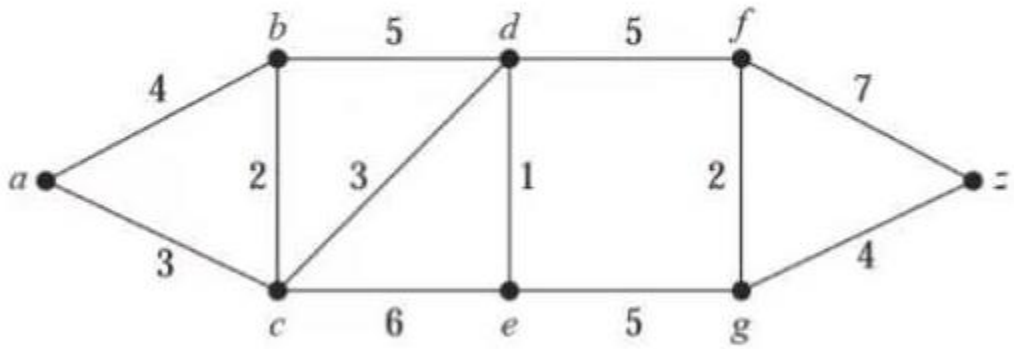
第二次理论作业题解

1 搜索

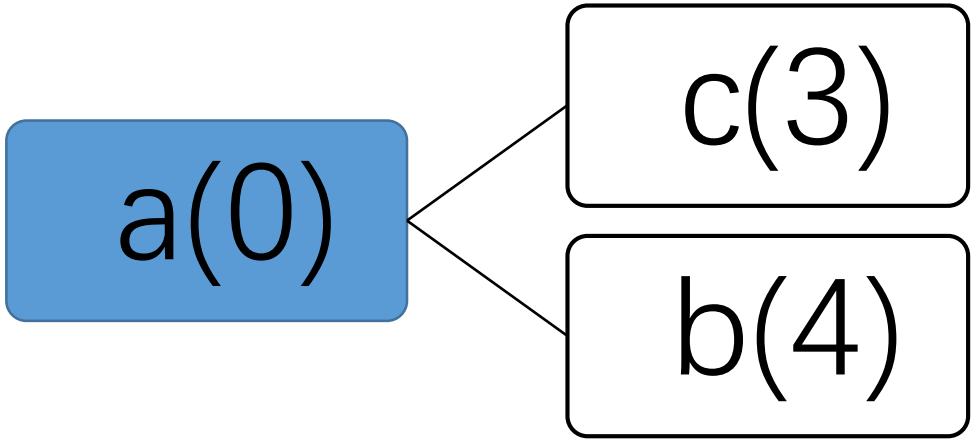
1. 在下面的带权无向图中找到 a 到 z 的最短路径。请使用带环检测的一致代价搜索算法求解，并画出搜索树。（*注意：请在搜索树的节点旁边标明扩展顺序）

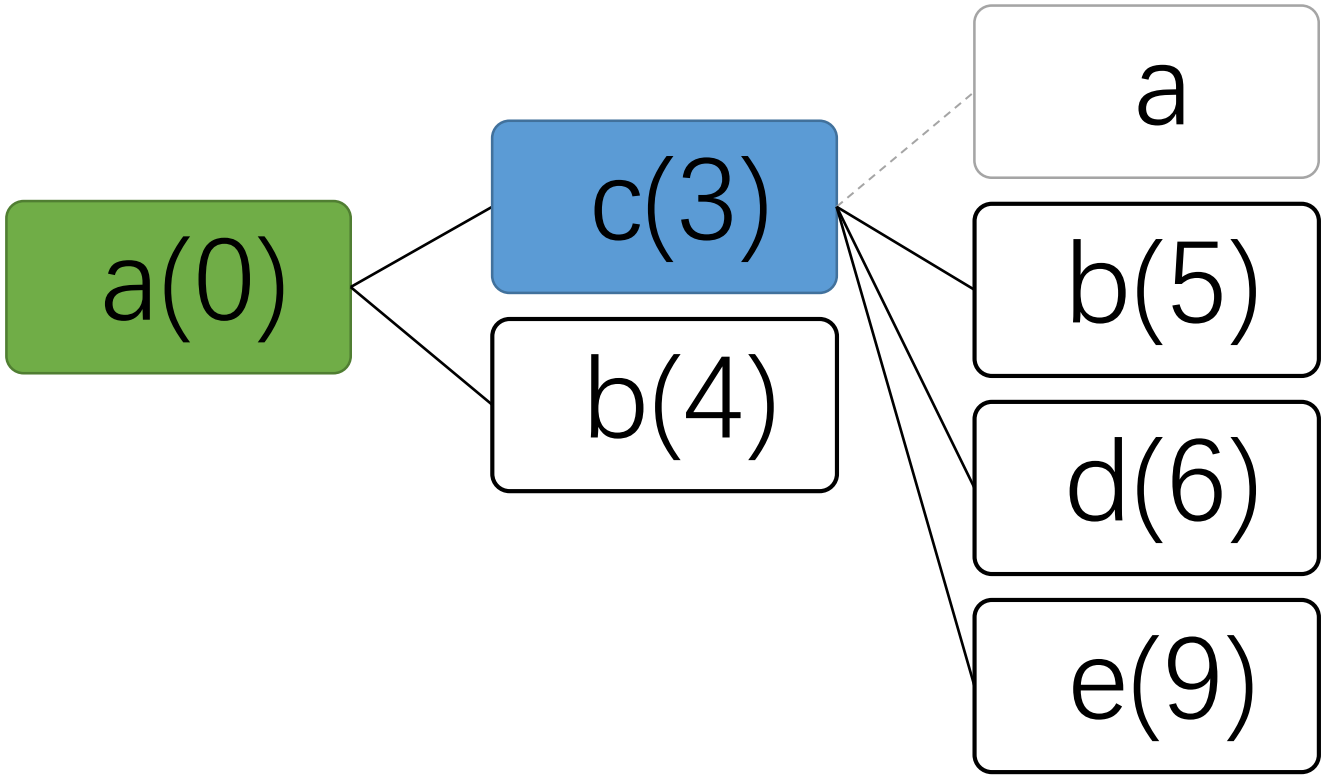


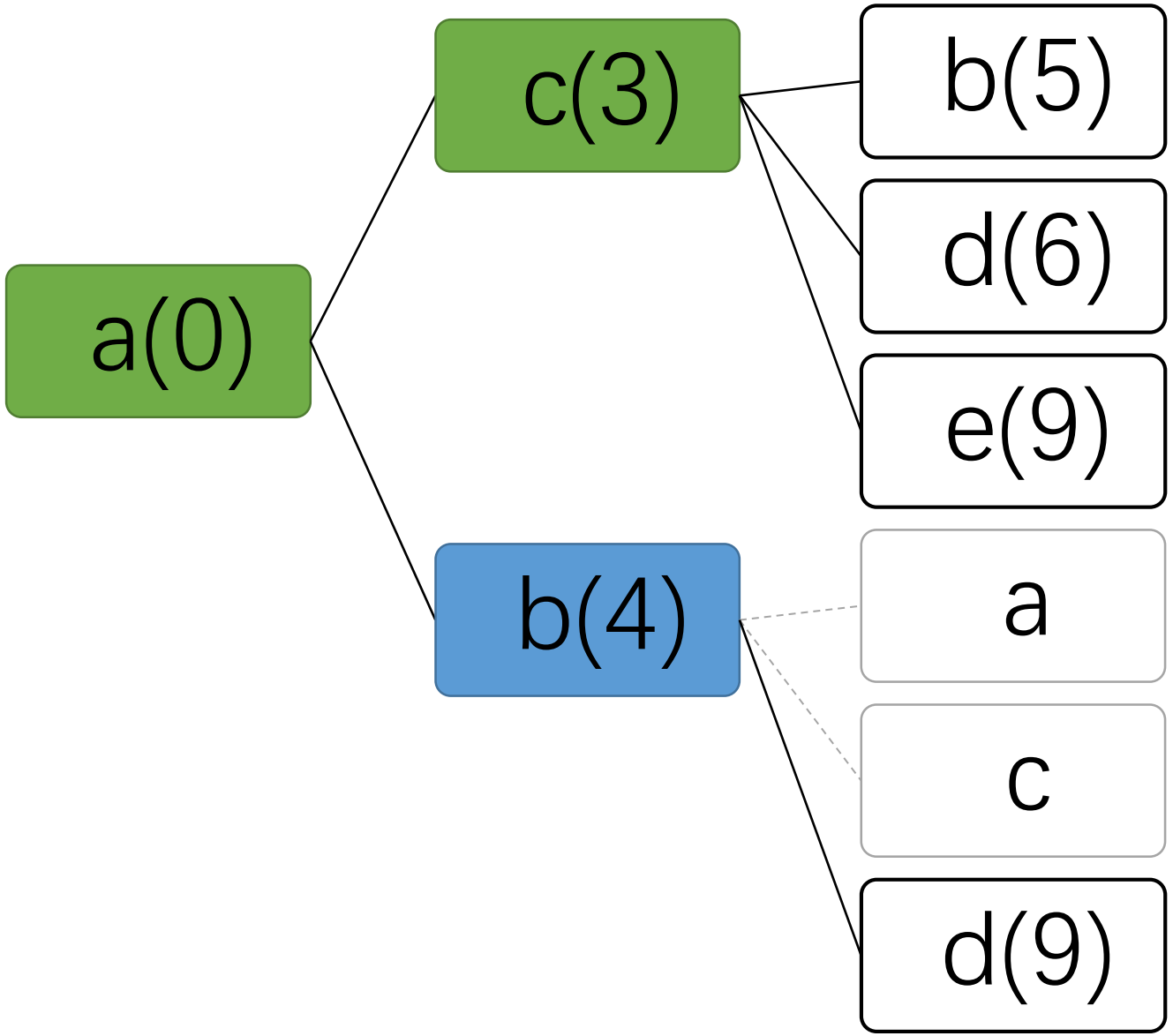
■ 附加题：试分析Dijkstra算法和带环检测的一致代价搜索算法之间的关系。

以下为搜索过程。作业画出最后的树即可

绿：已扩展
蓝：正扩展
深灰：入队但可不扩展
虚线节点：环节点



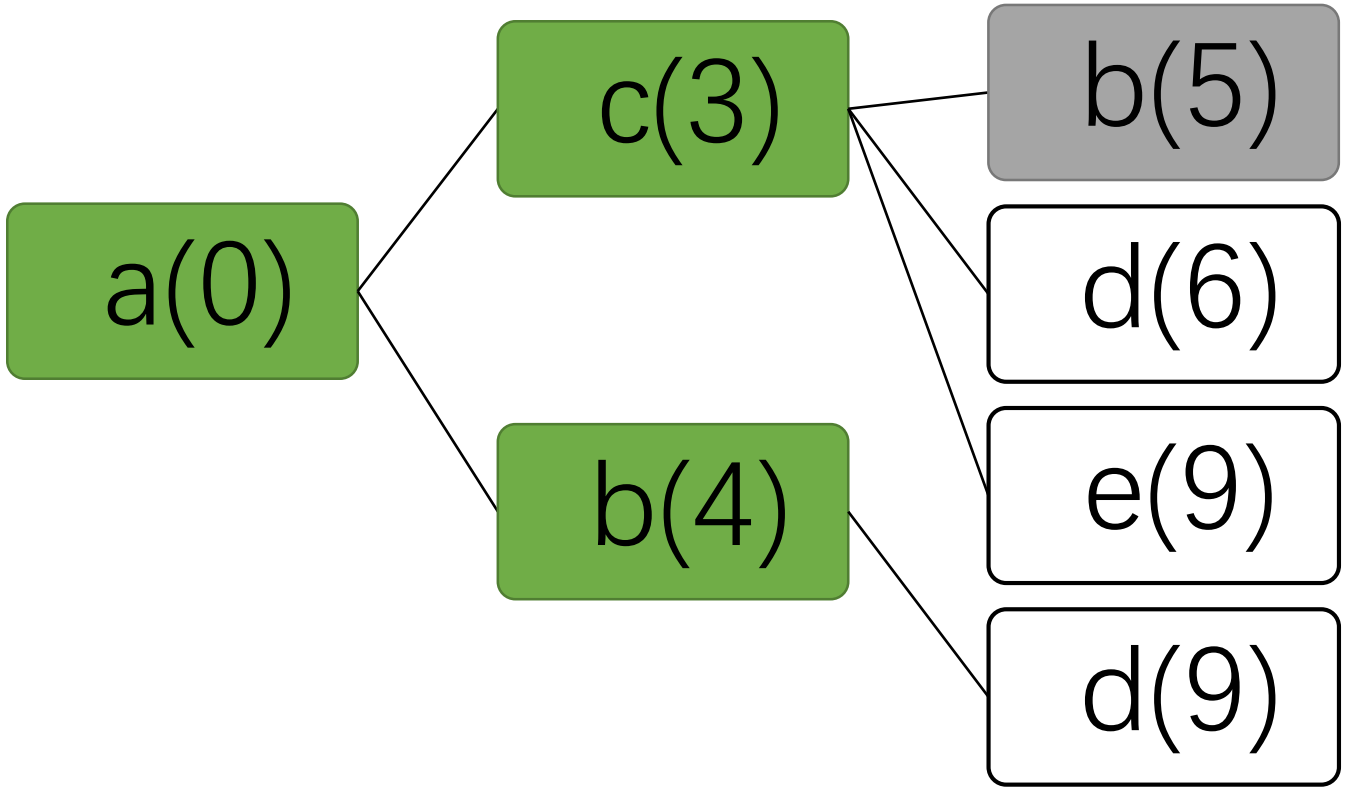

a(0)
c(3)
b(4)
a
b(5)
d(6)
e(9)

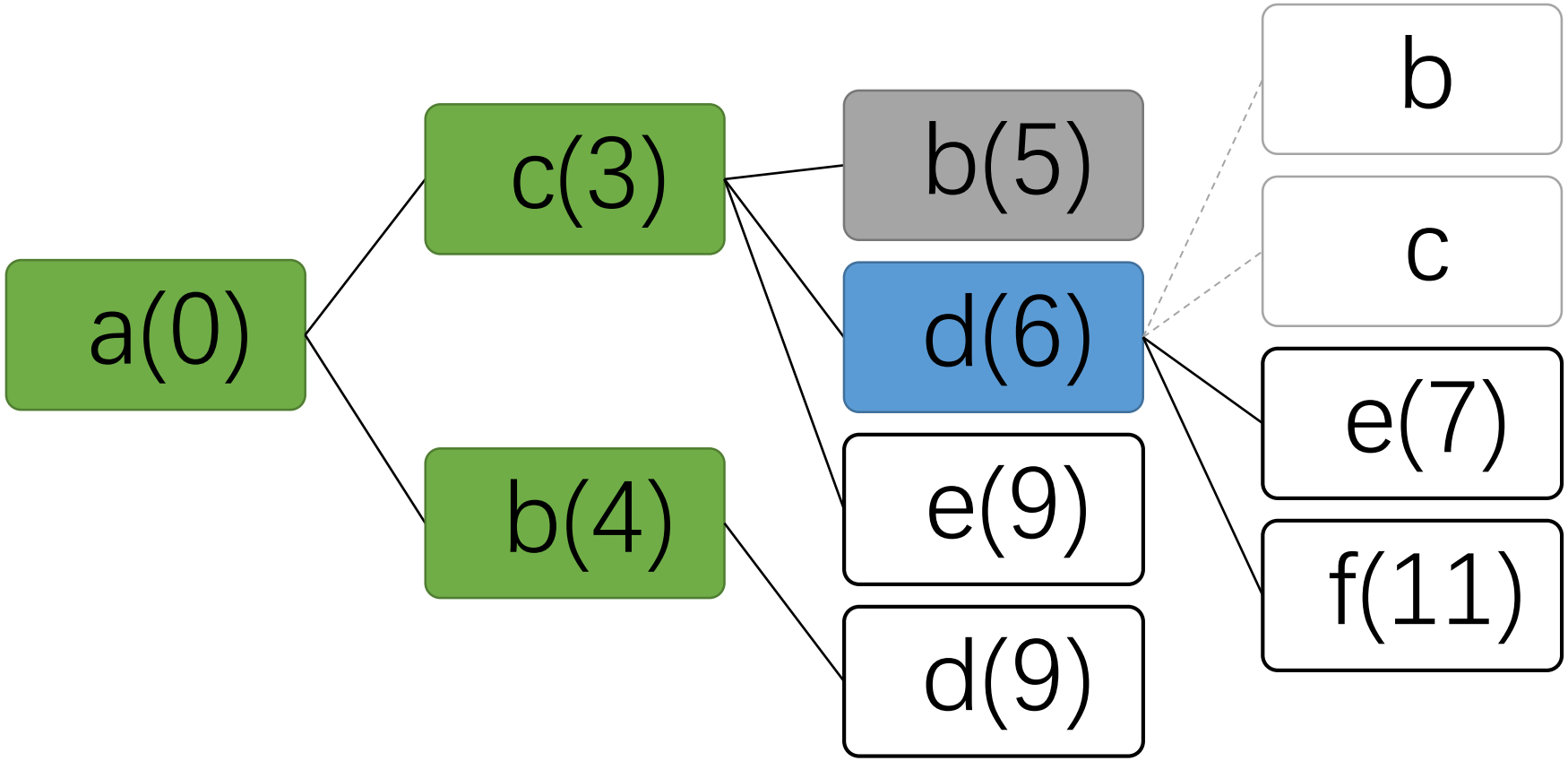

a(0)
c(3)
b(4)
b(5)
d(6)
e(9)
a
c
d(9)

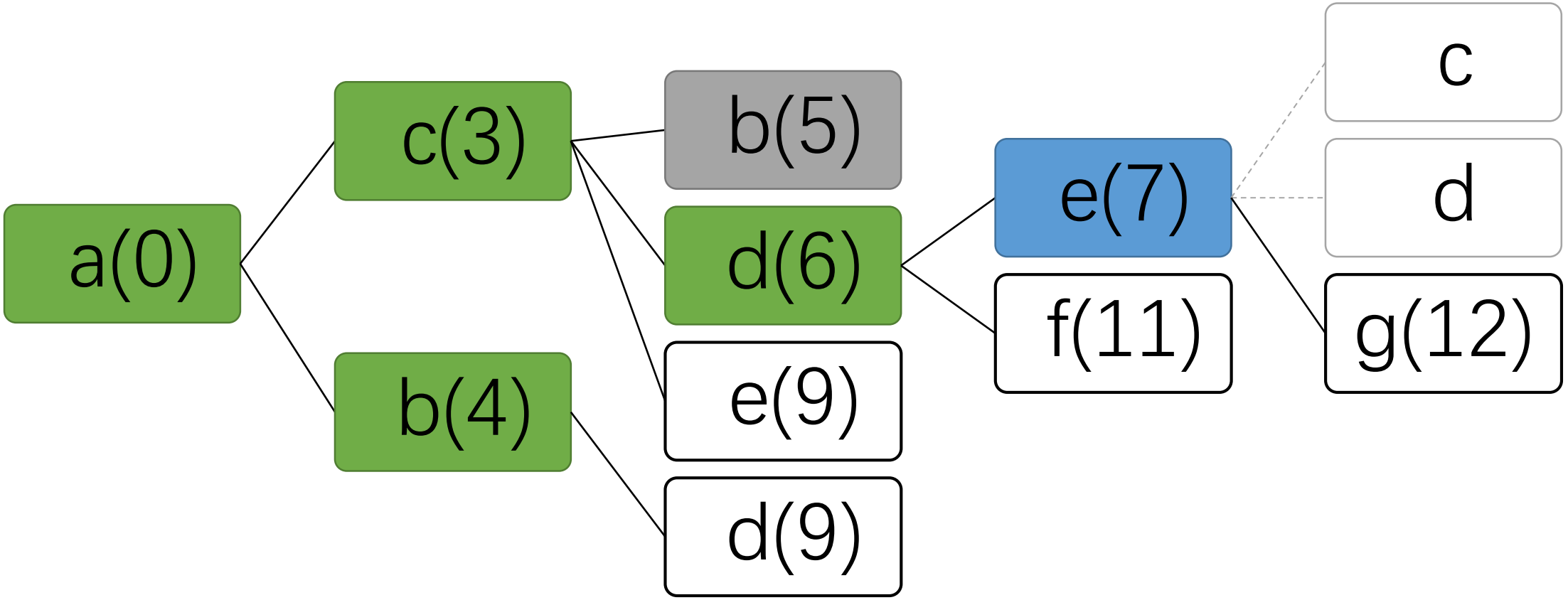
此时无需扩展b(5)。

另一种理解是：把环检测只理解成“后继已被扩展过，则不将该后继入队”，也就是说在扩展节点时不再判断它是否被扩展过（换种说法就是节点只要入队就可以被扩展）。这种理解下也可以扩展b(5)。

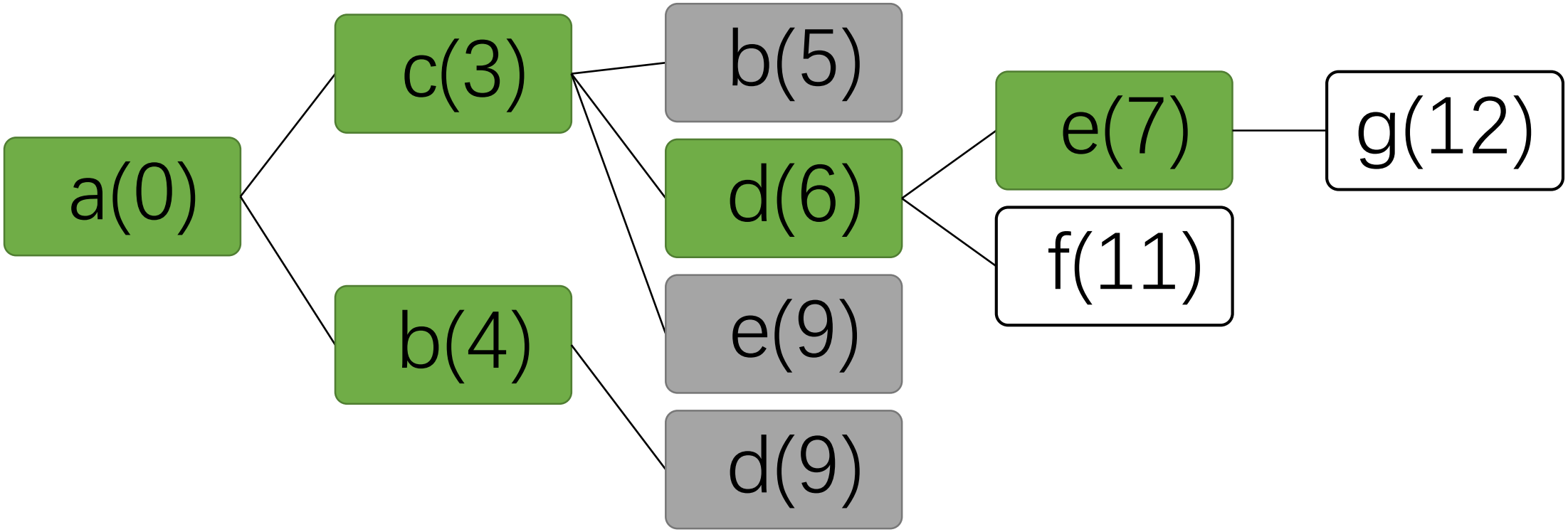
事实上扩展过的节点就不用再扩展了，因为第一次扩展的时候已经找到了到该节点的最小路径。

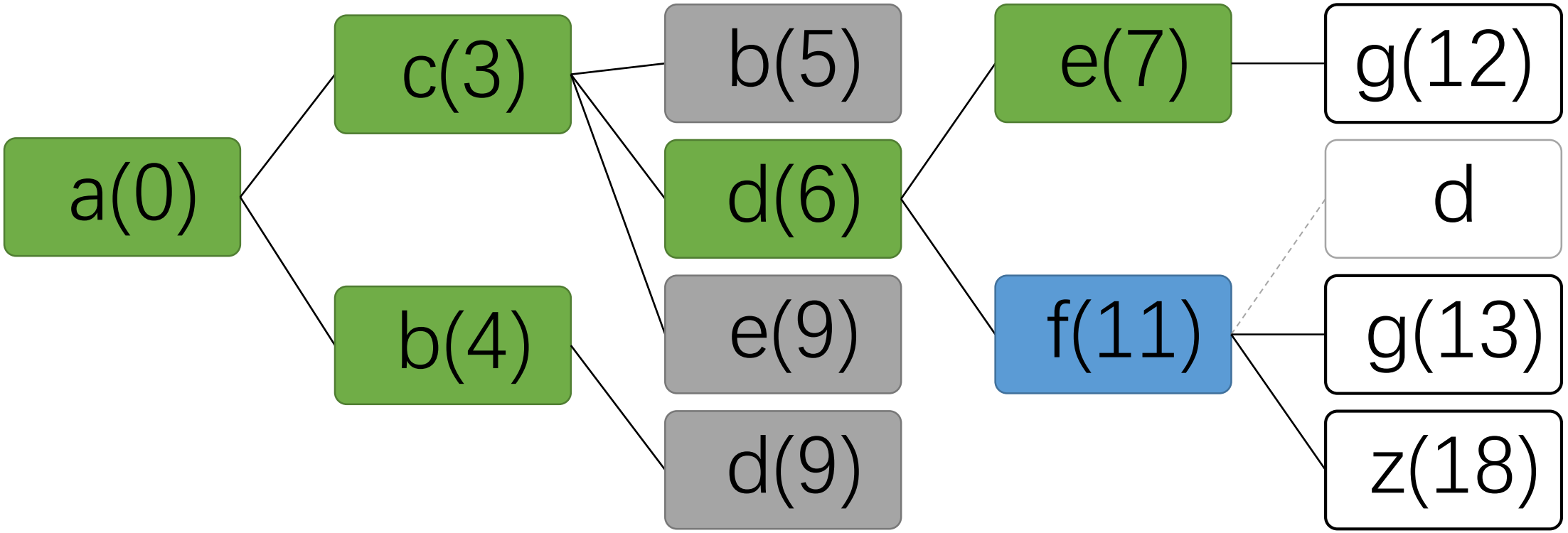


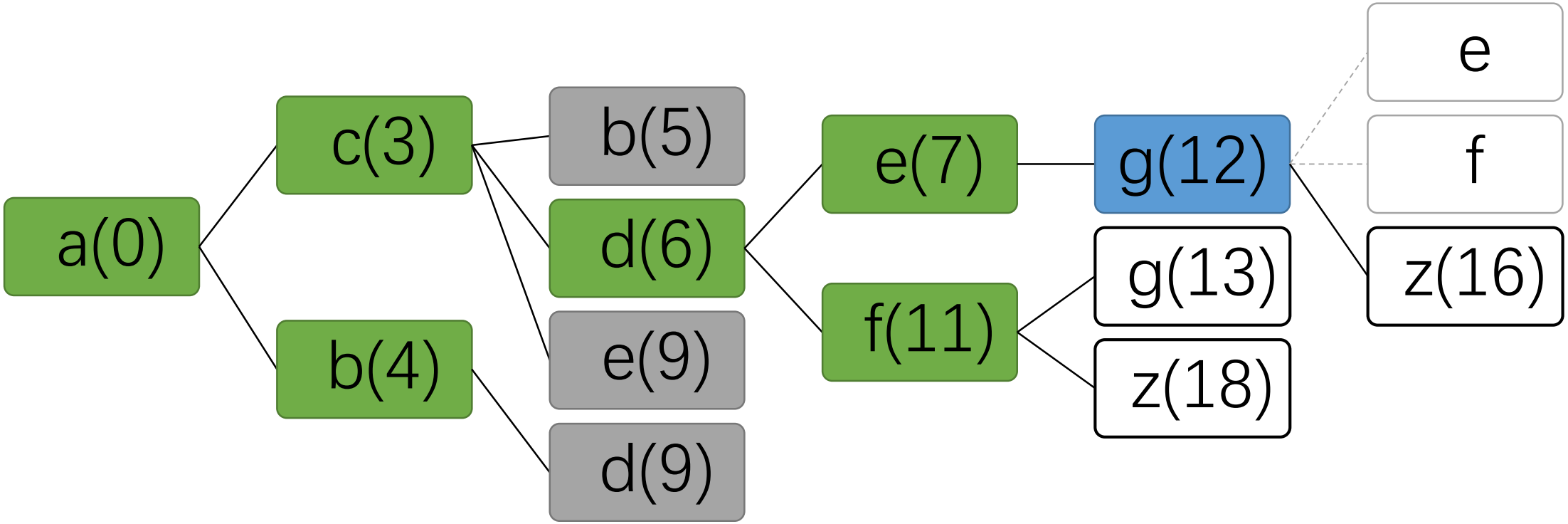

a(0)
c(3)
b(4)
b(5)
d(6)
e(9)
d(9)
b
c
e(7)
f(11)

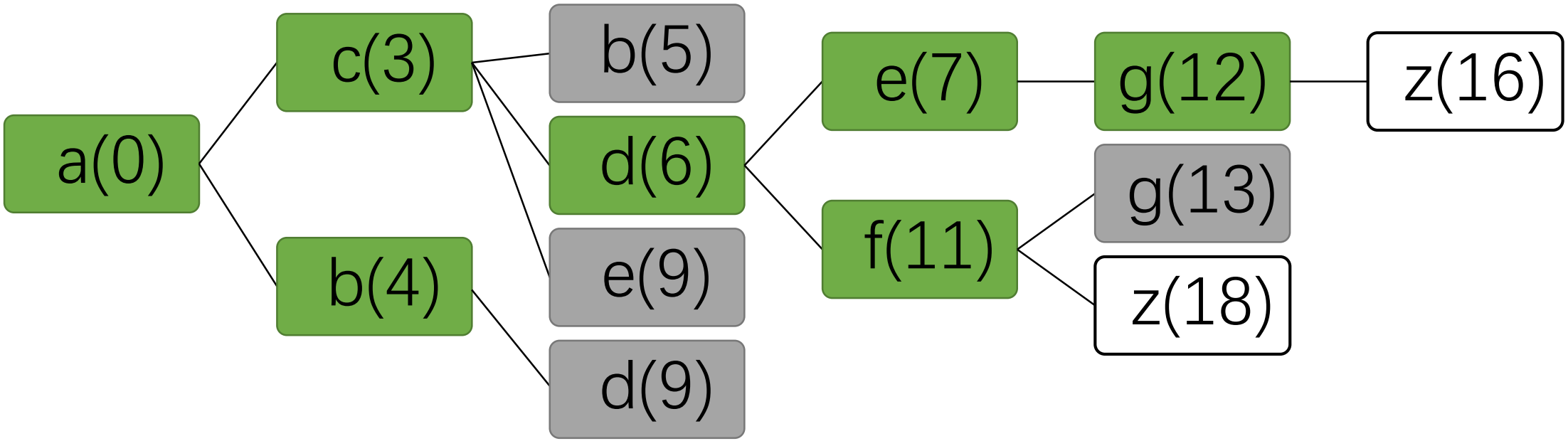

a(0)
c(3)
b(4)
b(5)
d(6)
e(9)
d(9)
e(7)
f(11)
c
d
g(12)

类似b(5)，无需扩展

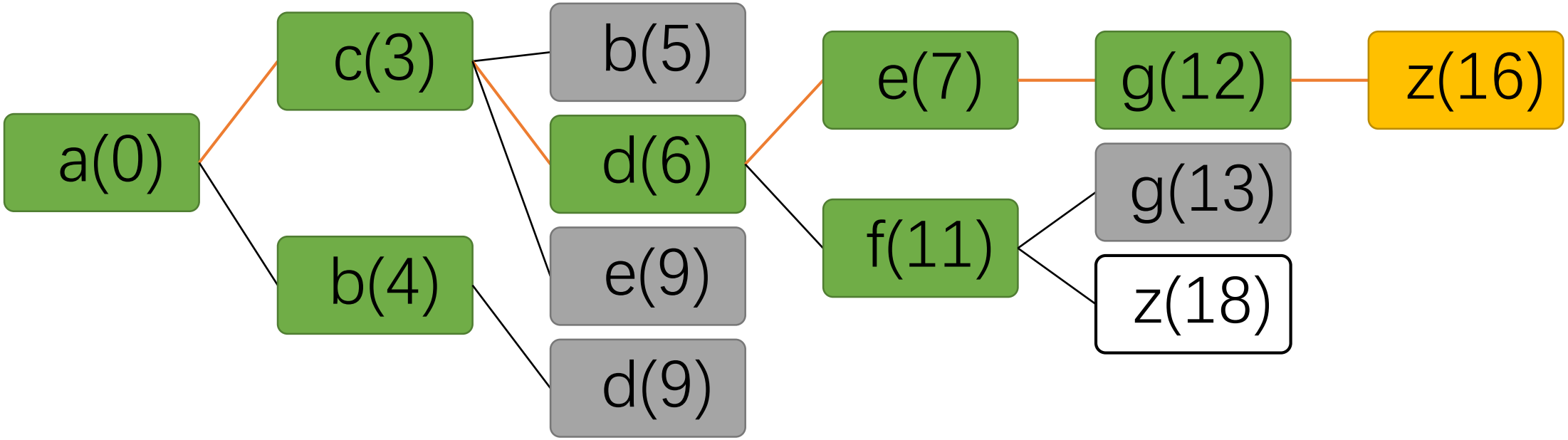



a(0)
c(3)
b(4)
b(5)
d(6)
e(9)
d(9)
e(7)
f(11)
g(12)
d
g(13)
z(18)

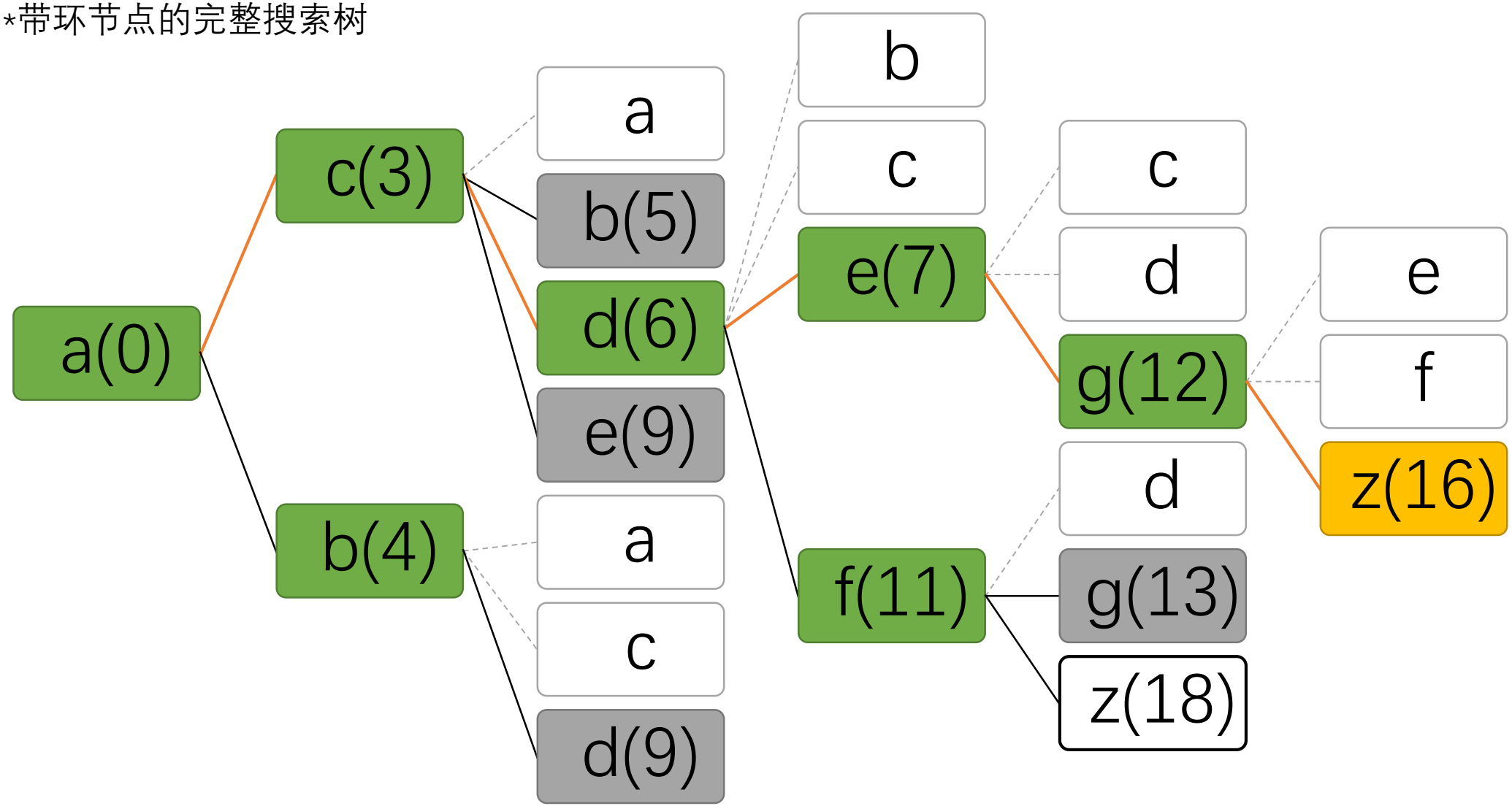

a(0)
c(3)
b(4)
b(5)
d(6)
e(9)
d(9)
e(7)
f(11)
g(12)
g(13)
z(18)
e
f
z(16)


a(0)
c(3)
b(4)
b(5)
d(6)
e(9)
d(9)
e(7)
f(11)
g(12)
g(13)
z(16)
z(18)

*画出本图即可



*带环节点的完整搜索树



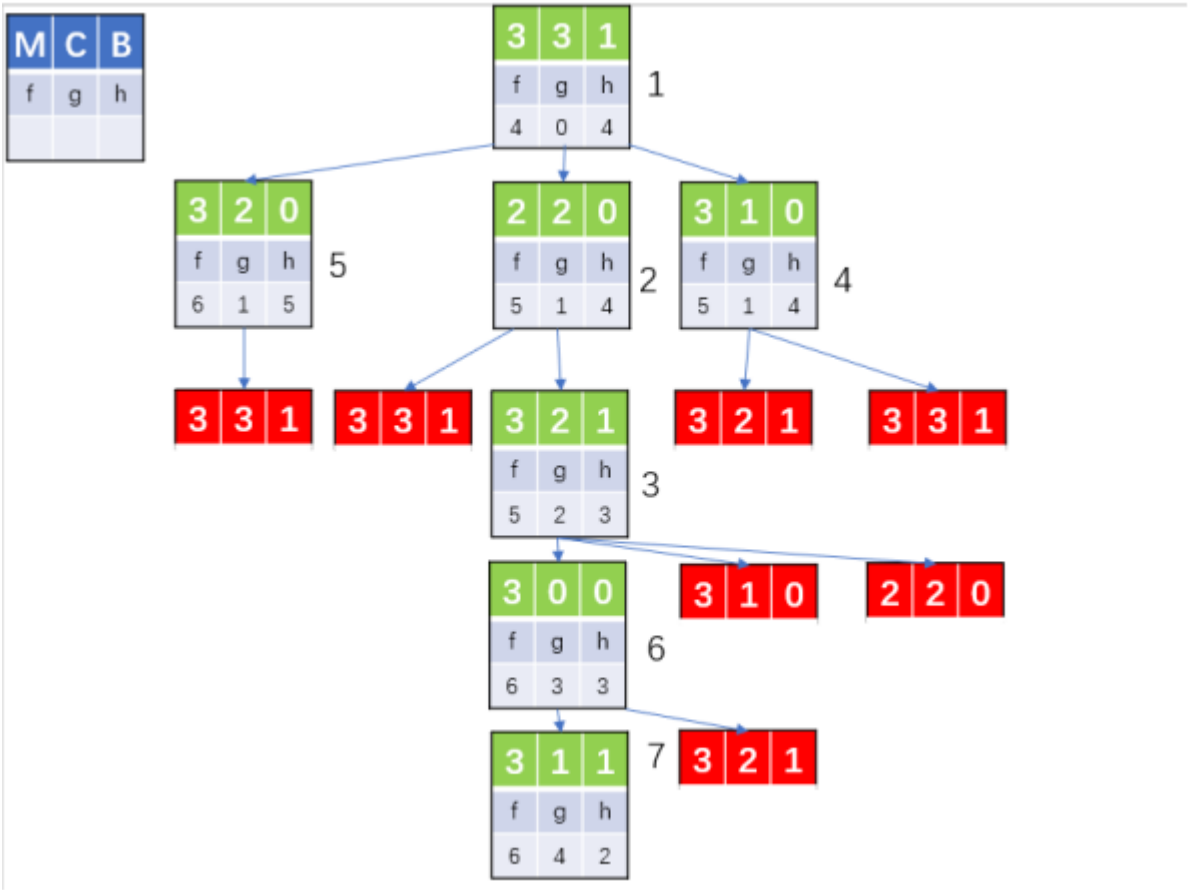
2 过河问题

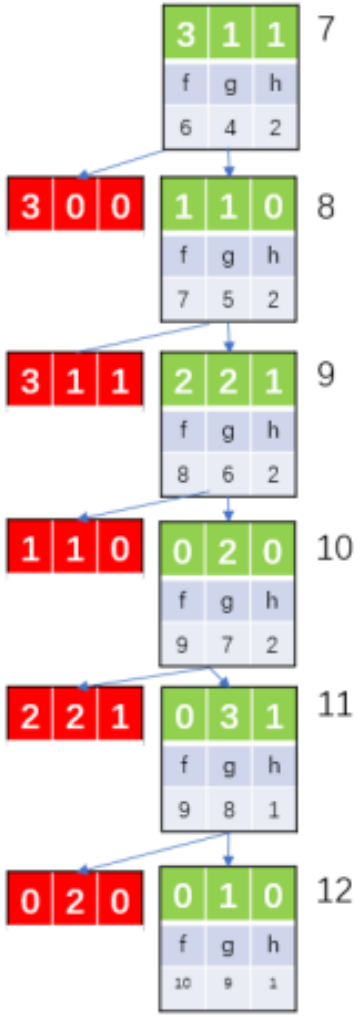
2. 传教士和食人族过河问题（详见课件）：开始时左岸有$M = 3$个传教士和$C = 3$个食人族。船的容量为$K = 2$。请将$h(n) = M + C - 2B$作为启发式函数，用带环检测的A*搜索来求解。请画出搜索树，并标出每个节点的h值和g值。（*注意：请在搜索树的节点旁边标明扩展顺序）

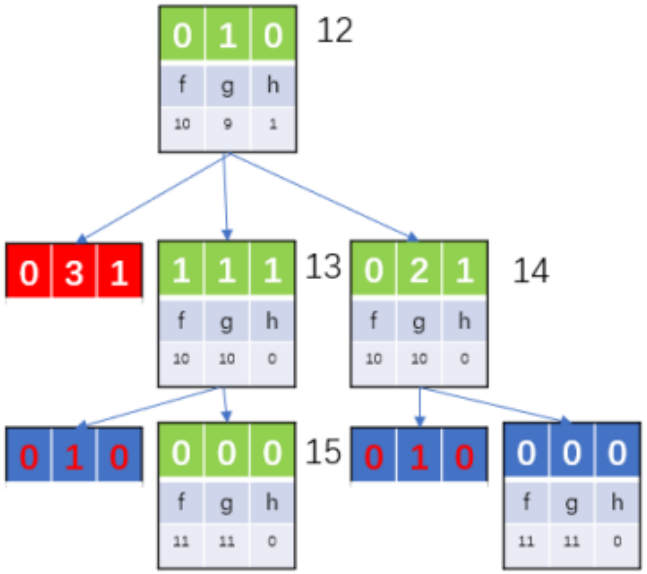
提醒：1、传教士和食人族都可以划船，但空船不能来回河两岸；2、请时刻关注状态是否合法。

- 明确在M≥C或C=0的约束下的可行状态：两岸都要满足“M≥C或C=0”。
- 可行状态：<3,3,B>, <3,2,B>, <3,1,B >, <3,0,B >, <2,2,B >, <2,0,B >, <1,3,B >, <1,1,B >, <0,3,B >, <0,2,B >, <0,1,B >, <0,0,B >
- 禁止状态：<2,3,B >, <2,1,B >, <1,2,B >, <1,0,B >
- 船：K=2，任意组合均可。

- 感谢谢泽辉同学的答案

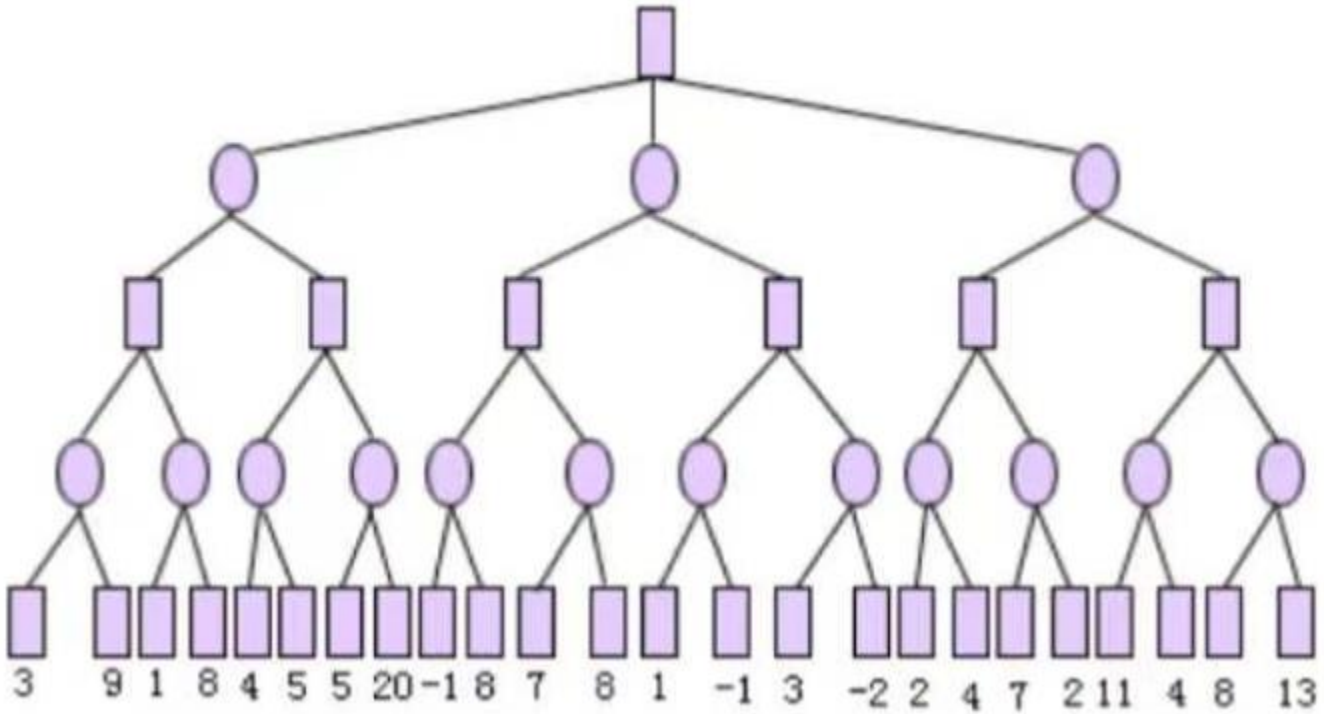

M C B
f g h
3 3 1
f g h
4 0 4
1
3 2 0
f g h
6 1 5
5
2 2 0
f g h
5 1 4
2
3 1 0
f g h
5 1 4
4
3 3 1
3 3 1
3 2 1
f g h
5 2 3
3
3 2 1
3 3 1
3 0 0
f g h
6 3 3
6
3 1 0
2 2 0
3 1 1
f g h
6 4 2
7
3 2 1


3 1 1
f g h
6 4 2
7
3 0 0
1 1 0
f g h
7 5 2
8
3 1 1
2 2 1
f g h
8 6 2
9
1 1 0
0 2 0
f g h
9 7 2
10
2 2 1
0 3 1
f g h
9 8 1
11
0 2 0
0 1 0
f g h
10 9 1
12


0 1 0
f g h
10 9 1
12
0 3 1
1 1 1
f g h
10 10 0
13
0 2 1
f g h
10 10 0
14
0 1 0
0 0 0
f g h
11 11 0
15
0 1 0
0 0 0
f g h
11 11 0

3 alpha-beta剪枝

3. 对下面的博弈树使用$\alpha-\beta$剪枝算法，并标出节点值的变化过程。

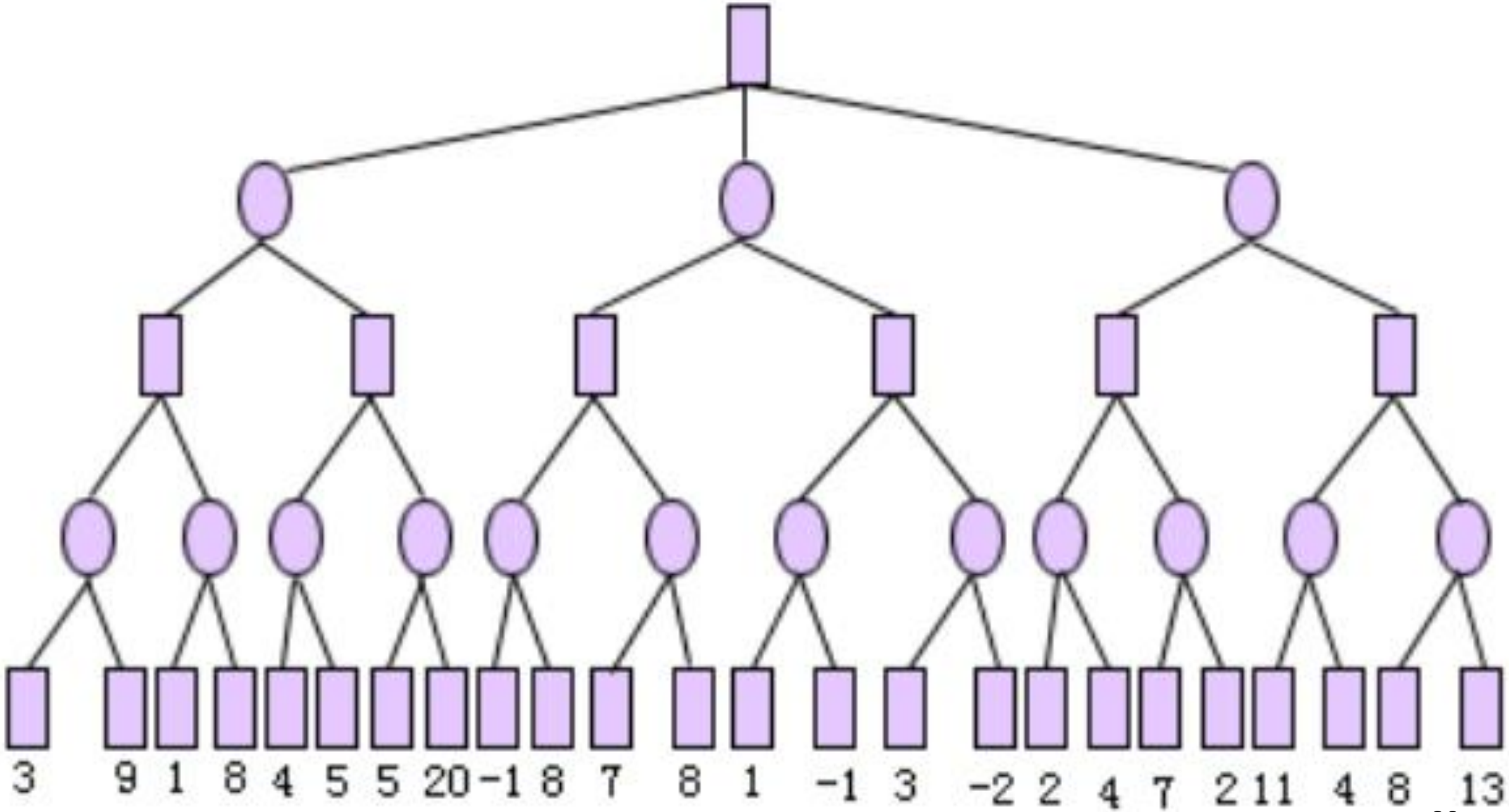


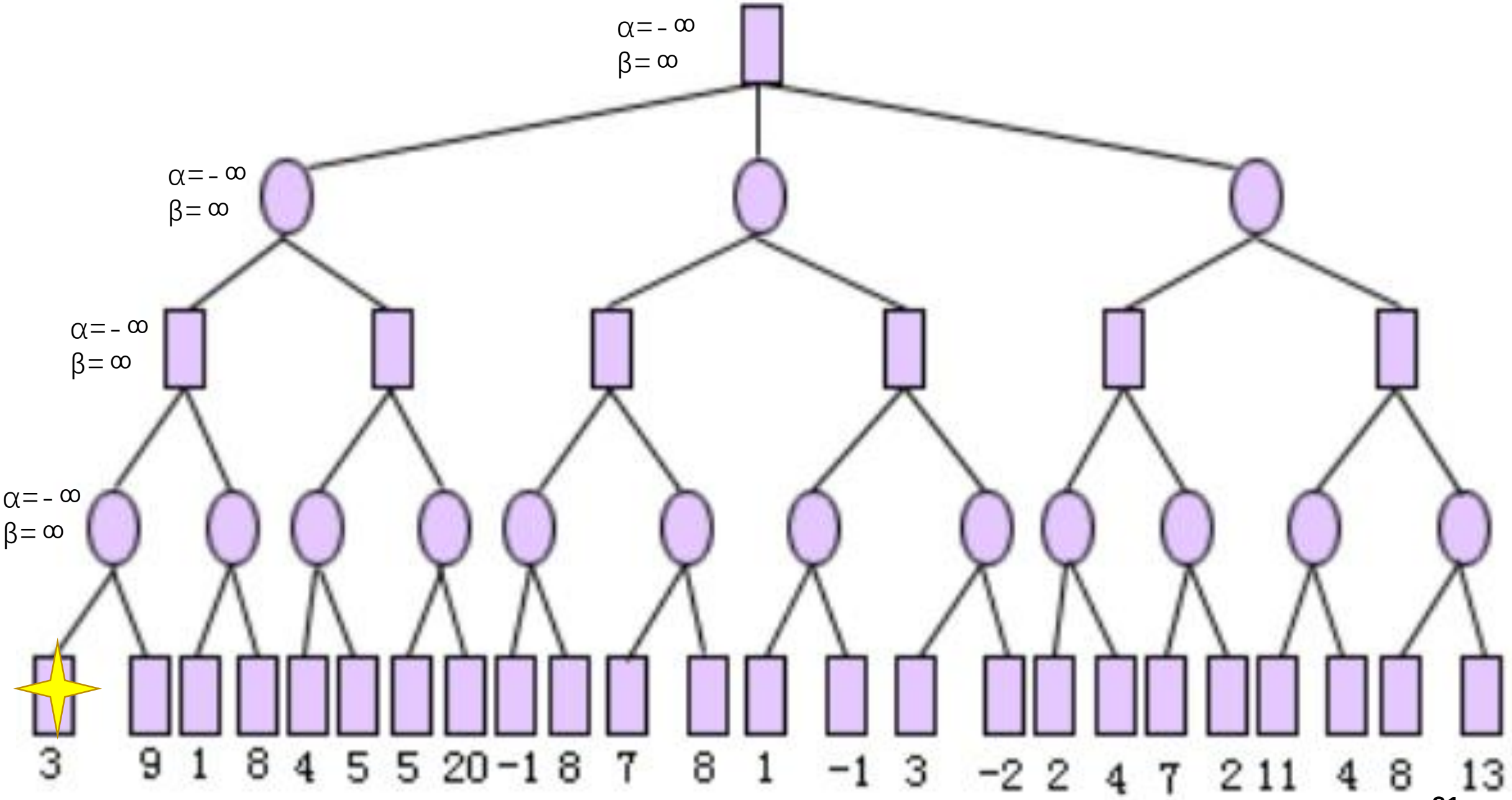
Implementing Alpha-Beta Pruning

```
AlphaBeta(n,Player,alpha,beta) //return Utility of state
If n is TERMINAL
    return V(n) //Return terminal states utility
ChildList = n.Successors(Player)
If Player == MAX
 for c in ChildList
    alpha = max(alpha, AlphaBeta(c,MIN,alpha,beta))
    If beta <= alpha
        break
 return alpha
Else //Player == MIN
  for c in ChildList
    beta = min(beta, AlphaBeta(c,MAX,alpha,beta))
    If beta <= alpha
        break
 return beta
```

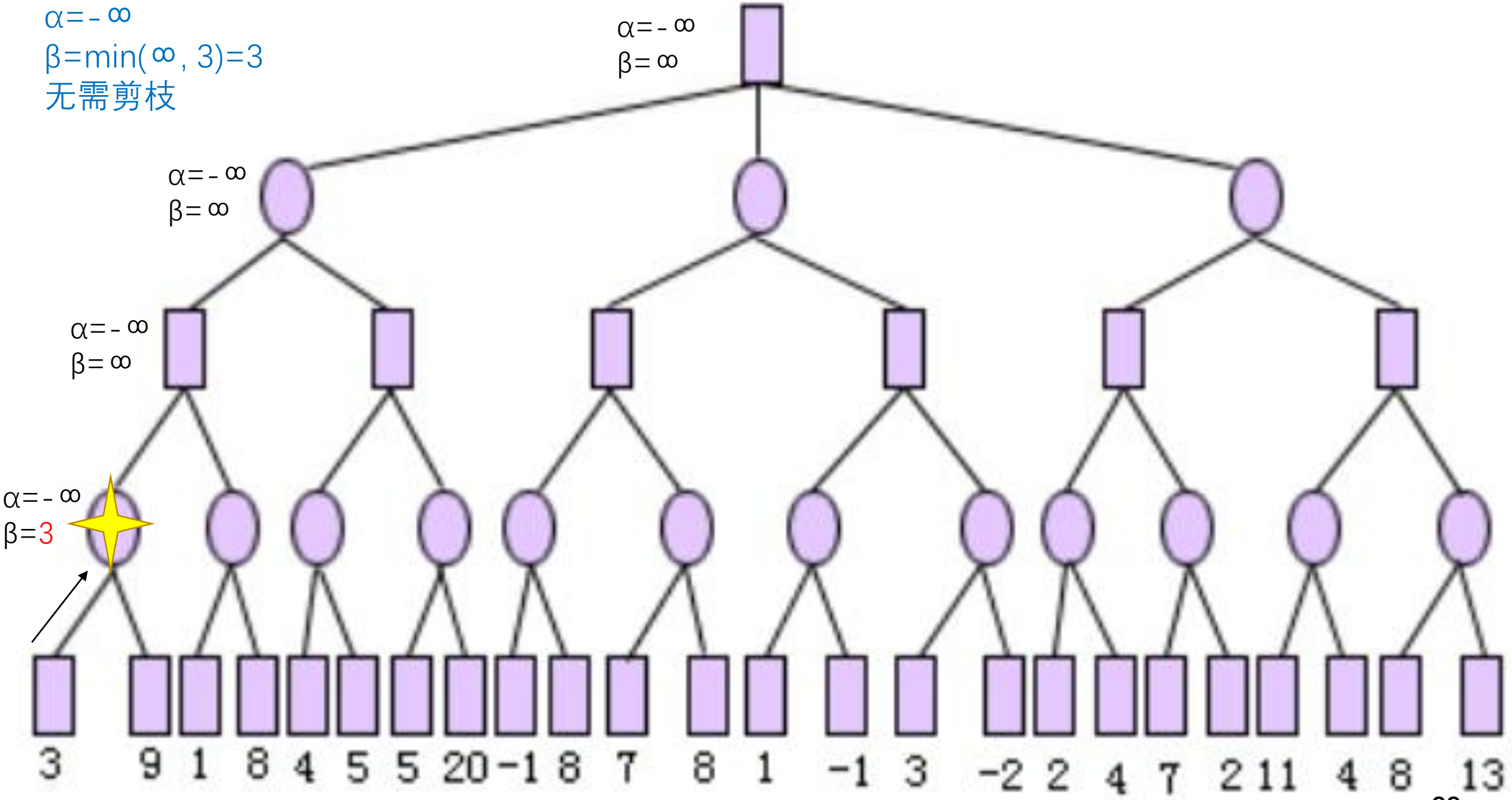
When AlphaBeta(n,Player,alpha,beta) is called, alpha is the maximum alpha value of n's ancestor Max nodes, and beta is the minimum beta value of n's ancestor Min nodes

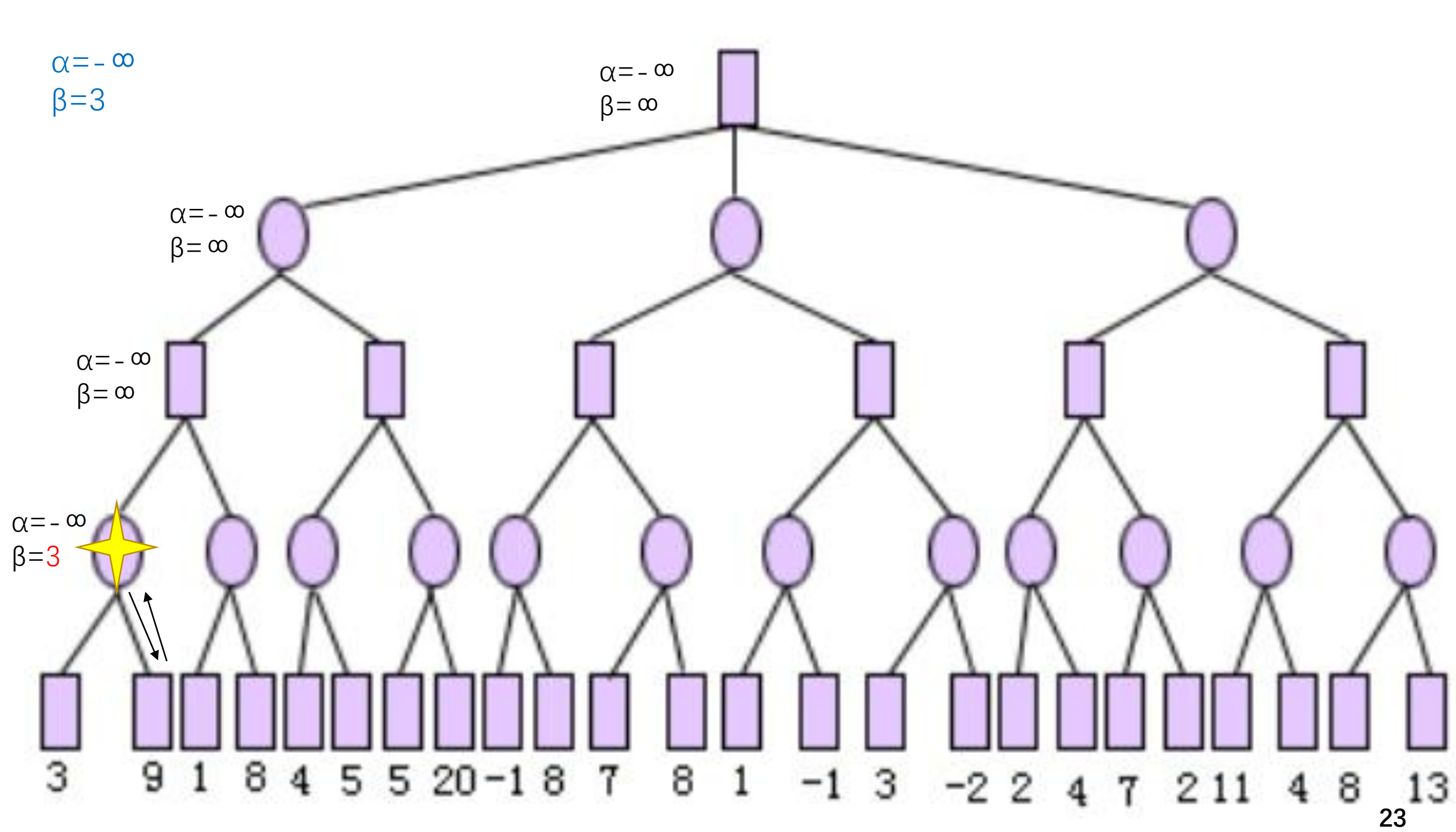
Initial call: AlphaBeta(START-NODE,Player,-infinity,+infinity)


3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

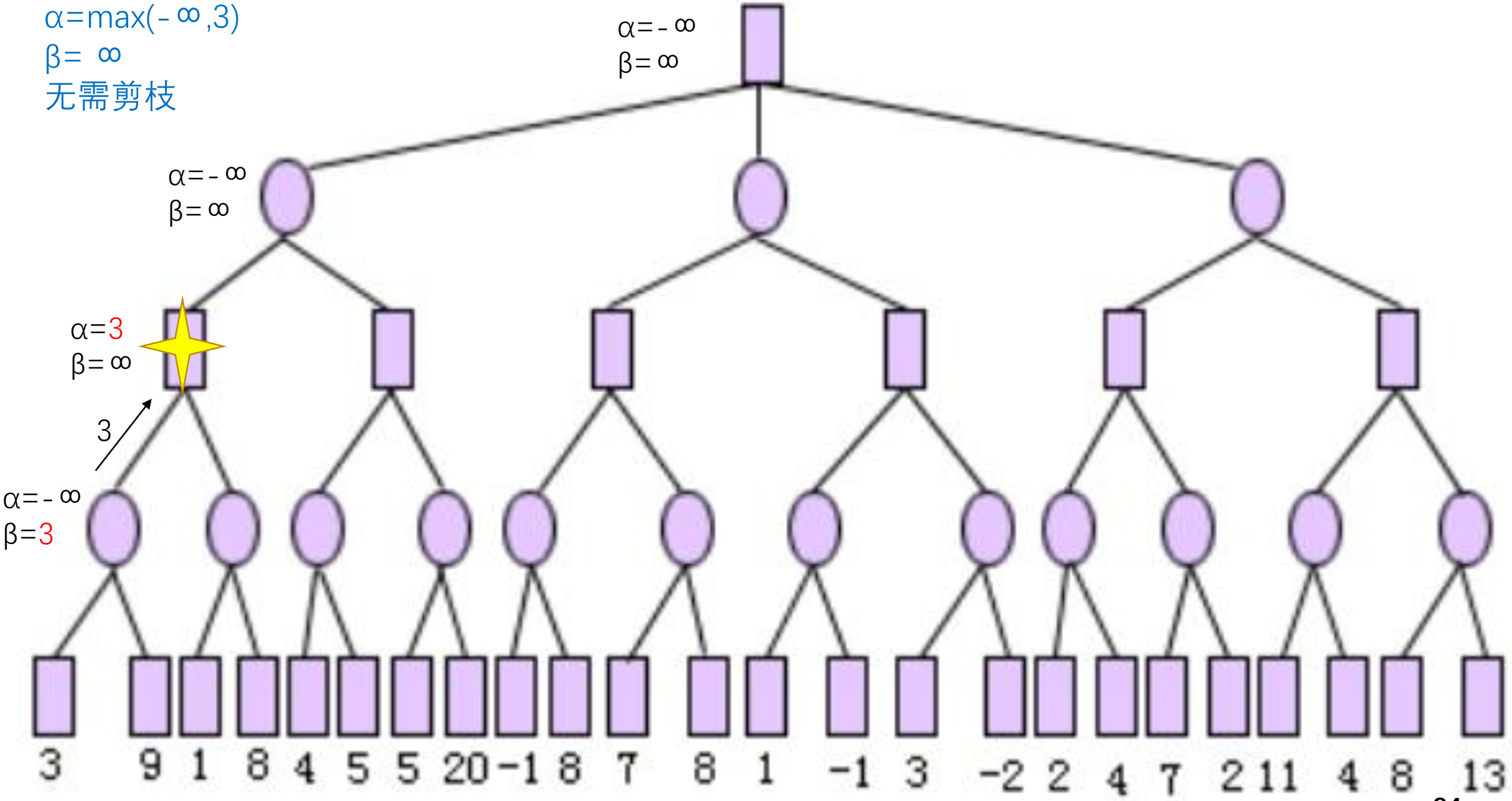

α = - ∞
β = ∞
α = - ∞
β = ∞
α = - ∞
β = ∞
α = - ∞
β = ∞
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α=-∞
β=min(∞, 3)=3
无需剪枝

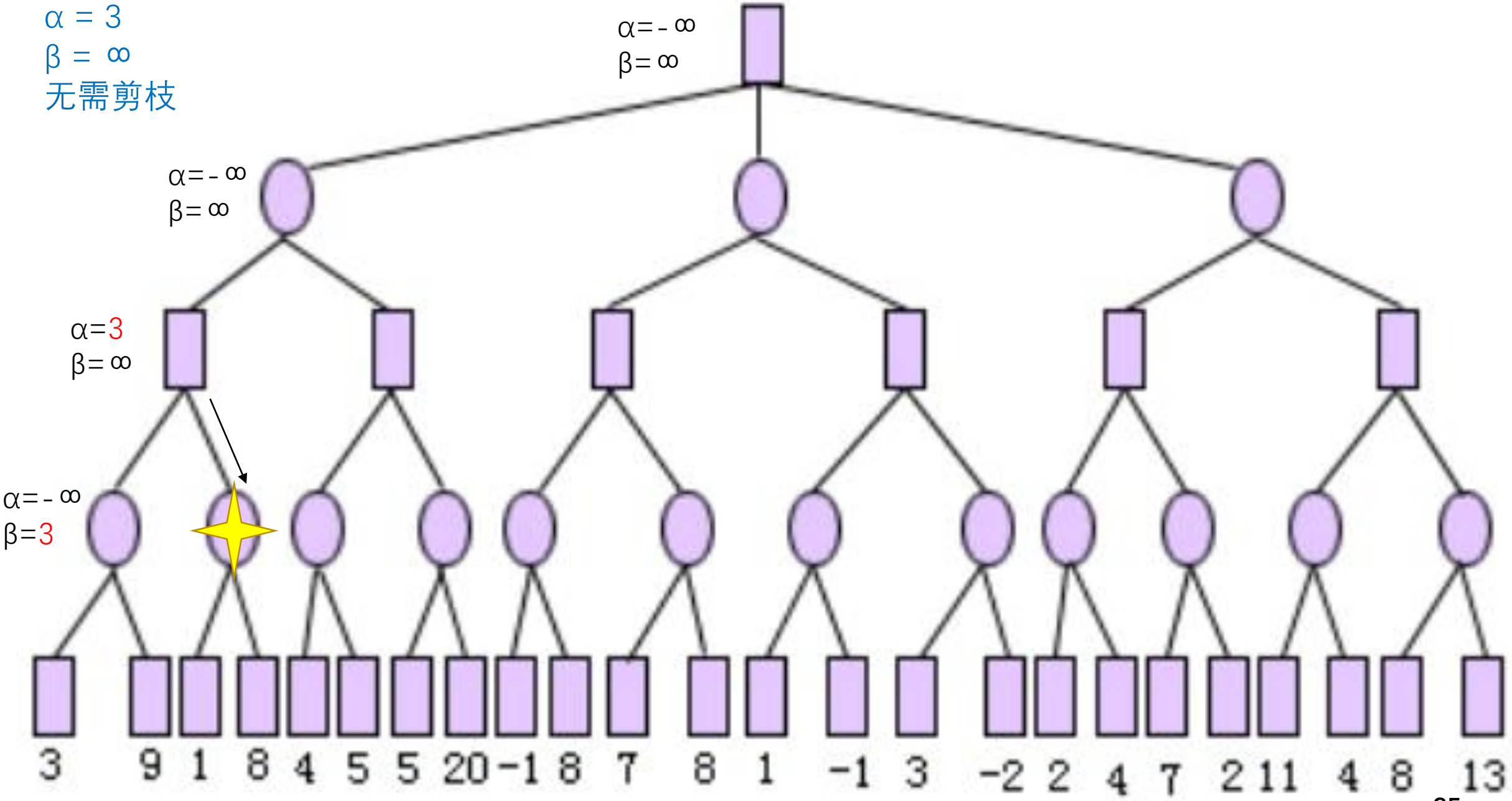



α=-∞
β=3
α=-∞
β=∞
α=-∞
β=∞
α=-∞
β=∞
α=-∞
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

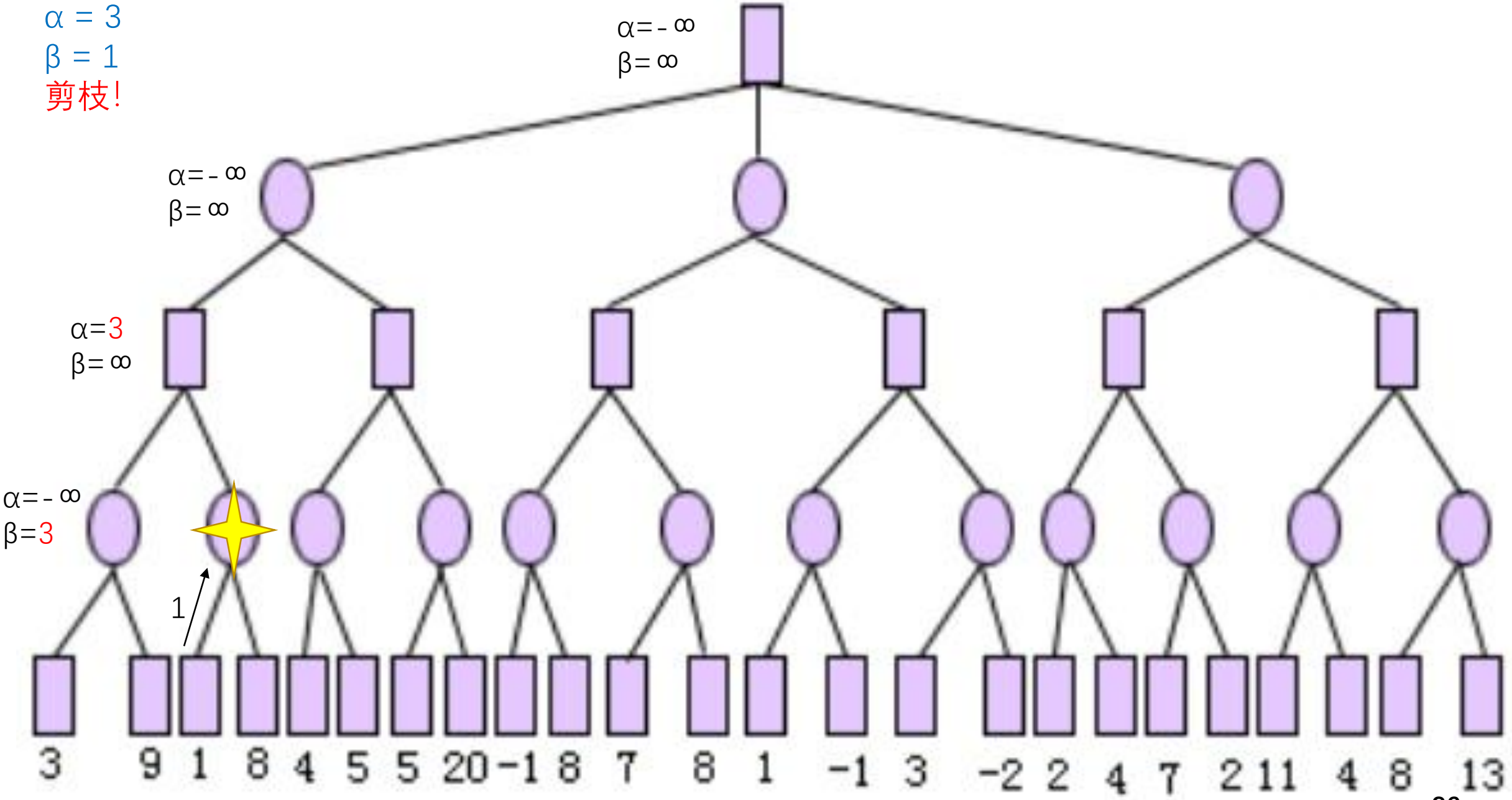
α=max(-∞,3)
β= ∞
无需剪枝



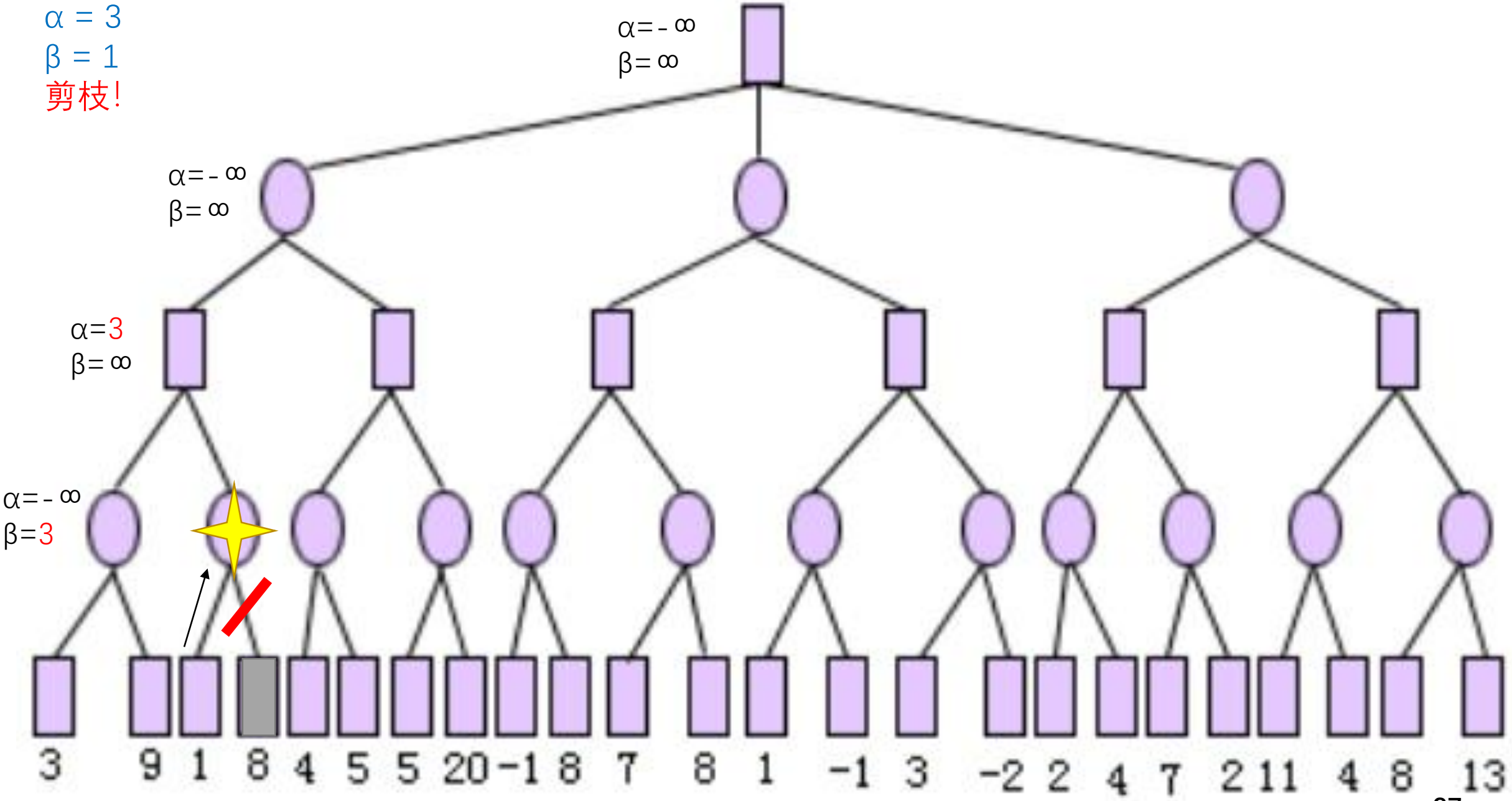
α = 3
β = ∞
无需剪枝



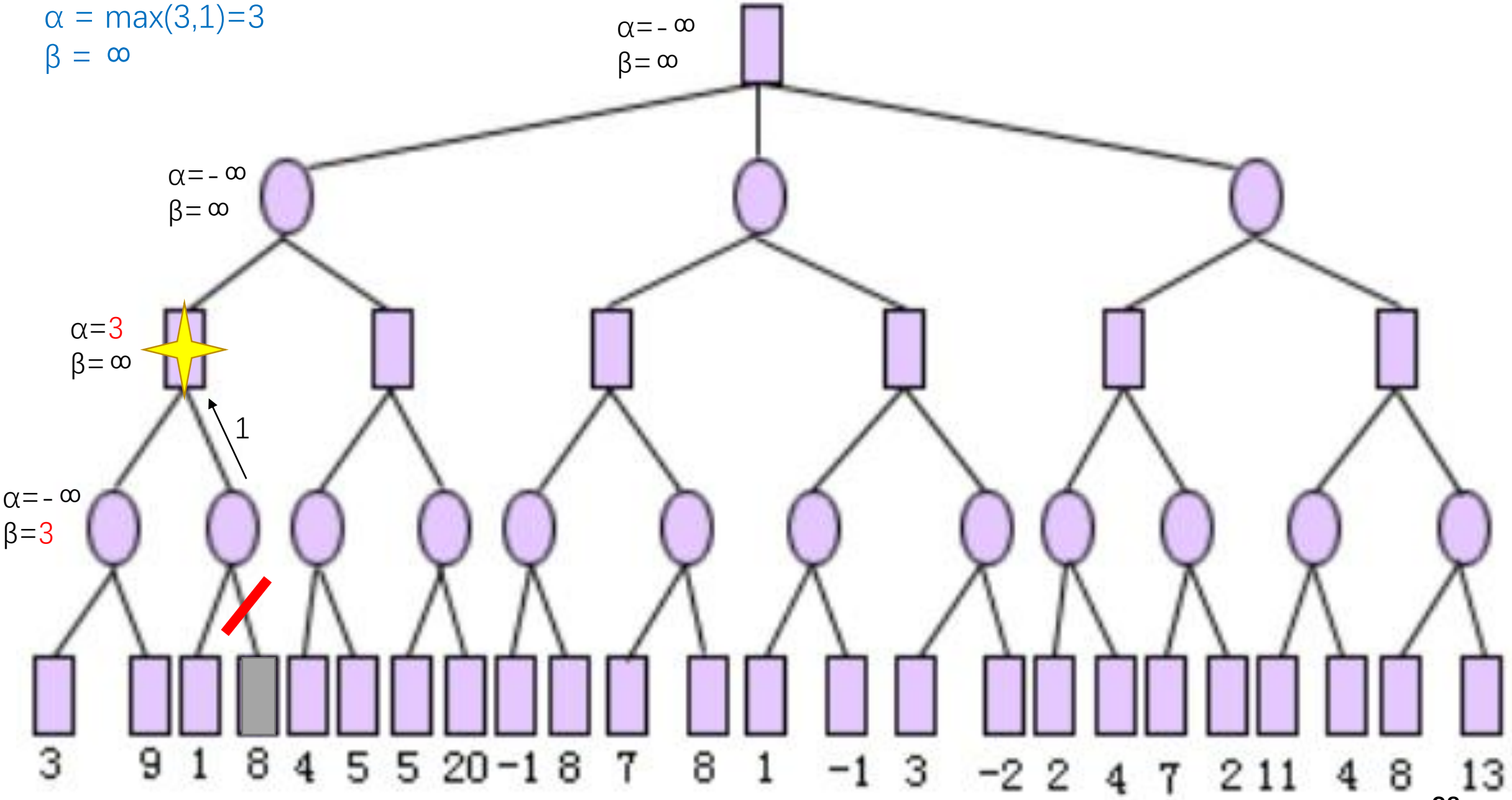
α = 3
β = 1
剪枝!



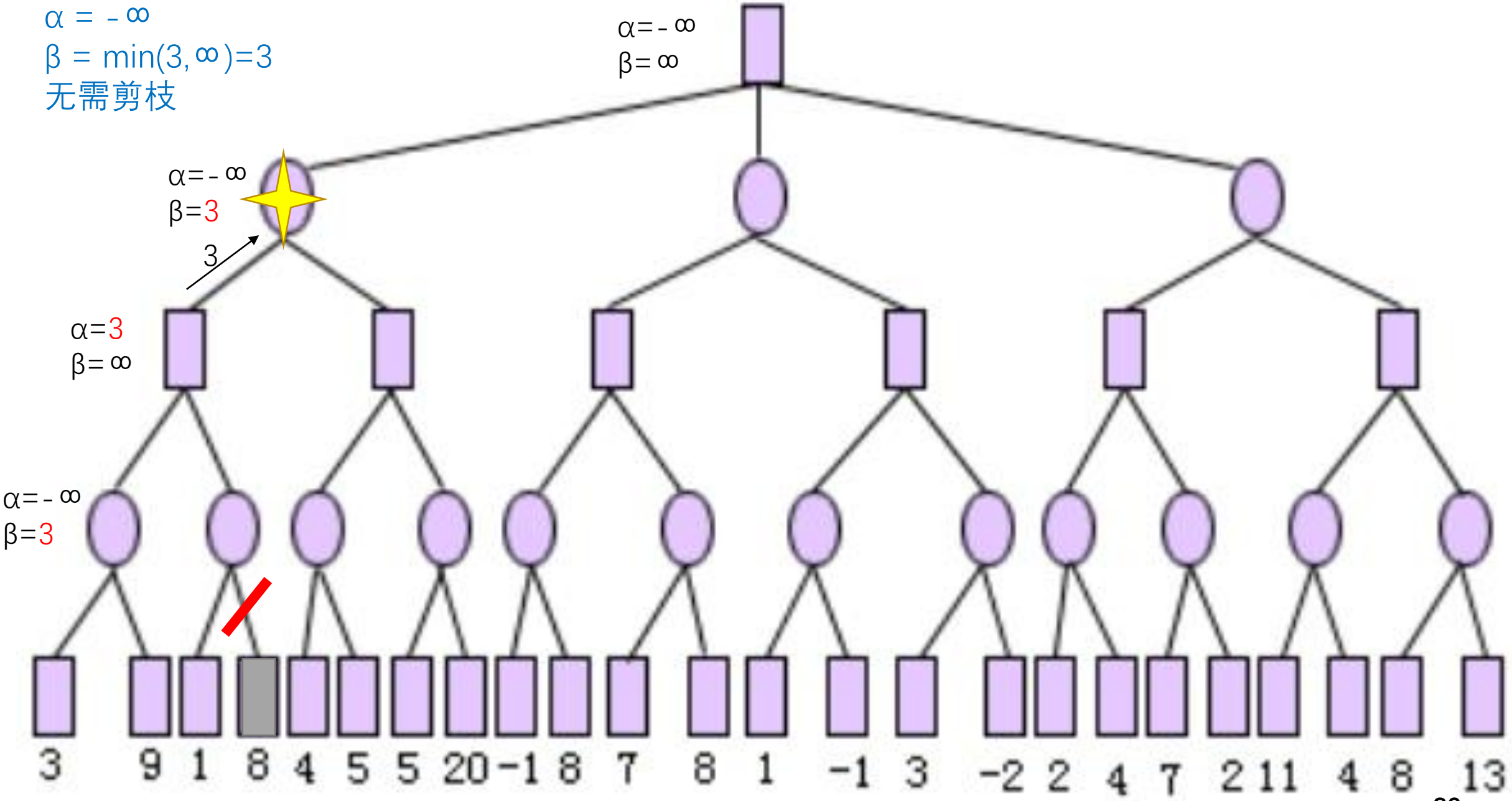
α = 3
β = 1
剪枝!



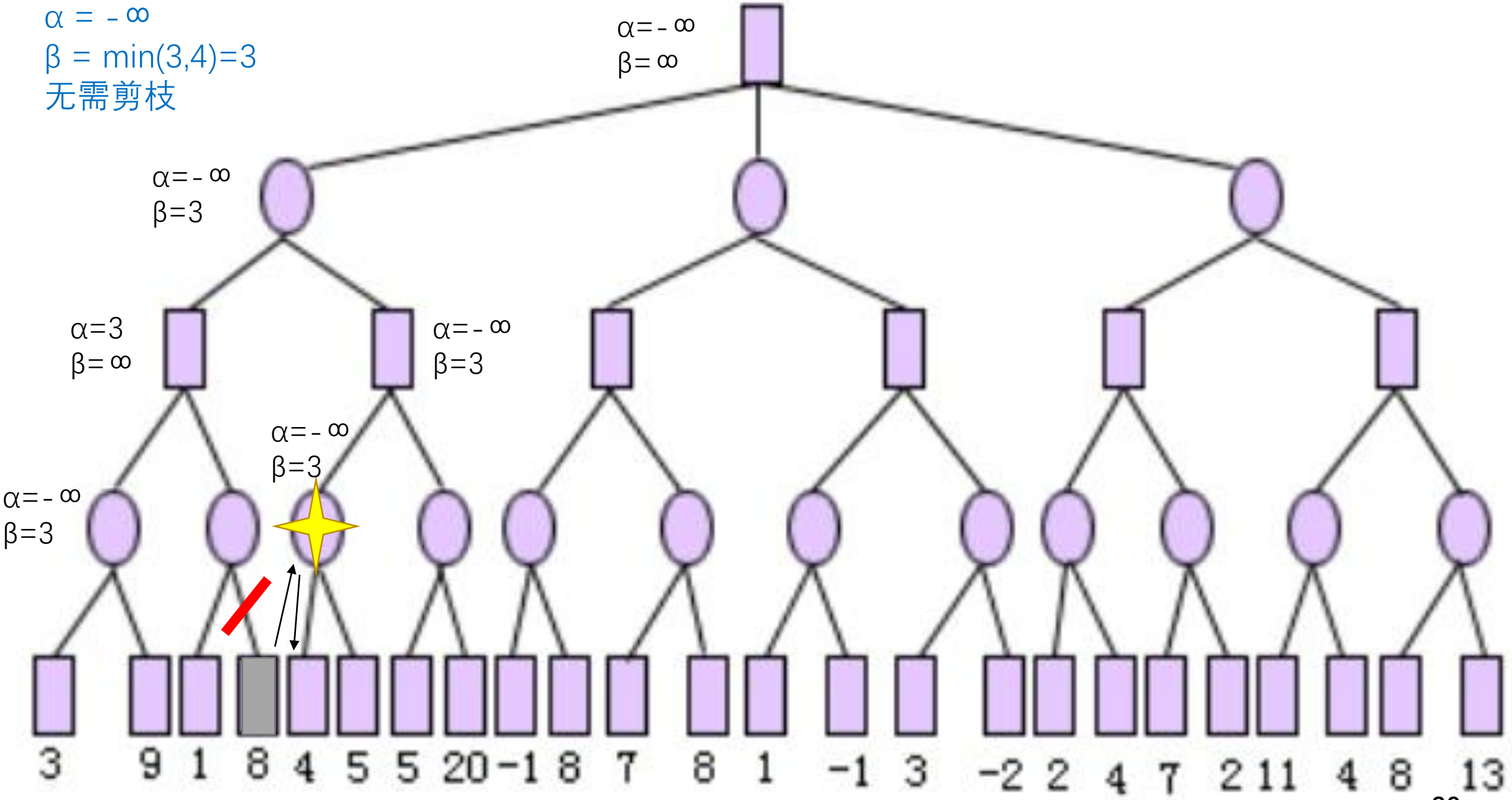
α = max(3,1)=3
β = ∞



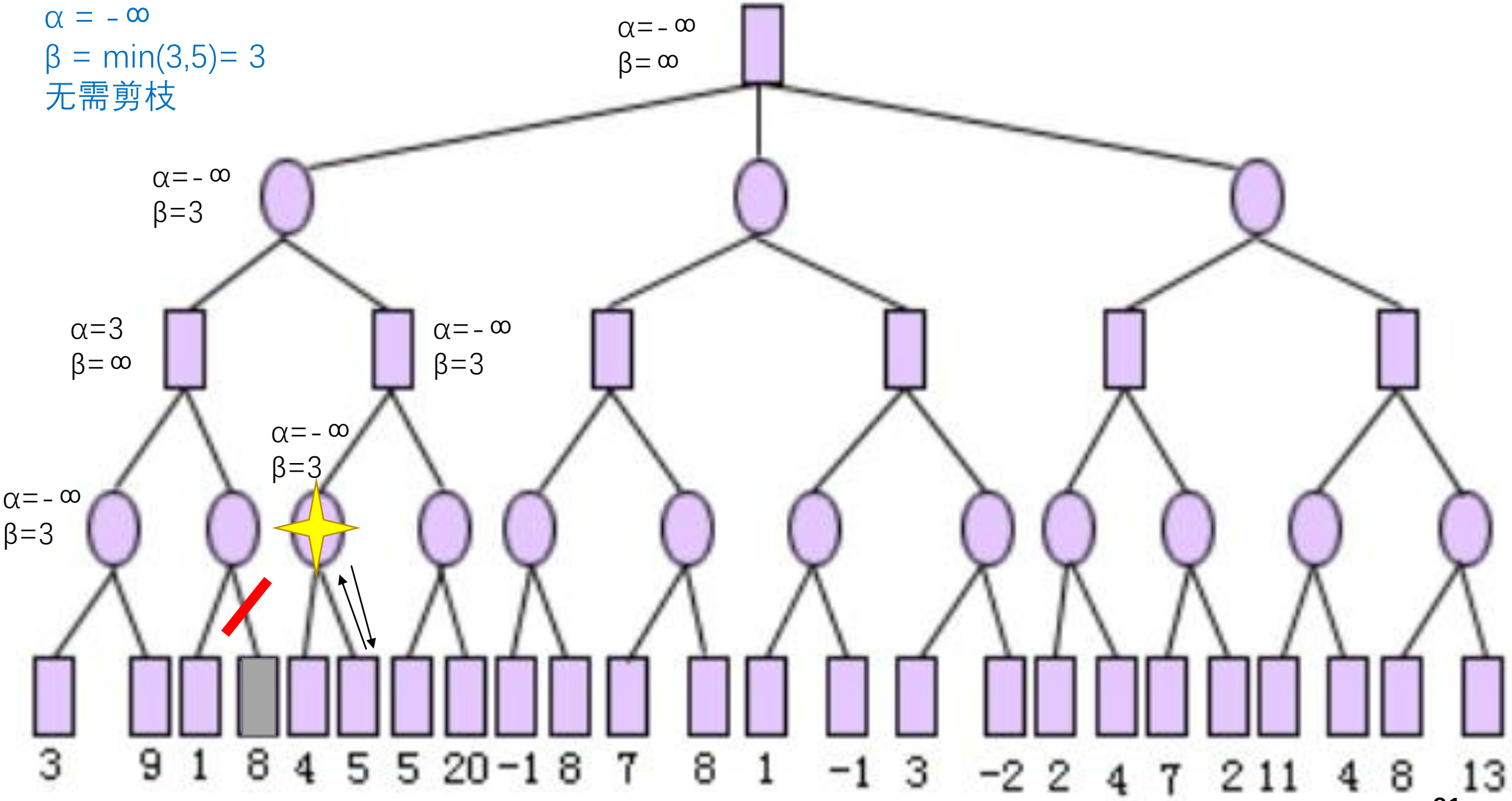
α = - ∞
β = min(3, ∞)=3
无需剪枝



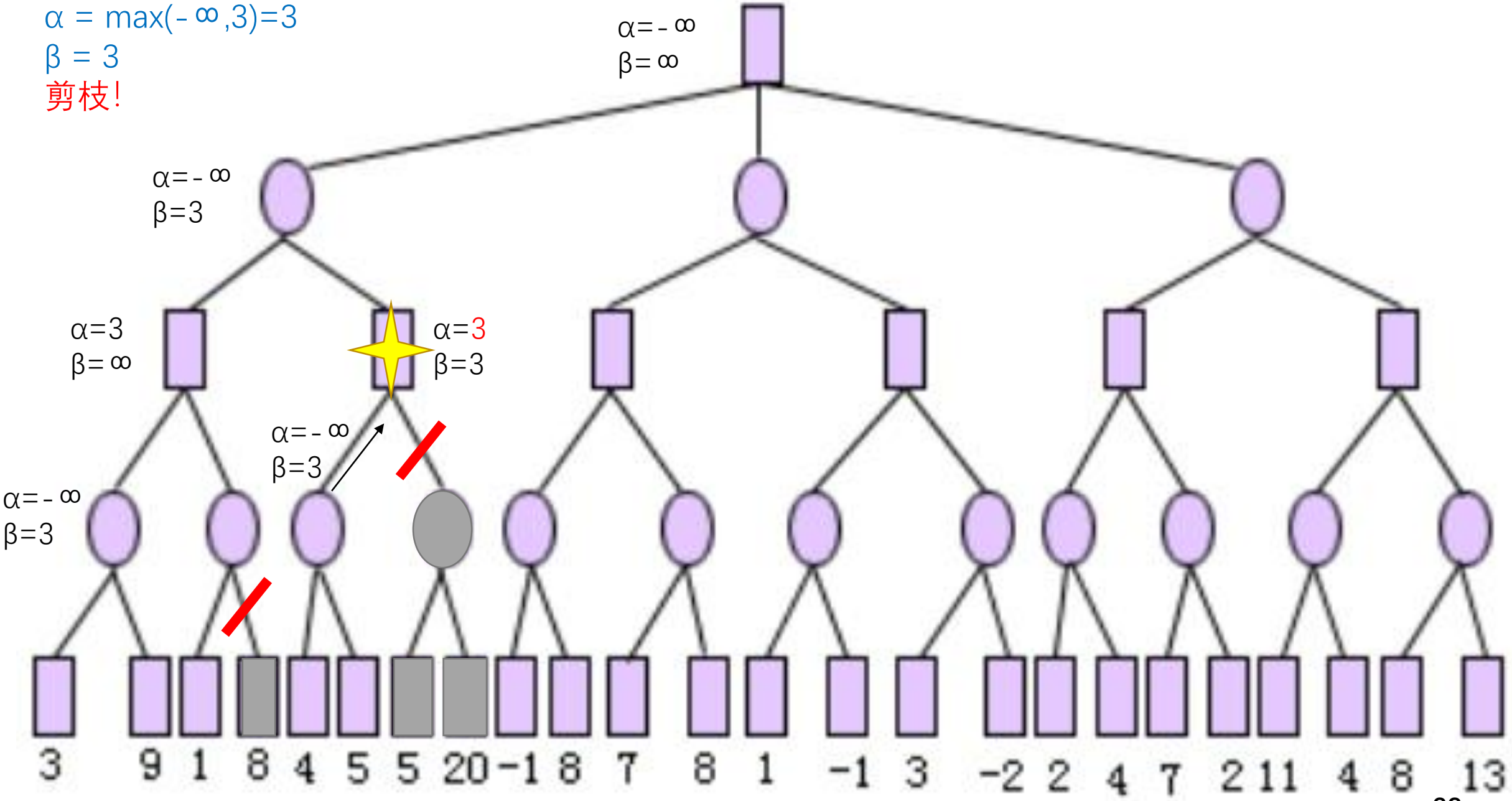
α = - ∞
β = min(3,4)=3
无需剪枝

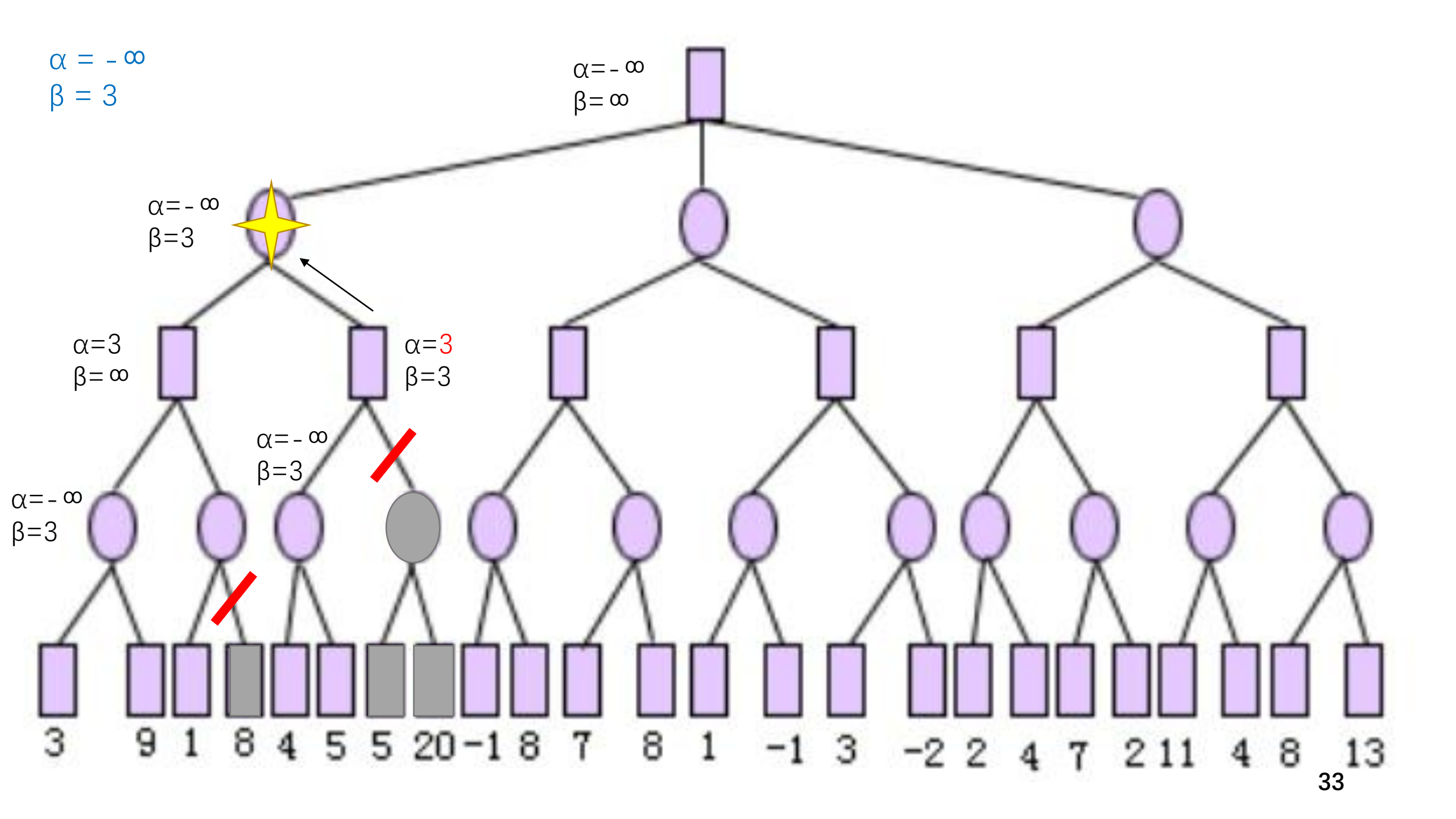


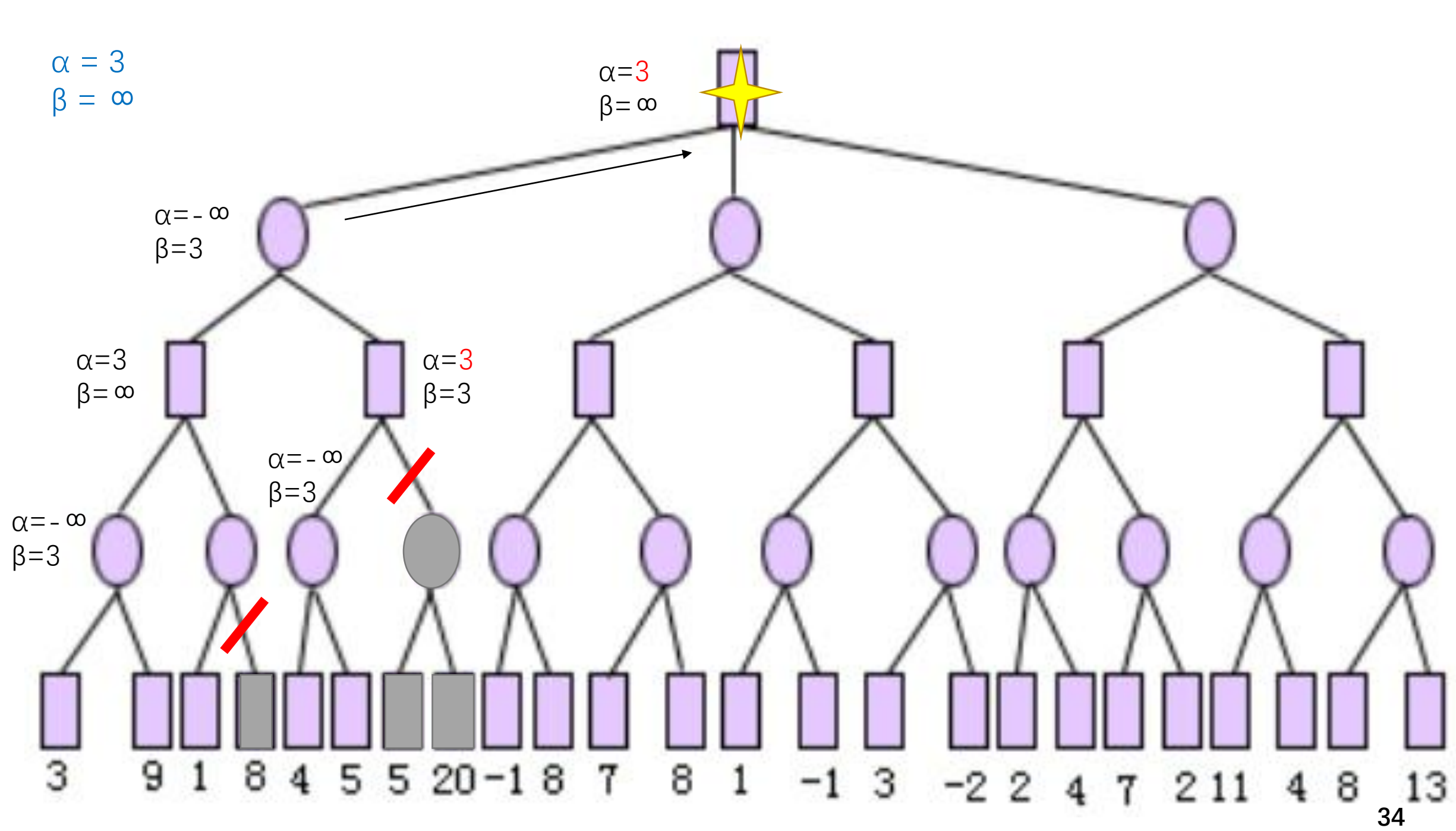
α = - ∞
β = min(3,5)= 3
无需剪枝

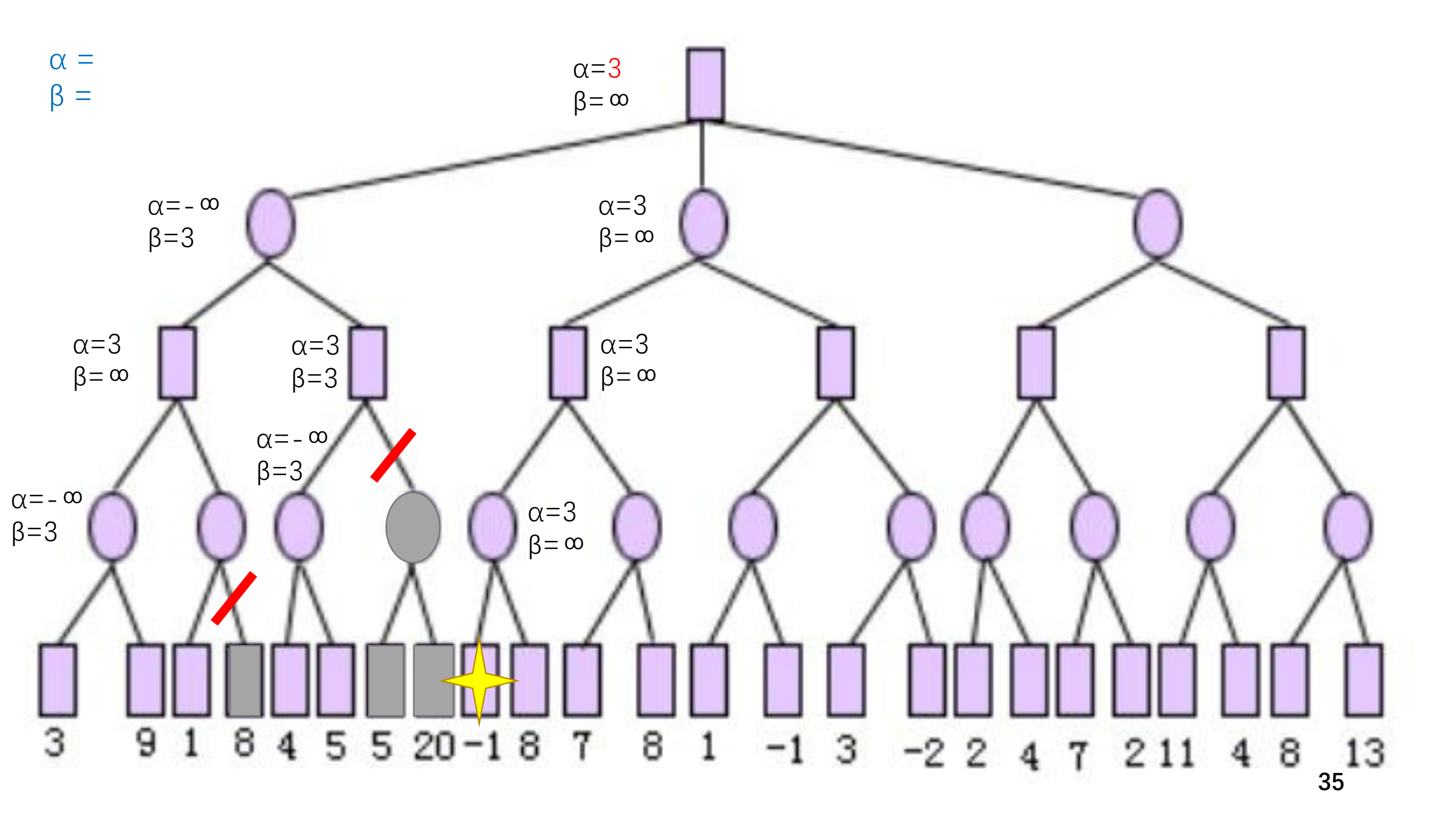


α = max(-∞,3)=3
β = 3
剪枝!

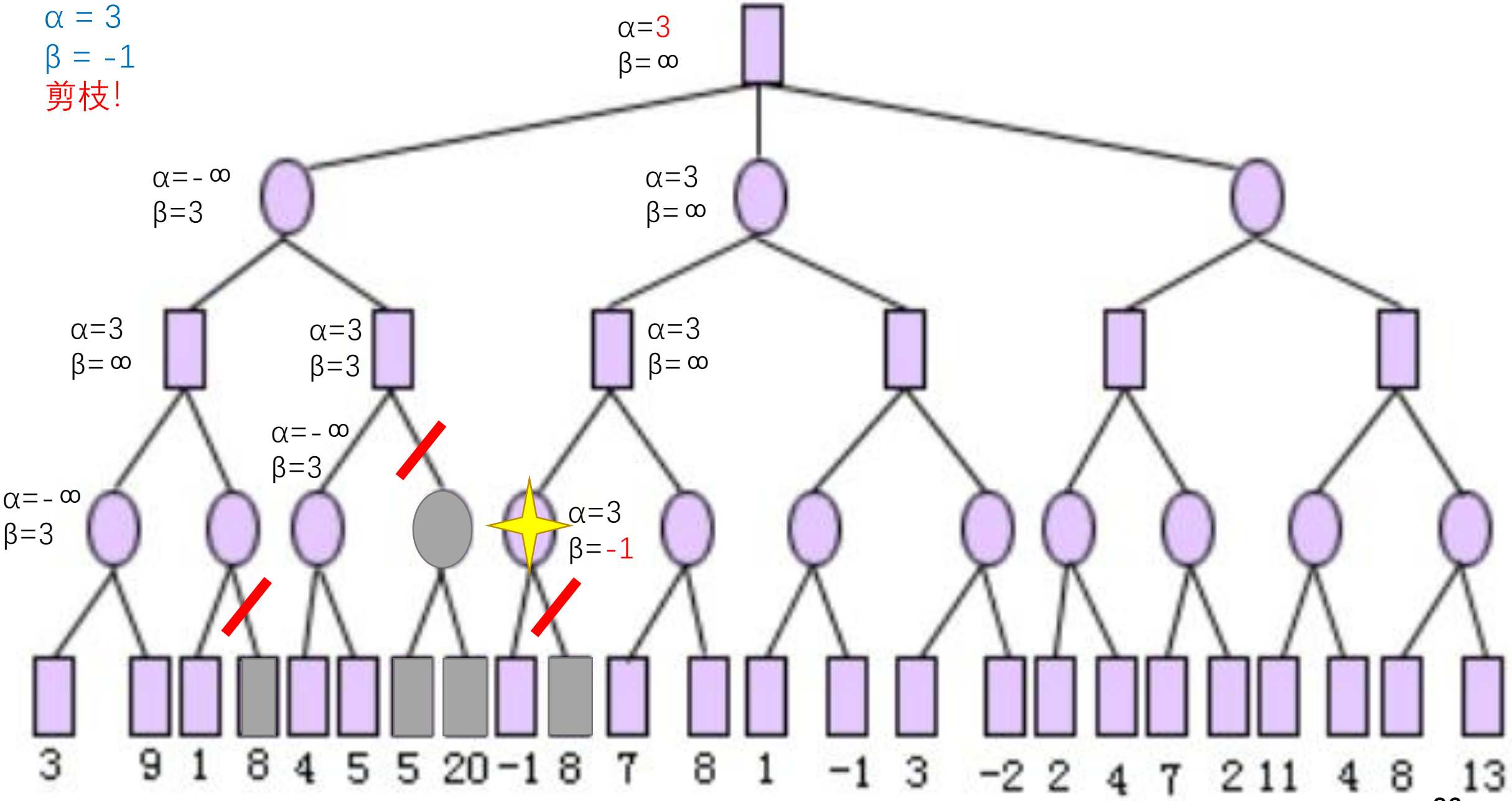



α = - ∞
β = 3
α=- ∞
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=3
β=3
α=- ∞
β=3
α=- ∞
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

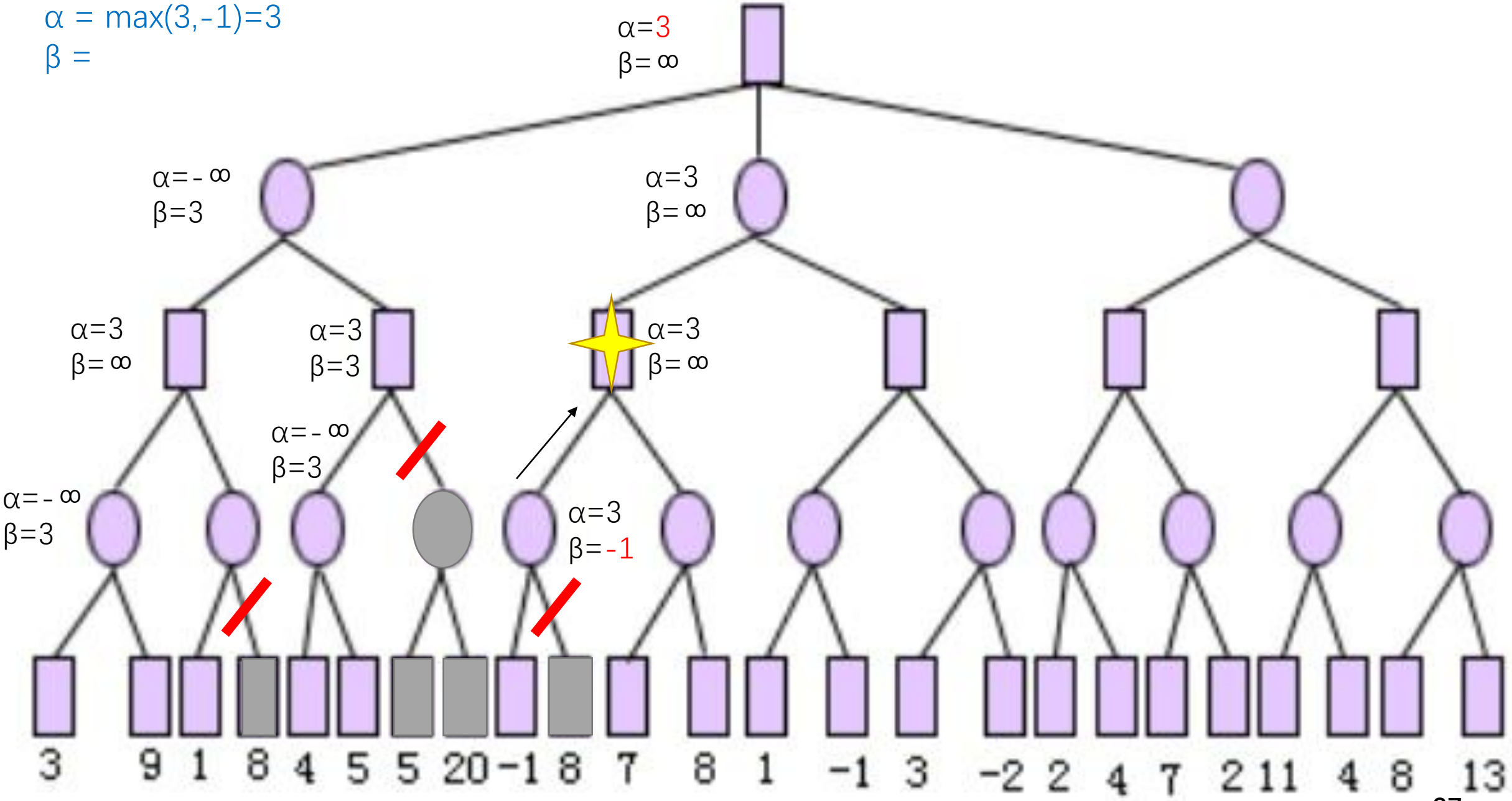

α = 3
β = ∞
α=3
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=3
β=3
α=- ∞
β=3
α=- ∞
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

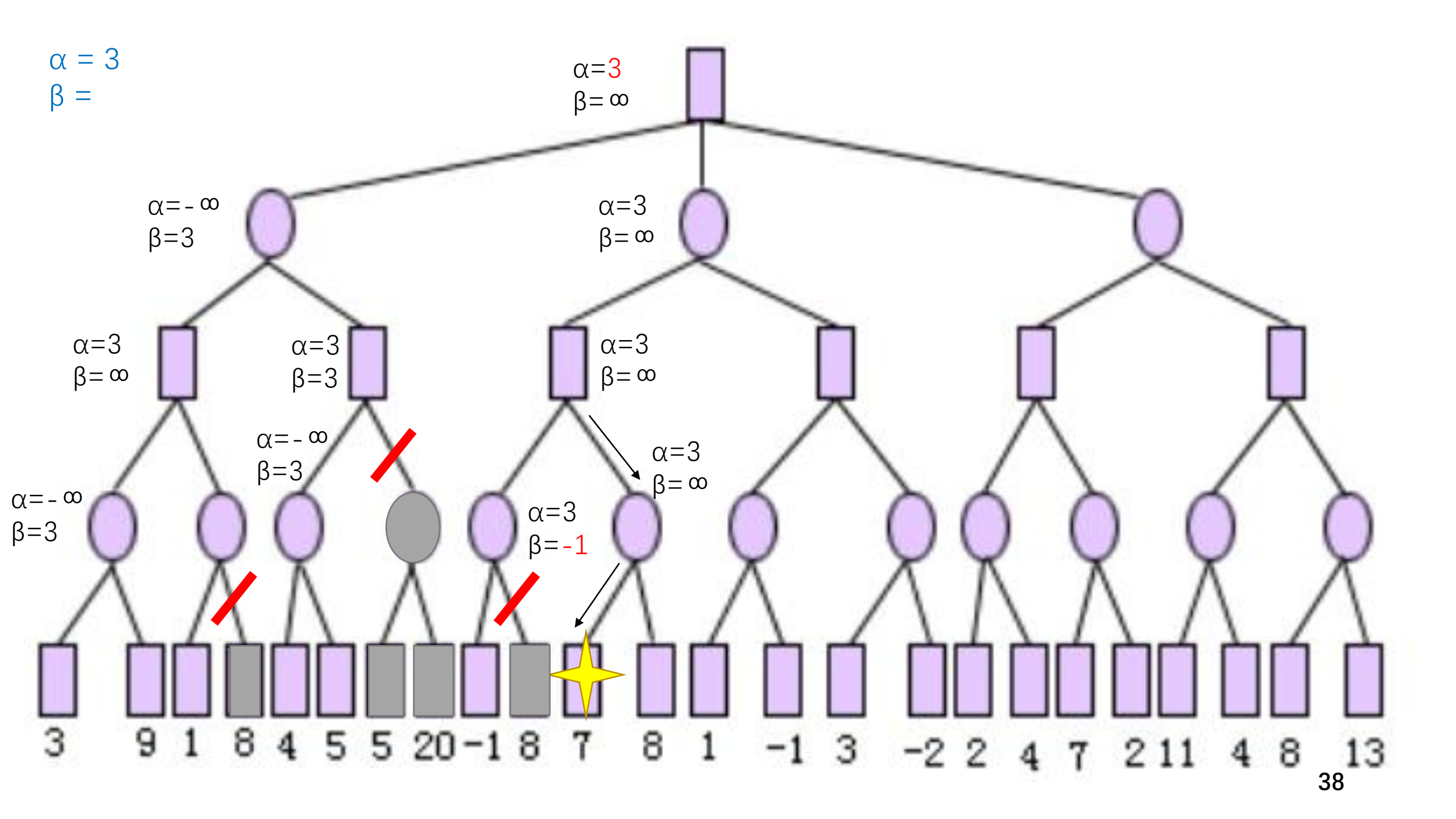

α =
β =
α=3
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=3
β= ∞
α=3
β=3
α=3
β= ∞
α=- ∞
β=3
α=- ∞
β=3
α=3
β= ∞
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

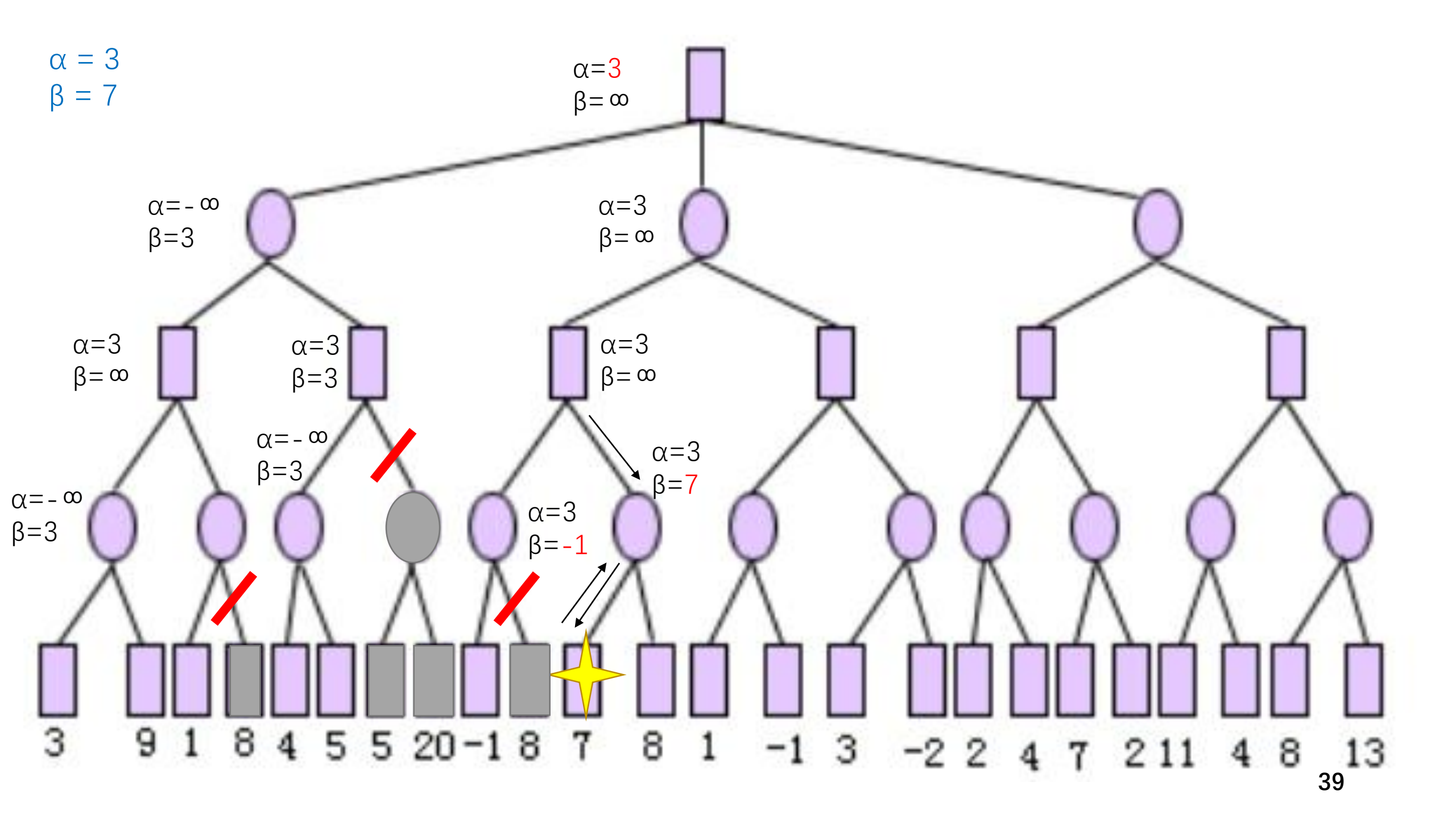
α = 3
β = -1
剪枝!


α=3
β=∞
α=-∞
β=3
α=3
β=∞
α=3
β=∞
α=3
β=3
α=3
β=∞
α=-∞
β=3
α=-∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

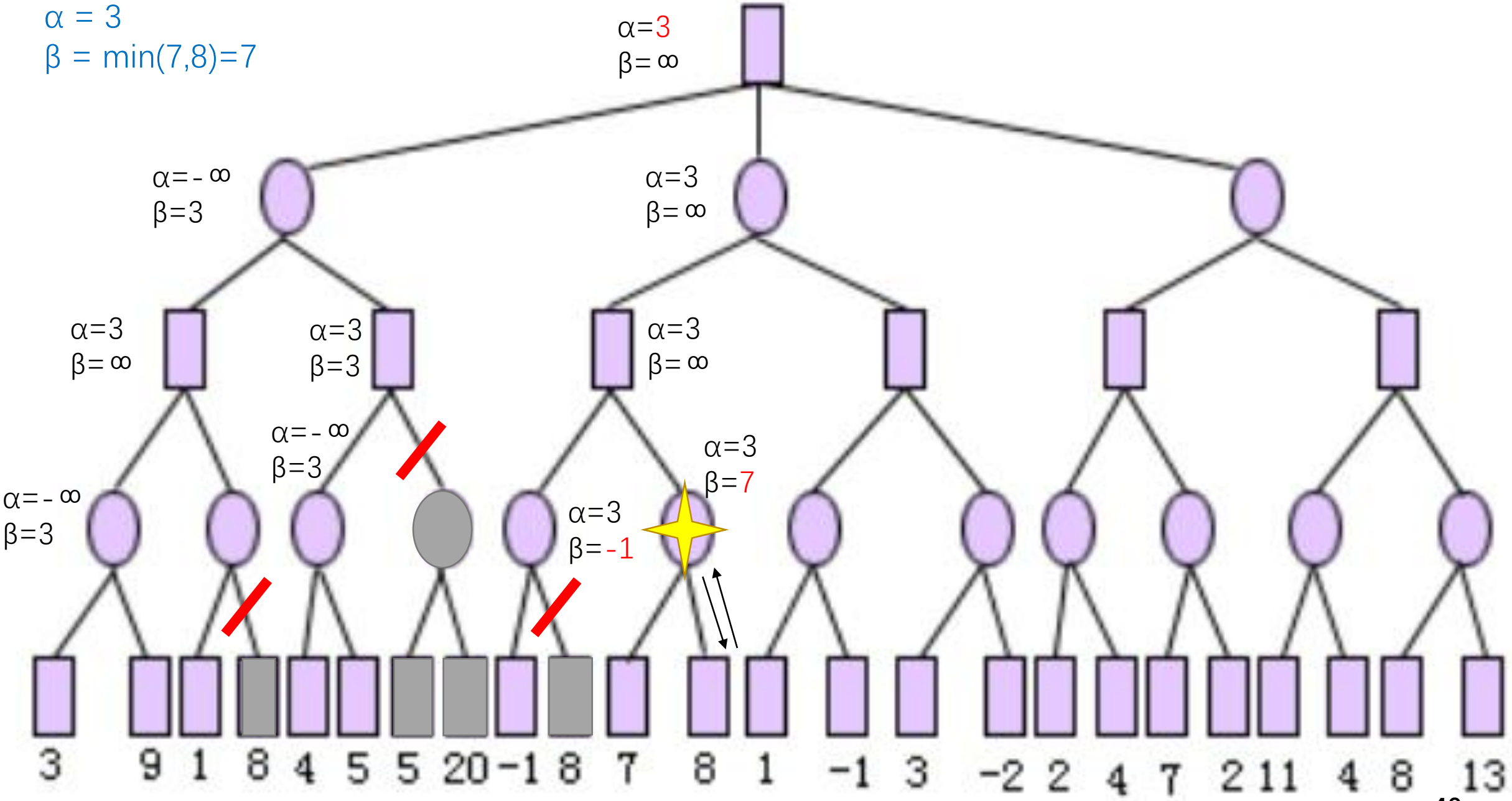
α = max(3,-1)=3
β =


α=3
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=3
β= ∞
α=3
β=3
α=3
β= ∞
α=- ∞
β=3
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13


α = 3
β =
α=3
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=3
β= ∞
α=3
β=3
α=3
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13


α = 3
β = 7
α=3
β= ∞
α=- ∞
β=3
α=3
β= ∞
α=3
β= ∞
α=3
β=3
α=3
β= ∞
α=- ∞
β=3
α=3
β=7
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = 3
β = min(7,8)=7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β= ∞
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α=3
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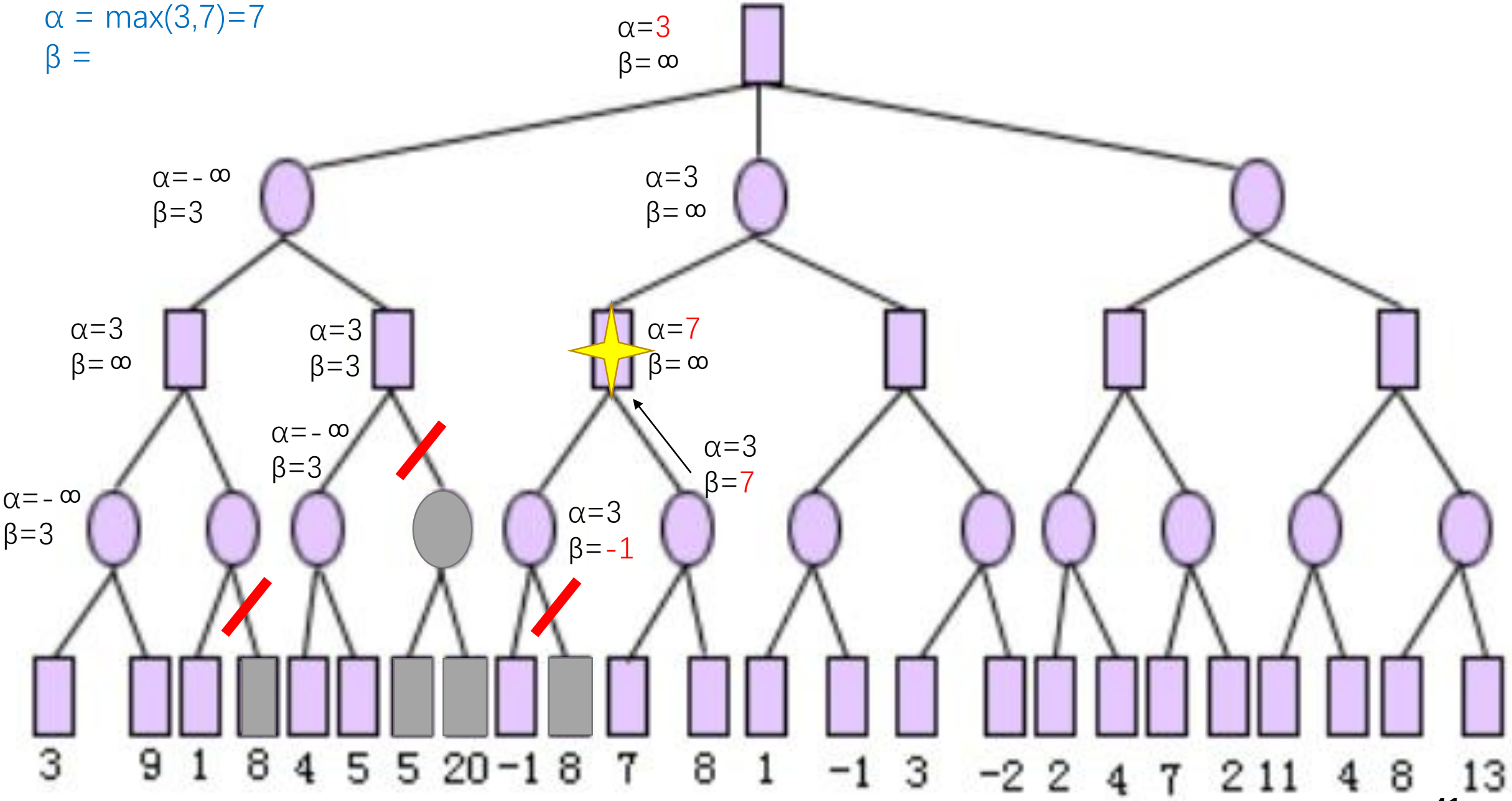
β=3
α=3
β= ∞
α=- ∞
β=3
α=3
β=7
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = max(3,7)=7
β =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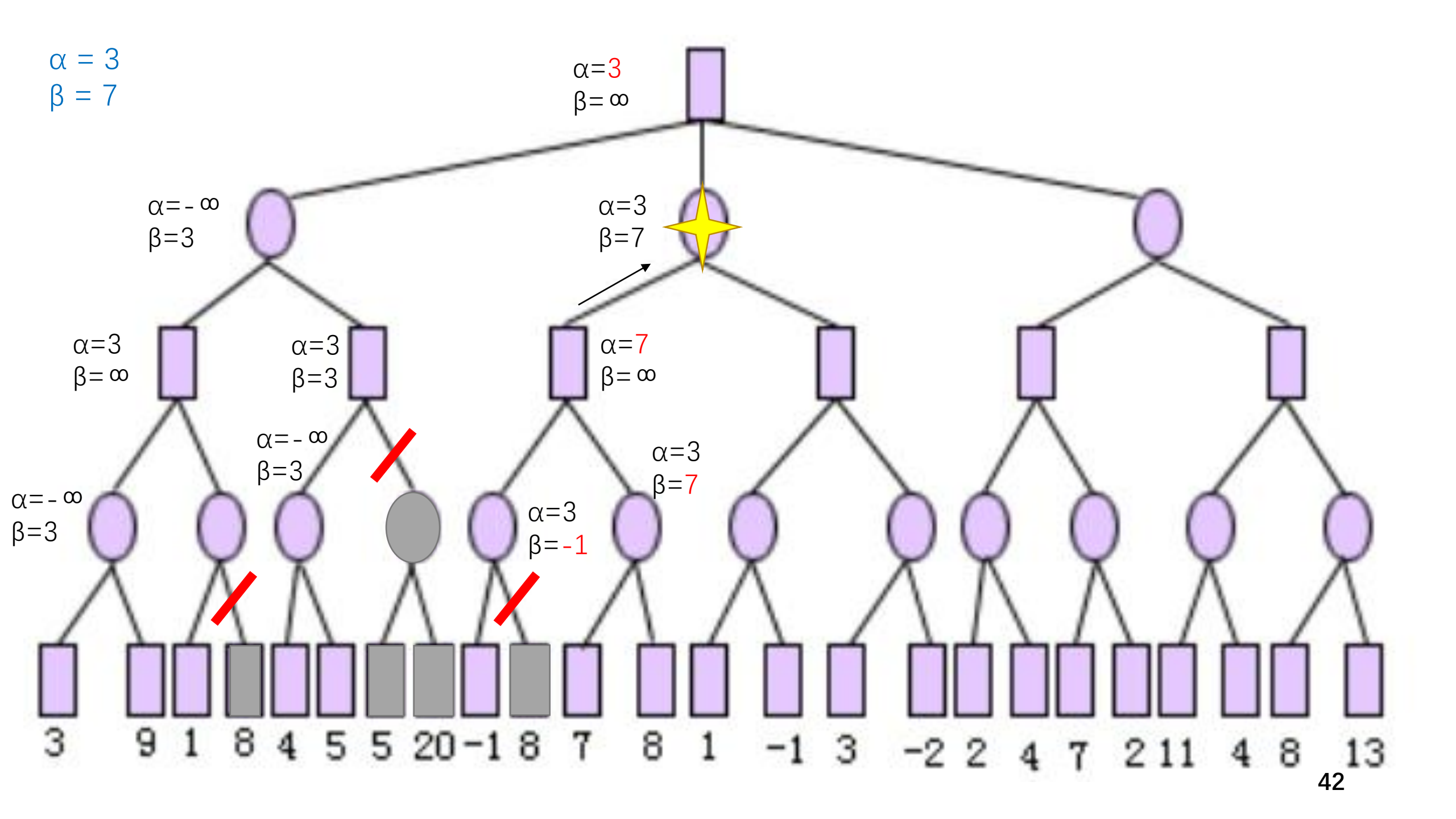
β= ∞
α=- ∞
β=3
α=3
β=7
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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α=- ∞
β=3
α=3
β=7
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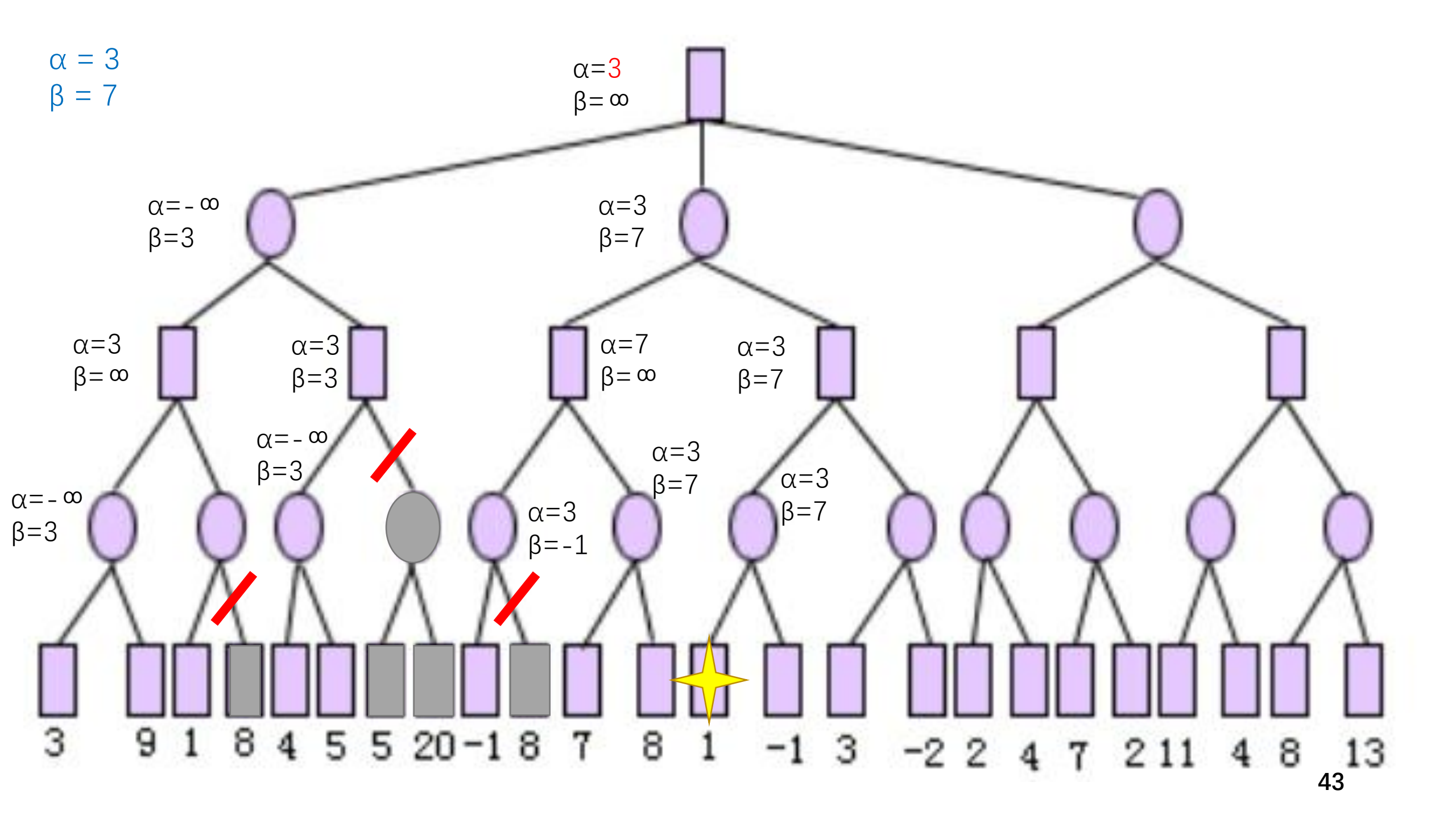
β= ∞
α=3
β=3
α=7
β= ∞
α=- ∞
β=3
α=3
β=7
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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β = 7
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β=3
α=3
β=7
α=3
β= ∞
α=3
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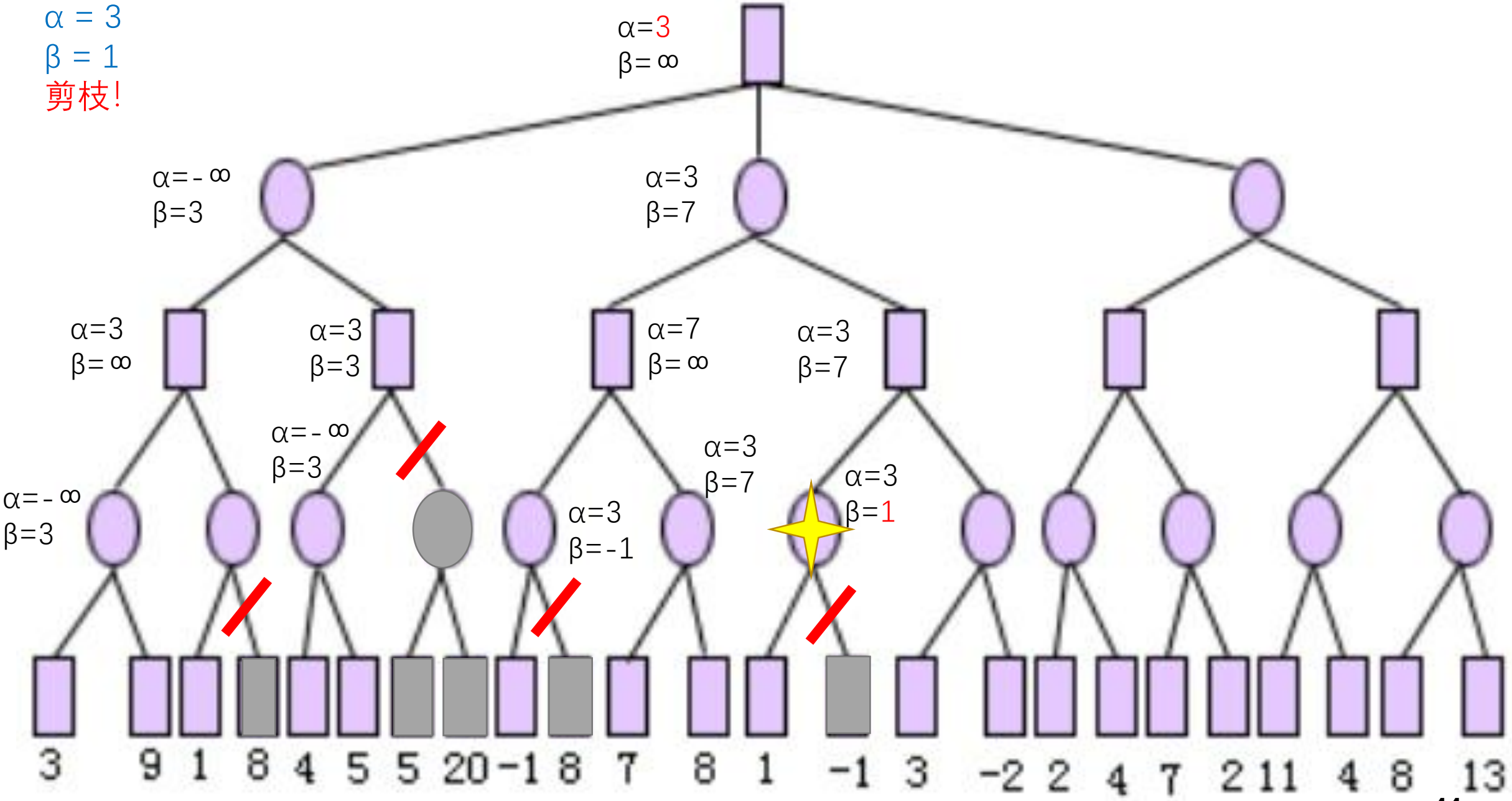
α=- ∞
β=3
α=3
β=7
α=3
β=7
α=- ∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = 3
β = 1
剪枝!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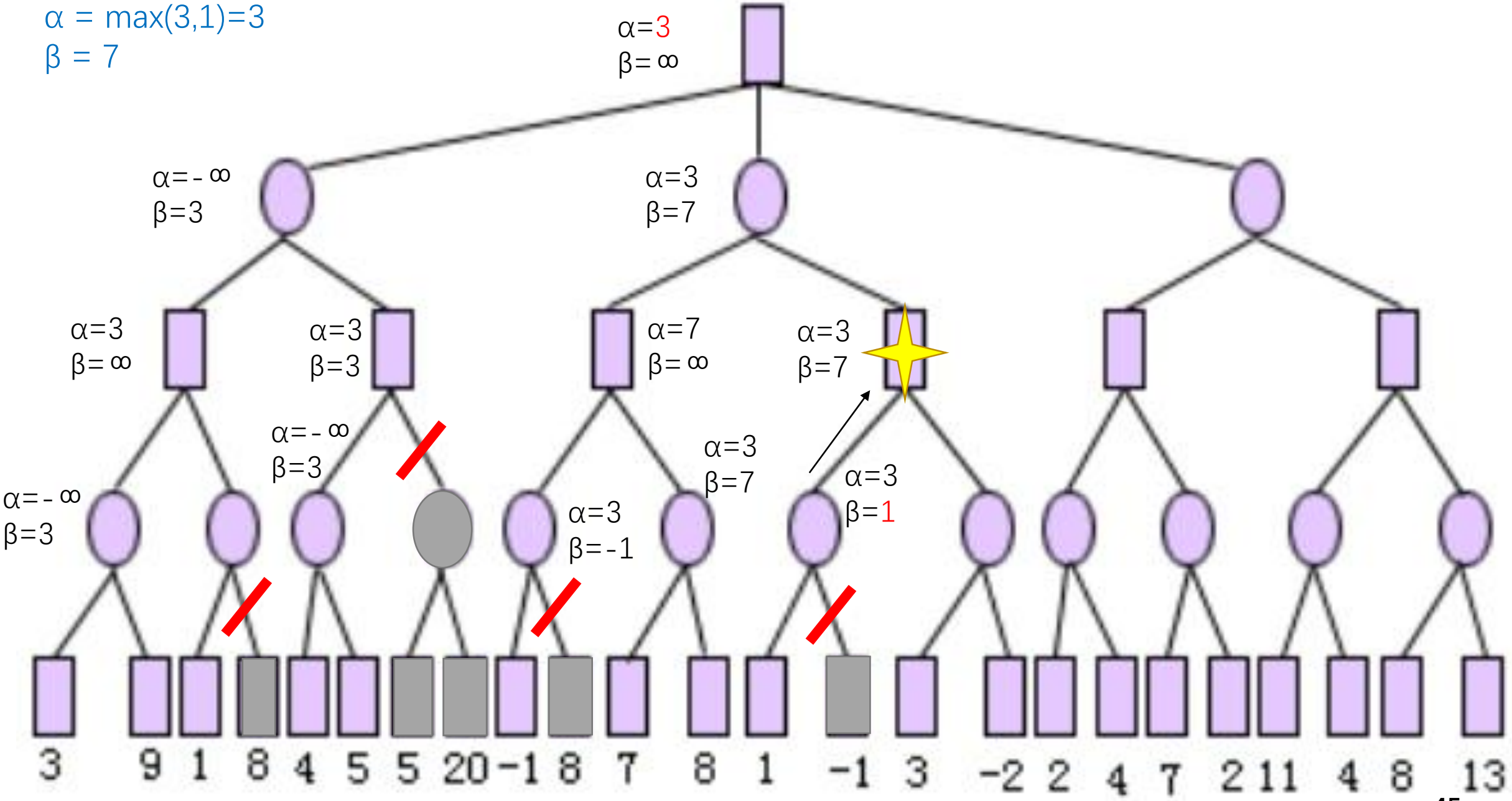
α=3
β=7
α=-∞
β=3
α=3
β=7
α=3
β=1
α=-∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = max(3,1)=3
β = 7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α=3
β=7
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β=3
α=3
β=7
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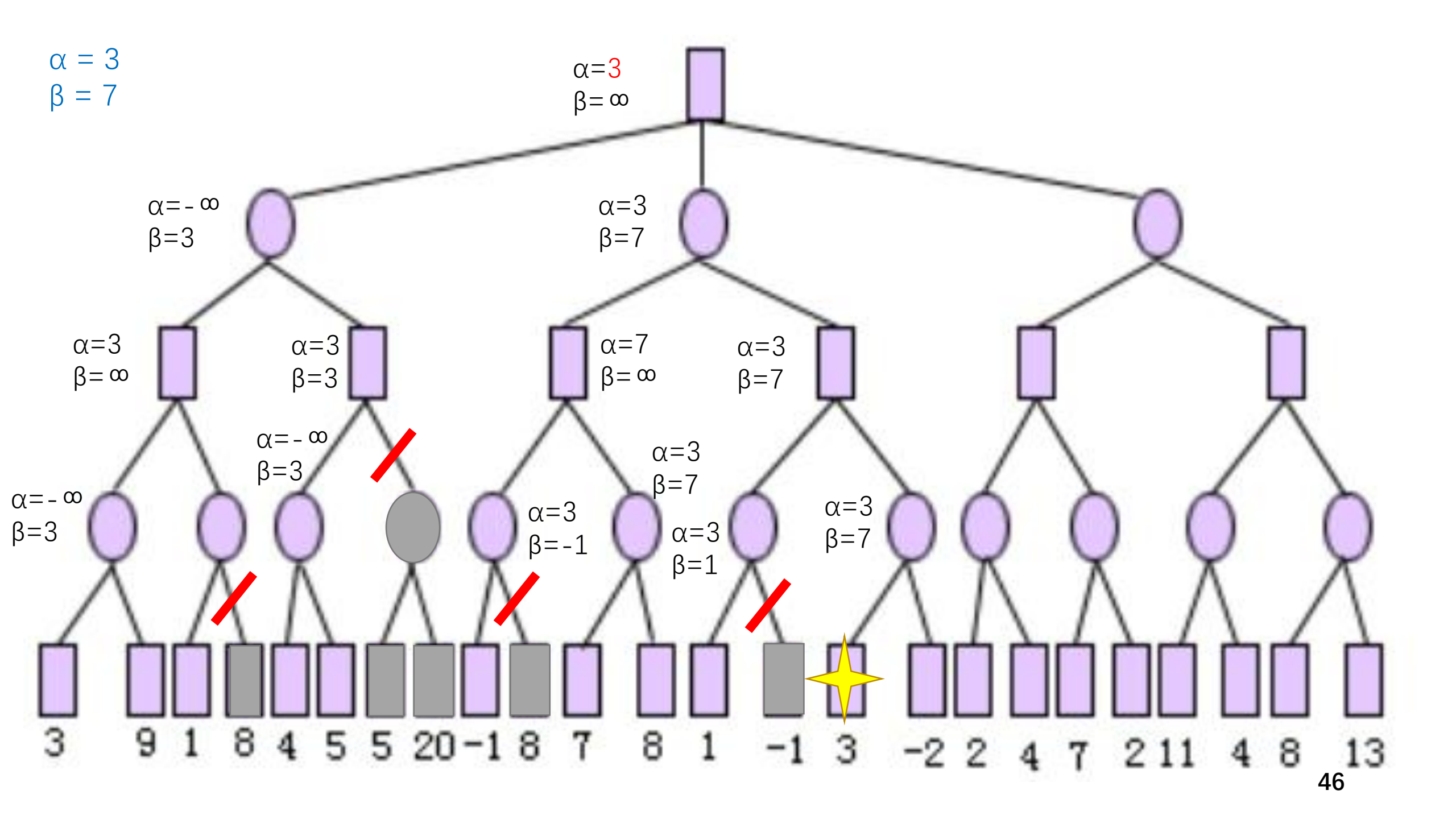
α=-∞
β=3
α=3
β=-1
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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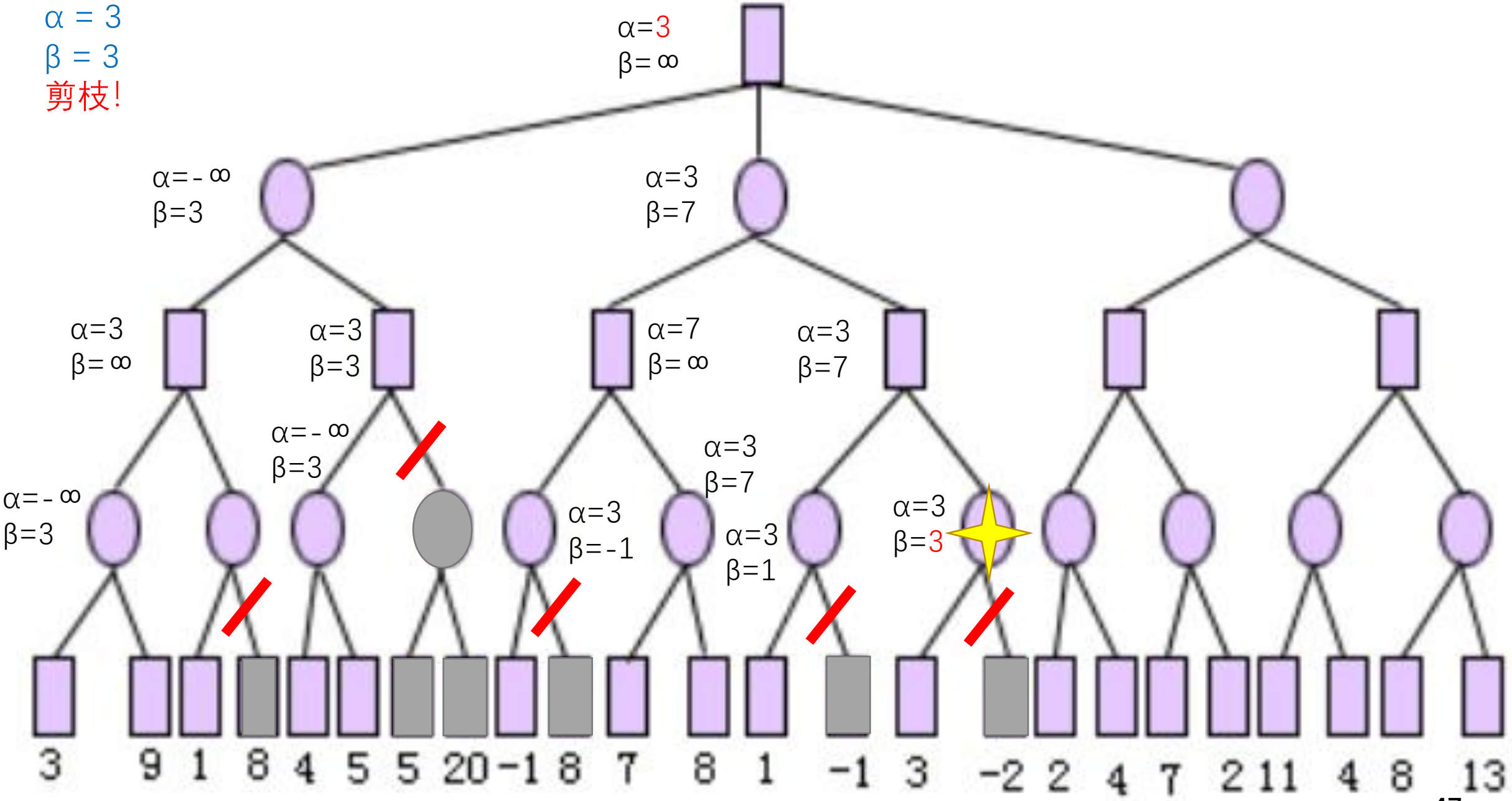
α=3
β=7
α=-∞
β=3
α=3
β=-1
α=3
β=1
α=3
β=7
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = 3
β = 3
剪枝!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β=7
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β=3
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α=-∞
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α=3
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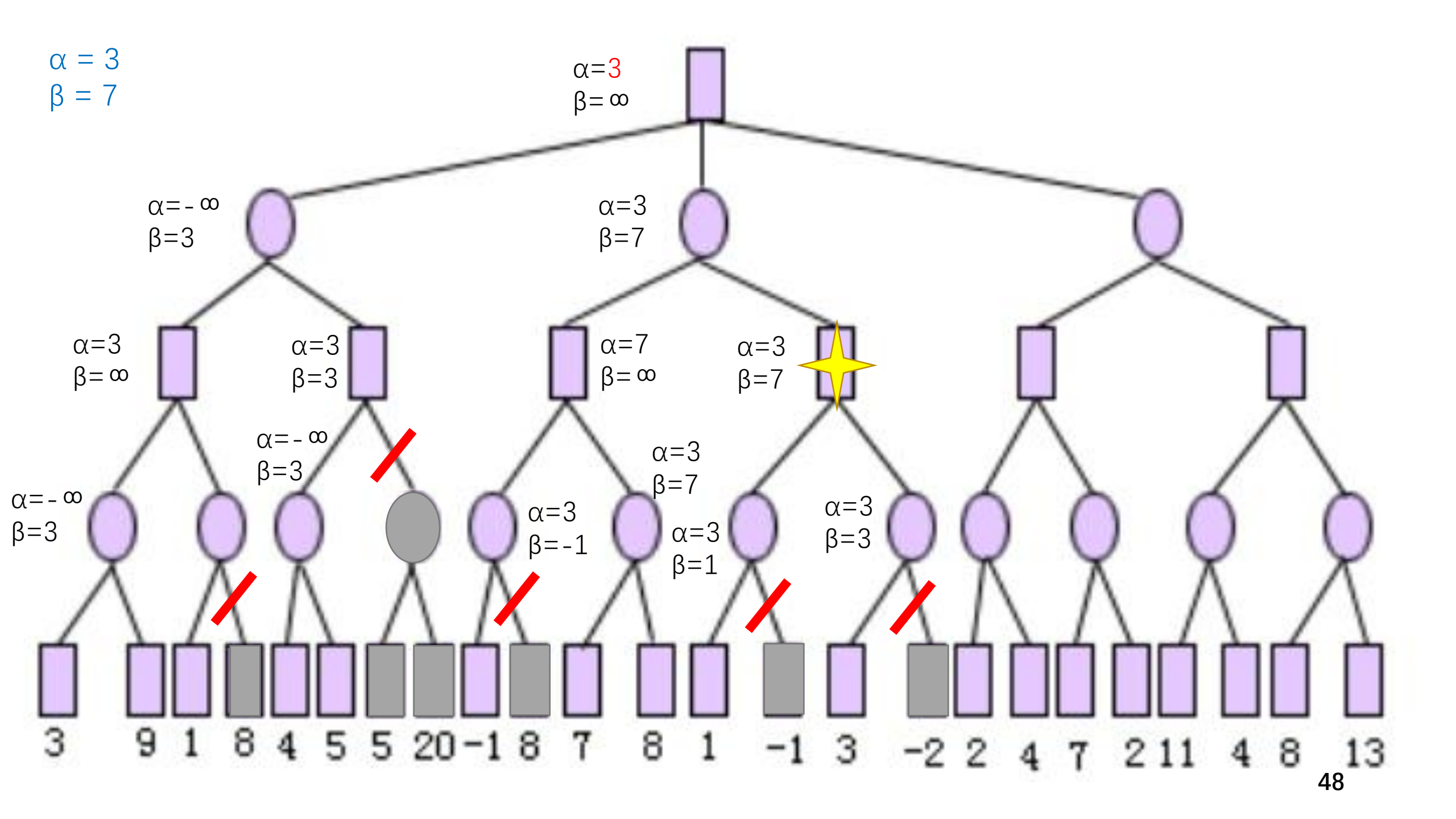
α=3
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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β=7
α=- ∞
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β=7
α=- ∞
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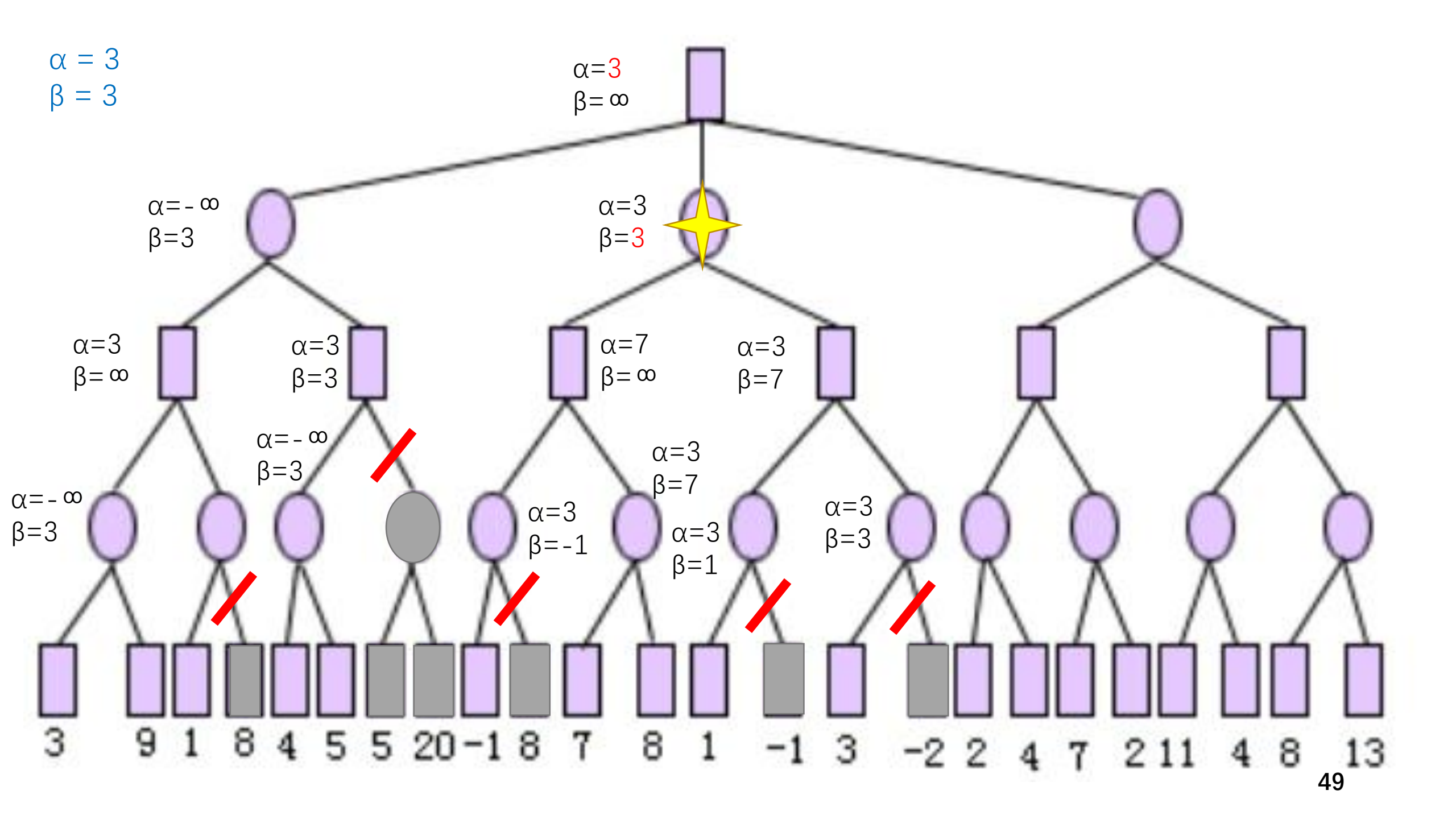
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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β=7
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α=- ∞
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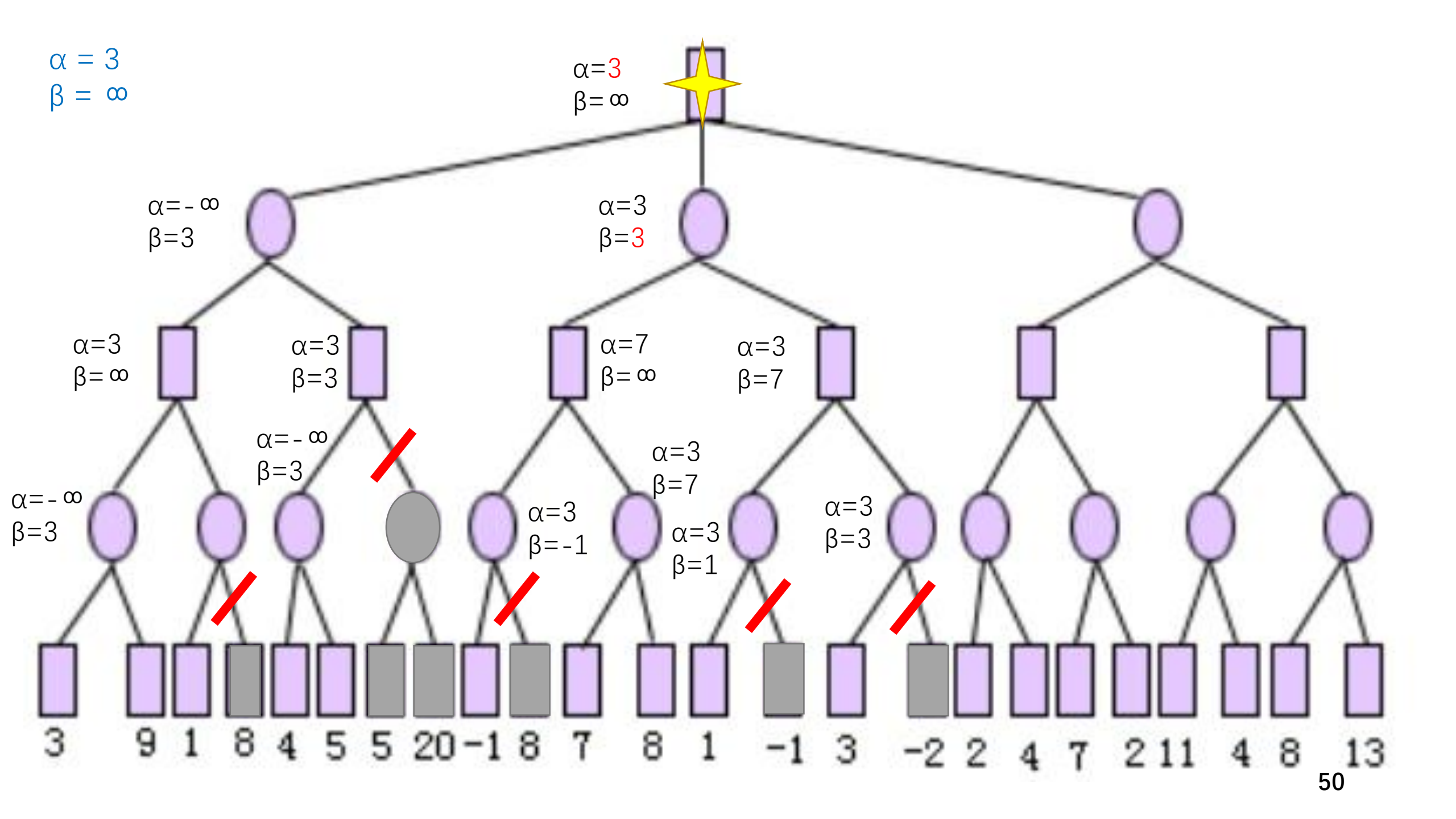
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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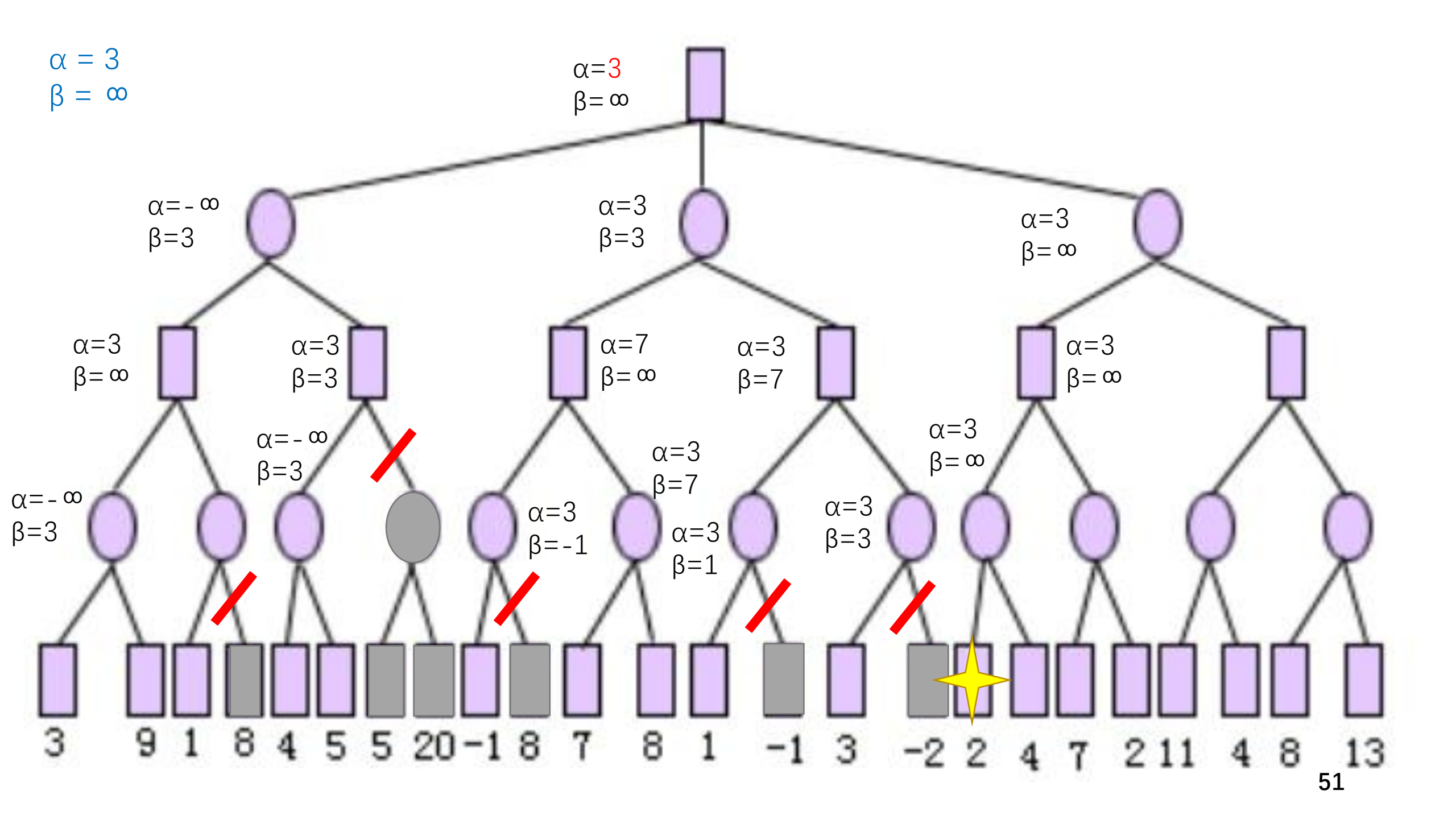
α=-∞
β=3
α=3
β=7
α=-∞
β=3
α=3
β=-1
α=3
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13


α = 3
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β=3
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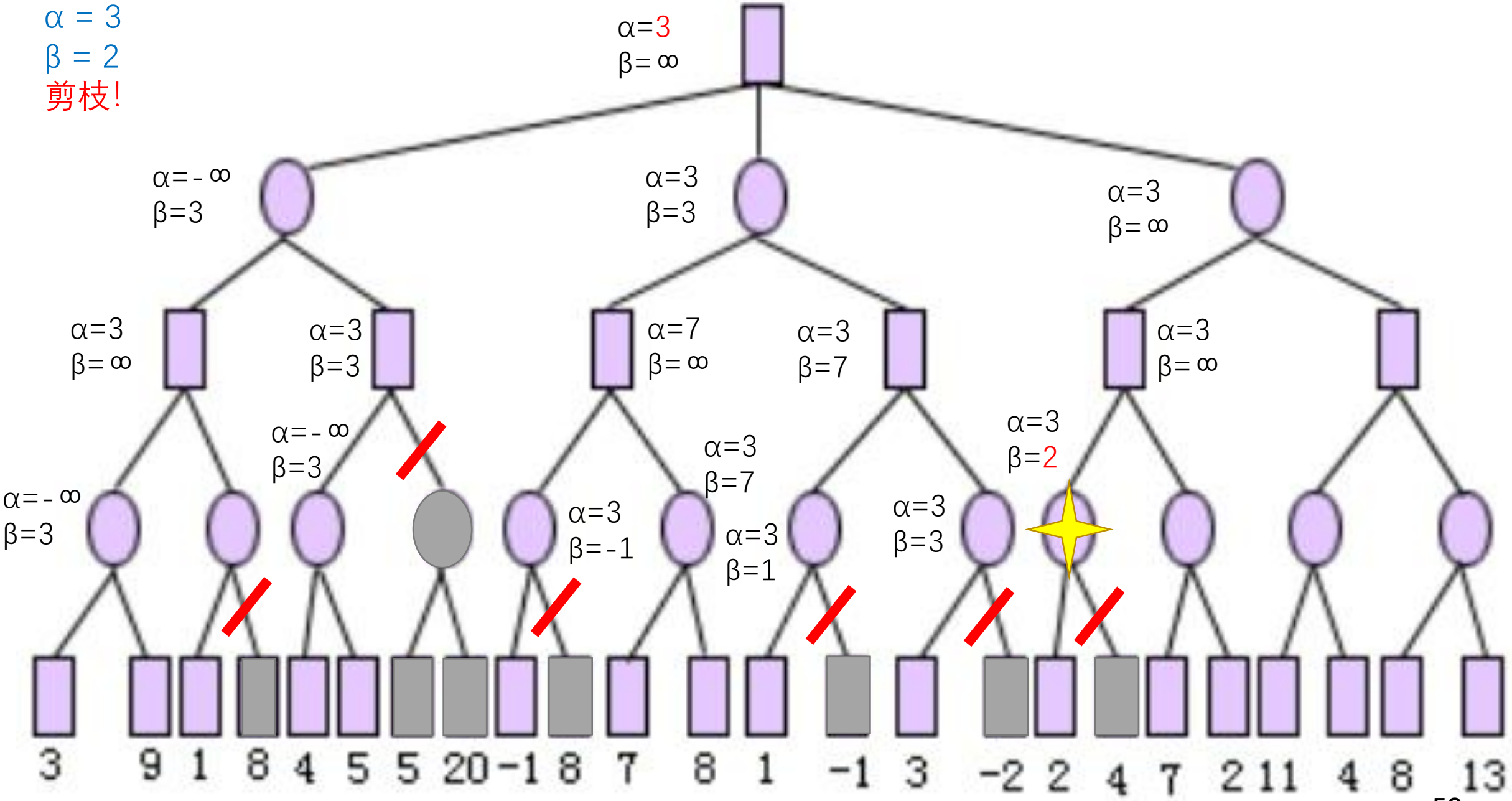
β=7
α=3
β=-1
α=3
β=1
α=3
β=3
α=3
β=∞
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = 3
β = 2
剪枝!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α=7
β=∞
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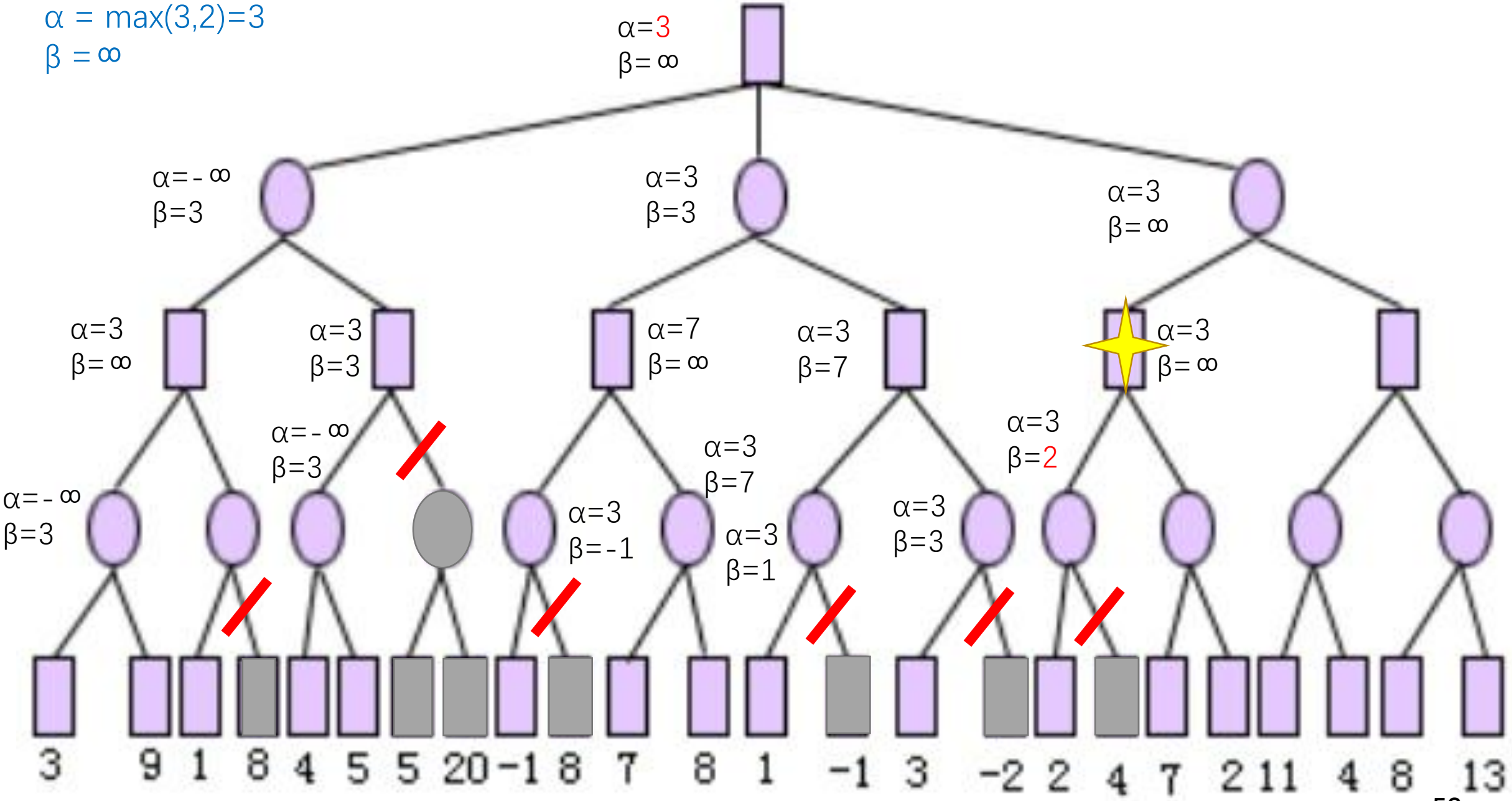
β=7
α=3
β=∞
α=-∞
β=3
α=-∞
β=3
α=3
β=-1
α=3
β=7
α=3
β=1
α=3
β=3
α=3
β=2
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = max(3,2)=3
β = ∞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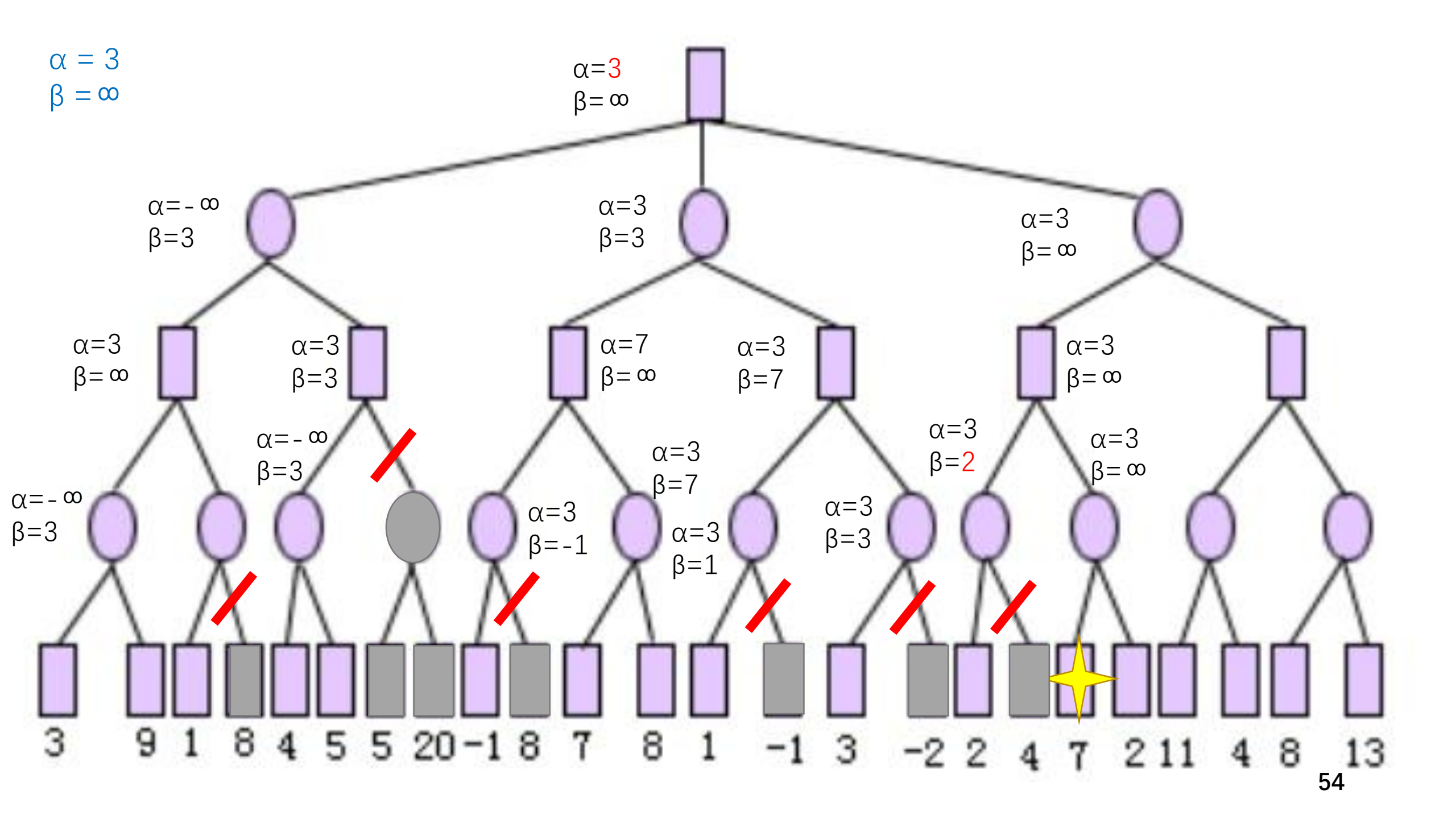
β= ∞
α=3
β=7
α=3
β= ∞
α=- ∞
β=3
α=3
β=7
α=3
β=2
α=- ∞
β=3
α=3
β=-1
α=3
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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β = ∞
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α=- ∞
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β=3
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α=3
β=2
α=3
β= ∞
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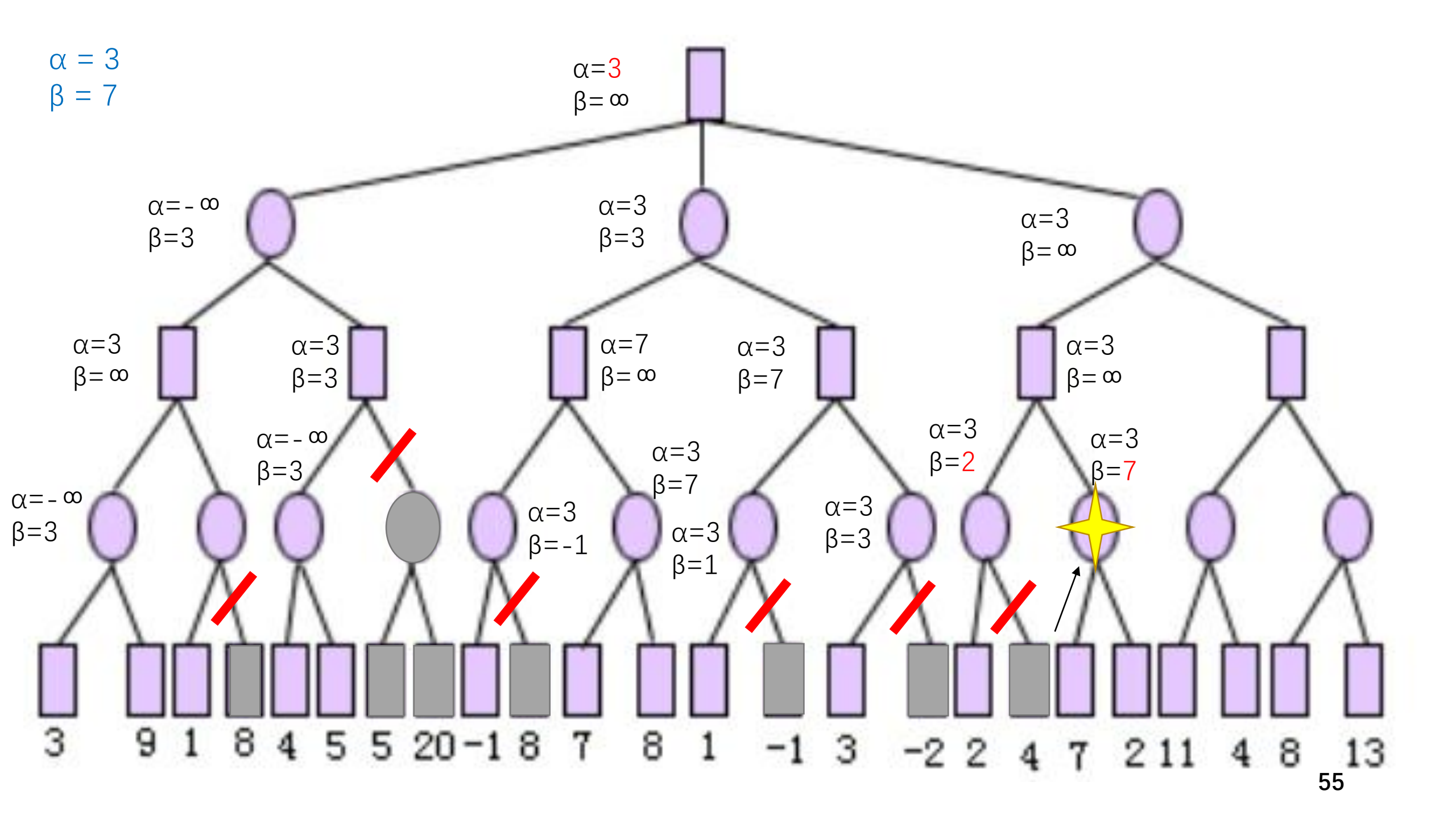
α=3
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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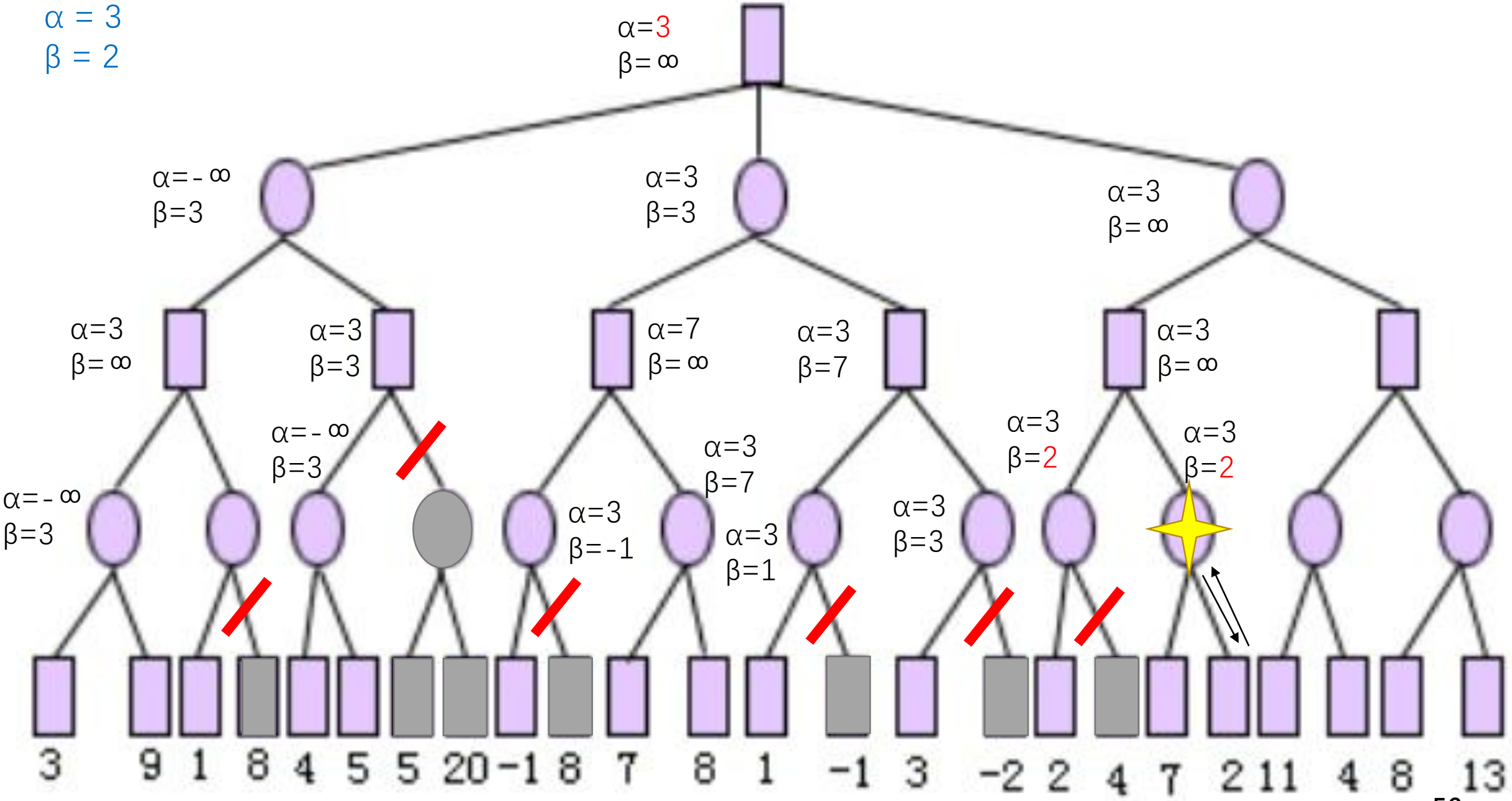
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = 3
β = 2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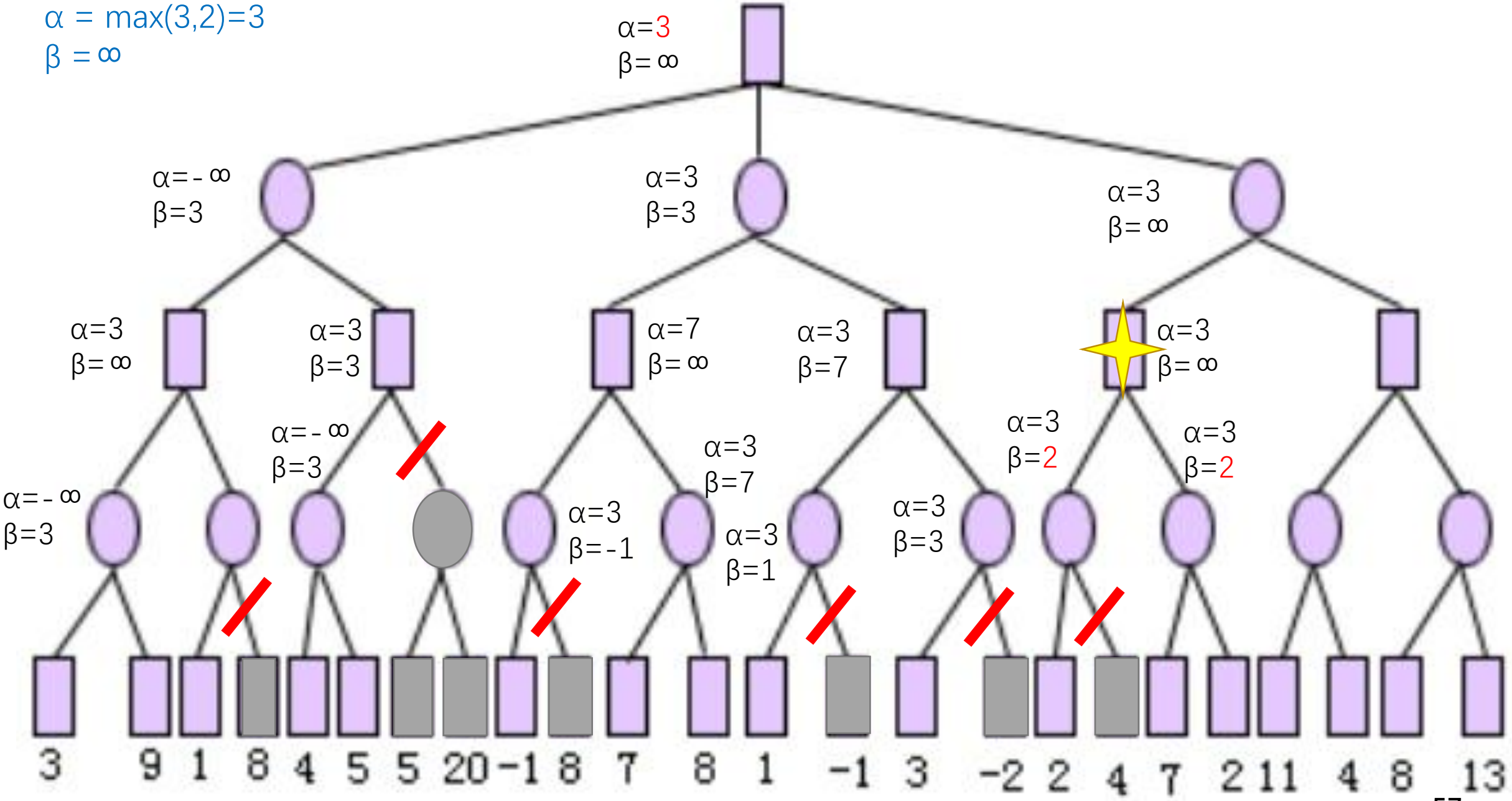
α=3
β=-1
α=3
β=1
α=3
β=3
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = max(3,2)=3
β = ∞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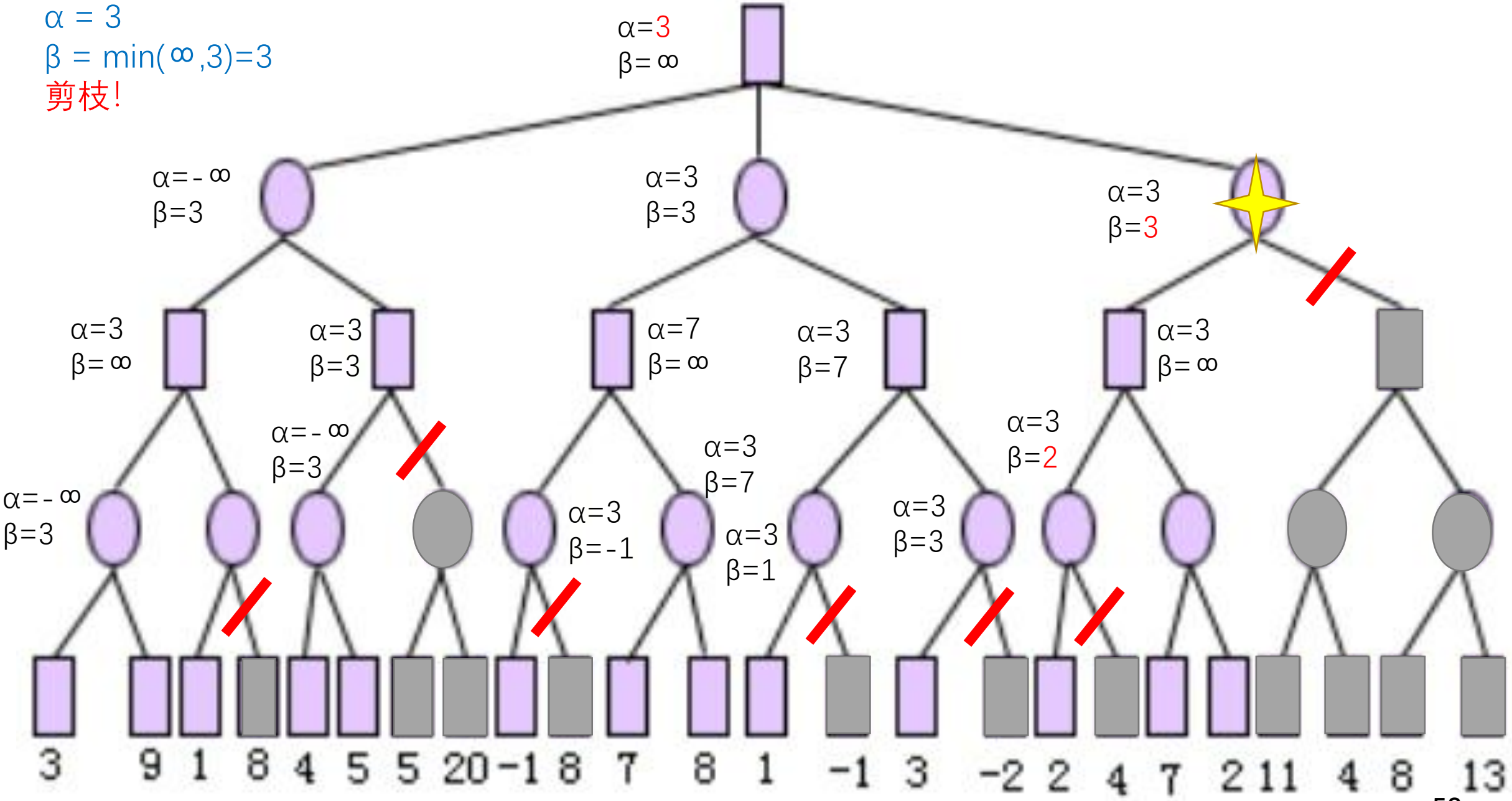
β=1
α=3
β=3
α=3
β=2
α=3
β=2
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13

α = 3
β = min(∞,3)=3
剪枝!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β=7
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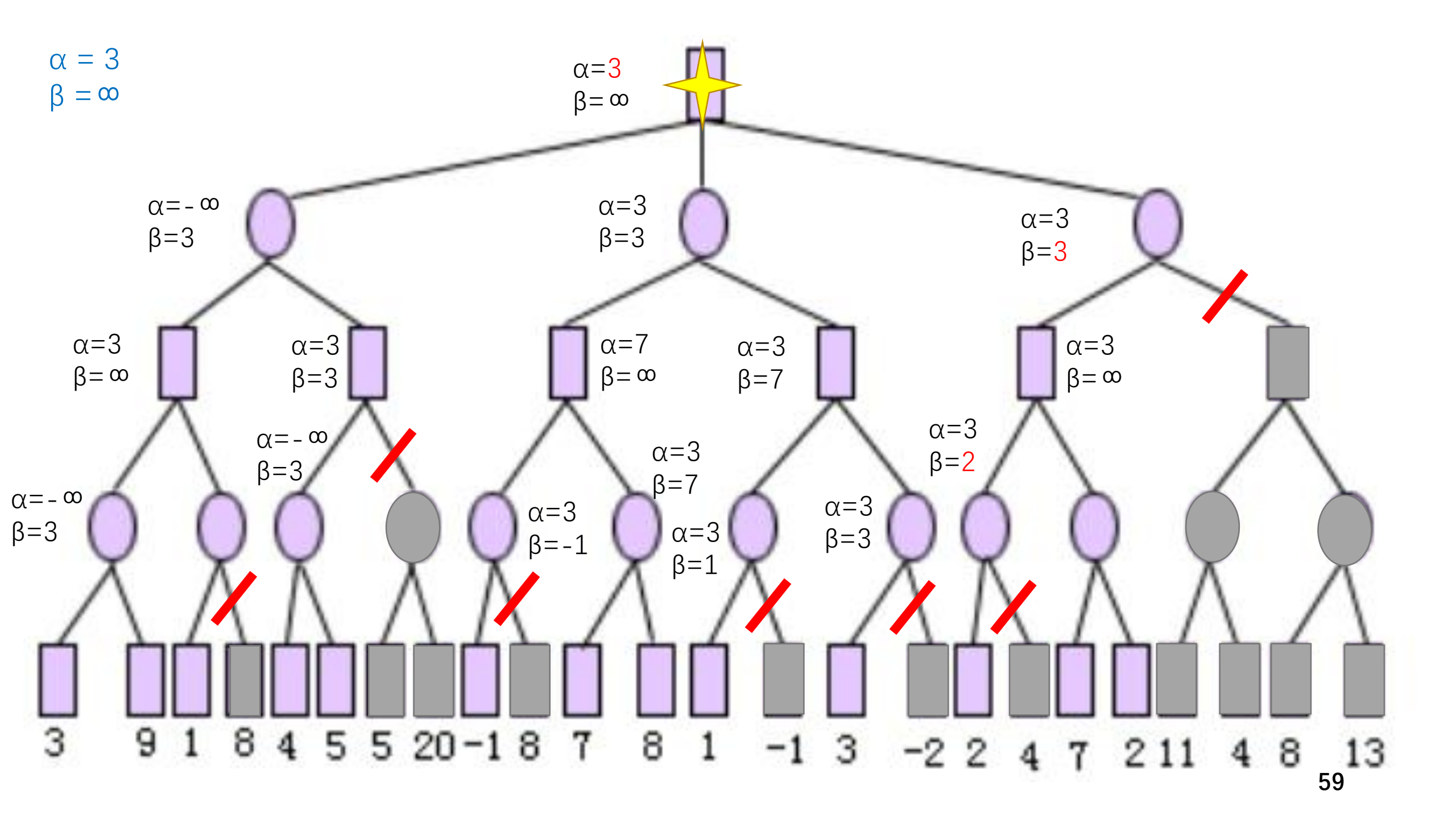
3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13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β=3
α=3
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3 9 1 8 4 5 5 20 -1 8 7 8 1 -1 3 -2 2 4 7 2 11 4 8 13