CS202 - Algorithm Analysis

Quick Sort

Aravind Mohan

Allegheny College

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Discussion Based On ...

Sedgewick 2.3 Quick Sort

Quick Sort Algorithm

Strategy:

- **Divide:** partition array into 2 subarrays such that elements in the lower part $\leq$ elements in the higher part.
- **Conquer:** recursively sort the 2 subarrays.
- **Combine:** trivial since sorting is done in place.

Quick Sort Algorithm

Characteristics:

- sort almost in ”place”, i.e., does not require an additional array.
- **pivot** is generally chosen as the last element.
- very practical, average and best case sort performance $O(N \times log(N))$, with small constant factors and efficient for large size data only.
- worst case running time is $O(N^2)$

Quick Sort Algorithm

Partitioning Procedure (linear)

Algorithm - Partition(A, p, r)

Input: an n-element un-sorted array A of integer values, a lower bound p of the array A, and a pivot r in the array A.

Output: an n-element sorted array A of integer values.

$i \leftarrow p - 1$
for j = p to r-1 **do**
  if A[j] $\leq$ A[r] **then**
    $i \leftarrow i + 1$
    swap A[i] and A[j]
  end if
end for
swap A[i+1] and A[r]
return i+1

Quick Sort Algorithm

QuickSort Procedure (linear)

Algorithm - QuickSort(A, p, r)

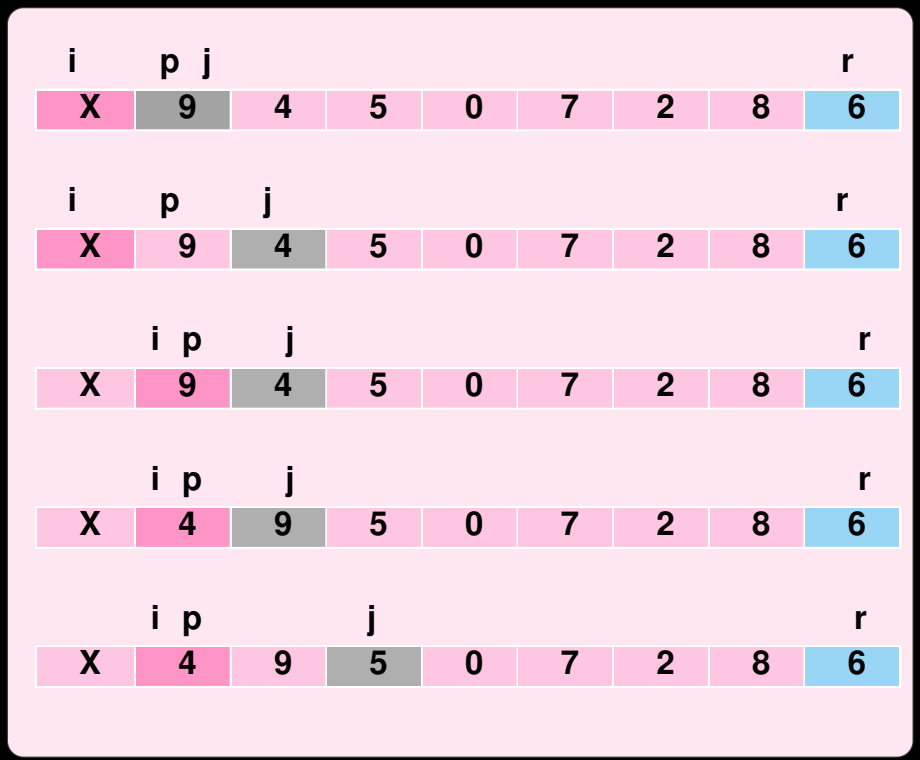
Input: an n-element un-sorted array A of integer values, a lower bound p of the array A, and a pivot r in the array A.

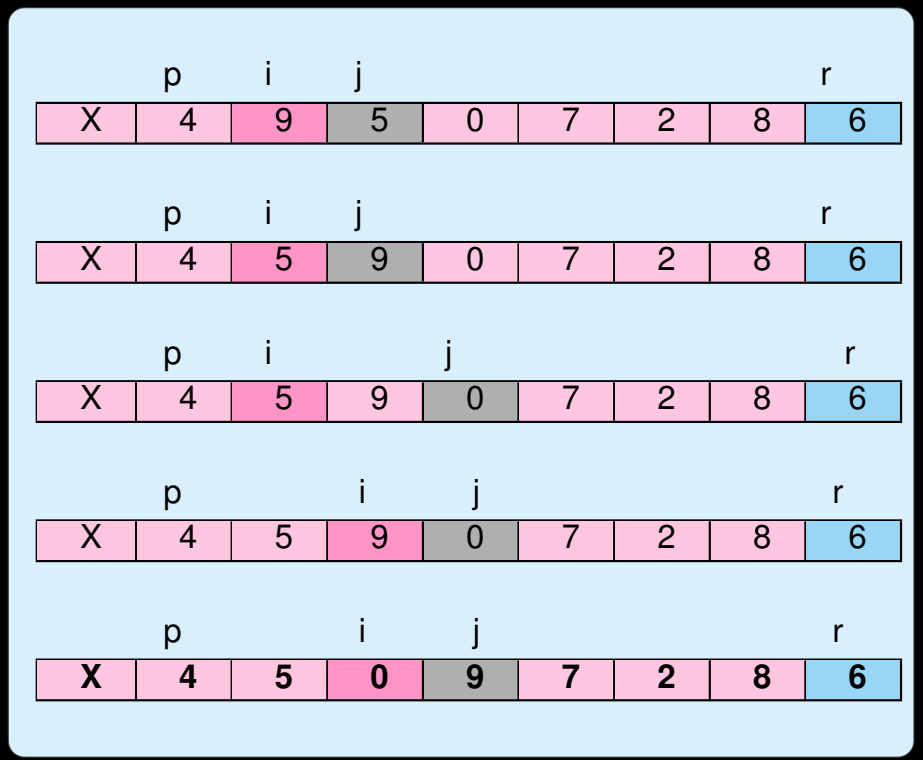
Output: an n-element sorted array A of integer values.

if p $<$ r **then**
  $q \leftarrow$ Partition(A,p,r)
  QuickSort(A, p, q-1)
  QuickSort(A, q+1, r)
end if

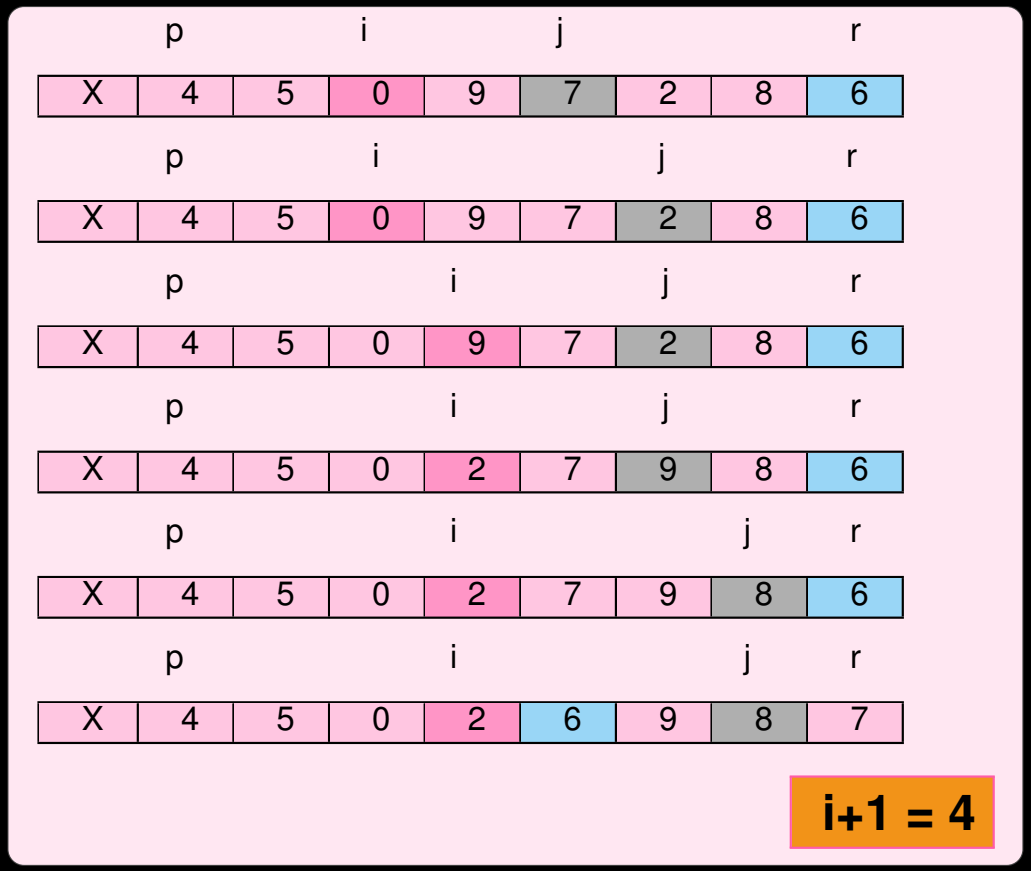
Partitioner Example

9	4	5	0	7	2	8	6



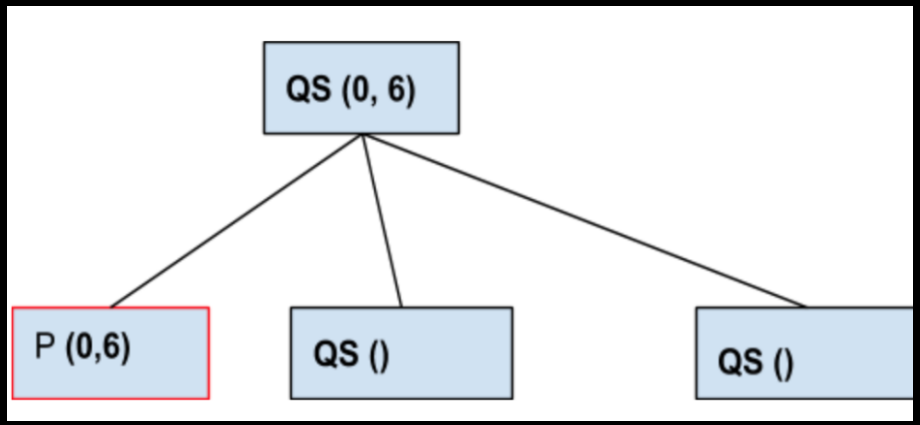


Partitioner Example



Quick Sort Example

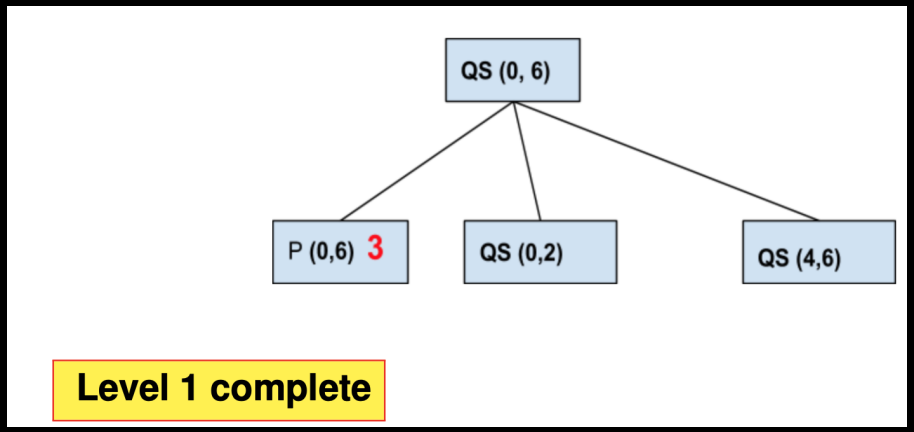
5	7	6	1	3	2	4



	i	p	j				r
X	5	7	6	1	3	2	4
	i	p		j			r
X	5	7	6	1	3	2	4
	i	p			j		r
X	5	7	6	1	3	2	4
	i	p				j	r
X	5	7	6	1	3	2	4
	i	p				j	r
X	1	7	6	5	3	2	4
	i	p					j r
X	1	7	6	5	3	2	4

Quick Sort Example

5	7	6	1	3	2	4

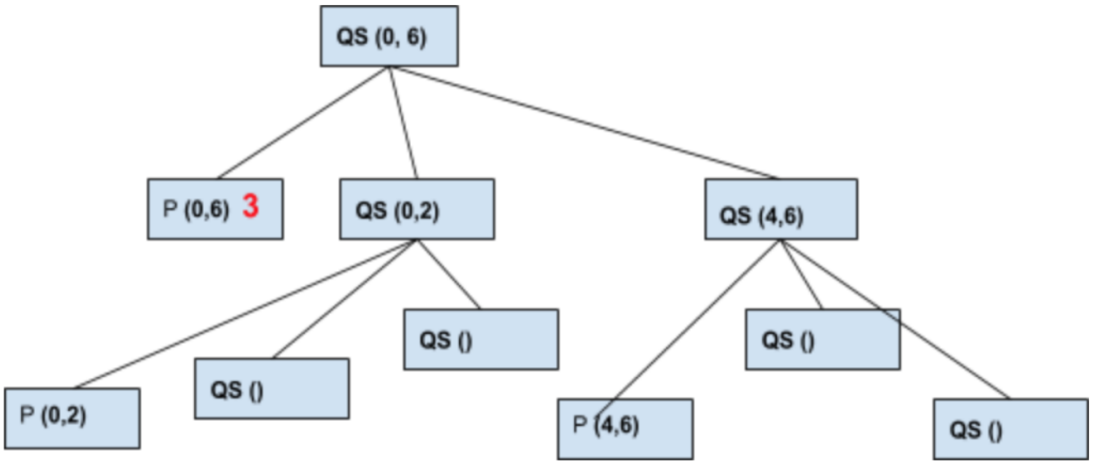


	p	i			j		r
X	1	7	6	5	3	2	4
	p	i			j		r
X	1	3	6	5	7	2	4
	p	i				j	r
X	1	3	6	5	7	2	4
	p		i			j	r
X	1	3	6	5	7	2	4
	p		i			j	r
X	1	3	2	5	7	6	4
	p		i			j	r
X	1	3	2	4	7	6	5

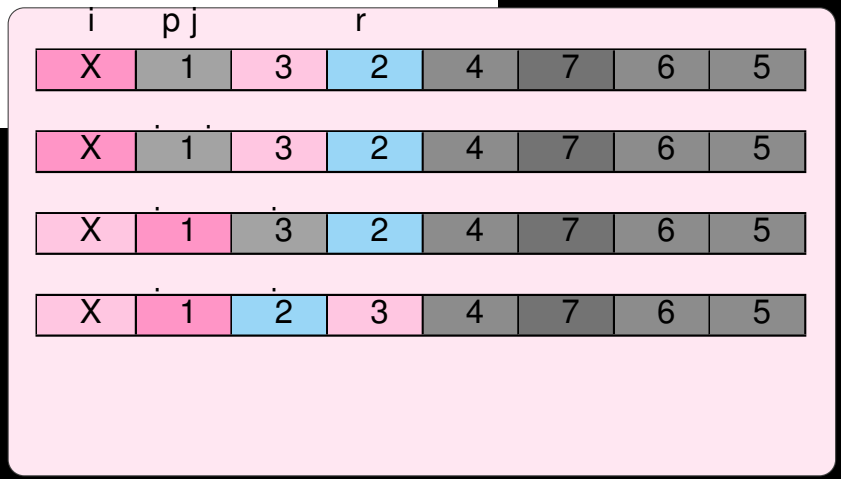
i+1 = 3

Quick Sort Example

1	3	2	4	7	6	5

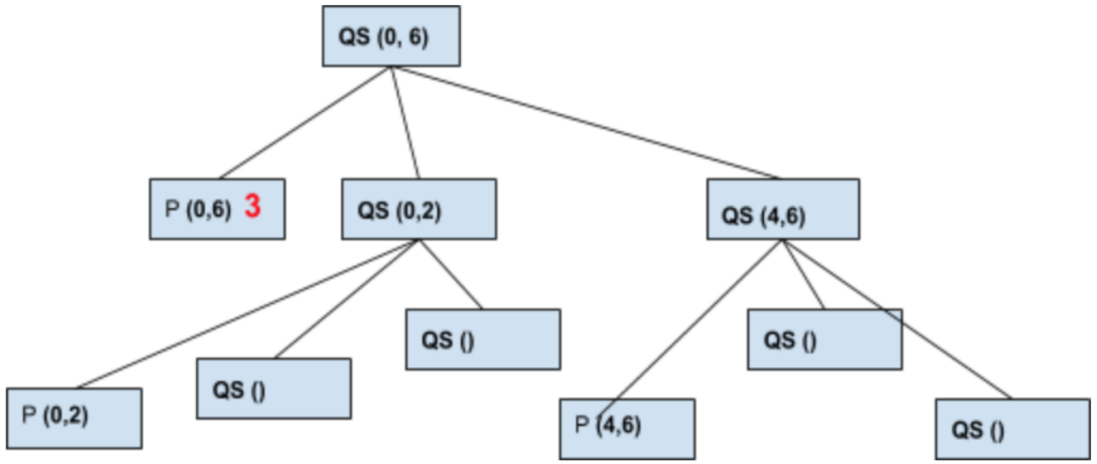


Find the partition P(0,2) & P(4,6)?

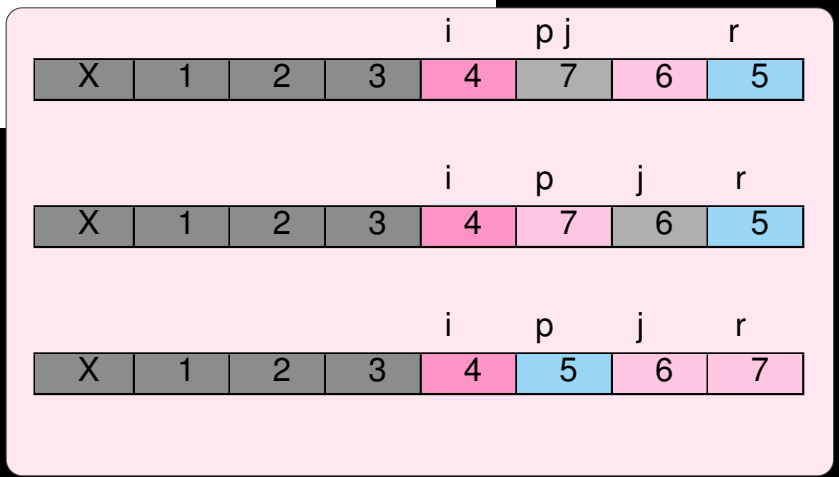


Quick Sort Example

1	2	3	4	7	6	5



Find the partition P(0,2) & P(4,6)?



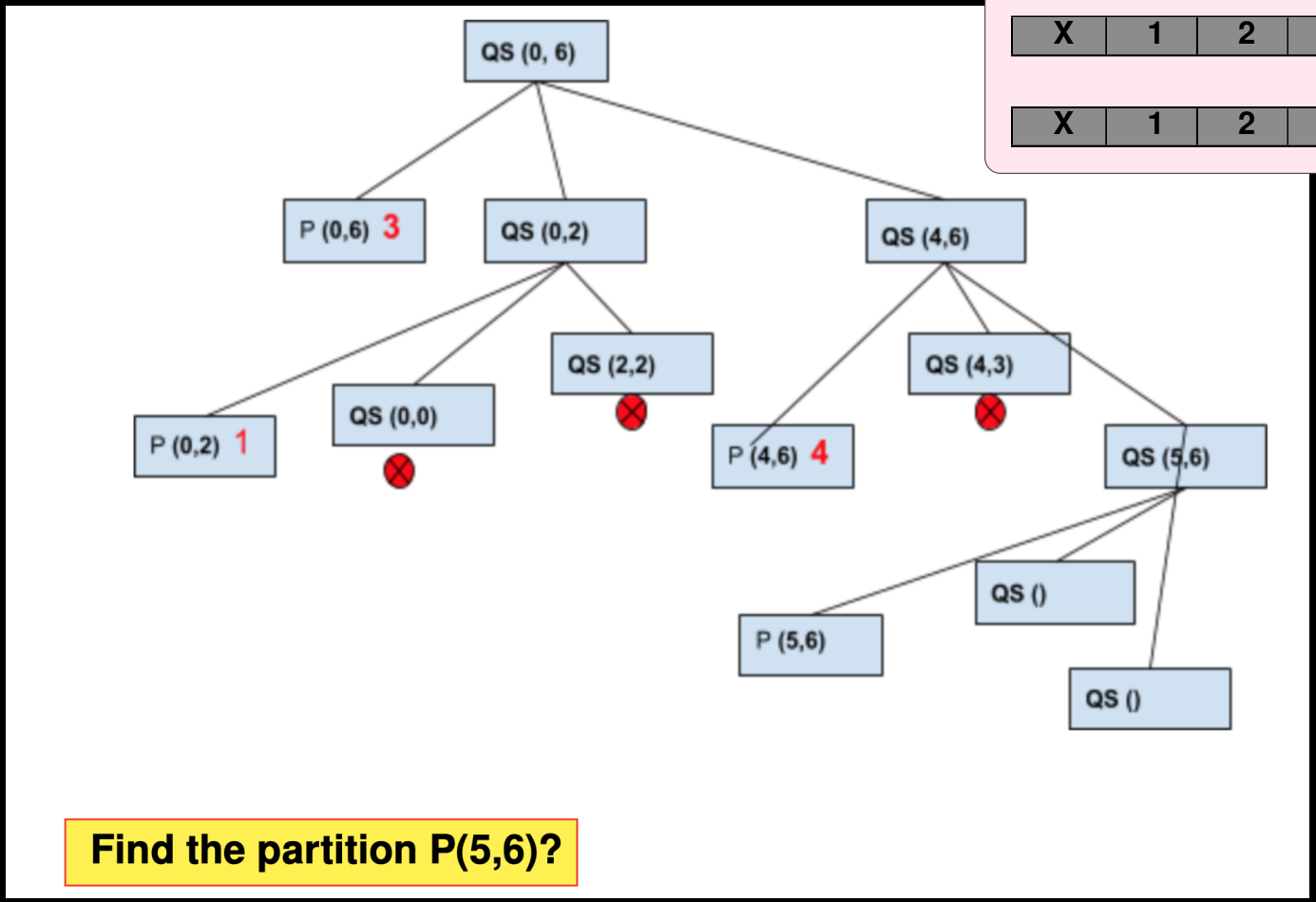
Quick Sort Example

1	2	3	4	5	6	7

					i	p j	r
X	1	2	3	4	5	6	7

						i p j	r
X	1	2	3	4	5	6	7

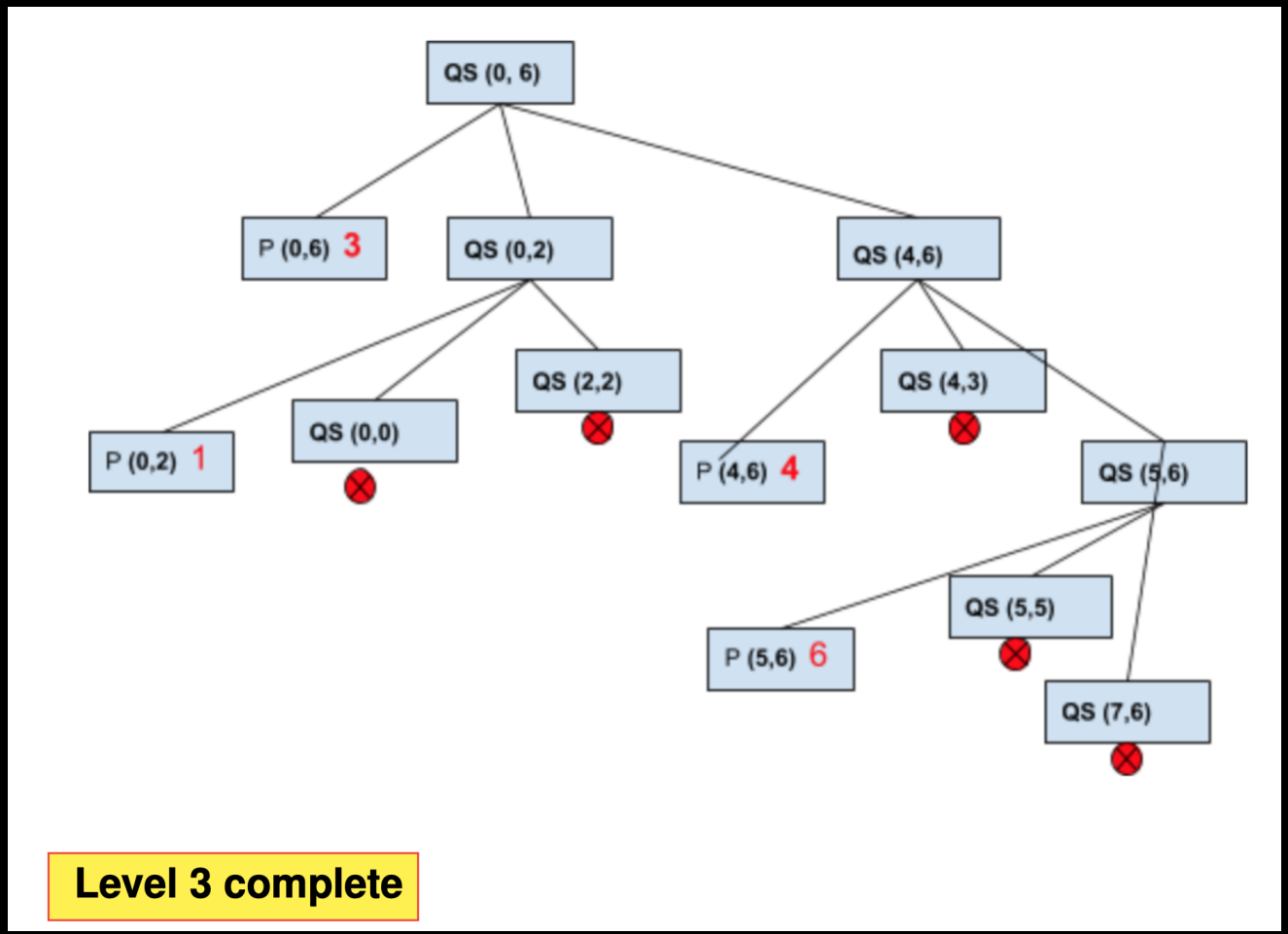
						i p j	r
X	1	2	3	4	5	6	7



Find the partition P(5,6)?

Quick Sort Example

1	2	3	4	5	6	7



Quick Sort Algorithm - An analysis

Running Time:

- **Worst case:** $O(n^2)$
- **Best case:** $O(n \times log(n))$
- **Average case:** $O(n \times log(n))$

Quick Sort Split

- 1:9 split $O(n \times log(n))$
- 1:99 split $O(n \times log(n))$
- 1:999 split $O(n \times log(n))$
- 0:n split $O(n^2)$

Quick Sort Example (Analyze)

- Running time : O(n^2)

Quick Sort Example (Analyze)

- Running time : O(n^2)

Quick Sort Finishing Up

One question to think of is can we do a better job in selecting the pivot element? **Random position for [pivot] better split? - In Lab**

Reading Assignment

Sedgewick 2.3 Quick Sort

Questions?

Please ask if there are any Questions!