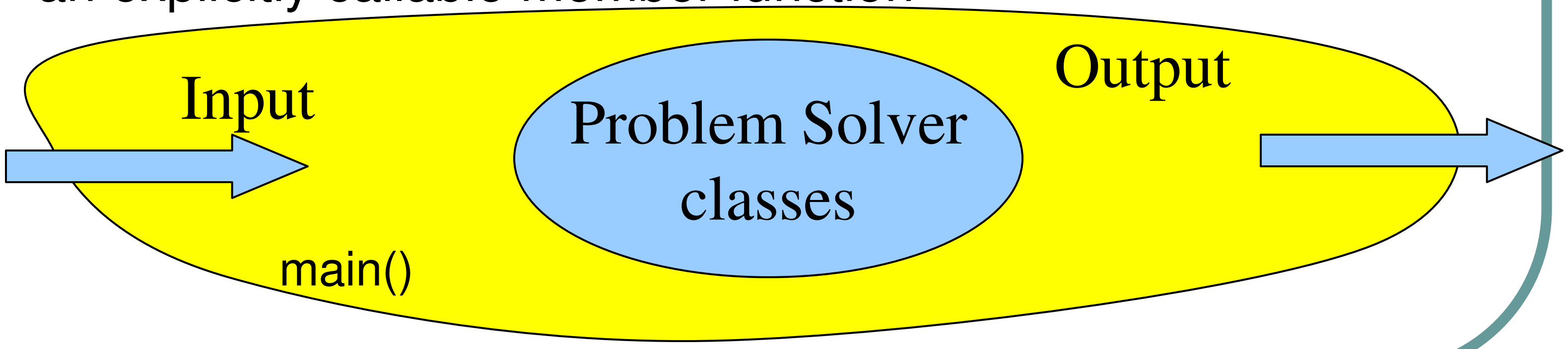
Practice of Programming using Java

Lecture 4
June 20, 2006
6-8pm LT

A Problem Solving Architecture

- Problem Solver
  - Data Structures
  - Algorithms
- Main: glue between problem solver classes, input and output
  - This makes your problem solver reusable
  - If you implement everything in main, you won't be able to reuse the solution easily in other programs since main is not an explicitly callable member function



How do you start?

- Write down the main() first
  - Write code with which you will test your solvers
  - Compile it and keep it ready
  - This gives you an idea about the interface that your solver should support
- Then implement your problem solver
- Keep your implementation compliable and executable at all times.
  - You are not faced with all the problems in one go
  - The solution architecture will evolve incrementally from externally available interfaces down to detailed implementation structures.

Some Data Structures

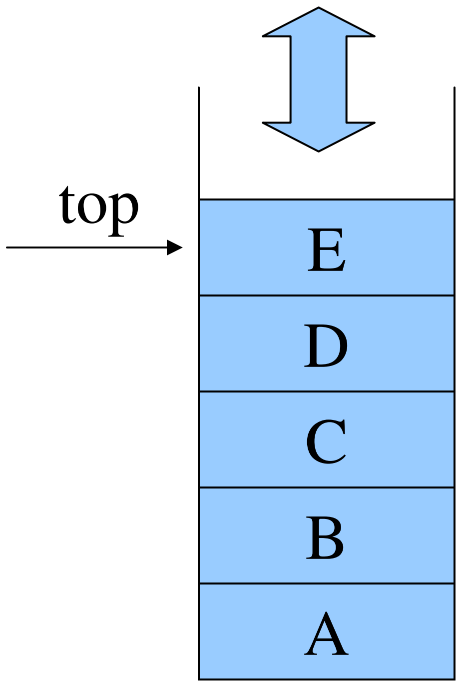
- Stacks
  - e.g. a stack of books on my table
- Lists
  - e.g. a list of students in my class
- Trees
  - e.g. a family tree
- Graphs
  - e.g. cities in India connected by rail network

Some Algorithms

- Search
  - e.g. search a word in a dictionary
- Sort
  - e.g. rank the students in my class
- Traversal over Graphs
  - e.g. find shortest path between two cities

The Stack (last in first out)

Operations



push ( ) : pushes an element on the top of stack

pop ( ) : removes the element at the top of stack

empty ( ): returns true if stack empty else returns false

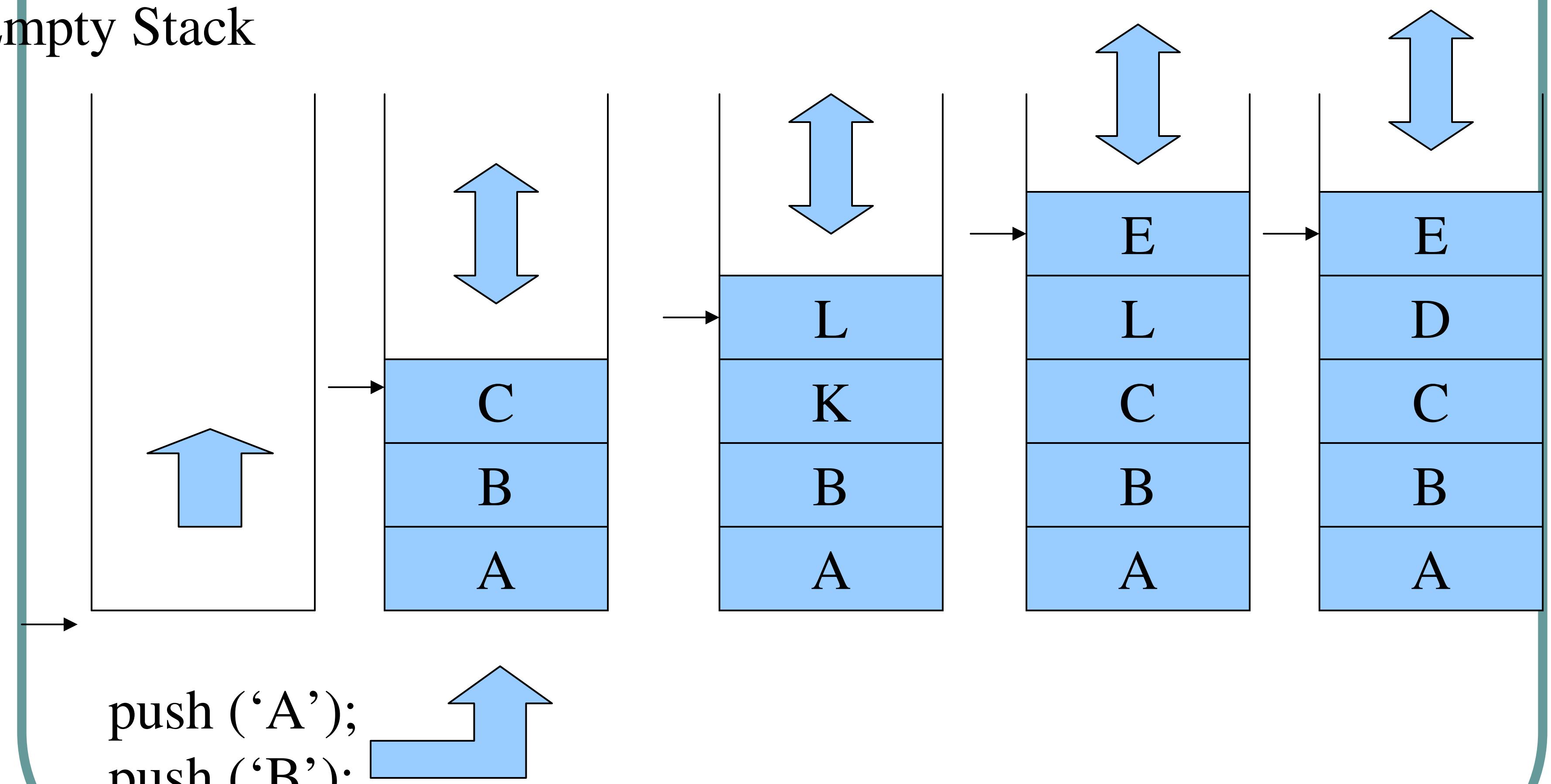
full ( ): returns true if stack is full else returns false

(full is implemented on bounded stacks)

initially stack is empty

Stack - Snapshots

Empty Stack



push ('A');
push ('B');
push ('C');

Boundary Conditions

- Initialize the object with appropriate initial values (e.g. what is the initial value of the variable *top*?)
- Take care of boundary conditions when operations are invoked
- e.g. when push is called : *is stack full ?*
- When pop is called : *is stack empty ?*
- *Either throw exceptions or return error codes on unsuccessful operations*

Checking for Matching Parenthesis in expressions

✓ { [2*a - 2 (b+c)] * [sin (x+y)] }

✗ { [2*a - 2 (b+c) } * [sin (x+y)]]

The Solution?

Checking Matching Parenthesis in expressions using parenthesis Stack

{ [2*a - 2 (b+c)] * [sin (x+y)] }

The Algorithm:

Stack is initially empty

Scan the expression string from left to right

If a left parenthesis is encountered: push it on the stack

If a right parenthesis is encountered, pop the top of stack and check if the type of popped parenthesis is the same as the type of scanned parenthesis

failure: upon mismatch

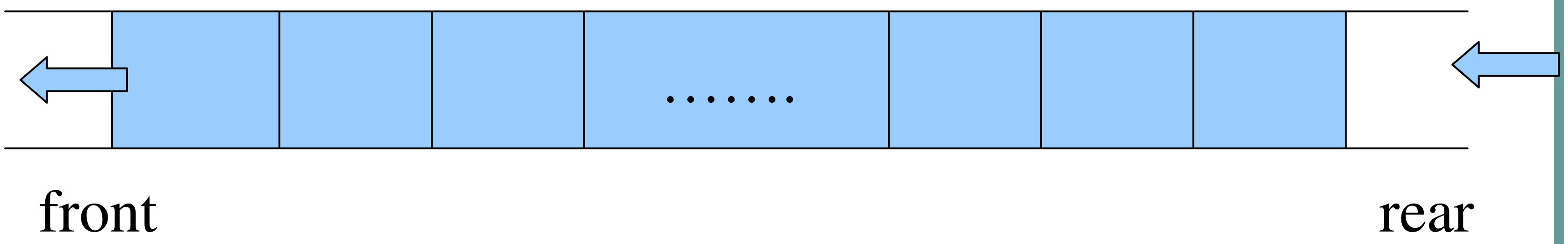
success: if whole string gets scanned without a mismatch

Evaluating postfix expressions using Stack

- Infix expression
  - operand Operator operand
- Postfix expression
  - operand operand Operator

Infix	Postfix
(x+y)	x y +
(x-y-z)	x y - z -
(x-y-z)/(u+v)	x y - z - u v + /

The Queue: FIFO



Operations

insert ( ) : insert an element at the rear end of the queue

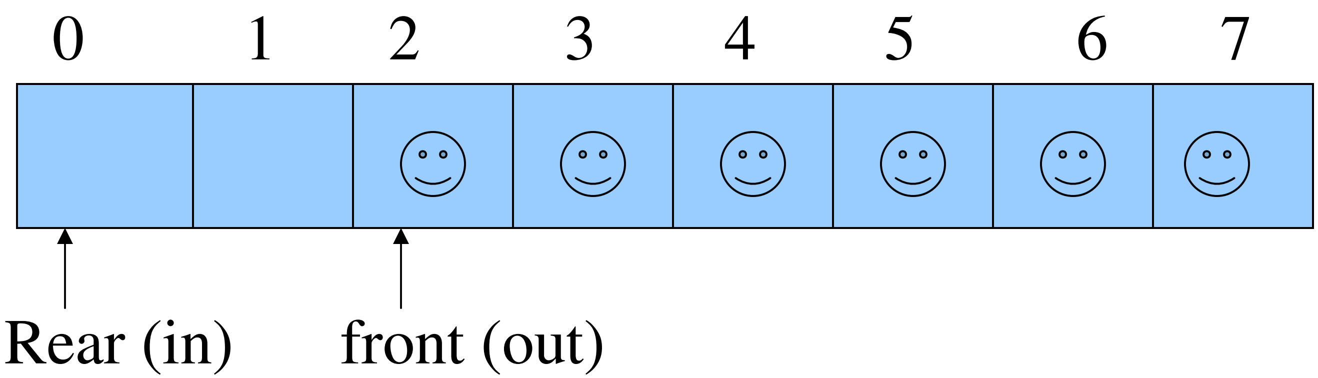
fetch ( ): remove the element at the front of the queue

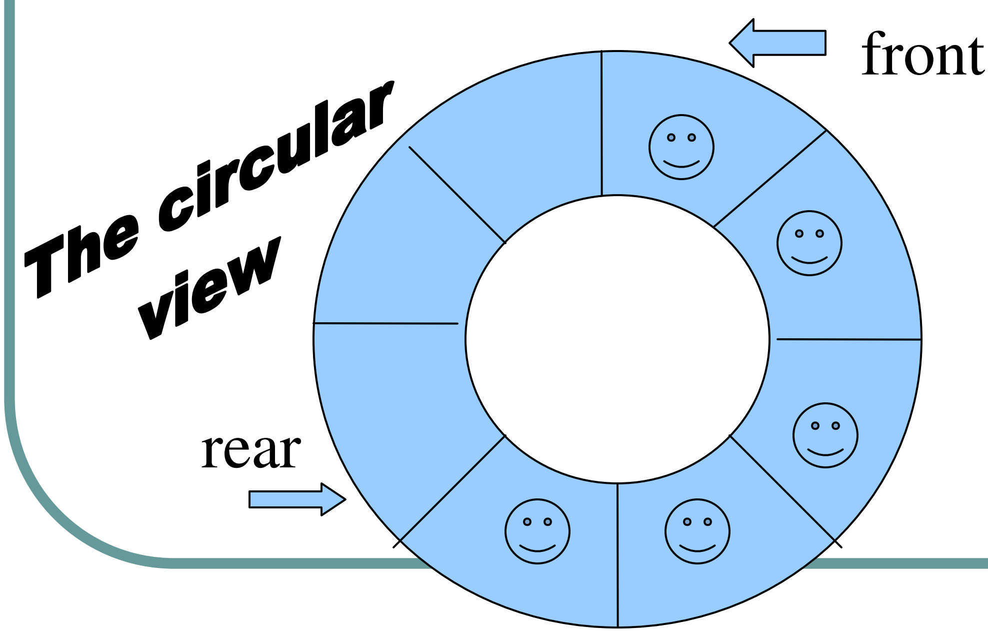
empty ( ) : determine whether the queue is empty

full ( ): determine whether the queue is full

initially queue is empty

Implementing Queues (The circular implementation)

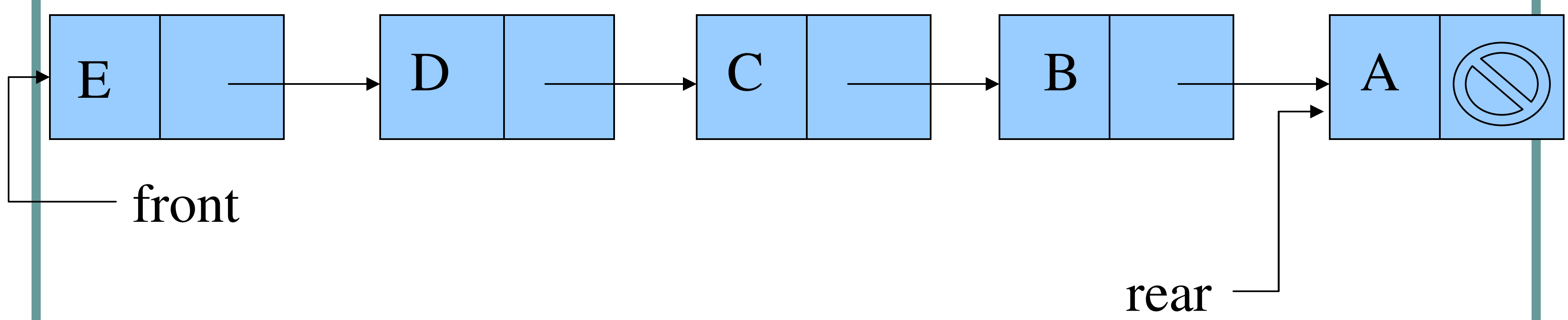




Incrementing the indices:
Modulo Array size

Boundary Conditions
When is the queue empty?
When is it full?

Implementing Queues (The linked implementation)



Some Examples of Queues

- Process Queues in operating systems
  - ready queues
  - wait queues
- Printer Queues
- Mail queues for incoming and outgoing messages

Arrays: Merge two sorted Arrays

1 4 4 20 25 28 50 100 120

Array A

5 7 7 23 30 35 40 45

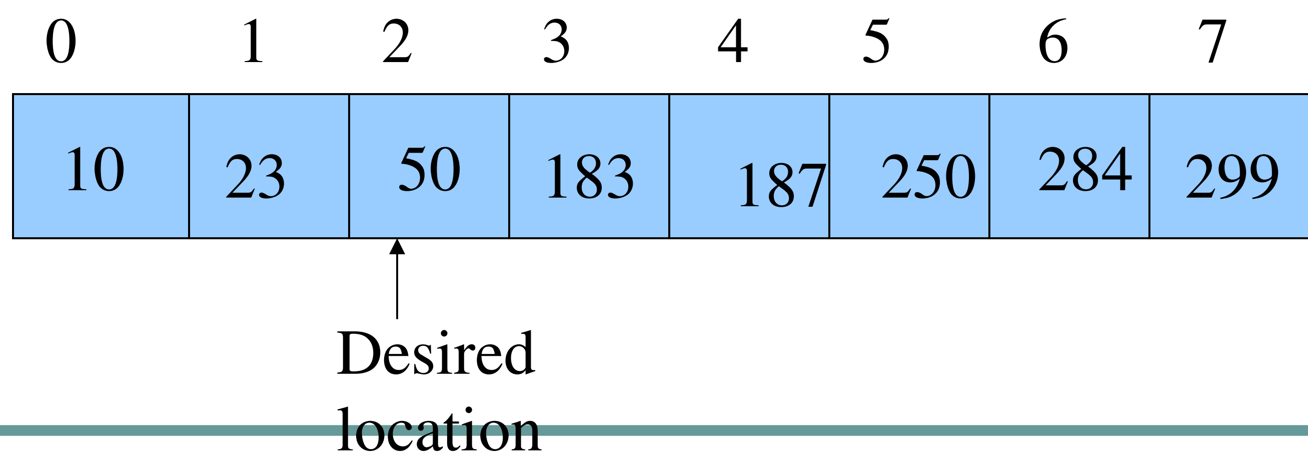
Array B

Array C: the merged list in sorted order

1 4 4 5 7 7 20 23 25 28 30 35 40 45 50 100 120

Searching through arrays

- Find out the smallest index i such that A[i]==x in an ordered list of elements
- When do you terminate your search, and what index value do you return when the element is not found?



Exercise 3: More Stack based Exercises

1. Implement a solution to the matching parenthesis problem using the stack class that you have developed.
2. Implement a solution for postfix expression evaluation

Implement at least one of the above

Exercise 4: Some Array based Problems

1. Implement a circular queue using a bounded array.
2. Implement a function that merges 2 sorted integer arrays
3. Implement binary search on a sorted integer array

Implement all of them.

Exercise 5: More Recursive solutions

- Implement function *factorial* to compute and return the factorial of nonnegative number k provided as its input argument.
- Implement a recursive function *fibonacci* that computes and returns k^{th} Fibonacci number when a nonnegative value k is provided as its input argument.

Implement at least one.

Also print the total no. of calls made to the function.