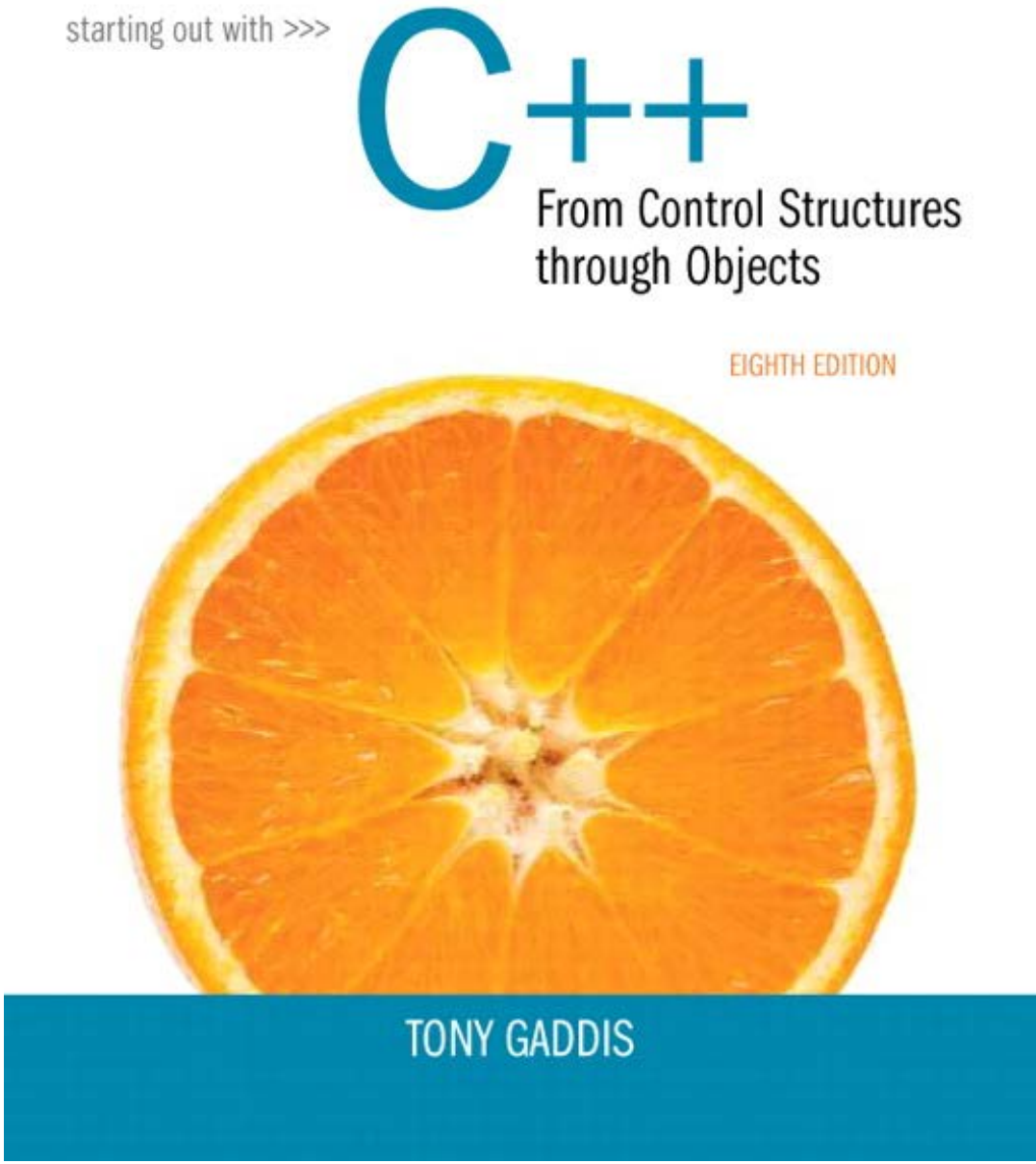
Chapter 18:

Stacks and Queues



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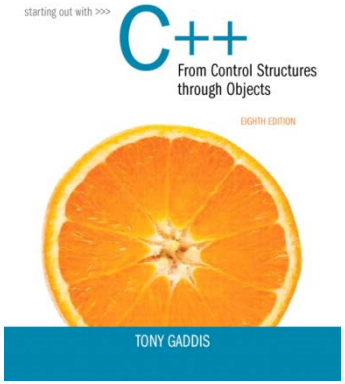

18.1

Introduction to the Stack ADT

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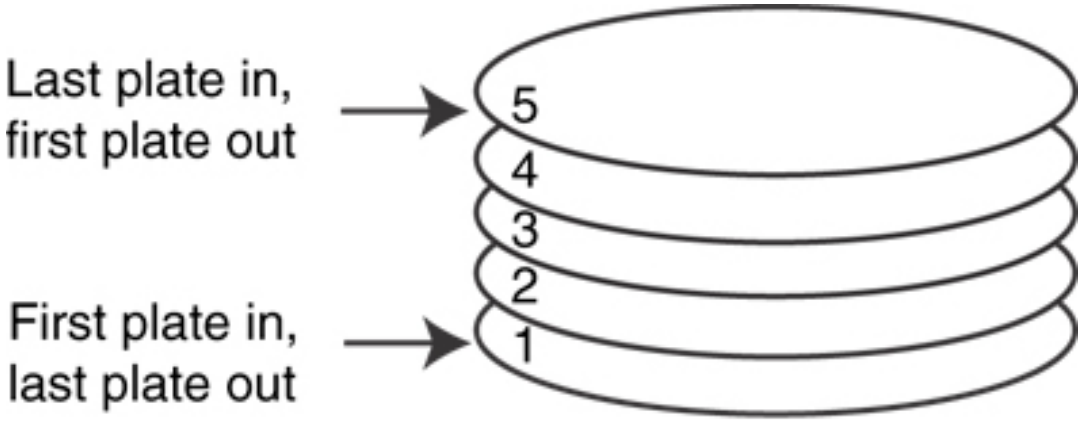
Introduction to the Stack ADT

- Stack: a LIFO (last in, first out) data structure
- Examples:
  - plates in a cafeteria
  - return addresses for function calls
- Implementation:
  - static: fixed size, implemented as array
  - dynamic: variable size, implemented as linked list

A LIFO Structure

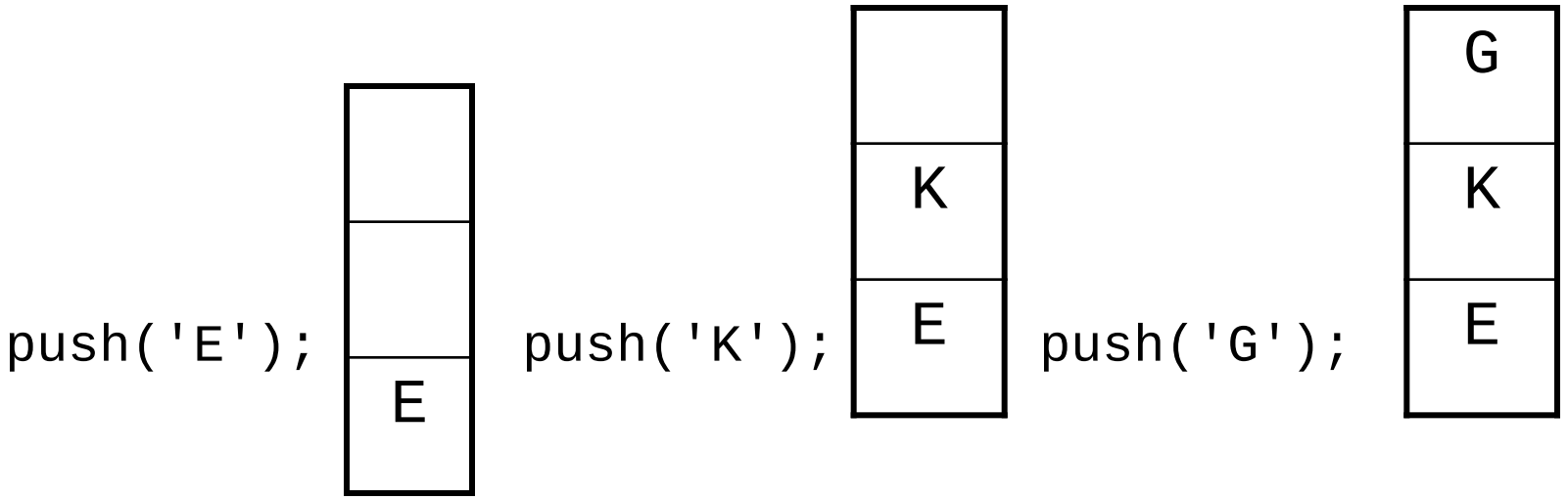


Stack Operations and Functions

- Operations:
  - push: add a value onto the top of the stack
  - pop: remove a value from the top of the stack
- Functions:
  - `isFull`: `true` if the stack is currently full, *i.e.*, has no more space to hold additional elements
  - isEmpty: `true` if the stack currently contains no elements

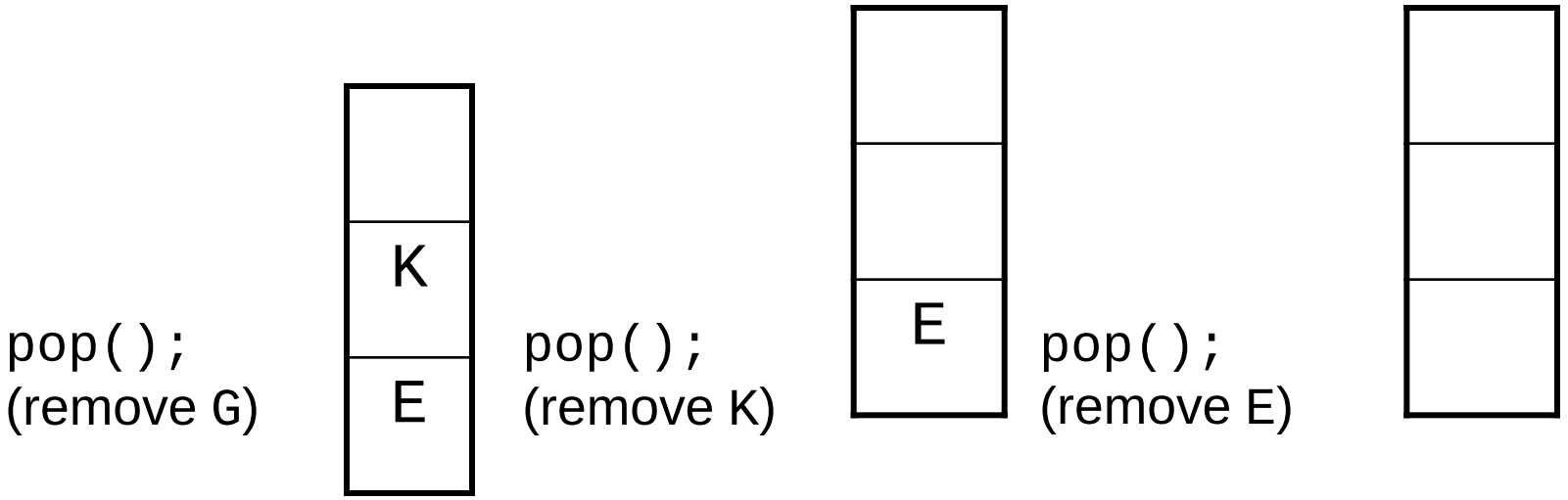
Stack Operations - Example

- A stack that can hold `char` values:



Stack Operations - Example

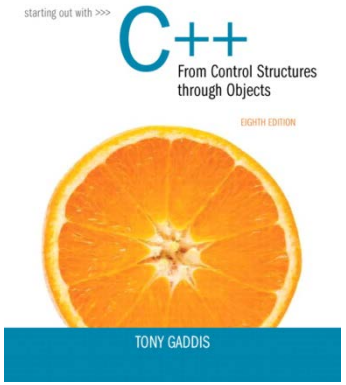
- A stack that can hold `char` values:



Contents of IntStack.h

```
1  // Specification file for the IntStack class
2  #ifndef INTSTACK_H
3  #define INTSTACK_H
4
5  class IntStack
6  {
7  private:
8     int *stackArray;  // Pointer to the stack array
9     int stackSize;    // The stack size
10    int top;          // Indicates the top of the stack
11
12 public:
13    // Constructor
14    IntStack(int);
15
16    // Copy constructor
17    IntStack(const IntStack &);
18
19    // Destructor
20    ~IntStack();
21
22    // Stack operations
23    void push(int);
24    void pop(int &);
25    bool isFull() const;
26    bool isEmpty() const;
27 };
28 #endif
```

(See `IntStack.cpp` for the implementation.)



18.2

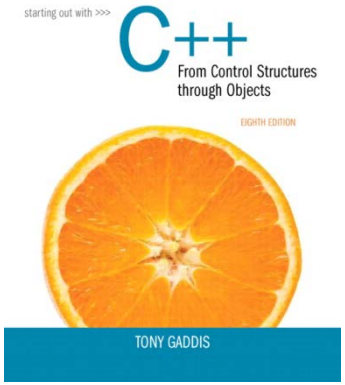
Dynamic Stacks

Dynamic Stacks

- Grow and shrink as necessary
- Can't ever be full as long as memory is available
- Implemented as a linked list

Implementing a Stack

- Programmers can program their own routines to implement stack functions
- See `DynIntStack` class in the book for an example.
- Can also use the implementation of stack available in the STL



18.3

The STL `stack` Container

The STL `stack` container

- Stack template can be implemented as a `vector`, a linked list, or a `deque`
- Implements `push`, `pop`, and `empty` member functions
- Implements other member functions:
  - `size`: number of elements on the stack
  - `top`: reference to element on top of the stack

Defining a `stack`

- Defining a stack of `chars`, named `cstack`, implemented using a `vector`:

```
stack< char, vector<char>> cstack;
```

- implemented using a list:

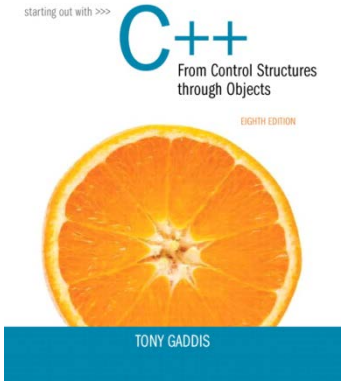
```
stack< char, list<char>> cstack;
```

- implemented using a `deque`:

```
stack< char > cstack;
```

- When using a compiler that is older than C++ 11, be sure to put spaces between the angled brackets that appear next to each other.

```
stack< char, vector<char> > cstack;
```



18.4

Introduction to the Queue ADT

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Introduction to the Queue ADT

- Queue: a FIFO (first in, first out) data structure.
- Examples:
  - people in line at the theatre box office
  - print jobs sent to a printer
- Implementation:
  - static: fixed size, implemented as array
  - dynamic: variable size, implemented as linked list

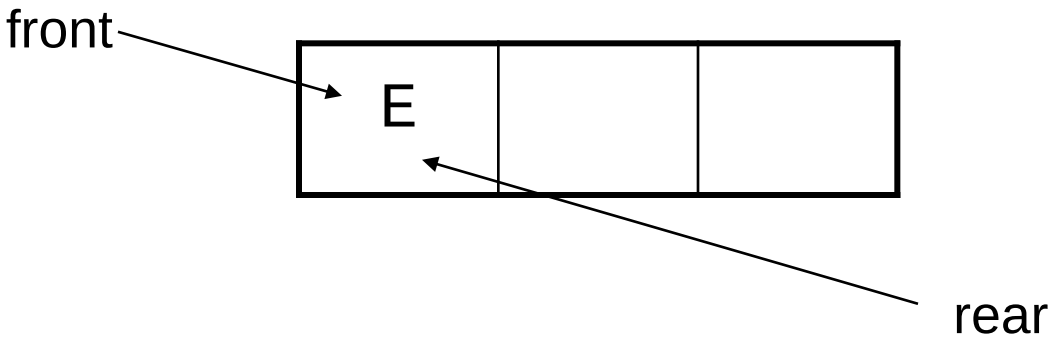
Queue Locations and Operations

- rear: position where elements are added
- front: position from which elements are removed
- enqueue: add an element to the rear of the queue
- dequeue: remove an element from the front of a queue

Queue Operations - Example

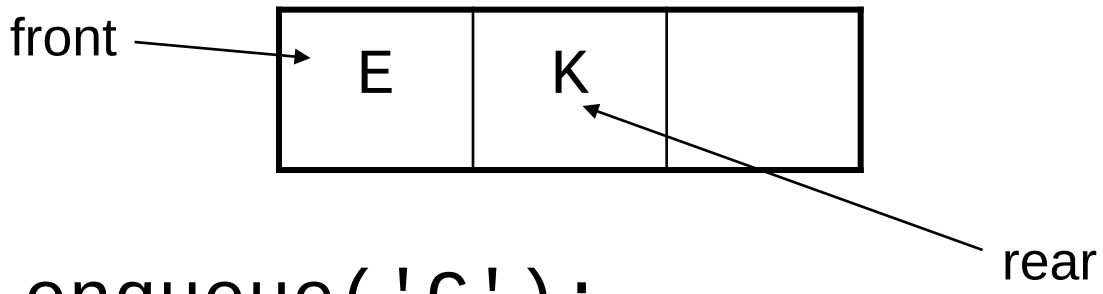
- A currently empty queue that can hold `char` values:

- `enqueue('E');`

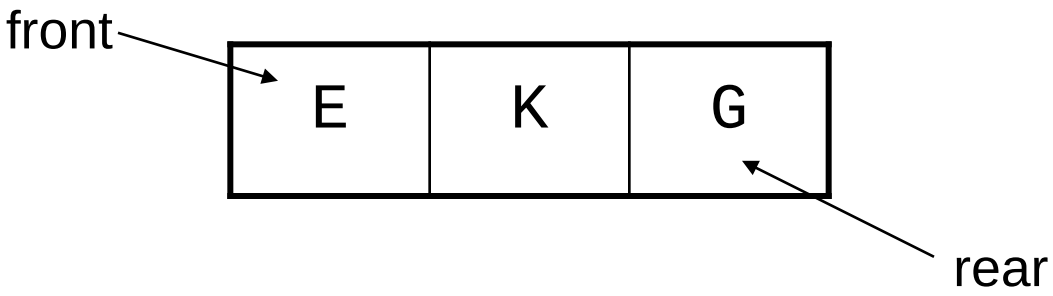


Queue Operations - Example

- `enqueue('K');`

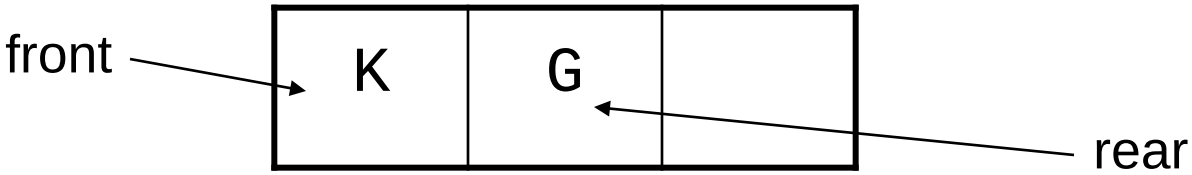


- `enqueue('G');`

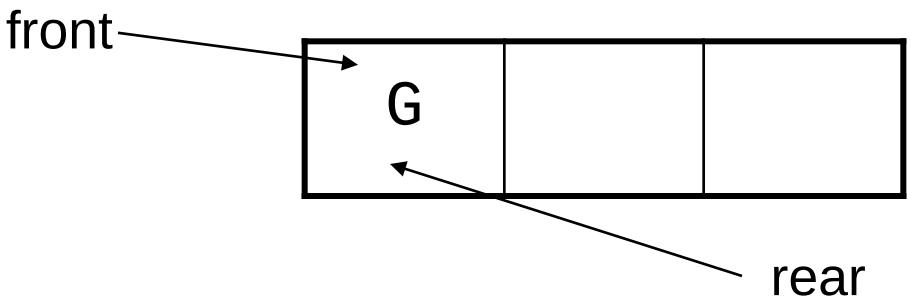


Queue Operations - Example

- `dequeue(); // remove E`



- `dequeue(); // remove K`



dequeue Issue, Solutions

- When removing an element from a queue, remaining elements must shift to front
- Solutions:
  - Let front index move as elements are removed (works as long as rear index is not at end of array)
  - Use above solution, and also let rear index "wrap around" to front of array, treating array as circular instead of linear (more complex enqueue, dequeue code)

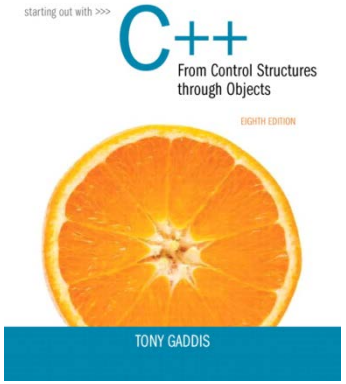
Contents of `IntQueue.h`

```
 1  // Specification file for the IntQueue class
 2  #ifndef INTQUEUE_H
 3  #define INTQUEUE_H
 4
 5  class IntQueue
 6  {
 7  private:
 8     int *queueArray;  // Points to the queue array
 9     int queueSize;    // The queue size
10     int front;        // Subscript of the queue front
11     int rear;         // Subscript of the queue rear
12     int numItems;     // Number of items in the queue
```

Contents of `IntQueue.h` (Continued)

```
13  public:
14     // Constructor
15     IntQueue(int);
16
17     // Copy constructor
18     IntQueue(const IntQueue &);
19
20     // Destructor
21     ~IntQueue();
22
23     // Queue operations
24     void enqueue(int);
25     void dequeue(int &);
26     bool isEmpty() const;
27     bool isFull() const;
28     void clear();
29  };
30  #endif
```

(See `IntQueue.cpp` for the implementation)



18.5

Dynamic Queues

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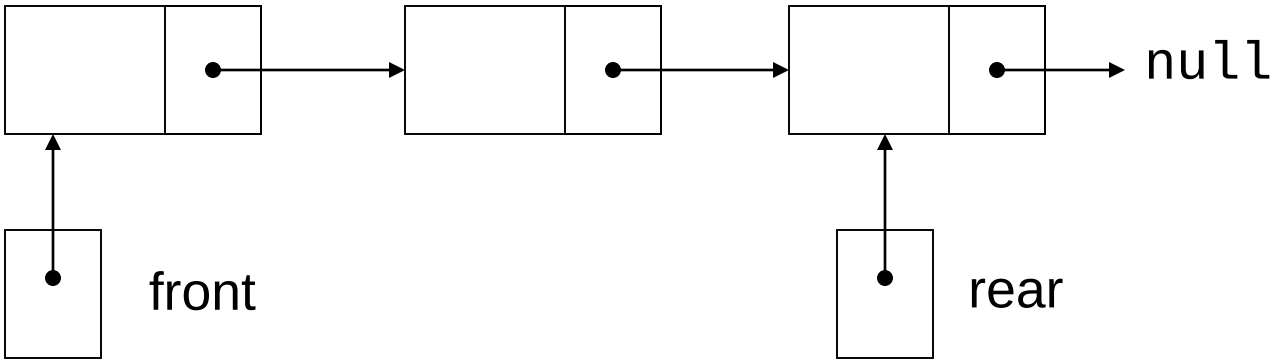
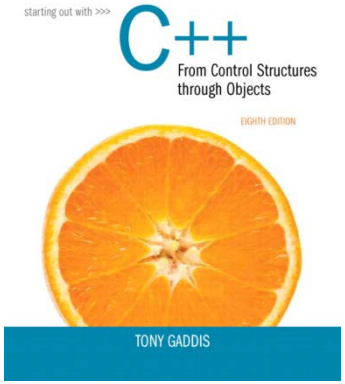
Dynamic Queues

- Like a stack, a queue can be implemented using a linked list
- Allows dynamic sizing, avoids issue of shifting elements or wrapping indices



Implementing a Queue

- Programmers can program their own routines to implement queue operations
- See the `DynIntQue` class in the book for an example of a dynamic queue
- Can also use the implementation of queue and dequeue available in the STL



18.6

The STL deque and queue Containers

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The STL deque and queue Containers

- `deque`: a double-ended queue. Has member functions to enqueue (`push_back`) and dequeue (`pop_front`)
- `queue`: container ADT that can be used to provide queue as a `vector`, list, or `deque`. Has member functions to enque (`push`) and dequeue (`pop`)

Defining a queue

- Defining a queue of `chars`, named cQueue, implemented using a deque:

```
deque<char> cQueue;
```

- implemented using a queue:

```
queue<char> cQueue;
```

- implemented using a `list`:

```
queue<char, list<char>> cQueue;
```