Queues

- **Object visibility : public, private, protected**
- **Queues - another useful ADT**
  - **Class interface**
  - **Polymorphism**
  - **Using a List to represent a Queue**
  - **Using stacks to represent a Queue**

Object Visibility

- **Modifiers - applied to object declarations**
  - ***public*: visible wherever its class is visible**
    - **Few instance variable examples because this breaks ADT control over access**
  - ***private:* visible only within its own class**
    - **in Binary_Expr: operand1, operand2**
  - ***protected:* visible to subclasses and to other classes in same package**

Object Visibility

- *final:* **object may not be changed**
- *static:* **object is a class object**
  - **only one exists in its class, accessed using class_name.object_name**
  - **constants as in** `static final int limit = 30;`
- *no modifier:* **object is visible within its package only**

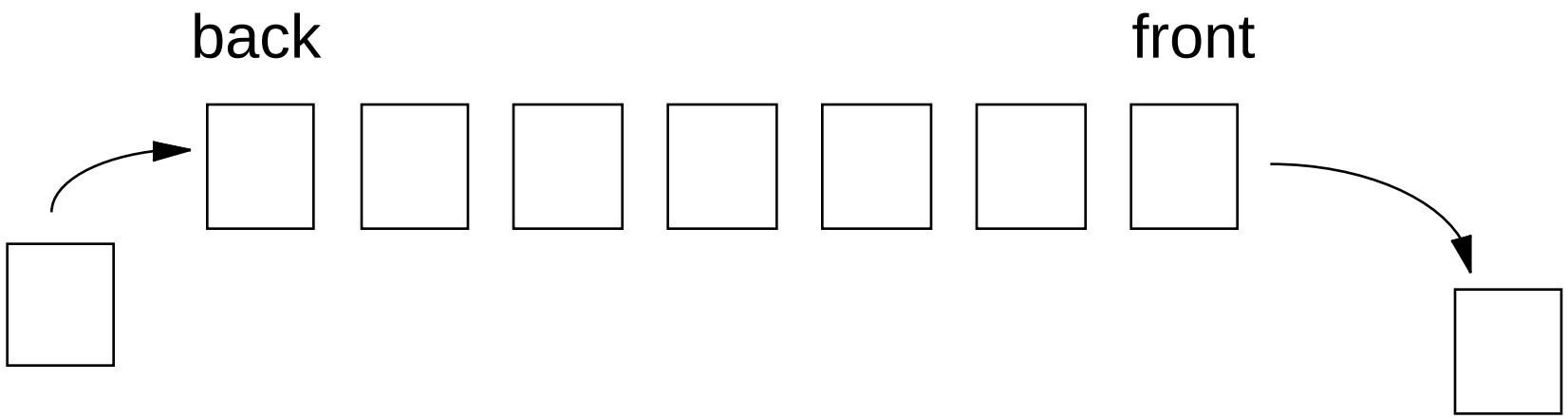
Queues

- **Example: waiting in line for anything**
- **Intuitively, something resembling a stream to which you can add or from which you can remove data**
- **Data is always removed from the front of a queue and added to the back of a queue**
- **Allows data items to be removed in the order in which they entered.**
- **FIFO discipline: First In First Out**

Queues

- **Used for simulations where order is important**
  - **e.g. restaurant patrons of one waiter, requests to use the printer received by an operating system, requests for special permission numbers by students**
- **Implementation is hidden from user and can be changed without changing program behavior**

Queues



What are the primitive operations of a queue?
How to hold objects in a queue?
How to provide access to them?
How to represent an empty queue?
Must design class to avoid special cases and to be efficient. How?

- use an array?
- use a linked list?

Queue Class: Instance Methods

- void enter(Object newItem)
- Object remove () throws QueueException
- Object peek() throws QueueException
- int getLength()
- boolean empty()
- String toString()
- Enumeration getEnumeration()

Instance Methods Specification

- **void enter(Object newItem)**
  - **adds new element to end of (back of) queue**
- **int getLength()**
  - **returns current number of items in queue**
- **boolean empty()**
  - **returns *true* if queue is empty, else *false***

Instance Methods Specification

- **String toString()**
  - **usual conversion for printing a queue object**
  - **uses individual toString() methods on each element**
- **Enumeration getEnumeration()**
  - **returns enumeration object corresponding to Queue receiver**
  - **Queue object not altered by enumeration**

Instance Method Specification

- **Object remove() throws QueueException**
  - **removes an element from front of queue**
- **Object peek() throws QueueException**
  - **returns the element at the front of queue WITHOUT removing it!**
- **remove() and peek() throw QueueException when invoked on an empty queue**
- **similar to Stack's pop() and peek()**

Queue Representation

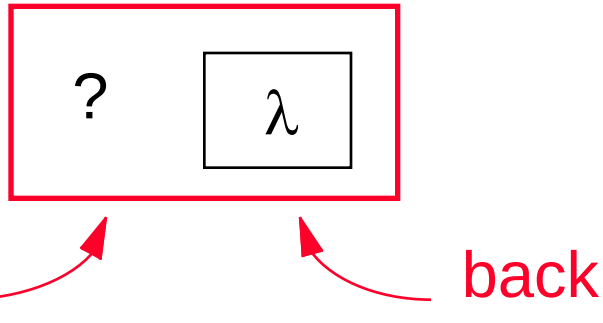
- **How to avoid special cases?**
  - **Adding to an empty queue**
  - **Removing from a queue with only 1 element**
- **Idea: use a fake header in front of every queue**
  - **Only subList field will contain significant information**
  - **Then special cases are eliminated (How?)**

Queue Representation

- **Front - a list**
  - **subList field contains actual list with info**
  - **info field not used**
- **Back - a list**
  - **info field contains last object in queue**
  - **subList field is null**
  - **is “innermost” list in queue representation**

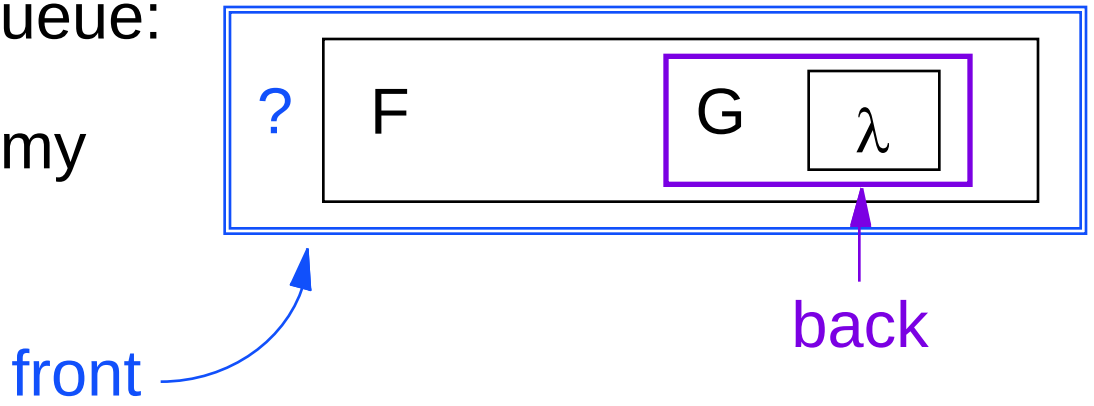
Queue Representation

empty queue:



non-empty queue:

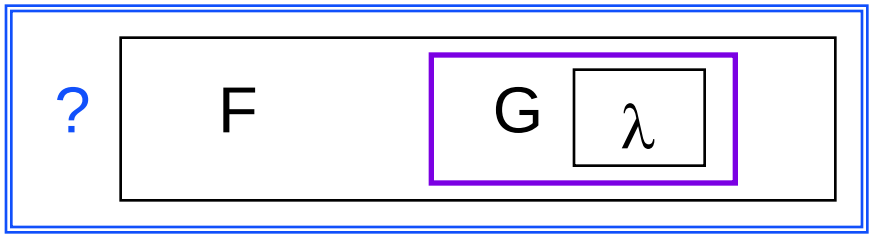
? is dummy info field



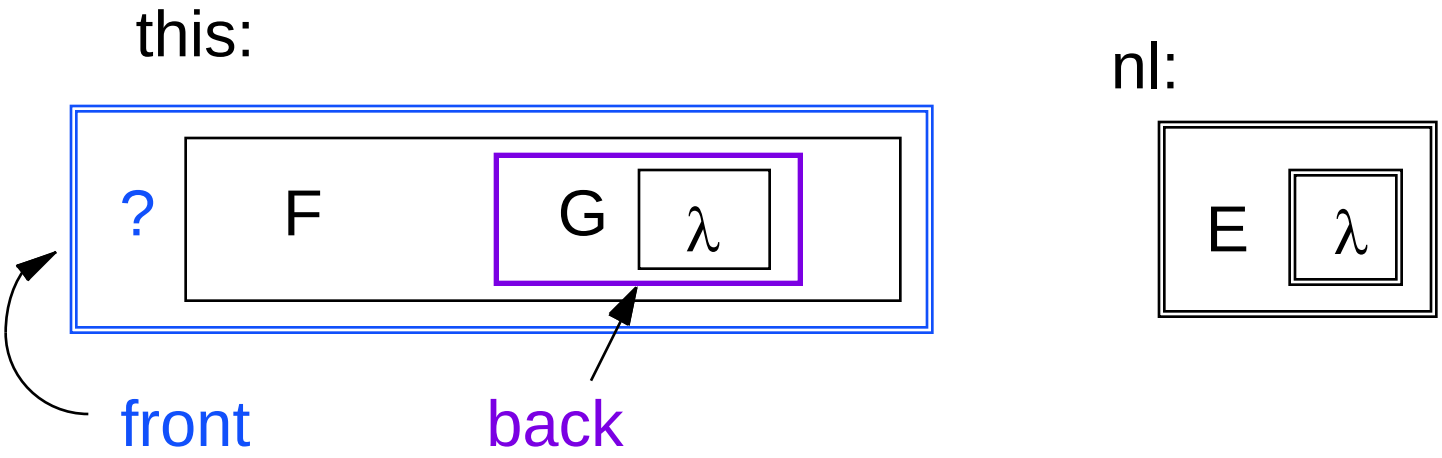
Enter Method

```
public void enter (Object newItem){
   List nl = new List (newItem,null);
   List oldBack = back;
   oldBack.subList = nl;
   back = nl;
   length++;
}
```

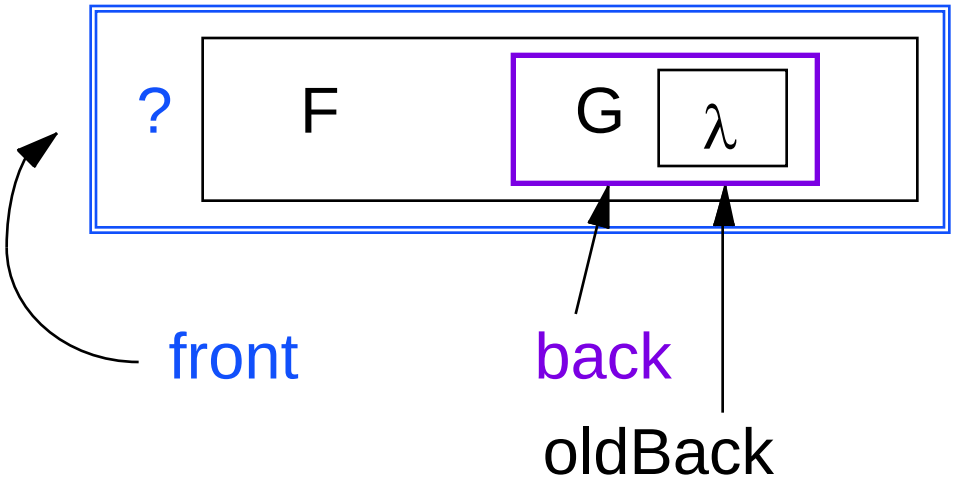
receiver: newItem: E



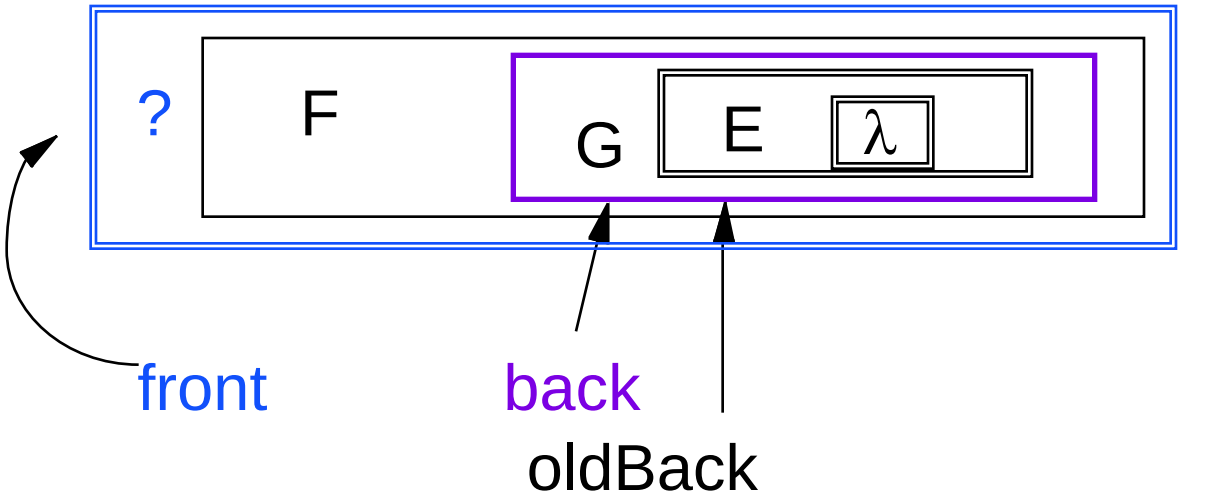
Enter - How it works?

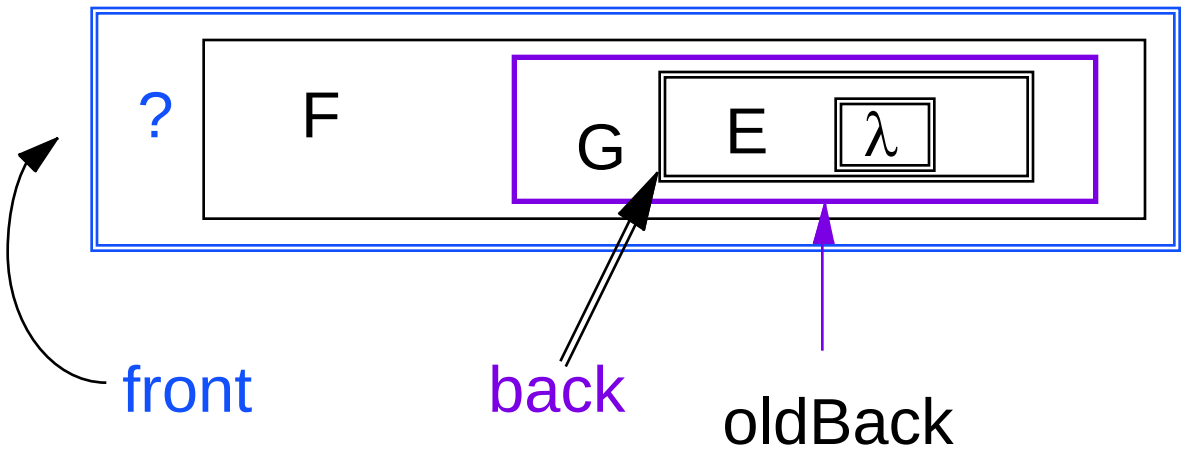


newItem: E

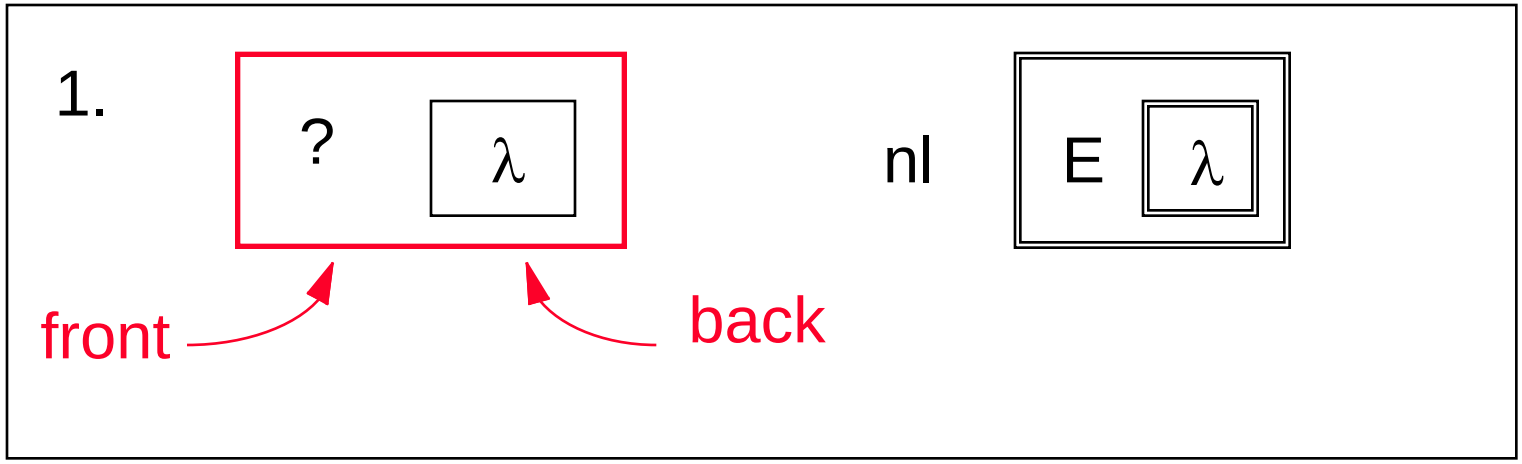


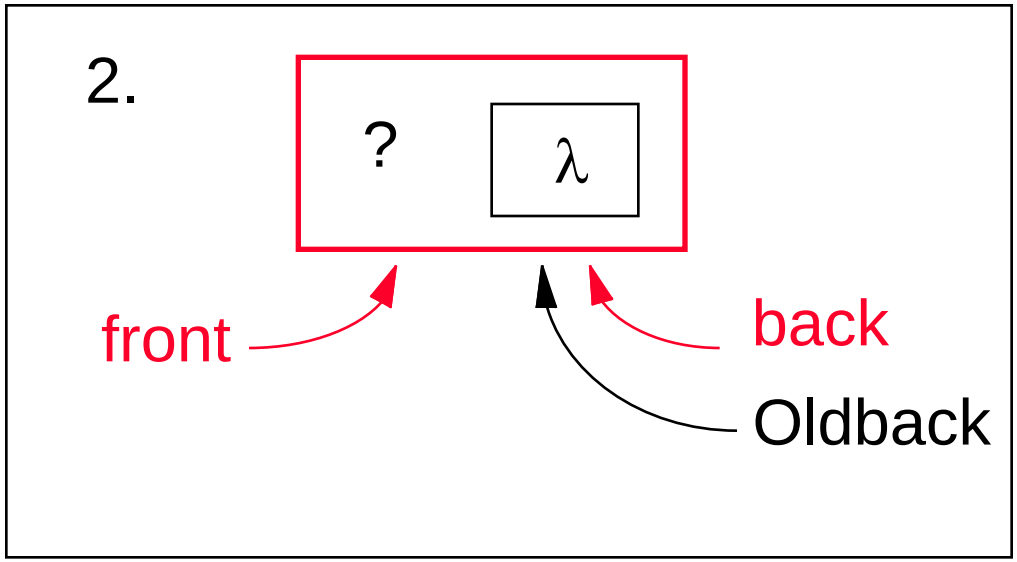
Enter - How it works?



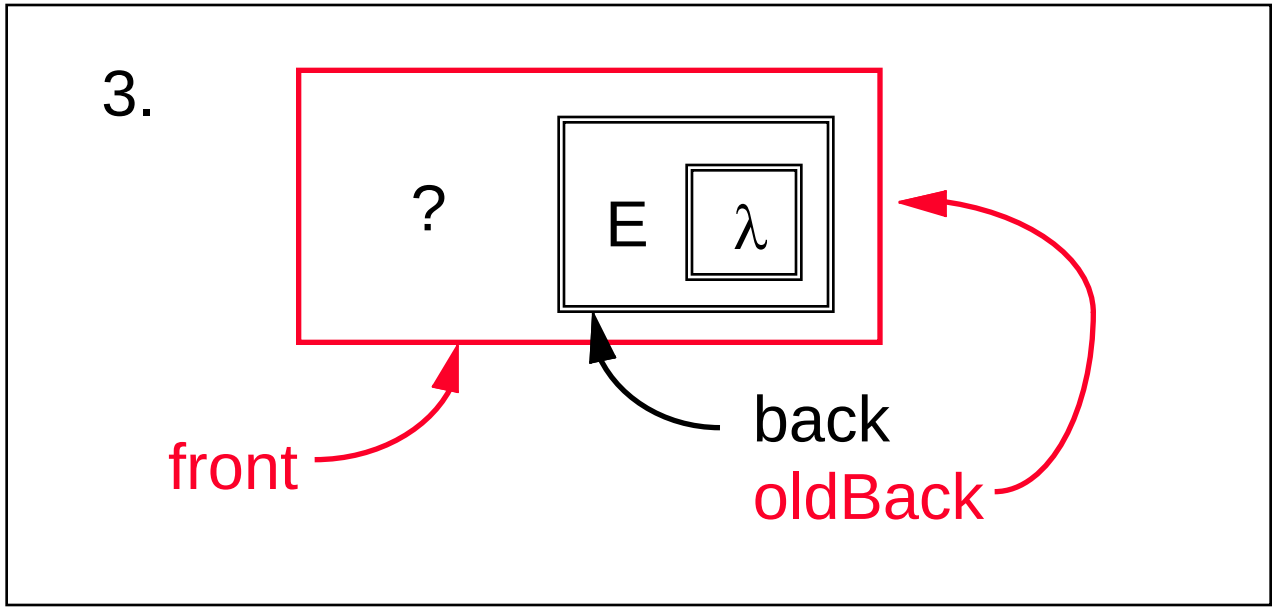


Enter(E) on Empty Queue





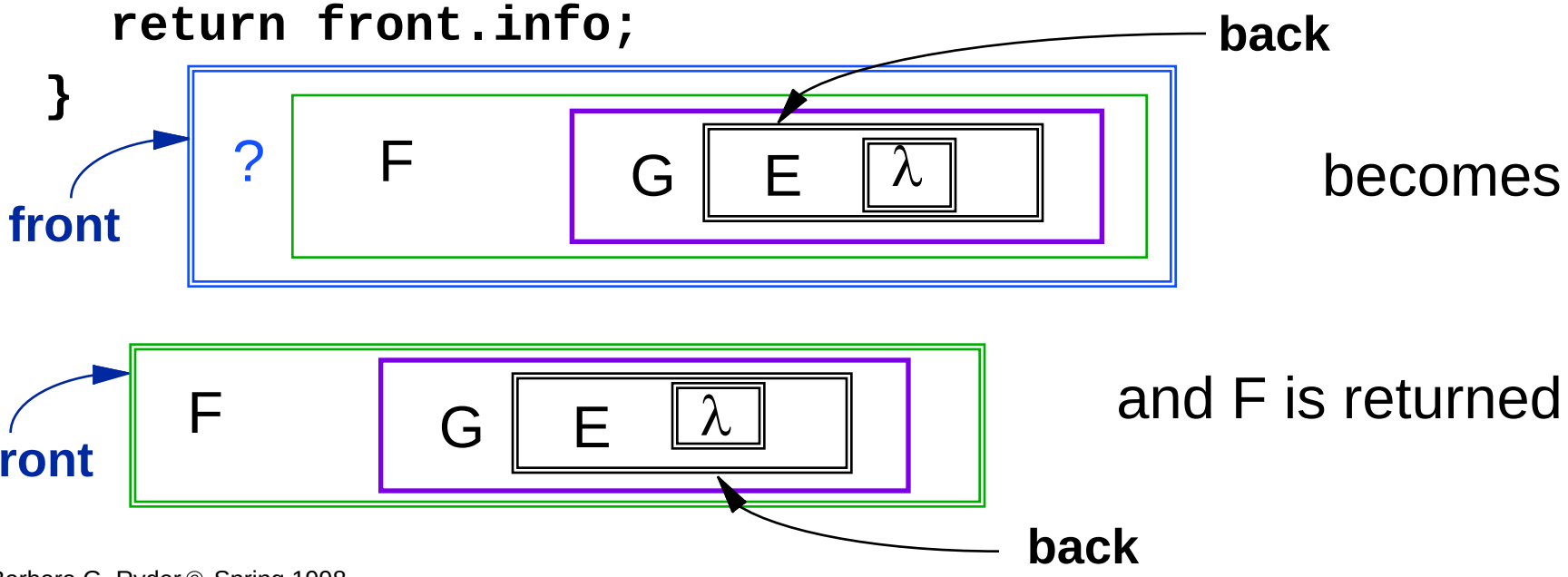
Enter(E) on empty Queue



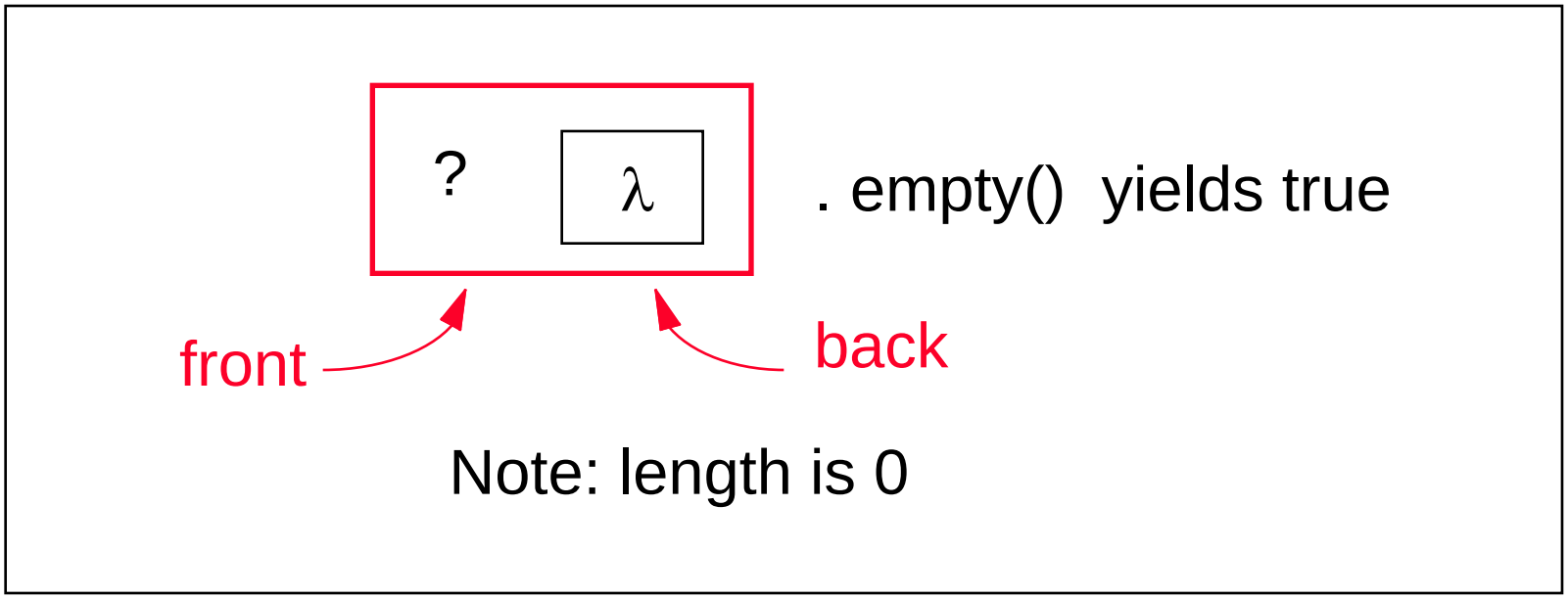
Note: this is treated just like an add to an already existing queue.

Method remove()

```
public Object remove() throws QueueException{
   if (empty())
       throw new QueueException("Attempt to remove" +
             + "from an empty queue");
   front = front.subList;//destructive operation
   length--;                  //changes receiver queue
   return front.info;
}
```



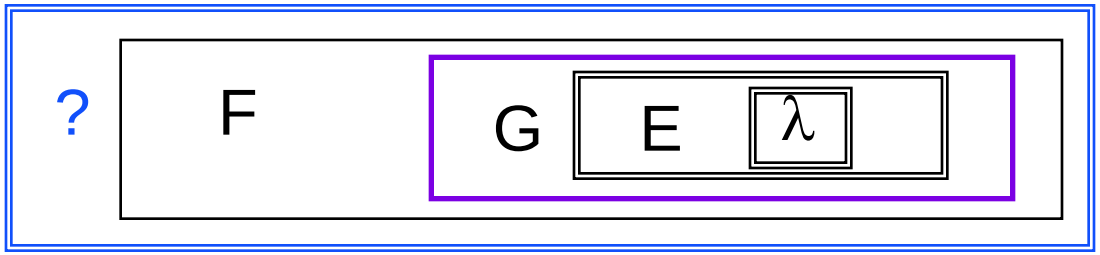
remove() on empty Queue



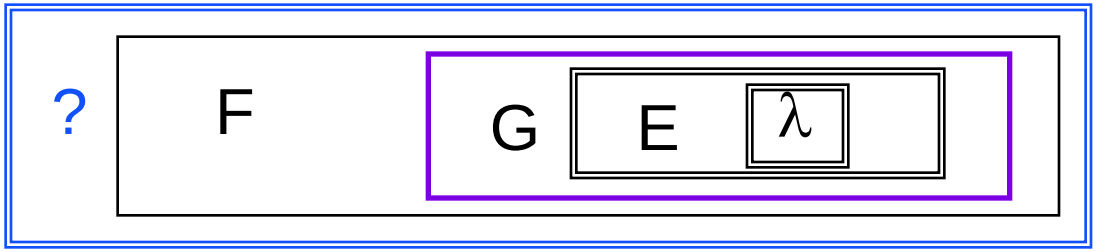
whereas null.empty() yields NullPointerException

Method peek()

```
public Object peek() throws QueueException{
  if (empty())
      throw new QueueException(" Attempt to peek"+
            "at an empty queue");
  return front.subList.info;
}//note no decrement to length here
```



remains as



and F is returned

Method toString() in Queue

```
public String toString(){
  String ret = "Queue length is " +
            Integer.toString(getLength()) + "\n";
  Enumeration qe = getEnumeration();
  String line = "";//empty String
  while (qe.hasMoreElements()) {
      line = line + (qe.nextElement()).toString();
      if (line.length() > 60){
            ret = ret + line + "\n";
            line = " ";
      }
      else line = line + " ";
  }
  return (ret + line + "\n");
}
```

polymorphism

choice of which toString() to call based on run-time type of object extracted