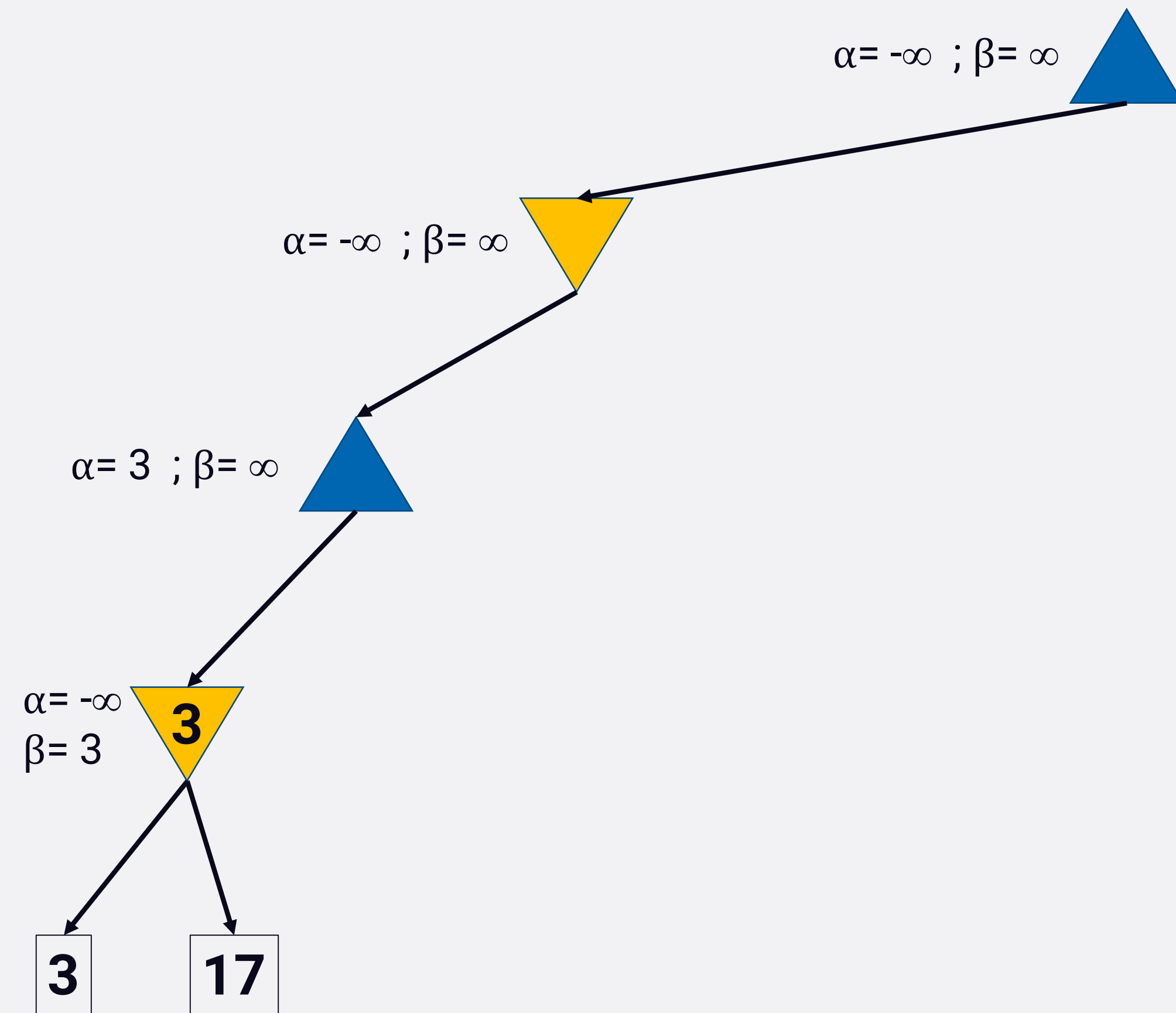
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- Minimax with alpha-beta pruning



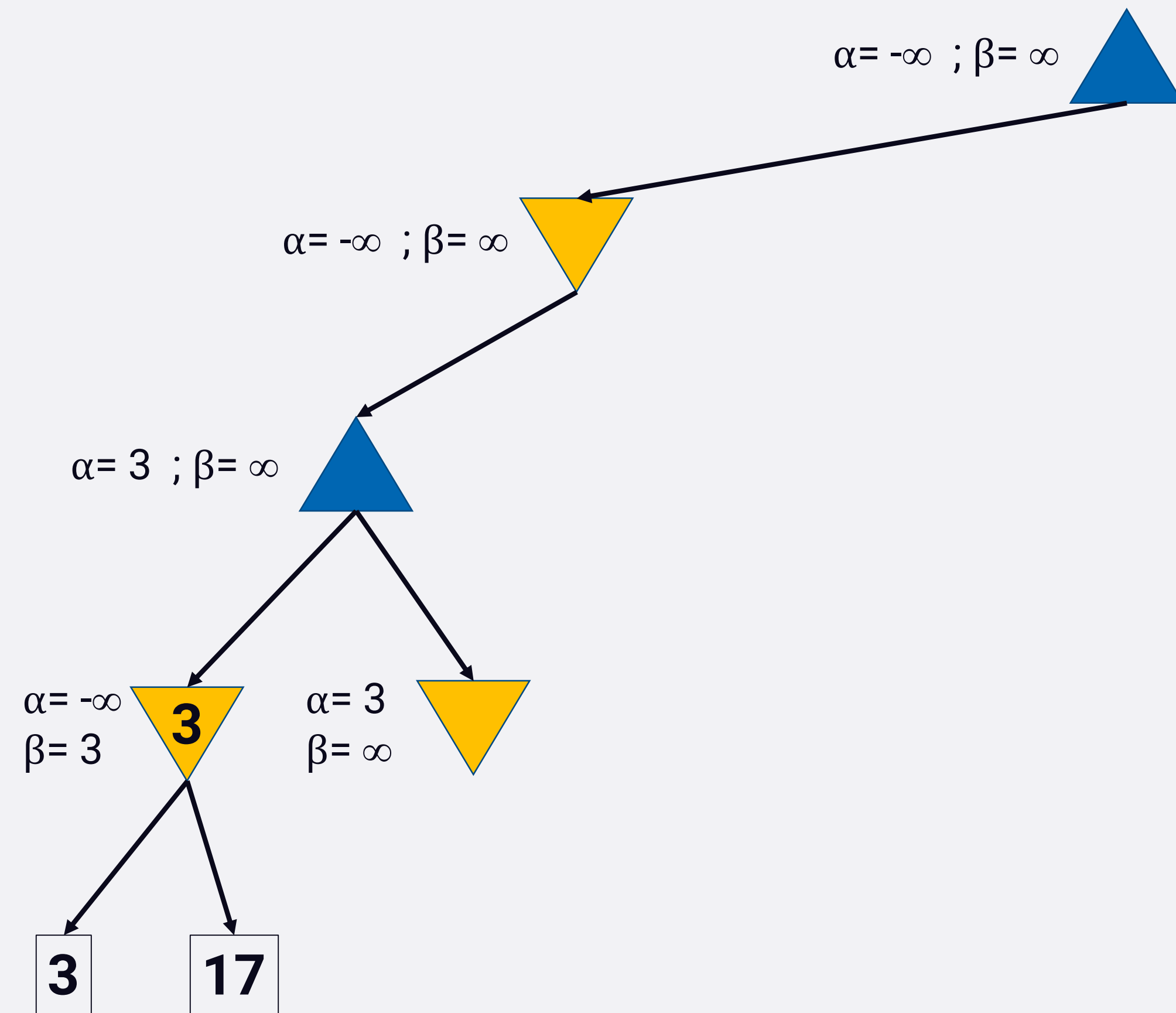
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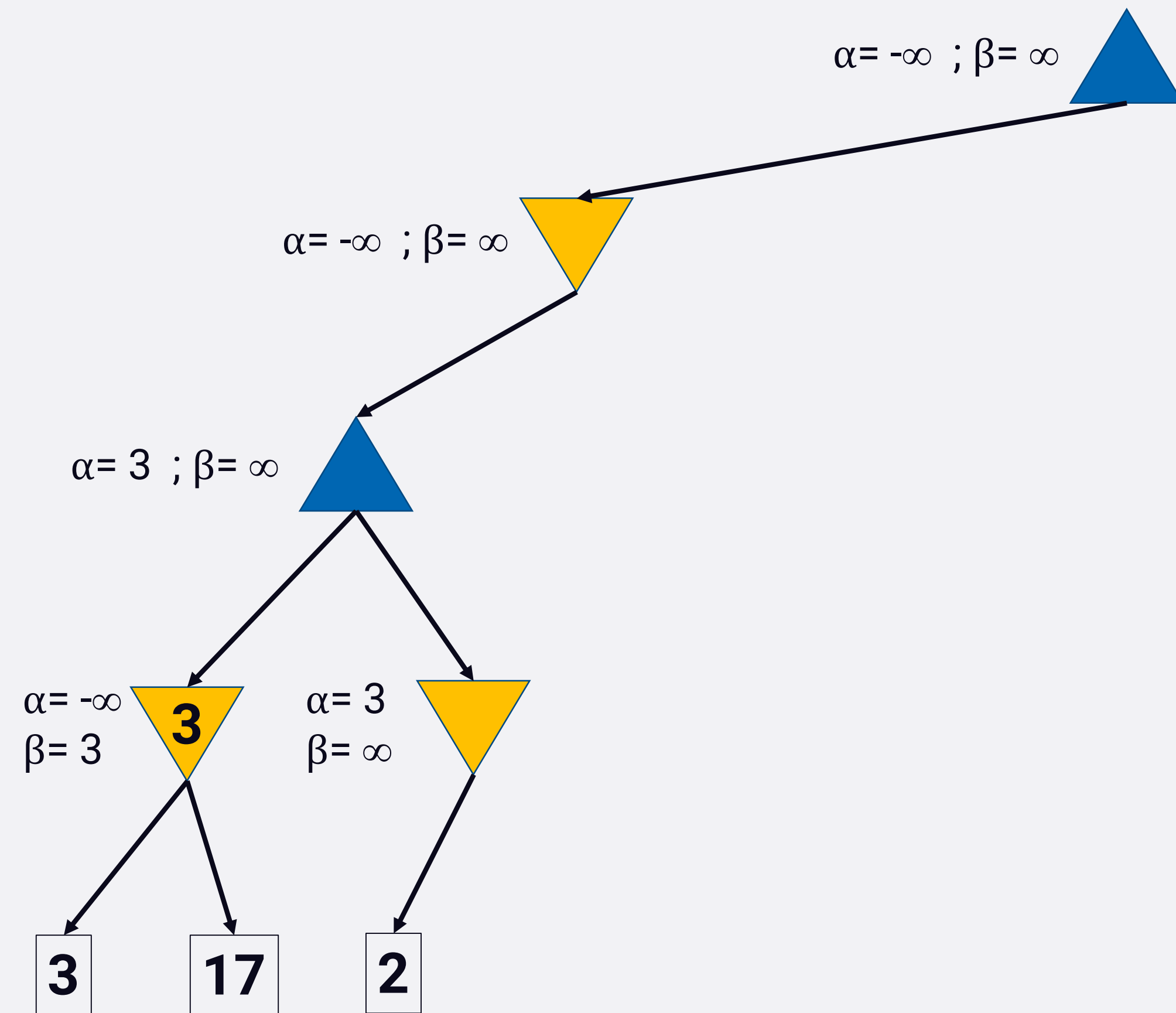
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- Minimax with alpha-beta pruning



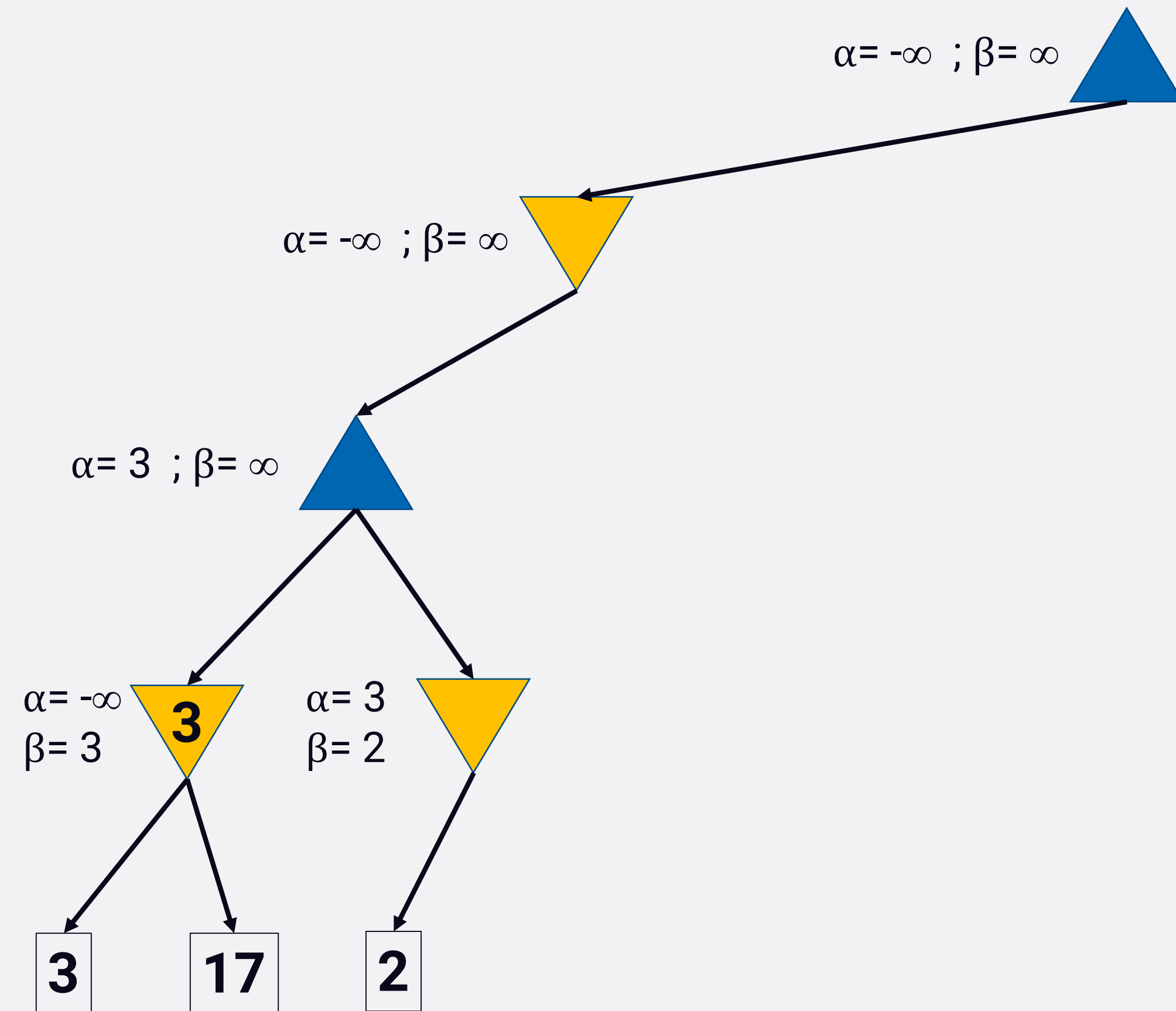
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# Exercise 5.1

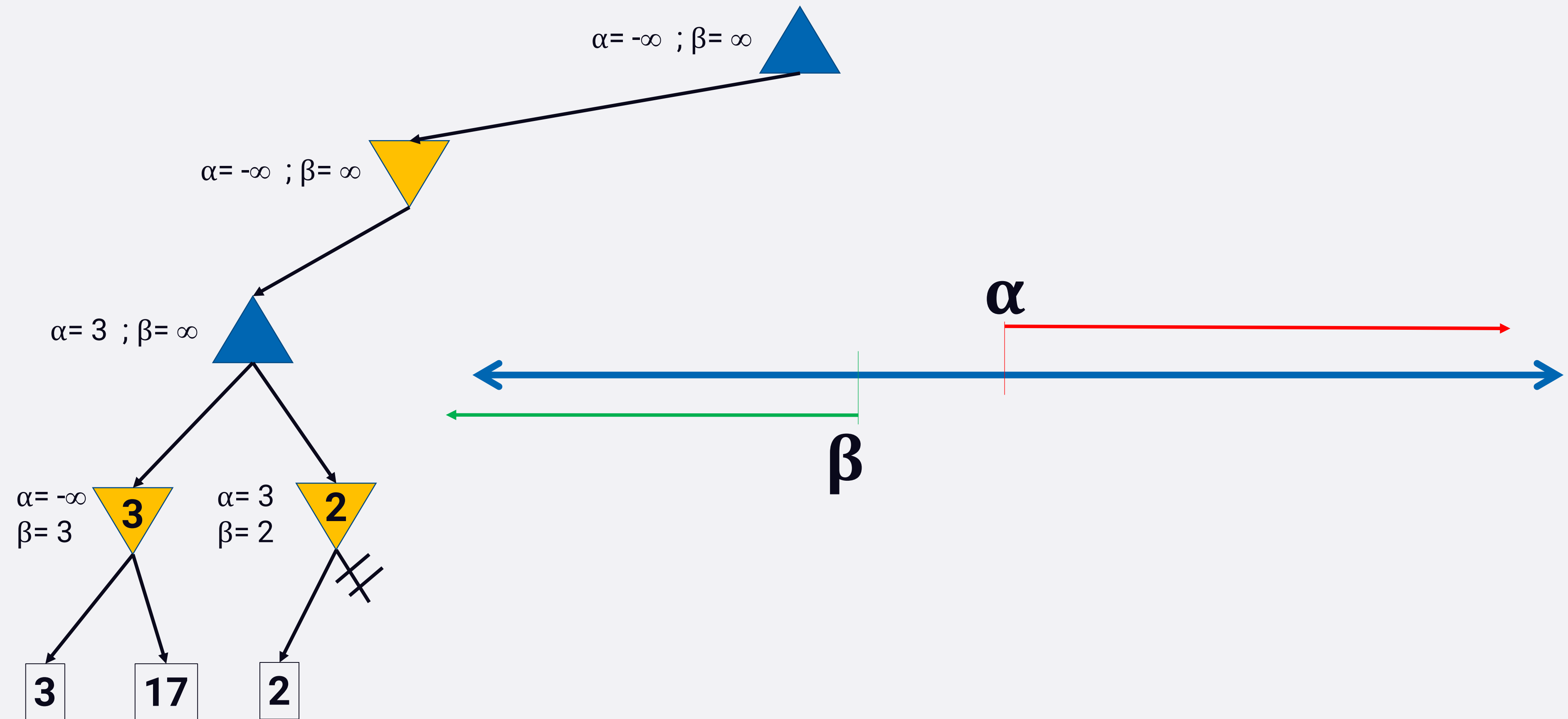
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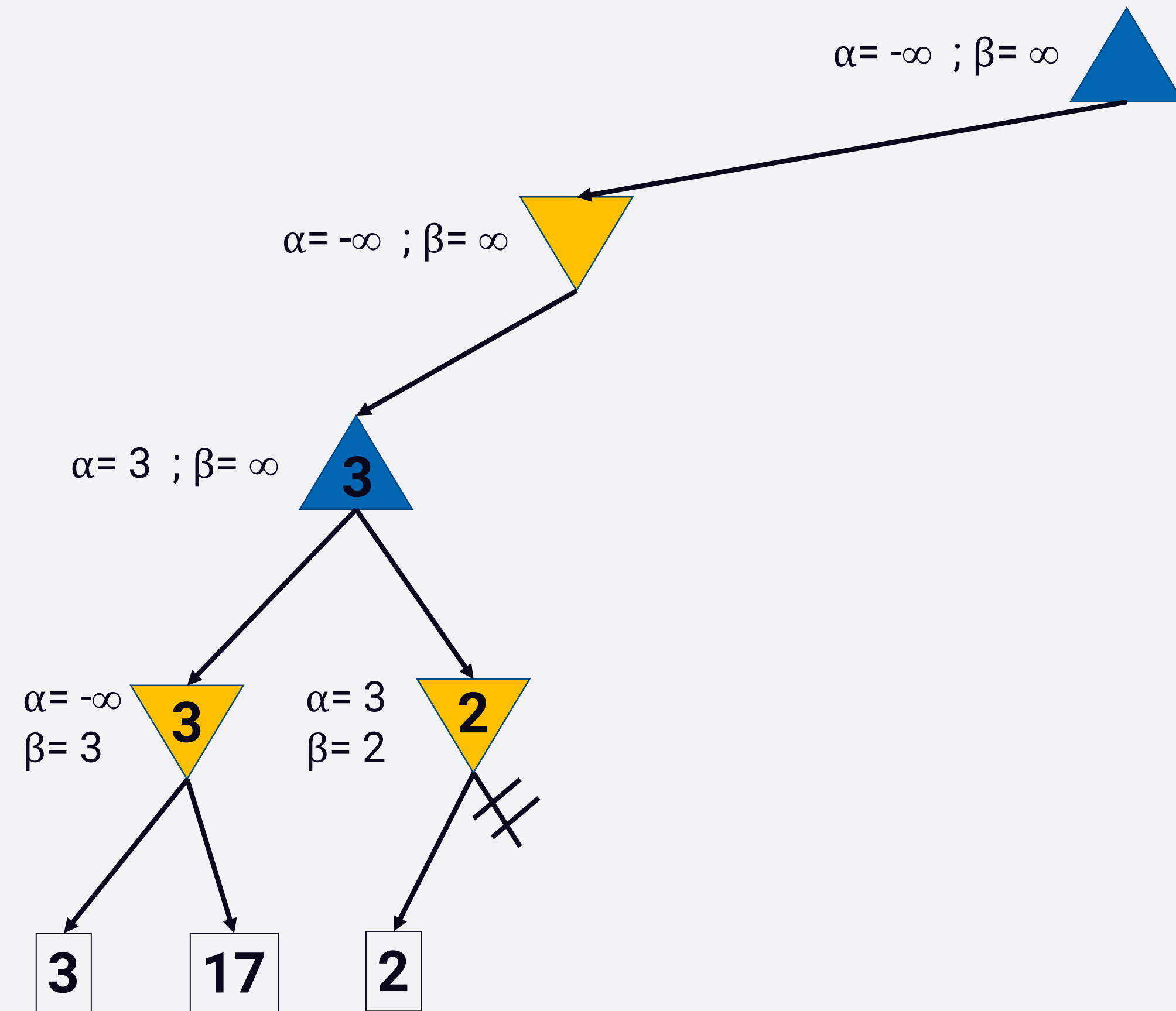
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- Minimax with alpha-beta pruning



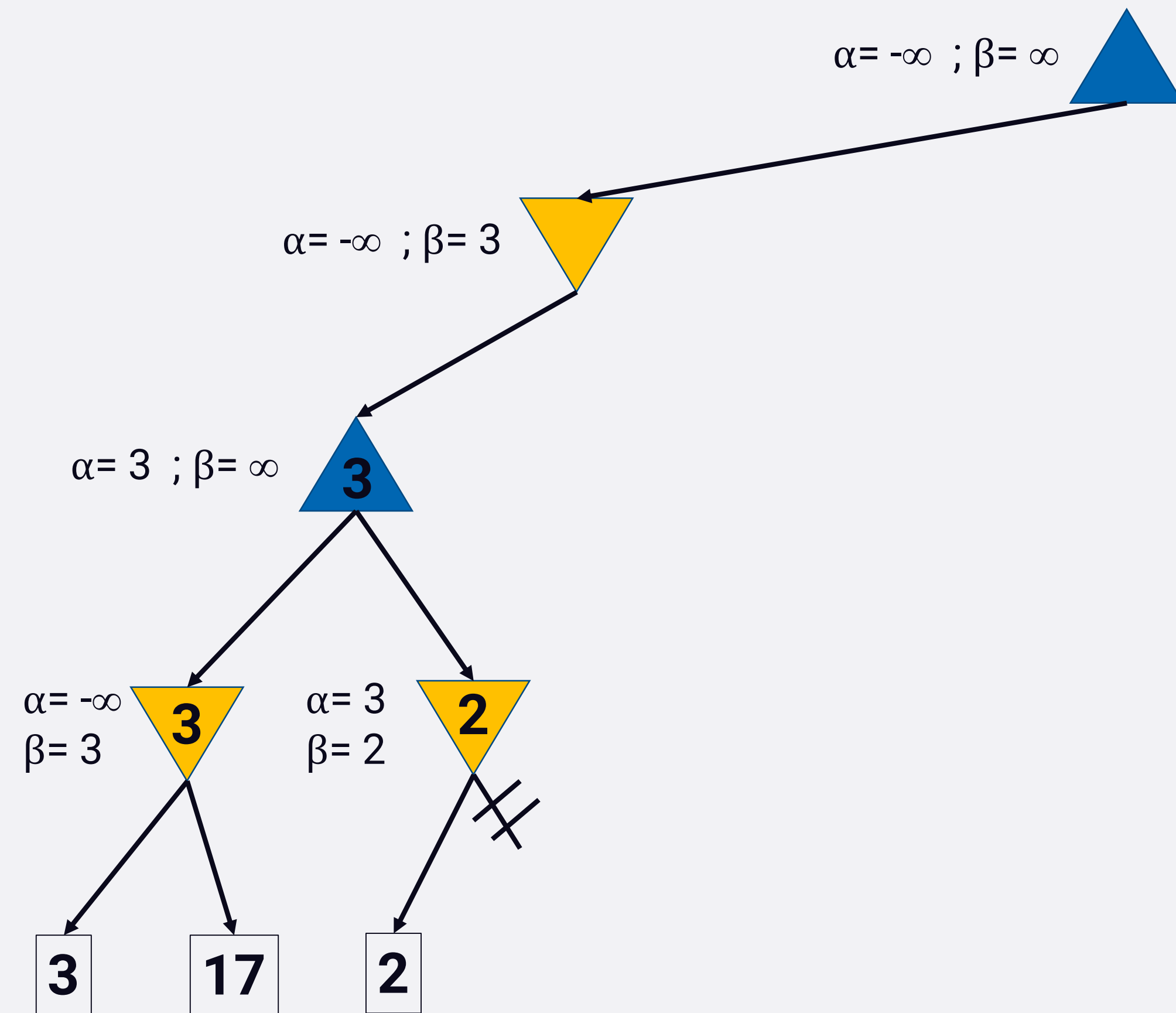
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- Minimax with alpha-beta pruning



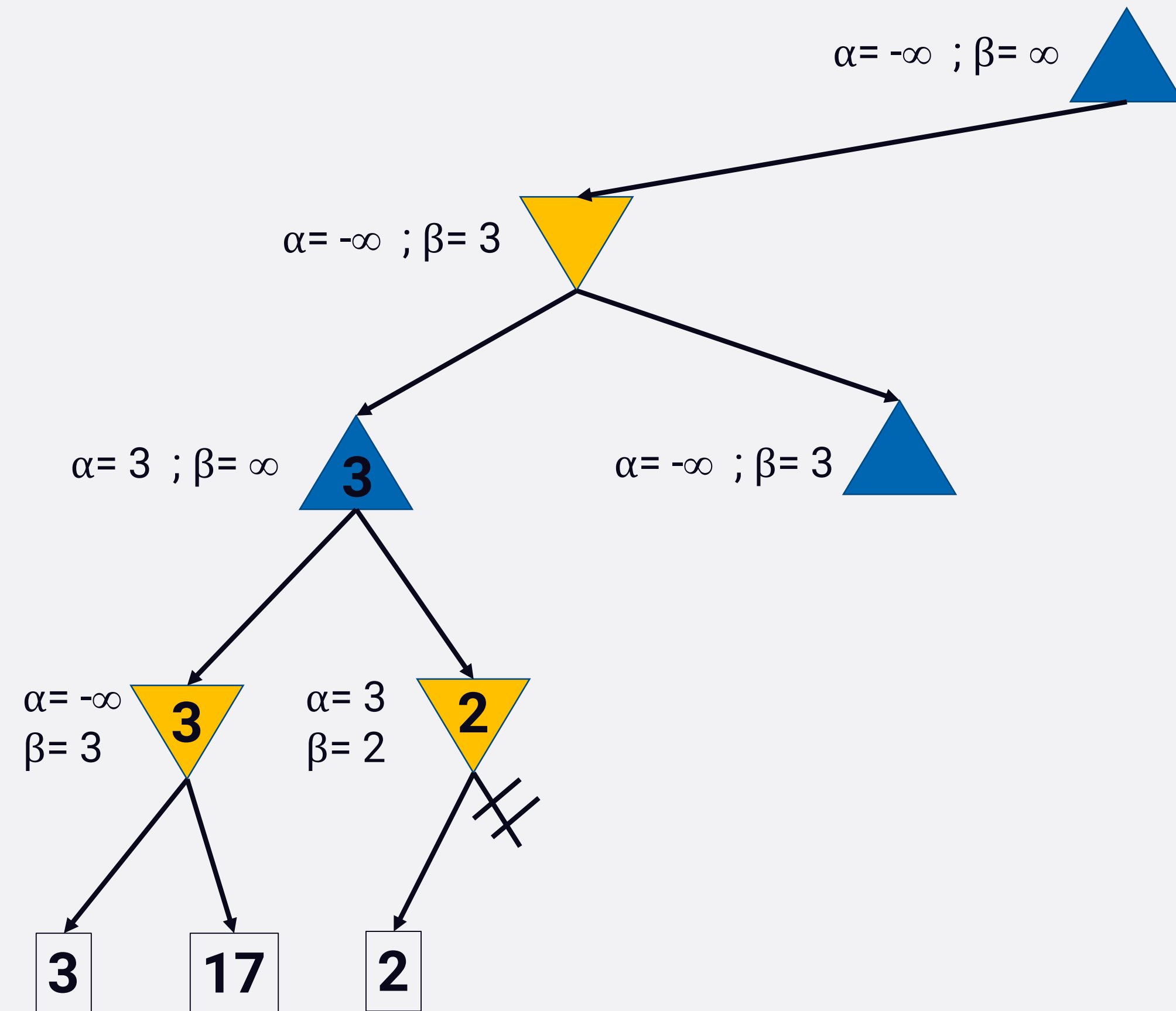
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- Minimax with alpha-beta pruning



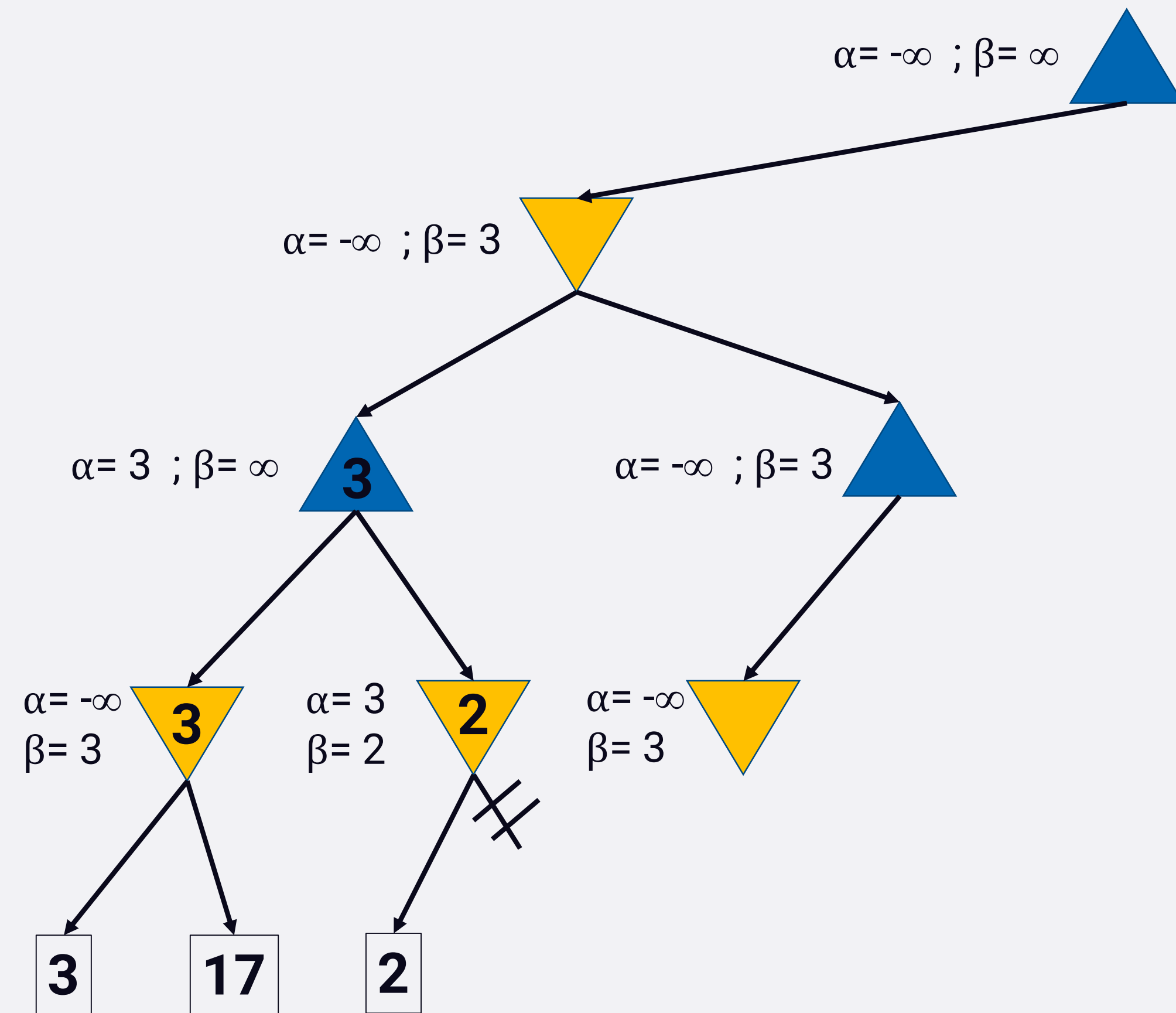
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- Minimax with alpha-beta pruning



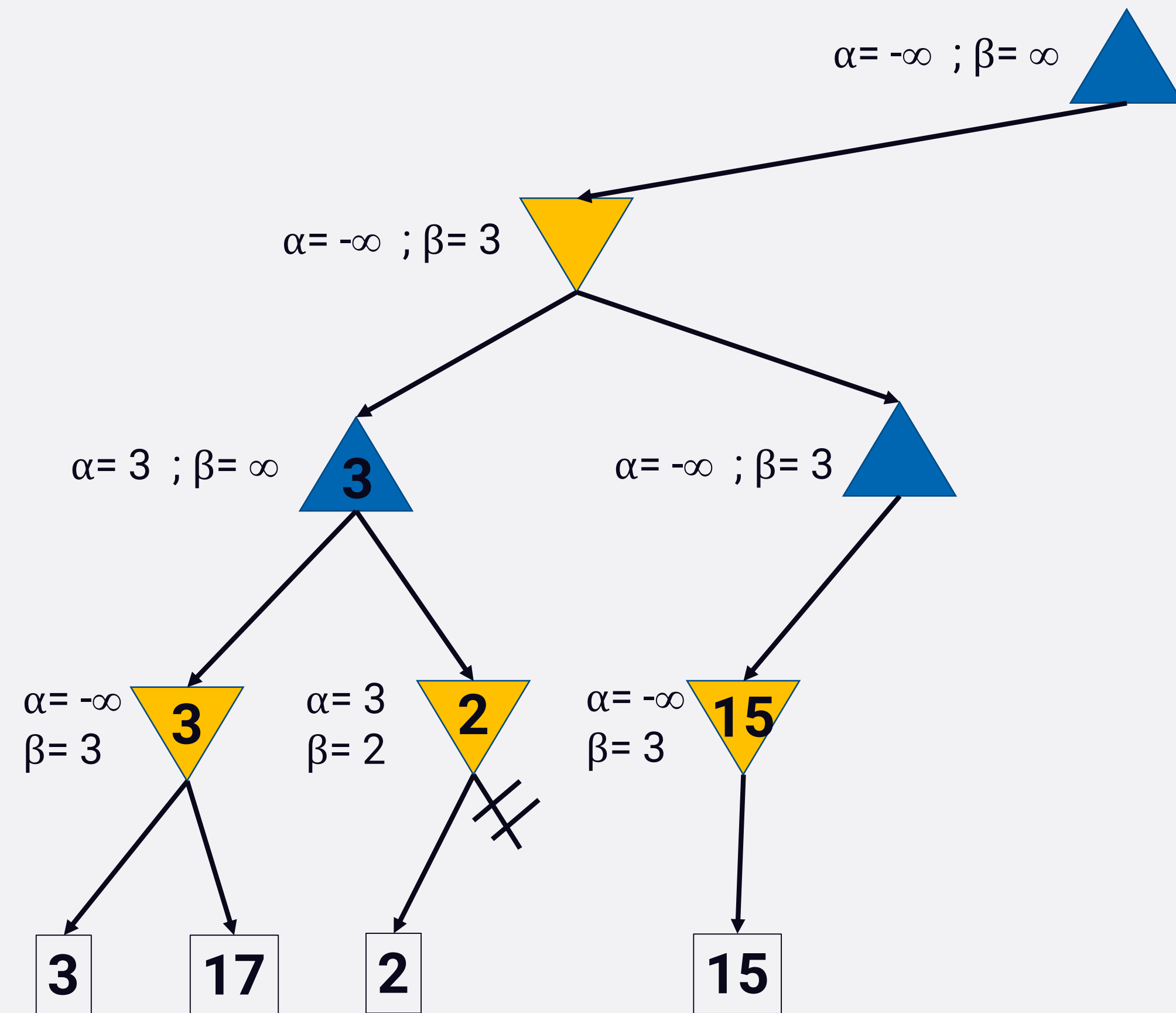
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- Minimax with alpha-beta pruning



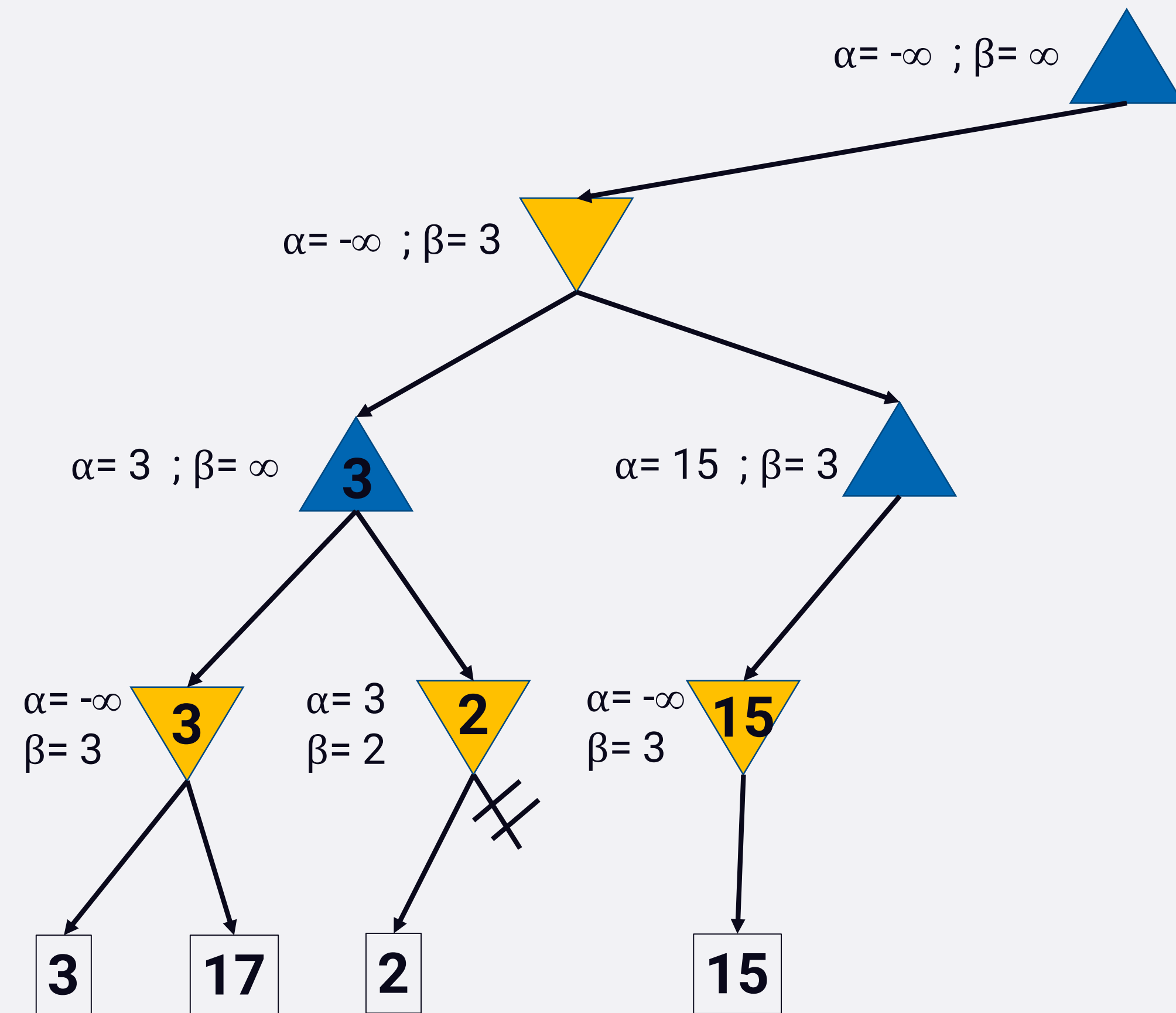
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- Minimax with alpha-beta pruning



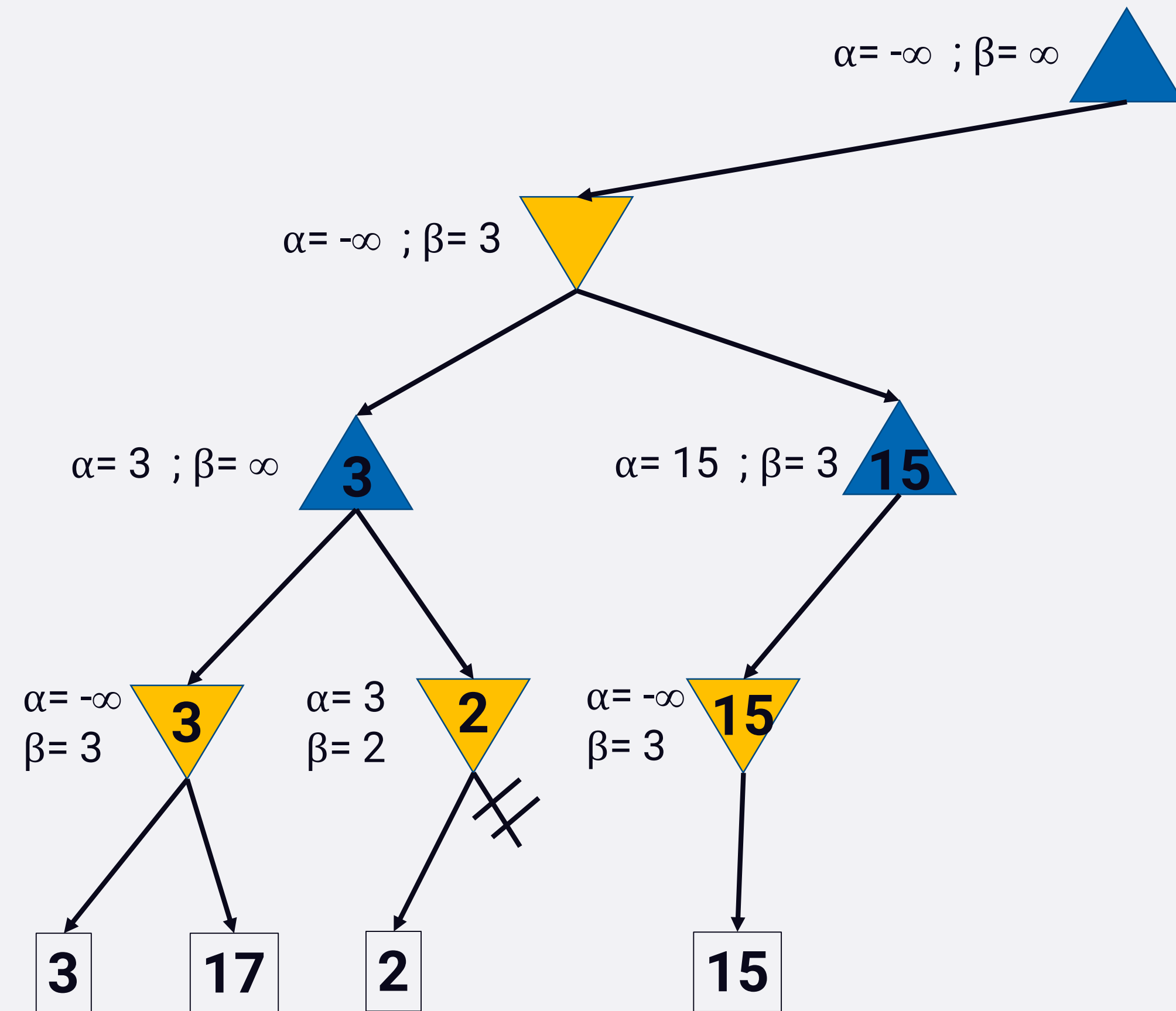
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- Minimax with alpha-beta pruning



# Exercise 5.1

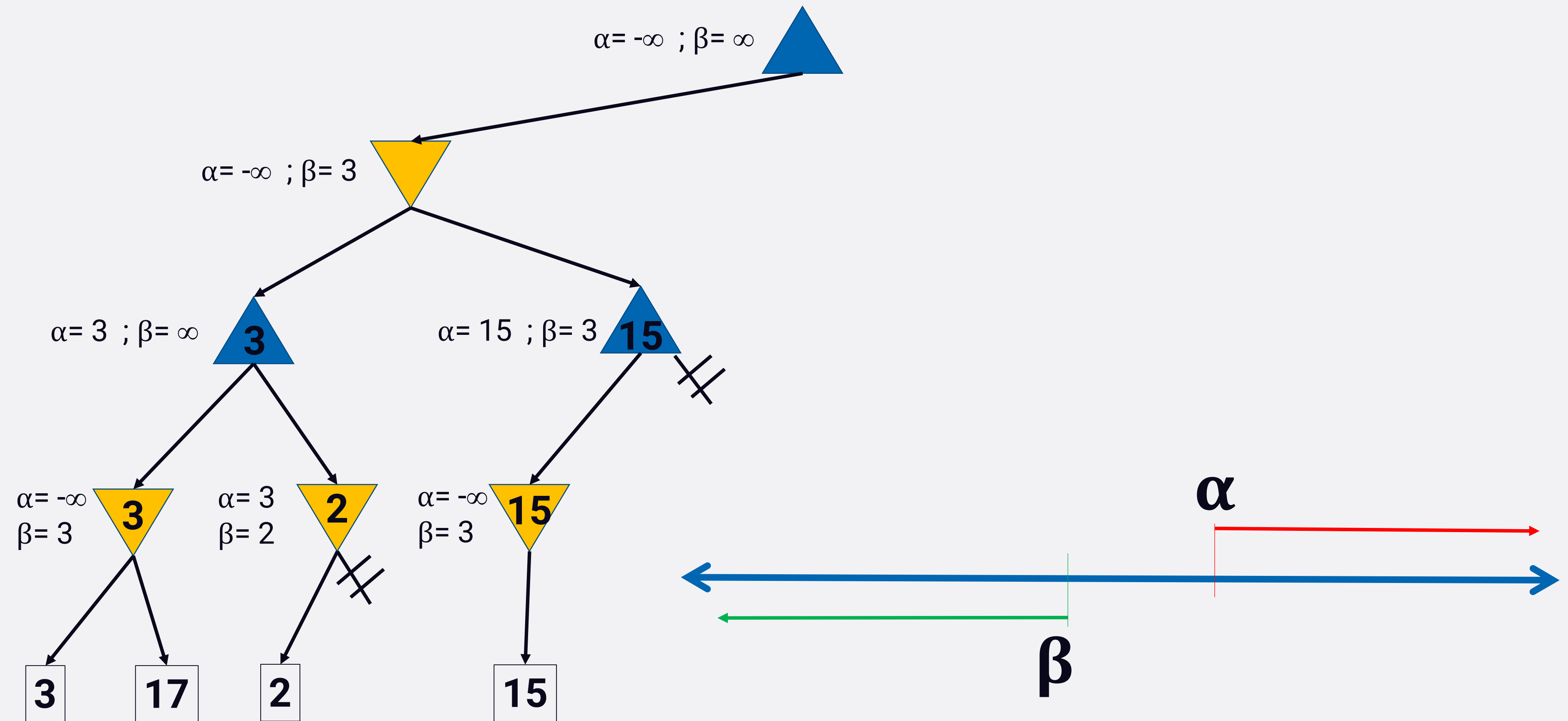
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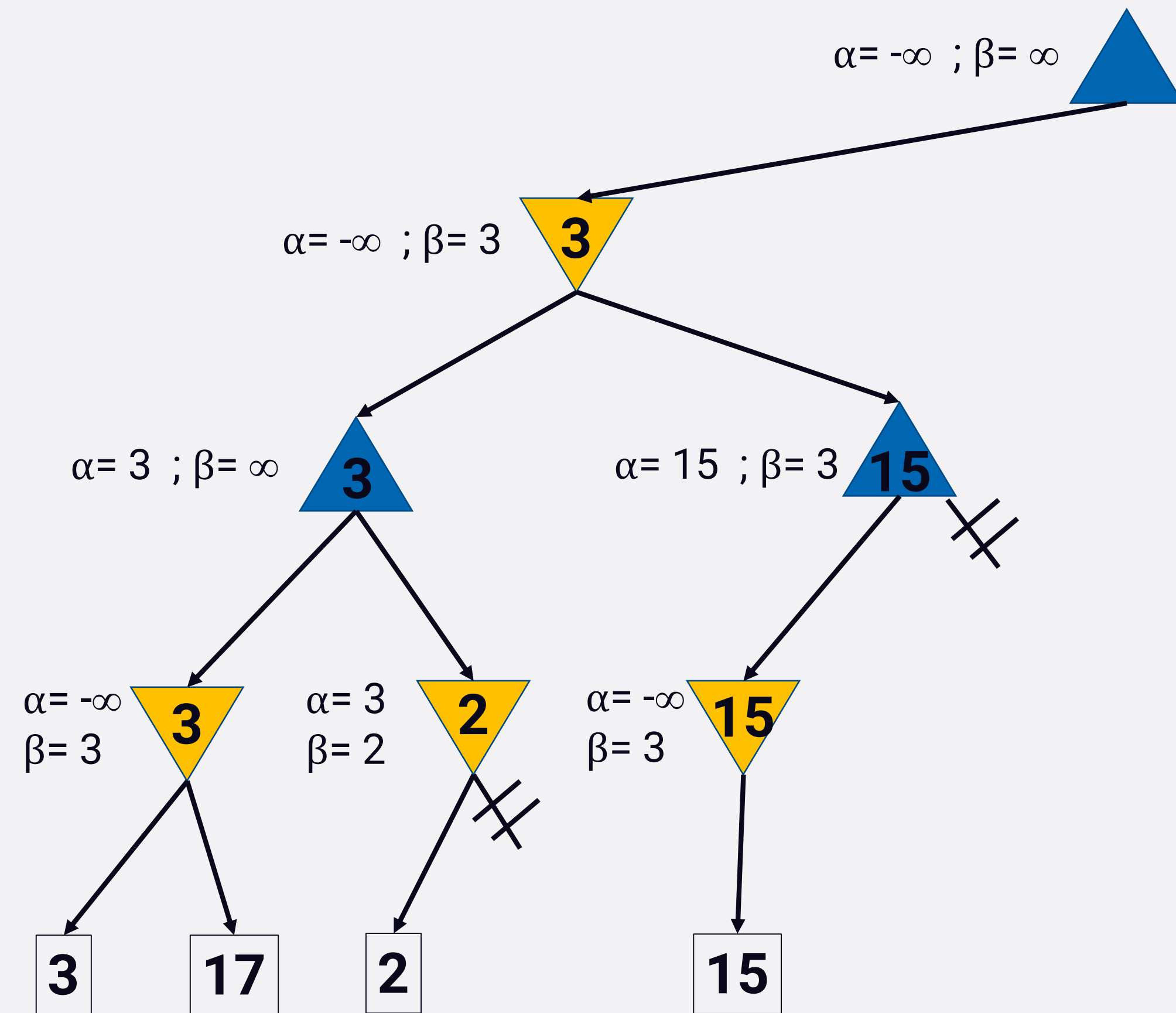
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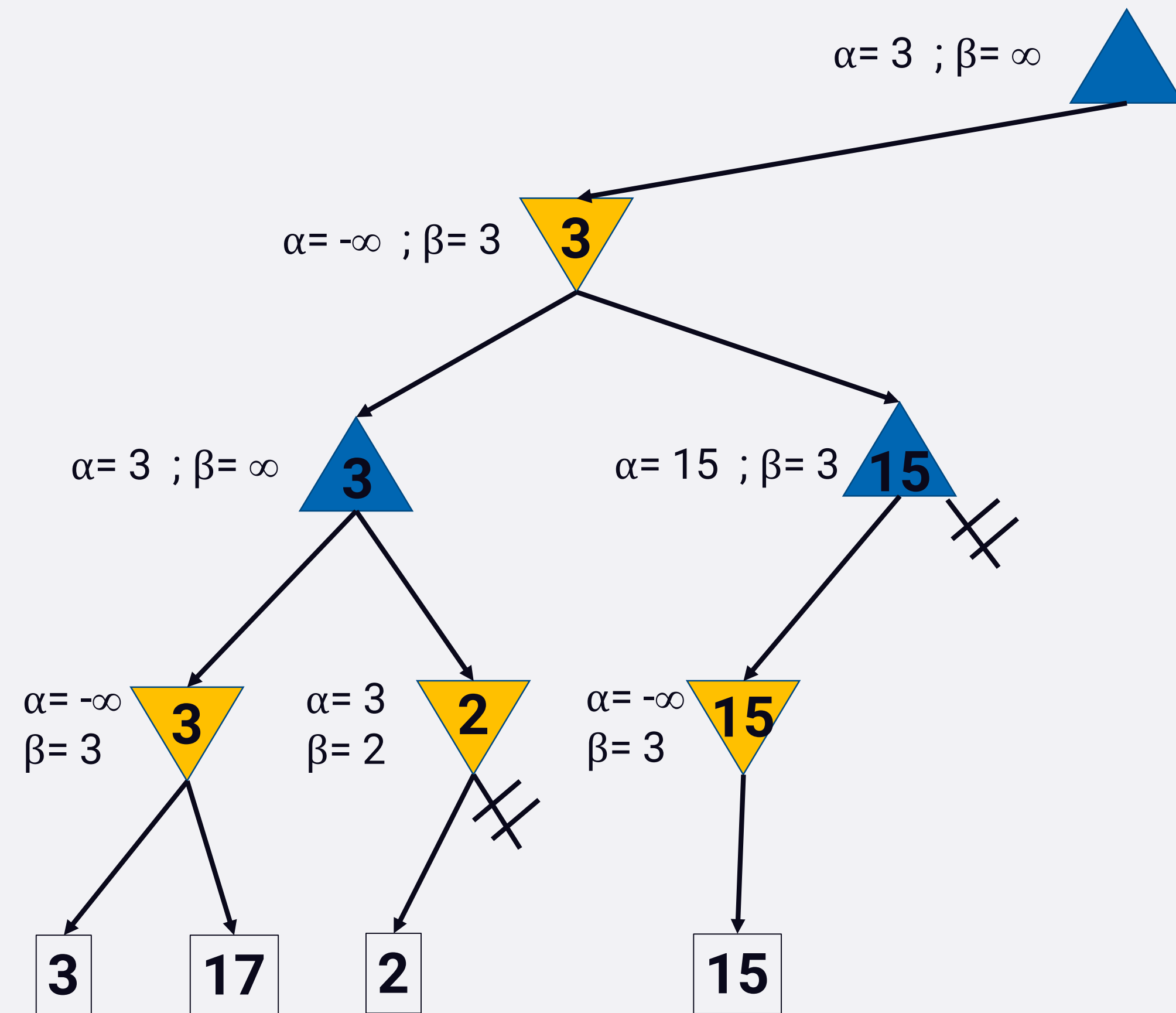
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- Minimax with alpha-beta pruning



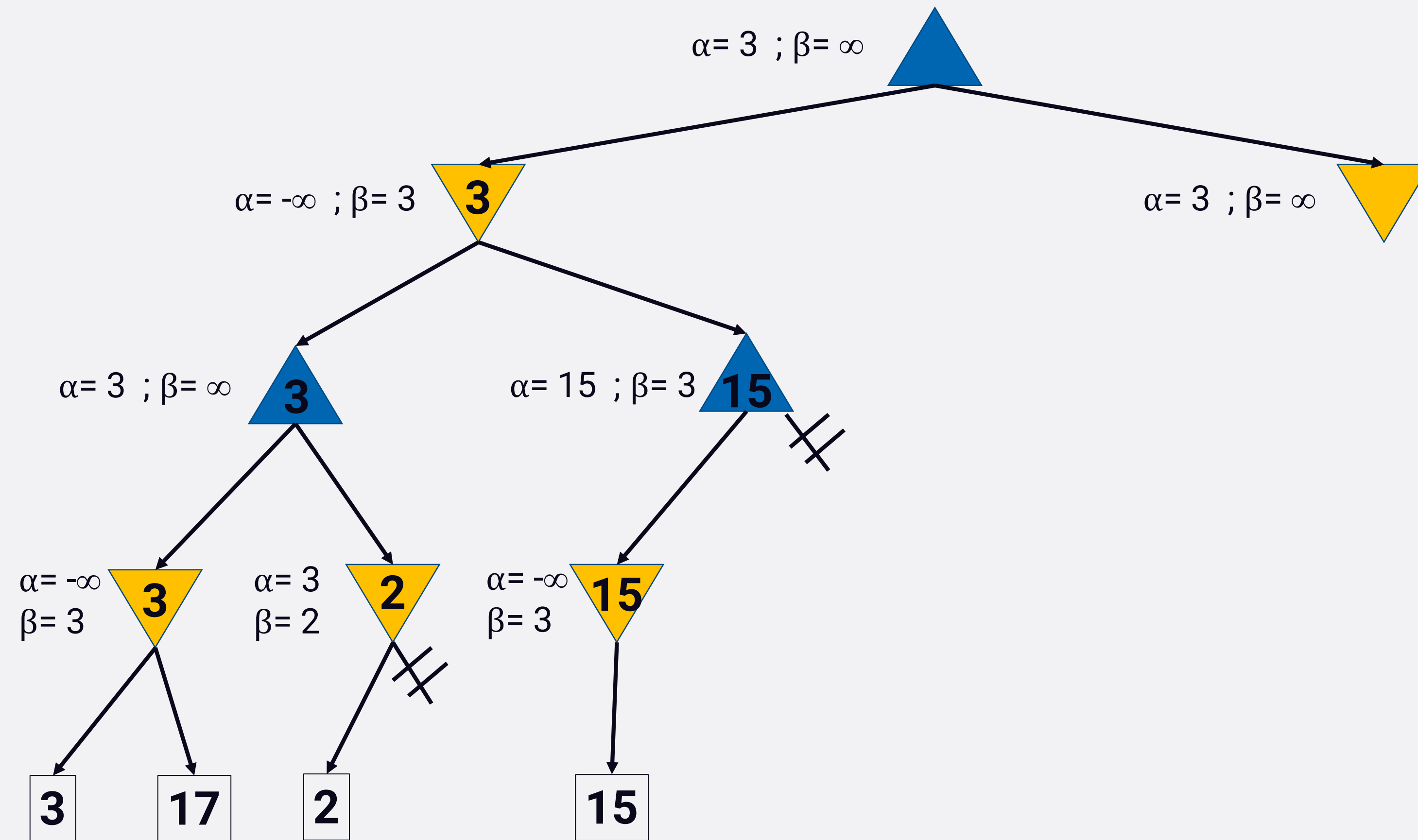
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- Minimax with alpha-beta pruning



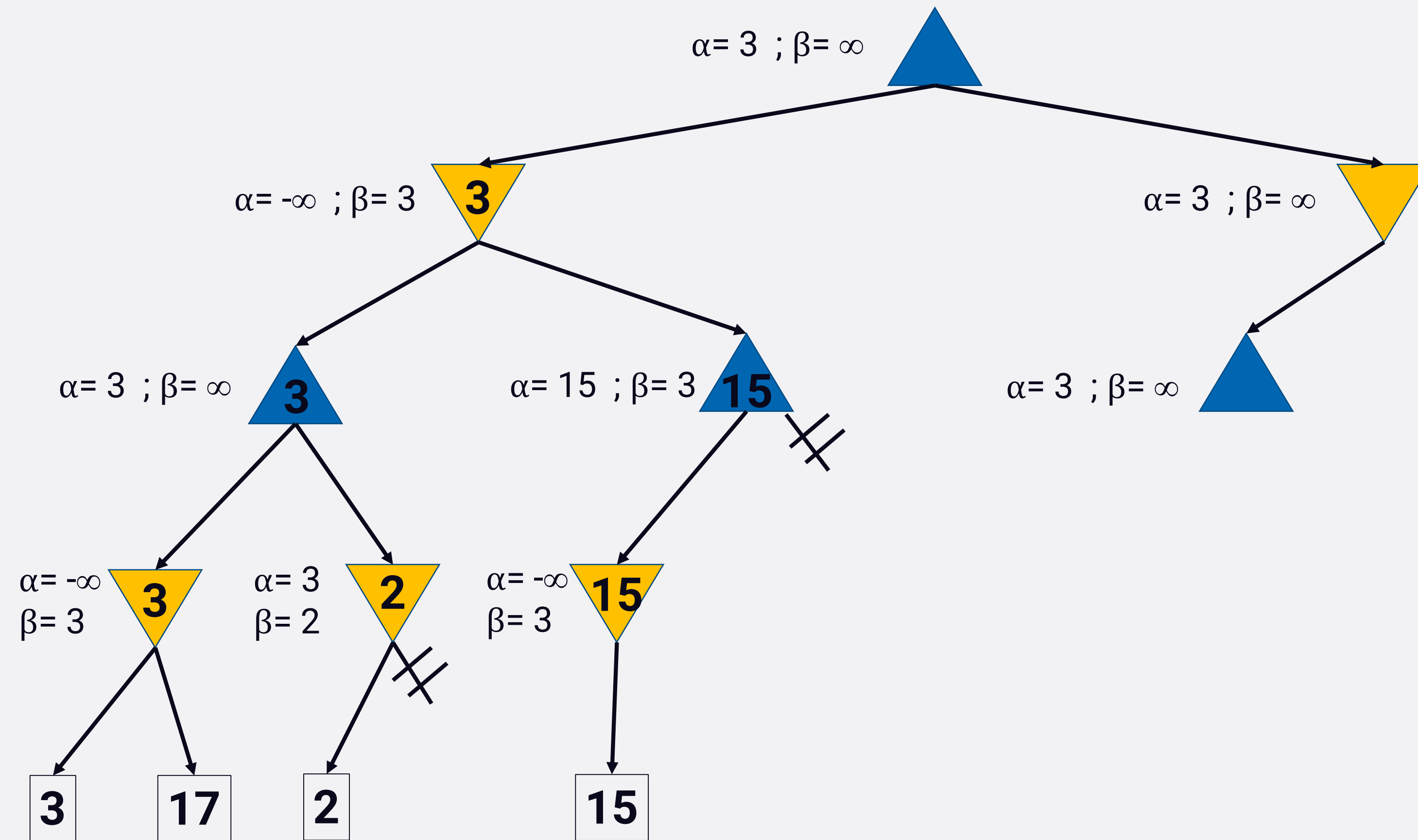
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- Minimax with alpha-beta pruning



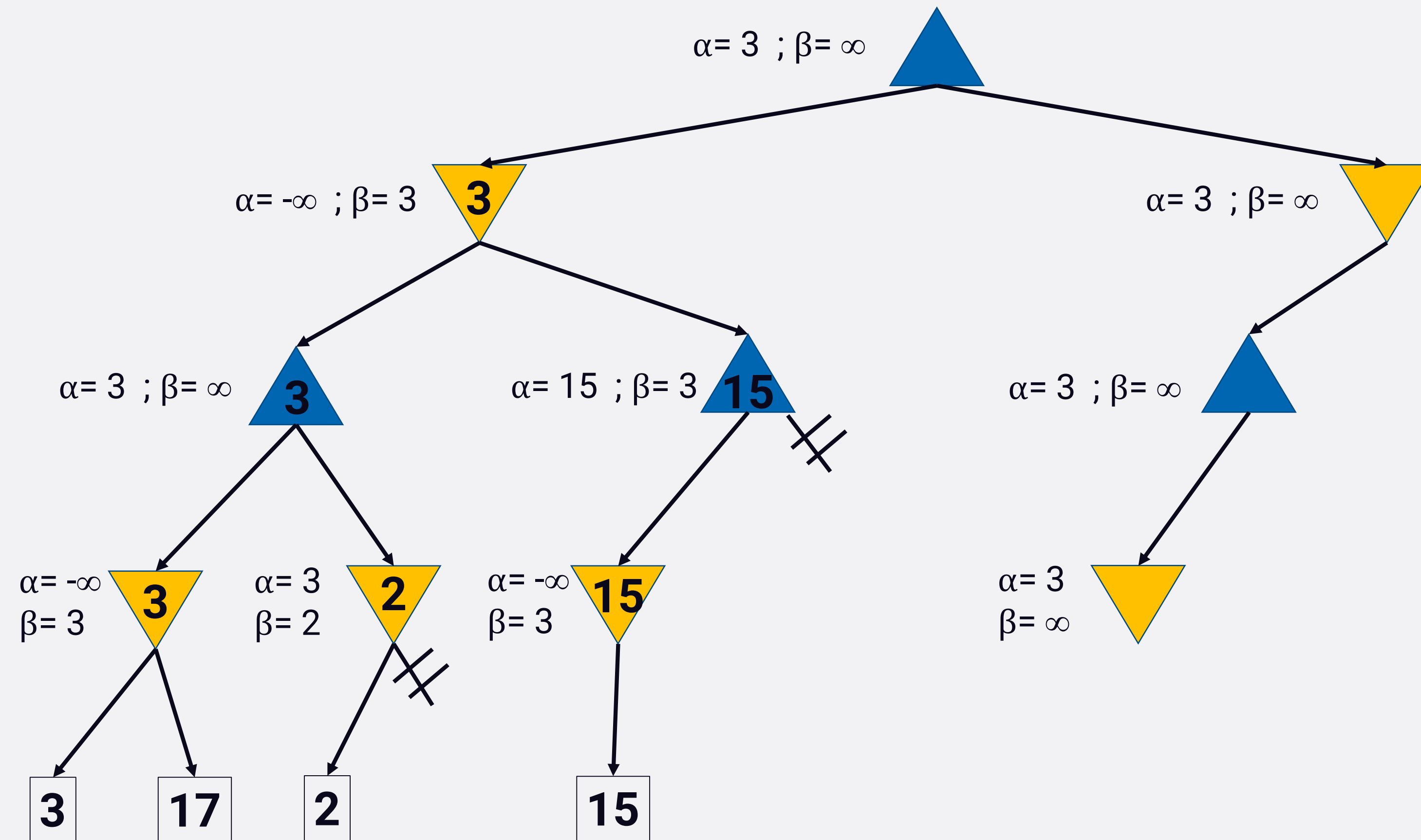
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- Minimax with alpha-beta pruning



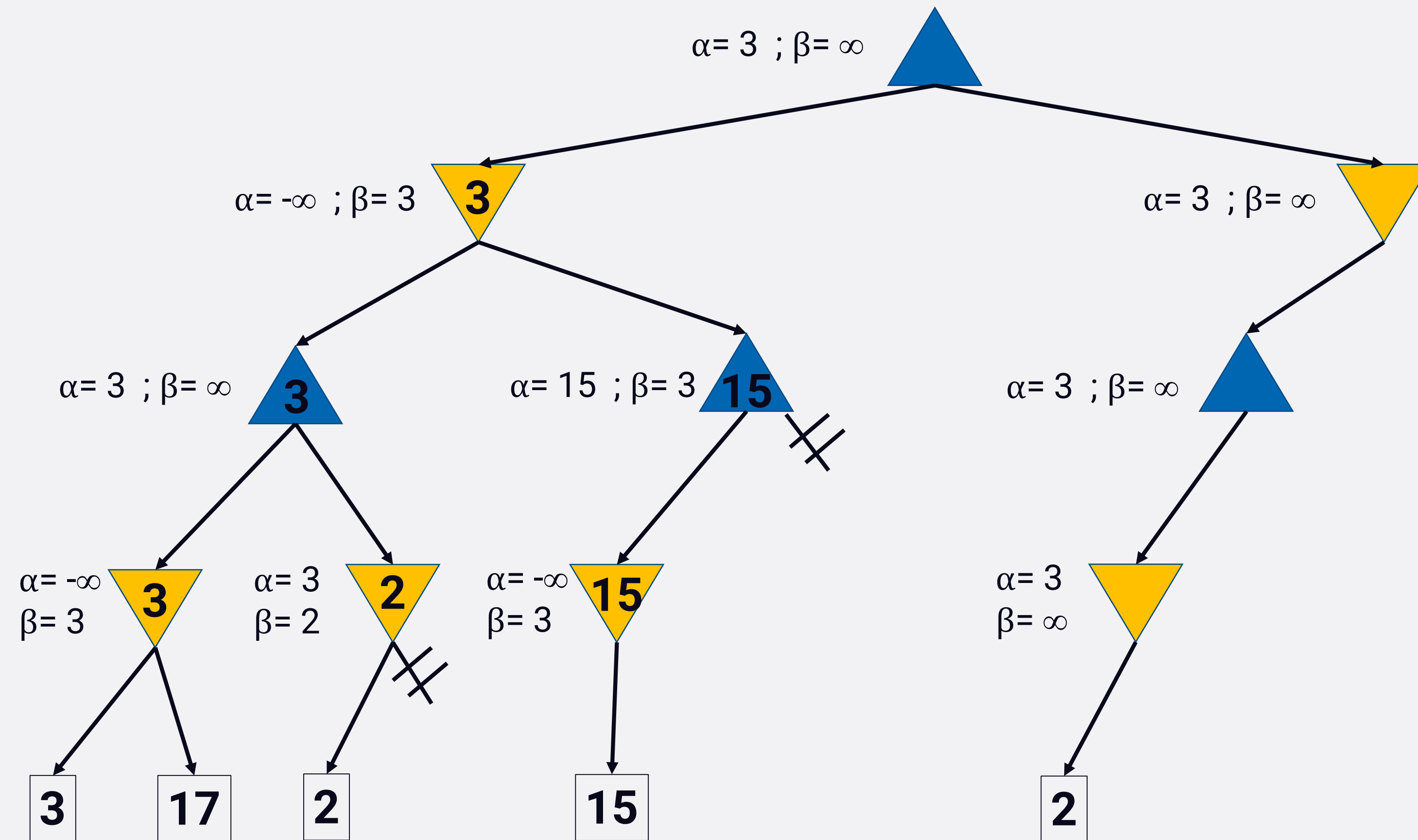
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- Minimax with alpha-beta pruning



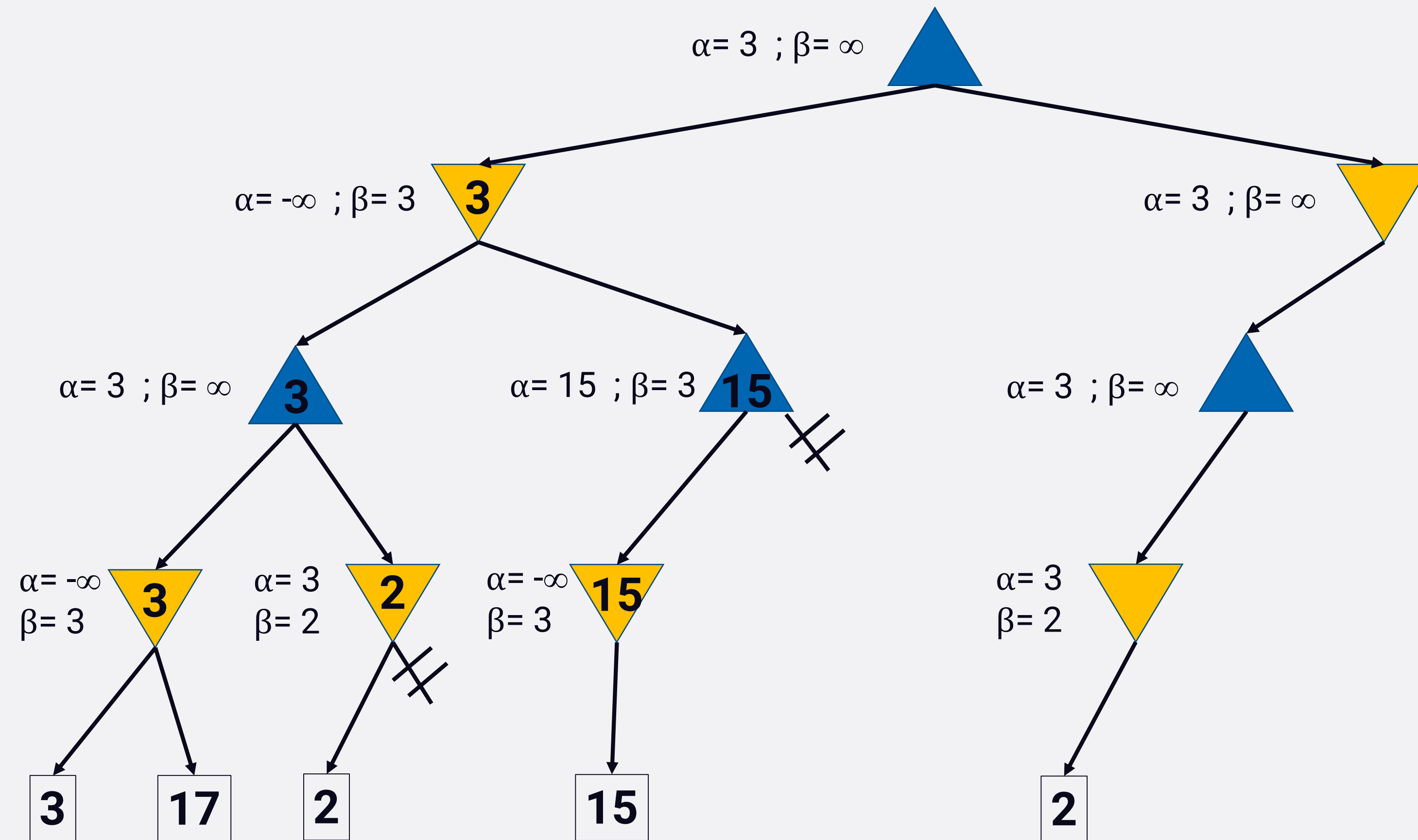
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- Minimax with alpha-beta pruning



# Exercise 5.1

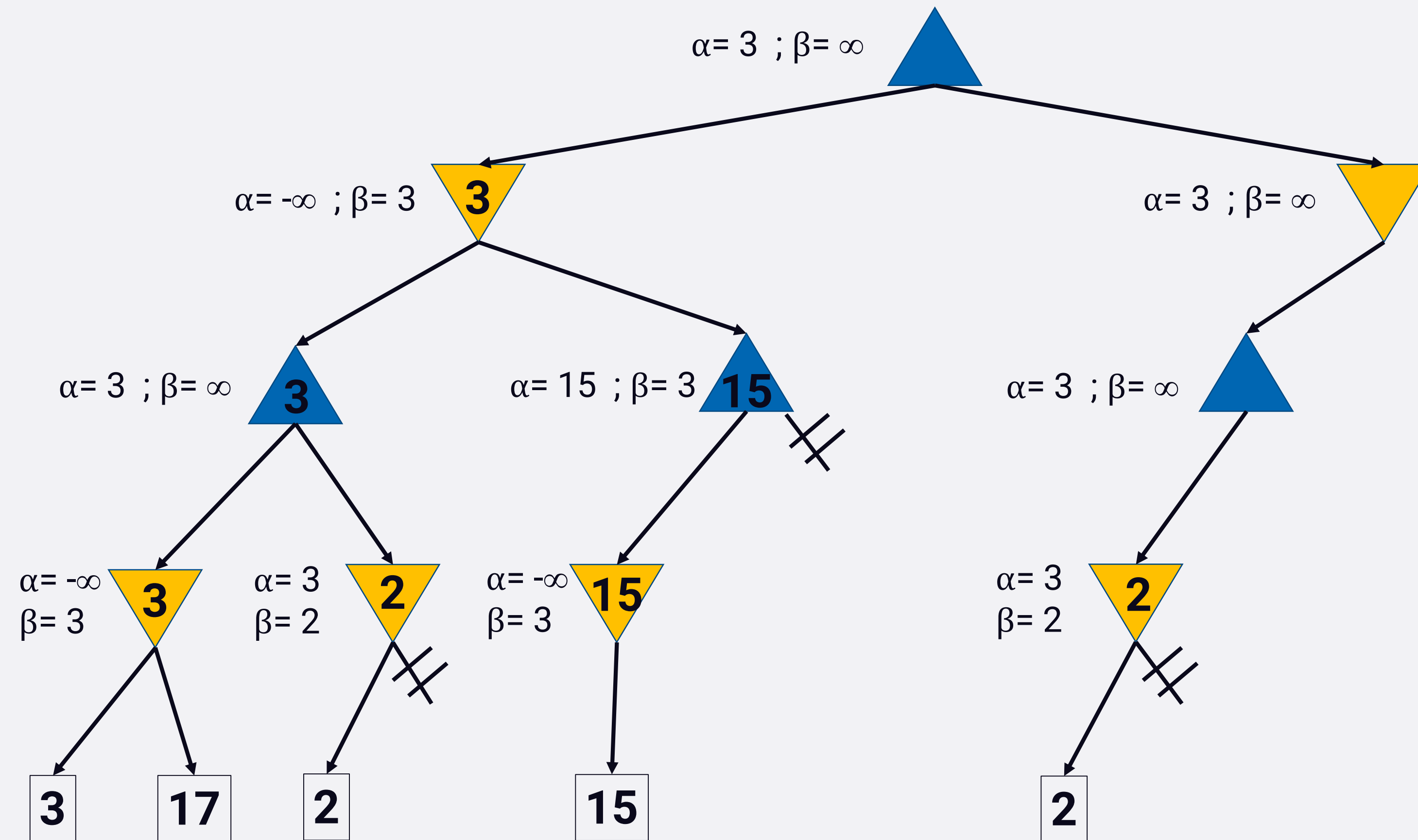
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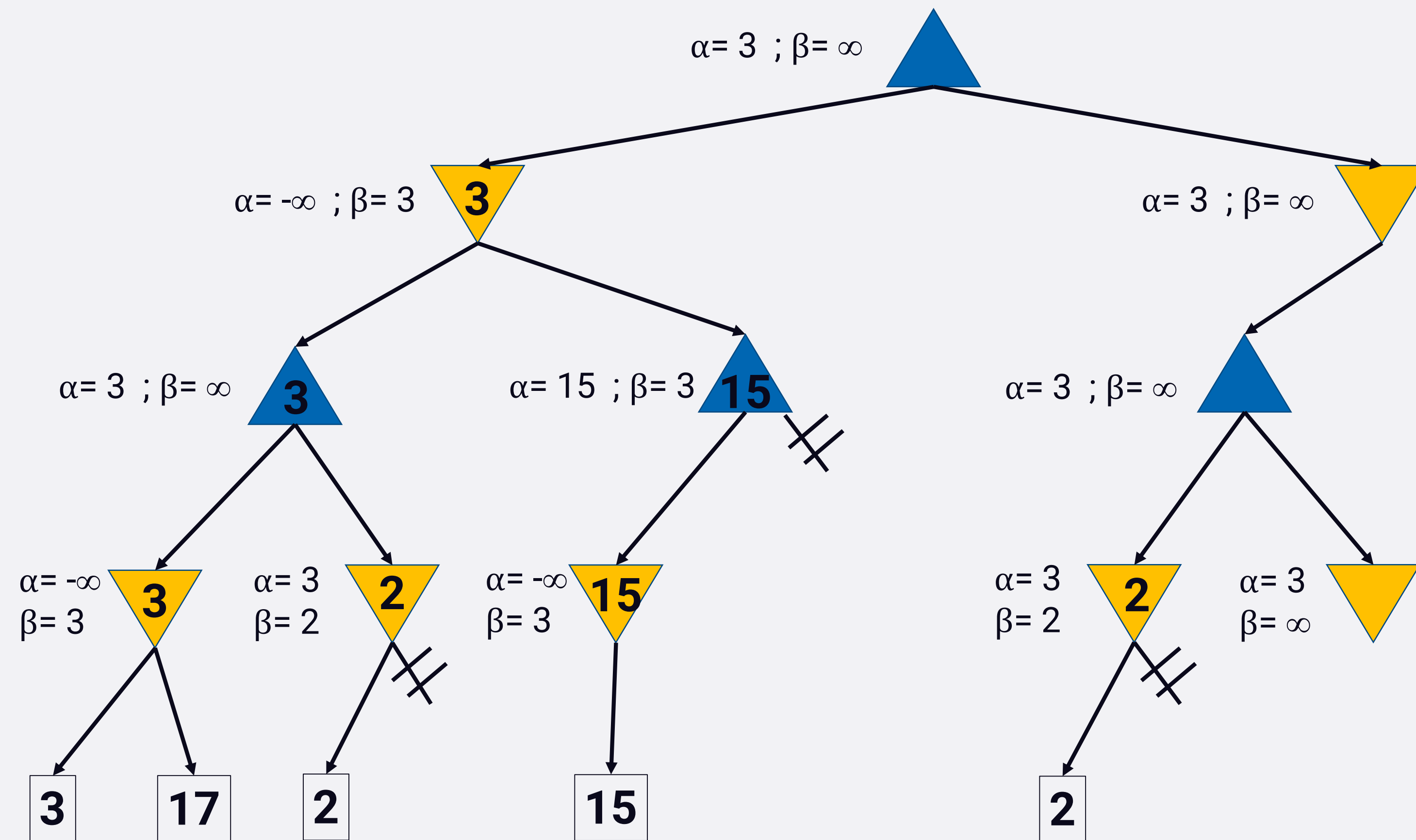
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- Minimax with alpha-beta pruning



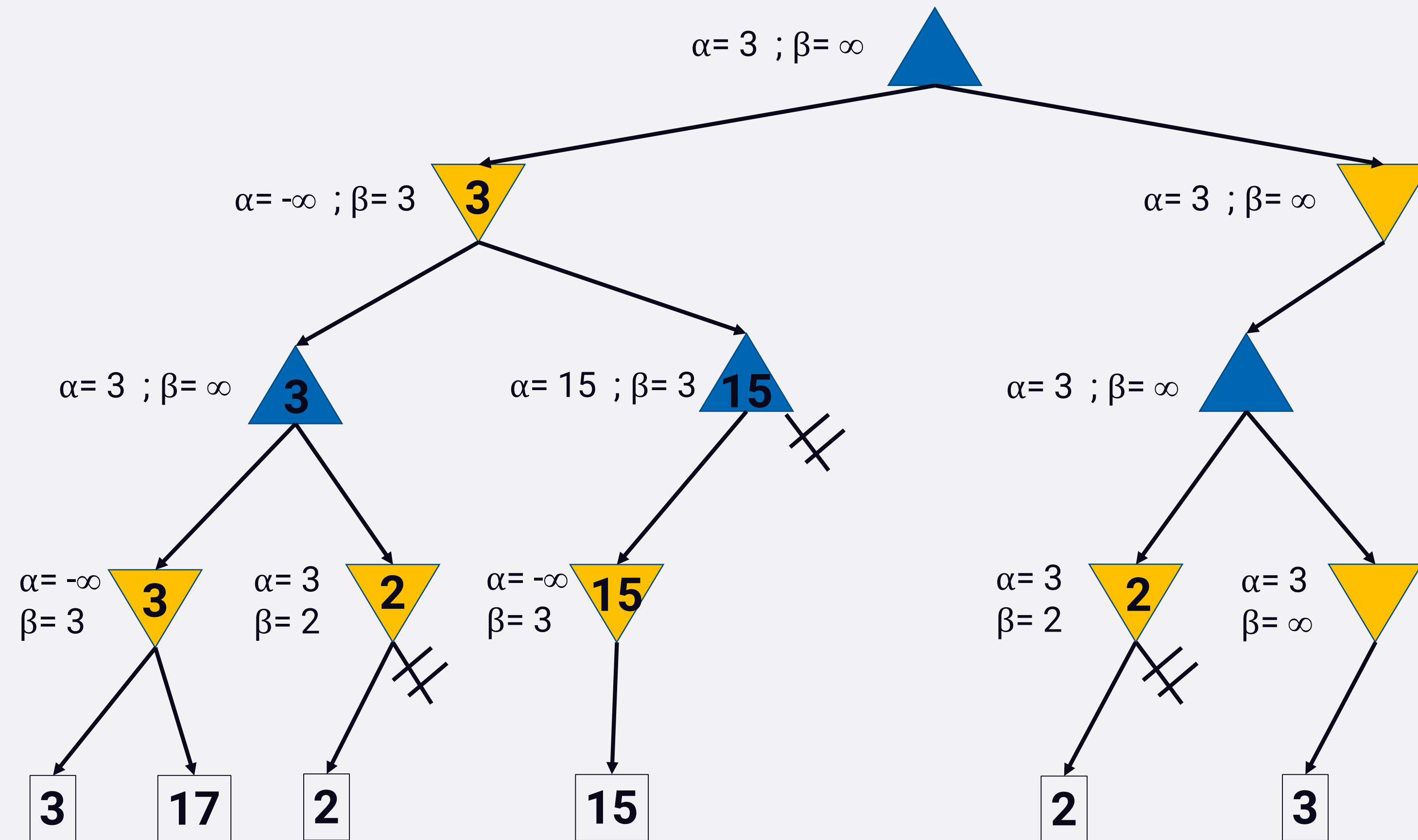
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- Minimax with alpha-beta pruning



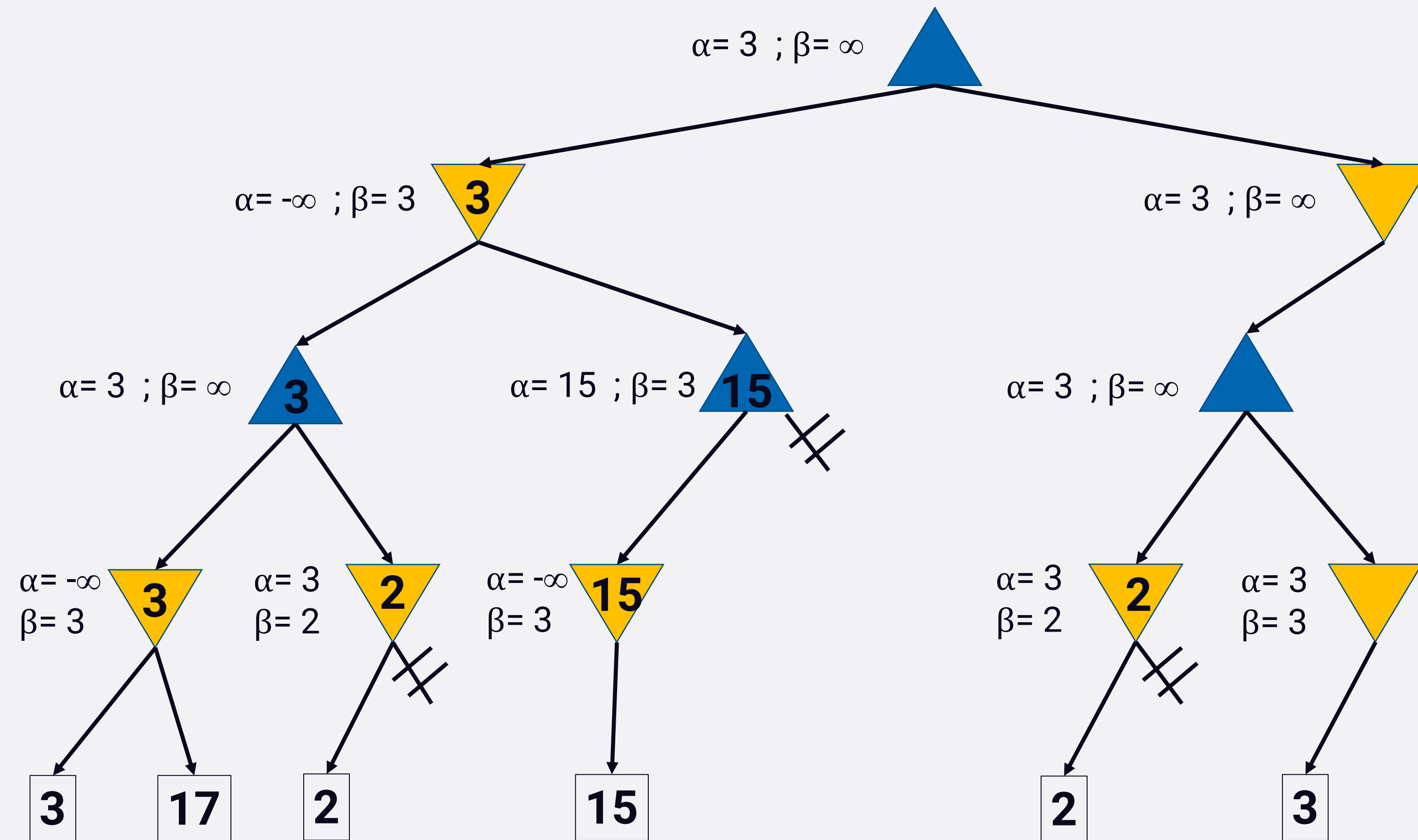
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- Minimax with alpha-beta pruning



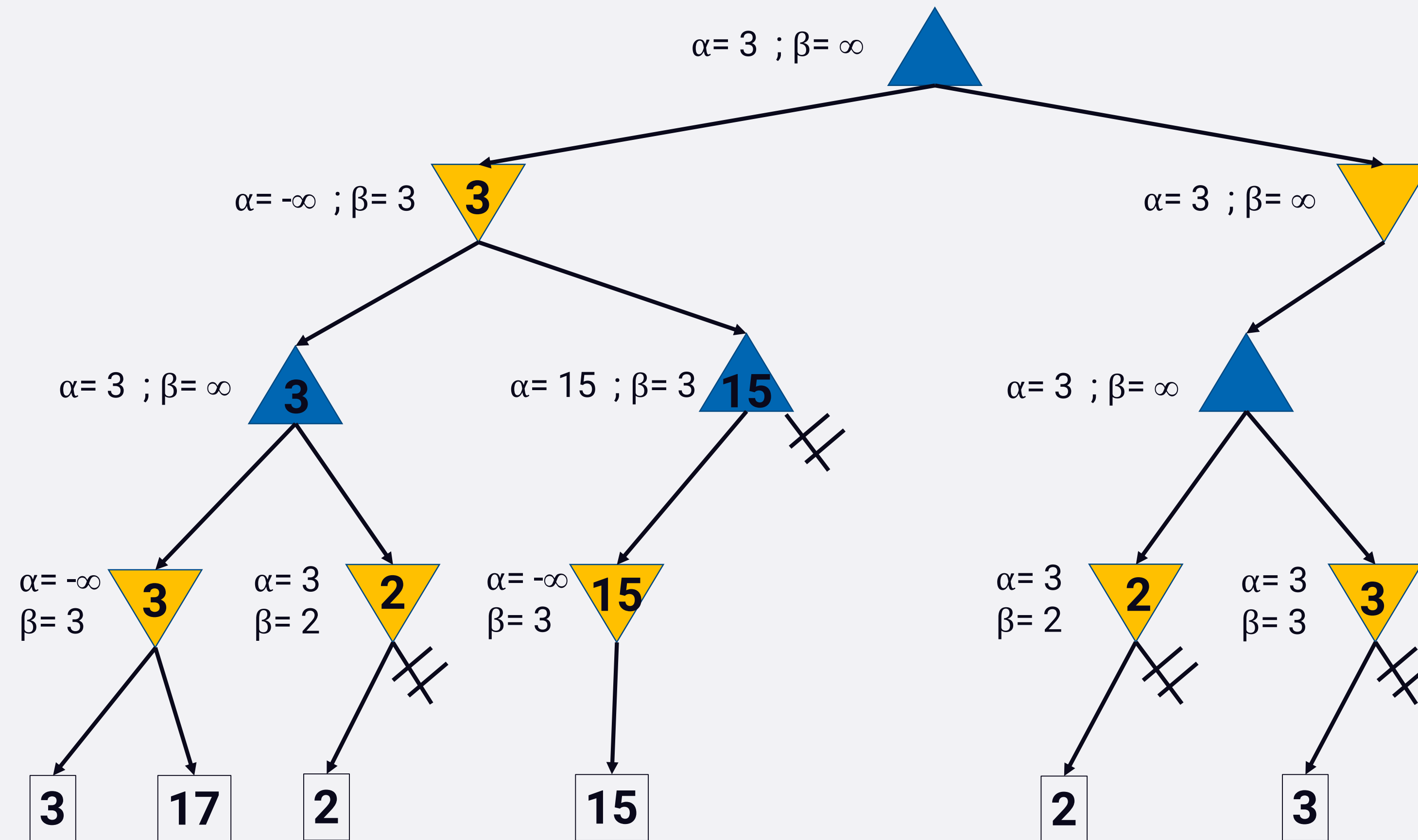
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- Minimax with alpha-beta pruning



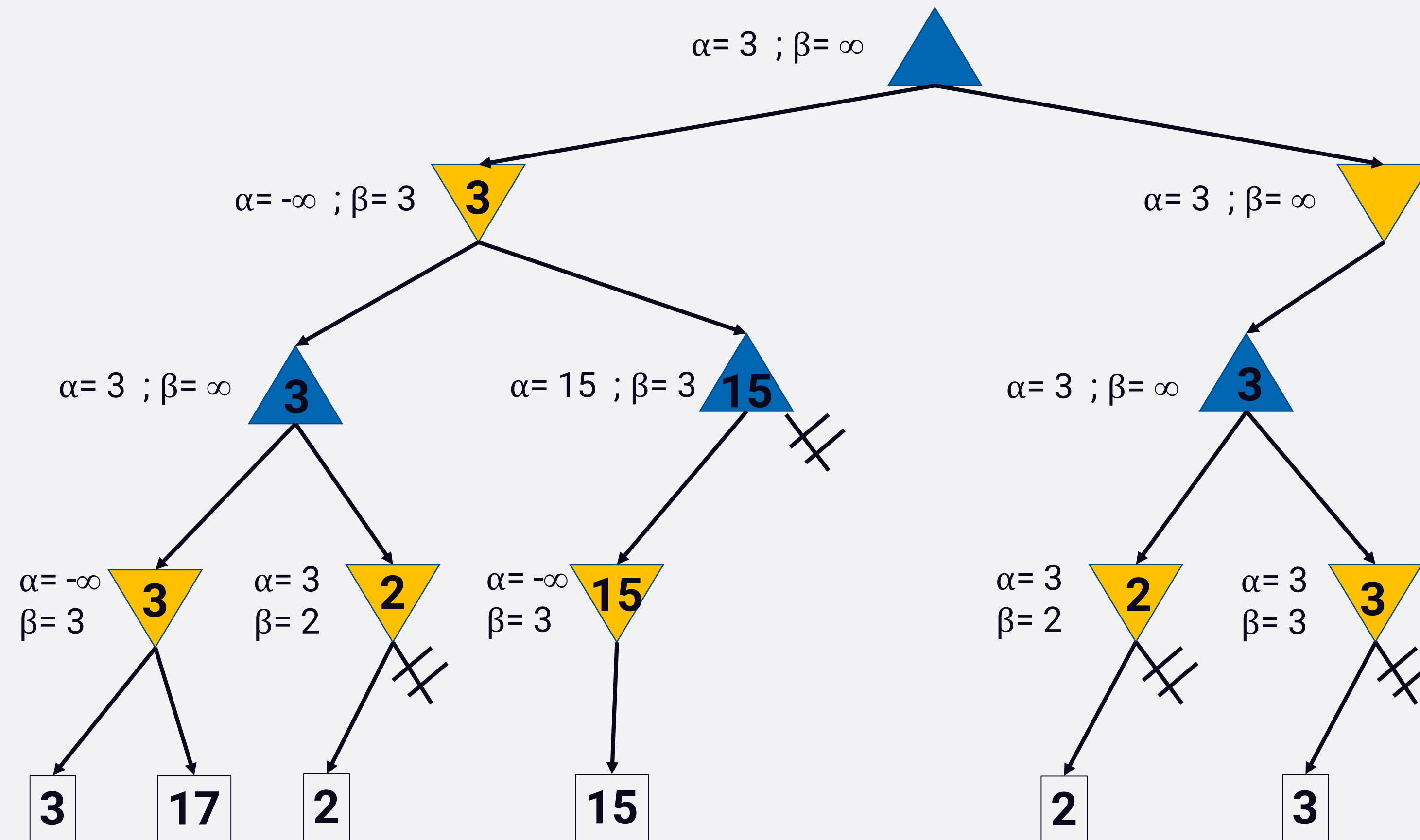
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- Minimax with alpha-beta pruning



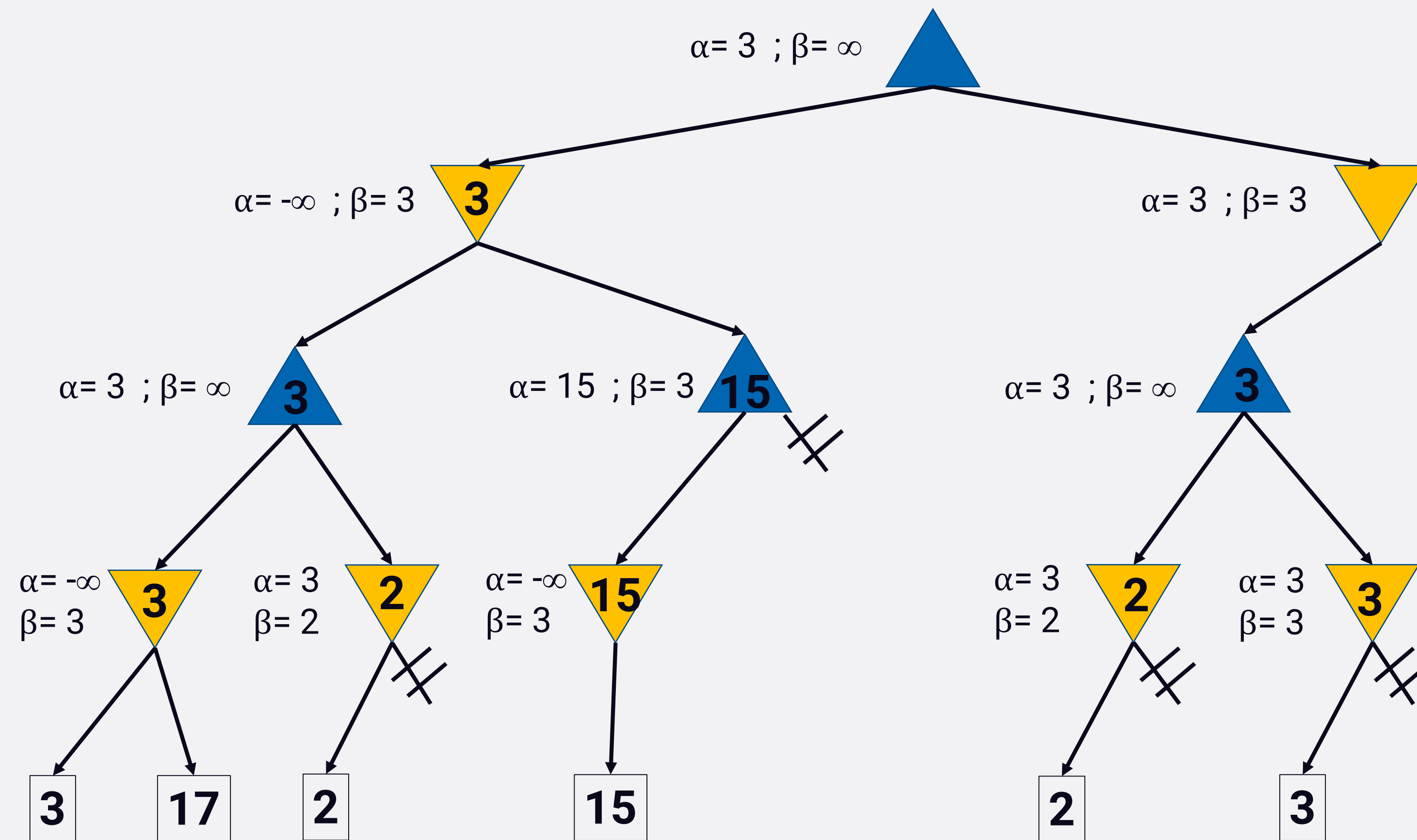
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- Minimax with alpha-beta pruning



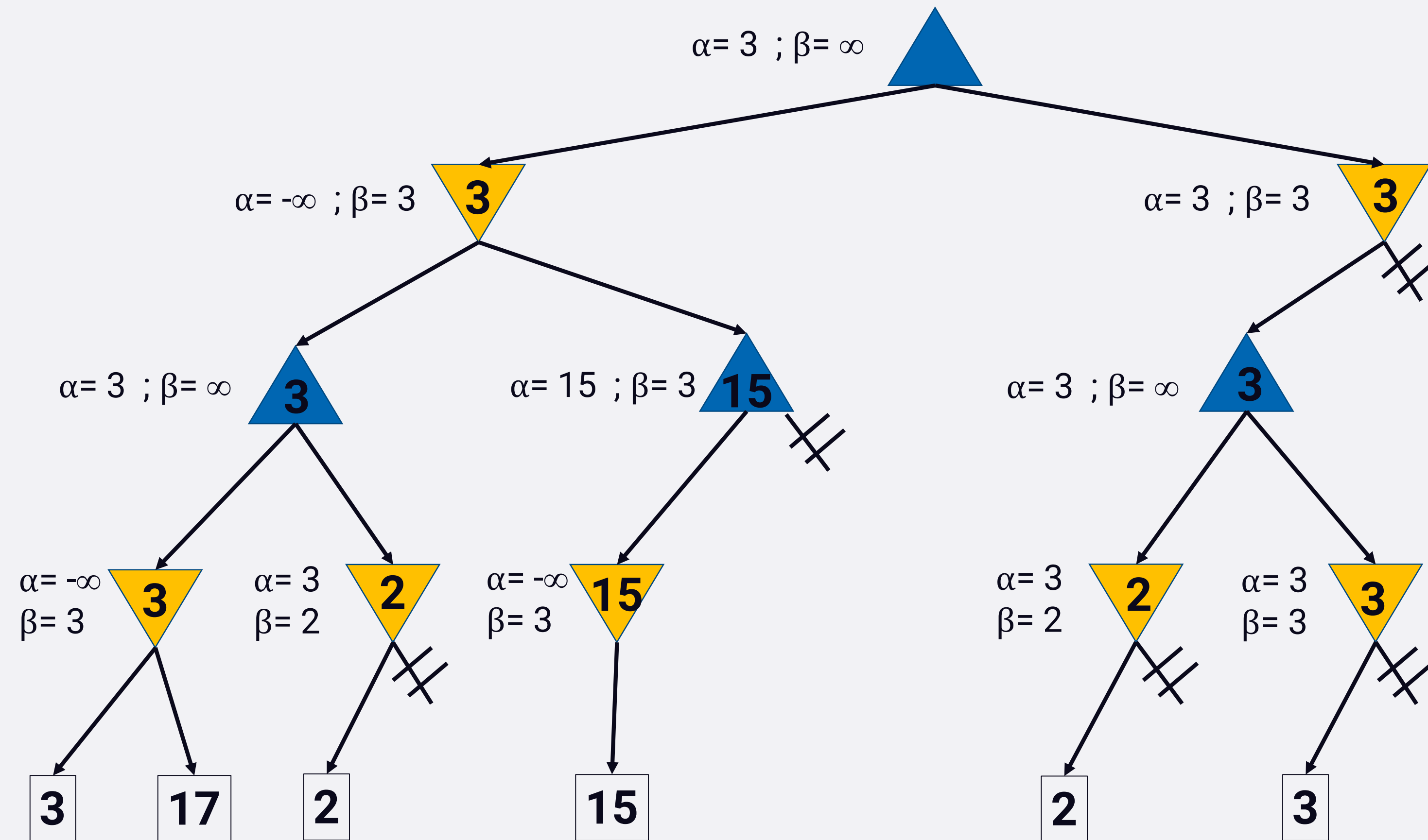
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- Minimax with alpha-beta pruning



# Exercise 5.1

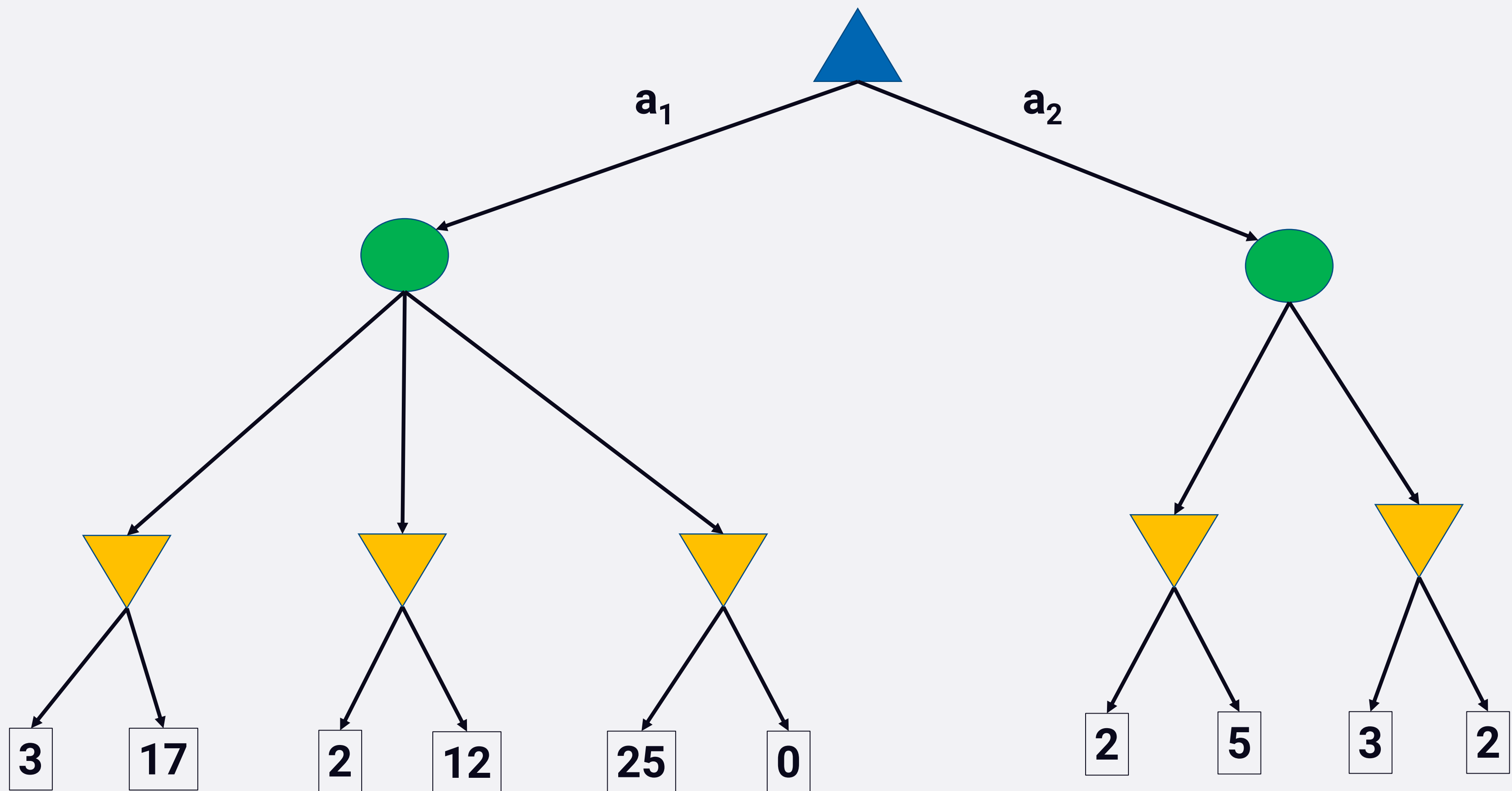
- Minimax with alpha-beta pruning





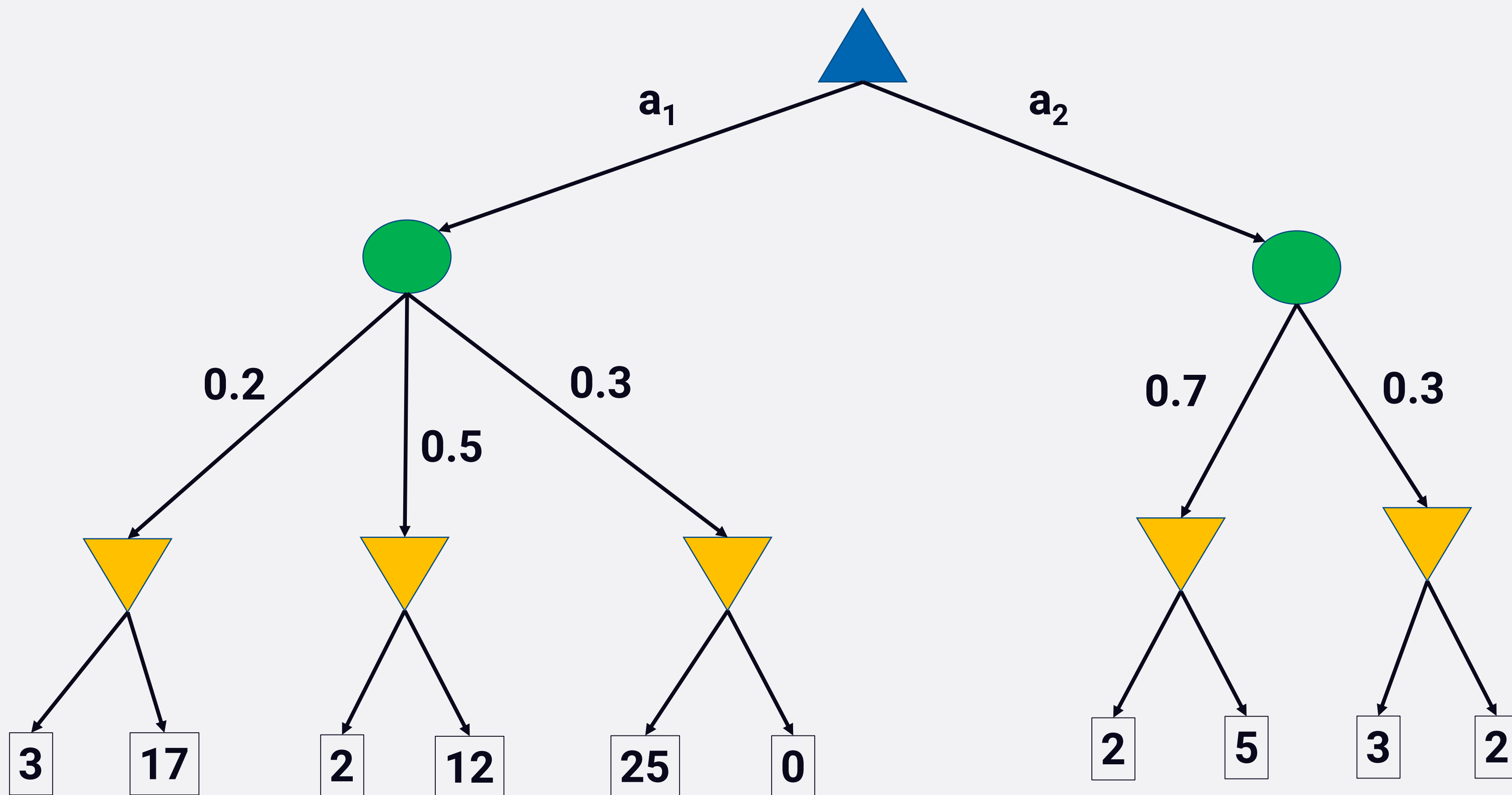
## Exercise 5.2

- Expectiminimax



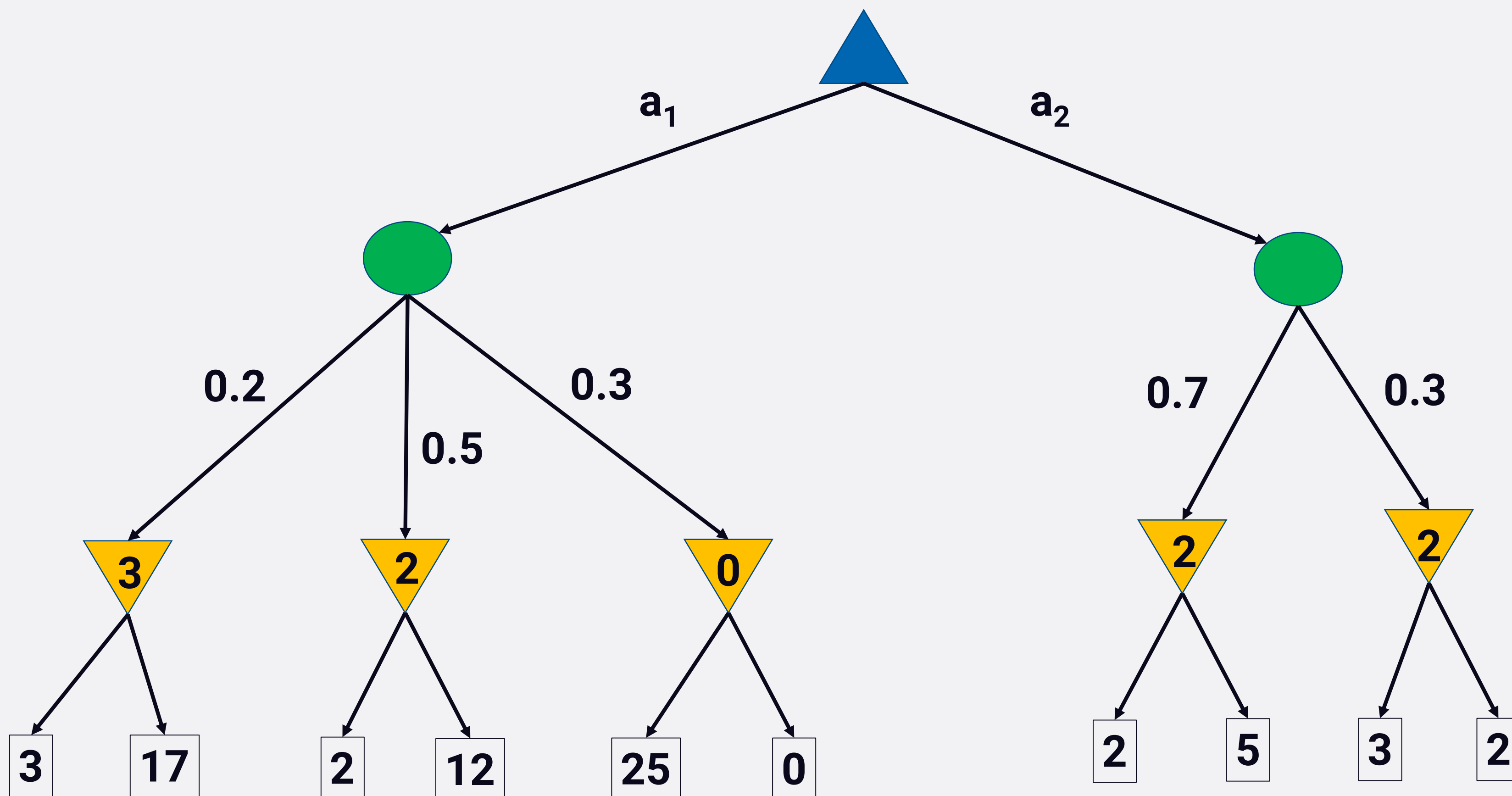
## Exercise 5.2

- Expectiminimax



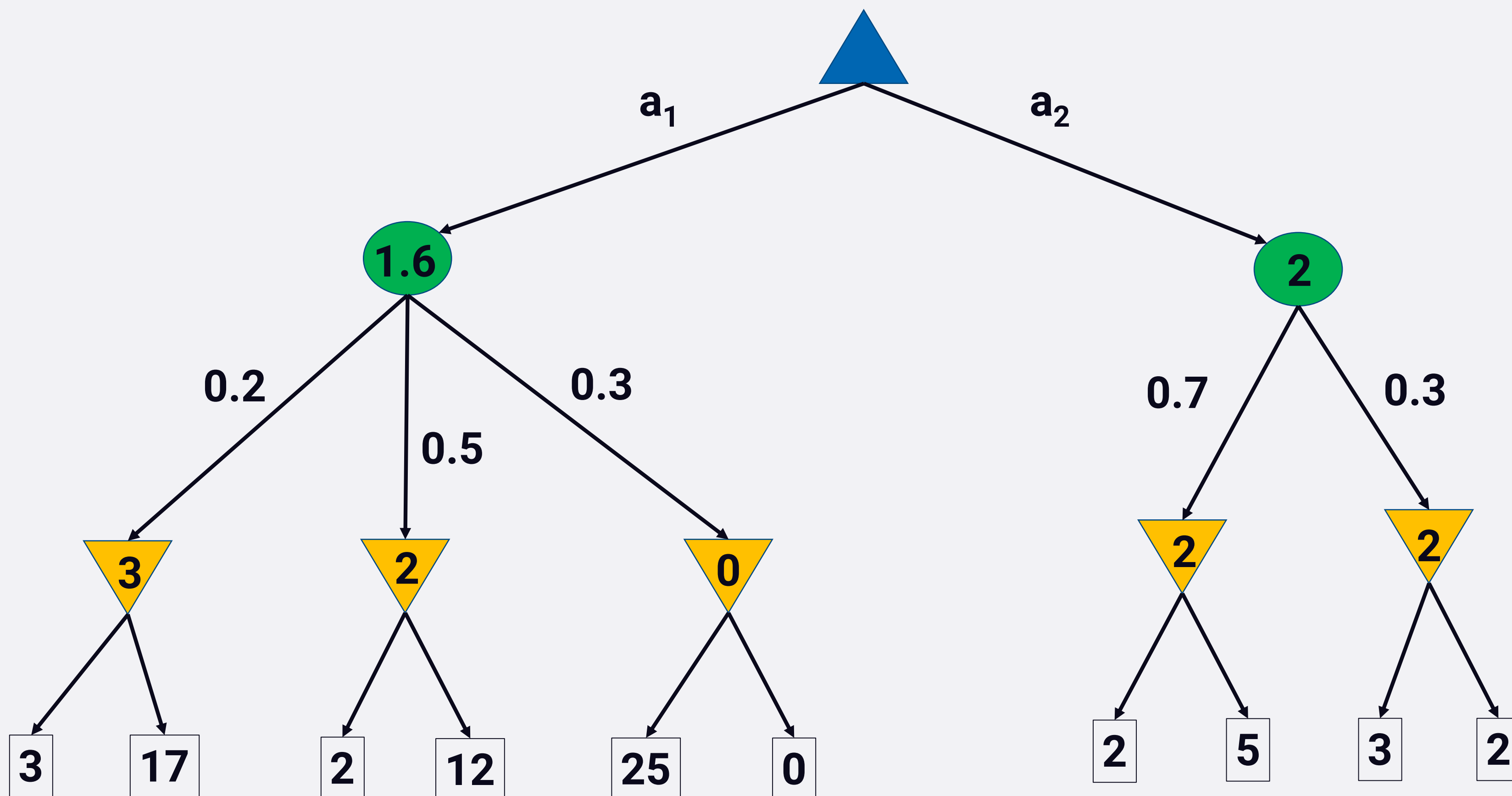
## Exercise 5.2

- Expectiminimax



## Exercise 5.2

- Expectiminimax



## Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2				
3				
4	<b>S</b>			

- The agent starts from S, it has to reach G. Each step costs 1. Heuristic is based on Manhattan distance.
- In case of same  $h(s)$  values, the order of possible actions are: UP, RIGHT, DOWN, LEFT

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2				
3	4			
4	<b>S (5)</b>	4		

	1	2	3	4
1			<b>G</b>	
2				
3	<b>4</b>			
4	<b>S (6)</b>	4		

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2				
3	<b>4</b>			
4	<b>S (6)</b>	4		

	1	2	3	4
1			<b>G</b>	
2				
3	5			
4	<b>S (6)</b>	4		

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2				
3	5			
4	<b>S (6)</b>	4		

	1	2	3	4
1			<b>G</b>	
2				
3	5	3		
4	<b>S (7)</b>	<b>4</b>	3	



# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2				
3	5	3		
4	<b>S (7)</b>	4	3	

	1	2	3	4
1			<b>G</b>	
2				
3	5	3		
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2				
3	5	3		
4	<b>S (7)</b>	5	3	

	1	2	3	4
1			<b>G</b>	
2		2		
3	5	3	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2		2		
3	5	<b>3</b>	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1			<b>G</b>	
2		<b>2</b>		
3	5	4	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2		2		
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		1	<b>G</b>	
2	3	2	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1			<b>G</b>	
2		2		
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		1	<b>G</b>	
2	3	3	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1		1	<b>G</b>	
2	3	3	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		2	<b>G</b>	
2	3	3	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1		2	<b>G</b>	
2	3	3	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		2	<b>G</b>	
2	3	4	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1		2	<b>G</b>	
2	3	4	1	
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		2	<b>G</b>	
2	3	4	1	2
3	5	4	2	
4	<b>S (7)</b>	5	3	



# Exercise 5.3

- LRTA\*

	1	2	3	4
1		2	<b>G</b>	
2	3	4	1	2
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		2	<b>G</b>	
2	3	4	2	2
3	5	4	2	
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1		2	<b>G</b>	
2	3	4	2	2
3	5	4	2	
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		2	<b>G</b>	1
2	3	4	2	2
3	5	4	2	3
4	<b>S (7)</b>	5	3	

# Exercise 5.3

- LRTA\*

	1	2	3	4
1		2	<b>G</b>	1
2	3	4	2	2
3	5	4	2	3
4	<b>S (7)</b>	5	3	

	1	2	3	4
1		2	<b>G (0)</b>	1
2	3	4	2	3
3	5	4	2	3
4	<b>S (7)</b>	5	3	

# Exercise 5.1

- Minimax with alpha-beta pruning

