

Linked Lists

Linda Seiter

Why are linked lists so challenging to learn?

- Composition (LinkedList + Node) **and** Self-Referential (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)

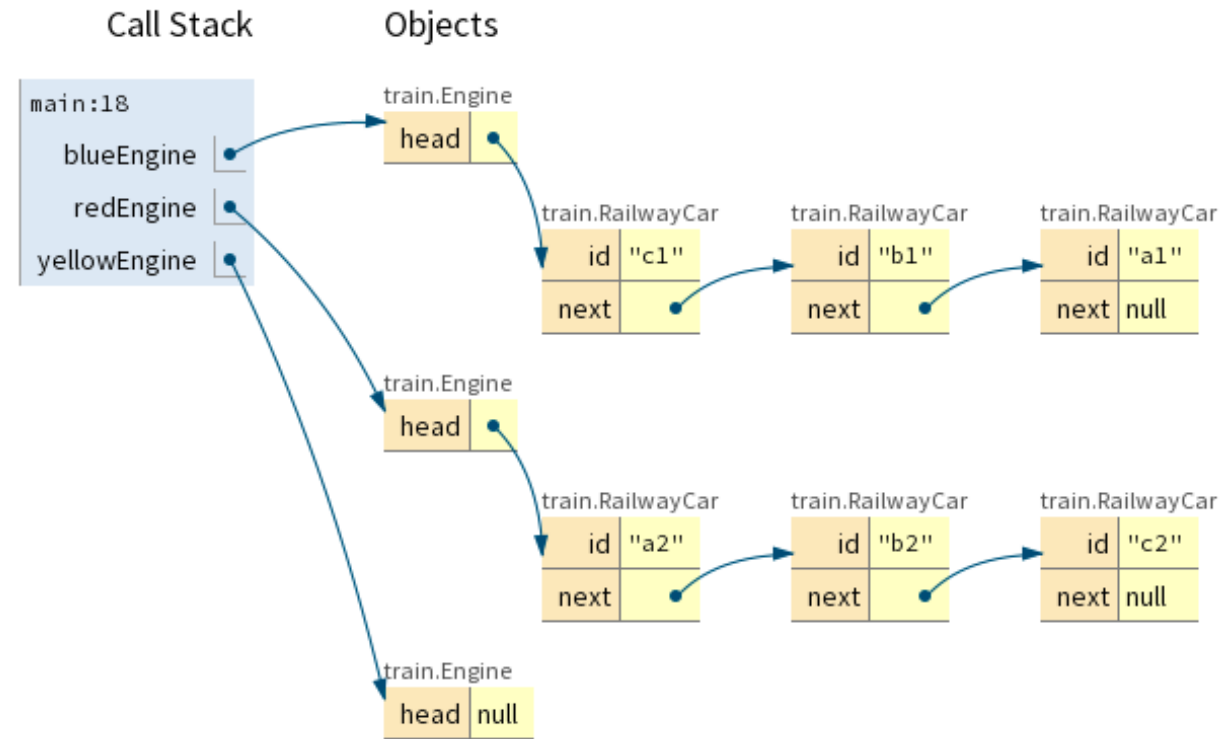
Object Traversal, Reference Reassignment (code/debug activities):

- 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 to help students understand object references

- Visual debugger
- Builtin IDE debugger

Linked List 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 field for weight. Update the Engine class with a field for maximum weight it can pull. Update Engine methods to prevent too heavy a load.

Teaching Linked Lists

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

- Participation Activities (formative throughout lesson)
- Challenge Activities (summative per lesson)

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*

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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 linked lists, shallow vs deep copying

Assignment with 4-5 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 to 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()`.