CS61B Lecture #4: Simple Pointer Manipulation

Announcement

- **Lecture Change:** Starting Friday, the MWF lecture is moving to 2040 VLSB.
- **Discussion Change:** Starting next Thursday (13 September), discussion section 111 (10-11AM) will move from 3109 Etch. to 6 Evans.

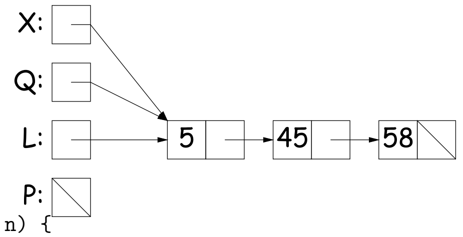
Today: More pointer hacking.

Destructive Incrementing

Destructive solutions may modify the original list to save time or space:

```
/** List of all items in P incremented by n. May destroy original. */
static IntList dincrList (IntList P, int n) {
  if (P == null)
    return null;
  else {
    P.head += n;
    P.tail = dincrList (P.tail, n);
    return P;
  }
}
```

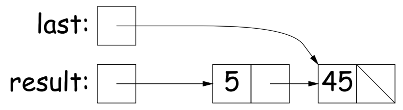
```
X = IntList.list (3, 43, 56);
/* IntList.list from HW #1 */
Q = dincrList (X, 2);
```



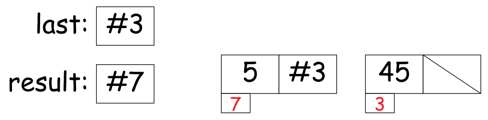
```
/** List L destructively incremented
 *  by n. */
static IntList dincrList (IntList L, int n) {
  // 'for' can do more than count!
  for (IntList p = L; p != null; p = p.tail)
    p.head += n;
  return L;
}
```

Another Way to View Pointers

- Some folks find the idea of “copying an arrow” somewhat odd.
- Alternative view: think of a pointer as a *label*, like a street address.
- Each object has a permanent label on it, like the address plaque on a house.
- Then a variable containing a pointer is like a scrap of paper with a street address written on it.
- One view:



- Alternative view:



Another Example: Non-destructive List Deletion

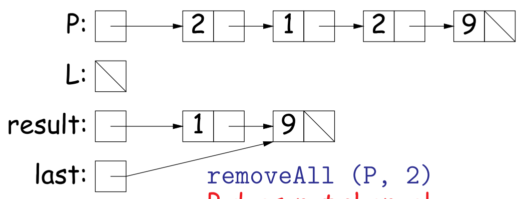
If L is the list [2, 1, 2, 9, 2], we want `removeAll(L,2)` to be the new list [1, 9].

```
/** The list resulting from removing all instances of X from L
 *  non-destructively. */
static IntList removeAll (IntList L, int x) {
  if (L == null)
     return null;
  else if (L.head == x)
     return removeAll (L.tail, x);
  else
     return new IntList (L.head, removeAll (L.tail, x));
}
```

Iterative Non-destructive List Deletion

Same as before, but use front-to-back iteration rather than recursion.

```
/** The list resulting from removing all instances of X from L
 *  non-destructively. */
static IntList removeAll (IntList L, int x) {
  IntList result, last;
  result = last = null;
  for ( ; L != null; L = L.tail) {
    /* L != null and ℐ is true. */
    if (x == L.head)
      continue;
    else if (last == null)
      result = last = new IntList (L.head, null);
    else
      last = last.tail = new IntList (L.head, null);
  }
  return result;
}
```



removeAll (P, 2)
P *does not* change!

Here, $\mathcal{I}$ is the *loop invariant:*

Result is all elements of L_0 not equal to x up to and not including L, and last points to the last element of result, if any. We use L_0 here to mean "the original value of L."

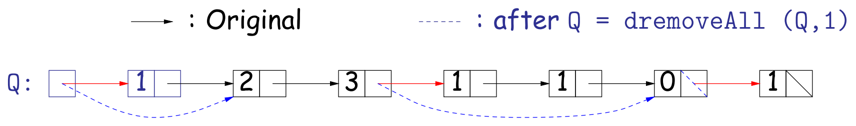
Aside: How to Write a Loop (in Theory)

- Try to give a description of how things look on *any arbitrary iteration* of the loop.
- This description is known as a *loop invariant*, because it is true from one iteration to the next.
- The loop body then must
  - Start from any situation consistent with the invariant;
  - Make progress in such a way as to make the invariant true again.

```
while (condition) {
  // Invariant true here
  loop body
  // Invariant again true here
}
// Invariant true and condition false.
```

- So if (*invariant* and not *condition*) is enough to insure we've got the answer, we're done!

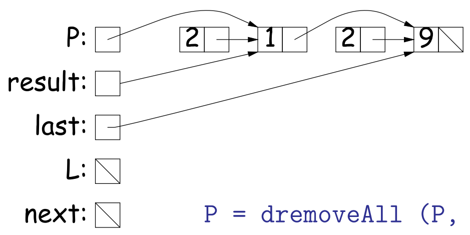
Destructive Deletion



```
/** The list resulting from removing all instances of X from L.
 *  The original list may be destroyed. */
static IntList dremoveAll (IntList L, int x) {
  if (L == null)
     return null;
  else if (L.head == x)
     return dremoveAll (L.tail, x);
  else {
     L.tail = dremoveAll (L.tail, x);
     return L;
  }
}
```

Iterative Destructive Deletion

```
/** The list resulting from removing all instances of X from L.
 *  Original contents of L may be destroyed. */
static IntList dremoveAll (IntList L, int x) {
  IntList result, last;
  result = last = null;
  while (L != null) {
    IntList next = L.tail;
    if (x != L.head) {
      if (last == null)
        result = last = L;
      else
        last = last.tail = L;
      L.tail = null;
    }
    L = next;
  }
  return result;
}
```



P = dremoveAll (P, 2)