SFU

Abstract Data Types

CMPT 125
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Lecture 17

Today

- Abstract Data Types
- Interfaces
- Dynamic Arrays
- Linked Lists

Stacks (Review)

A *stack* is an ordered collection of items, to which you may insert an item (a *push*) or remove an item (a *pop*), where removal follows a last-in-first-out order (LIFO).

- the definition of a stack was independent from its implementation
- the first example of an *abstract data type*

Abstract data type (ADT): a collection of data and a set of allowed operations on that data.

- describes data + operations, not how the data are stored or how operations are carried out

Stacks (Review)

A *stack* is an ordered collection of items, to which you may insert an item (a *push*) or remove an item (a *pop*), where removal follows a last-in-first-out order (LIFO).

a stack of plates

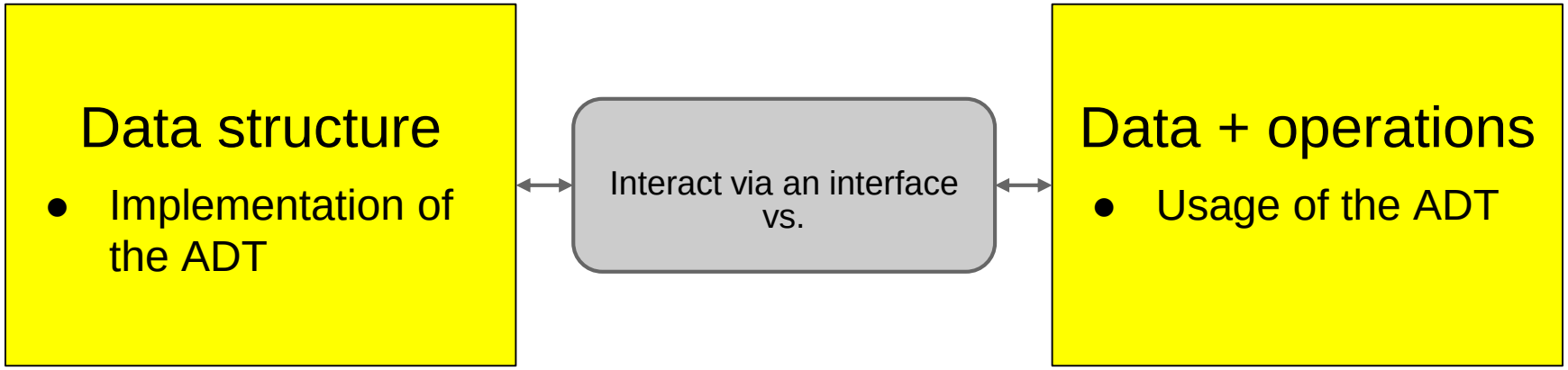
a stack of books

a stack of passengers

Abstract Data Types

Abstract data type (ADT): a collection of data and a set of allowed operations on that data.

- specifies data and operations, not how the data are stored or how operations are carried out
- different from the data structure, which deals with the implementation



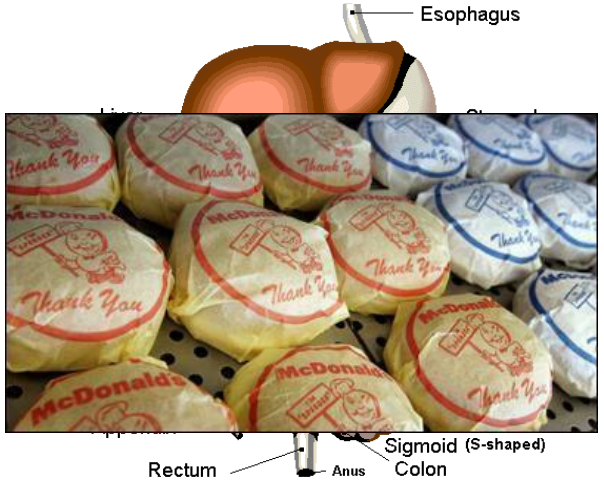
Another Common ADT

Queue ADT: A *queue* is another sequence of data, but the insert / remove operations work on opposite ends of the sequence.

- order is first-in-first-out (FIFO)
- like a line-up

queue for service

queue of traffic



queue of food

Interfaces

An *interface* refers to an expected collection of data and behaviours

- parametrized by inputs
- serves as a contract

Q. What interfaces have you seen in CMPT 125?

- functions, pre-, post-conditions, invariants
- collections of functions, typedefs, constants
- header files

Why use interfaces?

Code re-usage

Code independence

A tale of three programmers

Algorithm that implements a resizable ADT

Interface:

- a sequence of data
- read element
- set element
- append

Algorithm that requires a resizable data type

Why use interfaces?

Code re-usage

Code independence

A tale of three programmers

Resizable ADT, implemented using arrays

Interface:

- a sequence of data
- read element
- set element
- append

Code that instantiates and uses a resizable ADT

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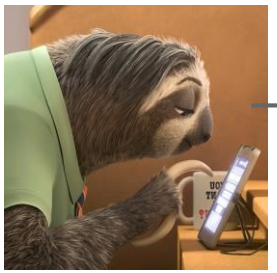
Resizable ADT, implemented using arrays



Resizable ADT, implemented by linked lists

Interface:

- a sequence of data
- read element
- set element
- append

Code that instantiates and uses a resizable ADT

Why use interfaces?

Code re-usage

Code independence

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Implementation of an ADT

Interface:

- function spec
- preconditions
- return codes
- . . .

Code that uses an ADT, according to its interface

Why use interfaces?

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Implementation of an ADT

Interface:

- function spec
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- . . .

Code that uses an ADT, according to its interface

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Implementation of an ADT

Interface:

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Code that uses an ADT, according to its interface

Why use interfaces?

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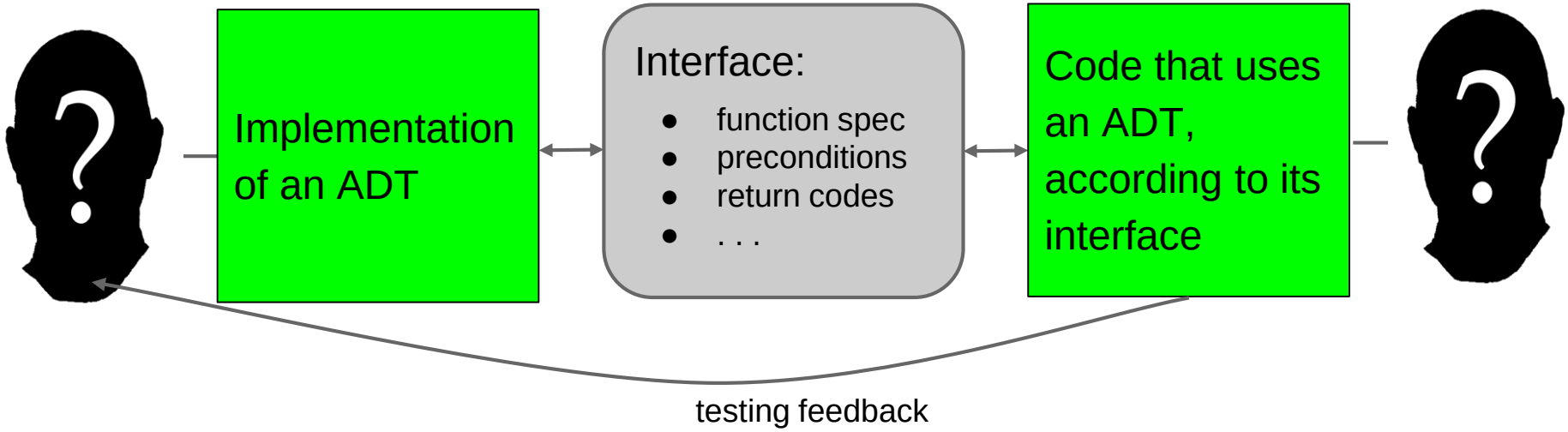


Software Engineering Principles

Encapsulation

- bundle related data and operations together

Modularity

- break up the problem into smaller, manageable programming tasks

Information Hiding

- keep the implementation details private
- keep the interface stable

Finding a good selection of interfaces is the foundation for writing large scale software

Fleshing out some ADTs

Q. What sort of data (properties) and operations (functions) would apply to:

Stack ADT:

- a sequence of data
- last in first out order
- insert (push)
- remove (pop)
- isEmpty
- top
- size (length)

Appendable array ADT:

- a sequence of data
- append (to the end)
- size (length)
- access (get)
- change (set)

Appendable Array ADT

One possible implementation is an array

- keep track of current length
- keep a pointer to the array
- *access* - trivial + bounds check
- *change* - trivial + bounds check
- *append* - not so trivial - malloc and copy

Q. What's the total running time for N appends?

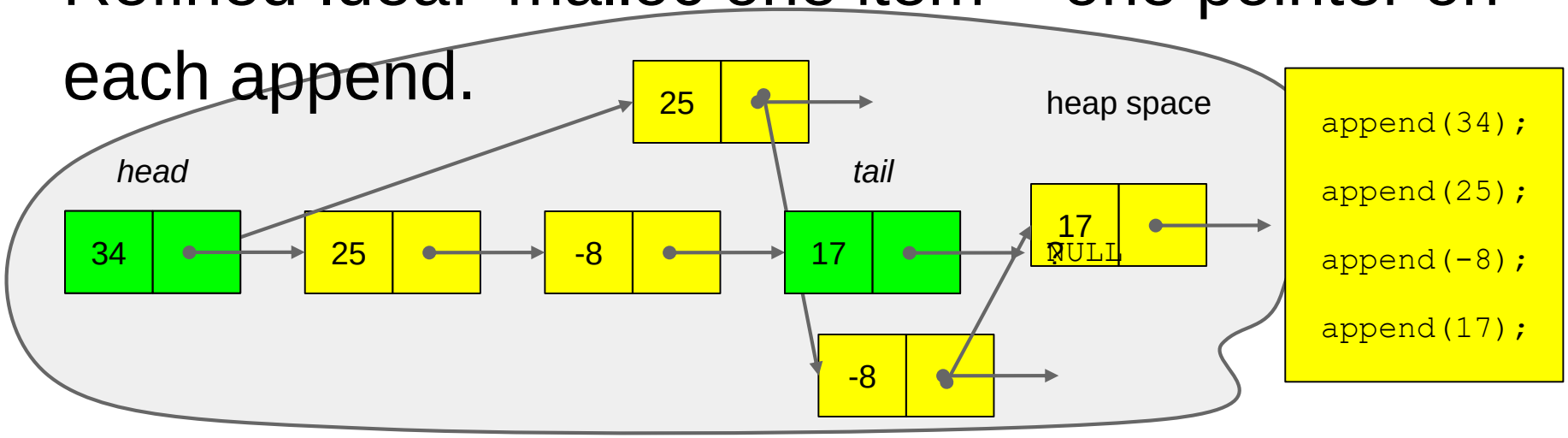
Linked Lists

memory allocation

Another Idea: malloc one item on each append

- items might not be contiguous anymore
- Q. How to find next item in the sequence?
- use a sequence of pointers

Refined Idea: malloc one item + one pointer on each append.



Heap Memory vs. Stack Memory

- Heap memory
  - Special command needed to add (malloc, new) and remove (free, delete) variables
  - Useful for ADTs that vary in size
  - Different variables typically do not occupy contiguous memory locations
- Stack memory
  - Memory used to hold the function call stack
    - Includes local variables and function parameters
  - No special commands or manual maintenance needed
  - Cannot resize easily, since everything is in the function call stack