CSSE 220 Day 26

Linked List Implementation
Data-structure-palooza

Checkout *LinkedLists* project from SVN

Questions

Data Structures

- Understanding the engineering trade-offs when storing data

Data Structures

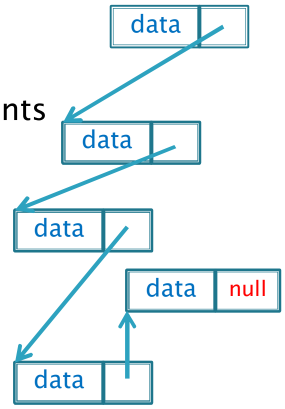
- Efficient ways to store data based on how we'll use it
- The main theme for the rest of the course
- So far we've seen ArrayLists
  - Fast addition **to end of list**
  - Fast access to any existing position
  - Slow inserts to and deletes from middle of list

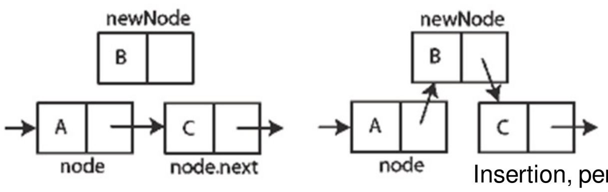
Q1

Another List Data Structure

- What if we have to add/remove data from a list frequently?
- LinkedLists support this:
  - Fast insertion and removal of elements
    - Once we know where they go
  - Slow access to arbitrary elements

"random access"





Insertion, per Wikipedia

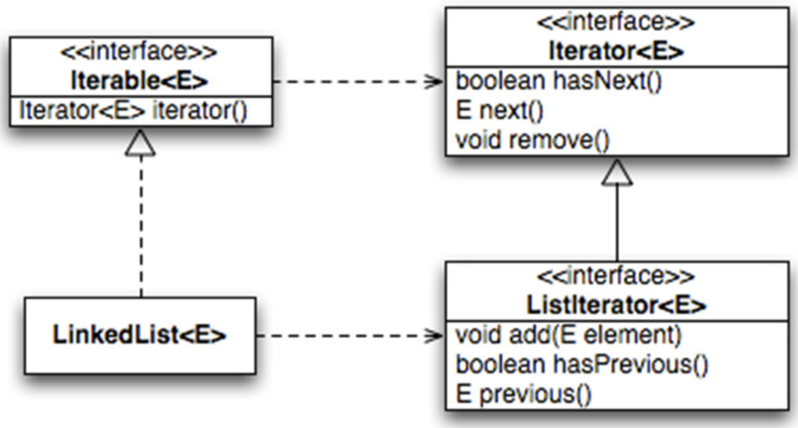
Q2, Q3

LinkedList<E> Methods

- `void addFirst(E element)`
- `void addLast(E element)`
- `E getFirst()`
- `E getLast()`
- `E removeFirst()`
- `E removeLast()`

- What about accessing the middle of the list?
  - `LinkedList<E> implements Iterable<E>`

Accessing the Middle of a LinkedList



An Insider's View

```
for (String s : list) {
  // do something
}
```

Enhanced For Loop

```
Iterator<String> iter =
    list.iterator();

while (iter.hasNext()) {
  String s = iter.next();
  // do something
}
```

What Compiler Generates

Implementing LinkedList

- A simplified version, with just the essentials
- Won't implement the java.util.List interface
- Will have the usual linked list behavior
  - Fast insertion and removal of elements
    - Once we know where they go
  - Slow random access

Abstract Data Types (ADTs)

- Boil down data types (e.g., lists) to their essential operations
- Choosing a data structure for a project then becomes:
  - Identify the operations needed
  - Identify the abstract data type that most efficient supports those operations
- Goal: that you understand several basic abstract data types and when to use them

Common ADTs

- Array List
- Linked List
- Stack
- Queue
- Set
- Map

Implementations for all of these are provided by the Java Collections Framework in the `java.util` package.

Array Lists and Linked Lists

Operations Provided	Array List Efficiency	Linked List Efficiency
Random access	O(1)	O(n)
Add/remove item	O(n)	O(1)

Stacks

- A last-in, first-out (LIFO) data structure
- Real-world stacks
  - Plate dispensers in the cafeteria
  - Pancakes!
- Some uses:
  - Tracking paths through a maze
  - Providing "unlimited undo" in an application

Operations Provided	Efficiency
Push item	O(1)
Pop item	O(1)

Implemented by **`Stack`**, **`LinkedList`**, and **`ArrayDeque`** in Java

Q4

Queues

- A first-in, first-out (FIFO) data structure
- Real-world queues
  - Waiting line at the BMV
  - Character on Star Trek TNG
- Some uses:
  - Scheduling access to shared resource (e.g., printer)

Operations Provided	Efficiency
Enqueue item	O(1)
Dequeue item	O(1)

Implemented by **`LinkedList`** and **`ArrayDeque`** in Java

Q5

Sets

- **Unordered** collections **without duplicates**
- Real-world sets
  - Students
  - Collectibles
- Some uses:
  - Quickly checking if an item is in a collection

Operations	HashSet	TreeSet
Add/remove item	O(1)	O(lg n)
Contains?	O(1)	O(lg n)

Can hog space

Sorts items!

Q6

Maps

- Associate **keys** with **values**
- Real-world "maps"
  - Dictionary
  - Phone book
- Some uses:
  - Associating student ID with transcript
  - Associating name with high scores

Operations	HashMap	TreeMap
Insert key-value pair	O(1)	O(lg n)
Look up value for key	O(1)	O(lg n)

Can hog space

Sorts items by key!

Q7

Markov Chaining

Demonstration

Q8—10

Markov Chain Progam

- Input: a text file

  the skunk jumped over the stump
  the stump jumped over the skunk
  the skunk said the stump stunk
  and the stump said the skunk stunk

- Output: a randomly generated list of words that is "like" the original input in a well-defined way

Markov Chain Process

- Gather statistics on word patterns by building an appropriate data structure
- Use the data structure to generate random text that follows the discovered patterns

Markov Example, n = 1

- Input: a text file

the skunk jumped over the stump
the stump jumped over the skunk
the skunk said the stump stunk
and the stump said the skunk stunk

Prefix	Suffixes
NONWORD	the
the	skunk (4), stump (4)
skunk	jumped, said, stunk, the
jumped	over (2)
over	the (2)
stump	jumped, said, stunk, the
said	the (2)
stunk	and, NONWORD
and	the

Markov Example, n = 2

- Input: a text file

the skunk jumped over the stump
the stump jumped over the skunk
the skunk said the stump stunk
and the stump said the skunk stunk

Prefix	Suffixes
NW NW	the
NW the	skunk
the skunk	jumped, said, the, stunk
skunk jumped	over
jumped over	the
over the	stump, skunk
the stump	the, jumped, stunk, said
…	

Output

- n=1:

`the skunk the skunk jumped over the skunk stunk`

`the skunk stunk`

- n=2:

`the skunk said the stump stunk and the stump jumped over the skunk jumped over the skunk stunk`

- Note: it's also possible to hit the max before you hit the last nonword.

Markov Data structures

- For the prefixes?
- For the set of suffixes?
- To relate them?

Prefix	Suffixes
NW NW	the
NW the	skunk
the skunk	jumped, said, the, stunk
skunk jumped	over
jumped over	the
over the	stump, skunk
the stump	the, jumped, stunk, said
…	