Queues

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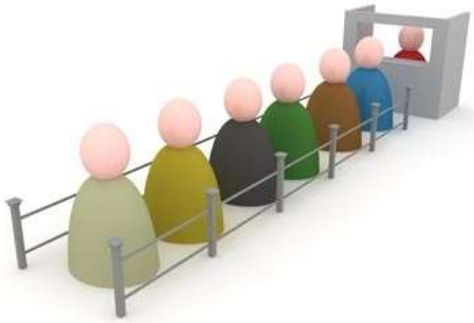
Queue

- What is a queue?
  - An ordered list where insertions occur at the rear while deletions occur at the front.
  - Also known as FIFO (first-in-first-out) list.
- Real-world examples



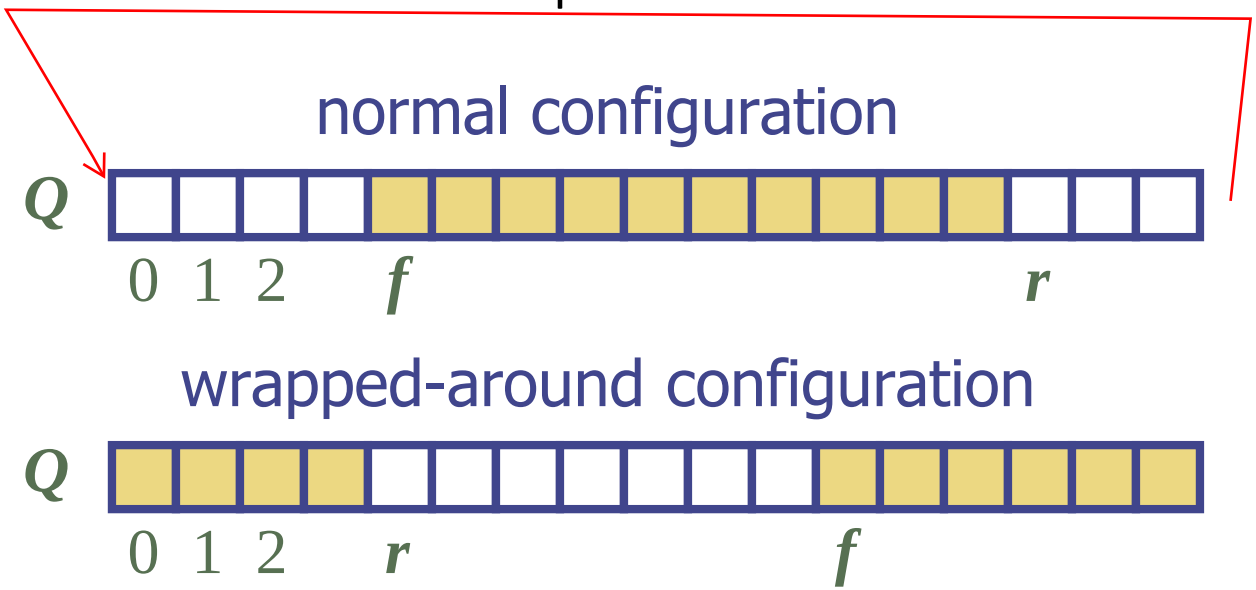
ADT of Queues

- Data
  - Arbitrary objects
- Operations
  - enqueue(object): inserts an element at the end
  - dequeue(): removes the element at the front
  - object front(): returns the element at the front without removing it
  - integer size(): returns the number of elements stored
  - boolean empty(): indicates whether no elements are stored
- Exceptions
  - dequeue() and front() cannot be performed if the queue is empty.
  - enqueue(object) cannot be performed if the queue is full.

Array-based Queues

To avoid element movement

- Use an array of size N in a circular fashion
- Three variables to keep track of the front and rear
  - f: index of the front element
  - r: index immediately past the rear element
  - n: number of items in the queue



Queue Interface in C++

- C++ interface corresponding to our Queue ADT
- Requires the definition of exception QueueEmpty
- Different from the built-in C++ STL class queue

```
template <typename E>
class Queue {
public:
   int size() const;
   bool empty() const;
   const E& front() const
      throw(QueueEmpty);
   void enqueue (const E& e);
   void dequeue()
      throw(QueueEmpty);
};
```

Queue Operations

```
Algorithm size()
  return n

Algorithm empty()
  return (n == 0)
```

```
Algorithm dequeue()
  if empty() then
    throw QueueEmpty
  else
    f ← (f + 1) mod N
    n ← n – 1
```

```
Algorithm enqueue(o)
  if size() = N – 1 then
    throw QueueFull
  else
    Q[r] ← o
    r ← (r + 1) mod N
    n ← n + 1
```

Why not N?

Modulo operator ("%" in C/C++)

STL Queue

- STL provides an implementation of a queue
  - Based on the STL vector class
  - Declaration

```
#include <queue>
using std::queue;                    // make queue accessible
queue<float> myQueue;                // a queue of floats
```

  - Operators

size():	Return the number of elements in the queue.
empty():	Return true if the queue is empty and false otherwise.
push(e):	Enqueue e at the rear of the queue.
pop():	Dequeue the element at the front of the queue.
front():	Return a reference to the element at the queue's front.
back():	Return a reference to the element at the queue's rear.

No exception is thrown if something goes wrong!

Extra for queues!

Operation		*Output*	*Q*
enqueue(5)	–	(5)	
enqueue(3)	–	(5, 3)	
dequeue()	*5*	(3)	
enqueue(7)	–	(3, 7)	
dequeue()	*3*	(7)	
front()	*7*	(7)	
dequeue()	*7*	()	
dequeue()	*"error"*	()	
isEmpty()		*true*	
enqueue(9)	–	(9)	
enqueue(7)	–	(9, 7)	
size()	*2*	(9, 7)	
enqueue(3)	–	(9, 7, 3)	
enqueue(5)	–	(9, 7, 3, 5)	
dequeue()	*9*	(7, 3, 5)	

Other Implementation of Queues

- We can also use linked lists to implement queues
  - Do not require contiguous memory
  - More codes for pointer manipulation
  - See textbook for more info.

Applications of Queues

- Access to shared resources
  - Printer
  - Requests received at a web server
- Breadth-first search (BFS) for graph traversal
- Many, many more…

Quiz!