COMP20007 Design of Algorithms

Design of Algorithms

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Lecture 2

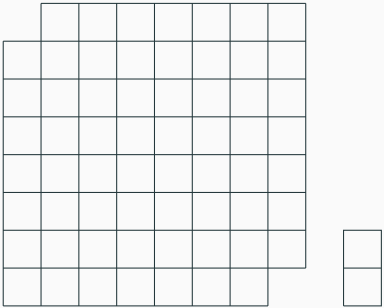
Semester 1, 2020

Approaching a Problem

Can we cover this board with 31 tiles of the form shown?

This is the mutilated checkerboard problem.

There are only finitely many ways we can arrange the 31 tiles, so there is a brute-force (and very inefficient) way of solving the problem.

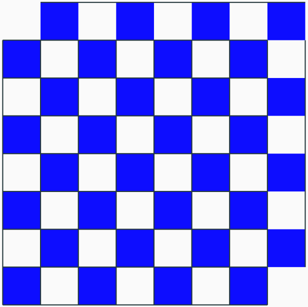


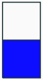
Transform and Conquer? Use Abstraction?

Can we cover this board with 31 tiles of the form shown?

Why can we quickly determine that the answer is no?

Hint: Using the way the squares are coloured helps.





Algorithms and Data Structures

Algorithms: for solving problems, transforming data.

Data structures: for storing data; arranging data in a way that suits an algorithm.

- Linear data structures: Stacks and queues
- Trees and graphs
- Dictionaries

Which data structures are you familiar with?

Exercise: Data Structures

Pick a data structure and describe:

- How to insert an item into the data structure
- How to find an item
- How to handle duplicate items

Primitive Data Structures: The Array

An array consists of a sequence of consecutive cells in memory.

Depending on programming language: `A[0]` up to `A[n-1]`, or `A[1]` up to `A[n]`.

Locating a cell, and storing or retrieving data at that cell is very fast.

The downside of an array is that maintaining a contiguous bank of cells with information can be difficult and time-consuming.

Primitive Data Structures: The Linked List

A collection of objects with links to one another, possibly in different parts of the computer's memory.

Often we use a dummy head node that points to the first object, or to a special `null` object that represents an empty list.

Inserting and deleting elements is very fast: just move a few links around.

Finding the *i*th element can be time-consuming.

Iterative Processing

Walk through the array or linked list. For example, to locate an item.

```
j := 0
while j < last
  if A[j] == x
    return j
  j := j+1
return null
```

```
p := head
while p != null
  if p.val == x
    return p
  p := p.next
return null
```

Recursive Processing

Solve the problem on a smaller collection and use that solution to solve on the full collection.

```
function find(A,x,lo,hi)
  if lo > hi
    return null
  else if A[lo] == x
    return lo
  else
    return find(A,x,lo+1,hi)
```

Initial call: `find(A,x,0,last)`

```
function find(p,x):
  if p == null
    return p
  else if p.val == x
    return p
  else
    return find(p.next,x)
```

Initial call: `find(head,x)`

We return to recursion in more depth later.

Abstract Data Types

A collection of data items, and a family of operations that operate on that data.

Think of an ADT as a set of promises, or contracts.

We must still implement these promises, but it is an advantage to separate the implementation of the ADT from the “concept”.

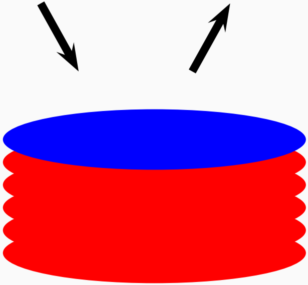
Good programming practice is to support this separation: Nothing outside of the definitions of the ADT should refer to anything inside, except through function calls for the basic operations.

Fundamental Data Structures: The Stack

Last-in-first-out (LIFO).

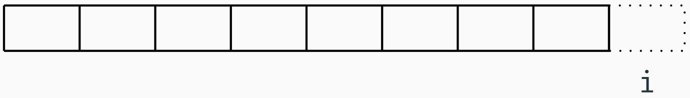
Operations:

- CreateStack
- Push
- Pop
- Top
- EmptyStack?
- ...

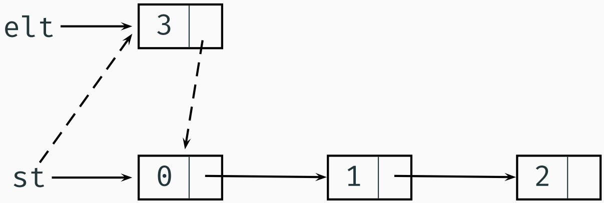


Usually implemented as an ADT.

By array:



By linked list (push):

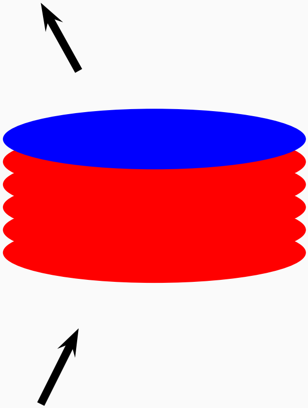


Fundamental Data Structures: The Queue

First-in-first-out (FIFO).

Operations:

- CreateQueue
- Enqueue
- Dequeue
- Head
- EmptyQueue?
- ...



Other Data Structures

We shall meet many other (abstract) data structures, such as

- The priority queue
- Various types of “tree”
- Various types of “graph”

Next Up

Algorithm analysis - how to reason about an algorithm's resource consumption.