CSE 143

Pointer-Based Linked Lists

[Chapter 4 p.157]

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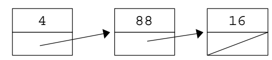
Linked Lists

- A linked list is a collection of “nodes” containing data
- Each node points to the next node in the list.
- That's it!
- Example: a list of 3 integers:



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Metacomment

- Linked lists -- a Great Idea In Programming
  - Simple, natural
  - Flexible

    Many variations are possible, once basic idea is mastered
- Linked lists are commonly implemented with dynamically allocated nodes
- But after all, this is C++.
  - So expect complications!

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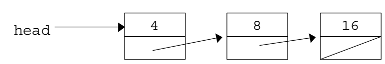
Implementing Linked Lists

- Each node has two members: a **data item** and a **next link** field which points to the successor node.
- The "next link" field of one node points to the next node in the list.
- Use a “head” or “front” variable to point to first node
- Example: a list of 3 integers:



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What’s the “data item”?

- Data is the same in every node of the list
  - Just like with arrays
- Could be ANY type: integer, double, Book, Bookshelf, Appointment, BankAccount, etc.
  - Most of our examples use int for simplicity

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Nodes for an int Linked List

- First we’ll declare a struct which we’ll use to represent a node:

```
struct Node {
   int item;
   Node* next;
};
```

- Now we can create new nodes:

```
Node* p;
p = new Node;
p->item = 100;     // shorthand for: (*p).item = 100
p->next = NULL;    // shorthand for: (*p).next = NULL
```

  - Note the use of the -> operator

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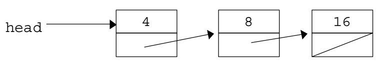
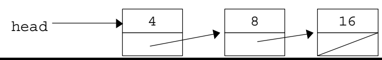
Printing a Linked List

```
Node* head;
. . . // Create list
Node* p;
p = head;
while (p != NULL) {
  cout << p->item;
  p = p->next;
}
cout << endl;
```



Summing a Linked List

```
int sumList(Node* p) {
  int sum = 0;
  while (p != NULL) {
    sum += p->item;
    p = p->next; }
  return sum
}
Node* head;
// build list ...
// print sum
cout << sumList(head) << endl;
```



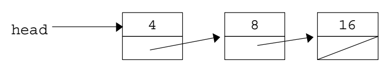
Manipulating Nodes

- Draw the picture that results from the following code:

```
Node* front;
Node* temp;

front = new Node;
front->item = 1;

front->next = new Node;
front->next->item = 2;
front->next->next = NULL; // what did we just do?

temp = front; front = front->next;
delete temp; // what did we just do?
```


Inserting a new link

Before:

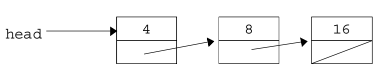


Insert "5" after 4.

After:

Deleting a link

Before:



Delete "8"

After:

Tips for Getting the Code Right

- Draw pictures
- These special cases often need slightly different code
  - Middle of the list
  - Beginning of the list
  - End of the list
  - Empty list
- Helper variables such prev, curr
  - make sure they have the right values!
- Careful as usual with dynamic memory
- Fail-safe programming: asserts, etc.
- Read code of others (e.g. textbook)

Recursion and Linked Lists

- A linked list is a recursive data structure
- Recursive algorithms are natural with linked lists
  - but not very efficient
- Good recursion practice!

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Printing a Linked List

```
void print(Node* first) {
  if (first == NULL)
    return;
  else {
    cout << endl << first->item;
    print(first->next);
  }
}
```

- How many recursive calls are needed?

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Printing in Reverse Order

- At first, seems difficult

  `All the pointers point only forward.`
- Recursion to the rescue!

```
void RPrint(Node* first) {
  if (first == NULL)
      return;
  else {
      RPrint(first->next);
      cout << endl << first->item;
    }
}
```

- Challenge: Try doing this without recursion

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Summing a List

```
int listSum(Node* list) {
  if (list == NULL)
    return 0;        // empty list has sum == 0
  else
    return list->item + listSum(list->next);
}
```

- Common pattern for a list "traversal"
- How would you modify this to...
  - Count the length of a list?
  - Add N to each element of a list?
  - Determine if a particular value occurred in the list?

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Puzzler: List Remove

- Make new list (copy), same data as old, except: don't include nodes with a given data value in the new list
  - The original list is to be unchanged!

```
Node* ListRemove(Node *first, int v);
```

- Draw a picture of an example first!
  - If you can't draw the picture, how can you hope to program it?

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Node* ListRemove(Node *first, int v)

```
{
  if (first == NULL)
    return NULL;
  else if (first->item != v){
        //make a node for the new list, copy data
    Node* newNode = new Node;
    newNode->item = first->item;
    newNode->next = ListRemove(first->next, v);
    return newNode;
  }
  else
    return ListRemove(first->next, v);
}
```

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Another Approach to Lists

- Some programmers use a slightly different approach to implementation
  - 1. Have a permanent, dummy node as the header
  - 2. Point the last link of the chain back to the dummy (header) node
- All the code changes!
  - On balance, may be a little simpler; fewer special cases when inserting and deleting

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