Searching

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Review

- A B+ tree is a variant of a B tree
  - A B tree can store both keys and records in its interior nodes
  - A B+ tree stores all the records at the leaf level of the tree and keys are stored in the interior nodes

- In a 2-3 tree, each interior node has either two or three children
  - All the leaf nodes are at the same level

Searching

- Searching means to find whether a particular value is present in an array or not

- There are two popular methods for searching the array elements: **linear search** and **binary search**
  - The algorithm that should be used depends entirely on how the values are organized in the array
    - For example, if the elements of the array are arranged in ascending order, then binary search should be used

Linear Search

- Linear search, also called as **sequential search**, is a very simple method used for searching an array for a particular value
  - It works by comparing the value to be searched with every element of the array one by one in a sequence until a match is found
  - It is mostly used to search an unordered list of elements

```
LINEAR_SEARCH(A, N, VAL)
Step 1: [INITIALIZE] SET POS = -1
Step 2: [INITIALIZE] SET I = 1
Step 3:     Repeat Step 4 while I<=N
Step 4:           IF A[I] = VAL
                        SET POS = I
                        PRINT POS
                        Go to Step 6
                  [END OF IF]
                   SET I = I + 1
             [END OF LOOP]
Step 5: IF POS = -1
        PRINT "VALUE IS NOT PRESENT
        IN THE ARRAY"
        [END OF IF]
Step 6: EXIT
```

Binary Search

- Binary search is a searching algorithm that works efficiently with a **sorted** list
  - Initially, BEG = lower_bound, END = upper_bound, and POS = MID
  - If VAL is not equal to A[MID], then the values of BEG, END, and MID will be changed depending on whether VAL is smaller or greater than A[MID]
    - If VAL < A[MID], then VAL will be present in the left segment of the array

      The value of END will be changed as END = MID – 1
    - If VAL > A[MID], then VAL will be present in the right segment of the array

      The value of BEG will be changed as BEG = MID + 1

Example

- For a data array, please find 9

```
int A[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10}
```

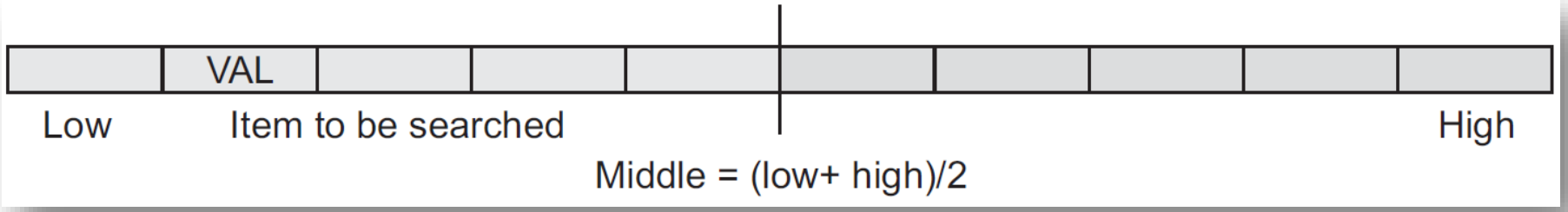
  - Step1: BEG = 0, END = 10, MID = (0 + 10)/2 = 5
    - A[MID] = A[5] = 5
  - Step2: BEG = MID + 1 = 6, END = 10, MID = (6 + 10)/2 =16/2 = 8
    - A[MID] = A[8] = 8
  - Step3: BEG = MID + 1 = 9, END = 10, MID = (9 + 10)/2 = 9
    - A[MID] = A[9] = 9

Binary Search – Algorithm

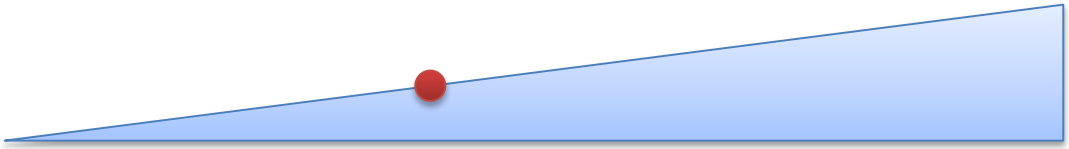
```
BINARY_SEARCH(A, lower_bound, upper_bound, VAL)
Step 1: [INITIALIZE] SET BEG = lower_bound
         END = upper_bound, POS = - 1
Step 2: Repeat Steps 3 and 4 while BEG <= END
Step 3:              SET MID = (BEG + END)/2
Step 4:              IF A[MID] = VAL
                           SET POS = MID
                           PRINT POS
                           Go to Step 6
                     ELSE IF A[MID] > VAL
                           SET END = MID - 1
                     ELSE
                           SET BEG = MID + 1
                     [END OF IF]
         [END OF LOOP]
Step 5: IF POS = -1
             PRINT "VALUE IS NOT PRESENT IN THE ARRAY"
         [END OF IF]
Step 6: EXIT
```

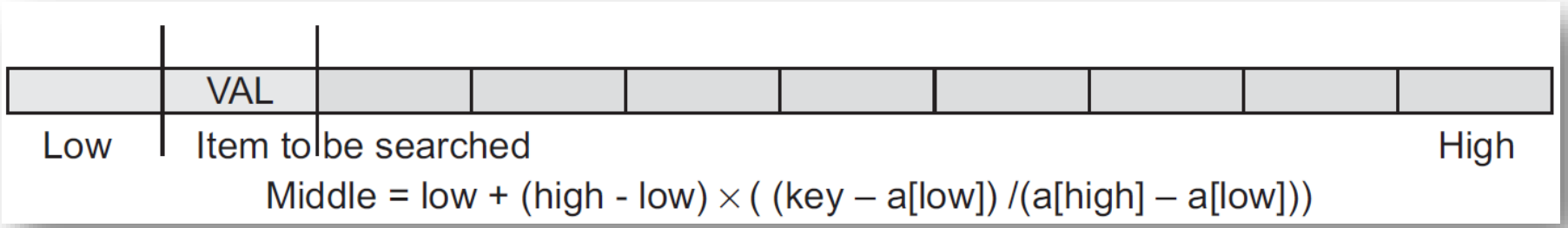
Interpolation Search

- Interpolation search, also known as extrapolation search, is a searching technique that finds a specified value in a sorted array
  - Interpolation search is similar to the binary search technique



  - The major difference is how to select the middle value





Example

- Given a list of numbers, please search for value 19 using interpolation search technique

```
a[] = {1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21}
```

  - Low = 0, High = 10, VAL = 19, a[Low] = 1, a[High] = 21
  - Middle
    = Low + (High − Low)×((VAL − a[Low]) /(a[High] − a[Low]))
    = 0 +(10 − 0) × ((19 − 1) / (21 − 1))
    = 0 + 10 × 0.9 = 9
  - a[Middle] = a[9] = 19

Interpolation Search – Algorithm

```
INTERPOLATION_SEARCH (A, lower_bound, upper_bound, VAL)

Step 1: [INITIALIZE] SET LOW = lower_bound,
        HIGH = upper_bound, POS = -1
Step 2:    Repeat Steps 3 to 4 while LOW <= HIGH
Step 3:         SET MID = LOW + (HIGH - LOW) ×
                ((VAL - A[LOW]) / (A[HIGH] - A[LOW]))
Step 4:         IF VAL = A[MID]
                  POS = MID
                  PRINT POS
                  Go to Step 6
                 ELSE IF VAL < A[MID]
                   SET HIGH = MID - 1
                  ELSE
                   SET LOW = MID + 1
                [END OF IF]
        [END OF LOOP]
Step 5: IF POS = -1
              PRINT "VALUE IS NOT PRESENT IN THE ARRAY"
        [END OF IF]
Step 6: EXIT
```

Jump Search

- When we have an already sorted list, then the other efficient algorithm to search for a value is jump search or block search
  - Given an array, please find value 8

```
a[] = {1,2,3,4,5,6,7,8,9}
```

Step 1: First three elements are checked. Since 3 is smaller than 8, we will have to make a jump ahead

Step 2: Next three elements are checked. Since 6 is smaller than 8, we will have to make a jump ahead

Step 3: Next three elements are checked. Since 9 is greater than 8, the desired value lies within the current boundary

Step 4: A linear search is now done to find the value in the array.

Questions?

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