Linked Lists

Linda Seiter

Why are linked lists challenging to learn?

- Composition (LinkedList + Node) **and** Self-Referential Class (Node)
- Object traversal, null reference, circular reference
- Reference reassignment
- Abstract software object, not a "real world" object

Have students had sufficient practice with these concepts?

Composition Warmup Lesson

Where to store the relationship?

One-to-many:

- Book -< Review
- Order -< Item

Many-to-many:

- Publisher -< Book -< Review
- Customer -< Order -< Item

Object Traversal (code/debug activities):

- Total cost of items in order 123.
- All book reviews for publisher Z?
- Which customers purchased item J?

Self-Referential Warmup Lesson

Self-Referential Class:

- A person has a best friend
- A person has an oldest sibling
- A course has prerequisite(s)

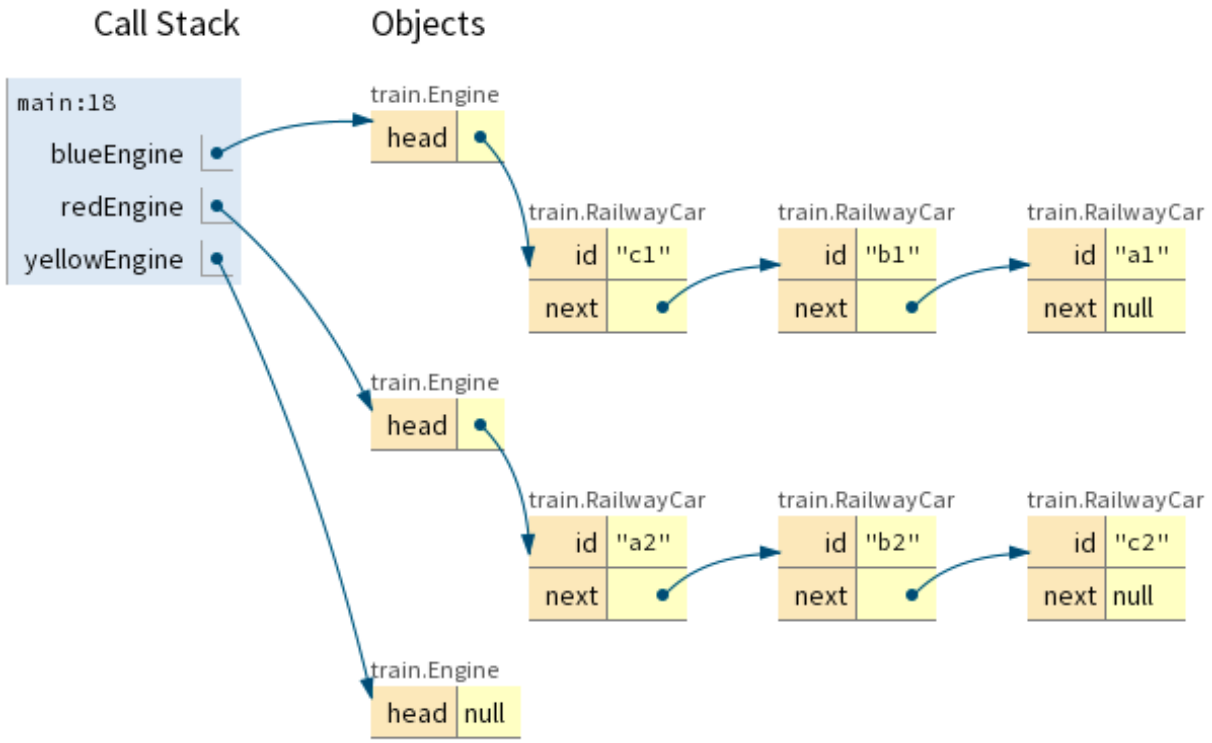
Object Traversal, Reference Reassignment (code/debug activities):

- Best friend’s best friend? Is X a prereq of Y? Oldest sibling’s best friend?
- Circular references (ok with friends, not ok with prereqs)
- Oldest sibling has new best friend, Dump best friend

Real World Composition + Self-Referential Warmup

Train engine pulling railway cars

```
public class RailwayCar {
    private String id;
    private RailwayCar next;

    ...
}

public class Engine {

    private RailwayCar head;

    public void addToFront(RailwayCar car) {
        ...
    }

    public void addToEnd(RailwayCar car) {
        ...
    }

    public void detach(String id) {
        ...
    }
}
```



Debugging helps students understand complex object concepts

- Map static algorithms/code to dynamic object state and control flow
- Learn how to find and fix errors
  - Visual debugger
  - Builtin IDE debugger

Warmup Assessment

- Worksheet: Object state <-> Code
- Coding Task: Update RailwayCar to store passenger class. Update Engine addTo..() methods to maintain class order:1st class cars, 2nd class cars, etc.
- Coding Task: Add a splice method that takes 2 car ids and removes that section of the train
- Coding Task: Update RailwayCar with fields for passenger capacity and occupancy. Update Engine with new method to load n passengers, starting with the front car. Method returns number of passengers unable to board.

Teaching Linked Lists

I've used Zybooks for some of my intro programming courses.

- Participation Activities (formative throughout lesson)
- Challenge Activities (summative per lesson)
- Exercises & Labs (summative per chapter)


Data Structures & Algorithms in Java, 6th Edition

Authors and contributors

Authors Michael T. Goodrich / University of California-Irvine
Roberto Tamassia / Brown University
Michael H. Goldwasser / Saint Louis University

Current release

June 2023 *Intended for class use in Fall 2023*

How I would tweak the lessons:

- **Non-Generics Singly Linked List (int or String)**
- Generics SLL
- Circular SLL
- **Circular SLL without explicit size field**
- **DLL without sentinels**
- DLL with sentinels
- Cloning, shallow vs deep copying

Use debugger to step through various implementations.

Assignment with 3-4 tasks

Some possibilities:

- Find the middle node of DLL
- Merge two linked lists
- Swap two nodes x and y (and not just their contents) in SLL given their references. Repeat for a DLL. Analyze the efficiency of each. Which algorithm takes more time?
- Given a circularly linked list containing an even number of nodes, implement a method two split into two circularly linked lists of half the size.
- Implement the DLL with a single sentinel that guards both ends.
- Implement a circular version of a doubly linked list, without any sentinels, that supports all the public behaviors of the original as well as two new update methods, rotate() and rotateBackward().