Lecture 10a: Linear Data Structures

CS 70: Data Structures and Program Development

Week of April 04, 2020

Motivation

ChunkyString (a CS70 Classic Linear Data Structure)

- HW 07 with current partner:
  - Plan and write pseudocode
  - Testing
    - 160 past student implementations
    - you try to break them
    - string-001 is a wrapper for `std::string`
- HW 08 with new partner:
  - Combine tests and plans
  - implement the core operations

Standard Linear Data Structures

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Every problem is different.

Why bother with "standardized" data structures? Arrays, stacks, vectors, trees, etc.

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Why bother with "standardized" data structures? Arrays, stacks, vectors, trees, etc.

We learn about standard data structures because doing so

- Gives us a common vocabulary
- Simplifies design
- Simplifies coding
- Simplifies documentation
- Simplifies maintenance
- Simplifies debugging
- Reusability
- Known performance characteristics

Stacks

Fundamental stack operations

Classically:

- `push(x)` – Add `x` onto top of stack
- `pop()` – Remove and return top of stack
- `isEmpty()` – Is the stack empty?

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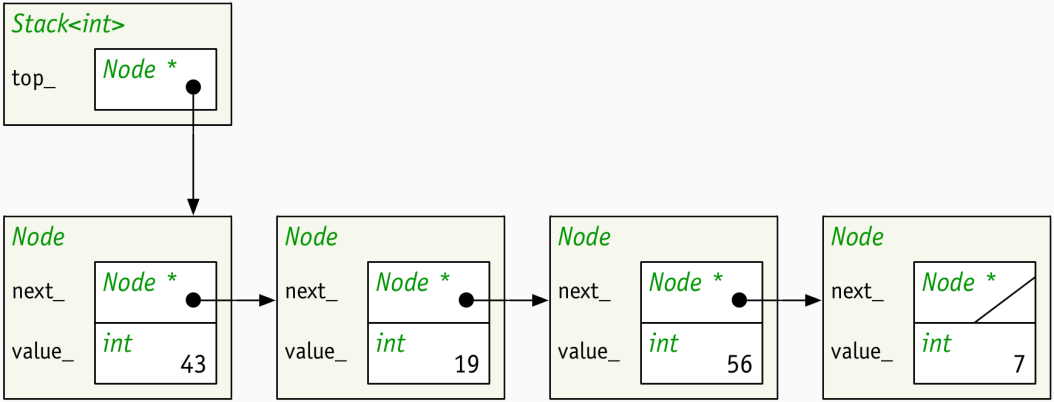
For C++ `std::stack<T>` (`#include <stack>`)

- `push(x)` – Add `x` onto top of stack
- `top()` – access the top element
- `pop()` – discards the top element
- `empty()` – Is the stack empty?

Stack Implementation: Singly Linked List



- How to return top element?
- How to pop (remove) top element?

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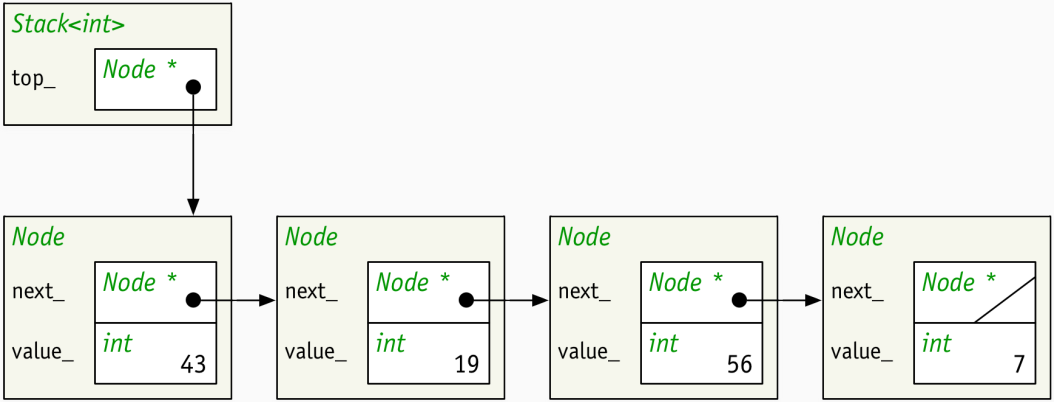
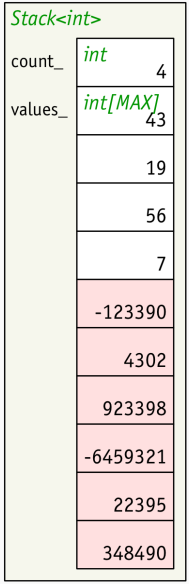


- How to push (insert) new top element?

Stack Implementation: Static Array



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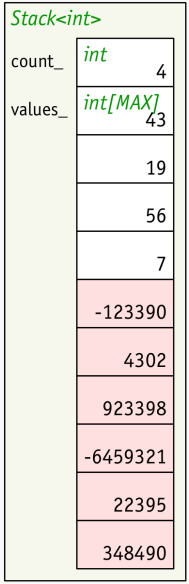

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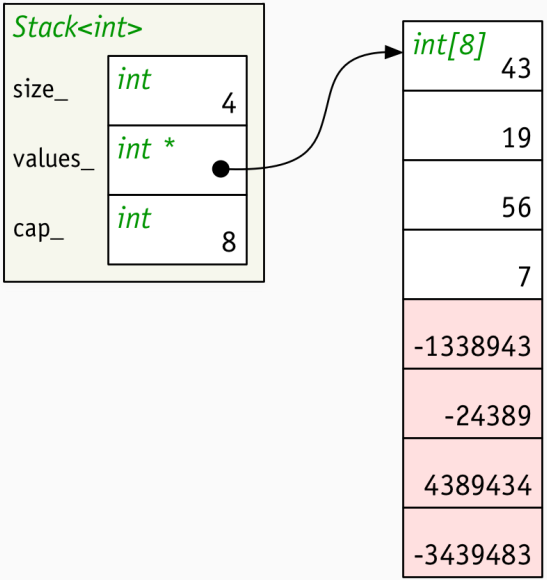

Tradeoffs: Arrays vs. Linked Lists

Arrays

- Time to access arbitrary element?

Arrays

- How much storage overhead?

Arrays

- How hard to do arbitrary insert?

Linked Lists

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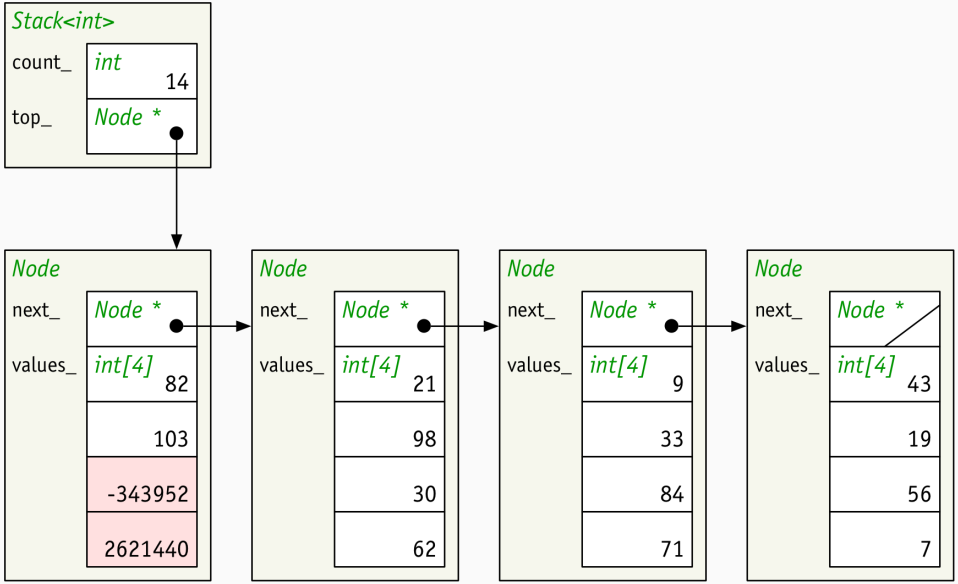
The Array / Linked List Spectrum

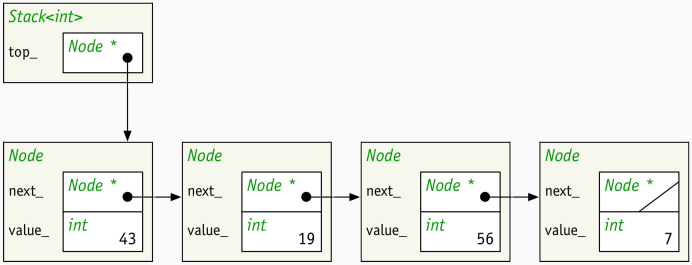
Stack Implementation: Chunky Lists (but why?)



Class Exercise

Suppose we'd like to have iterators for our stacks.

- What data must the iterator contain?
- What would ++ do?
- What would `begin()` and `end()` be?
- What order do we get stack items?
- If we push or pop, do iterators become "invalid"?



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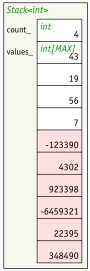

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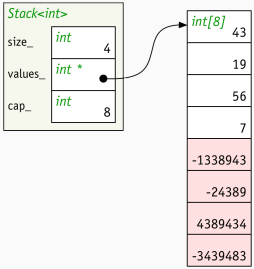

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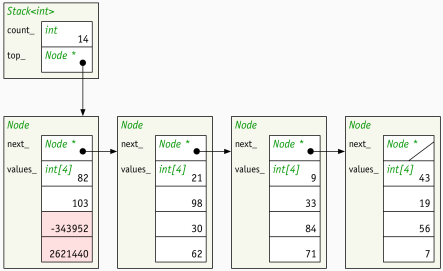

Queues

Fundamental queue operations

Classically:

- `enqueue(x)` – Add `x` onto back of queue
- `dequeue()` – Remove and return front of queue
- `isEmpty()` – Is the queue empty?

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- `isEmpty()` – Is the queue empty?

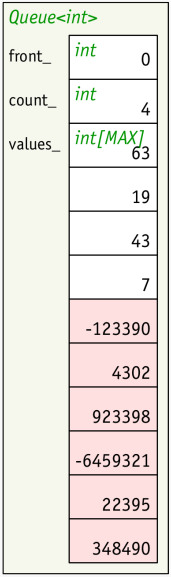
For C++ `std::queue<T>` (`#include <queue>`)

- `push(x)` – adds `x` to the back of the queue
- `front()` – access the front element
- `back()` – access the back element
- `pop()` – discards the front element
- `empty()` – Is the queue empty?

Stack or Queue?

a. FIFO
b. LIFO
c. FILO
d. LILO

Queue Implementation: Static Array



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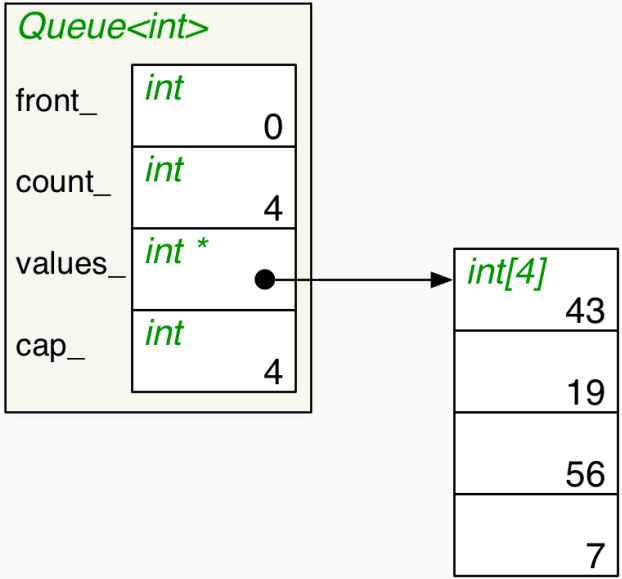
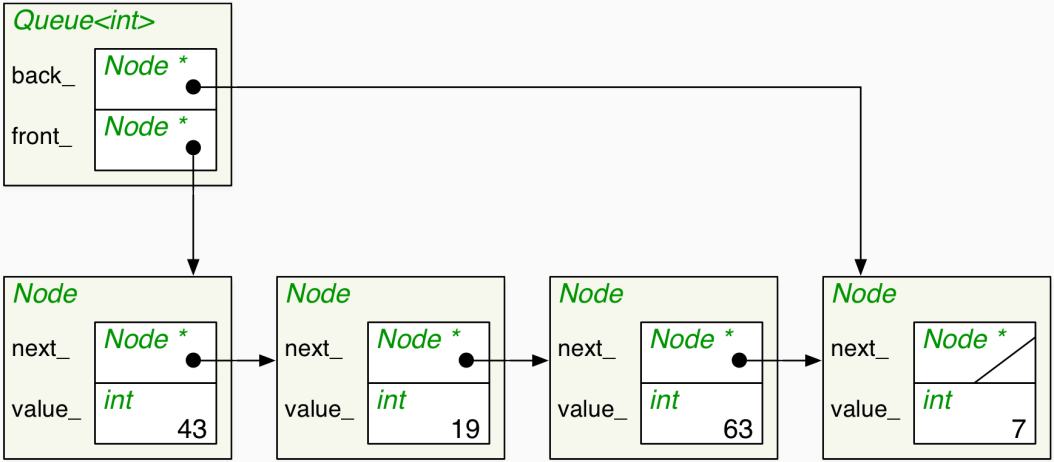
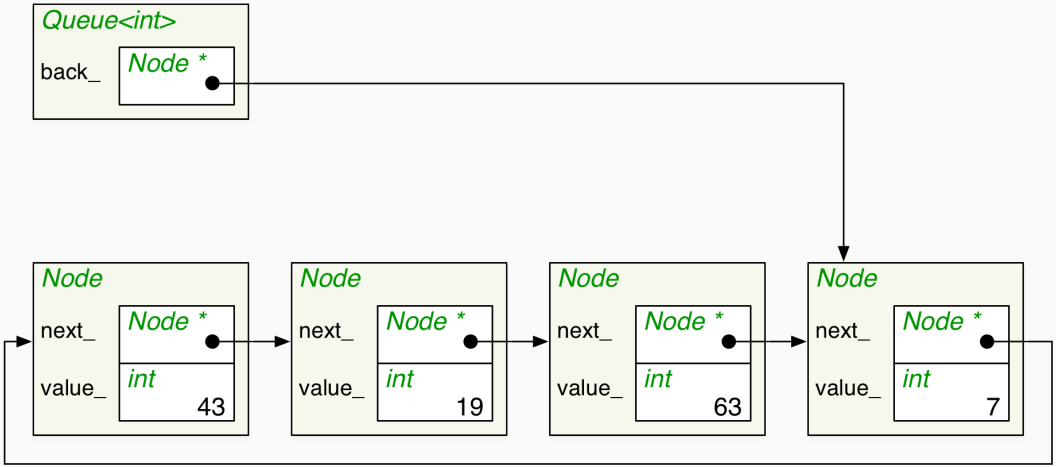


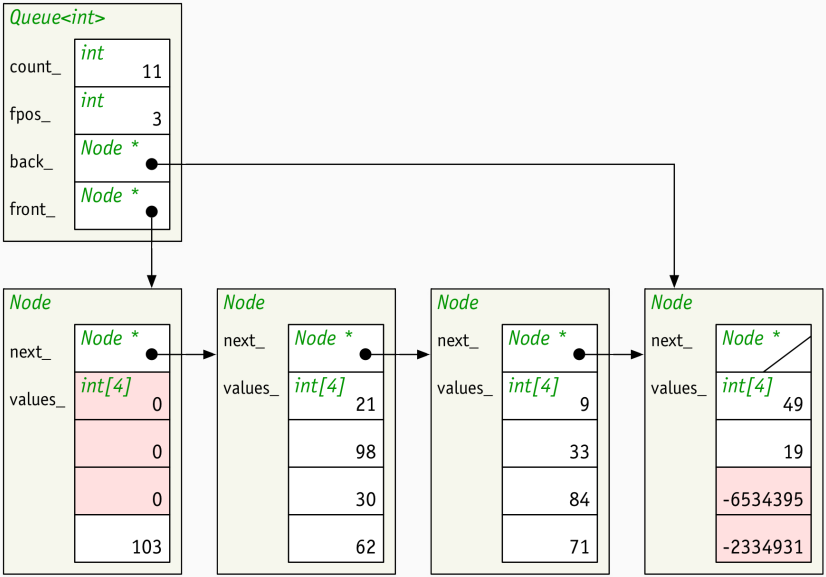
Queue Implementation: Linked List



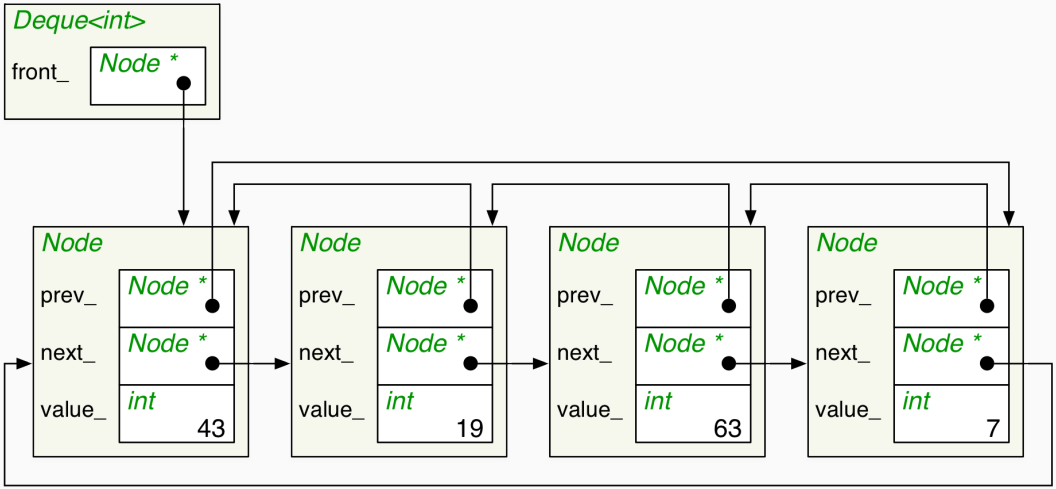
Queue Implementation: Circular Linked List



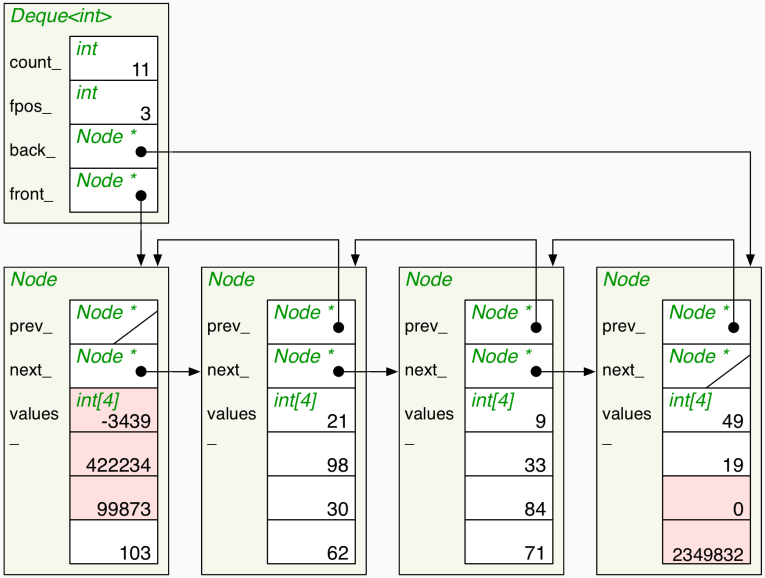
Queue Implementation: Chunky List



Deque (Double Ended Queue): via Circular Linked List



Chunky List


Deque<int>
count_
int
11
fpos_
int
3
back_
Node *
front_
Node *
Node
prev_
Node *
next_
Node *
values
int[4]
-3439
422234
99873
103
Node
prev_
Node *
next_
Node *
values
int[4]
21
98
30
62
Node
prev_
Node *
next_
Node *
values
int[4]
9
33
84
71
Node
prev_
Node *
next_
Node *
values
int[4]
49
19
0
2349832

Lists

A `List` class is more general than any of the previous data structures.

- Usually allows insertion and deletion at any point in the list
- May allow lists to be merged/spliced in constant time

Several varieties:

- Singly linked
- Circular singly linked
- Doubly linked
- Circular doubly linked

Learning Targets

For each of stacks, queues, chunky versions:

1. I can explain the public interface
2. I can describe several different implementation strategies
3. I can identify advantages & disadvantages of different implementations
4. I can design iterators for each implementation.