



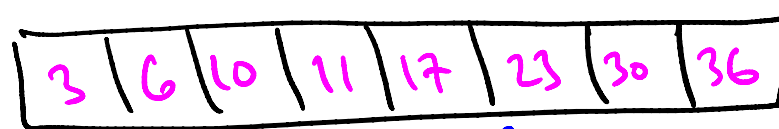
Design and Analysis  
of Algorithms I

# Data Structures

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Balanced Search  
Trees: Supported  
Operations

# Sorted Arrays: Supported Operations



BUT WHAT ABOUT  
INSERTIONS + DELETIONS ?  
(would take  $\theta(n)$  time)

## OPERATIONS

SEARCH

SELECT (given order statistic  $l$  )

MIN/MAX

PRED/SUCC (given pointer to a key)

**RANK** (i.e., # of keys less than or equal to  
a given value)

OUTPUT IN SORTED ORDER

## RUNNING TIME

$\theta(\log(n))$

$O(1)$

$O(1)$

$O(1)$

$O(\log(n))$

$O(n)$

# Balanced Search Trees: Supported Operations

Raison d'être : like sorted array + fast (logarithmic) inserts + deletes !

## OPERATIONS

SEARCH

SELECT

MIN/MAX

PRED/SUCC

RANK

OUTPUT IN SORTED ORDER

INSERT

DELETE

## RUNNING TIME

$\theta(\log(n))$

$O(\log(n))$

$O(\log(n))$

$O(\log(n))$

$O(\log(n))$

$O(n)$

$O(\log(n))$

$O(\log(n))$

Up from  
 $O(1)$

new

Also  
supported  
by hash  
tables

Also  
supported  
by heaps