Computer Programming

Dr. Deepak B Phatak
Dr. Supratik Chakraborty
Department of Computer Science and Engineering
IIT Bombay

Session: Sorting Strings and Other Data Types

Quick Recap of Relevant Topics

- The sorting problem
- Selection sort
- Merge sort
- Counting “basic” steps in sorting an array

Overview of This Lecture

- Sorting strings and other data types
- Other techniques for sorting …

Food For Thought …

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- We've looked at techniques for sorting arrays of integers
- What if we wanted to sort arrays of
  - floats, doubles, …
  - strings …
  - more complex data items …
- Do we need to re-invent sorting techniques?

NO!!! Almost the same techniques used for integers also work in these other settings!

Recap: How Did We Sort Integers?

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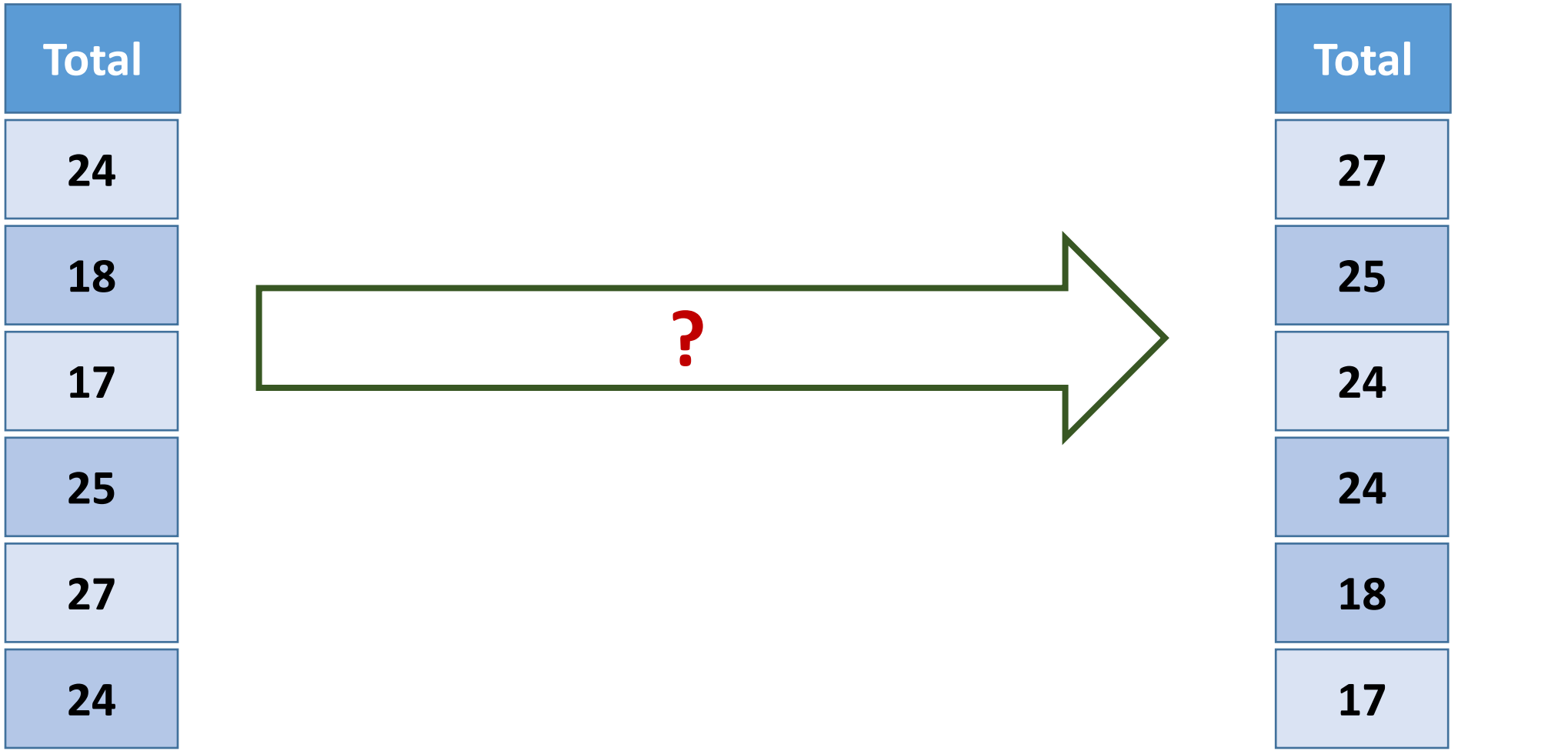

Recap: Selection Sort (Decreasing Order)

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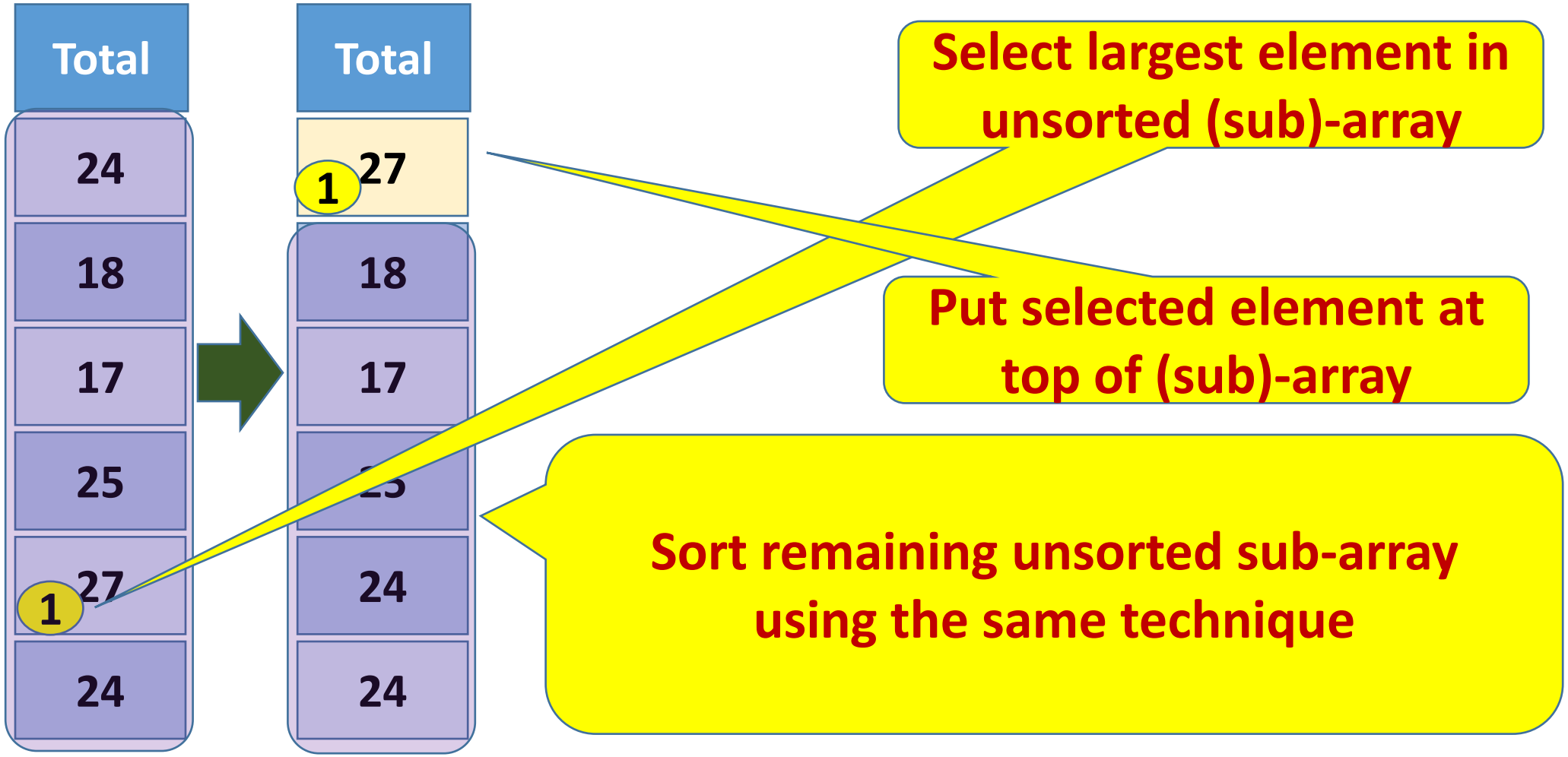

Recap: Selection Sort in C++ (For Integers)

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```
int main() {
  … Declarations, input validation and reading elements of array A …
  // Selection sort
  int currTop, currMaxIndex; // A[currTop] … A[n-1] is unsorted array
  for (currTop = 0; currTop < n; currTop ++) {
      currMaxIndex = findIndexOfMax(A, currTop, n);
      swap(A, currTop, currMaxIndex);
  }
  … Rest of code …
  return 0;
}
```

Recap: Selection Sort in C++ (For Integers)


```
// PRECONDITION: start <= end
// start, end within array bounds of A
int  findIndexOfMax(int A[],  int start,  int end) {
    int i, currMaxIndex = start;
    for ( i = start ; i < end; i++ ) {
      if (A[i] >= A[currMaxIndex]) { currMaxIndex = i; }
    }
   return currMaxIndex;
 }
// POSTCONDITION: A[currMaxIndex] at least as large as
// all elements in A[start] through A[end-1], no change in A
```

Can We Use The Same Idea To Sort Strings?

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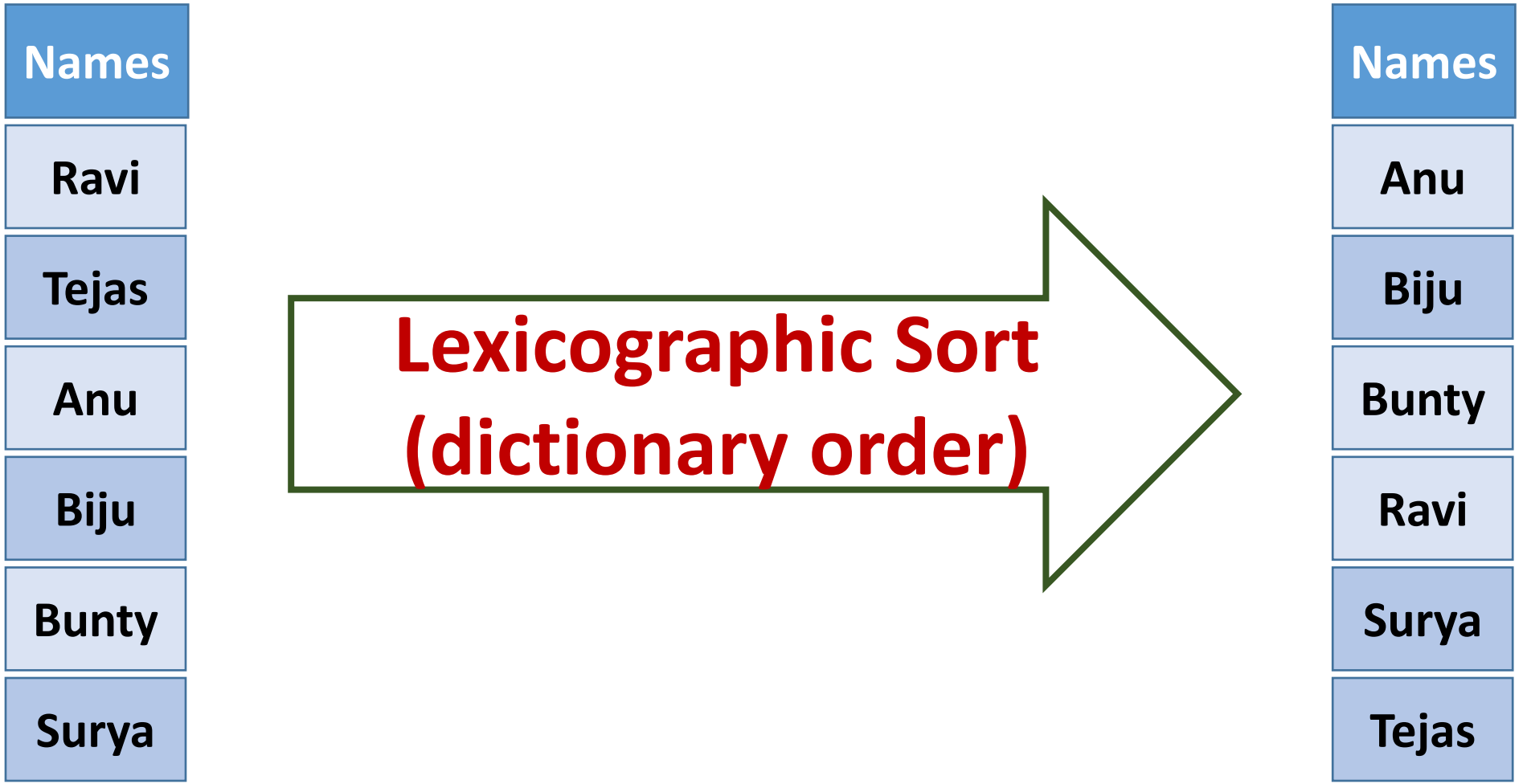

Selection Sort (Lexicographic Order)

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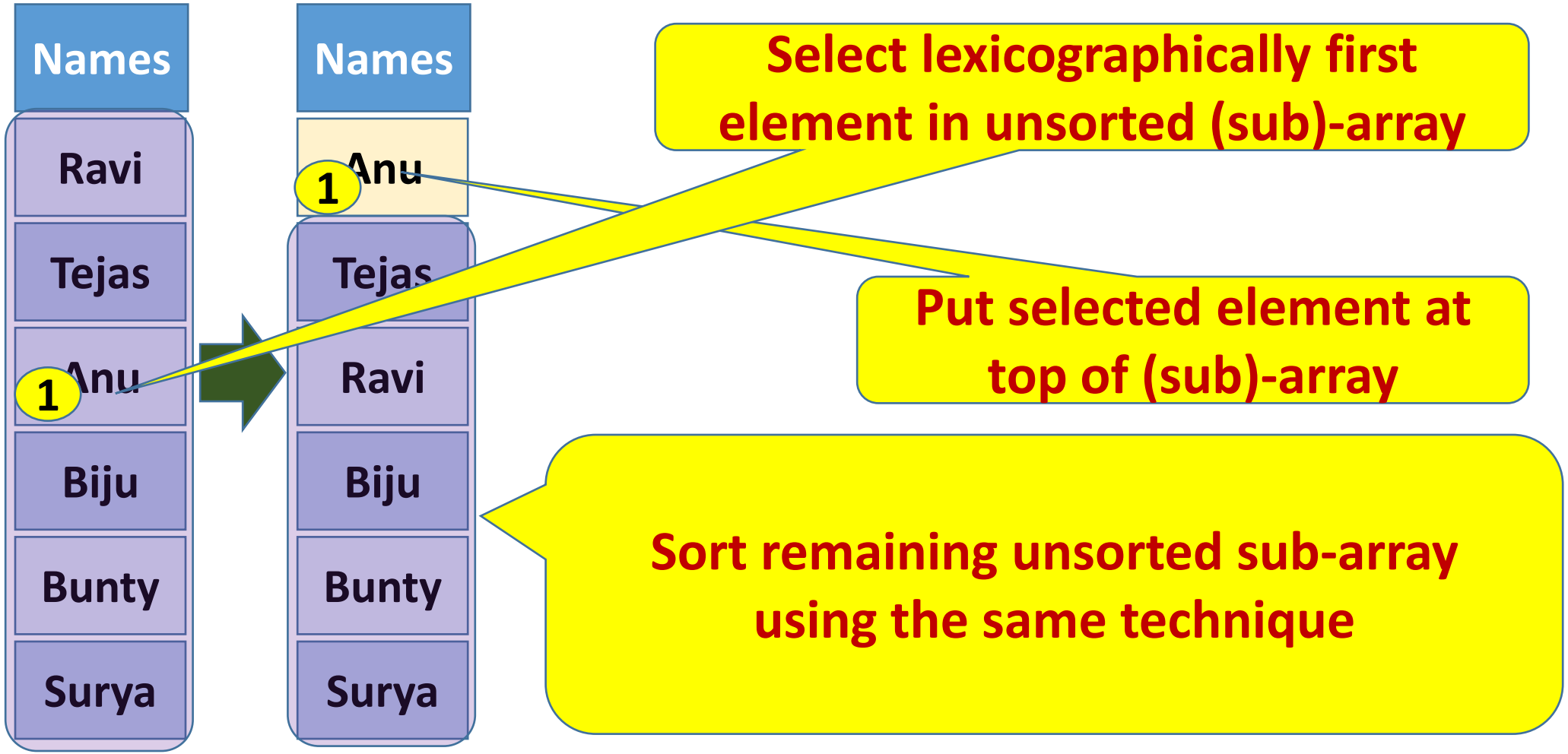

Selection Sort (Lexicographic Order)

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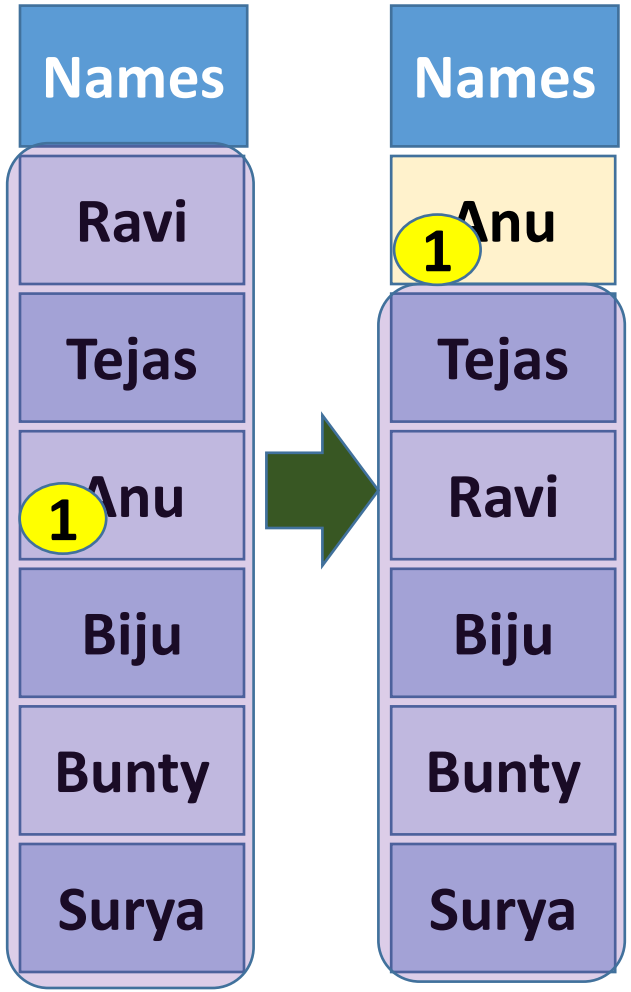

If we can select lexicographically first string in unsorted (sub)-array, we can sort strings lexicographically

How do we select lexicographically first element?

Iterate over array and compare (order) pairs of elements

Selection Sort (Lexicographic Order)

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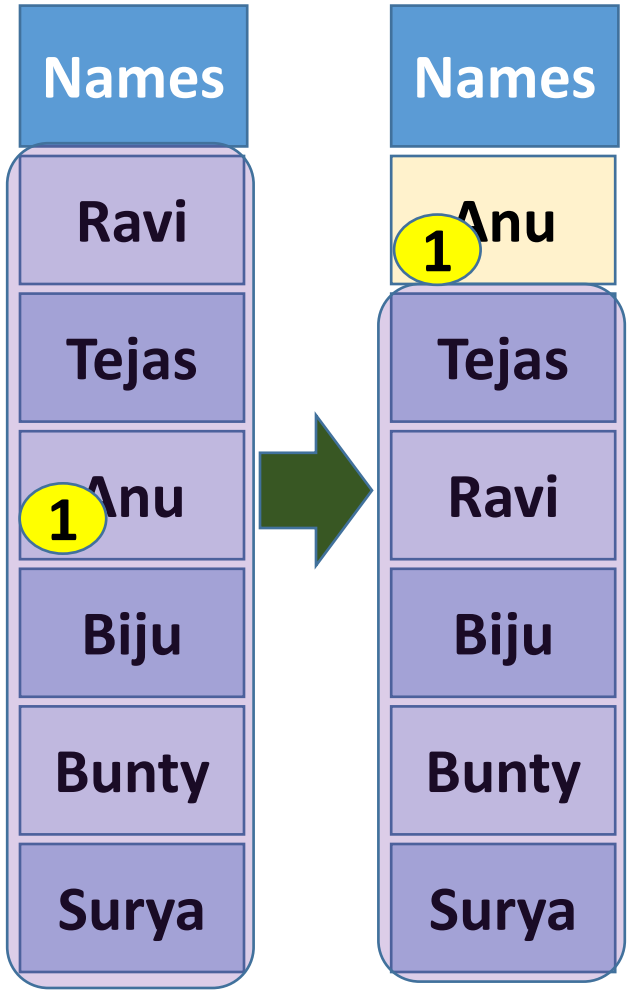

If we have a function to lexicographically compare a pair of strings, we can sort strings !!!

Comparing Strings

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- Assume availability of function

```
// PRECONDITION: s1, s2 strings
bool lexEarlier(string s1, string s2) {
                                    …
}
// POSTCONDITION: return true if and only if s1
// lexicographically before s2
```

- We'll see later (when we study strings) how to implement **lexEarlier**

Selection Sort in C++ (For Strings)

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```
int main() {
   … Declarations, input validation and reading elements of array A …
   // Selection sort: A is an array of strings
   int currTop, currLexFirstIndex; //A[currTop] … A[n-1] is unsorted array
   for (currTop = 0; currTop < n; currTop ++) {
       currLexFirstIndex = findIndexOfLexFirst(A, currTop, n);
       swap(A, currTop, currLexFirstIndex);
   }
   … Rest of code …
   return 0;
}
```

Selection Sort In C++ (For Strings)

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```
int  findIndexOfLexFirst(string A[],  int start,  int end) {
    int i, currLexFirstIndex = start;
    for ( i = start ; i < end; i++ ) {
      if ( lexEarlier (A[i], A[currLexFirstIndex]) ) {
         currLexFirstIndex = i;
      }
    }
   return currLexFirstIndex;
}
```

Array of strings

How About Merge Sort On Strings?

- Did we just get lucky with selection sort?
- Can we sort strings using merge sort, given the function **lexEarlier** ?

What Were The Steps In Merge Sort?

- Divide an array of size n into two sub-arrays of size ≈ n/2
  - Sub-array sizes may differ by 1 if n is odd
  - Easy!
- Sort each sub-array of size n/2
  - Use same technique as for sorting original array (recurse !!!)
  - Termination case of recursion: arrays of size 1
- Merge sorted sub-arrays, each of size n/2
  - One pass over each sorted sub-array

Crucial Step

Recap: Merging Sorted Sub-arrays (of int) In C++


```
// PRECONDITION: A[start] … A[mid-1]  and A[mid] … A[end-1] sorted in
//                          decreasing order
void mergeSortedSubarrays(int A[], int start, int mid, int end) {
   int i,   j; int tempA[100],  index = start;
   for (i = start, j = mid; ((i < mid) || (j < end)); ) {  // Merging loop
      // Determine whether A[i] or A[j] should appear next in sorted order
      // Update tempA[index] accordingly
     index ++;
  } // end of merging loop
  // Copy tempA[start] … tempA[end-1]  to  A[start] … A[end-1]
  return;
}
// POSTCONDITION:  A[start] … A[end-1] sorted in decreasing order
```

Recap: Merging Loop (for int) In C++

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```
for (i = start, j = mid; ((i < mid) || (j < end));  ) {  // Merging loop
    if ((i < mid) && (j < end)) {  // None of the two subarrays fully seen yet
            if (A[j] > A[i])     {tempA[index] = A[j];   j++;}
            else                 {tempA[index] = A[i];   i++;}
    }
    else { if (i < mid) {tempA[index] = A[i]; i++;}  // A[mid] … A[end-1] seen
            else         {tempA[index] = A[j]; j++;} // A[start] … A[mid-1] seen
    }
    index ++;
} // end of merging loop
```

Merging Sorted Sub-arrays Of Strings In C++


```
// PRECONDITION: A[start] … A[mid-1]  and A[mid] … A[end-1] sorted in
//                          lexicographic order
void mergeSortedSubarrays(string A[], int start, int mid, int end) {
   int i,   j; string tempA[100] ;  int index = start;
   for (i = start, j = mid; ((i < mid) || (j < end)); ) {  // Merging loop
      // Determine whether A[i] or A[j] should appear next in sorted order
      // Update tempA[index] accordingly
     index ++;
  } // end of merging loop
  // Copy tempA[start] … tempA[end-1]  to  A[start] … A[end-1]
  return;
}
// POSTCONDITION:  A[start] … A[end-1] sorted in lexicographic order
```

Merging Loop (For Strings) In C++


```
for (i = start, j = mid; ((i < mid) || (j < end)); ) {  // Merging loop
    if ((i < mid) && (j < end)) {  // None of the two subarrays fully seen yet
          if ( lexEarlier(A[j], A[i]) )  {tempA[index] = A[j];   j++;}
          else                           {tempA[index] = A[i];   i++;}
    }
    else { if (i < mid) {tempA[index] = A[i]; i++;}  // A[mid] … A[end-1] seen
          else          {tempA[index] = A[j]; j++;} // A[start] … A[mid-1] seen
    }
    index ++;
} // end of merging loop
```

What About Arrays Of Other Data Types?

- Pretty much the same technique as for int/string arrays
- Define an ordering function/operator
  - >= for integers
  - lexEarlier(s1, s2) for strings
  - …
- Rest of it is the same …

Other Sorting Techniques

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- Selection sort and merge sort not the only sorting techniques
- Other important sorting techniques
  - Quick sort
  - Heap sort
  - Insertion sort …

  All of these can be implemented in C++

- An extremely interesting area of study

Summary

- Sorting strings
  - Key use of comparison operator
- Sorting other data types
- Other sorting techniques