IIT Bombay

Computer Programming

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Session: Selection Sort

Quick Recap of Relevant Topics

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- Basic programming constructs
  - Iteration constructs
  - Functions
  - Arrays and matrices, among other things …
- The sorting problem
  - Motivation

Overview of This Lecture

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- Selection sort
  - A simple, intuitive sorting technique

Quiz1, Quiz2 and Quiz3 Marks in CS101

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Total
24
18
17
25
27
24

Rank all students in decreasing order of "Total" marks

Core problem:

Sort "Total" marks in decreasing order

Simplification:

If two marks are equal, any ordering between them ok

Quiz1, Quiz2 and Quiz3 Marks in CS101

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Total
3 24
4 18
5 17
2 25
1 27
3 24

Rank all students in decreasing order of "Total" marks

Core problem:

Sort "Total" marks in decreasing order

Simplification:

If two marks are equal, any ordering between them ok

Quiz1, Quiz2 and Quiz3 Marks in CS101

Total
1 27
2 25
3 24
3 24
4 18
5 17

Rank all students in decreasing order of "Total" marks

Core problem:

Sort "Total" marks in decreasing order

Simplification:

If two marks are equal, any ordering between them ok

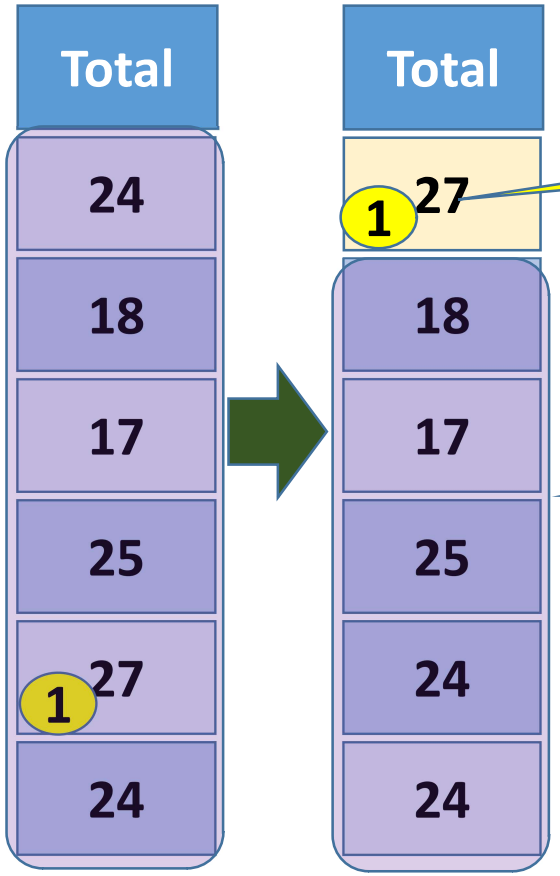
How Do We Do It?

Total
24
18
17
25
27
24

?

Total
27
25
24
24
18
17

How Do We Do It?



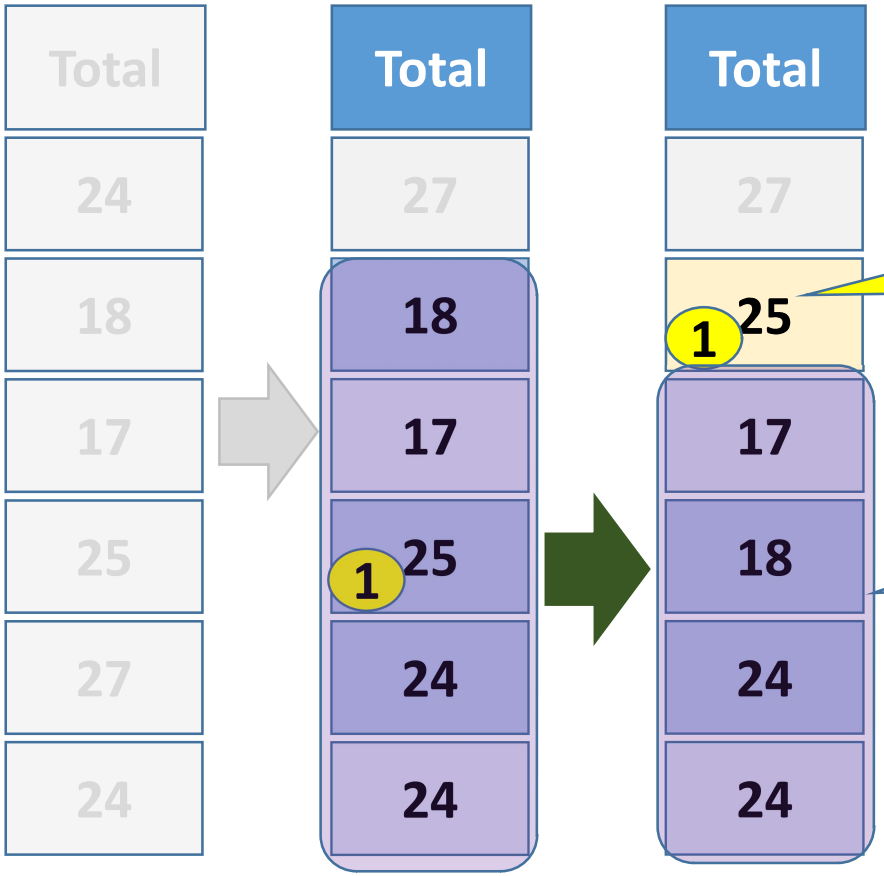
Get only the first element in its right place

Solve part of the problem

Arrive at a similar but "simpler" problem to solve:

Sort remaining marks

How Do We Do It?



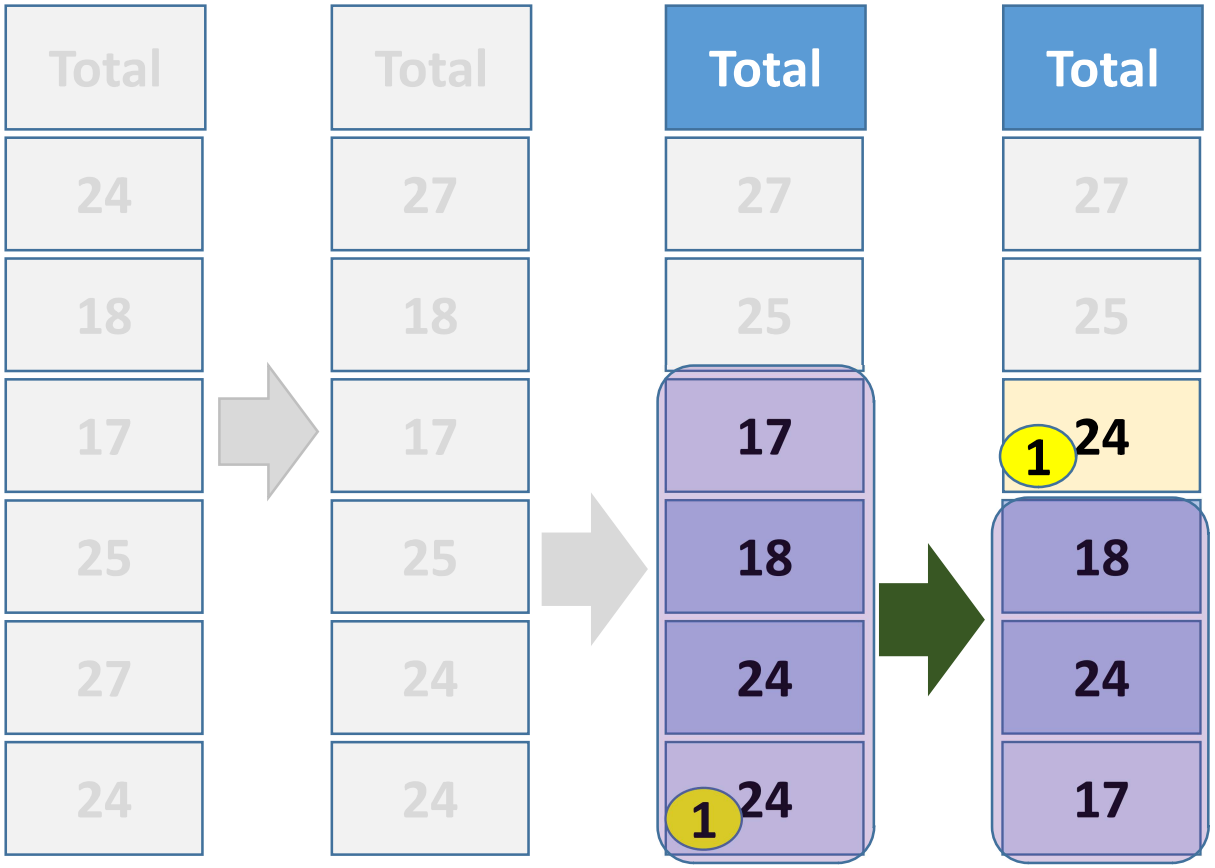
Solve part of the problem

Get only the first (in current subproblem) element in its right place

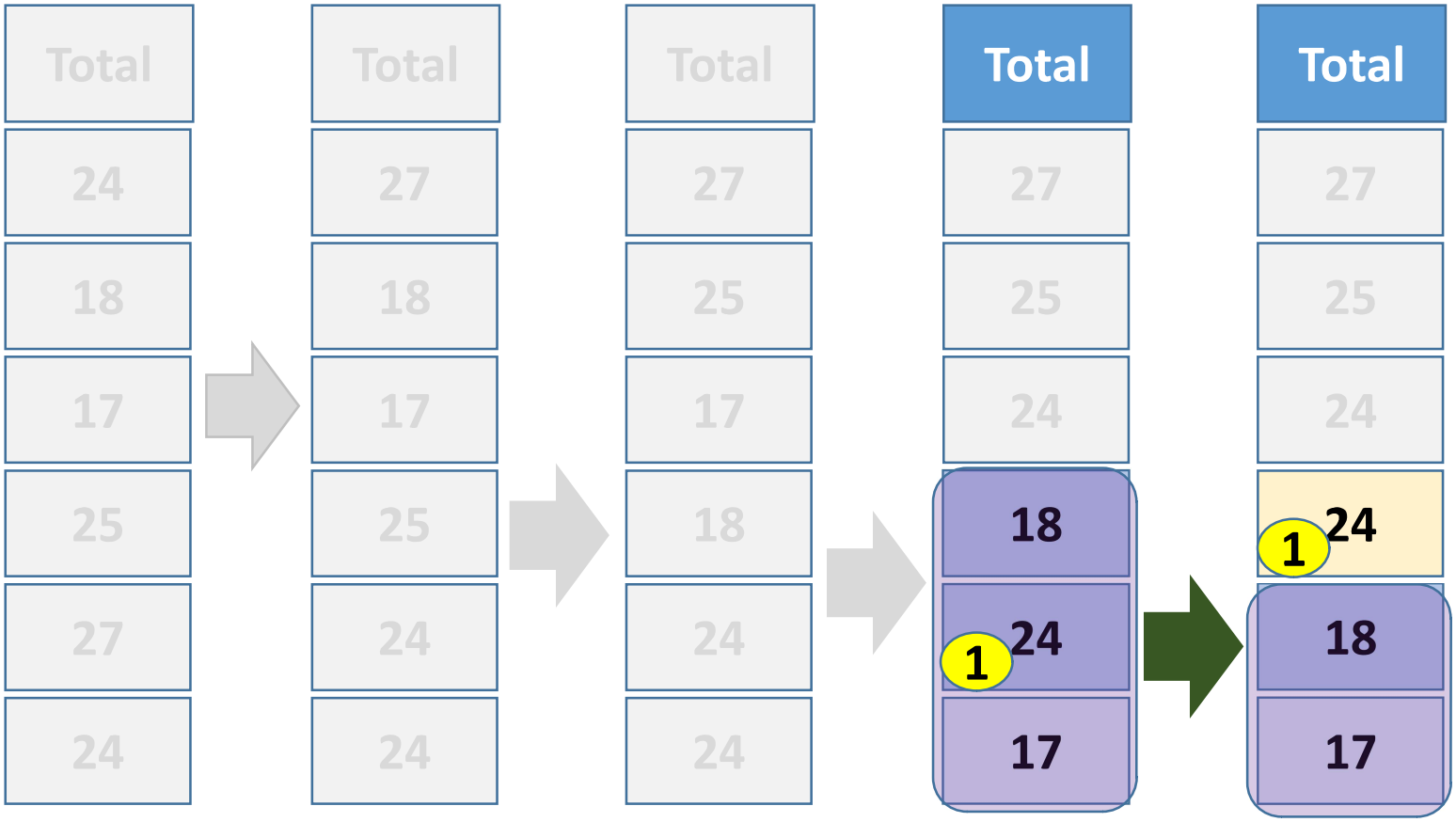
Arrive at a similar but "simpler" problem to solve:

Sort remaining marks

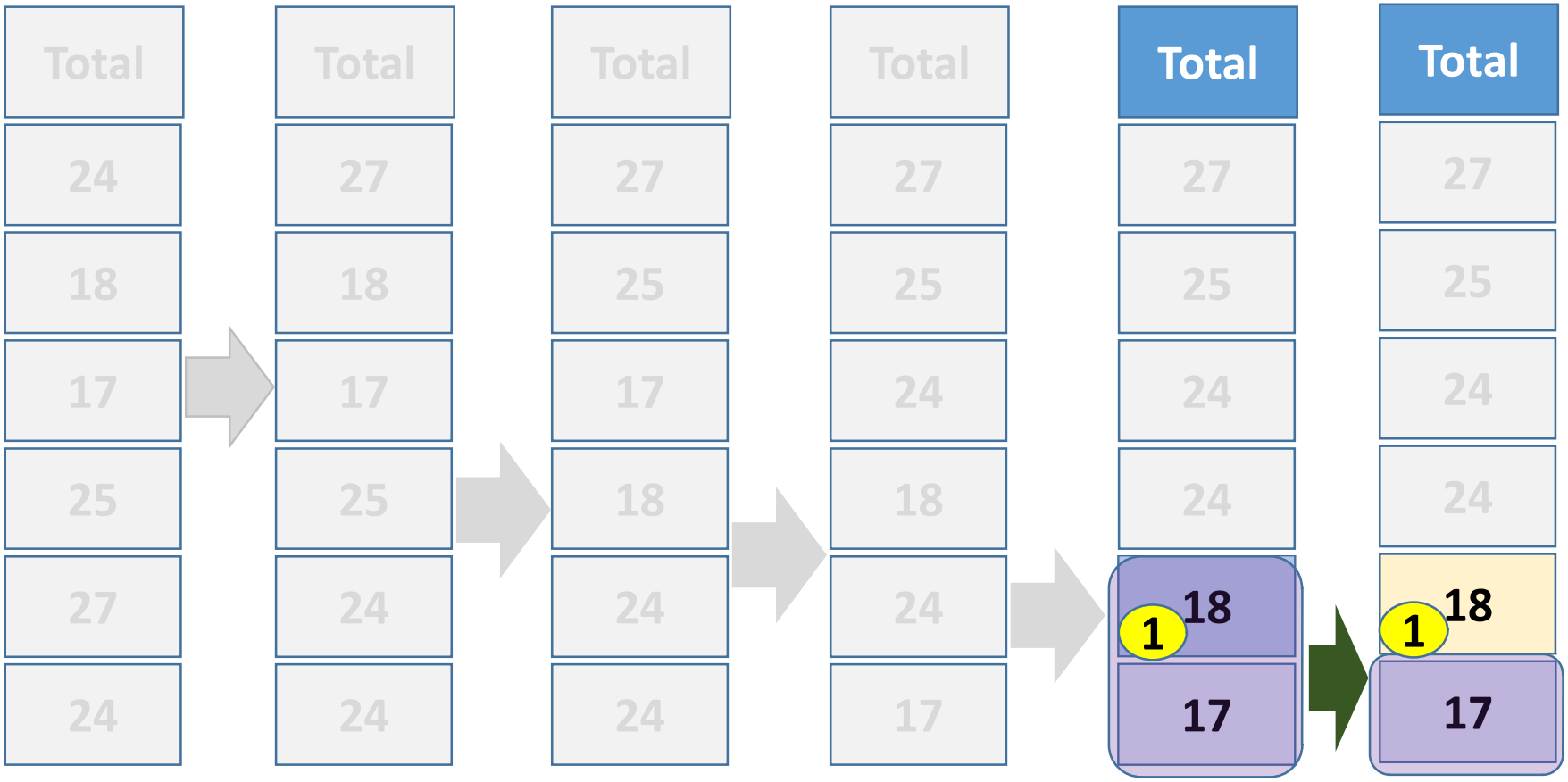
How Do We Do It?



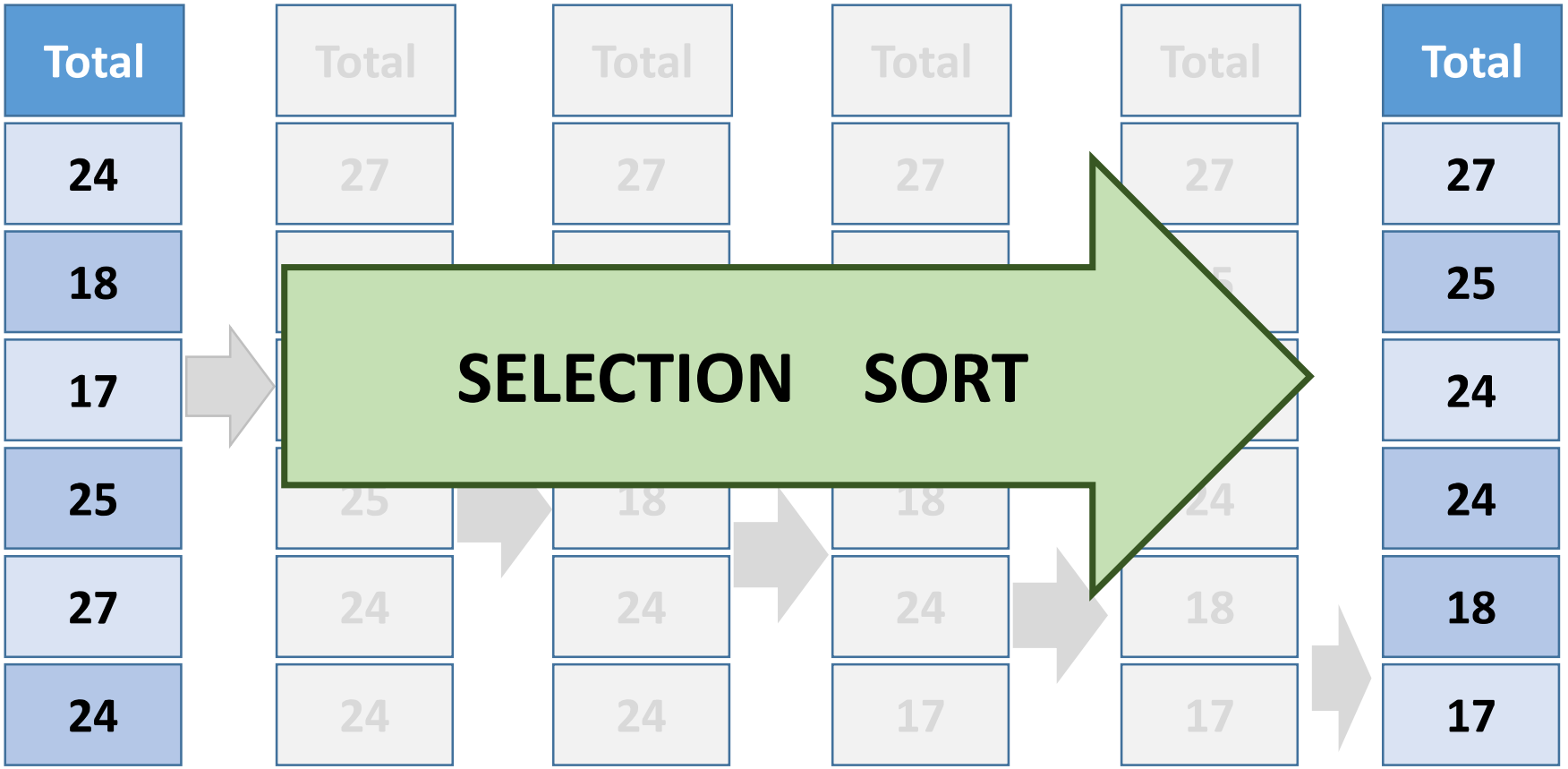
How Do We Do It?



How Do We Do It?



How Do We Do It?



A C++ Program For Selection Sort

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- Given an array A of n integers
  - Sort them in decreasing order

    $A[0] \geq A[1] \geq A[2] \geq \ldots A[n-1]$
  - If two elements are equal, either of them may be ordered before the other

[Once our program is written, final ordering among equal elements is of course completely determined]

Selection Sort in C++

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```
int main() {
  int  n;
  cout << “Give number of integers to sort: “;  cin >> n;
 // Input validation
 if (n > 100) { cout << “Too many elements!” << endl; return -1;}
  if (n <= 0) {cout << “Invalid input!” << endl; return -1;}
  …. Rest of code …
  return 0;
}
```

Selection Sort in C++

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```
int main() {
   … Declarations and input validation …
  int count, A[100];  // Array of integers to sort
  // Read integers to sort
  cout << “Give “ << n << “integers to sort.” << endl;
  for (count = 0; count < n; count++) { cin >> A[count]; }
   … Rest of code …
  return 0;
}
```

Selection Sort in C++

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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 ++) {
     // Select maximum element in unsorted part of  array A
     // Let currMaxIndex be its index in array A
     // Swap A[currTop] and A[currMaxIndex]
  }
   … Rest of code …
  return 0;
}
```

Selection Sort in C++

```
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;
}
```

Selection Sort in C++

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```
// PRECONDITION: start < end
// start, end within array bounds of A
int  findIndexOfMax(int A[],  int start,  int end) {


}
// POSTCONDITION: A[currMaxIndex] at least as large as
// all elements in A[start] through A[end-1], no change in A
```

Array as parameter (not call-by-value)

Selection Sort in C++

```
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;
}
```

Selection Sort in C++

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```
// PRECONDITION: index1, index2 withi
//                          bounds of A
void  swap(int A[],  int index1,  int index2) {



}
// POSTCONDITION: A[index1], A[index2] swapped
//                          Array A changed
```

Array as parameter
(not call-by-value)

Role of Comparison Operator

```
// PRECONDITION: start < end
// start, end within array bounds of A
int  findIndexOfMax(int A[],  int start,  int e
   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
```

Note the use of “>=”

Selection Sort Using >=

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currTop

start, i, currMaxIndex

Total	Total
A[0]	27
A[1]	25
A[2]	17
A[3]	18
A[4]	24
A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

Selection Sort Using >=

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	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
i, currMaxIndex	A[3]	18
	A[4]	24
	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

18 >= 17

Selection Sort Using >=

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	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
	A[3]	18
i, currMaxIndex	A[4]	24
	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

24 >= 18

Selection Sort Using >=

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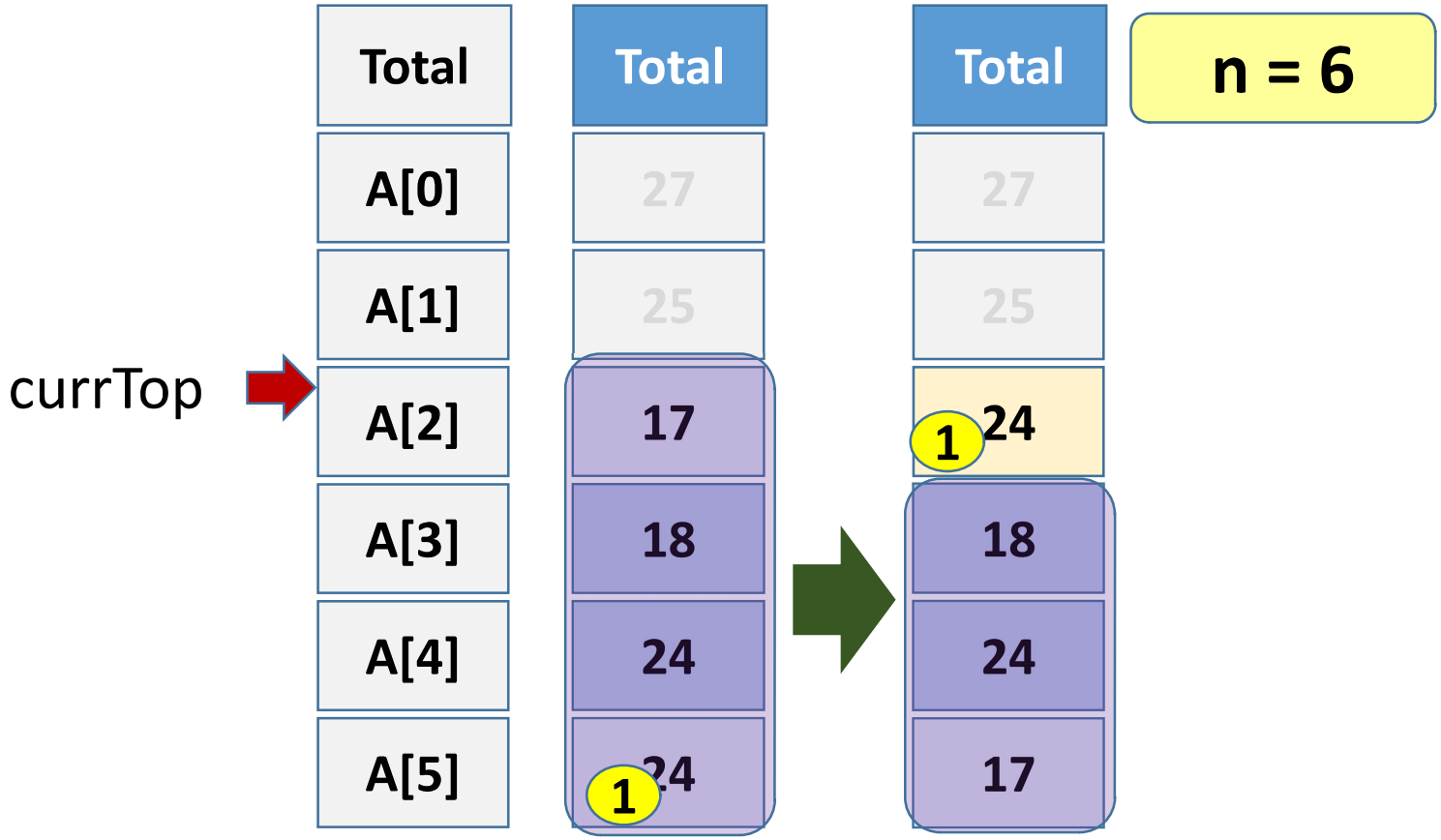
	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
	A[3]	18
	A[4]	24
i, currMaxIndex	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

24 >= 24

Selection Sort Using >=



Role of Comparison Operator

```
// PRECONDITION: start < end
// start, end within array bounds of A
int  findIndexOfMax(int A[],  int start
   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
```

What if we used “>” ?

Selection Sort Using >

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	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
start, i, currMaxIndex	A[3]	18
	A[4]	24
	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

Selection Sort Using >

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	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
i, currMaxIndex	A[3]	18
	A[4]	24
	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

18 > 17

Selection Sort Using >

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	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
	A[3]	18
i, currMaxIndex	A[4]	24
	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

24 > 18

Selection Sort Using >

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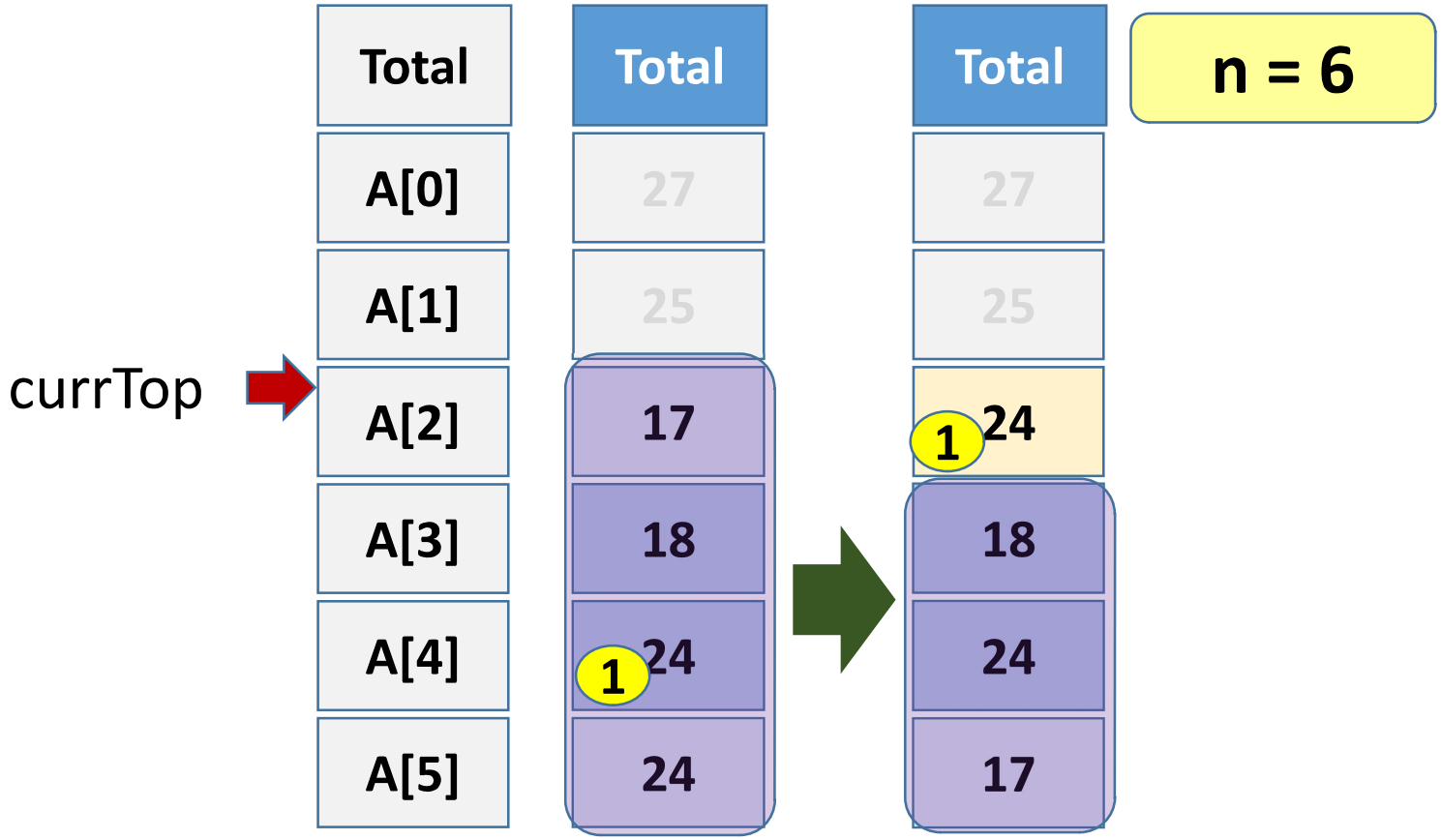
	Total	Total
	A[0]	27
	A[1]	25
currTop	A[2]	17
	A[3]	18
currMaxIndex	A[4]	24
i	A[5]	24

n = 6

findIndexOfMax(A, 2, 6)

24 ~~>~~ 24

Selection Sort Using >



Role of Comparison Operator

```
// PRECONDITION: start < end
// start, end within array bounds o
int  findIndexOfMax(int A[],  int star
   int i, currMinIndex = start
   for ( i = start ; i < end; i++ ) {
     if (A[i] <= A[ currMinIndex ]) { currMinIndex = i; }
```

What if we used "<=" ?

Choice of comparison operator crucially determines sorting order (increasing/decreasing), and also how equal elements are ordered!

```
// all elements in A[start] through A[end-1], no change in A
```

Summary

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- Selection sort
  - Intuition
  - C++ implementation
  - Choice of comparison operator and its effects