Data structure and algorithms lab

LINKED LIST

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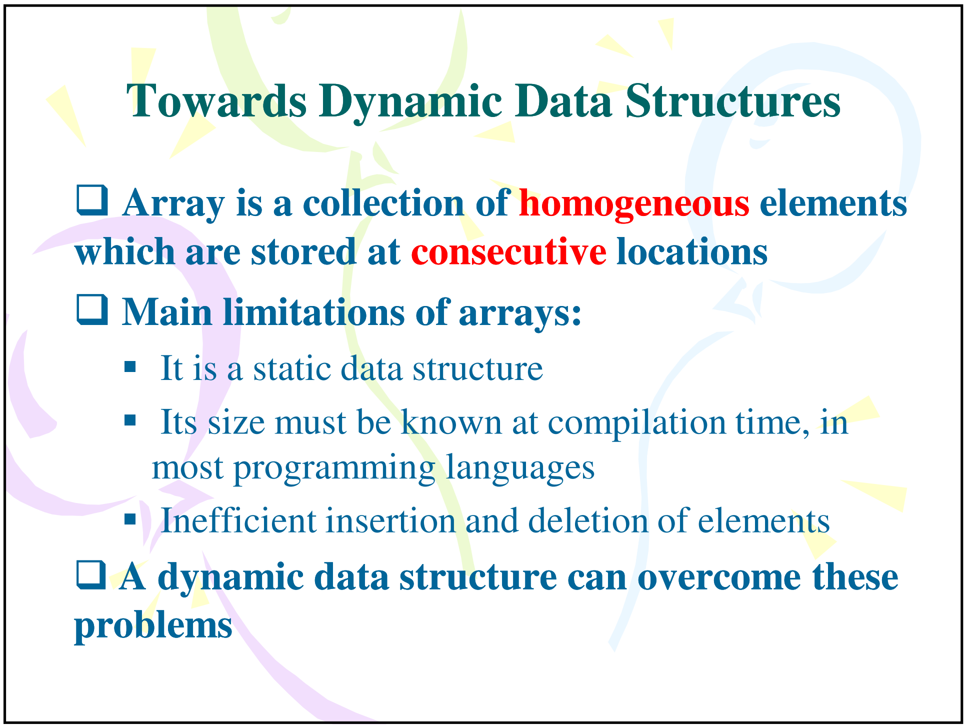
Today's topics

- Introduction to Linked List
- Self referential structure in C
- Data structure “single linked LIST”
  - Implementation of single linked LIST
  - Algorithm for inserting, deleting, traversing, …
- Data structure “double linked LIST”
  - Implementation of double linked LIST
  - Algorithm for inserting, deleting, traversing, …



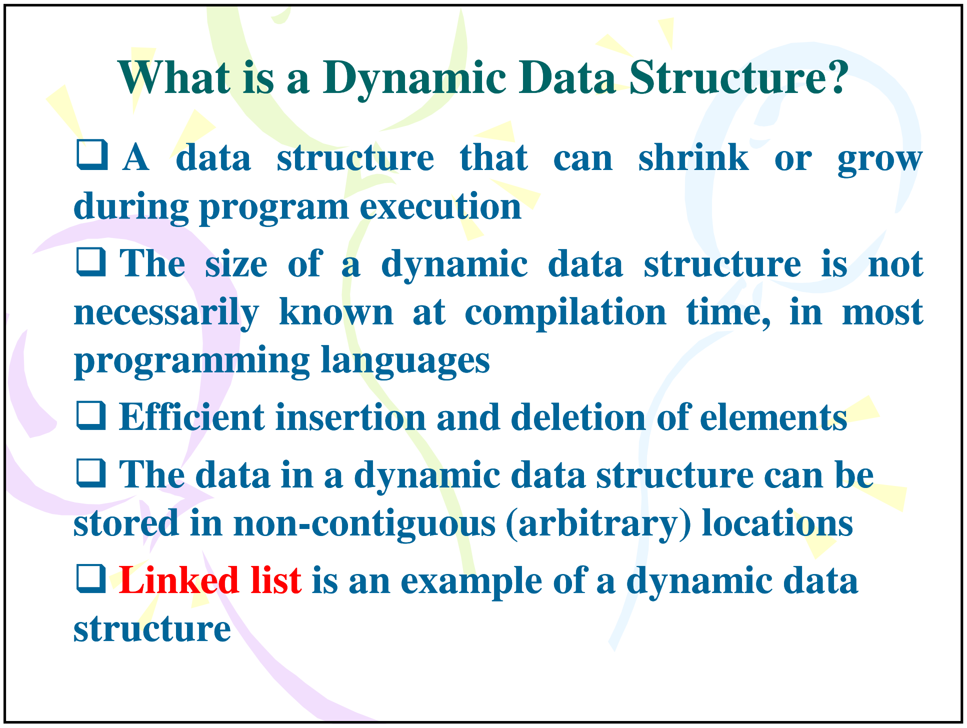
Towards Dynamic Data Structures

❑ Array is a collection of homogeneous elements which are stored at consecutive locations

❑ Main limitations of arrays:

- It is a static data structure
- Its size must be known at compilation time, in most programming languages
- Inefficient insertion and deletion of elements

❑ A dynamic data structure can overcome these problems



What is a Dynamic Data Structure?

❑ A data structure that can shrink or grow during program execution

❑ The size of a dynamic data structure is not necessarily known at compilation time, in most programming languages

❑ Efficient insertion and deletion of elements

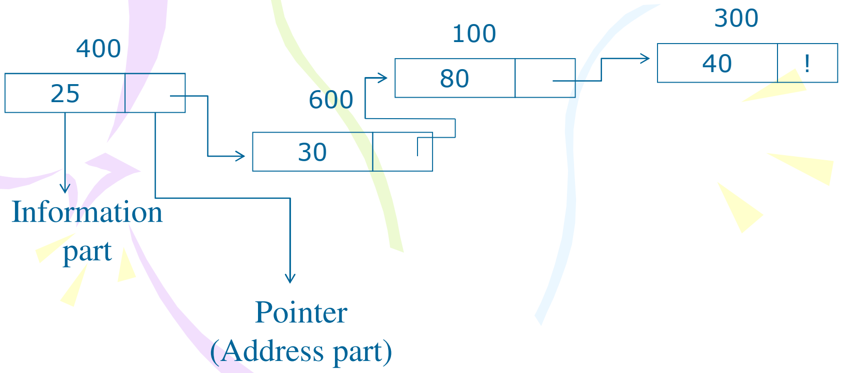
❑ The data in a dynamic data structure can be stored in non-contiguous (arbitrary) locations

❑ Linked list is an example of a dynamic data structure

What is a Linked List?

❑ A linked list is a collection of **nodes**, each node holding some **information** and a **pointer** to another node in the list

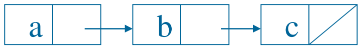
❑ In the following example, there are four nodes, which are not stored at consecutive locations



Self-Referential Structures

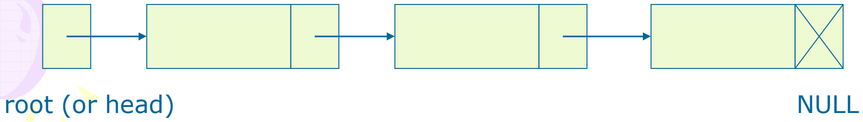
- One or more of its components is a pointer to itself.

```
struct list {
char data;
struct list *link;
};
list item1, item2, item3;
item1.data='a';
item2.data='b';
item3.data='c';
item1.link=item2.link=item3.link=NULL;
```



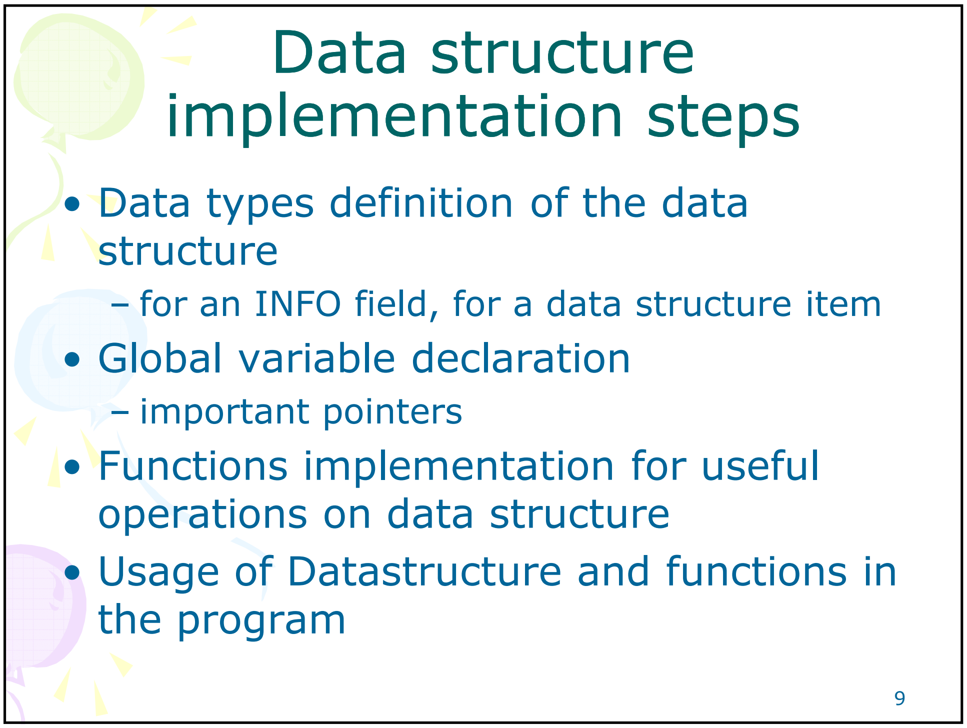
Implemetation of List in C

- “LIST” means data structure that keeps the information of the location of next element generally.
- The elements of “Single linked LIST” have only next location.
- In C, the pointer is used for the location of the next element.
- Array: We can access any data immediately.
- Linked List: We can change the number of data in it.



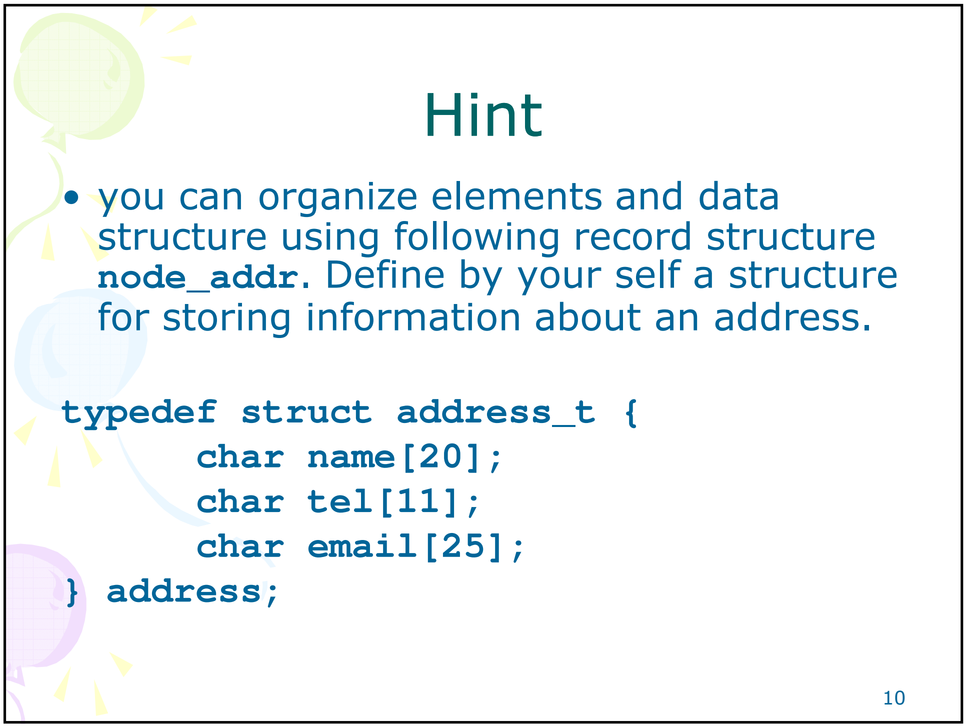
Question 3-1

- We are now designing “address list” for mobile phones.
- You must declare a record structure that can keep a name, a phone number, and a e-mail address at least.
- And you must make the program which can deals with any number of the data



Data structure implementation steps

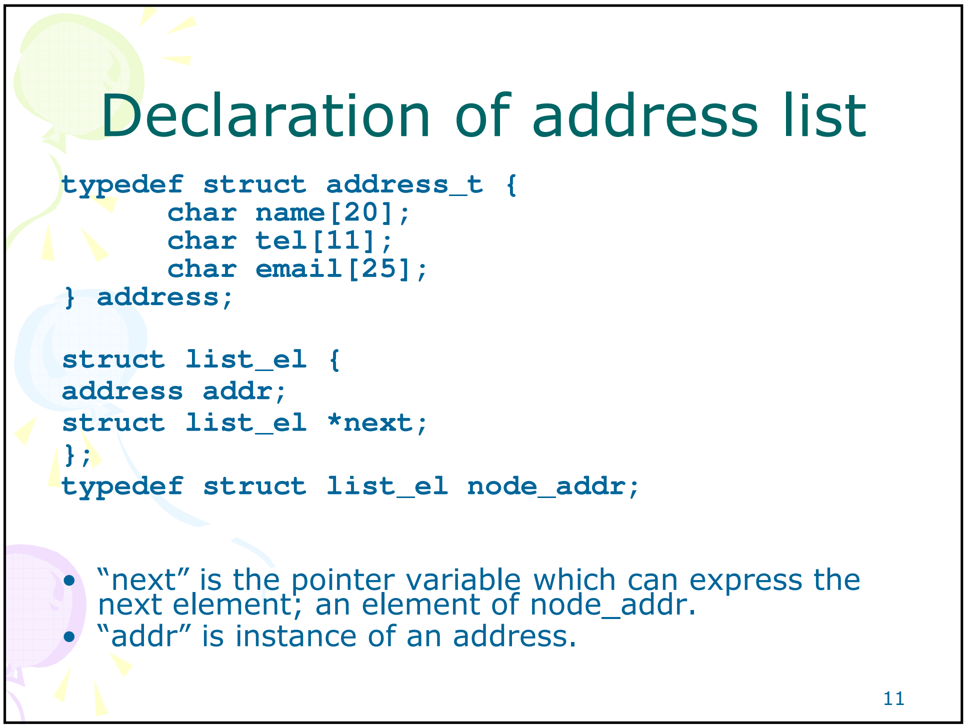
- Data types definition of the data structure
  - for an INFO field, for a data structure item
- Global variable declaration
  - important pointers
- Functions implementation for useful operations on data structure
- Usage of Datastructure and functions in the program



Hint

- you can organize elements and data structure using following record structure **node_addr**. Define by your self a structure for storing information about an address.

```
typedef struct address_t {
      char name[20];
      char tel[11];
      char email[25];
} address;
```

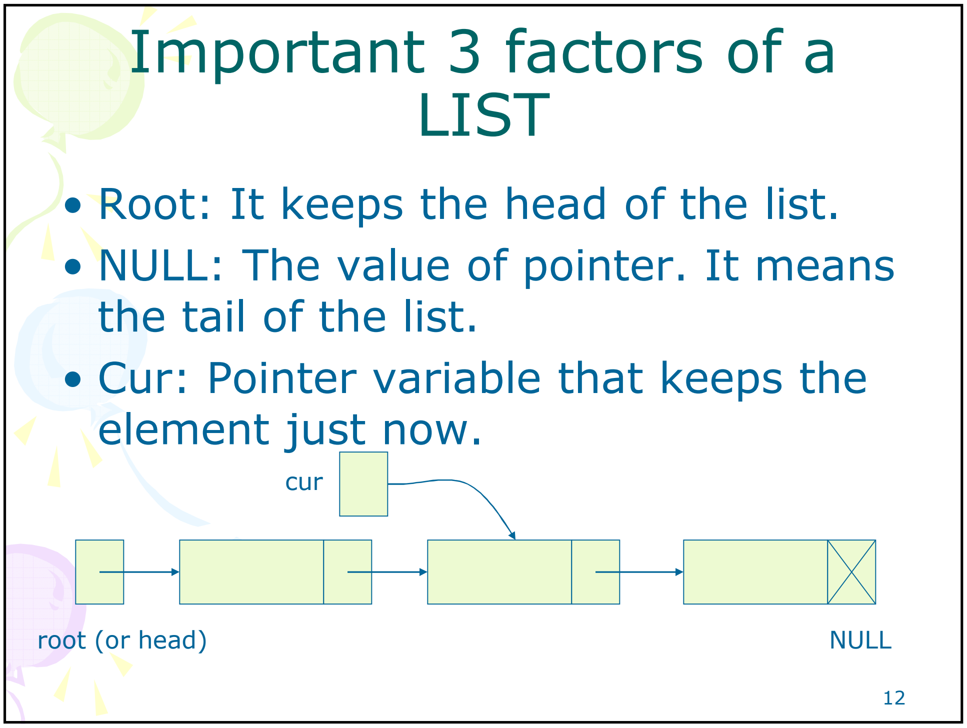


Declaration of address list

```
typedef struct address_t {
      char name[20];
      char tel[11];
      char email[25];
} address;

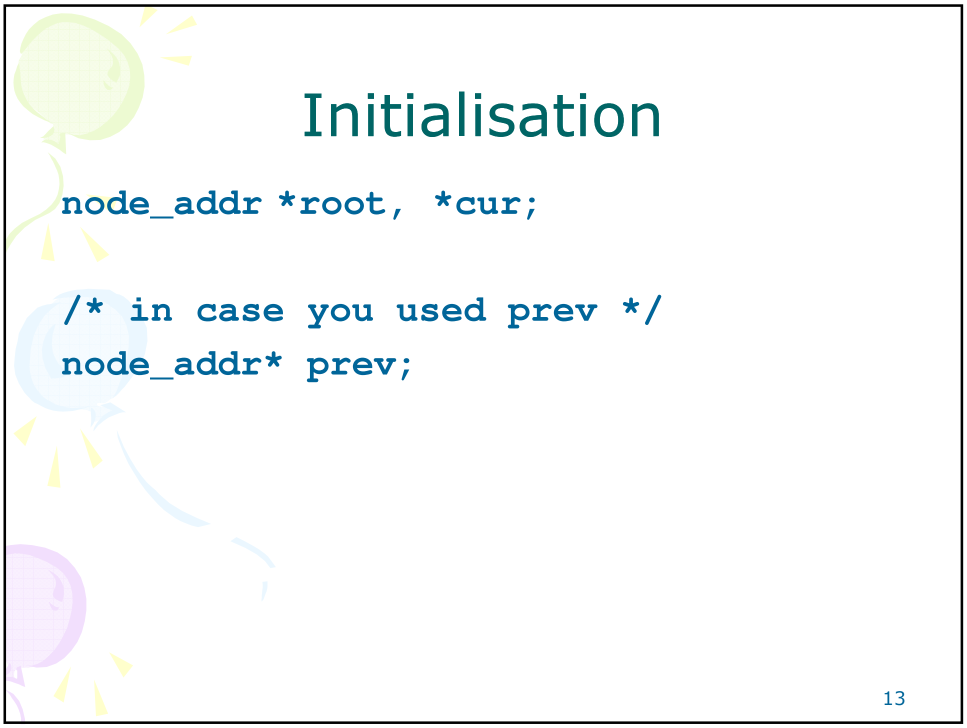
struct list_el {
address addr;
struct list_el *next;
};
typedef struct list_el node_addr;
```

- "next" is the pointer variable which can express the next element; an element of node_addr.
- "addr" is instance of an address.



Important 3 factors of a LIST

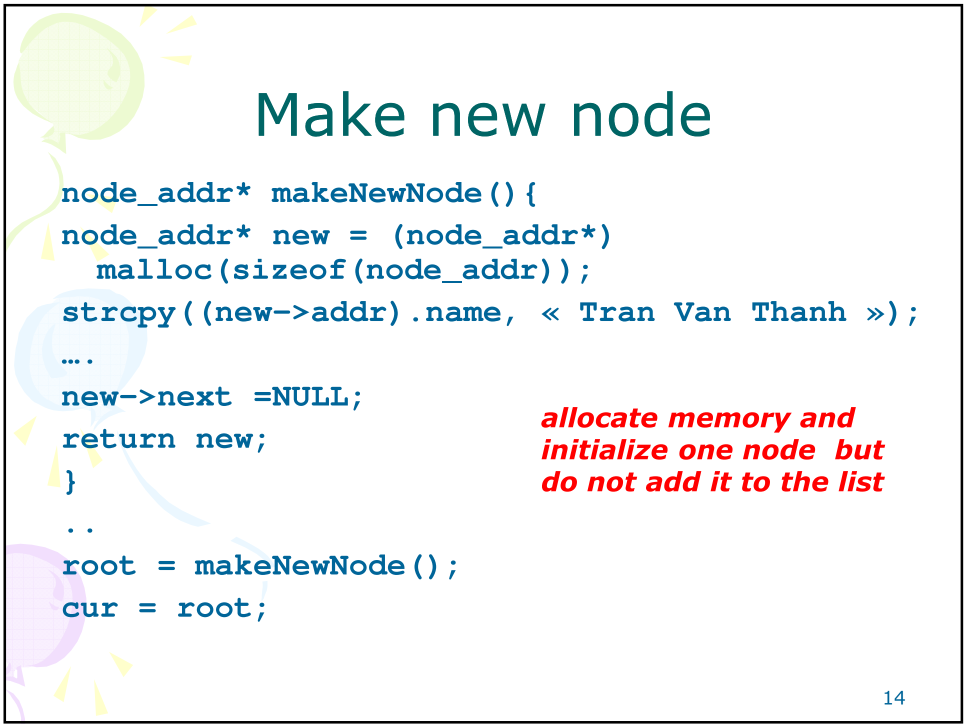
- Root: It keeps the head of the list.
- NULL: The value of pointer. It means the tail of the list.
- Cur: Pointer variable that keeps the element just now.



Initialisation

```
node_addr *root, *cur;

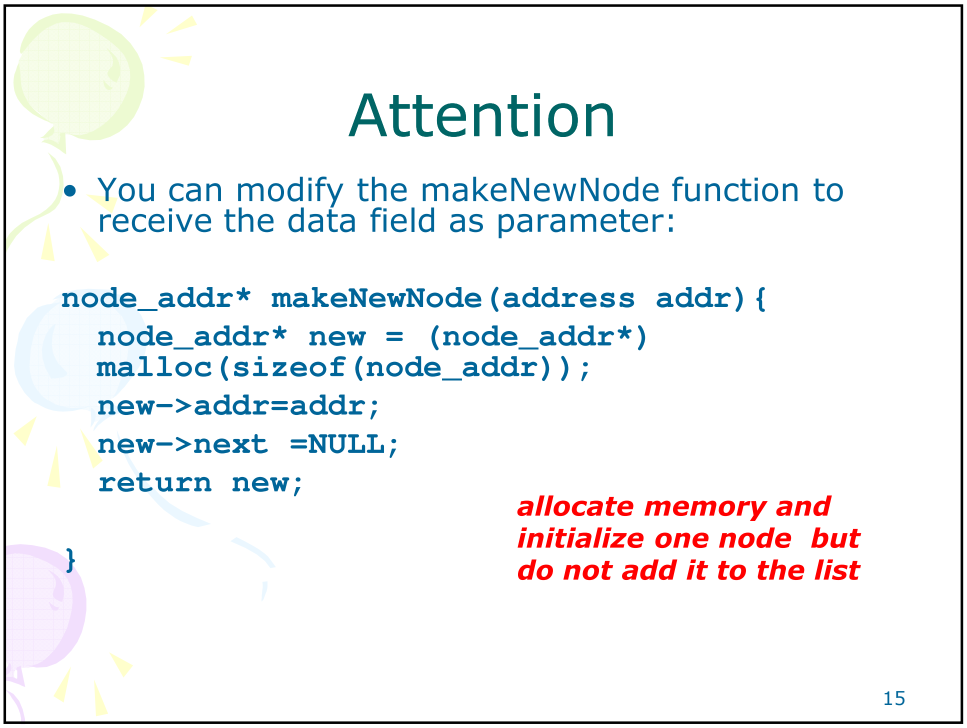
/* in case you used prev */
node_addr* prev;
```



Make new node

```
node_addr* makeNewNode(){
node_addr* new = (node_addr*)
  malloc(sizeof(node_addr));
strcpy((new->addr).name, « Tran Van Thanh »);
….
new->next =NULL;
return new;
}
..
root = makeNewNode();
cur = root;
```

allocate memory and initialize one node but do not add it to the list



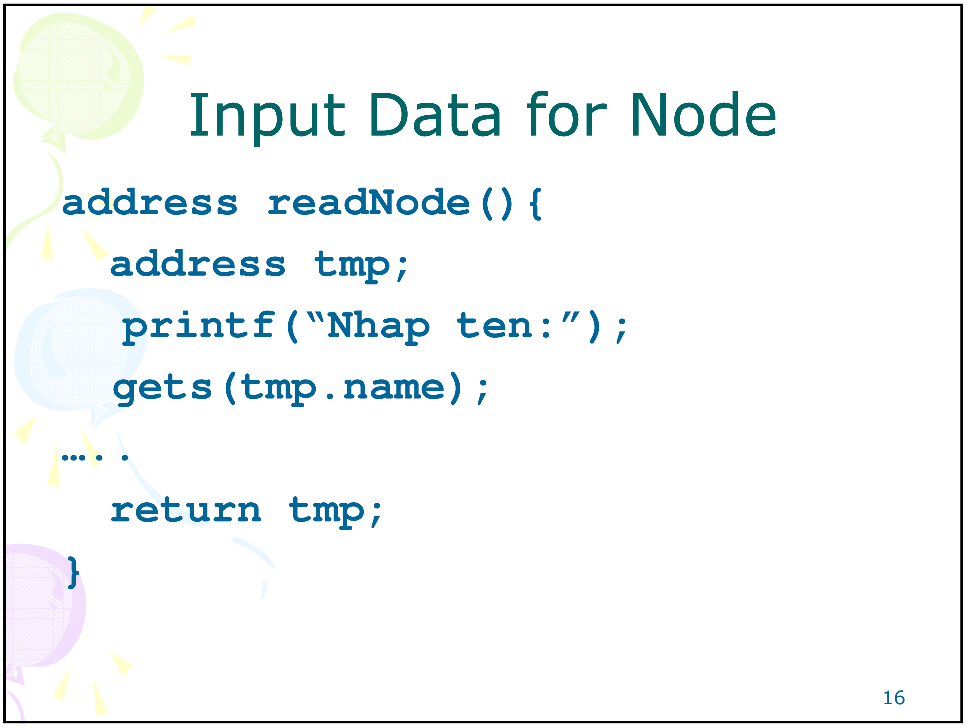
Attention

- You can modify the makeNewNode function to receive the data field as parameter:

```
node_addr* makeNewNode(address addr){
   node_addr* new = (node_addr*)
   malloc(sizeof(node_addr));
   new->addr=addr;
   new->next =NULL;
   return new;

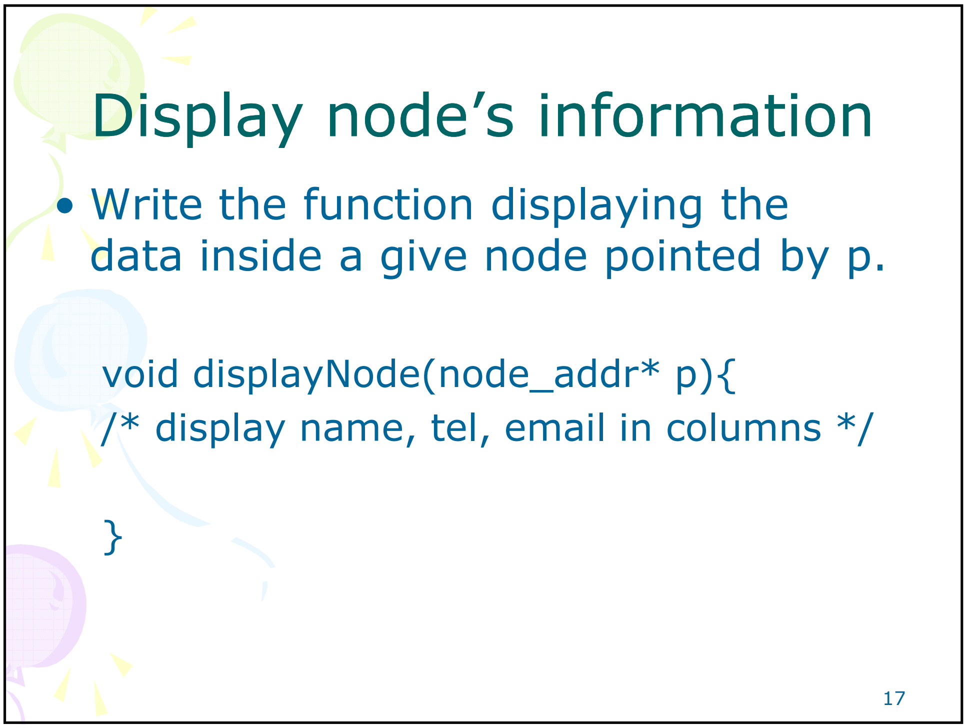
}
```

allocate memory and initialize one node but do not add it to the list



Input Data for Node

```
address readNode(){
   address tmp;
    printf(“Nhap ten:”);
   gets(tmp.name);
…. .
   return tmp;
}
```

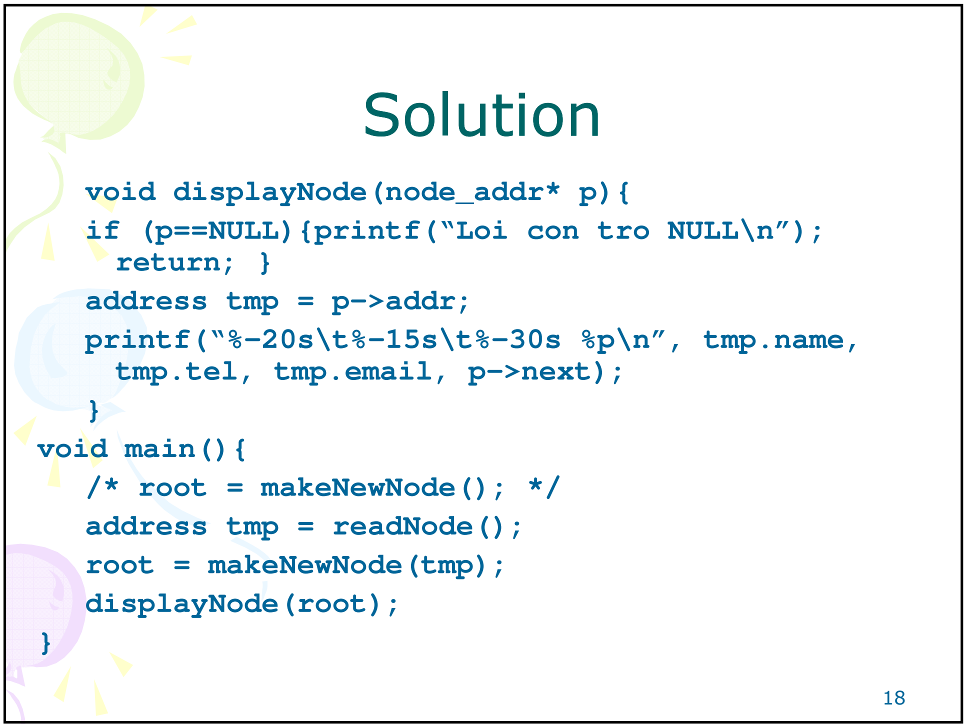


Display node’s information

- Write the function displaying the data inside a give node pointed by p.

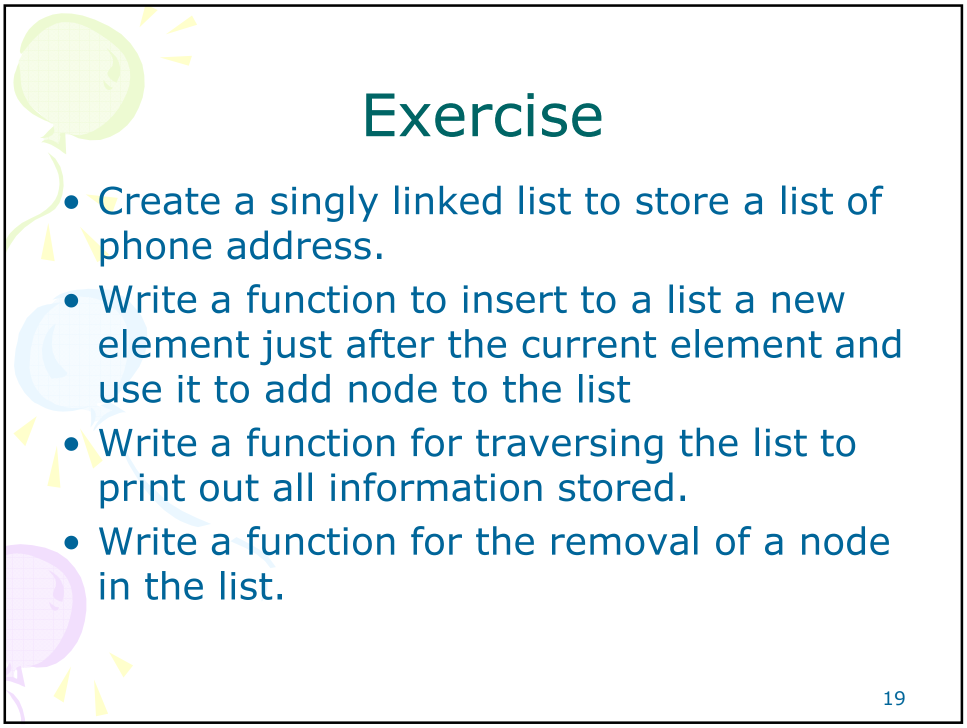
```
void displayNode(node_addr* p){
/* display name, tel, email in columns */

}
```



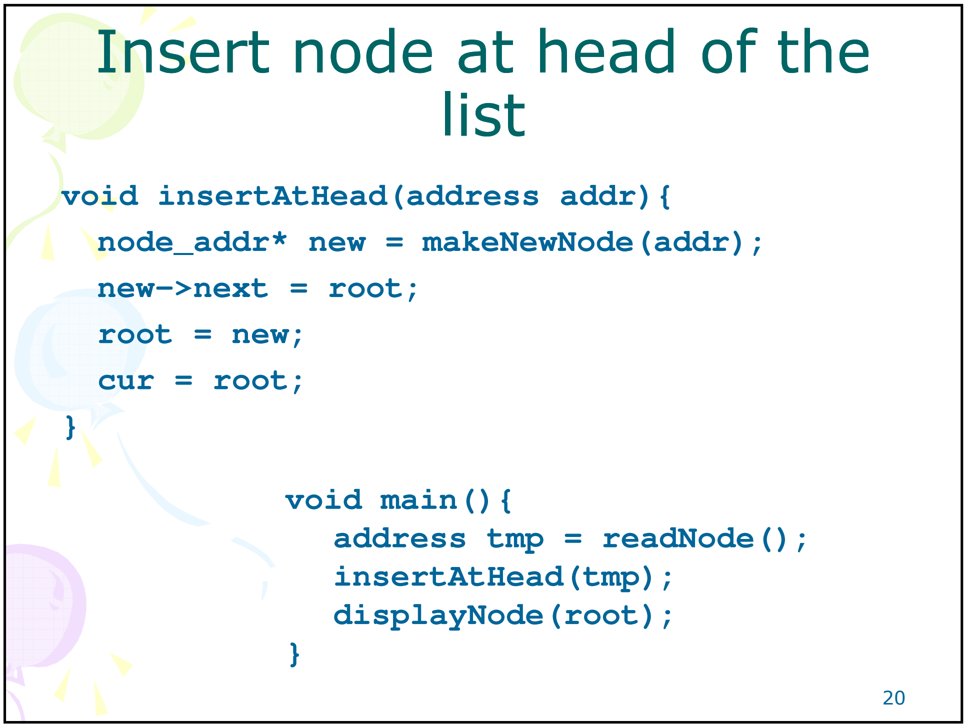
Solution

```
    void displayNode(node_addr* p){
    if (p==NULL){printf(“Loi con tro NULL\n”);
      return; }
    address tmp = p->addr;
    printf(“%-20s\t%-15s\t%-30s %p\n”, tmp.name,
      tmp.tel, tmp.email, p->next);
    }
void main(){
    /* root = makeNewNode(); */
    address tmp = readNode();
    root = makeNewNode(tmp);
    displayNode(root);
}
```



Exercise

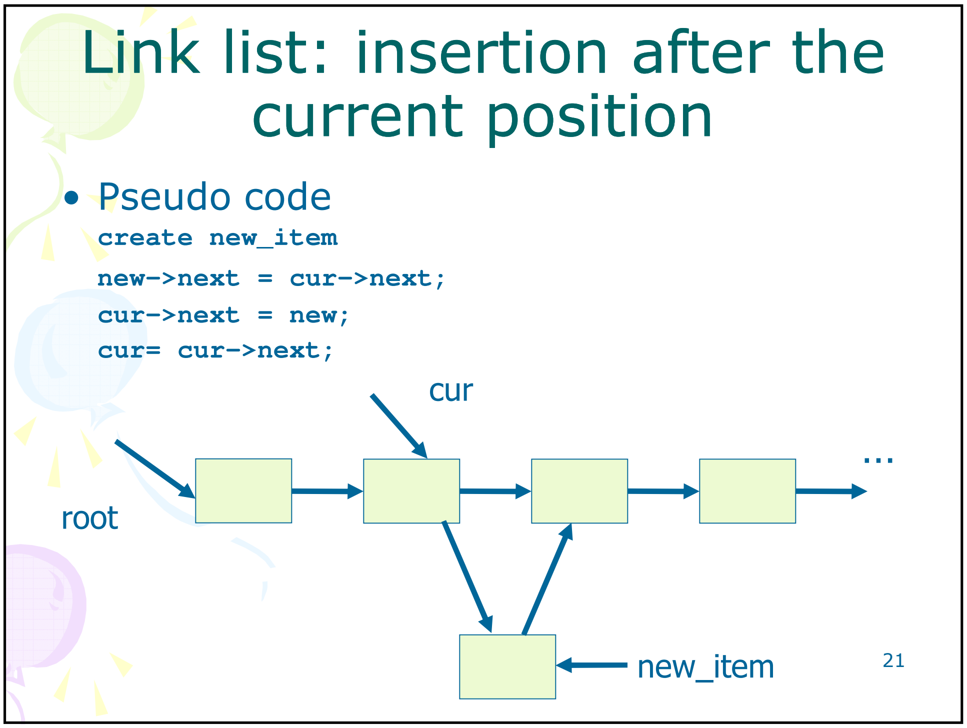
- Create a singly linked list to store a list of phone address.
- Write a function to insert to a list a new element just after the current element and use it to add node to the list
- Write a function for traversing the list to print out all information stored.
- Write a function for the removal of a node in the list.



Insert node at head of the list

```
void insertAtHead(address addr){
  node_addr* new = makeNewNode(addr);
  new->next = root;
  root = new;
  cur = root;
}
```

```
            void main(){
               address tmp = readNode();
               insertAtHead(tmp);
               displayNode(root);
            }
```



Link list: insertion after the current position

- Pseudo code

```
create new_item
new->next = cur->next;
cur->next = new;
cur= cur->next;
```

cur

…

root

new_item

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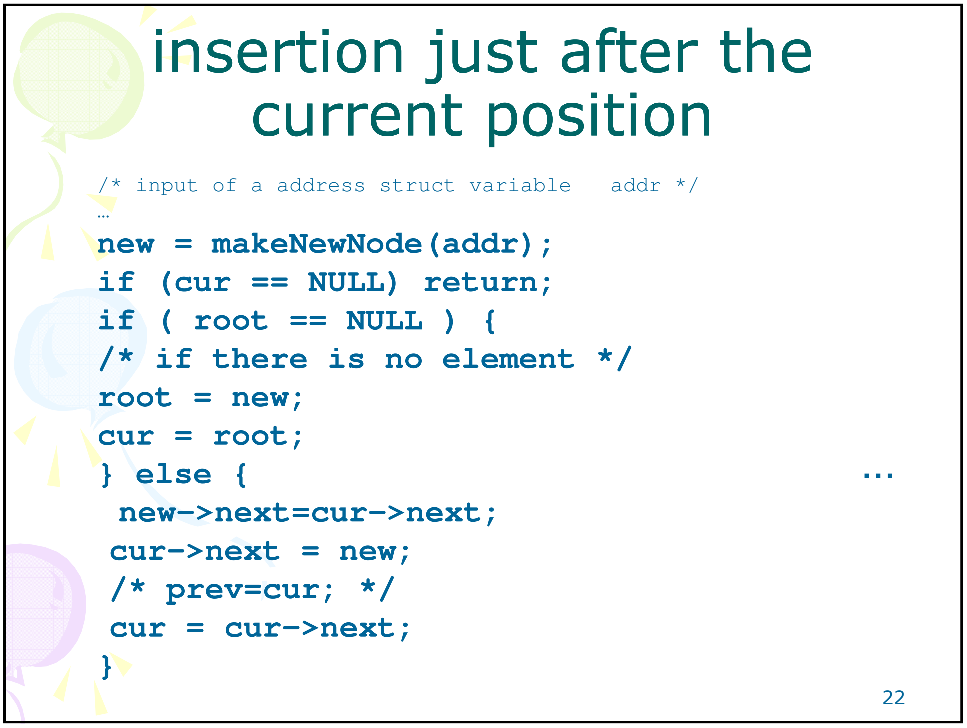

insertion just after the current position

```
/* input of a address struct variable   addr */
…
new = makeNewNode(addr);
if (cur == NULL) return;
if ( root == NULL ) {
/* if there is no element */
root = new;
cur = root;
} else {                                      …
  new->next=cur->next;
 cur->next = new;
 /* prev=cur; */
 cur = cur->next;
}
```

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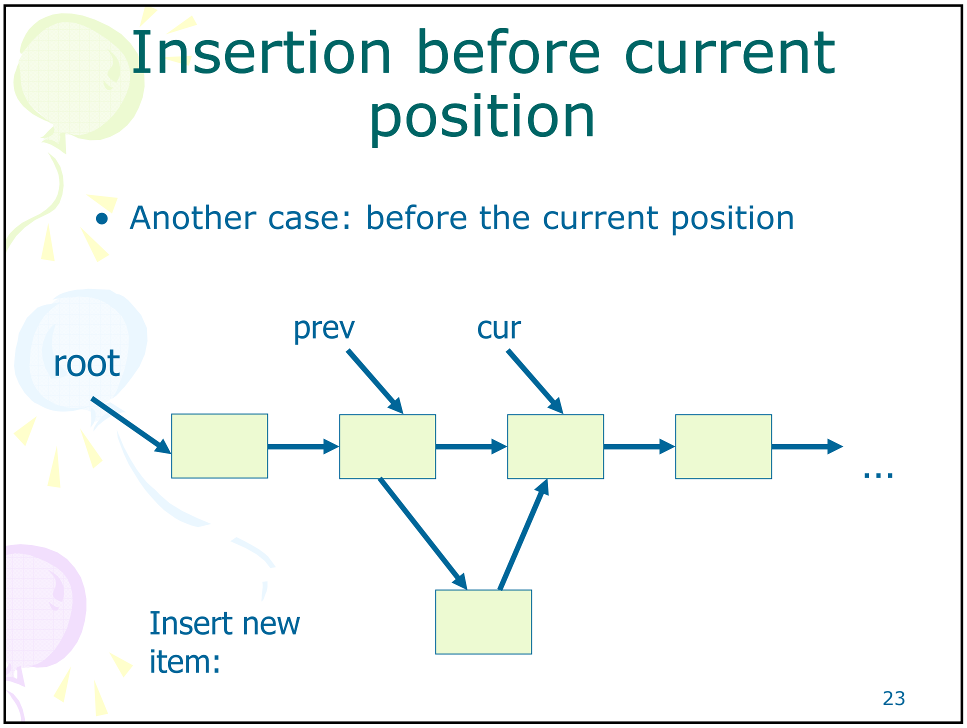


Insertion before current position

- Another case: before the current position

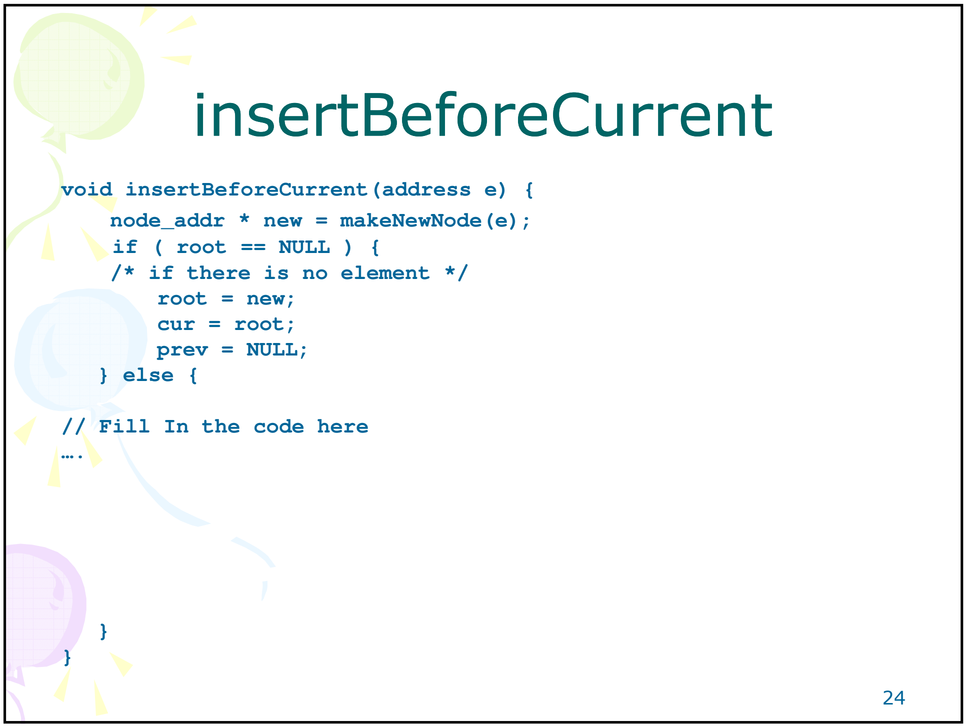
root

prev

cur

…

Insert new item:



insertBeforeCurrent

```
void insertBeforeCurrent(address e) {
    node_addr * new = makeNewNode(e);
    if ( root == NULL ) {
    /* if there is no element */
        root = new;
        cur = root;
        prev = NULL;
   } else {

// Fill In the code here
….



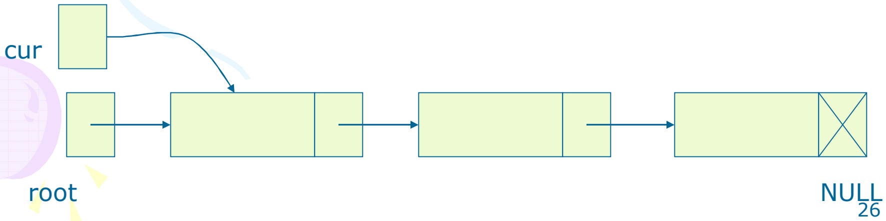

   }
}
```

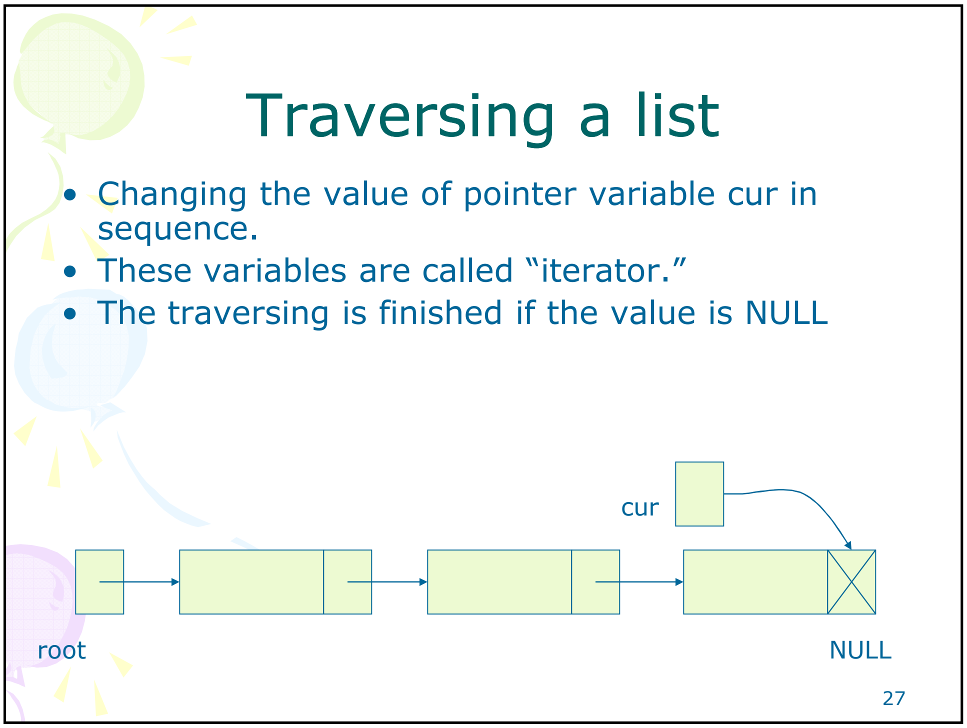
If you do not frenquently update pointer prev

```
/* determine prev if cur does
not point to first element */
tmp = root;
 while (tmp!=NULL && tmp-
>next!=cur && cur !=NULL)
       tmp=tmp->next;
prev = tmp;
```

Traversing a list

```
void traversingList(){
node_addr * p;
for ( p = root; p!= NULL; p = p->next )
  displayNode(p);
}
```





Traversing a list

- Changing the value of pointer variable cur in sequence.
- These variables are called “iterator.”
- The traversing is finished if the value is NULL

cur

root

NULL

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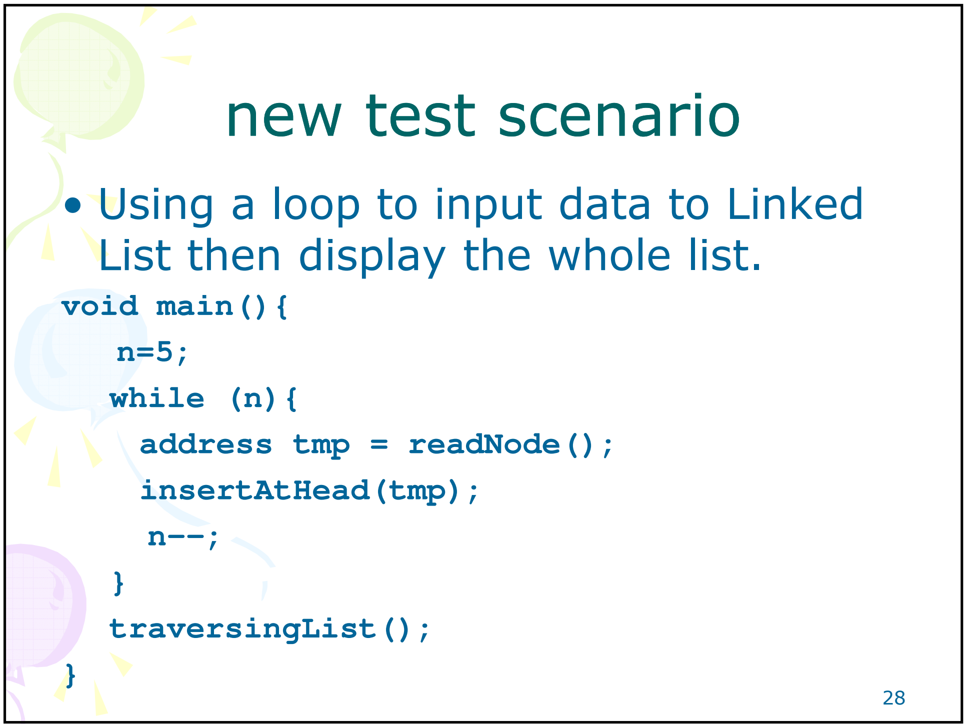

new test scenario

- Using a loop to input data to Linked List then display the whole list.

```
void main(){
   n=5;
  while (n){
    address tmp = readNode();
    insertAtHead(tmp);
     n--;
  }
  traversingList();
}
```

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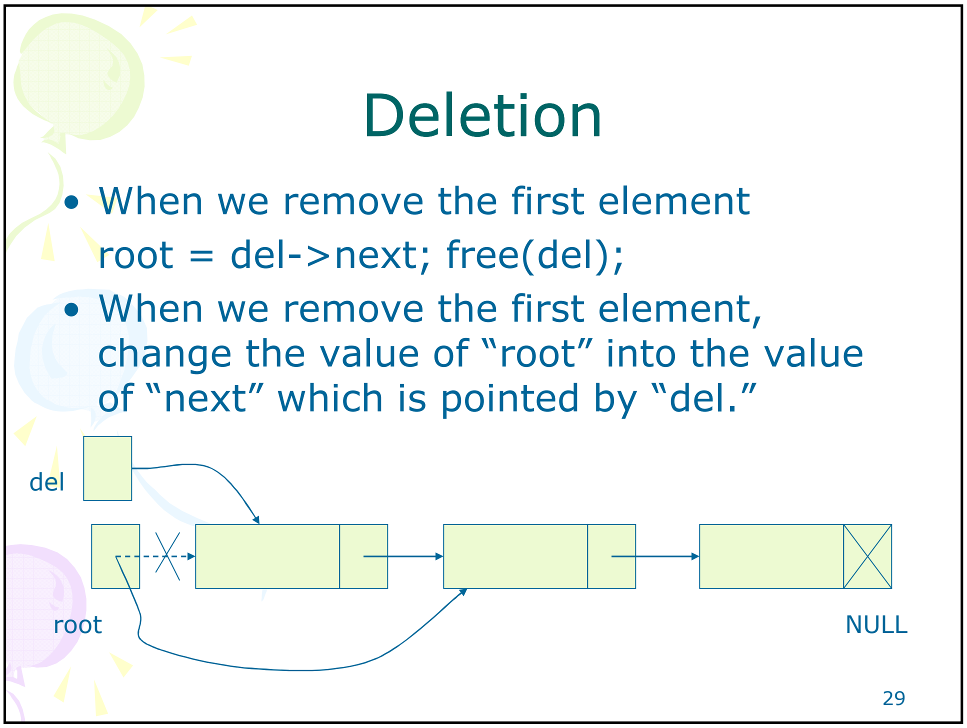
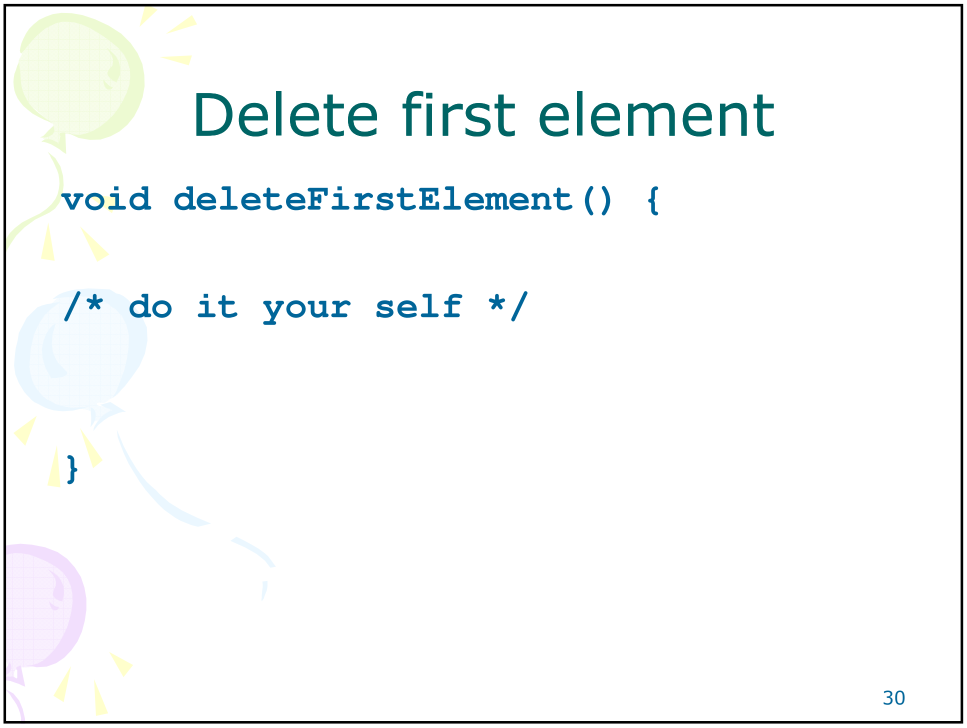


Deletion

- When we remove the first element
  root = del->next; free(del);
- When we remove the first element, change the value of "root" into the value of "next" which is pointed by "del."

del
root
NULL



Delete first element

```
void deleteFirstElement() {

/* do it your self */


}
```

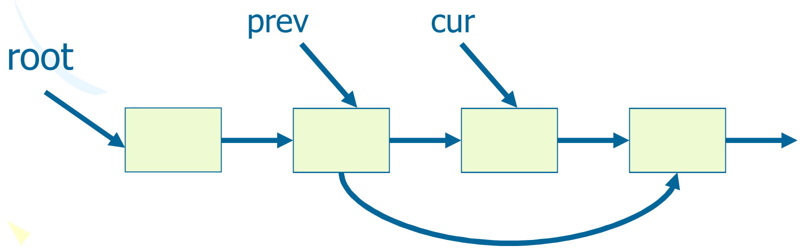
Delete first element of the list

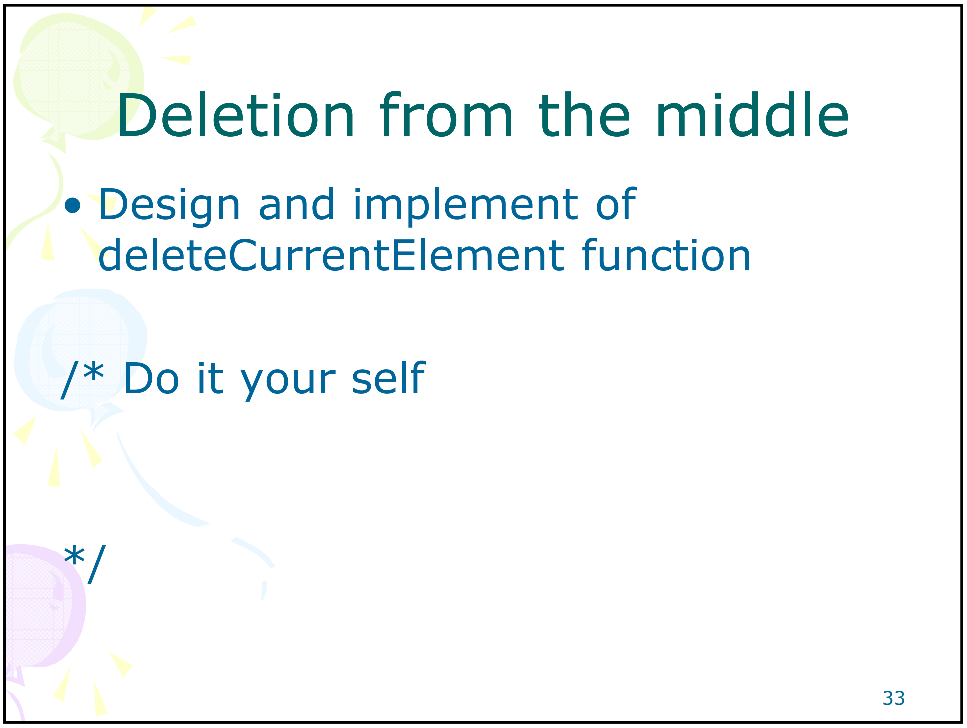
```
void deleteFirstElement(){
  node_addr* del = root;
  if (del == NULL) return;
  root = del->next;
  free(del);
  cur = root; /* prev = NULL; */
}
```

Deletion from the middle

- We want to remove the node pointed by cur
- Determine prev which point to the node just before the node to delete

```
prev->next = cur->next;
free(cur);
cur = prev->next;
```



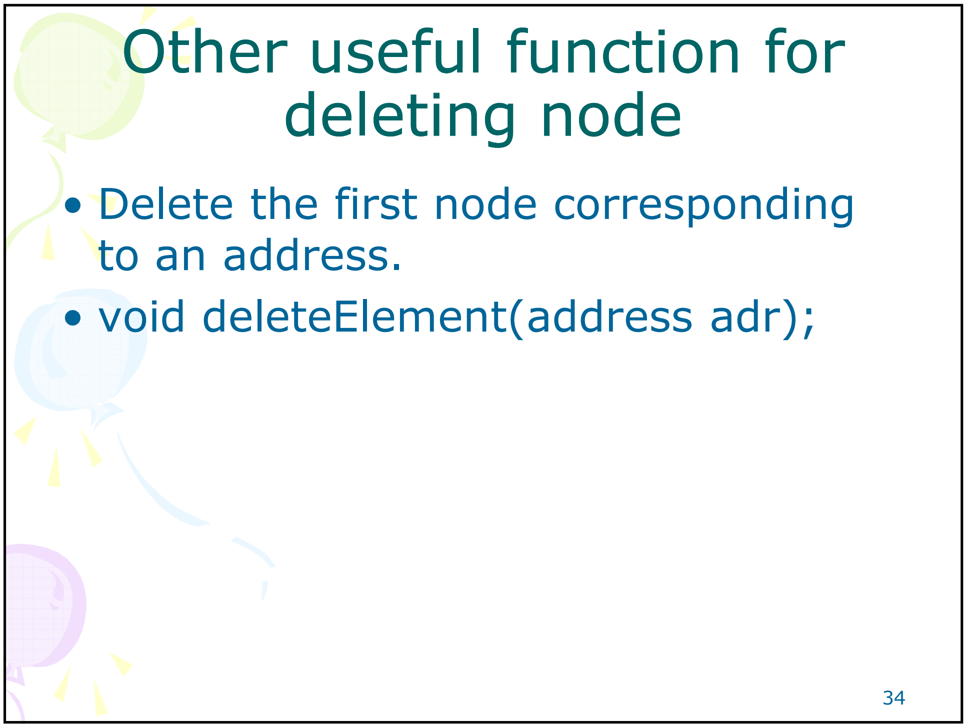


Deletion from the middle

- Design and implement of deleteCurrentElement function

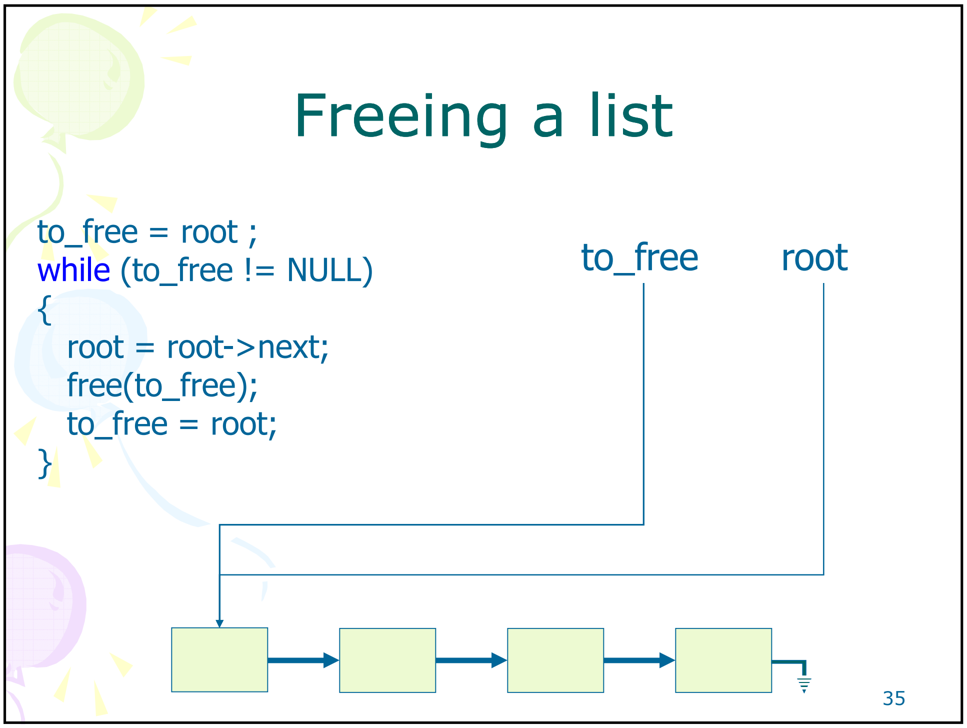
/* Do it your self

*/



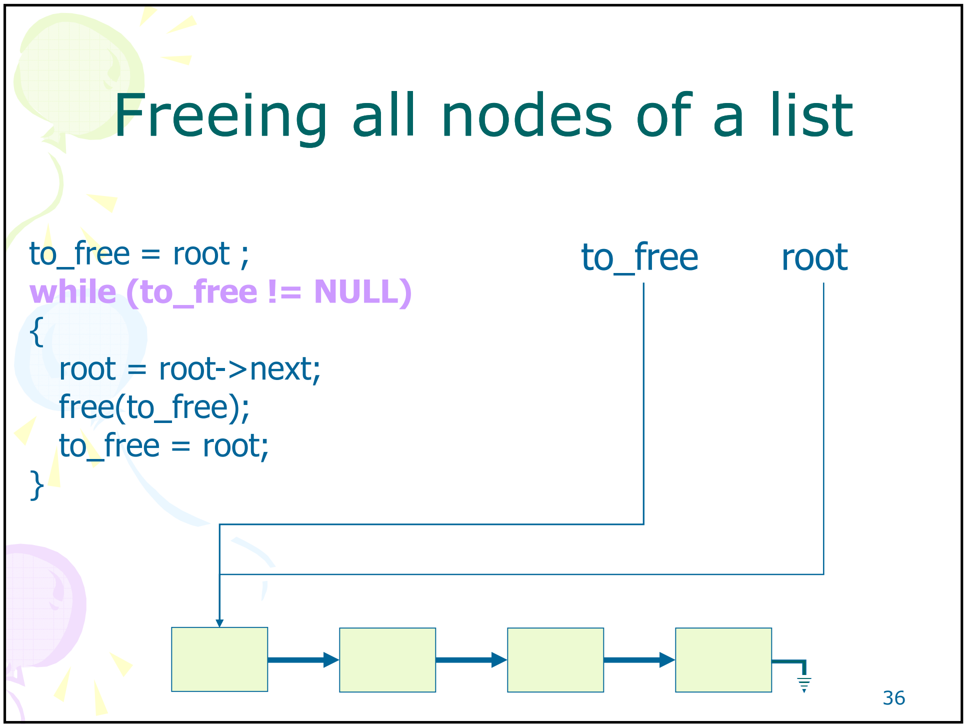
Other useful function for deleting node

- Delete the first node corresponding to an address.
- void deleteElement(address adr);



Freeing a list

```
to_free = root ;
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```



Freeing all nodes of a list

```
to_free = root ;
while (to_free != NULL)
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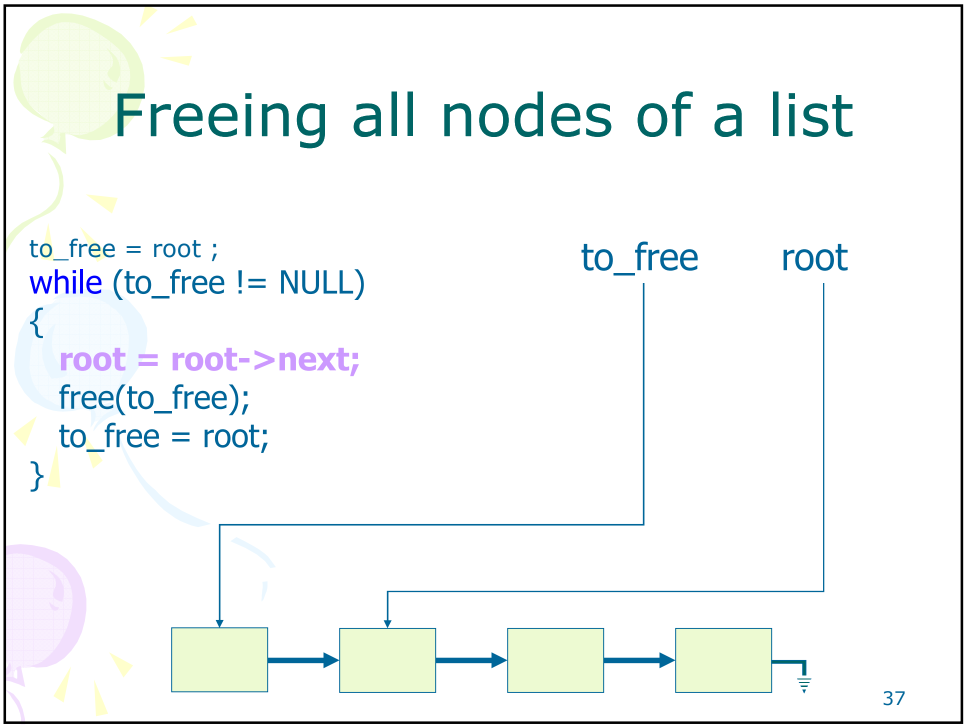
   to_free = root;
}
```



Freeing all nodes of a list

```
to_free = root ;
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

to_free root

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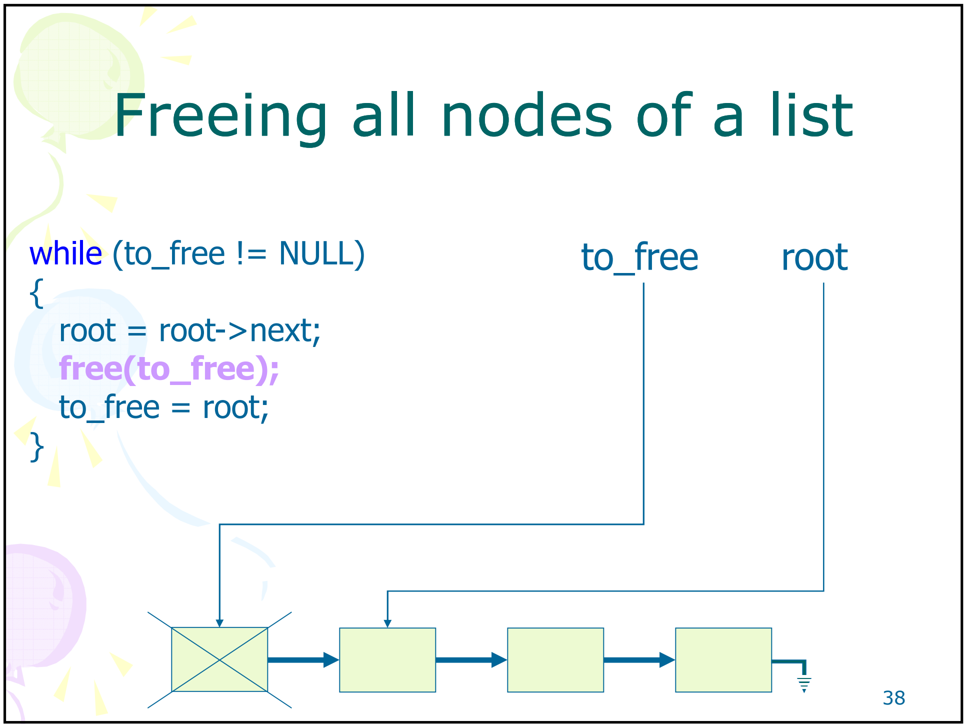

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

to_free root

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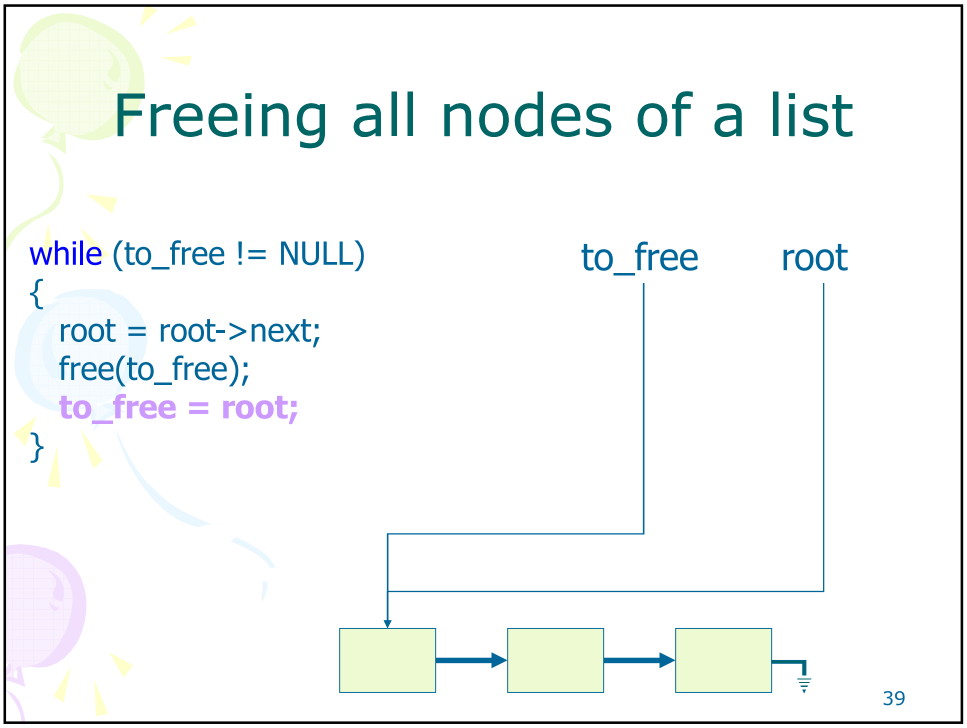

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
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   to_free = root;
}
```

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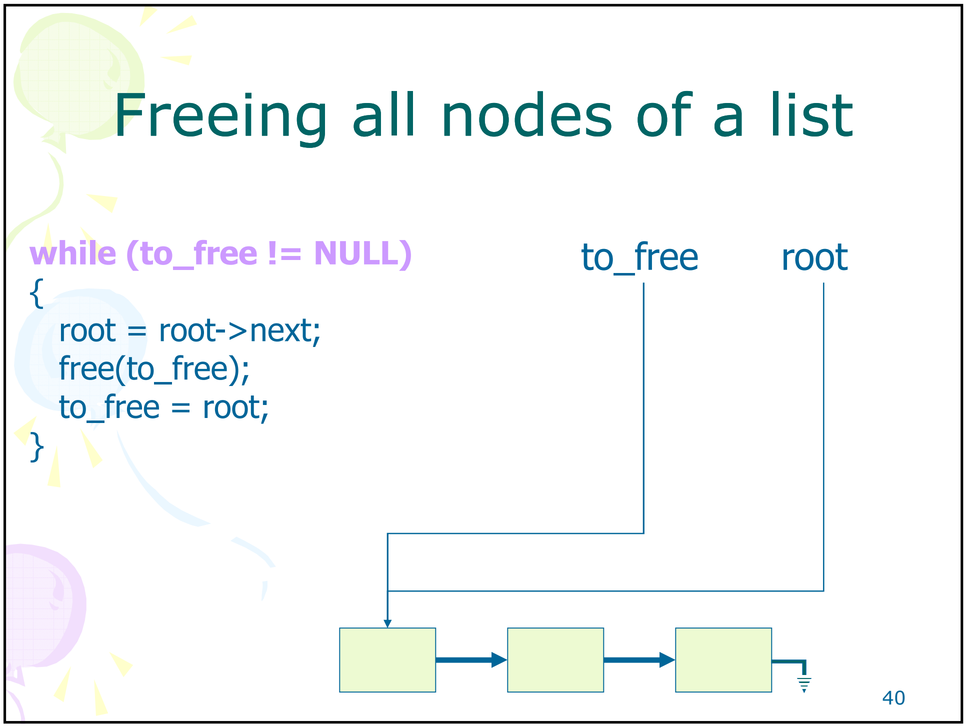

Freeing all nodes of a list

```
while (to_free != NULL)
{
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   free(to_free);
   to_free = root;
}
```

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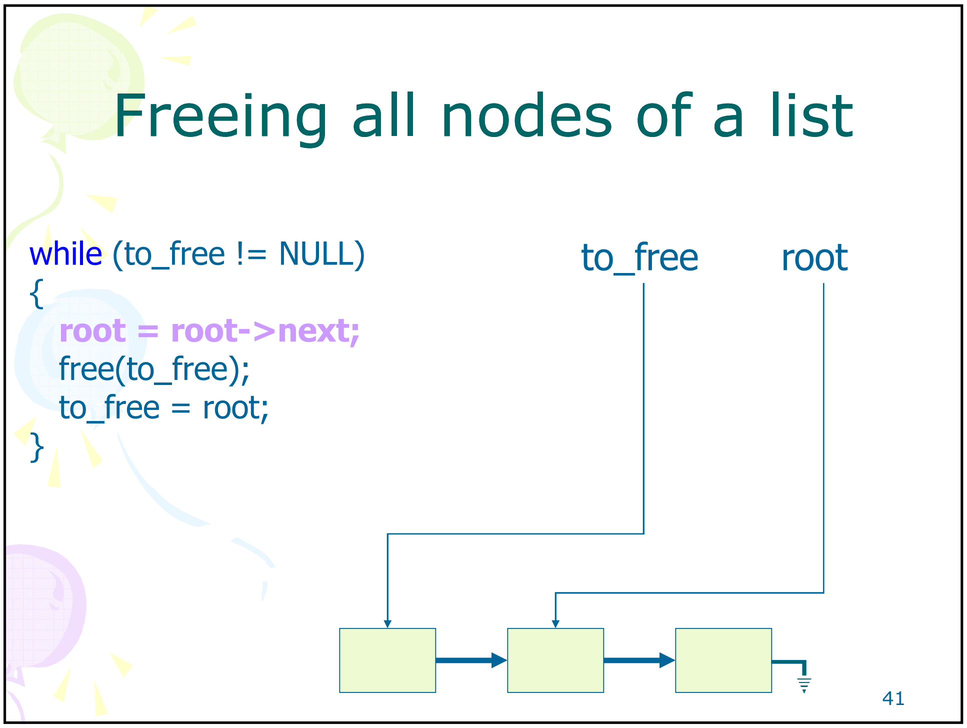

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

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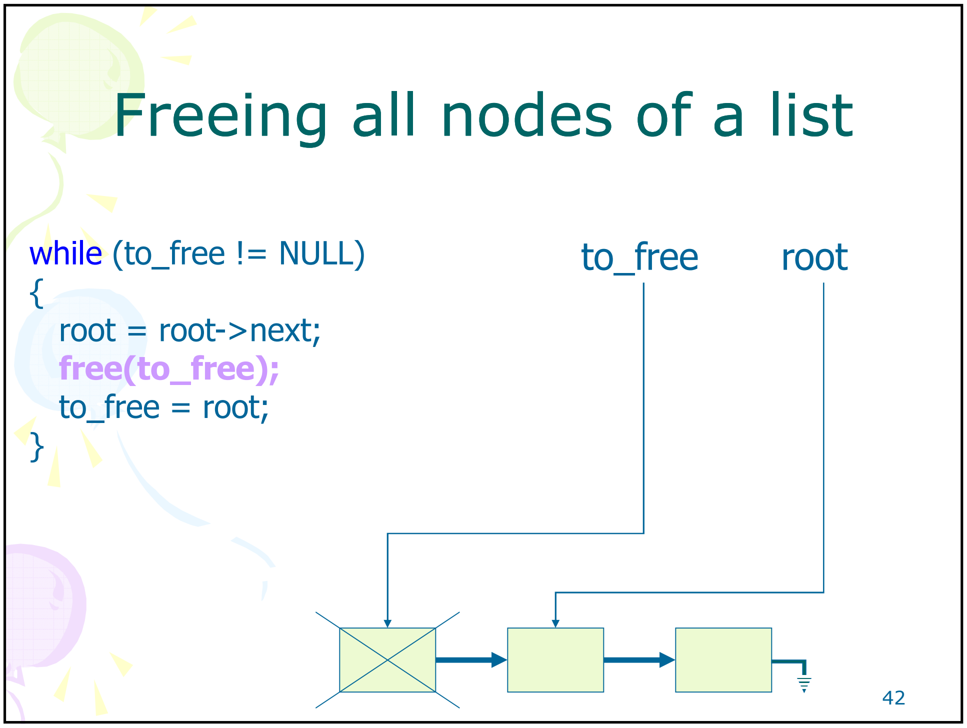

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

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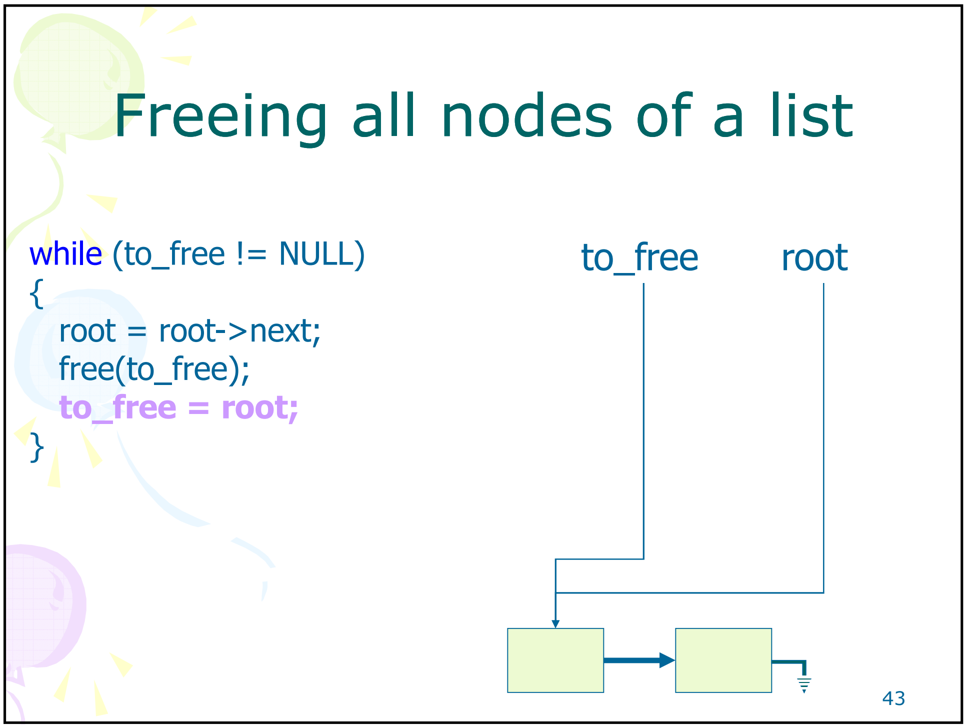

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

to_free root

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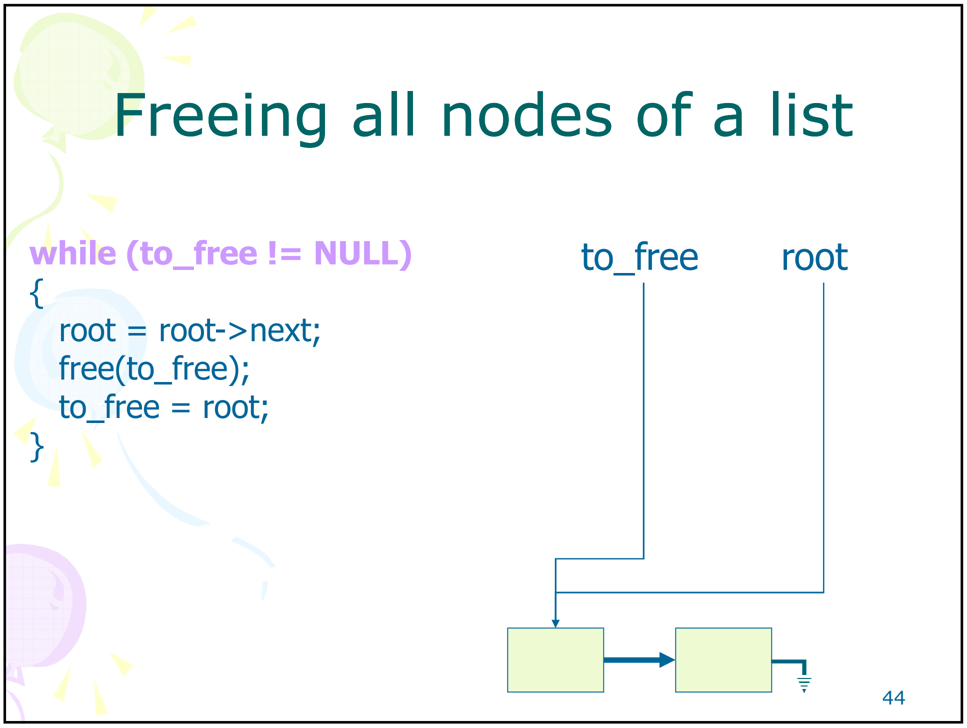

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

to_free root

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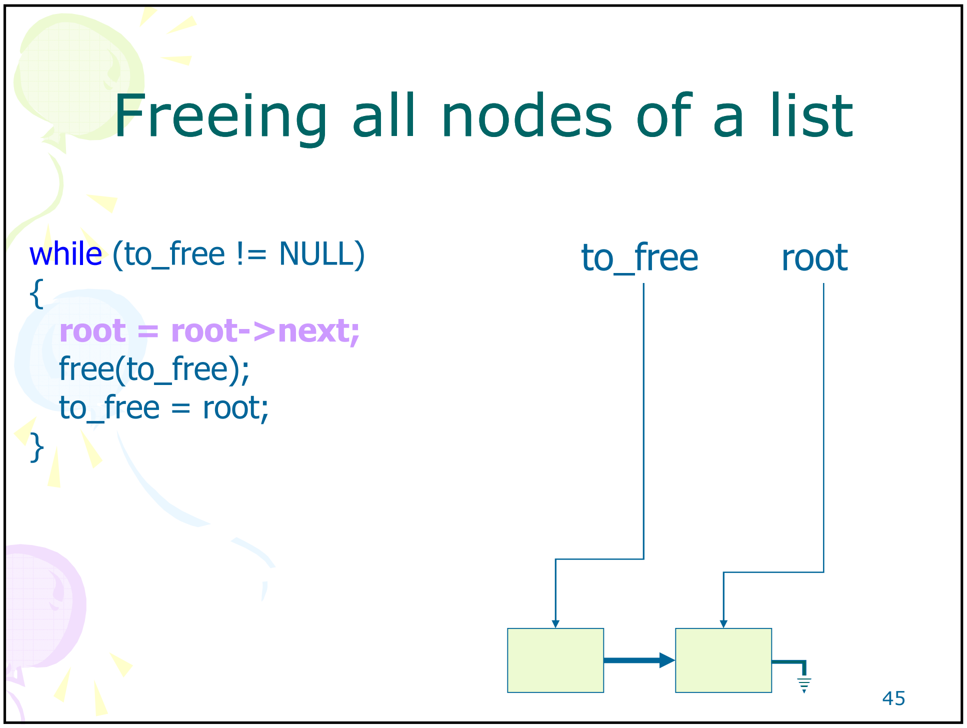

Freeing all nodes of a list

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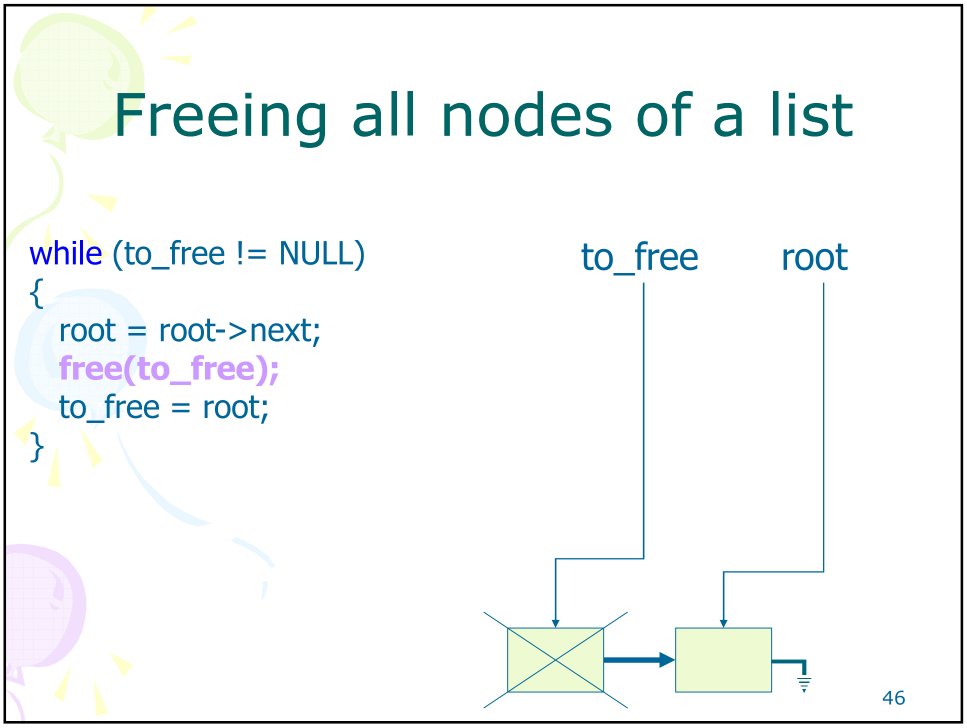
```



Freeing all nodes of a list

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  to_free = root;
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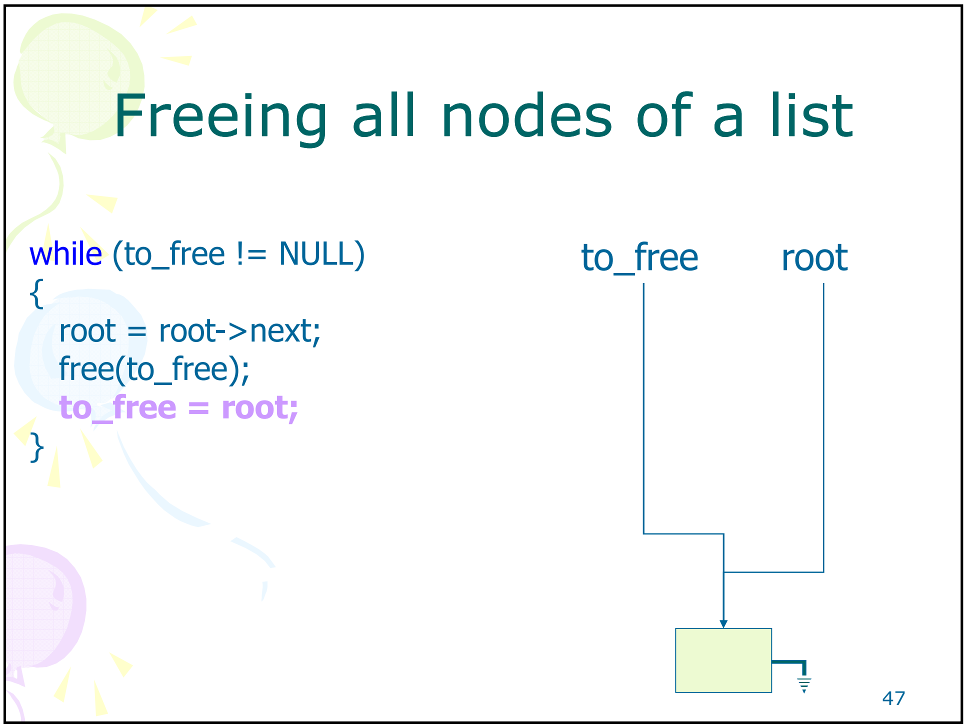
```



Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

to_free
root

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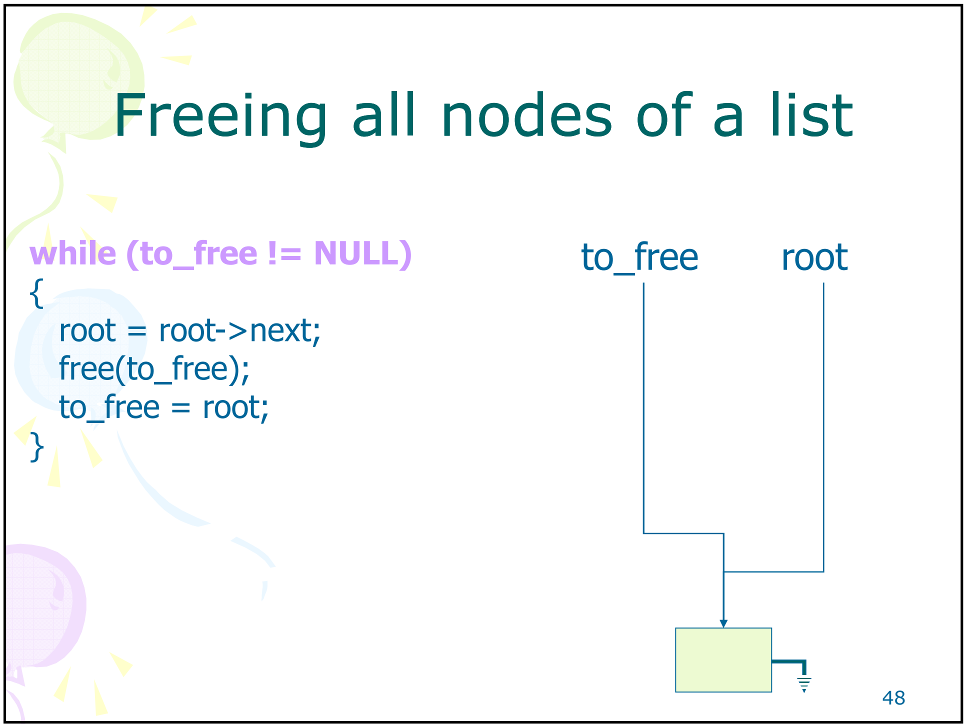

Freeing all nodes of a list

```
while (to_free != NULL)
{
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   free(to_free);
   to_free = root;
}
```

to_free
root

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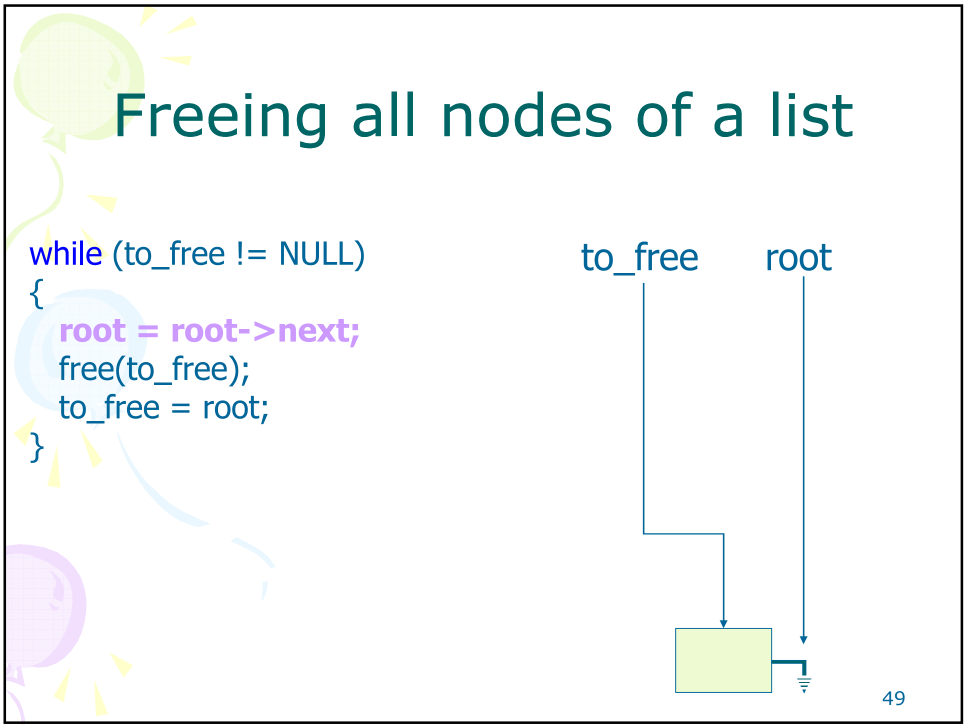

Freeing all nodes of a list

```
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   to_free = root;
}
```

to_free
root

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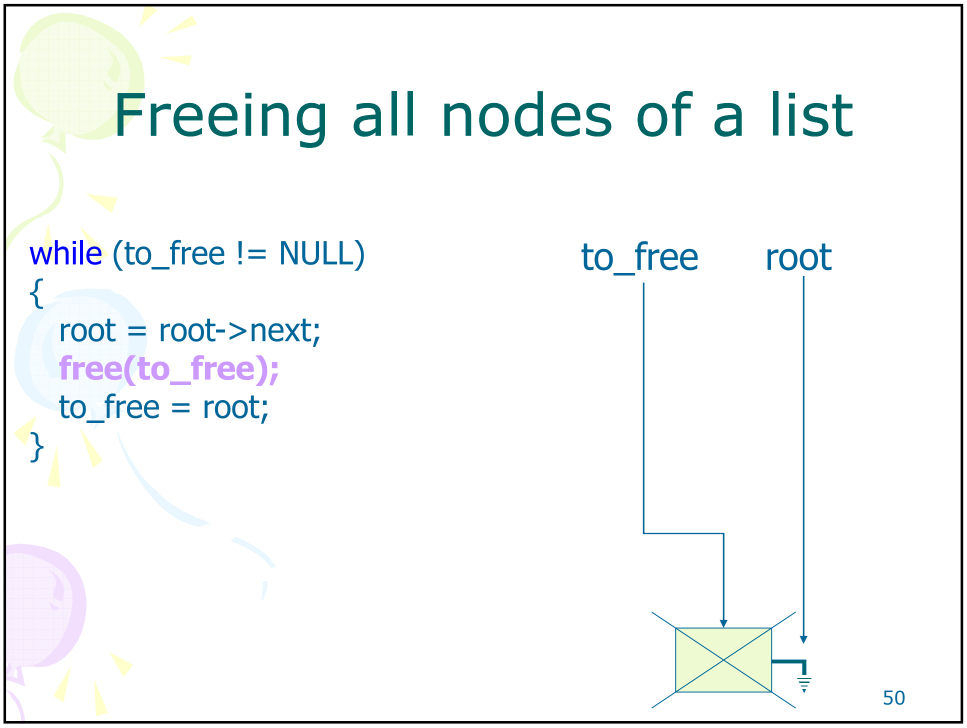


Freeing all nodes of a list

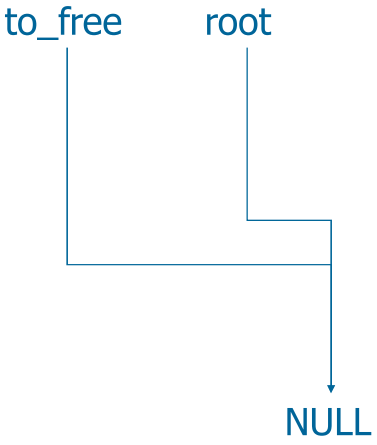
```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```

to_free
root

50

Freeing all nodes of a list

```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```



Freeing all nodes of a list

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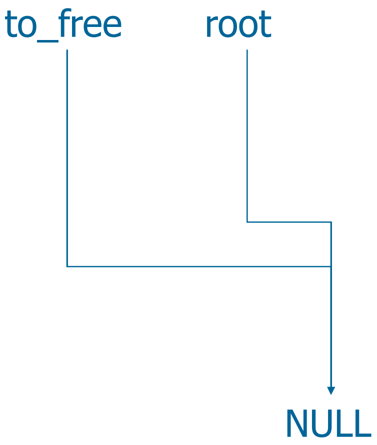
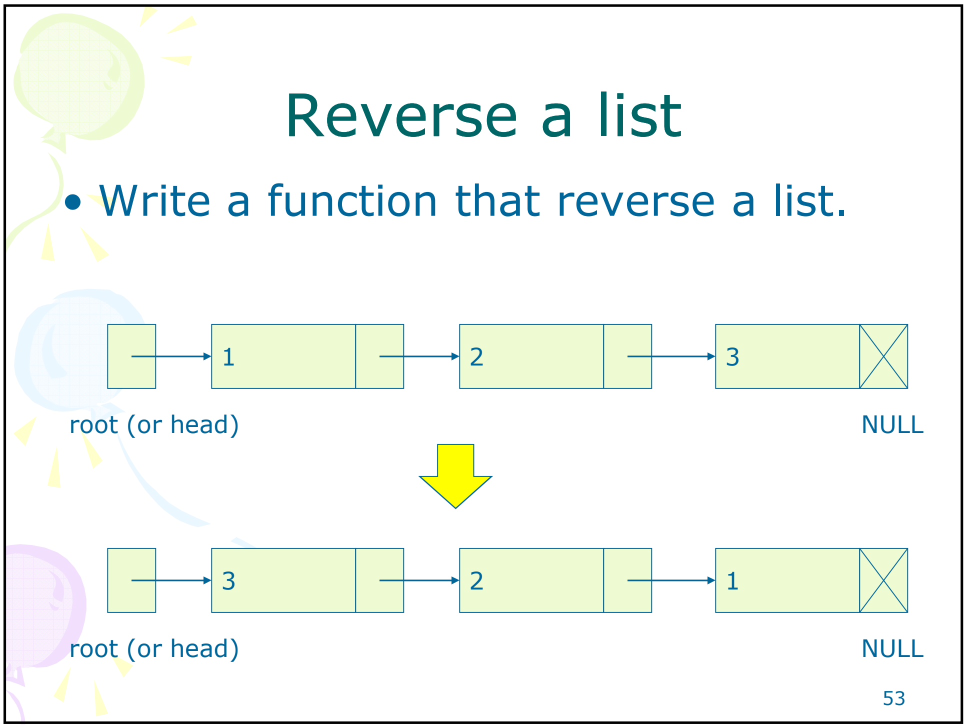
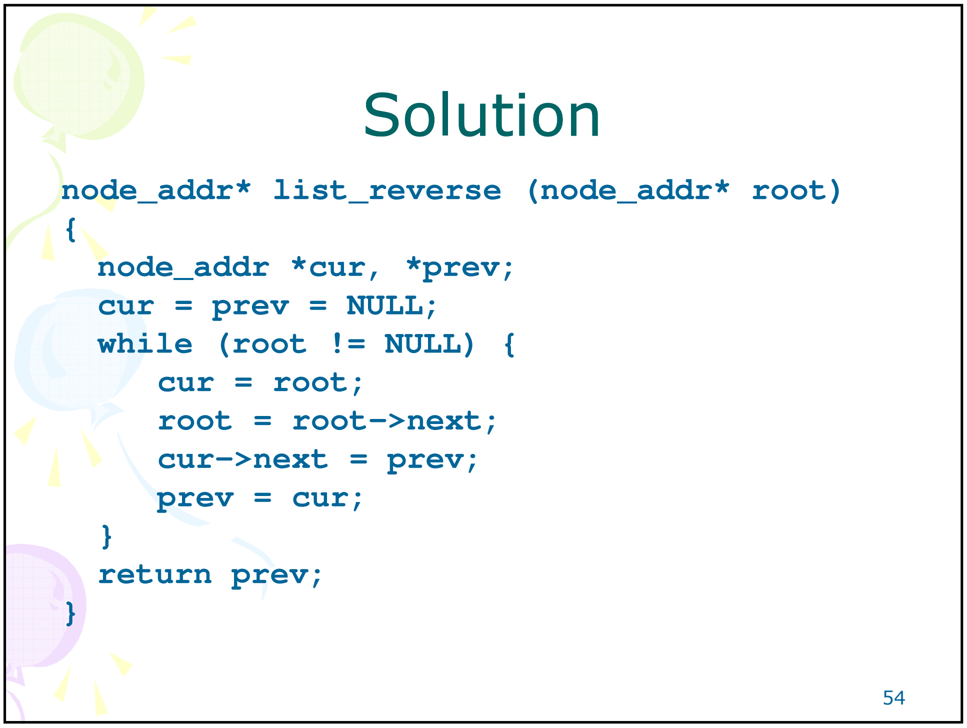
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```





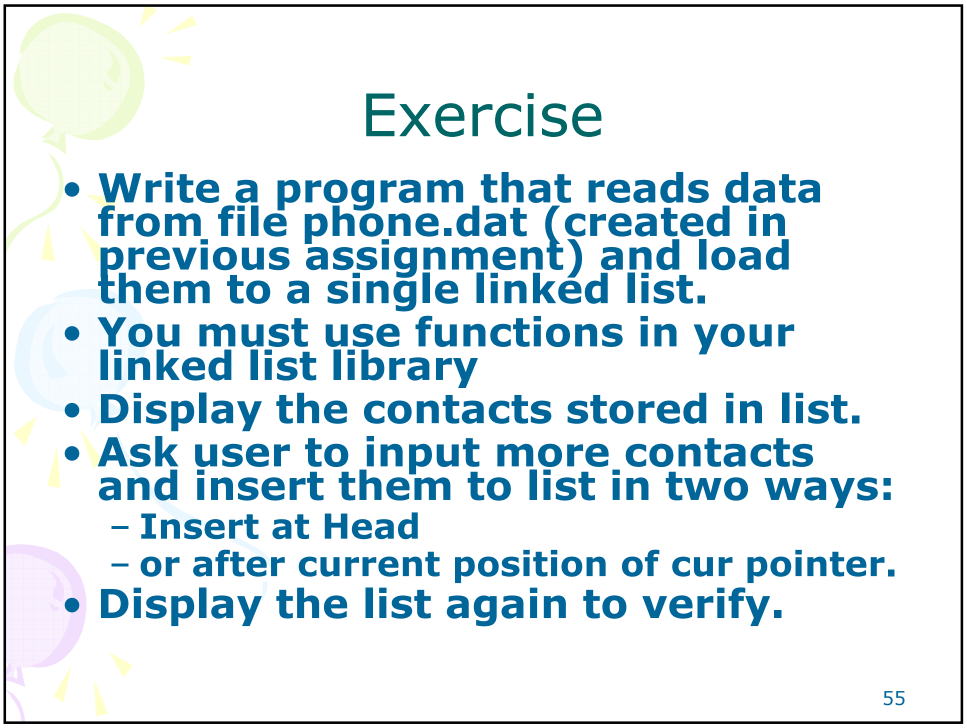
Reverse a list

- Write a function that reverse a list.



Solution

```
node_addr* list_reverse (node_addr* root)
{
  node_addr *cur, *prev;
  cur = prev = NULL;
  while (root != NULL) {
     cur = root;
     root = root->next;
     cur->next = prev;
     prev = cur;
  }
  return prev;
}
```



Exercise

- **Write a program that reads data from file phone.dat (created in previous assignment) and load them to a single linked list.**
- **You must use functions in your linked list library**
- **Display the contacts stored in list.**
- **Ask user to input more contacts and insert them to list in two ways:**
  - **Insert at Head**
  - **or after current position of cur pointer.**
- **Display the list again to verify.**

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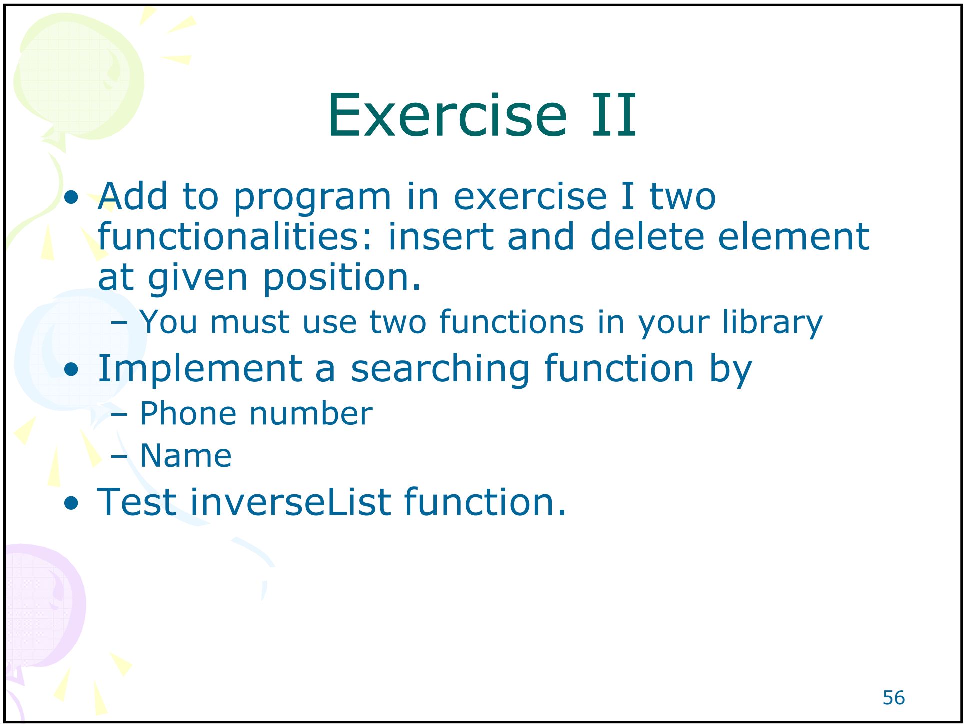

Exercise II

- Add to program in exercise I two functionalities: insert and delete element at given position.
  - You must use two functions in your library
- Implement a searching function by
  - Phone number
  - Name
- Test inverseList function.

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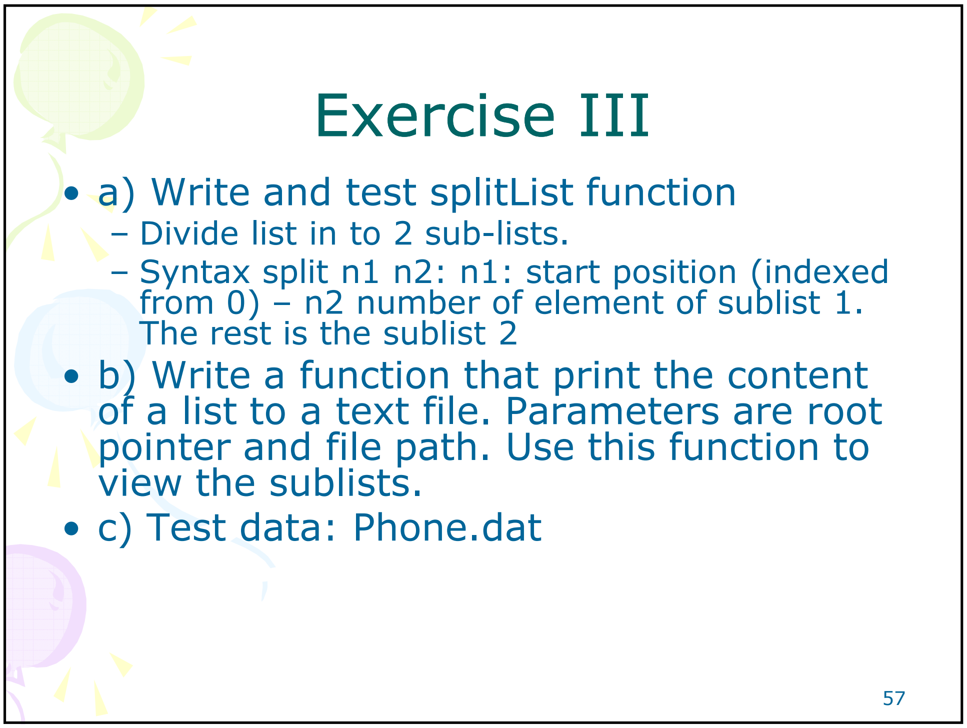
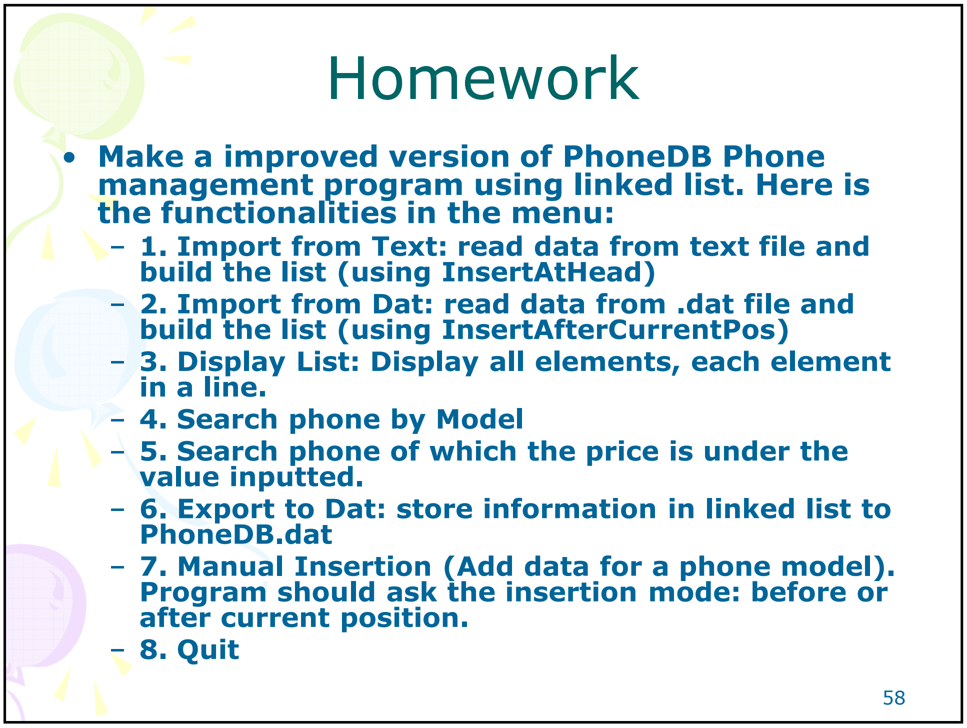


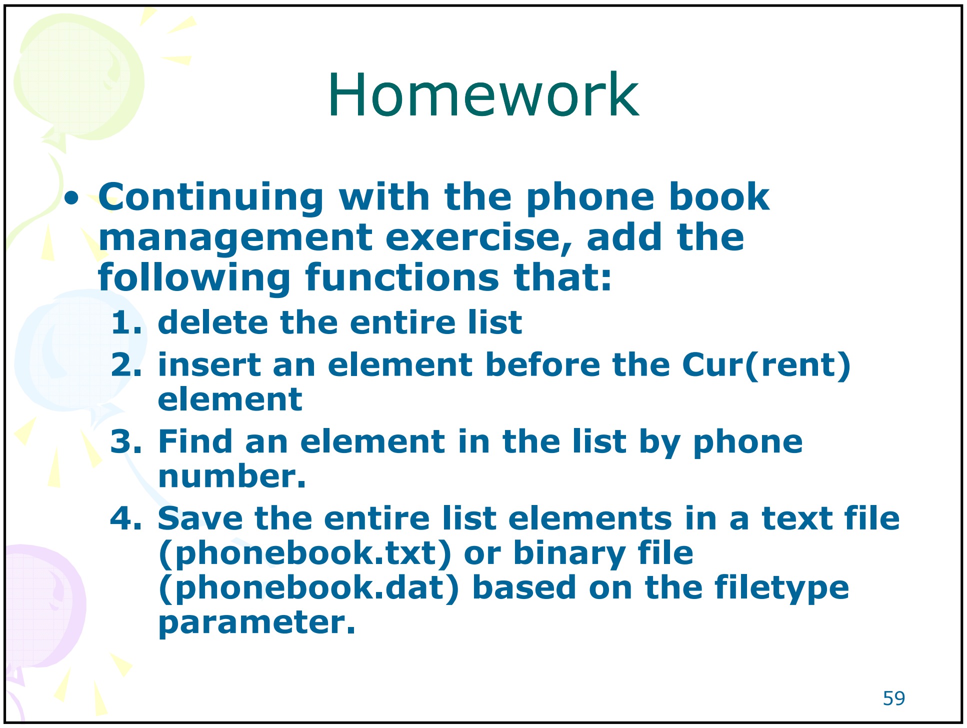
Exercise III

- a) Write and test splitList function
  - Divide list in to 2 sub-lists.
  - Syntax split n1 n2: n1: start position (indexed from 0) – n2 number of element of sublist 1. The rest is the sublist 2
- b) Write a function that print the content of a list to a text file. Parameters are root pointer and file path. Use this function to view the sublists.
- c) Test data: Phone.dat



Homework

- **Make a improved version of PhoneDB Phone management program using linked list. Here is the functionalities in the menu:**
  - **1. Import from Text: read data from text file and build the list (using InsertAtHead)**
  - **2. Import from Dat: read data from .dat file and build the list (using InsertAfterCurrentPos)**
  - **3. Display List: Display all elements, each element in a line.**
  - **4. Search phone by Model**
  - **5. Search phone of which the price is under the value inputted.**
  - **6. Export to Dat: store information in linked list to PhoneDB.dat**
  - **7. Manual Insertion (Add data for a phone model). Program should ask the insertion mode: before or after current position.**
  - **8. Quit**



Homework

- **Continuing with the phone book management exercise, add the following functions that:**
  1. **delete the entire list**
  2. **insert an element before the Cur(rent) element**
  3. **Find an element in the list by phone number.**
  4. **Save the entire list elements in a text file (phonebook.txt) or binary file (phonebook.dat) based on the filetype parameter.**