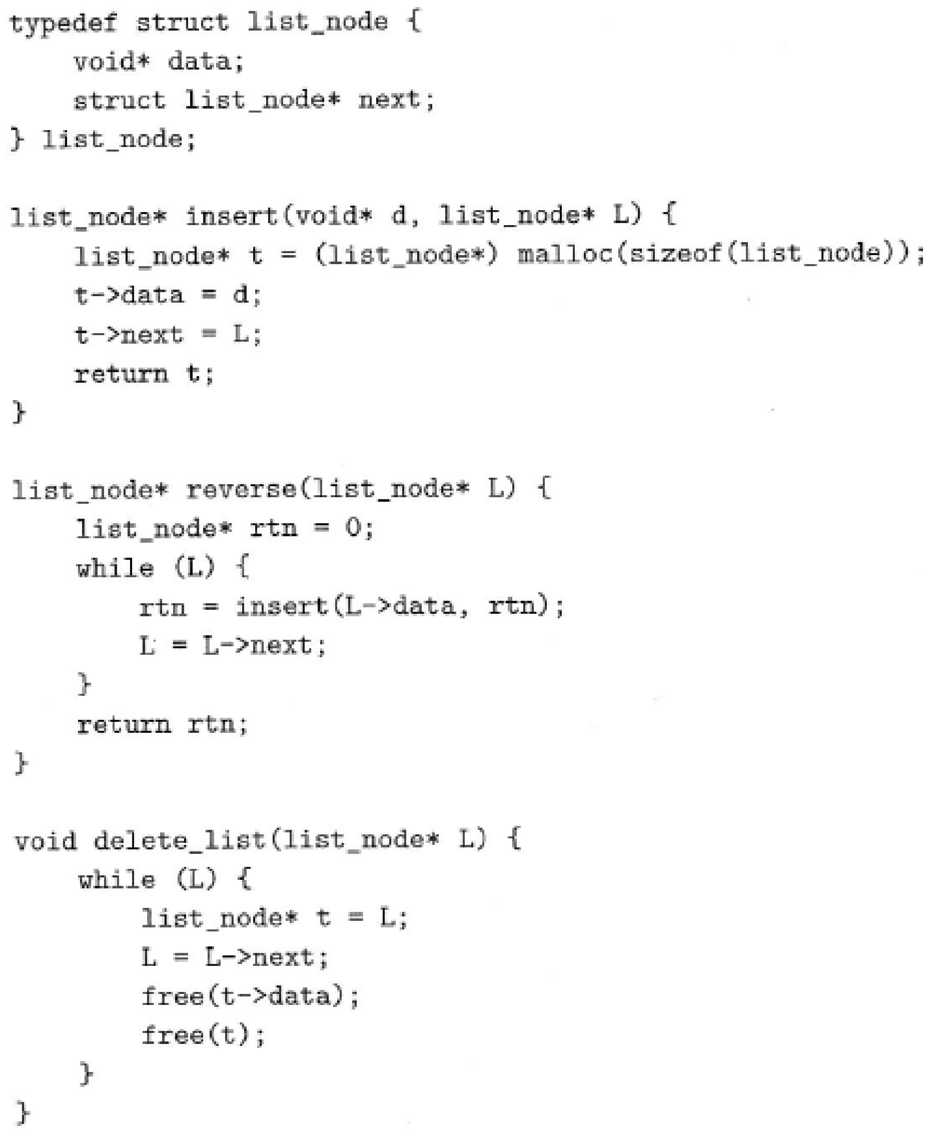
Concepts of Programming Languages, CSCI 305, Fall 2020
Homework #10, complete by class time Dec. 3

Exercises 3.7 and 3.13 from the text (pages 167-171), attribute grammar problem and Exercise 4.13 (pages 212-213).

1. Exercise 3.7 As part of the development team at MubleTech.com, Janet has written a list manipulation library for C that contains, among other things, the code in figure 3.16.



```
typedef struct list_node {
    void* data;
    struct list_node* next;
} list_node;

list_node* insert(void* d, list_node* L) {
    list_node* t = (list_node*) malloc(sizeof(list_node));
    t->data = d;
    t->next = L;
    return t;
}

list_node* reverse(list_node* L) {
    list_node* rtn = 0;
    while (L) {
        rtn = insert(L->data, rtn);
        L = L->next;
    }
    return rtn;
}

void delete_list(list_node* L) {
    while (L) {
        list_node* t = L;
        L = L->next;
        free(t->data);
        free(t);
    }
}
```

Figure 3.16 List management routines for Exercise 3.7.

a. Accustomed to Java, new team member Brad includes the following code in the main loop of his program:

```
list_node* L = 0;
while (more_widgets())  {
        L = insert(next_widget(), L);
}
L = reverse(L);
```

Sadly, after running for a while, Brad's program always runs out of member and crashes, Explain what's going wrong.

Janet's 'reverse' routine creates a new list, composed of new list nodes. This new list does not repeat the data, but does repeat the list nodes. When Brad assigns the return value of 'reverse' to L, Brad has lost the pointer to the old list nodes. Thus, Brad has created a memory leak. After the code runs for a while, the heap is exhausted and Brad's program can't continue.

I'd say that Janet's 'reverse' routine is misnamed. It ought to be named, 'createReverseAccessList'.

b. After Janet patiently explains the problem to him, Brad gives it another try:

```
list_node* L = 0;
while (more_widgets())  {
        L = insert(next_widget(), L);
}
List_node* T = reverse(L);
delete_list(L);
L = T;
```

This seems to solve the insufficient memory problem, but where the program used to produce correct results (before running out of memory), now its output is strangely corrupted, and Brad goes back to Janet for advice. What will she tell him this time?

Sorry, the 'delete_list' routine, reclaims both the old list nodes, but also the data. The new, reverse list now contains dangling references. These refer to locations in the heap that may be used for newly allocated data, which may be corrupted by use of the elements in the reverse list.

2. Exercise 3.13 Consider this problem in Scheme:

```
(define A
  (lambda()
    (let* ((x 2)
           (C  (lambda (P)
               (let  ((x  4))
                     (P))))
           (D  (lambda ()
                x ))
           (B  (lambda ()
               (let  ((x  3))
                     (C  D)))))
     (B))))
```

What does this program print?

2

A calls B, B calls C, passing D into C. C then calls D which prints the x that it sees.

Since Scheme uses static scope, D sees the x in A.

What would it print if Scheme used dynamic scoping and shallow binding?

4

The binding in effect is when D is executed. D was called from C, so the most recently declared x is the one in C.

Dynamic scoping and deep binding?

3

The binding which was in effect is when D was passed. This was the x within B.

Explain your answers.

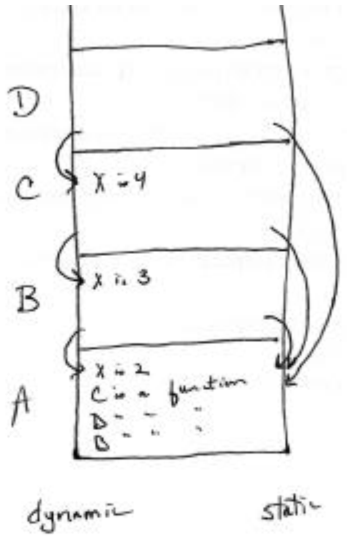
Function D was passed into C. When D is executed, there are 3 choices for which x to use.

With static scope, which x is determined lexically, just looking at the code. D is defined within A, so the x within A is used. This has the value 2.

Alternatively, the referencing environment for D could be the environment in effect when it is called. Since D doesn't have an x in it, it could use the environment from the function which called it. That is C. C has the value 4, so 4 is printed.

Alternatively, it could use the environment in effect when D was passed into C. This was B's environment. B has the value 3, so 3 is printed.

Here is a picture of the stack frames:



5. The following grammar parses binary numbers.

   binNum → bits | + bits | - bits
   bits → bits bit | bit
   bit → 0 | 1

   a.) Add attribute grammar rules to the grammar to accumulate the decimal value of the binary number into a 'value' attribute of binNum.

   binNum → bits
      binNnum.value = bits.value

   binNum → + bits
      binNnum.value = bits.value

   binNum → - bits
      binNnum.value = - bits.value

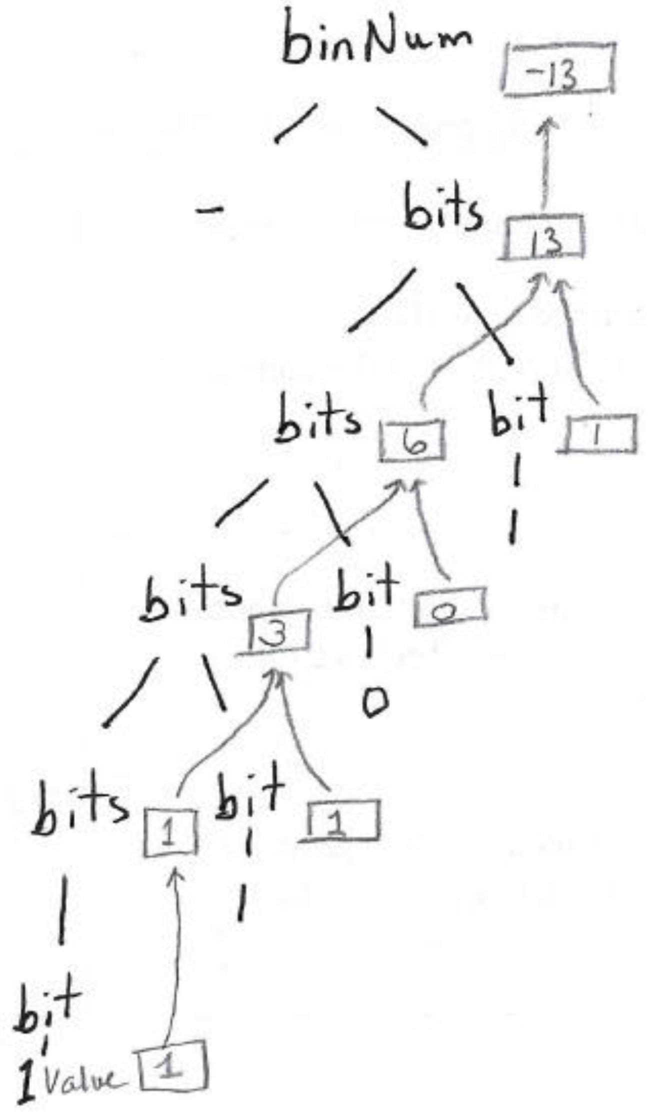
   $bits_1$ → $bits_2$ bit
      $bits_1$.value = 2 * $bits_2$.value + bit.value

   bits → bit
      bits.value = bit.value

   bit → 0
      bit.value = 0

   bit → 1
      bit.value = 1

b.) Show a parse tree for the string -1101, decorate it and show the flow of the values.



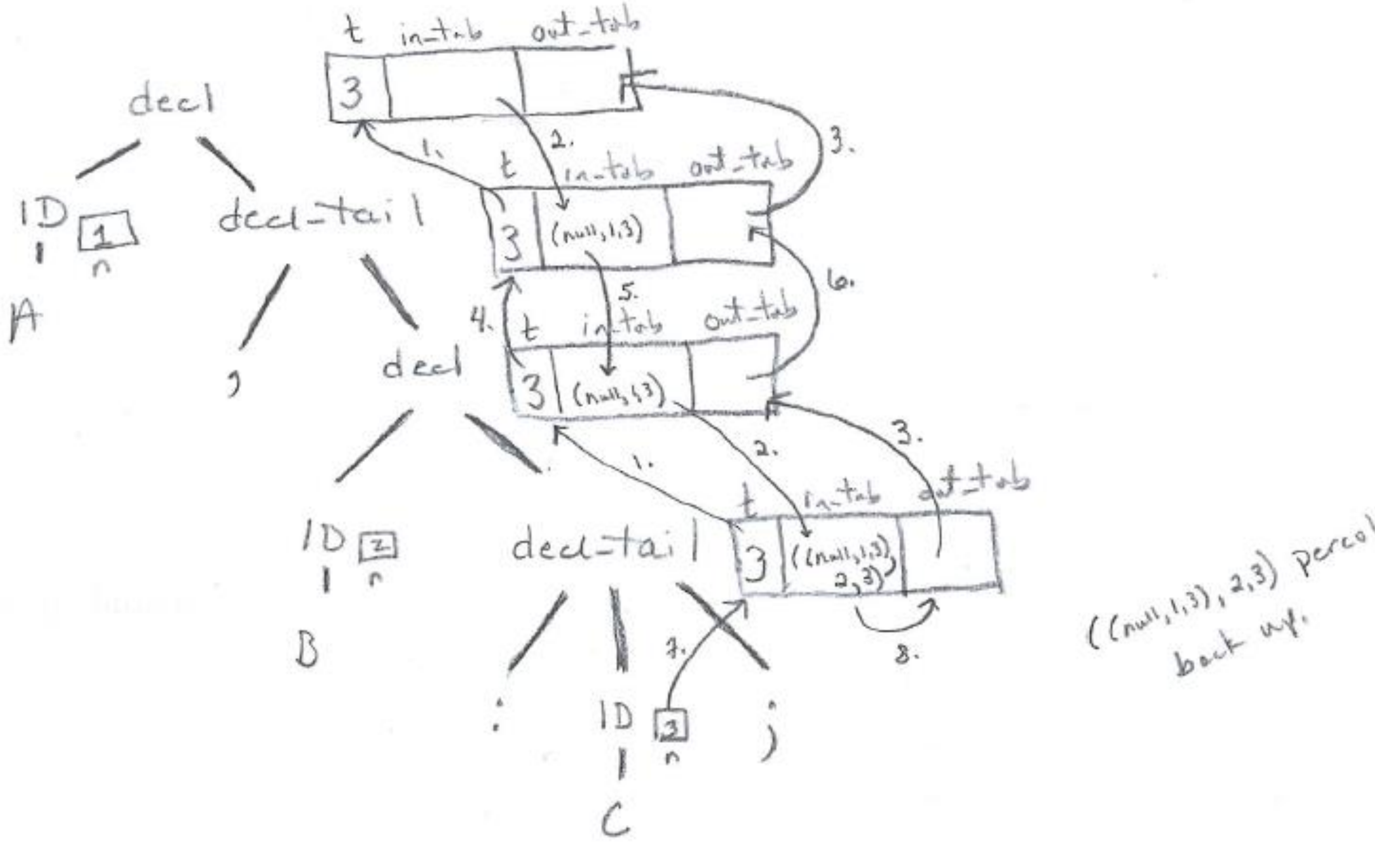
4.13 (page 212) Consider the following context-free grammar:

decl → ID decl_tail
decl_tail → , decl
decl_tail → : ID ;

with the attribute grammar

decl → ID decl_tail
decl.t := decl_tail.t 1.
decl_tail.in_tab := insert (decl.in_tab, ID.n, decl_tail.t) 2.
decl.out_tab := decl_tail.out_tab 3.
decl_tail → , decl
decl_tail.t := decl.t 4.
decl.in_tab := decl_tail.in_tab 5.
decl_tail.out_tab := decl.out_tab 6.
decl_tail → : ID ;
decl_tail.t := ID.n 7.
decl_tail.out_tab := decl_tail.in_tab 8.

Show a parse tree for the string A, B : C;. Then, using arrows and textual description specify the attribute flow required to fully decorate the tree.



General idea:

- t, ‘type’, percolates up, because the data type, C, comes at the end, but needs to be known to place into the final symbol table.
- out_tab, ‘output table’, also percolates up. It is the final symbol table.
- in_tab, ‘input table’, information travels down the tree, accumulating the identifiers that are getting this data type.