CSE 373: The ADT Toolbox

Miscellaneous

What We've Done

Up to this point, we've looked at a variety of fundamental data structures, each with its own unique strengths and limitations:

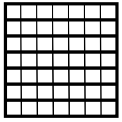
List:	*general-purpose storage*
Stack:	*FIFO ordering*
Queue:	*LIFO ordering*
Tree:	*hierarchical organization*
BST:	*searchable storage*
Hash Table:	*quick storage*
Heap:	*quick location of minimum*

The Toolbox

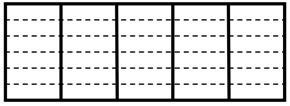
- These data structures are not the only ones you'll ever use or need
- Rather, think of them as a *basis set* from which you can build other data structures
  - by mixing multiple data structures
  - by adding additional functionality
  - by relaxing the "pure" version of the data structure

Mixing Data Structures

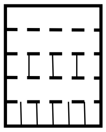
As we saw on day one, C's arrays and structures can be mixed and matched:



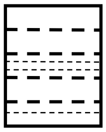
array of arrays



array of structures



structure of arrays



structure of structures

More Mixing Data Structures

This same thing can be done for all the data structures we've used in this class:

a… { List, Stack, Queue, Tree, BST, Hash Table, Heap } …*of*… { Lists, Stacks, Queues, Trees, BSTs, Hash Tables, Heaps }

- The Basil interpreter was a simple example of this (hash table of structs of trees…)

Adding Additional Functionality

In addition to the usual implementation of the data structure, add some more information

e.g., maze-solving example:

- most people kept a list of the moves they made to get to their current position
- once the goal was found, you could iterate over this list to find out its length (and if it was the shortest path)
- OR you could add a new field (inside or outside the List ADT) that would keep the length as the list grew
- though this doesn't change the algorithm asymptotically (this part of it is still O(n)), it may improve elegance

Relaxing the "Pure" ADT

We've already seen several examples of this:

- Microsoft's "recent documents list" is queue-like
  - but it only holds *n* elements at a time (breaks arbitrary size property)
  - if an document in the queue is accessed, it is removed and re-inserted at the back (breaks LIFO property)
- Avoiding some operators can change properties
  - `findMin`/`findMax` cheap on hash table if no deletes
- Iteration over hash tables can be useful
  - to implement a general `findMin`/`findMax`, *e.g.*

Application: Min/Max Heap

I'd like a heap that supports both `deleteMin()` and `deleteMax()` efficiently

How could I do this?

Application: Multi-sorted List

It's easy to imagine writing a List ADT that always inserts data in sorted order

What if I wanted to have a list "sorted" by all of its fields?

- *e.g.*, I'd like to print it out sorted by last name, by first name, by student ID, by grade, etc.

Sample Application: UW Registry

Our naive implementation was to declare an array of size # *students* × # *classes*

- this used way too much memory for the complexity of data we were storing
- we oversimplified "indexing by UWID" since they start at 9?????? and C arrays start at 0

What else could we do?

Next Assignment: Sparse Arrays

Sparse Array: an array in which most values are identical

- thus, it is better to store only those values that differ
- a single copy of the *unrepresented value* (URV) is stored

Examples:

- UW registry (most students are not taking most classes)
- Many scientific computations/simulations

Sample Sparse Array Operations

(We'll be doing Sparse 2D arrays…)

- **Main operations:**
  - `Object Read(i,j)` – return the value at (*i*,*j*) if it's stored, the unrepresented value otherwise
  - `void Store(i,j,Object)` – store val at index (*i*,*j*); stop storing a value for that position if val == the URV
- **Iterators:** allow the user to iterate over the data by row or column
- **I/O:** support read/write of sparse arrays