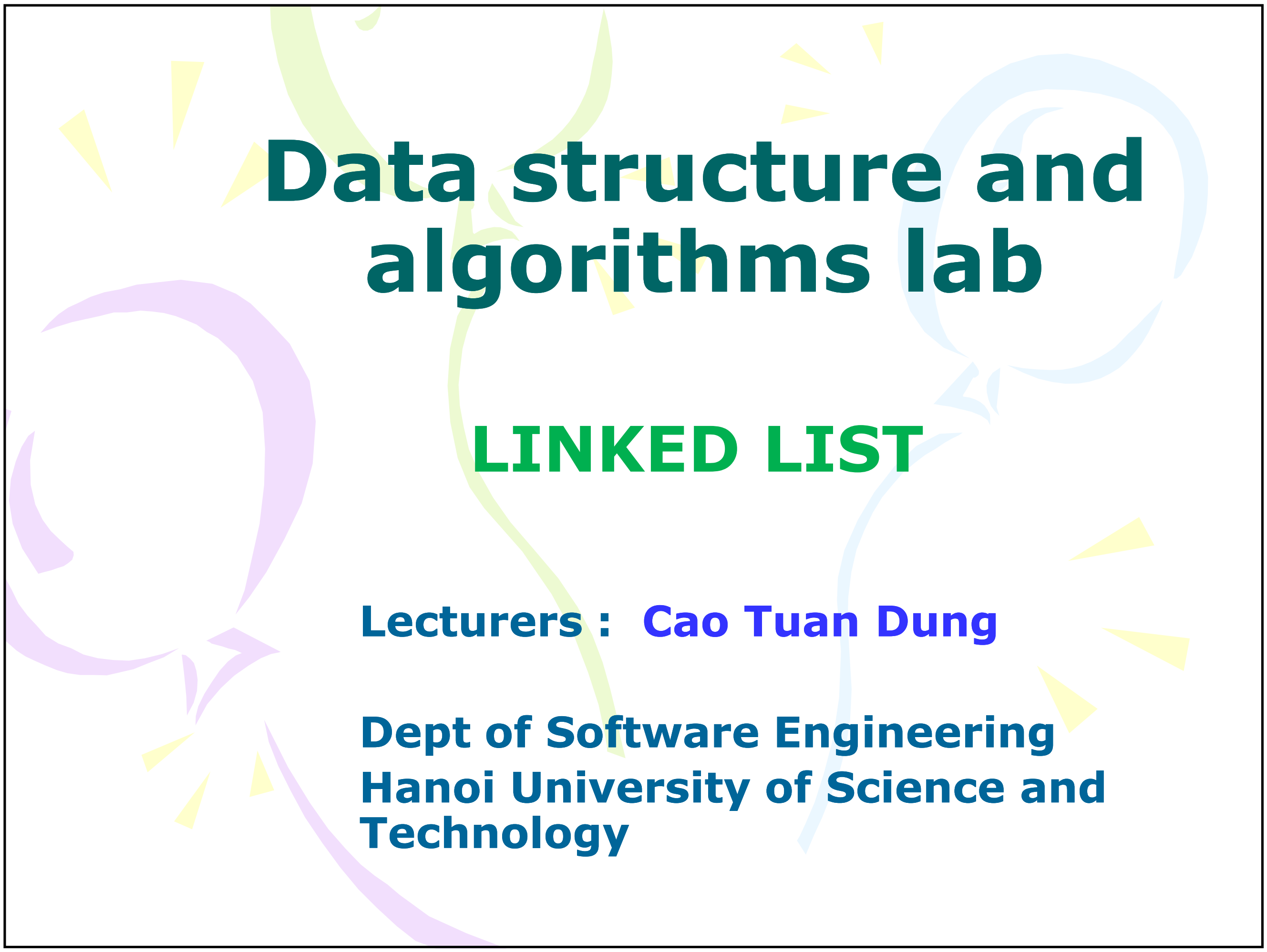

Data structure and algorithms lab

LINKED LIST

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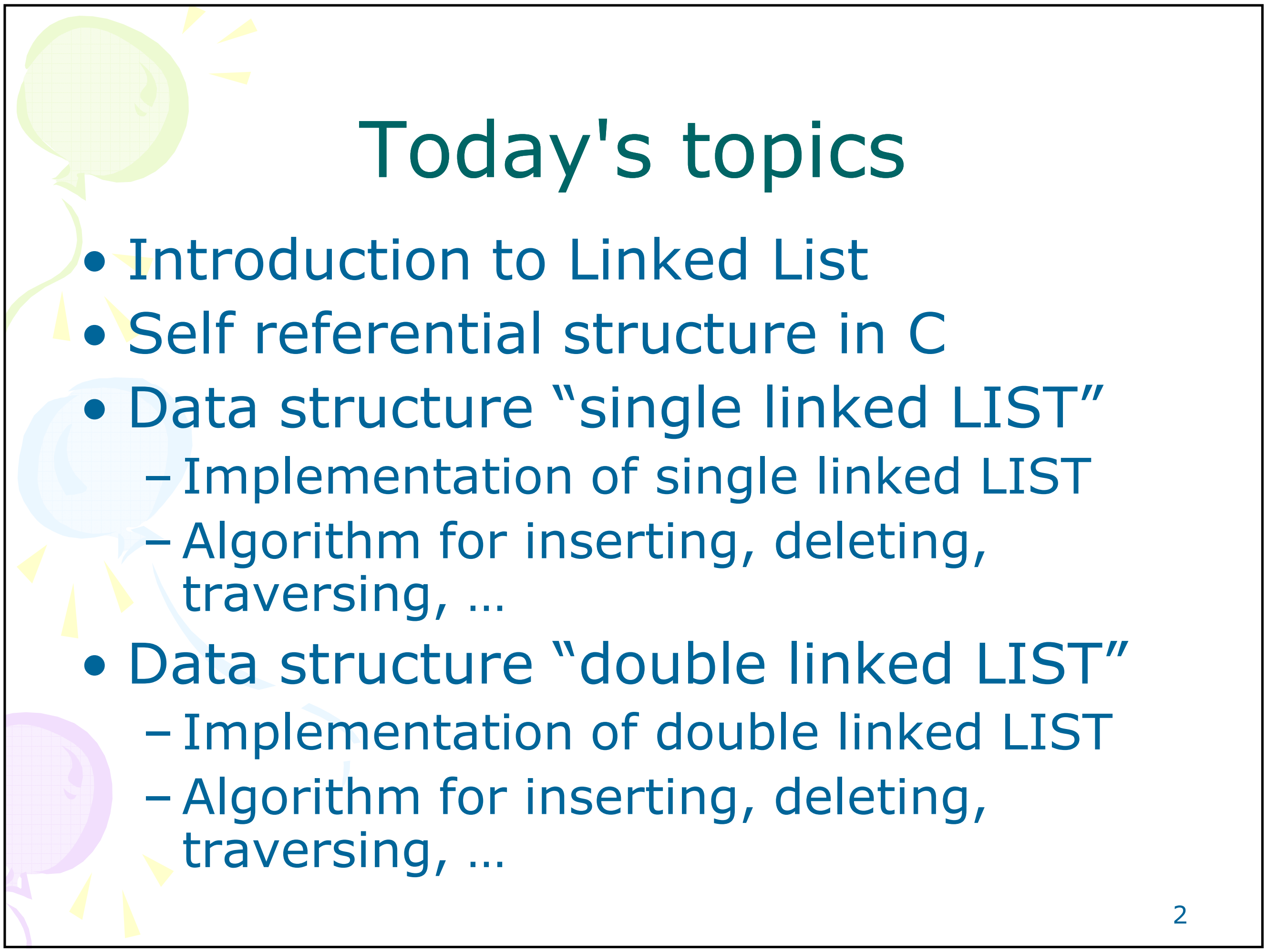
Dept of Software Engineering
Hanoi University of Science and Technology



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, …

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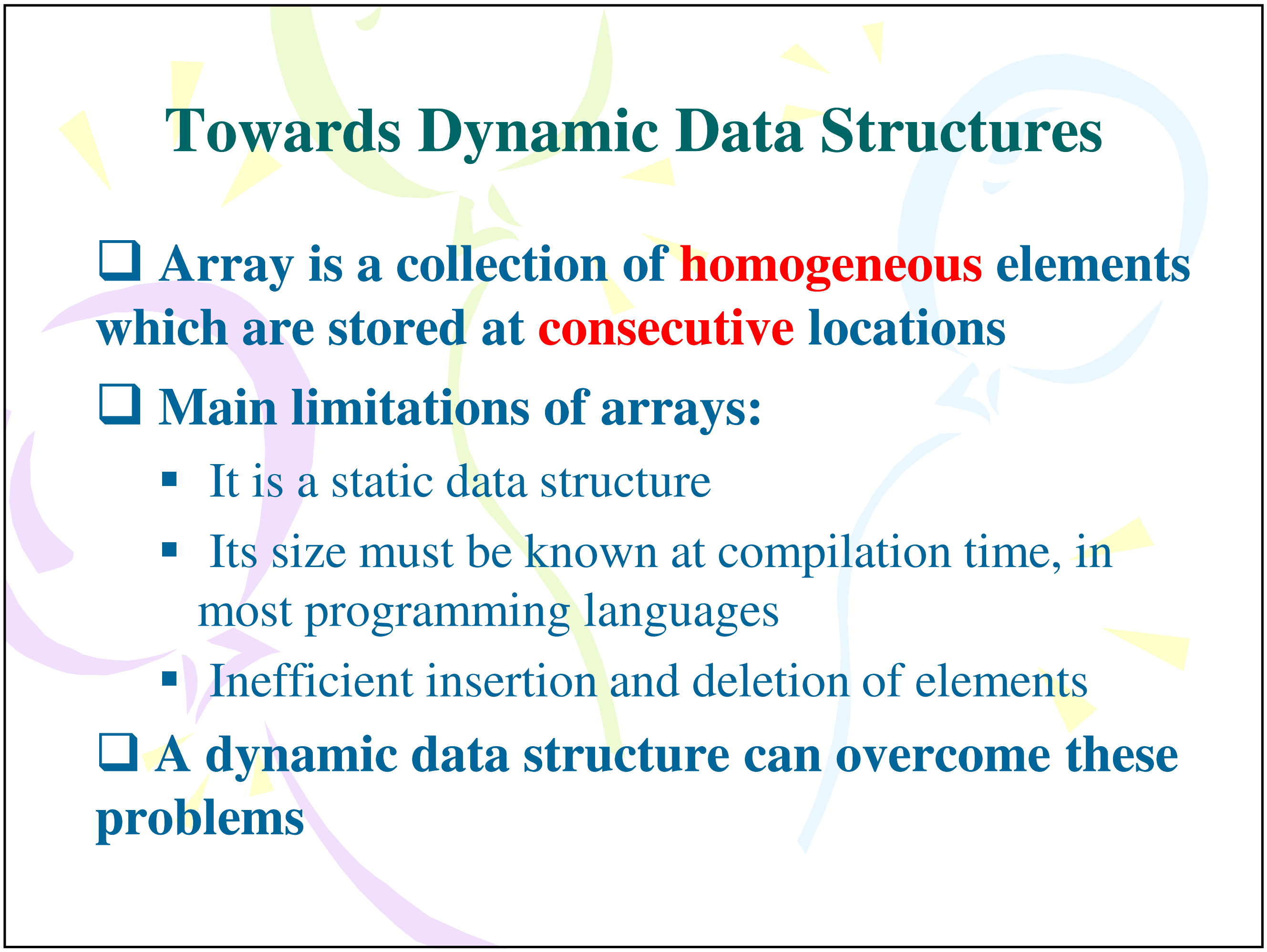
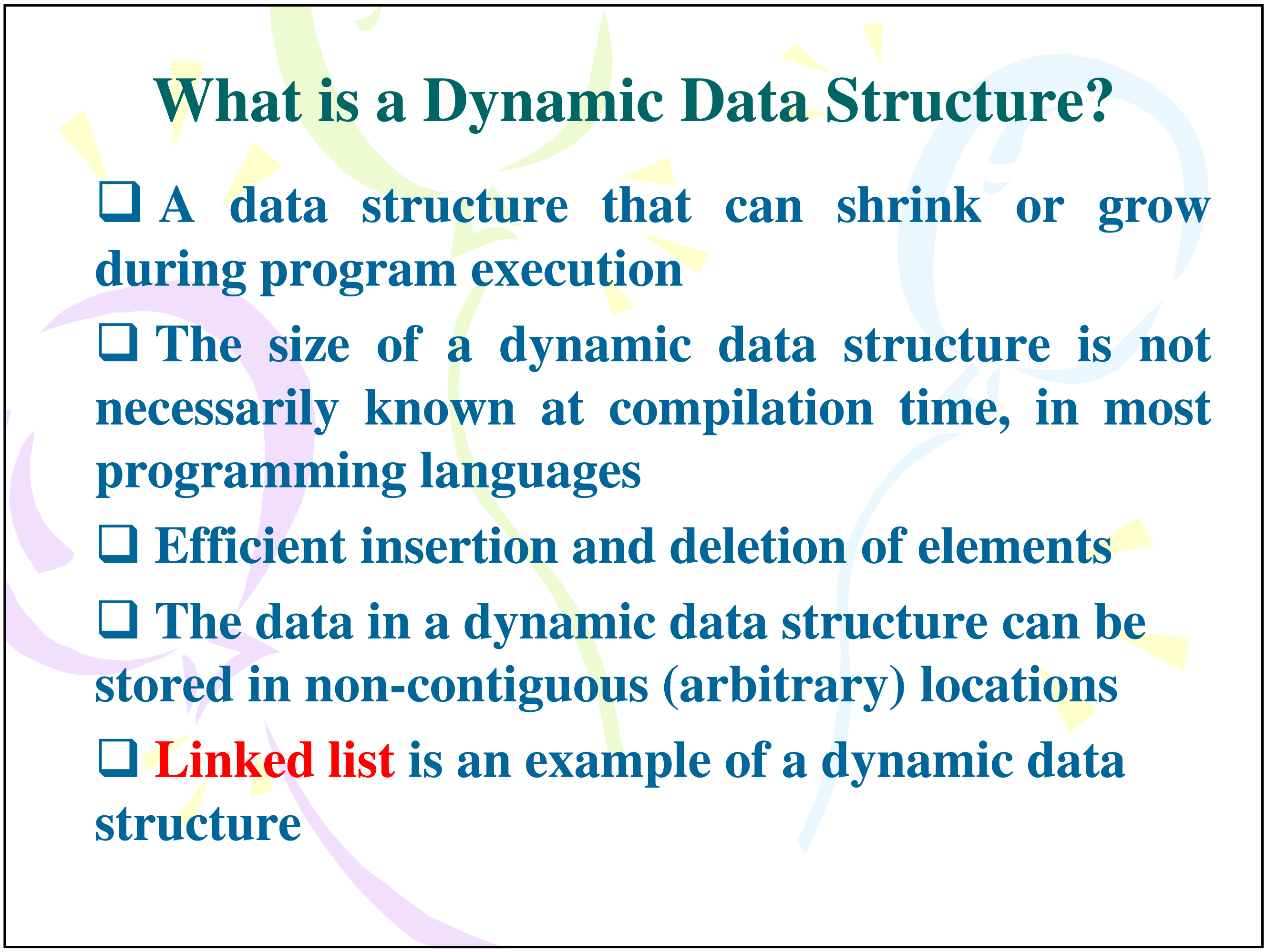


Towards Dynamic Data Structures

- ❑ **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

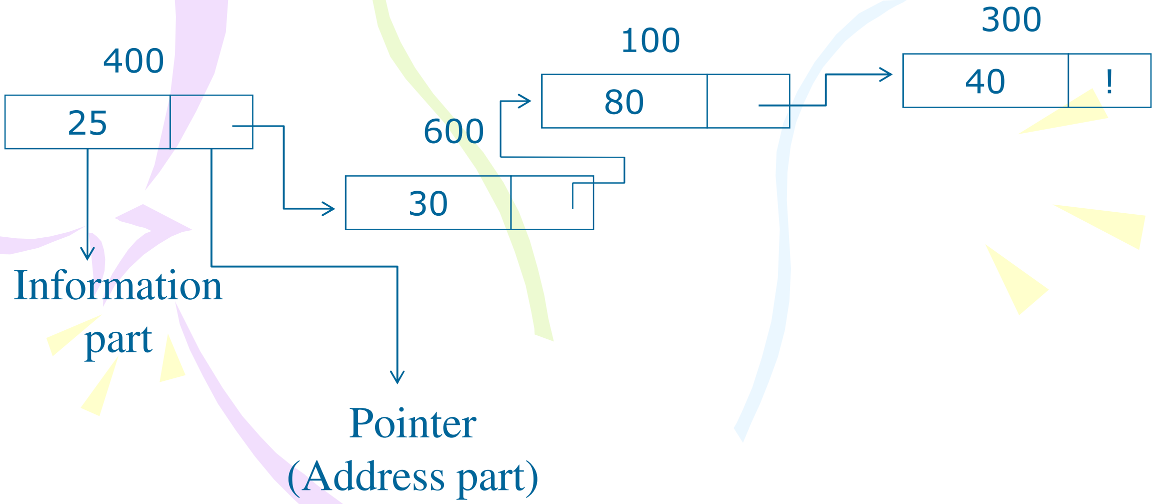
□ Efficient insertion and deletion of elements

□ 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



400

25

100

80

600

30

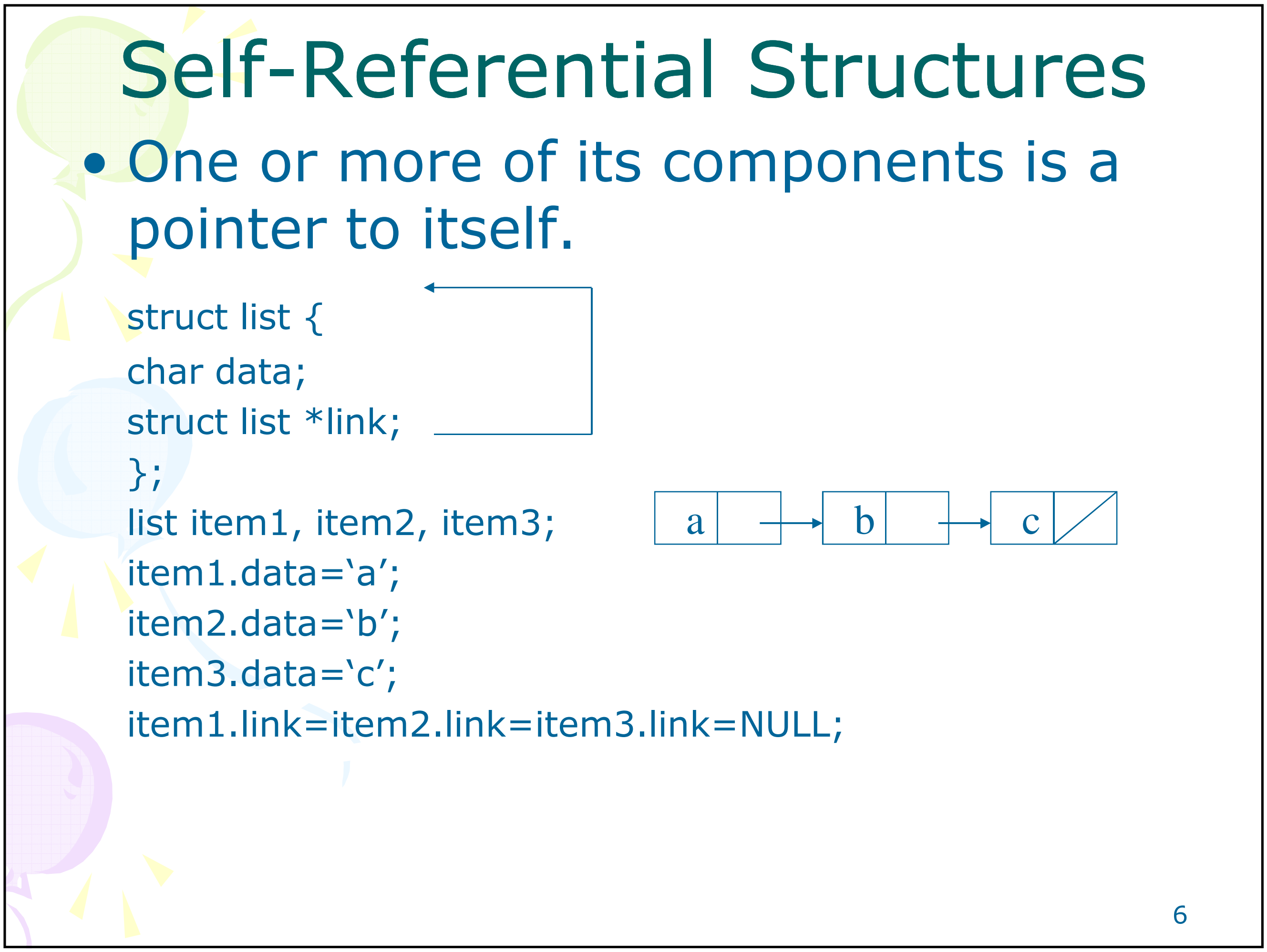
300

40

!

Information part

Pointer (Address part)

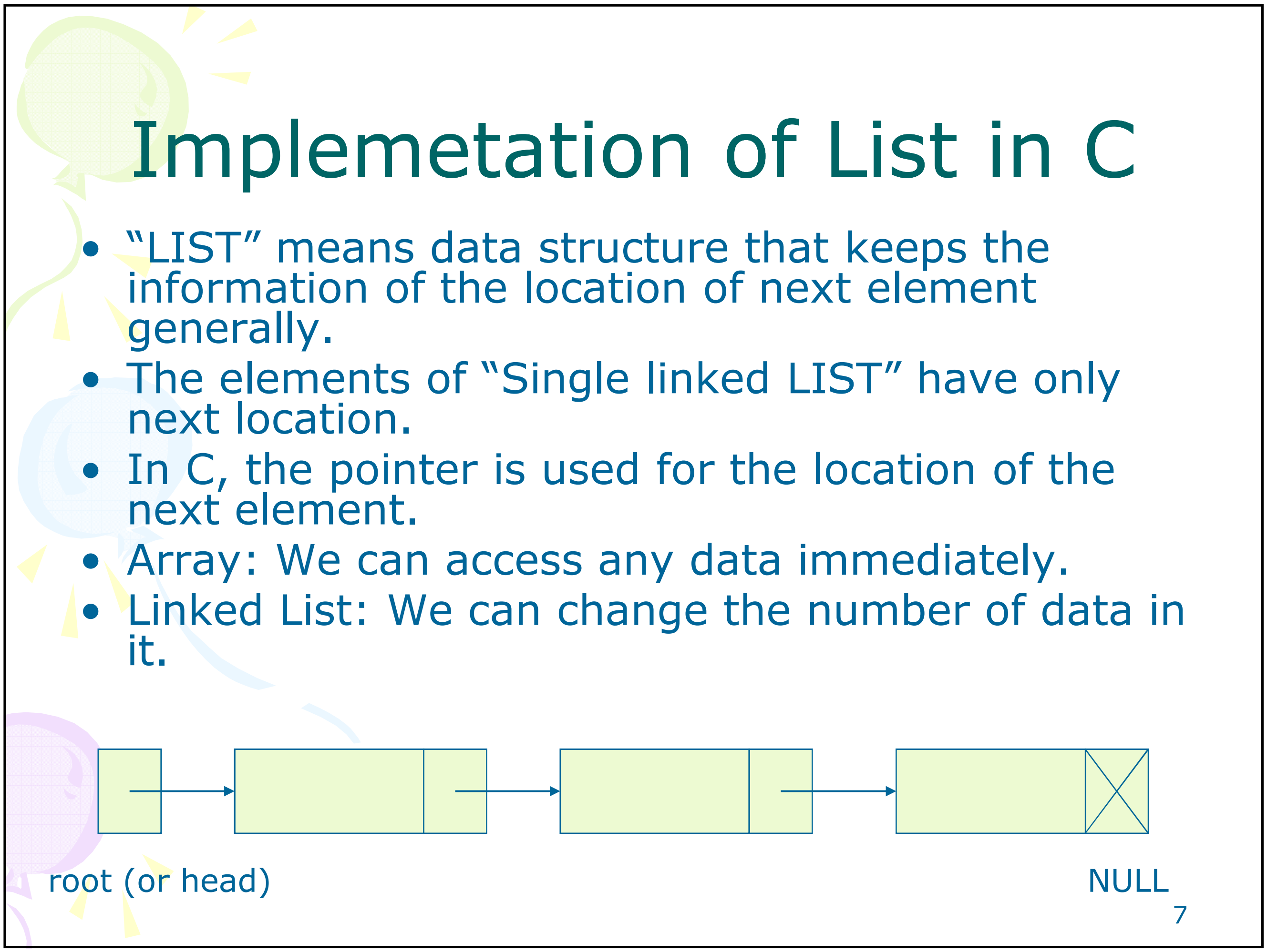


Self-Referential Structures

- 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;
```

6

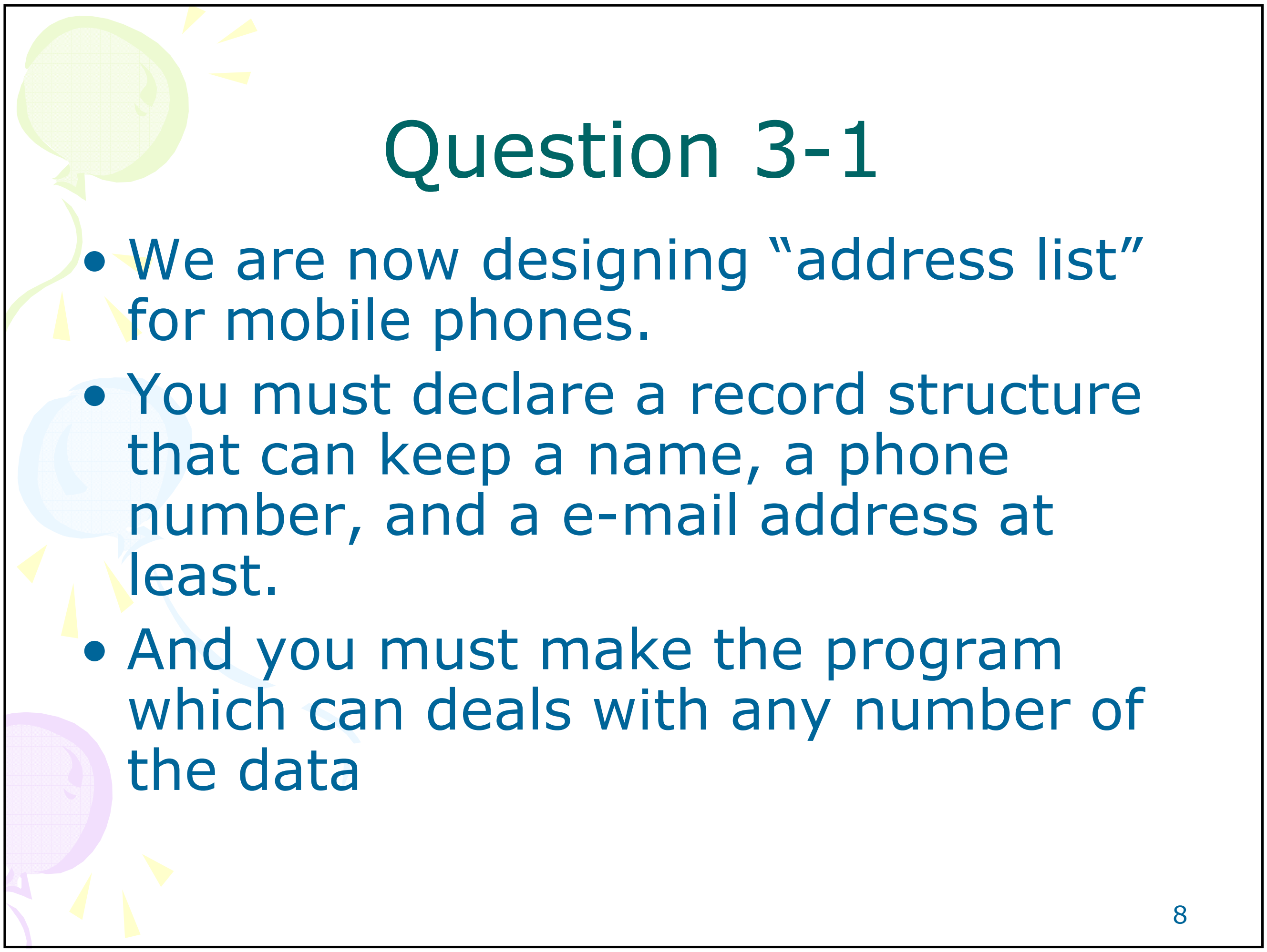


Implemetation of List in C

- “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.

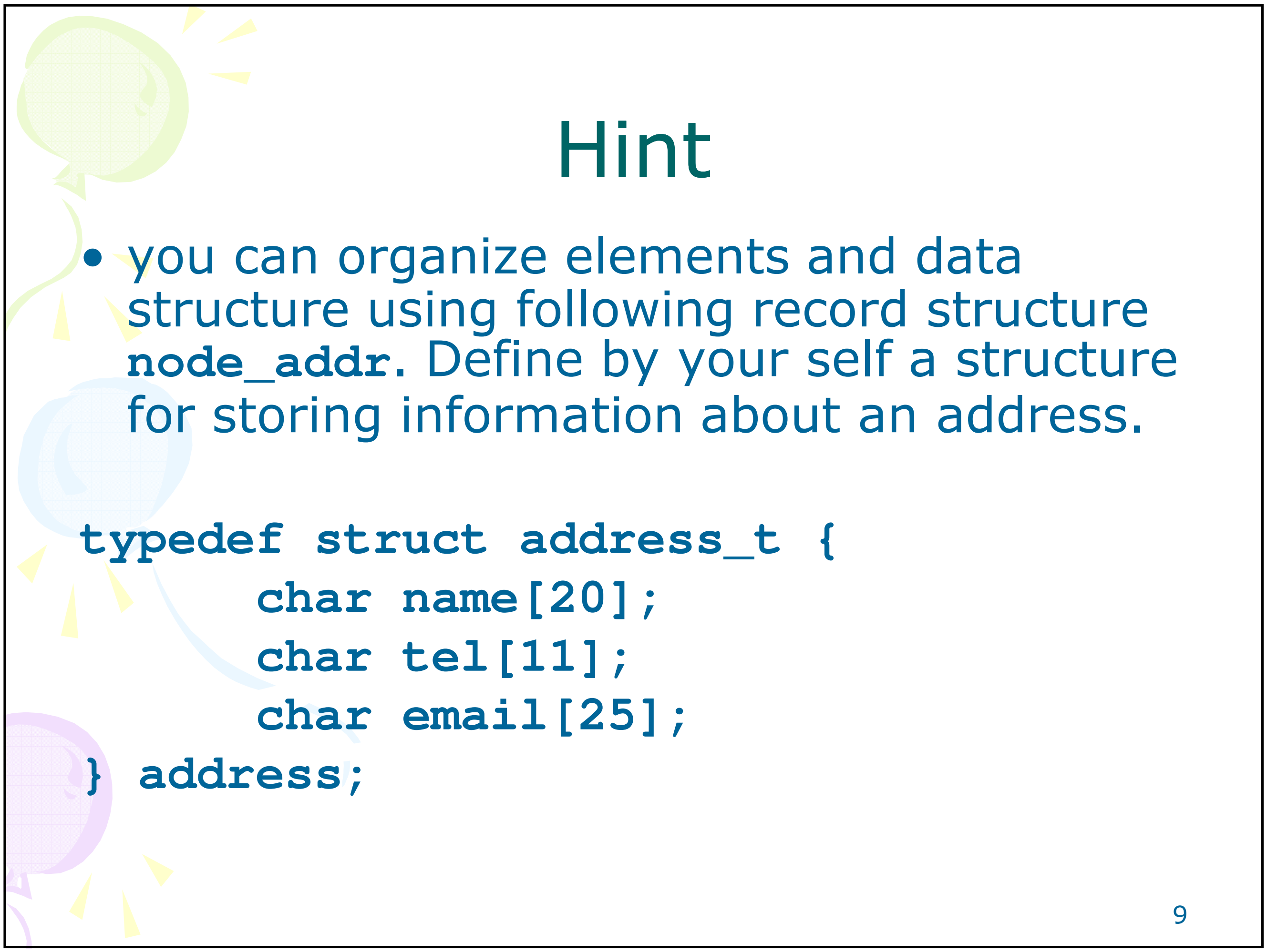
root (or head)

NULL



Question 3-1

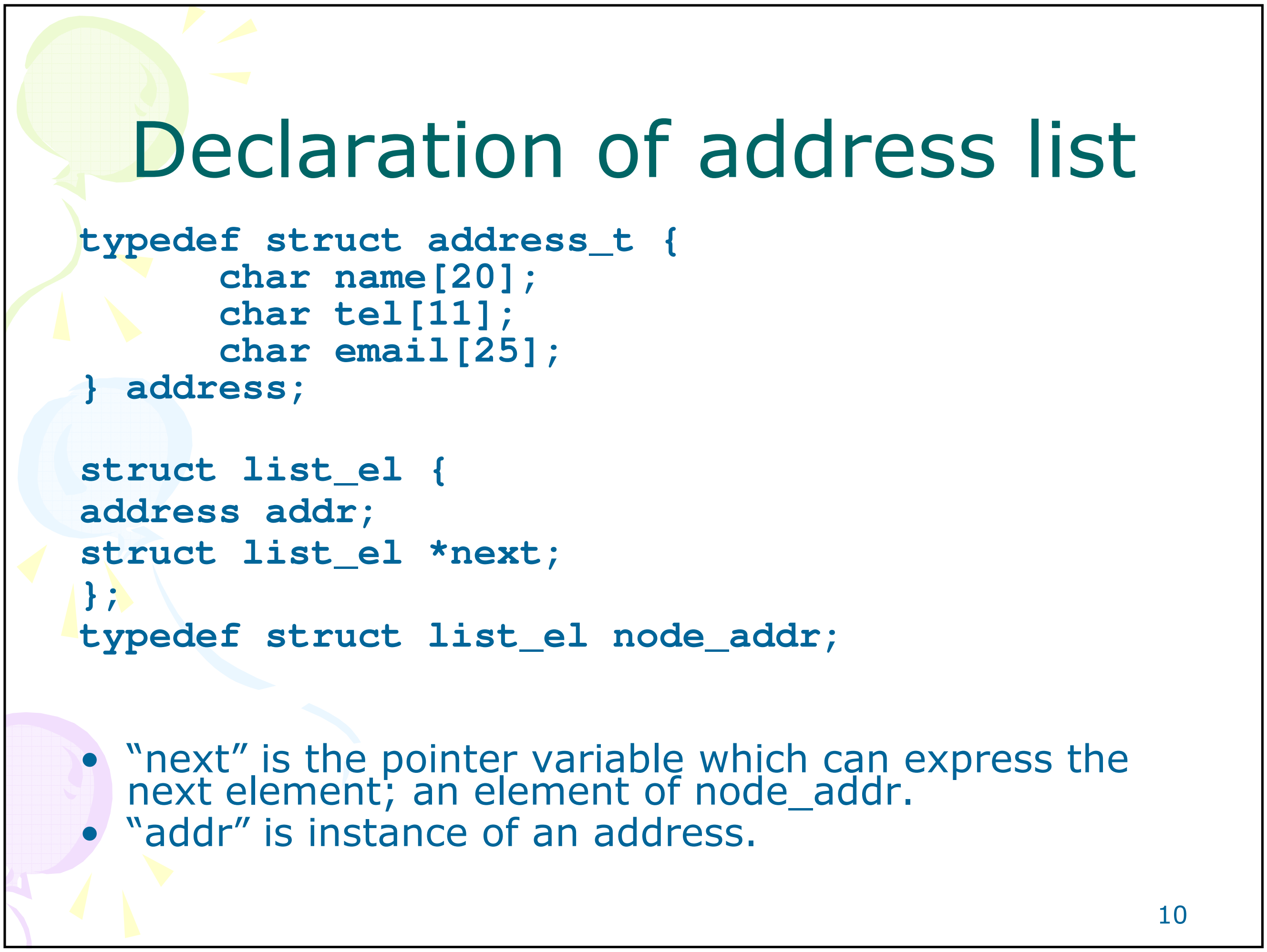
- We are now designing “address list” for mobile phones.
- You must declare a record structure that can keep a name, a phone number, and a e-mail address at least.
- And you must make the program which can deals with any number of the data



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

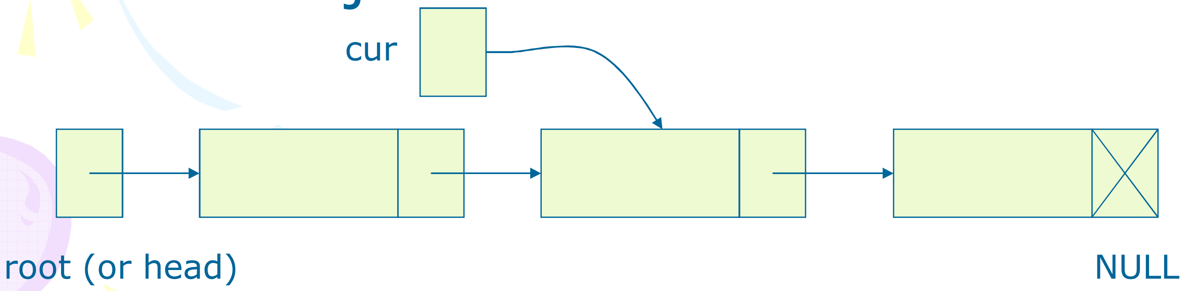
```
typedef struct address_t {
        char name[20];
        char tel[11];
        char email[25];
} address;

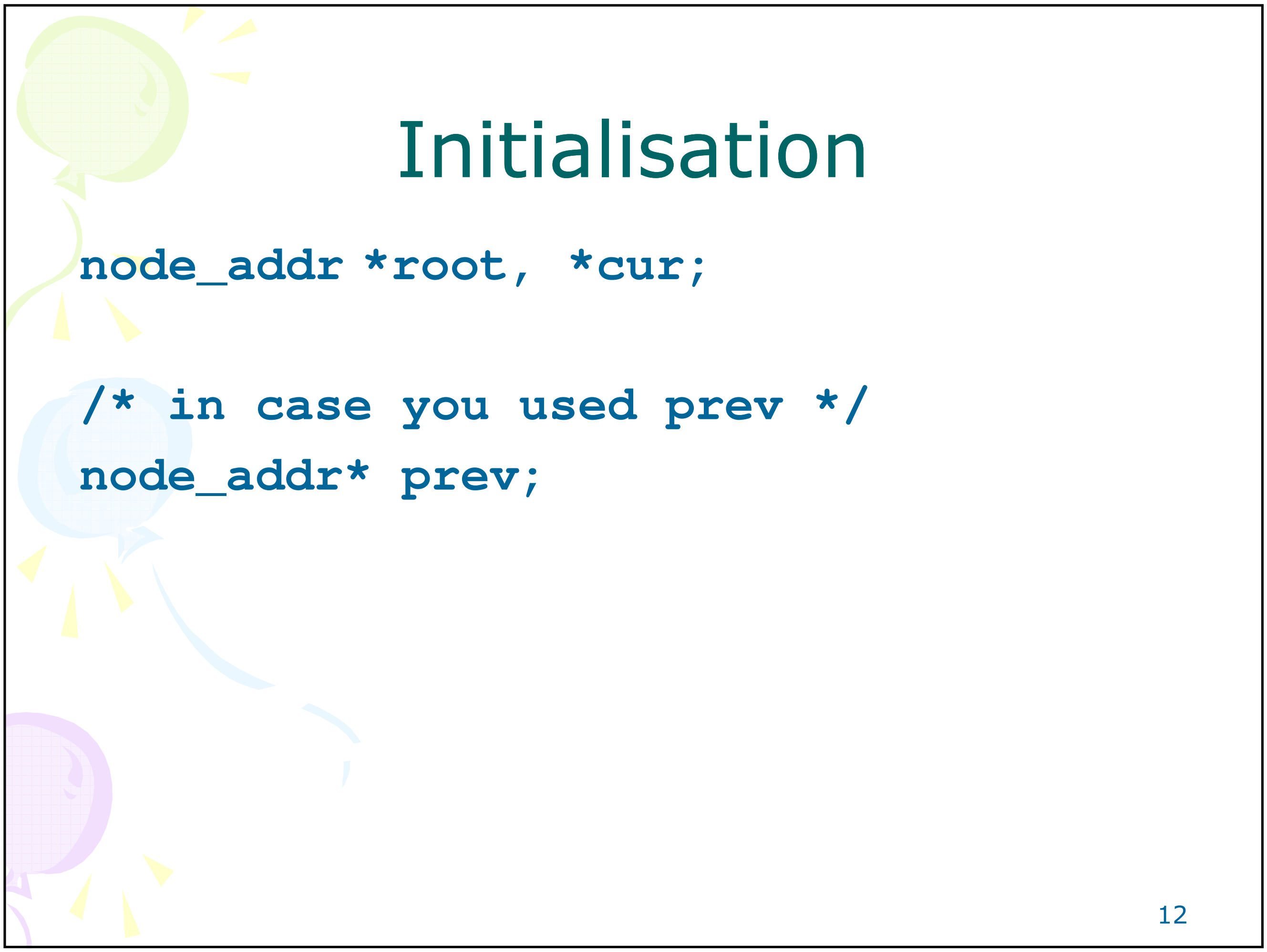
struct list_el {
address addr;
struct list_el *next;
};
typedef struct list_el node_addr;
```

- “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.

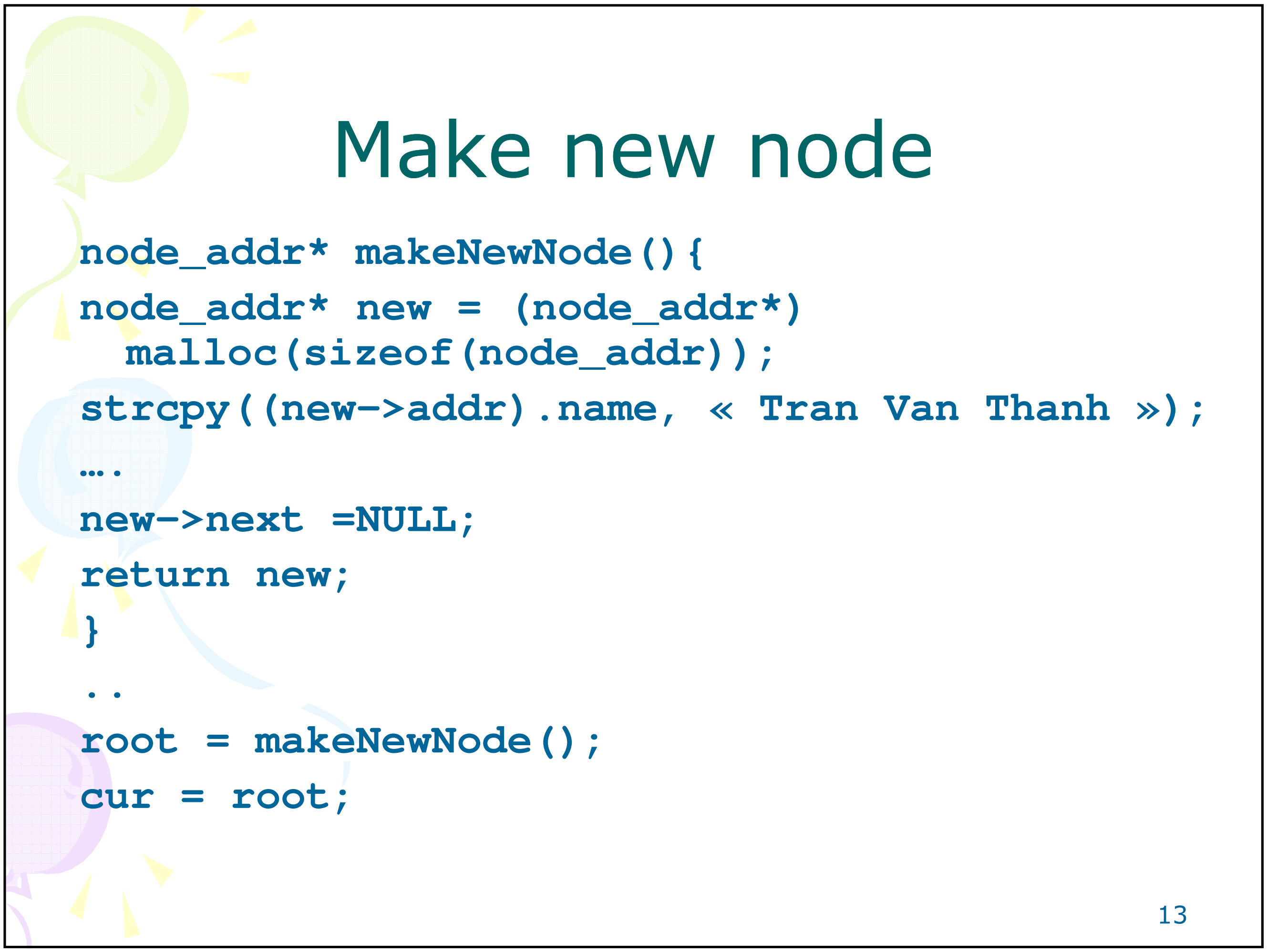




Initialisation

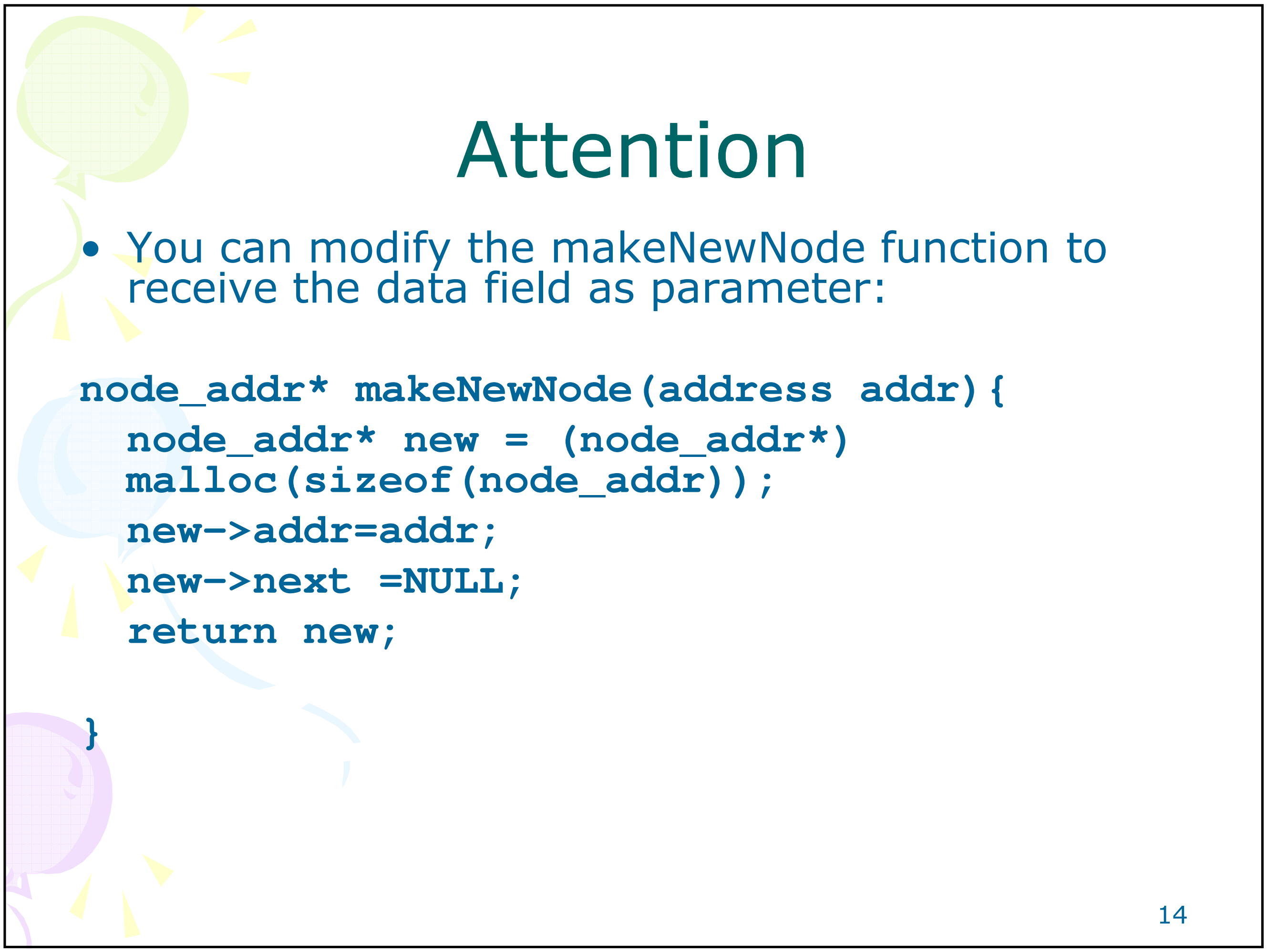
```
node_addr *root, *cur;

/* 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;
```

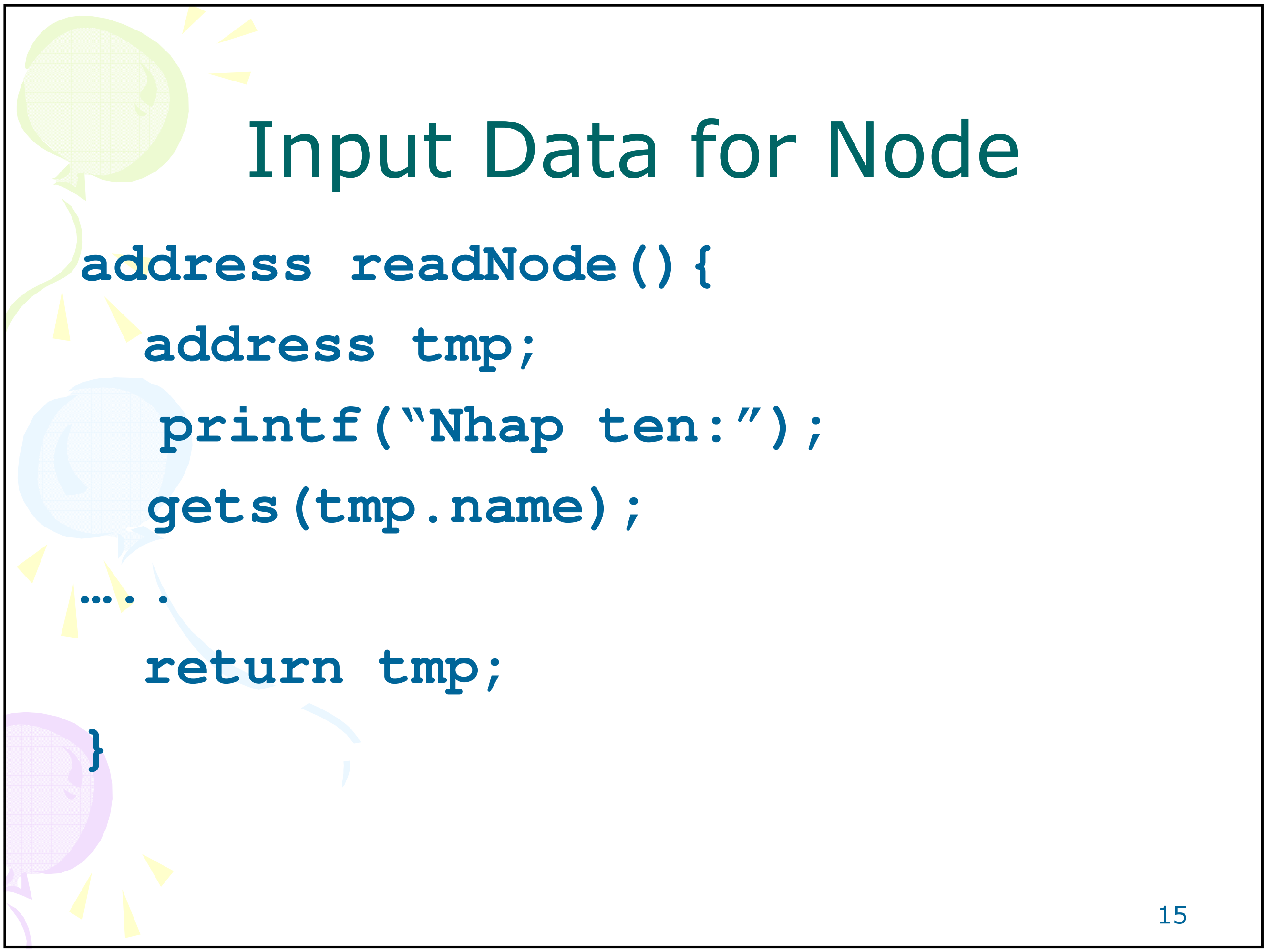


Attention

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

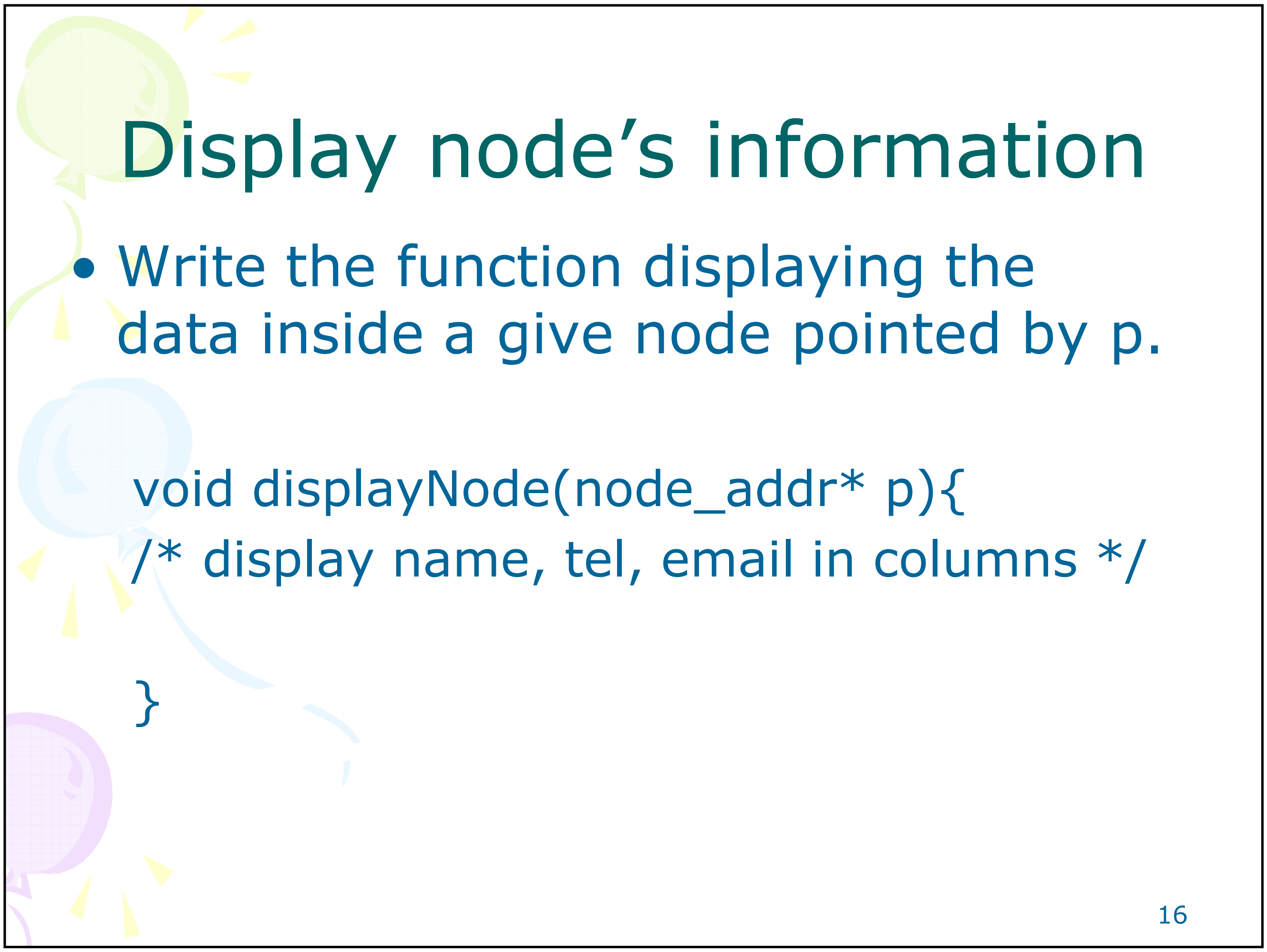
```
node_addr* makeNewNode(address addr){
   node_addr* new = (node_addr*)
   malloc(sizeof(node_addr));
   new->addr=addr;
   new->next =NULL;
   return new;

}
```



Input Data for Node

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

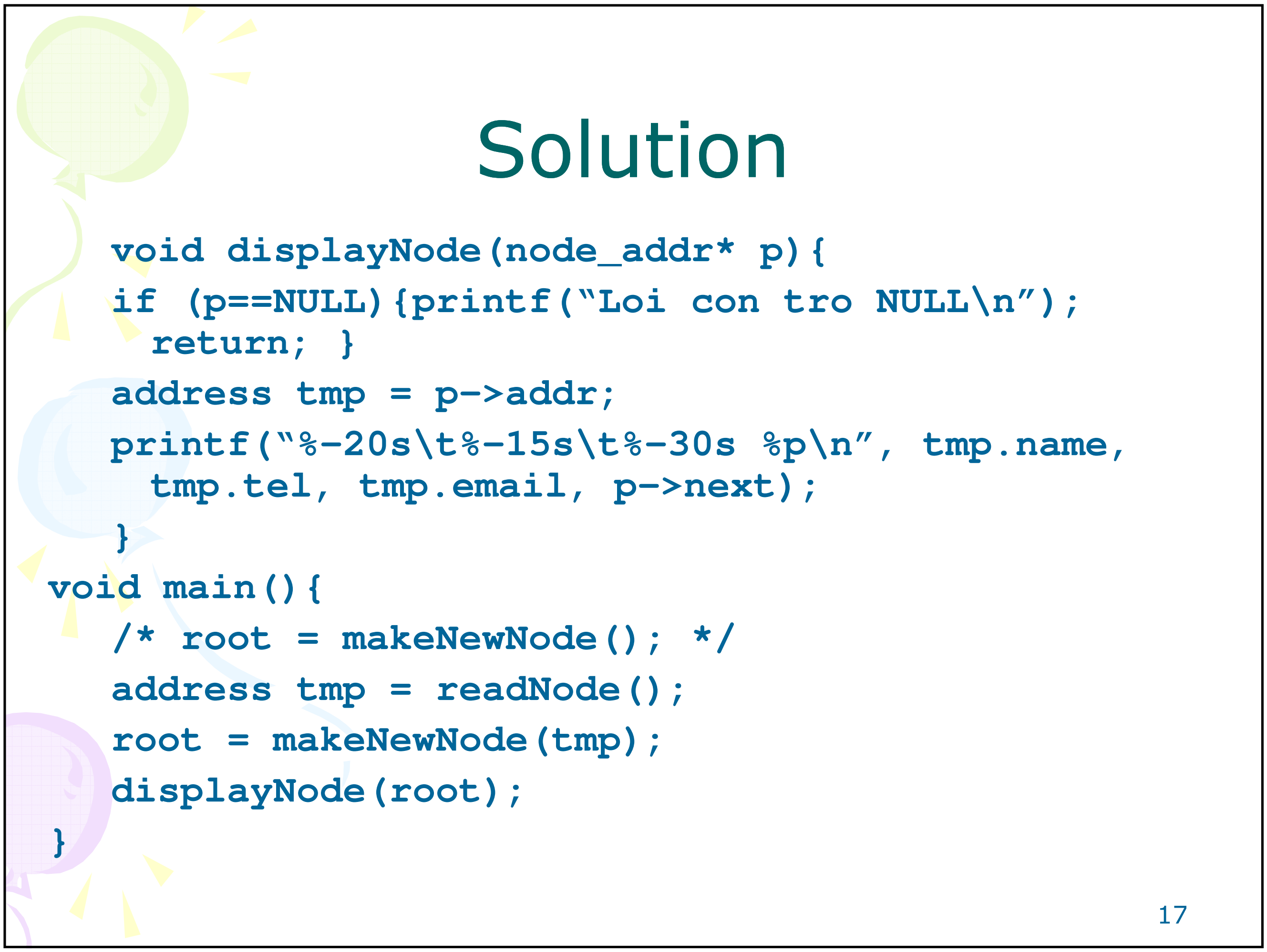


Display node’s information

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

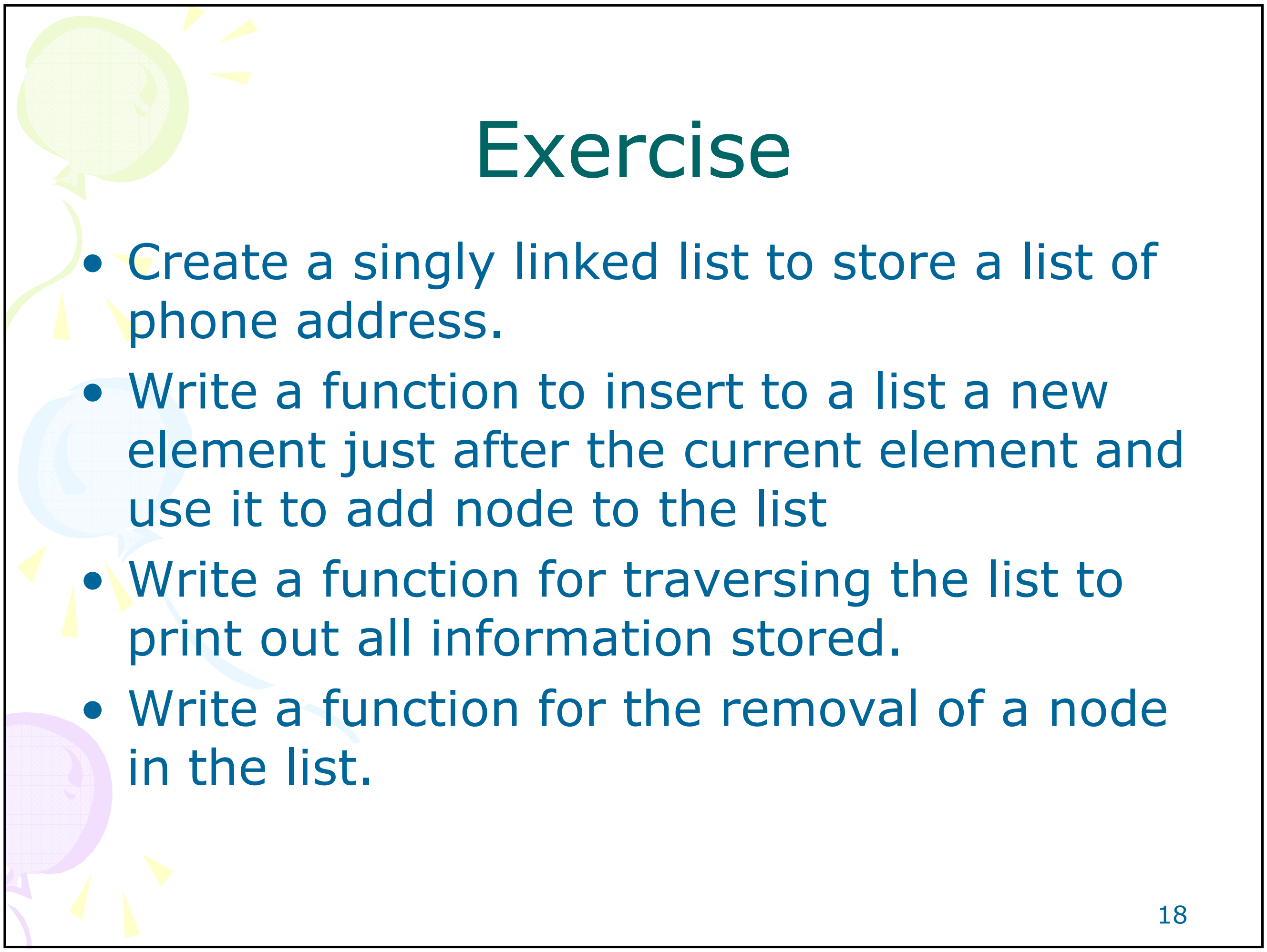
```
void displayNode(node_addr* p){
/* display name, tel, email in columns */


}
```



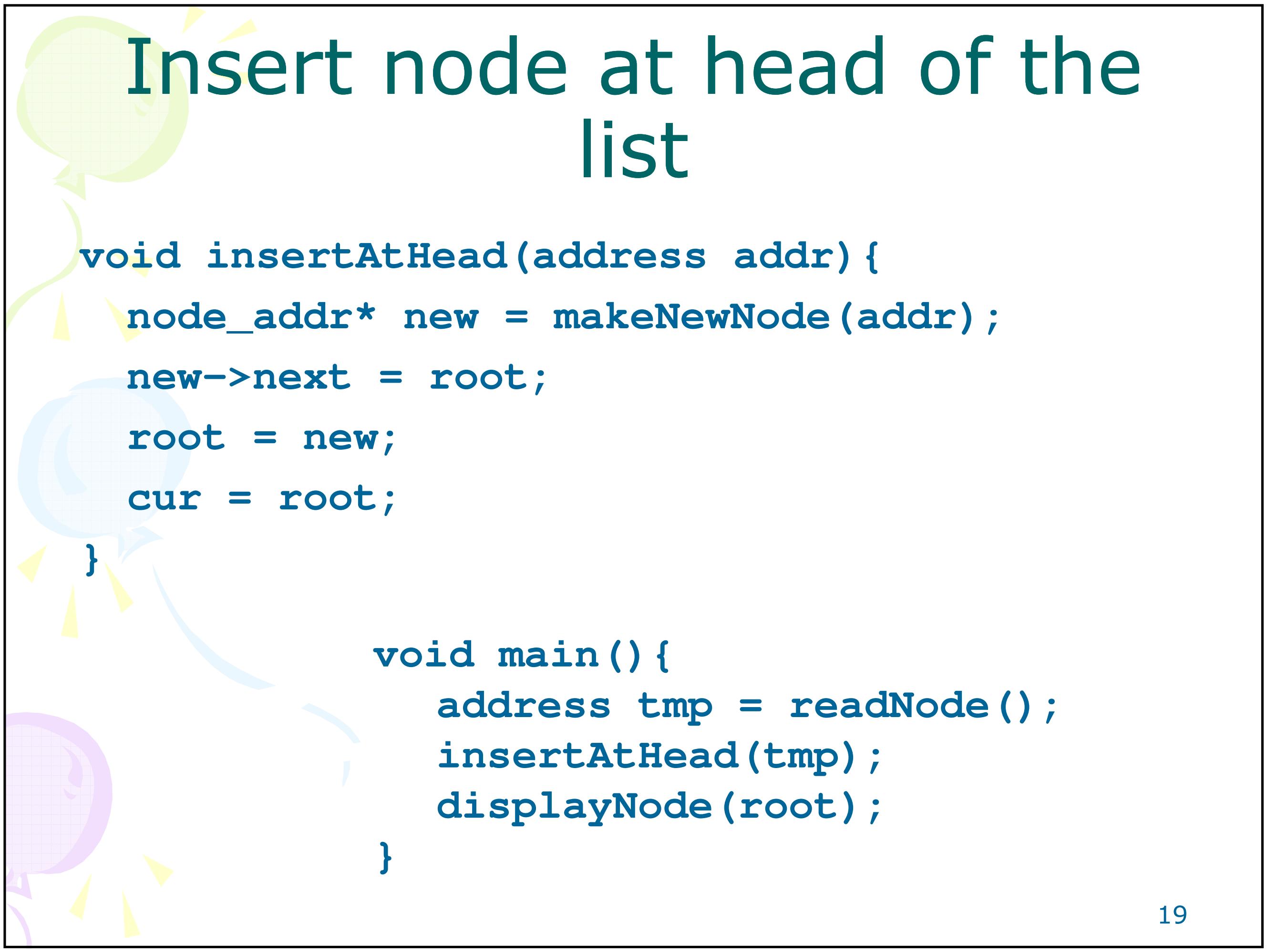
Solution

```
   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

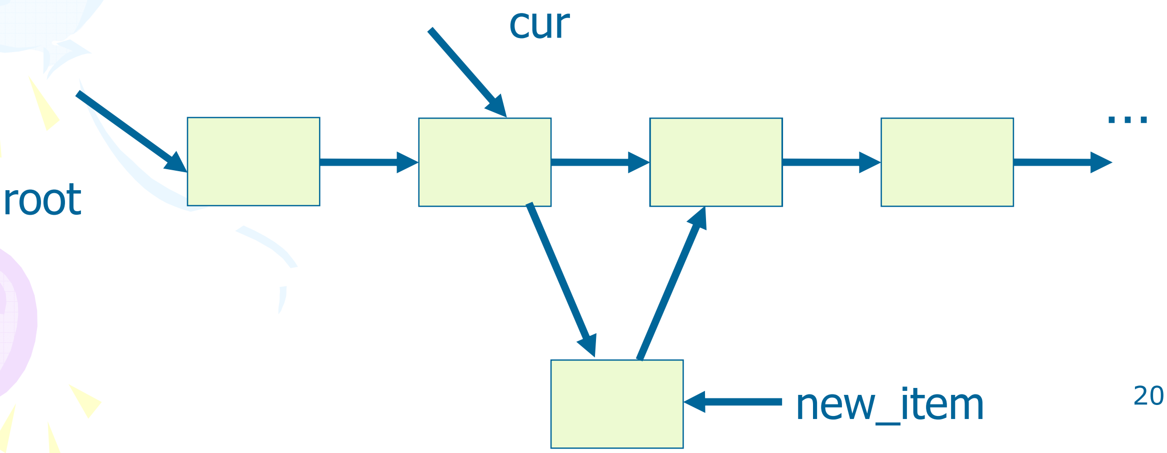
```
void insertAtHead(address addr){
  node_addr* new = makeNewNode(addr);
  new->next = root;
  root = new;
  cur = root;
}
```

```
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;
```



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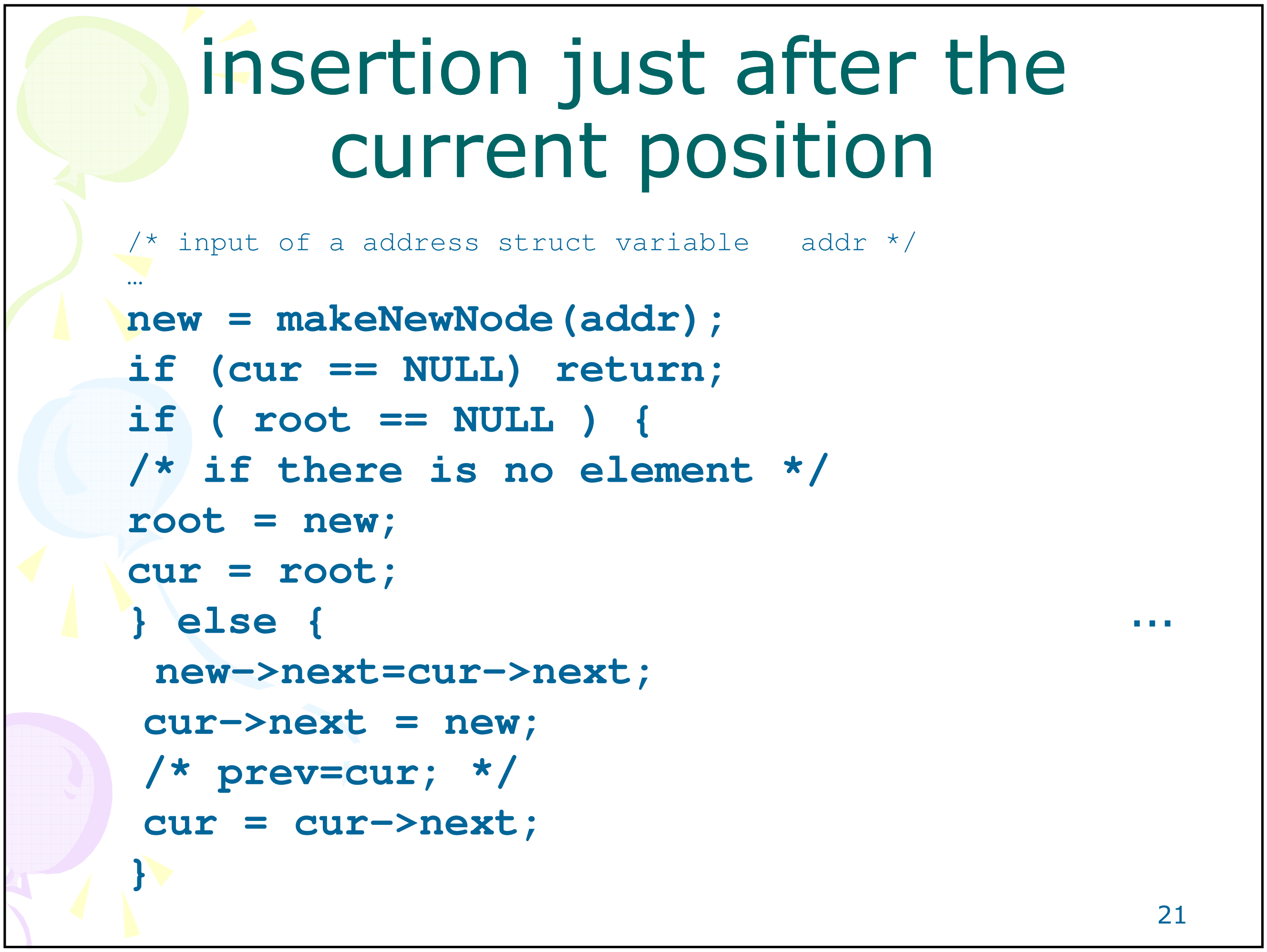
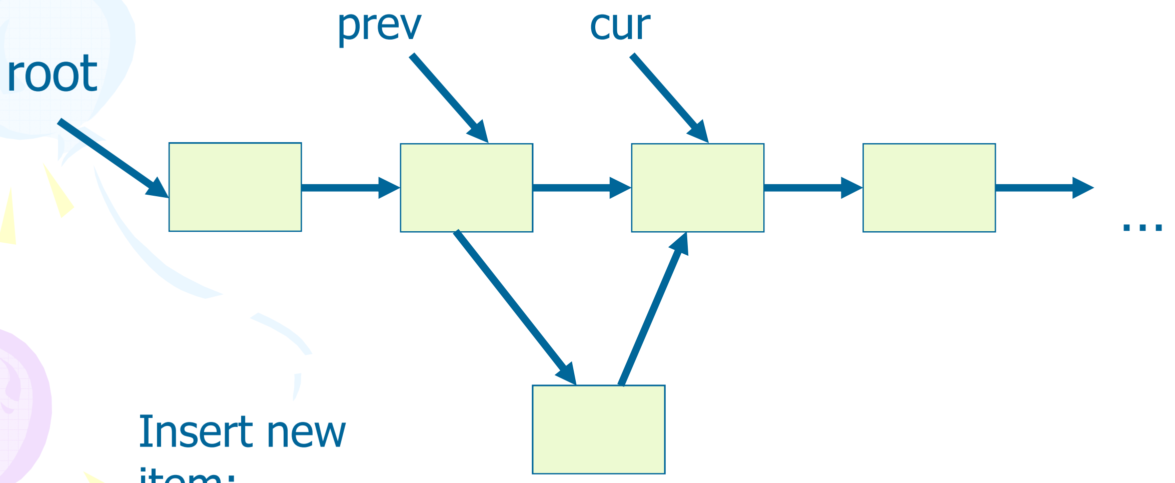


insertion just after the current position

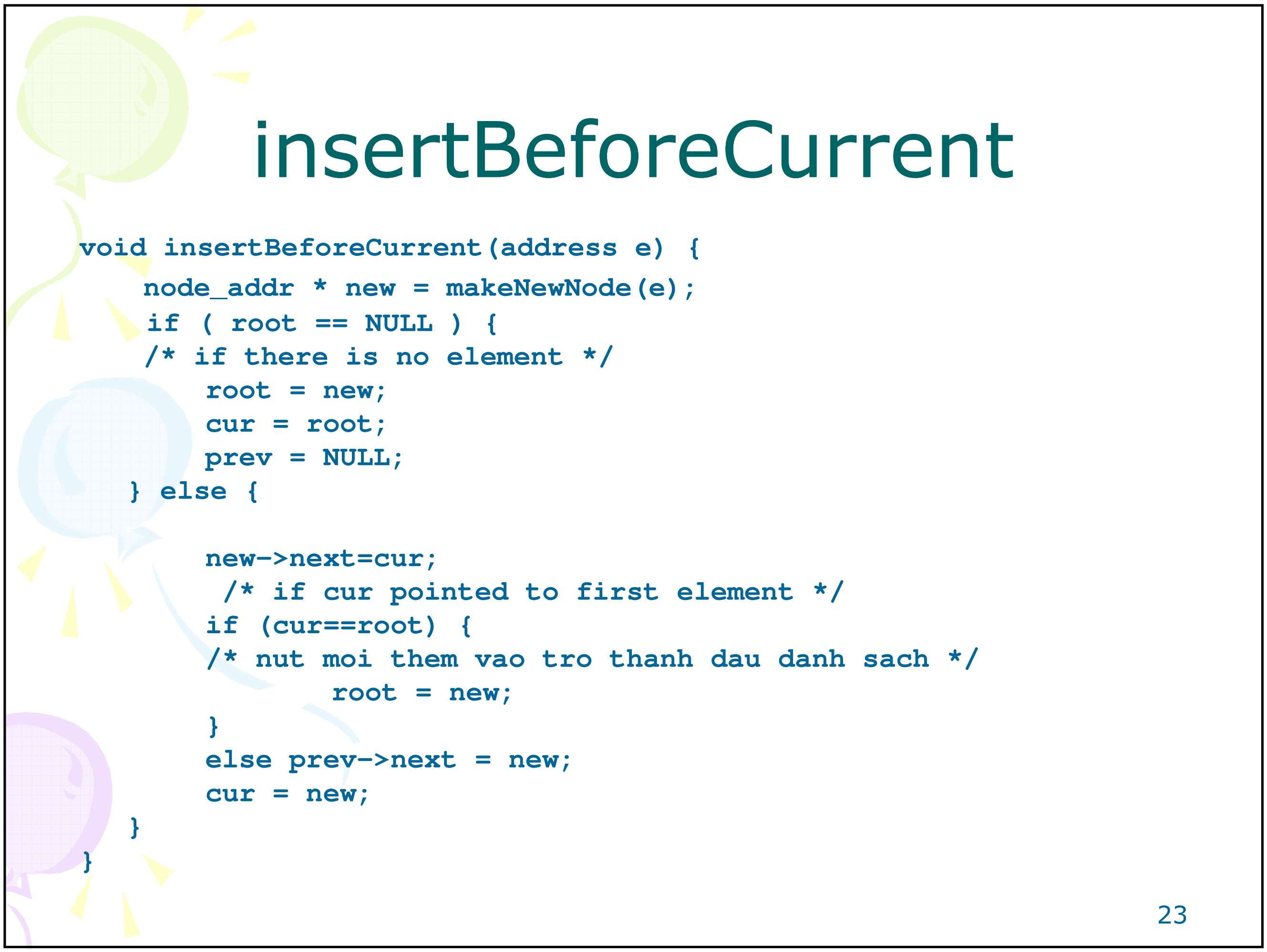
```
/* input of a address struct variable   addr */
…
new = makeNewNode(addr);
if (cur == NULL) return;
if ( root == NULL ) {
/* if there is no element */
root = new;
cur = root;
} else {                                      …
  new->next=cur->next;
 cur->next = new;
 /* prev=cur; */
 cur = cur->next;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

Insertion before current position

- Another case: before the current position



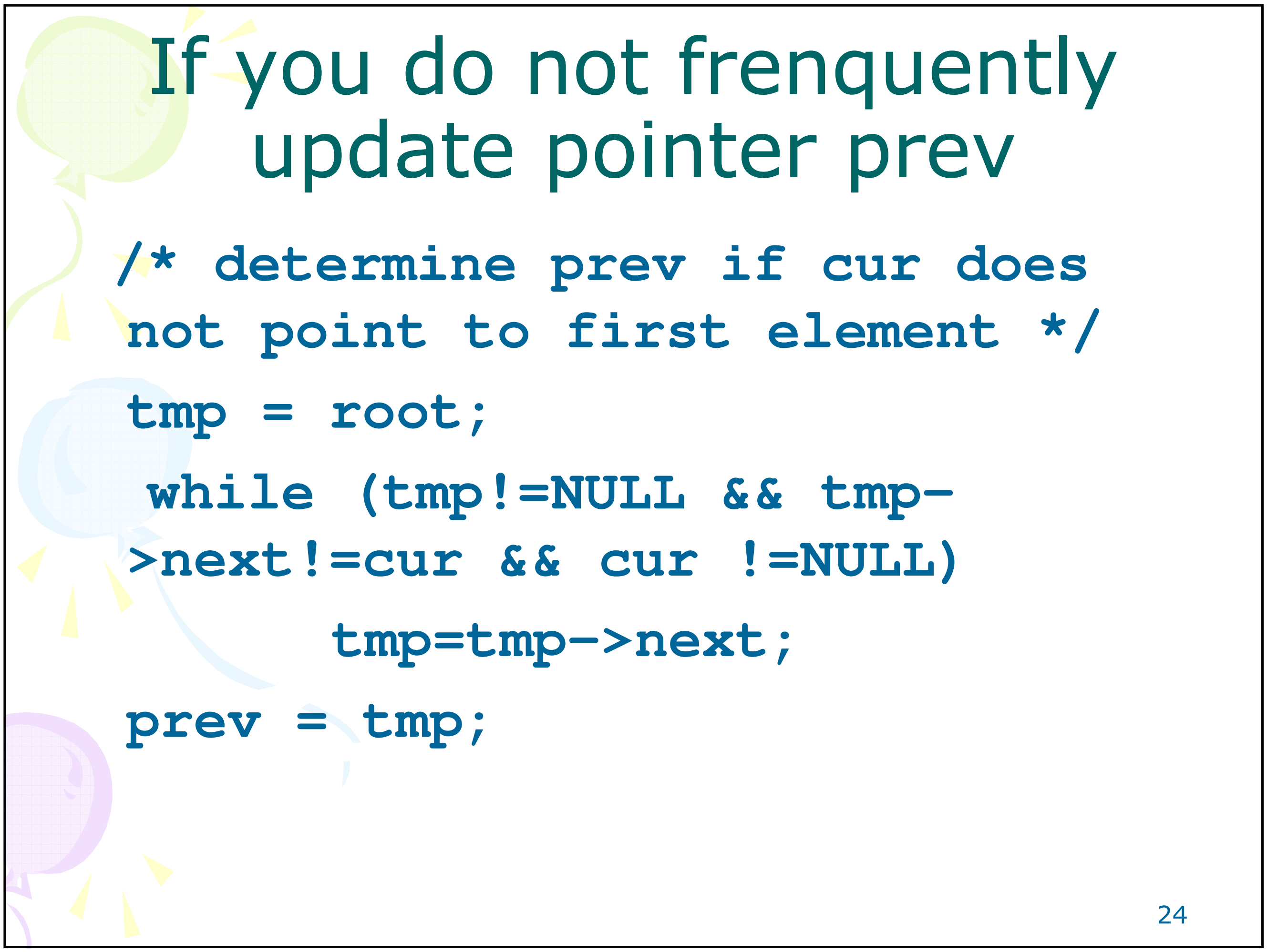
Insert new item:



insertBeforeCurrent

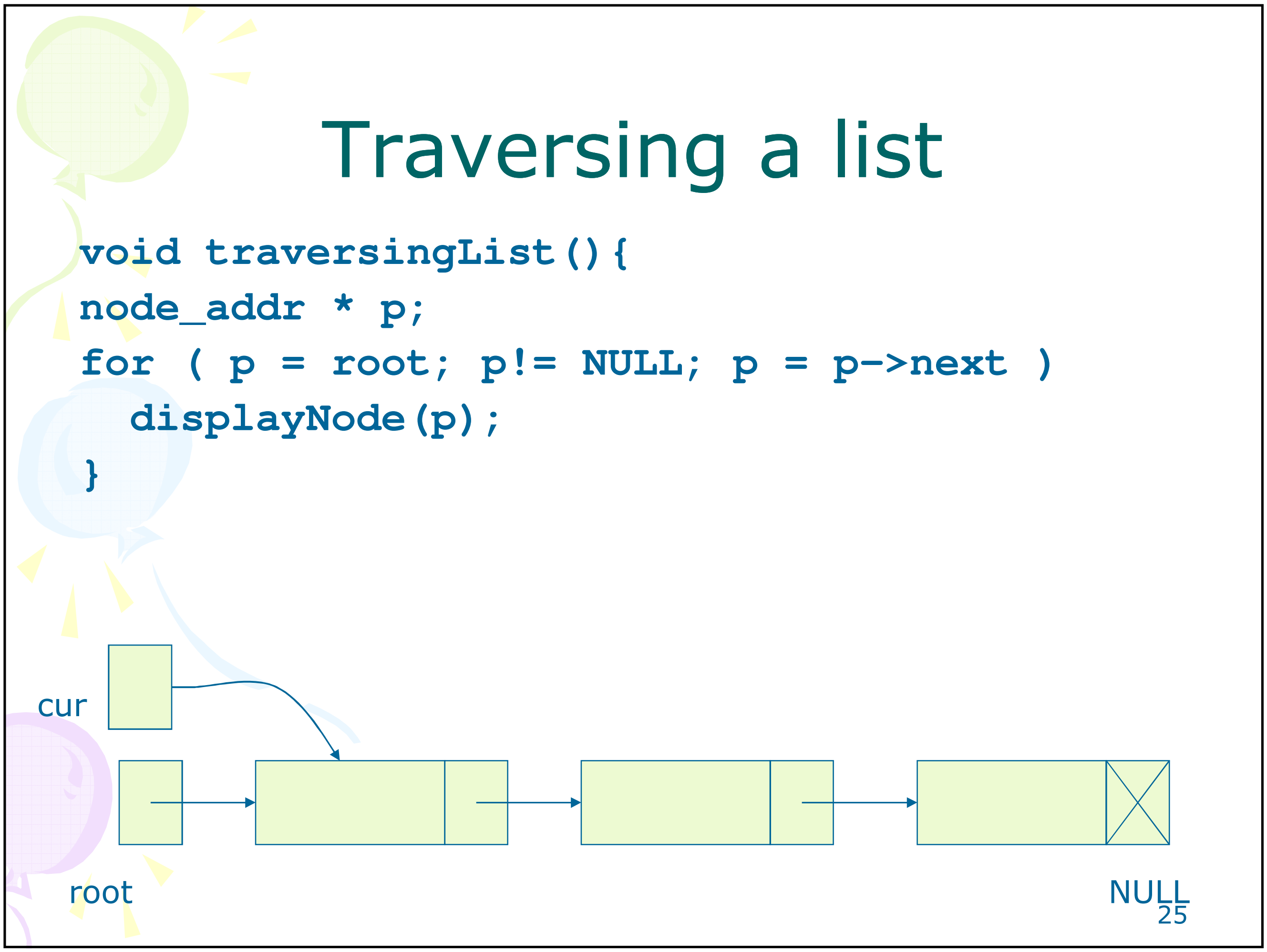
```
void insertBeforeCurrent(address e) {
    node_addr * new = makeNewNode(e);
    if ( root == NULL ) {
    /* if there is no element */
        root = new;
        cur = root;
        prev = NULL;
   } else {

        new->next=cur;
         /* if cur pointed to first element */
        if (cur==root) {
        /* nut moi them vao tro thanh dau danh sach */
               root = new;
        }
        else prev->next = new;
        cur = new;
   }
}
```



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;
```

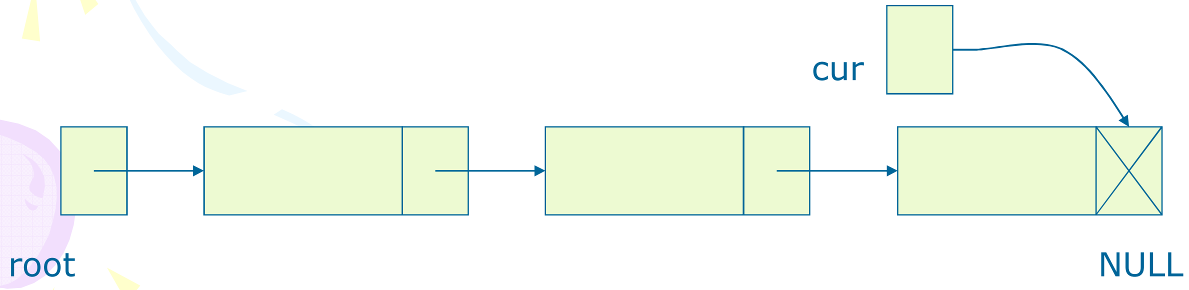


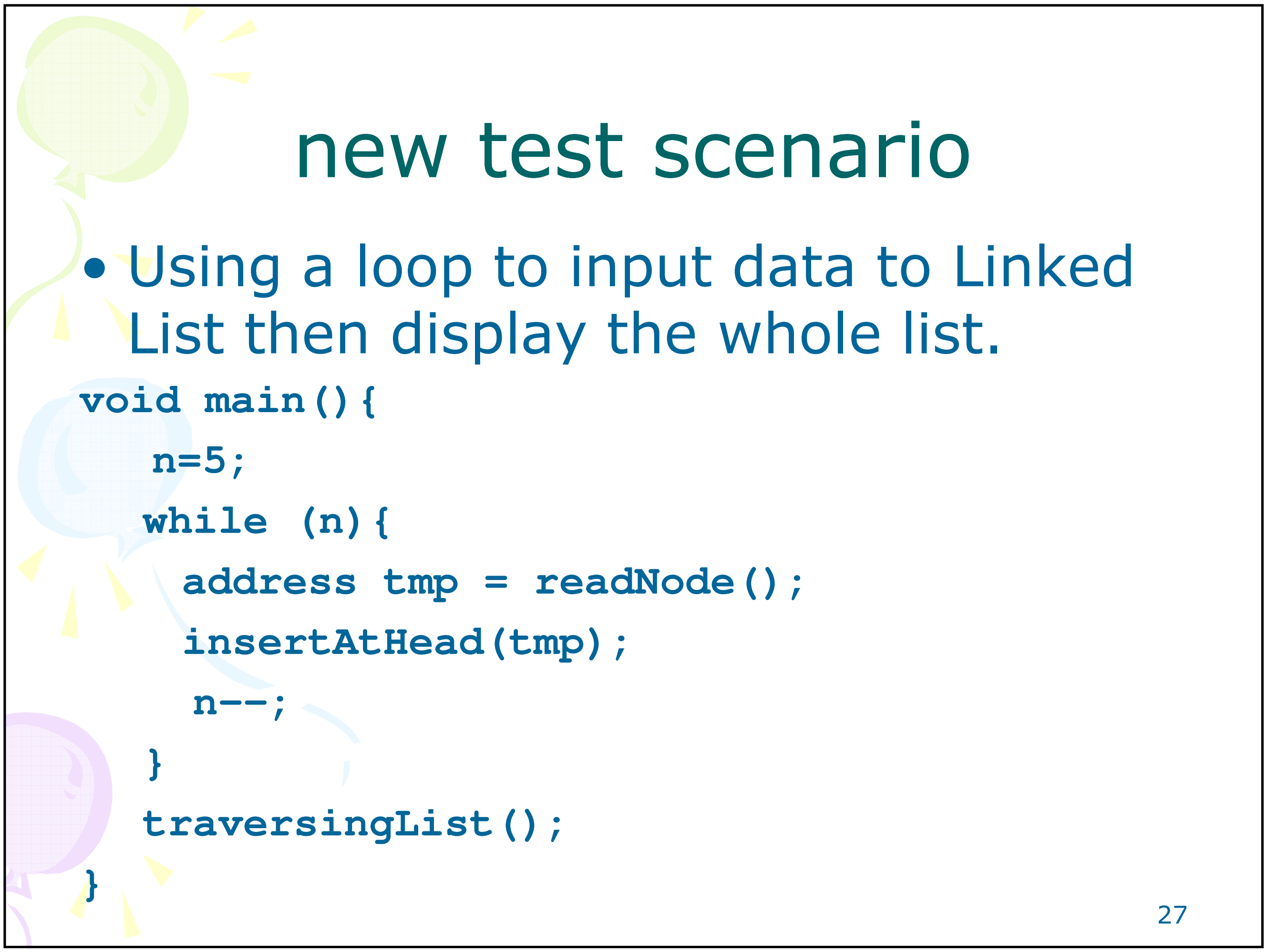
Traversing a list

```
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





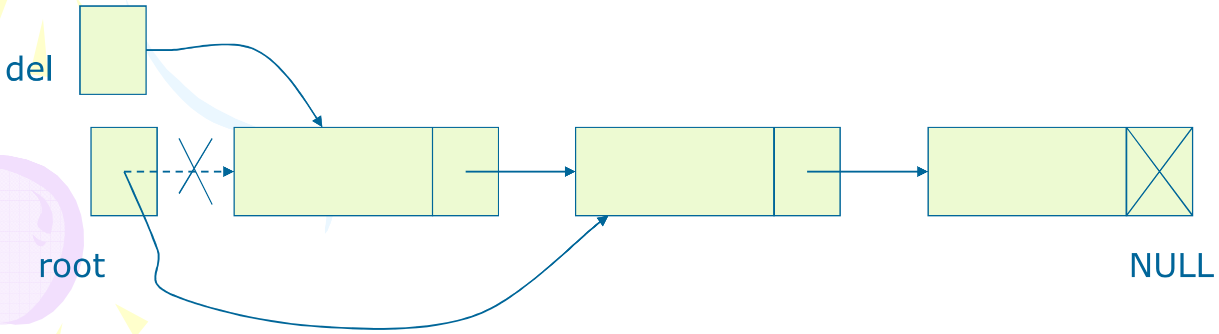
new test scenario

- 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();
}
```

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.”

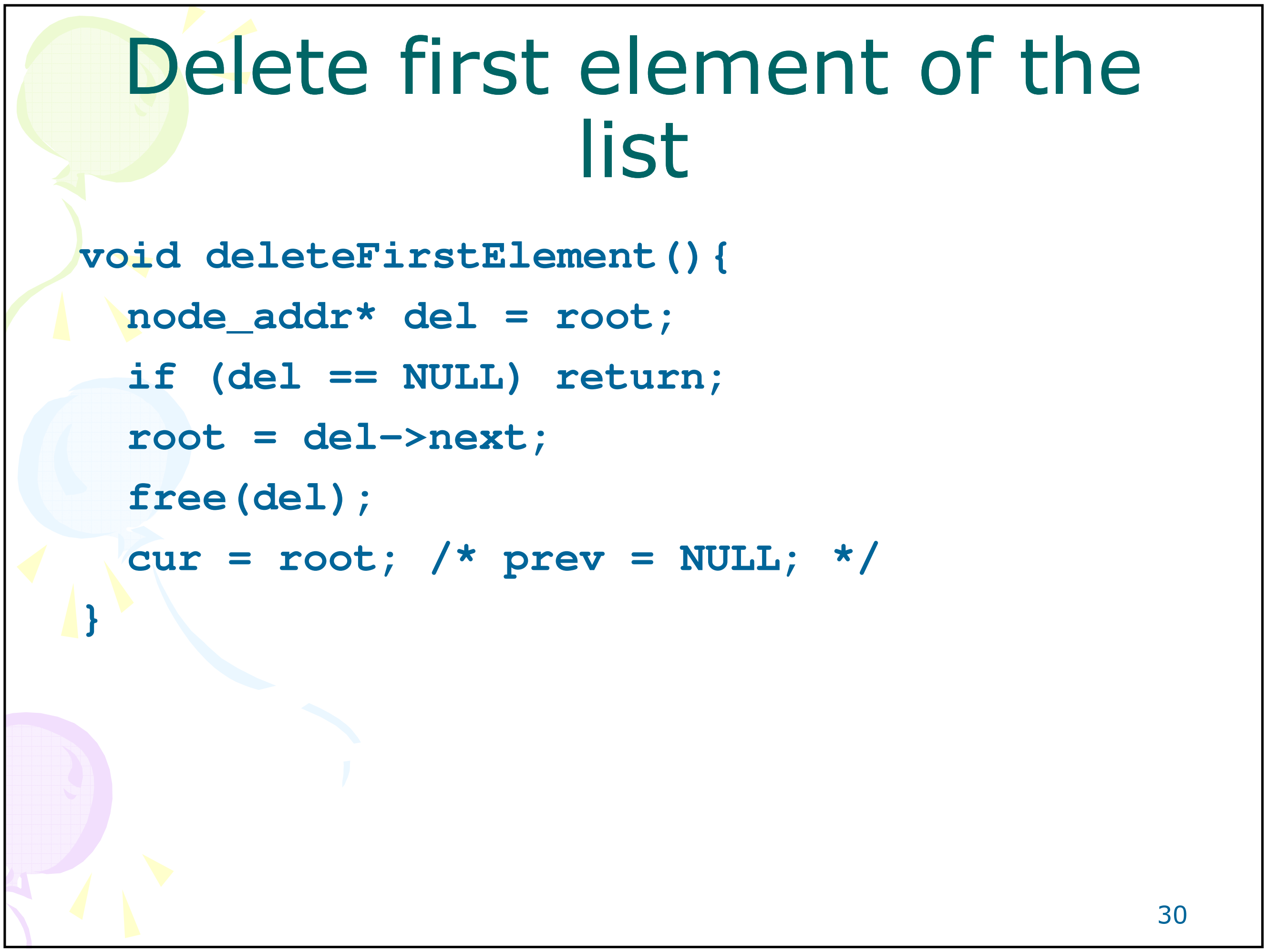


Delete first element

```
void deleteFirstElement() {

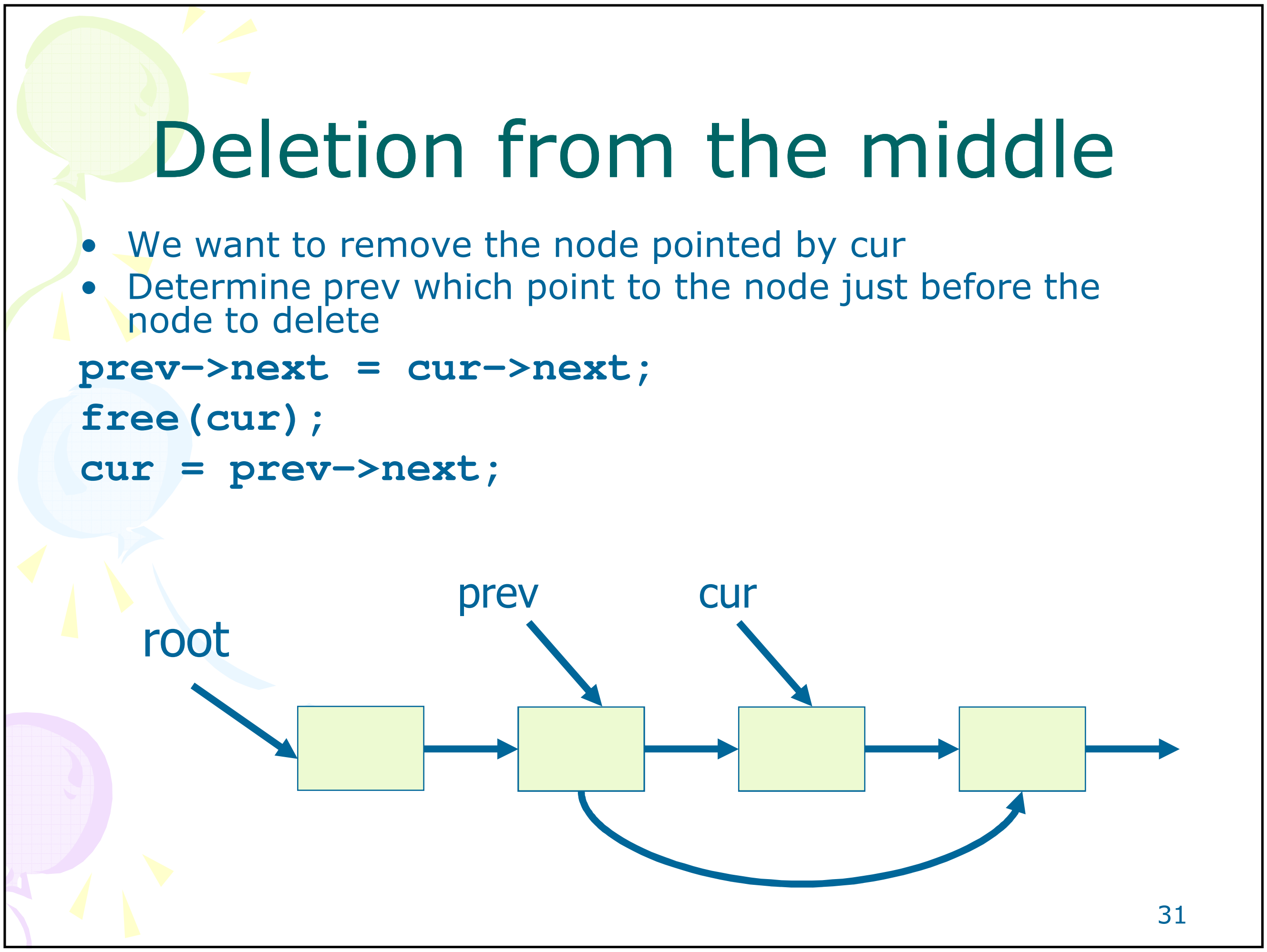
/* do it your self */


}
```



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; */
}
```

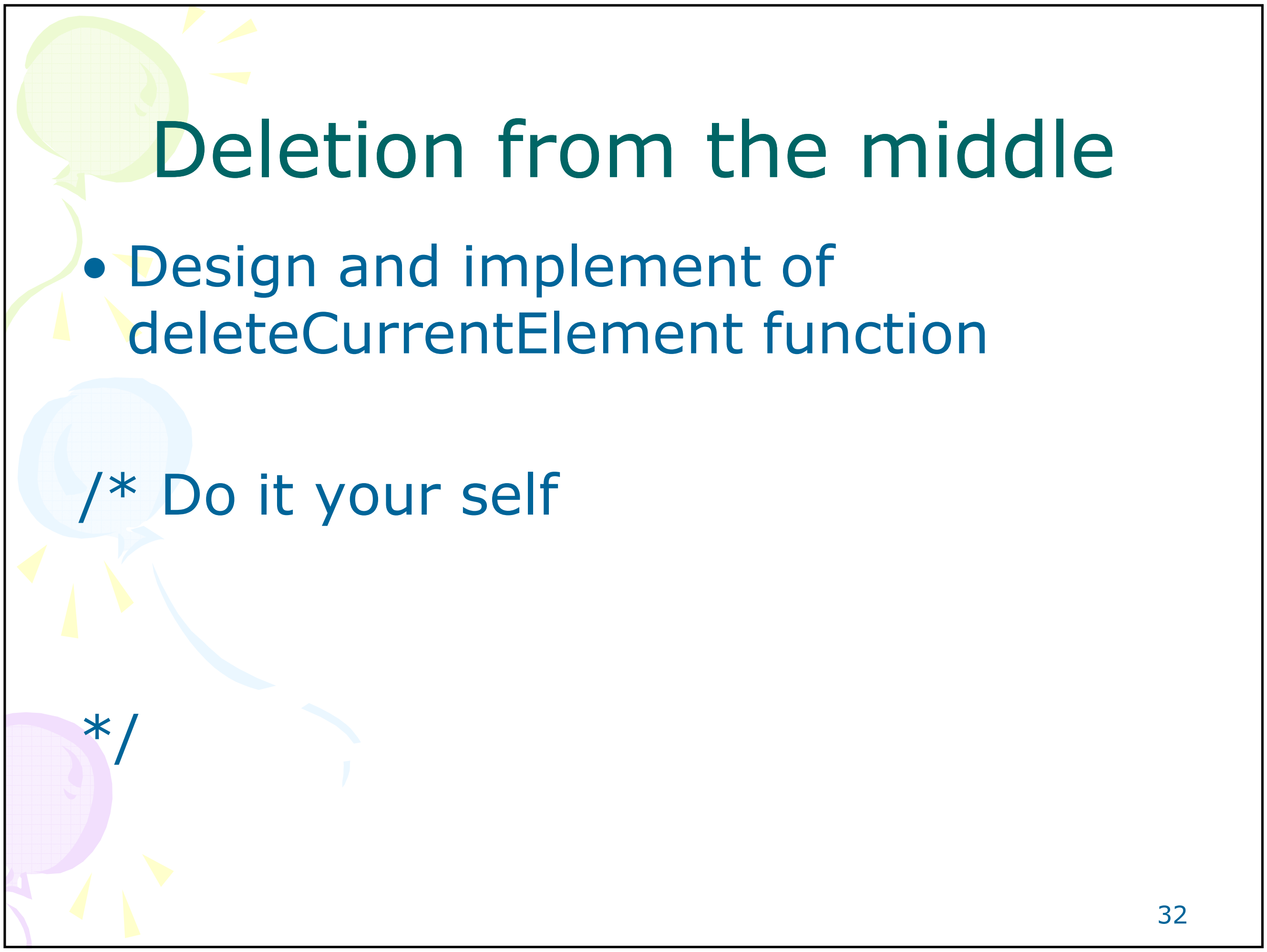


Deletion from the middle

- 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;
```

prev
cur
root

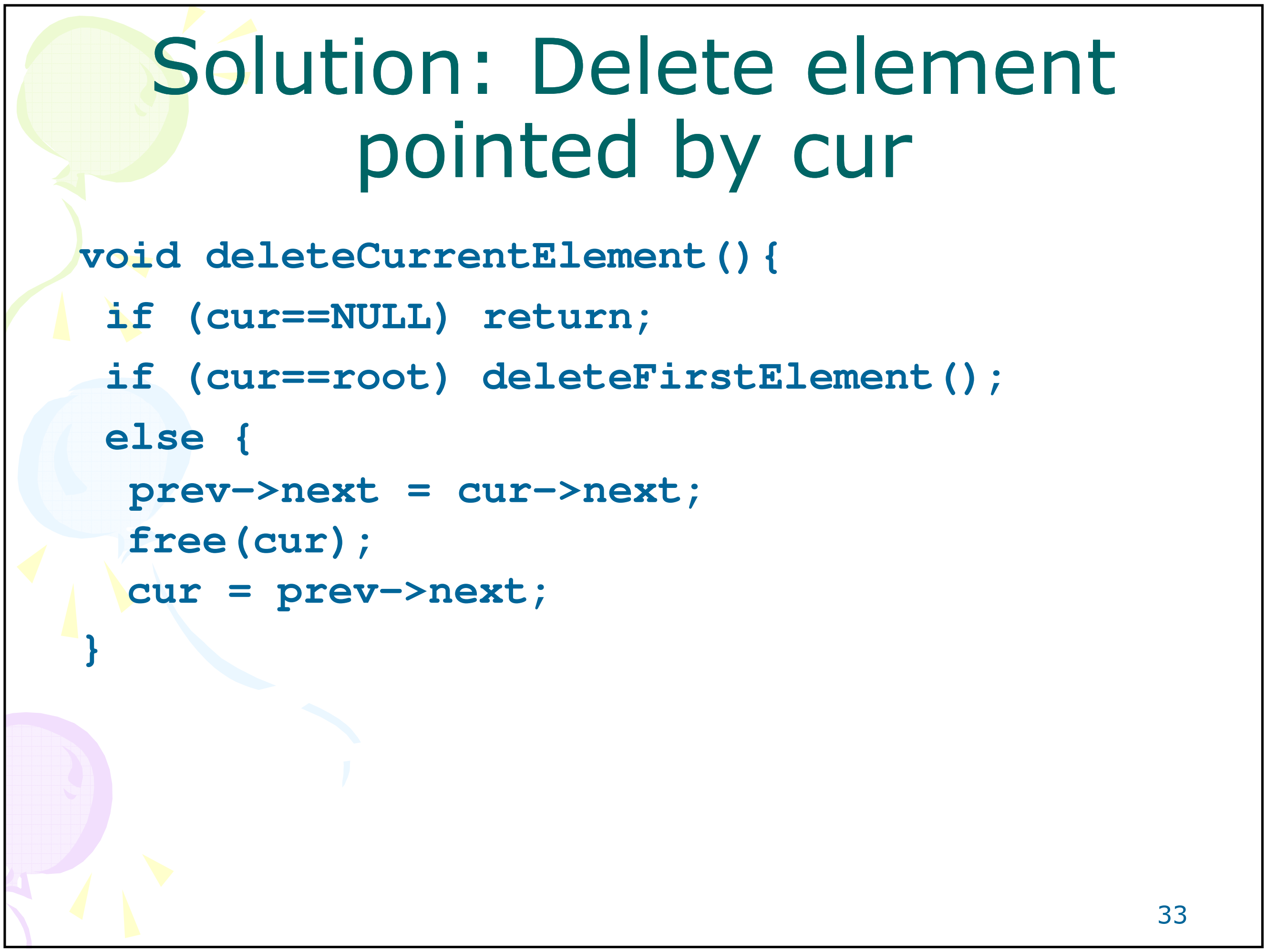


Deletion from the middle

- Design and implement of deleteCurrentElement function

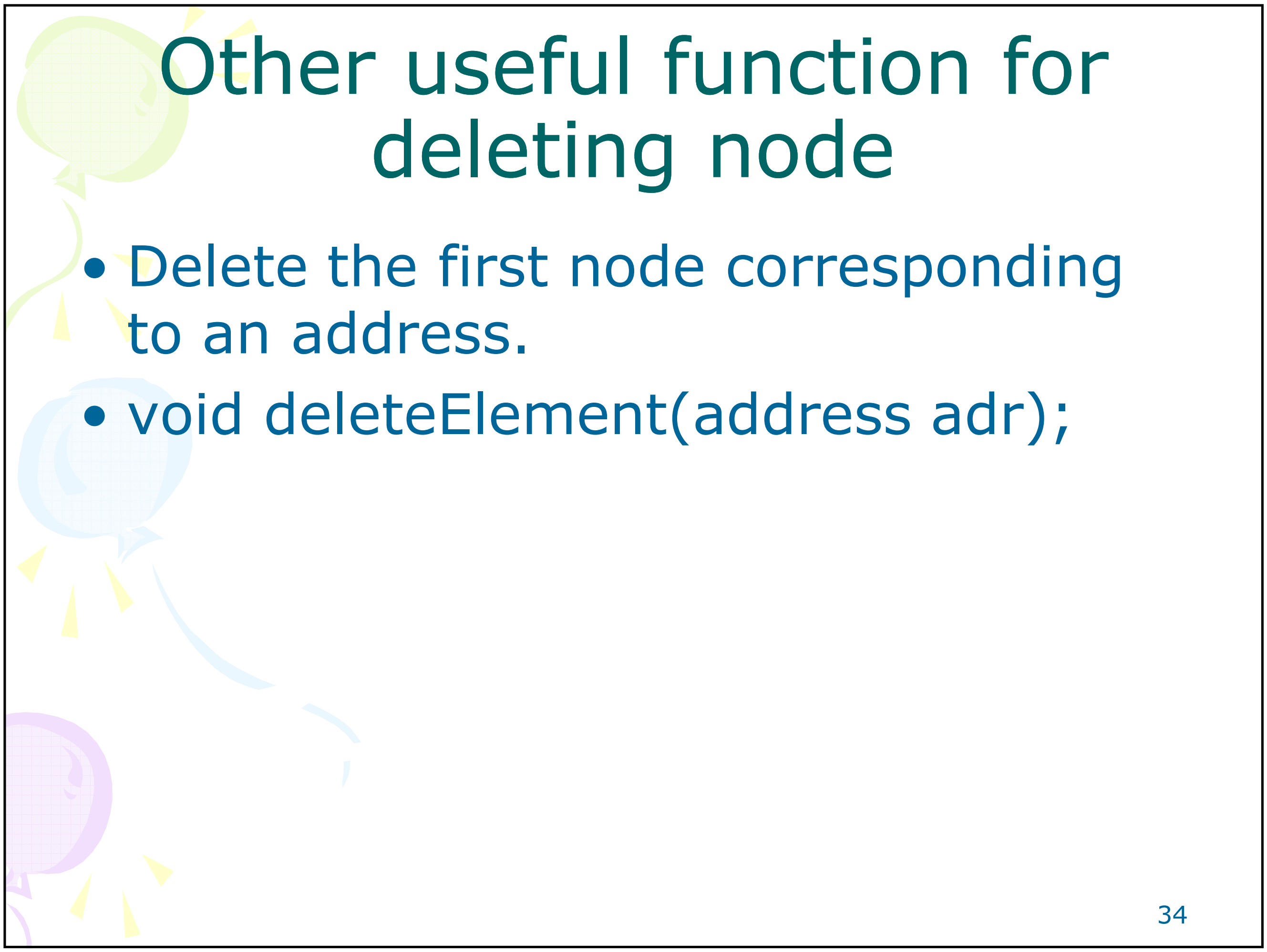
```
/* Do it your self


*/
```



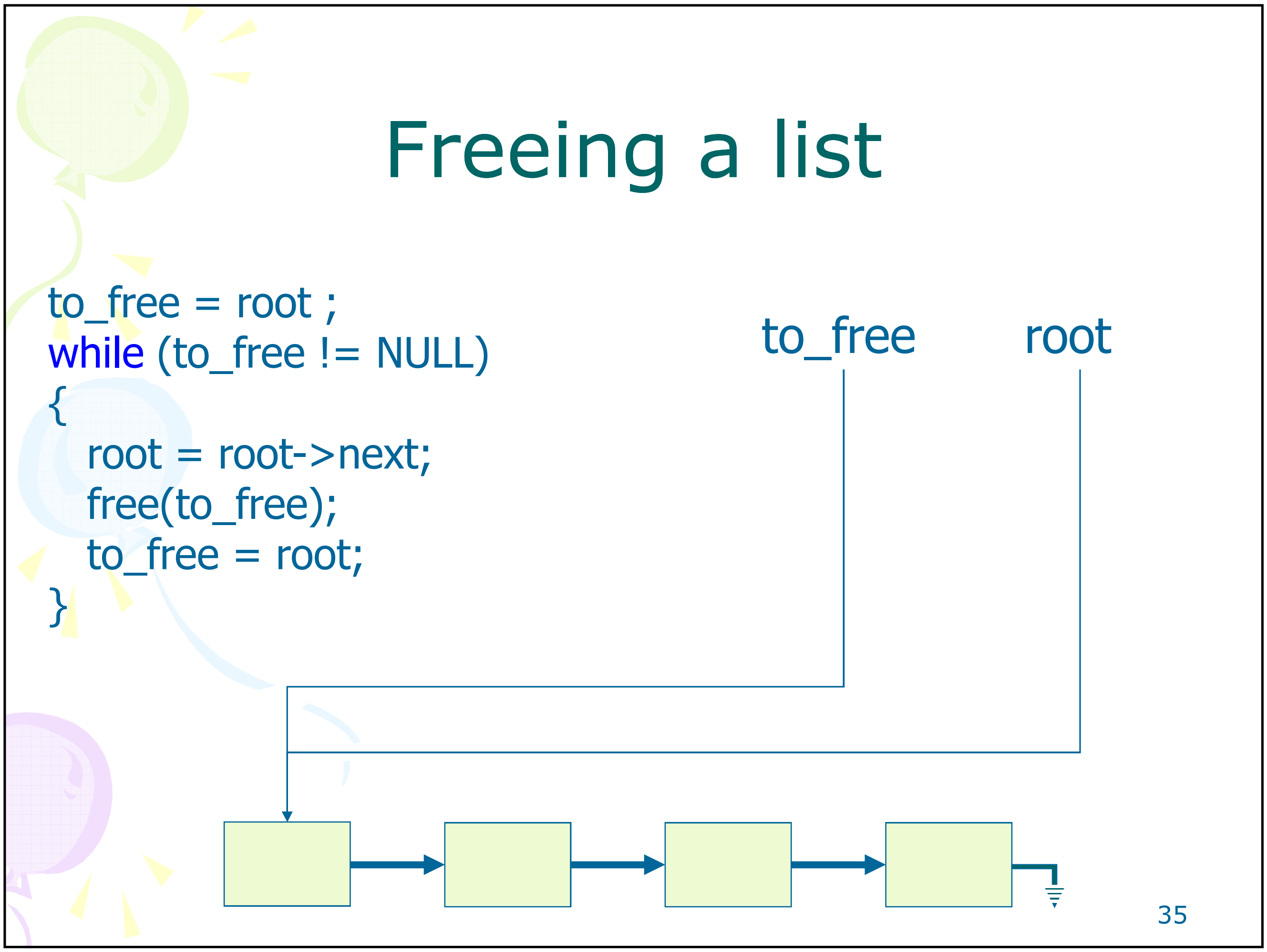
Solution: Delete element pointed by cur

```
void deleteCurrentElement(){
 if (cur==NULL) return;
 if (cur==root) deleteFirstElement();
 else {
  prev->next = cur->next;
  free(cur);
  cur = prev->next;
}
```



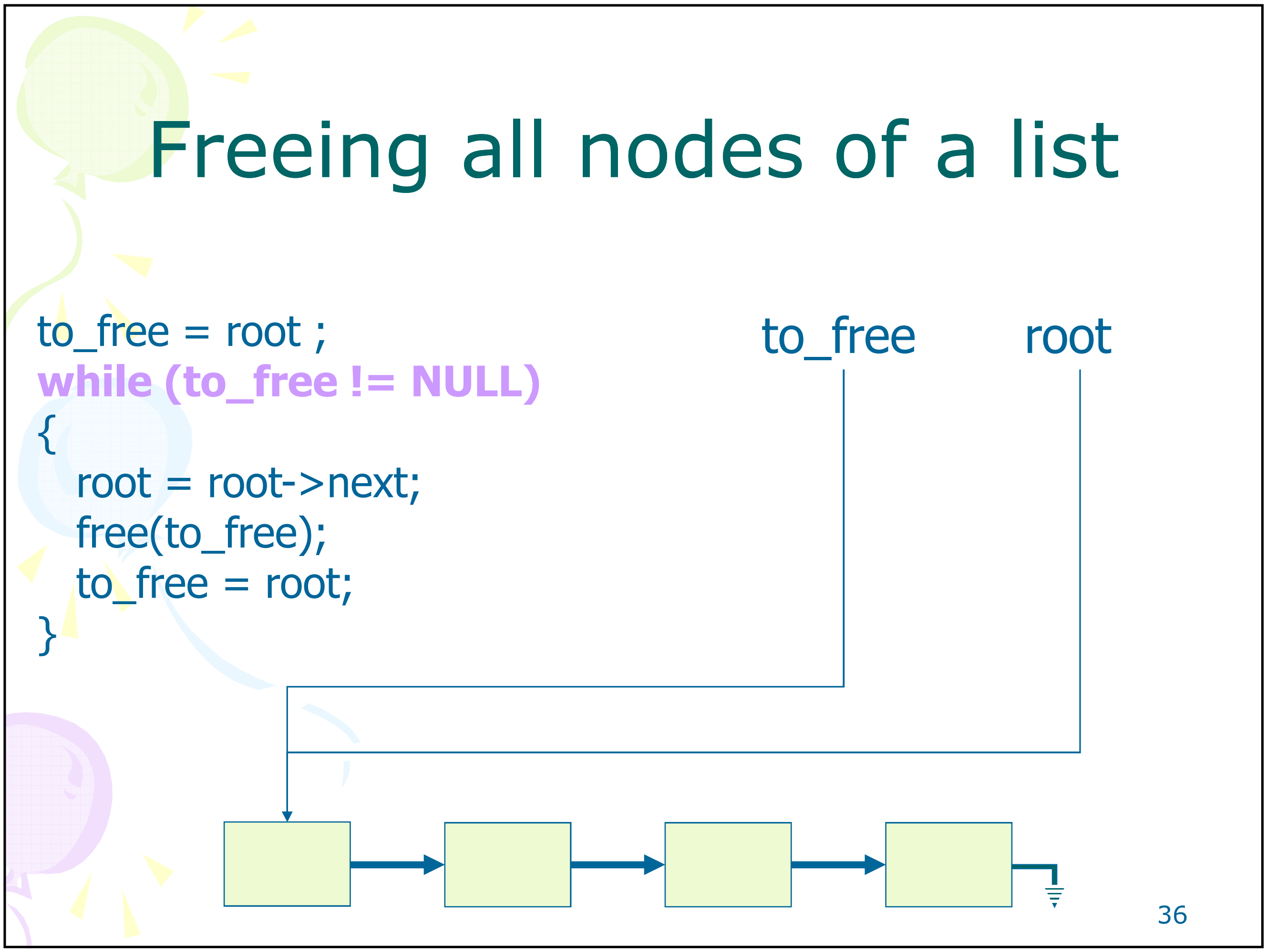
Other useful function for deleting node

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



Freeing a list

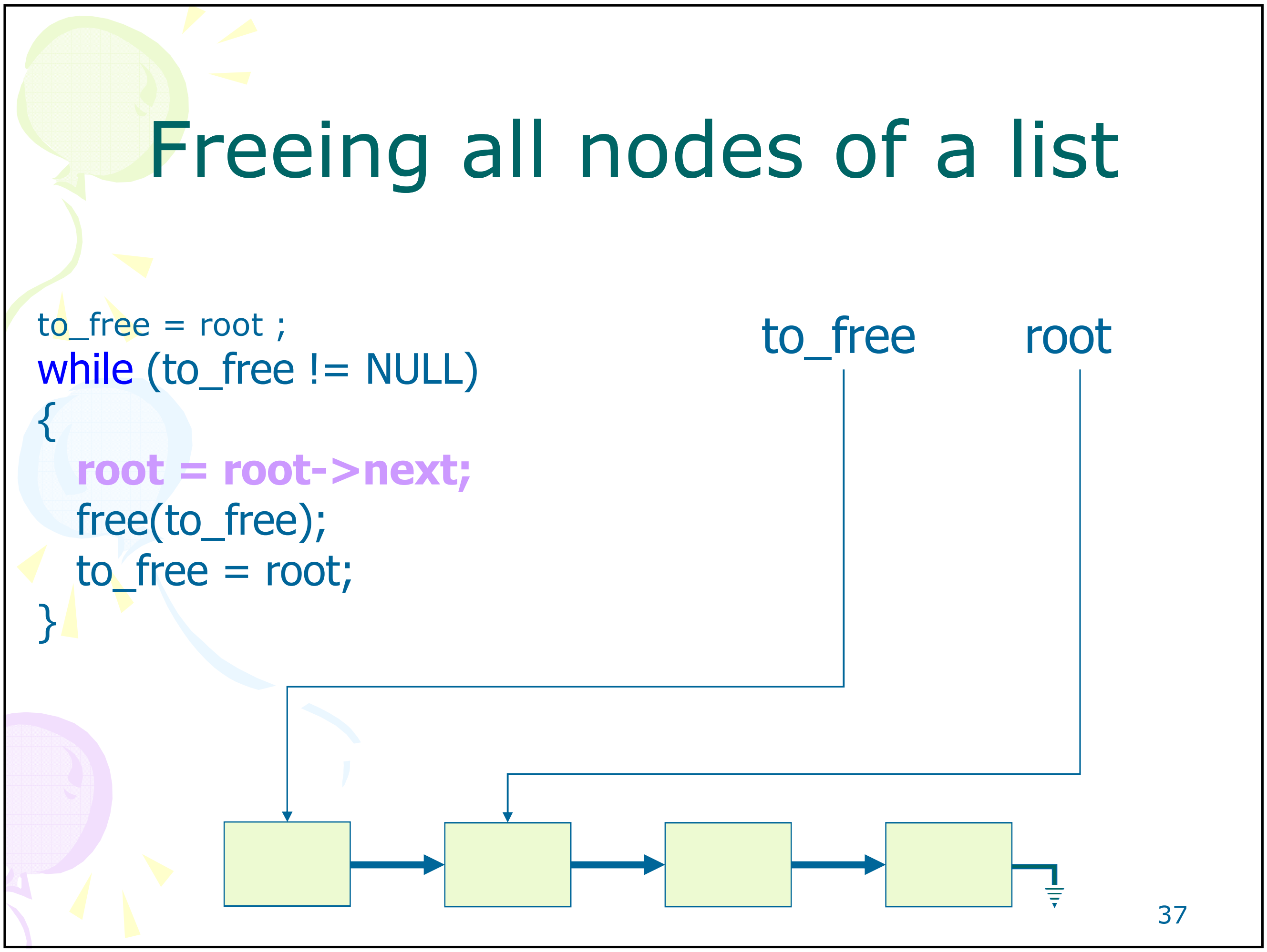
```
to_free = root ;
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```



Freeing all nodes of a list

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

36



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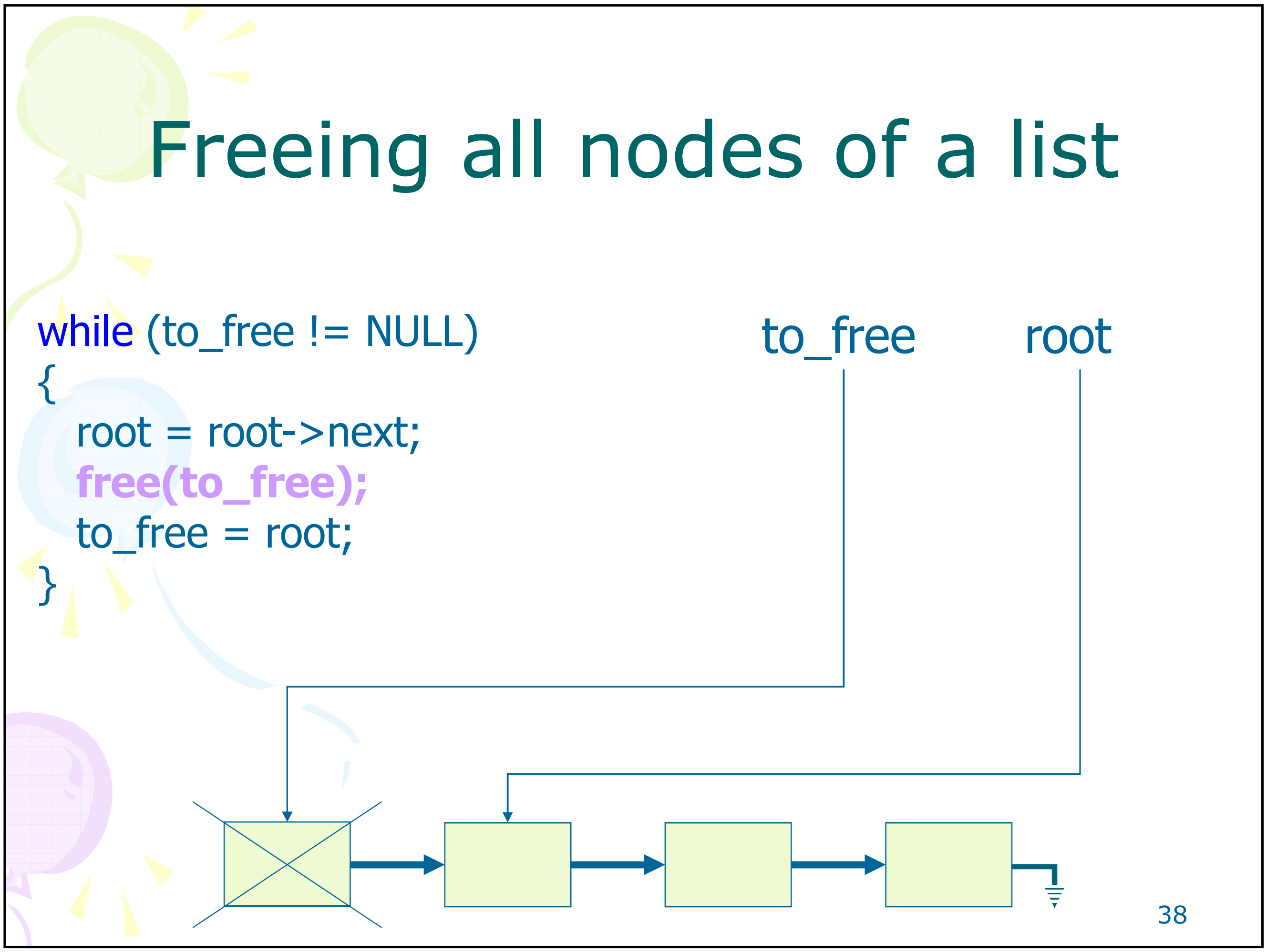

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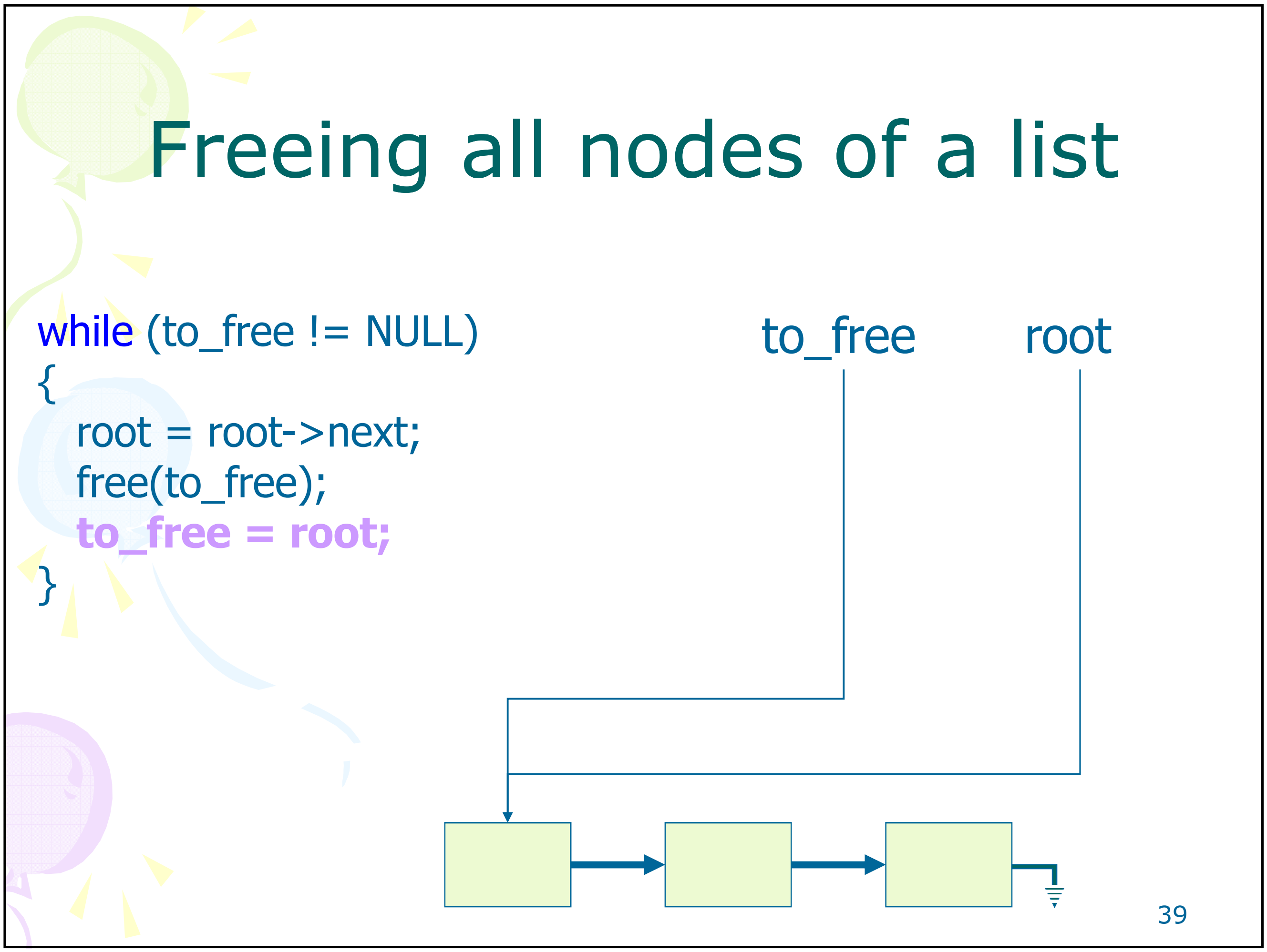
}
```



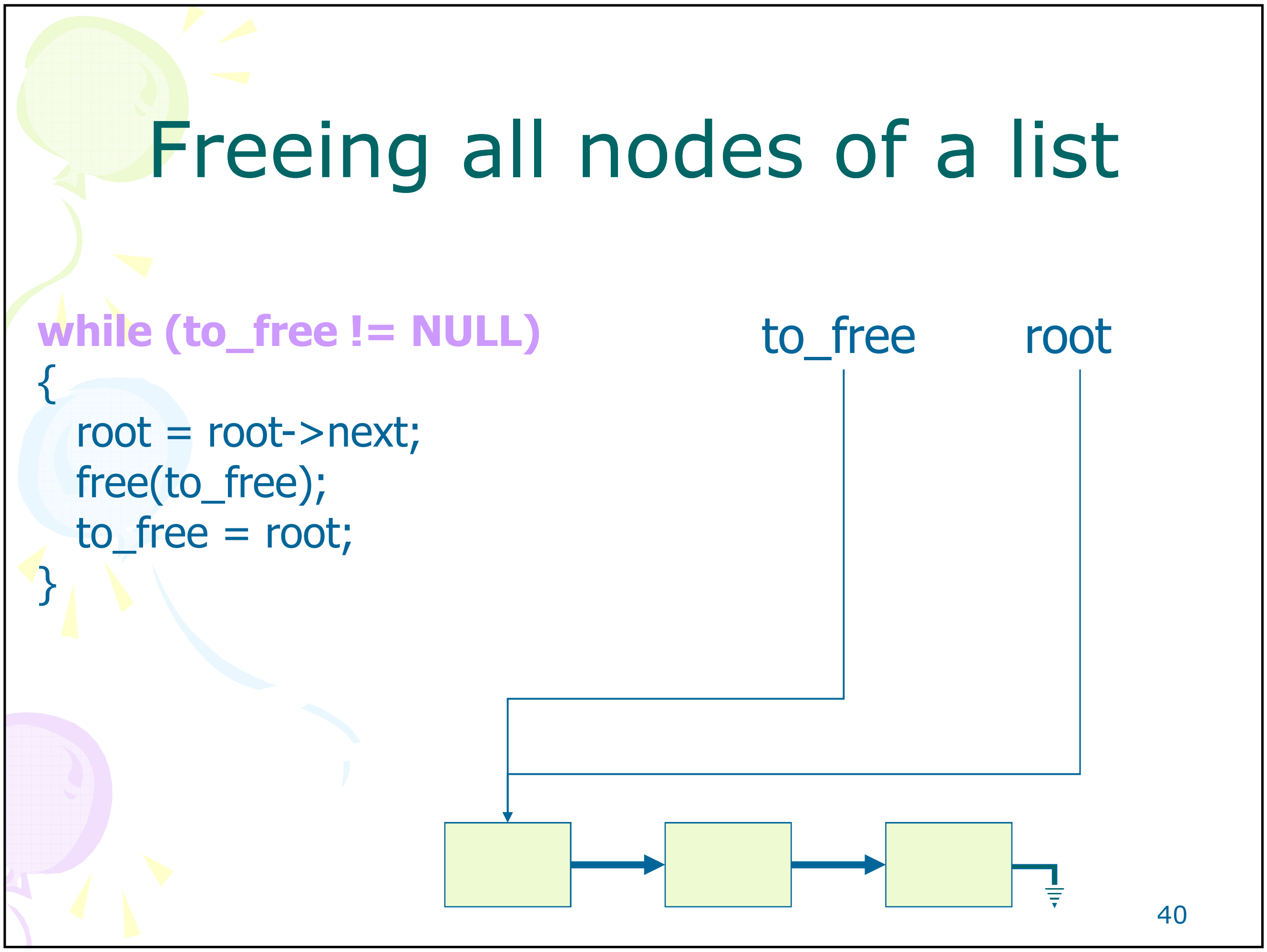
Freeing all nodes of a list

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

to_free

root

39



Freeing all nodes of a list

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

to_free

root

Freeing all nodes of a list

```
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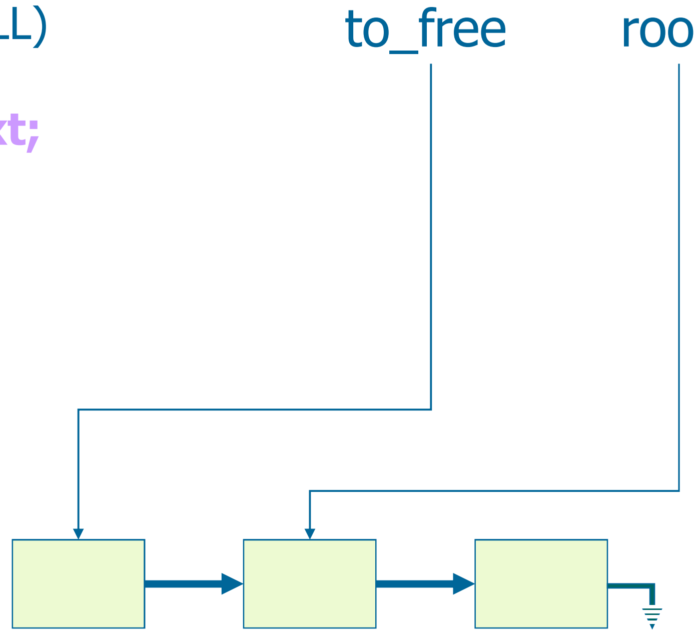
```



Freeing all nodes of a list

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   free(to_free);
   to_free = root;
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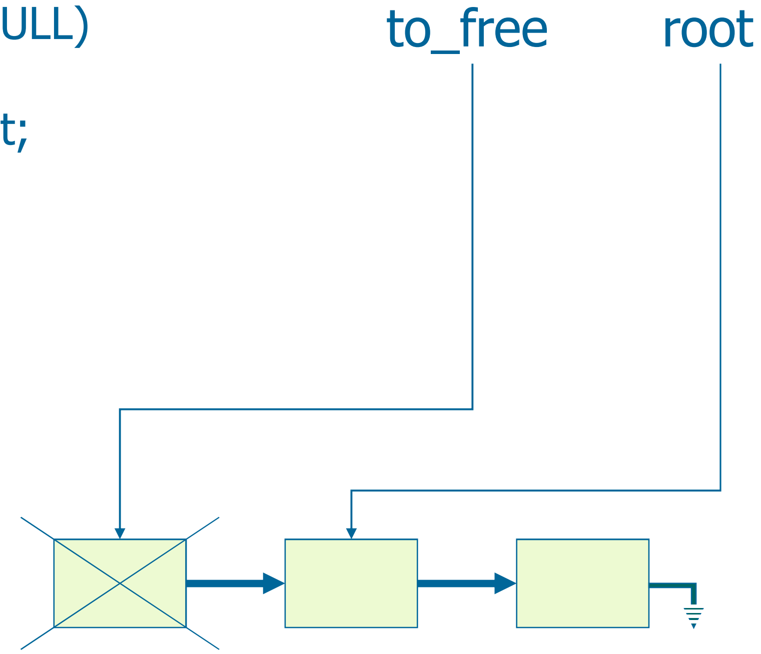
```



Freeing all nodes of a list

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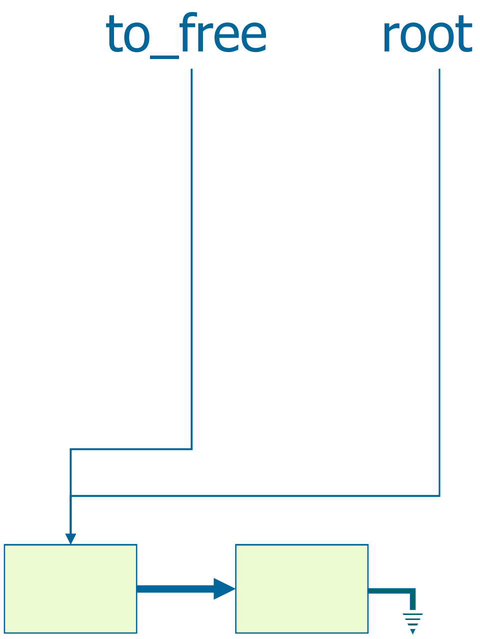
```



Freeing all nodes of a list

```
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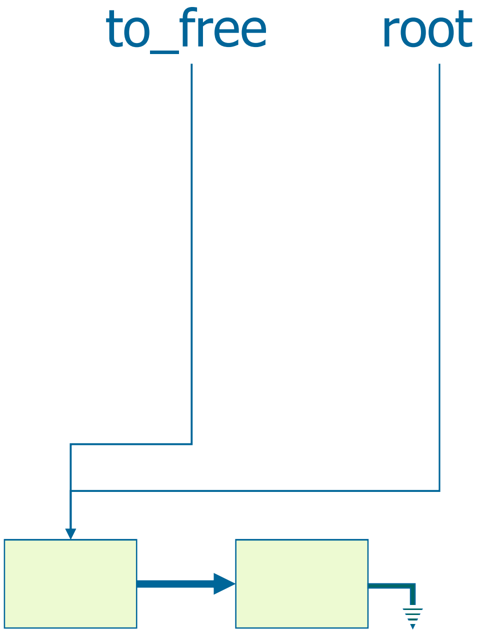
   to_free = root;
}
```



Freeing all nodes of a list

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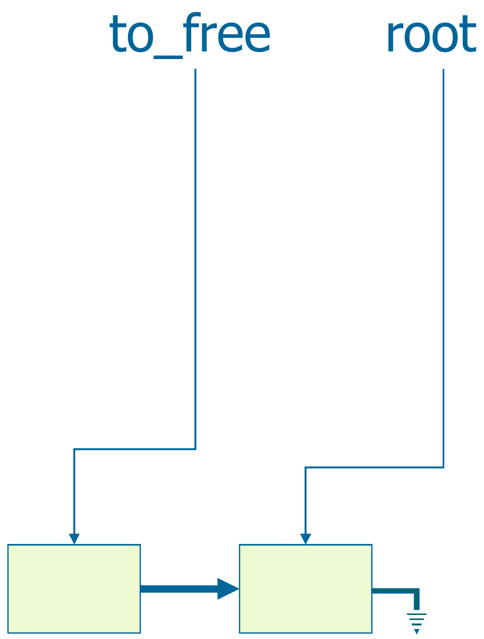
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```



Freeing all nodes of a list

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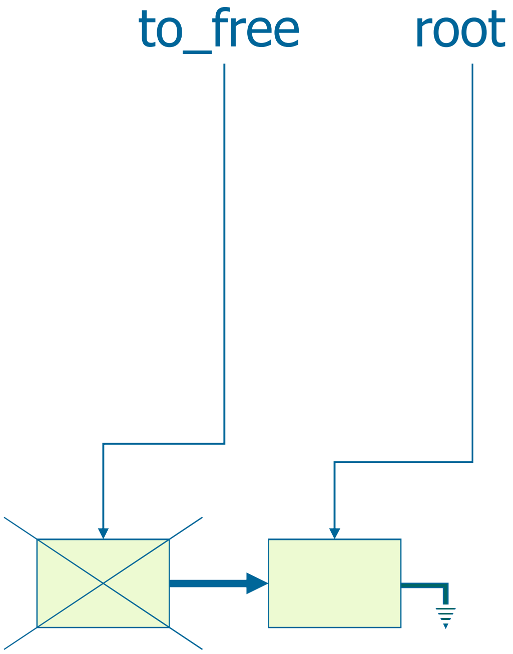
}
```



Freeing all nodes of a list

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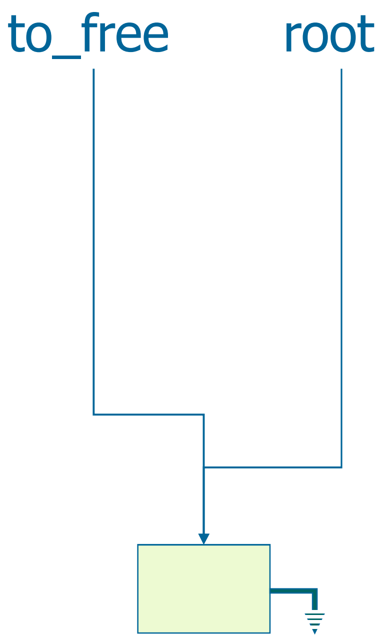
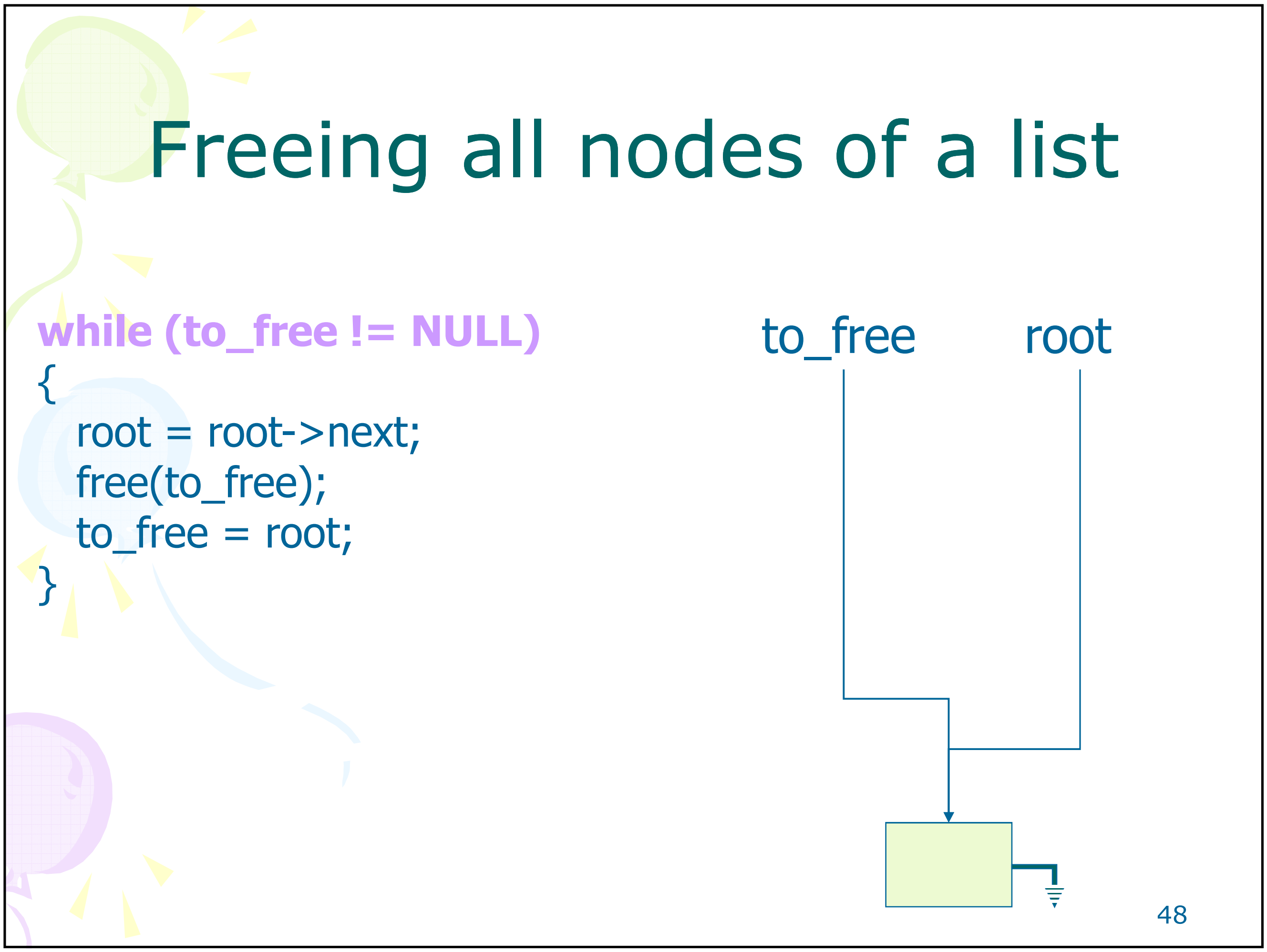
}
```



to_free root



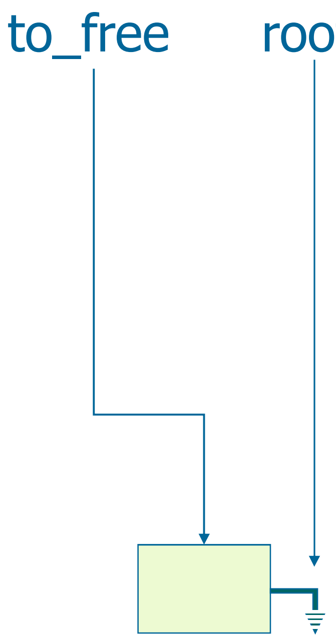
Freeing all nodes of a list

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

to_free root

Freeing all nodes of a list

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

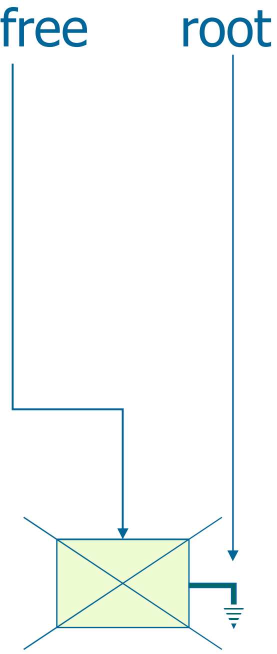


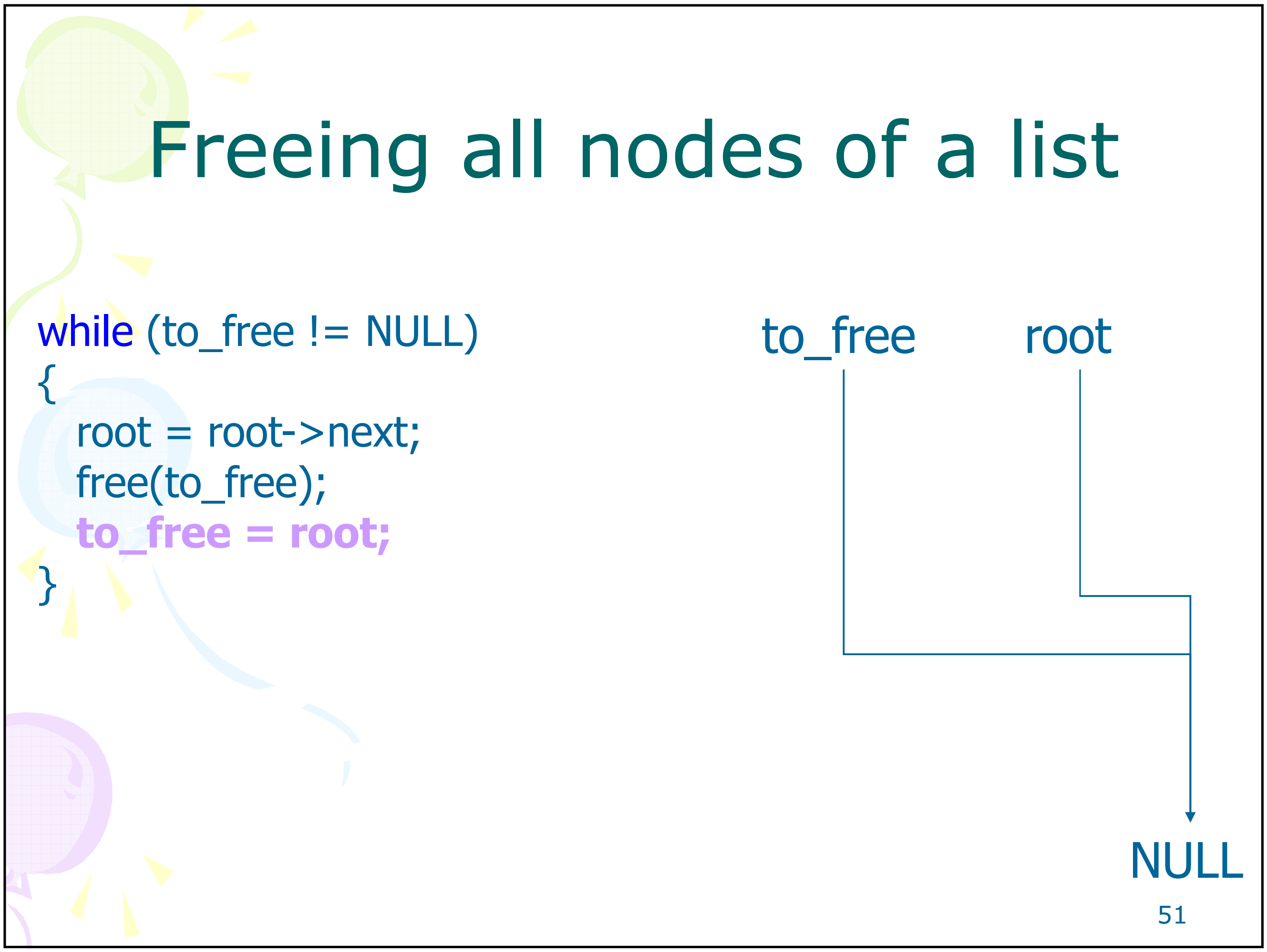
to_free

root

Freeing all nodes of a list

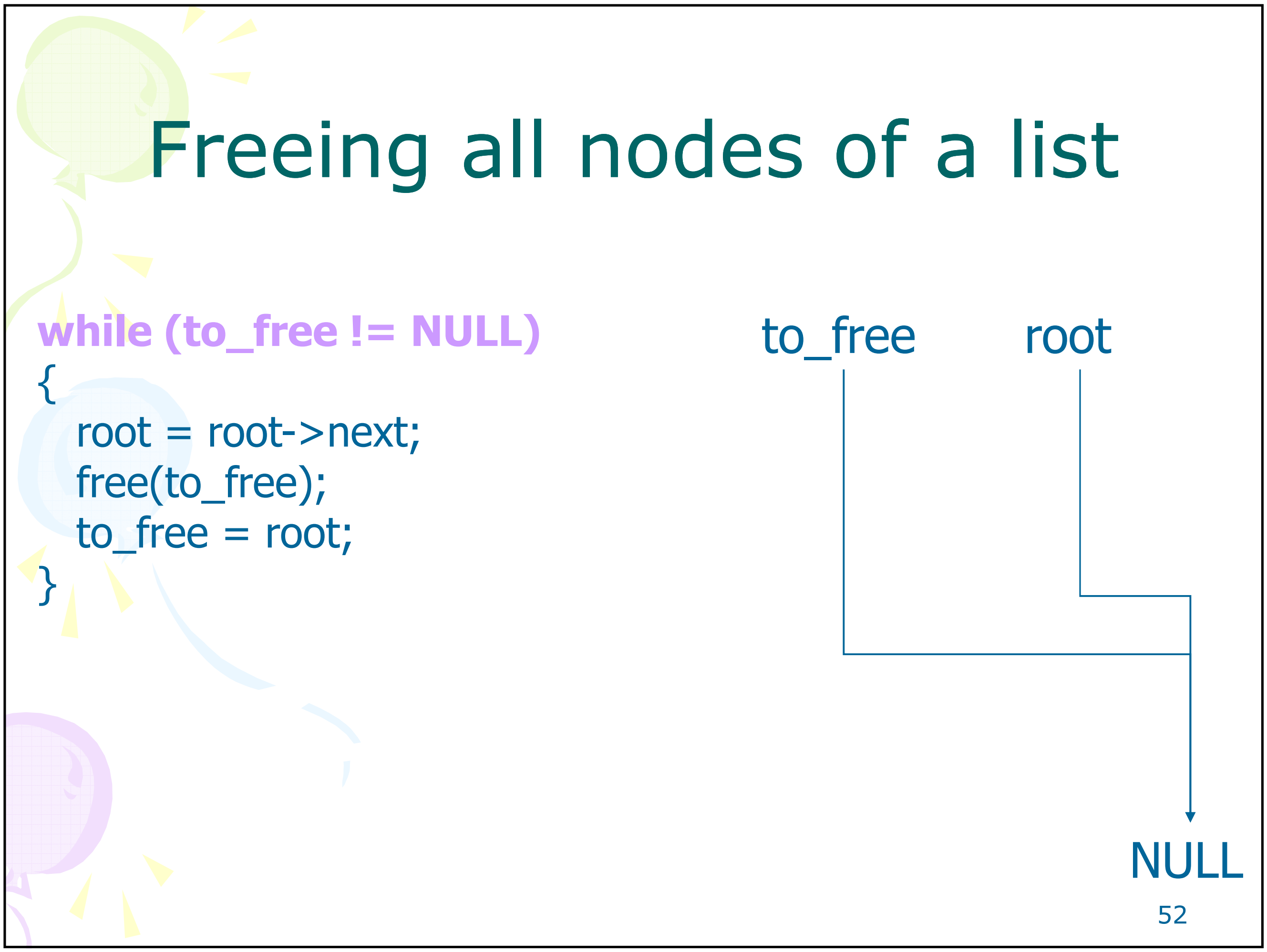
```
while (to_free != NULL)
{
   root = root->next;
   free(to_free);
   to_free = root;
}
```





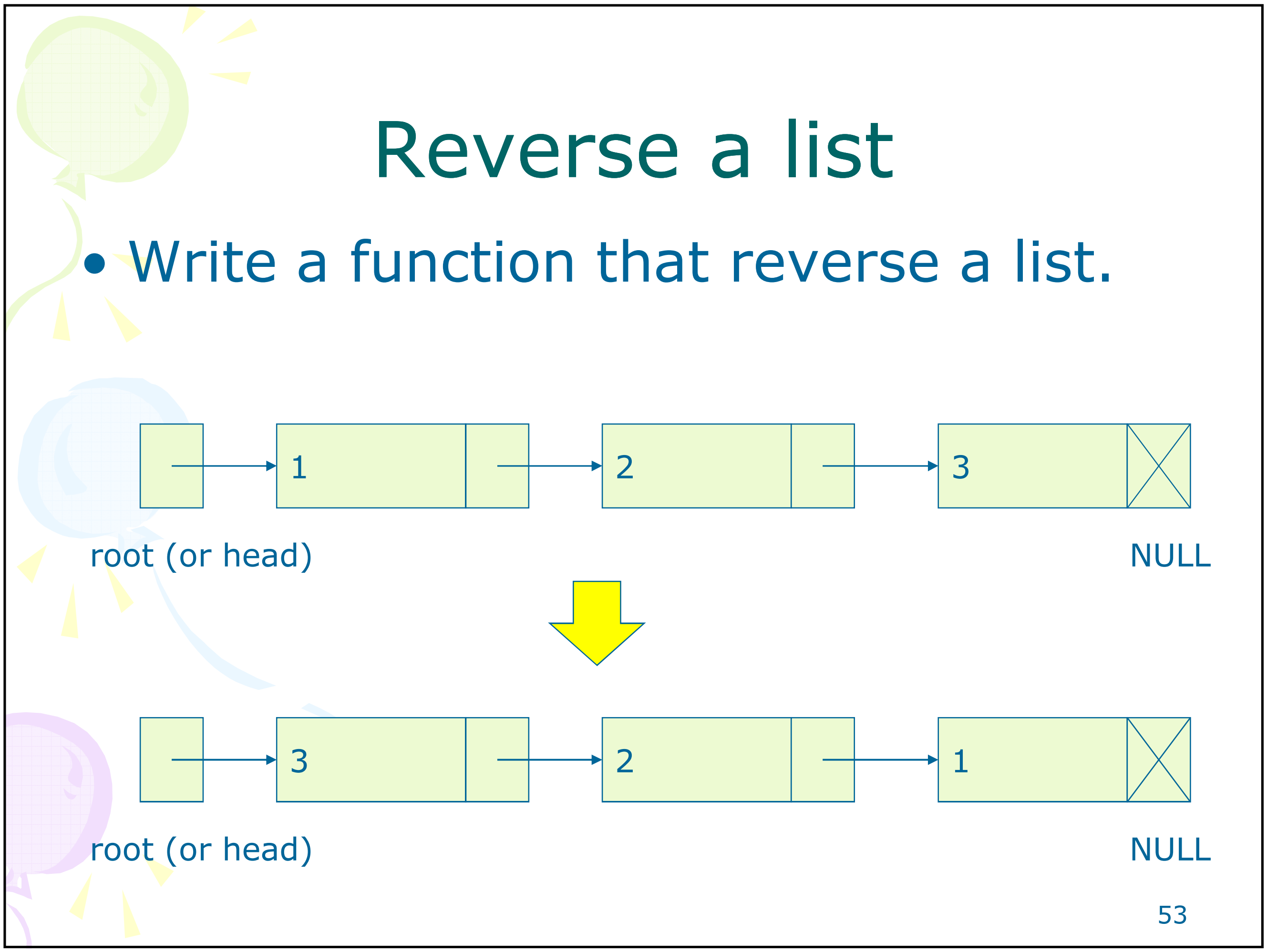
Freeing all nodes of a list

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



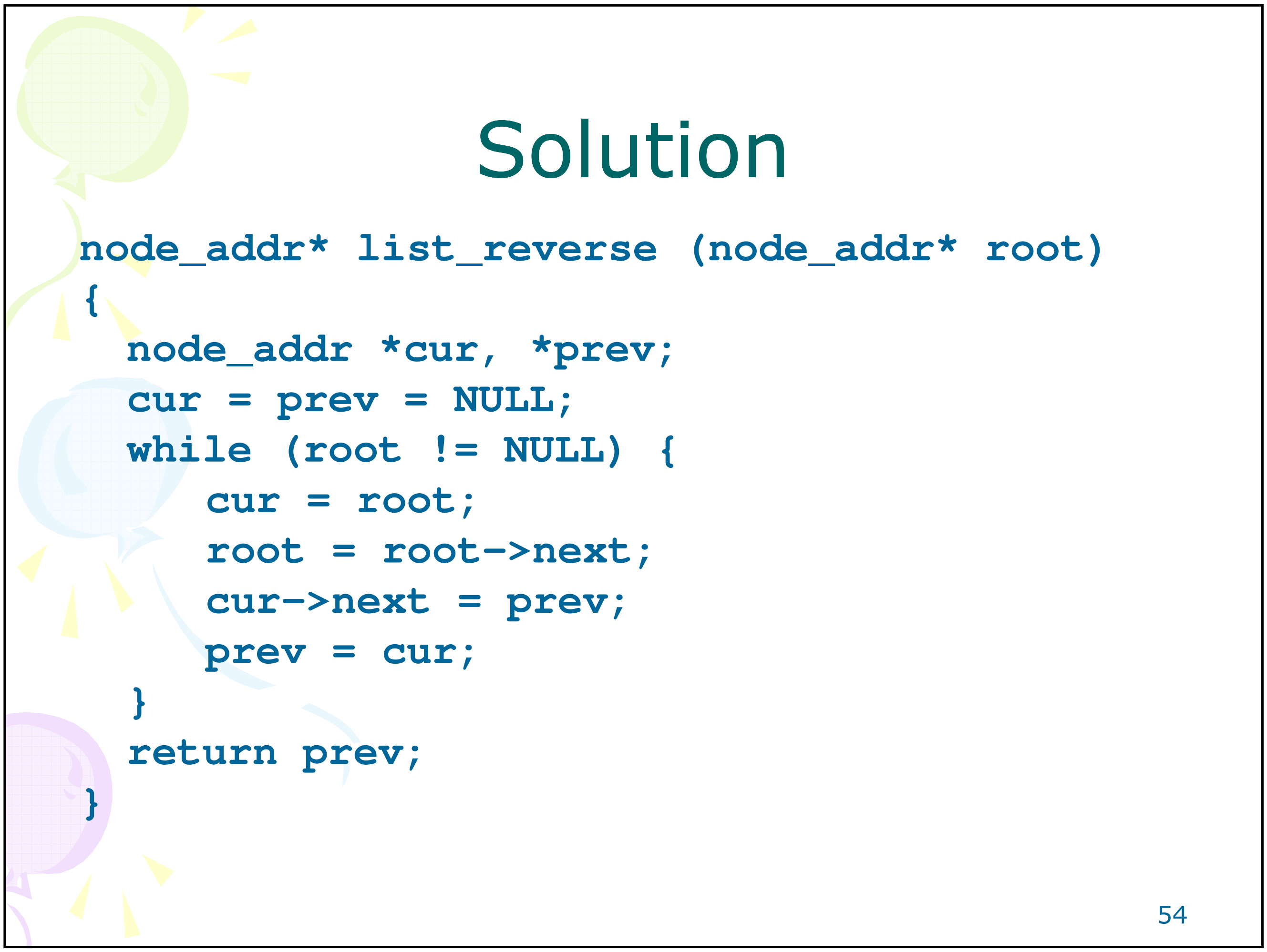
Freeing all nodes of a list

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



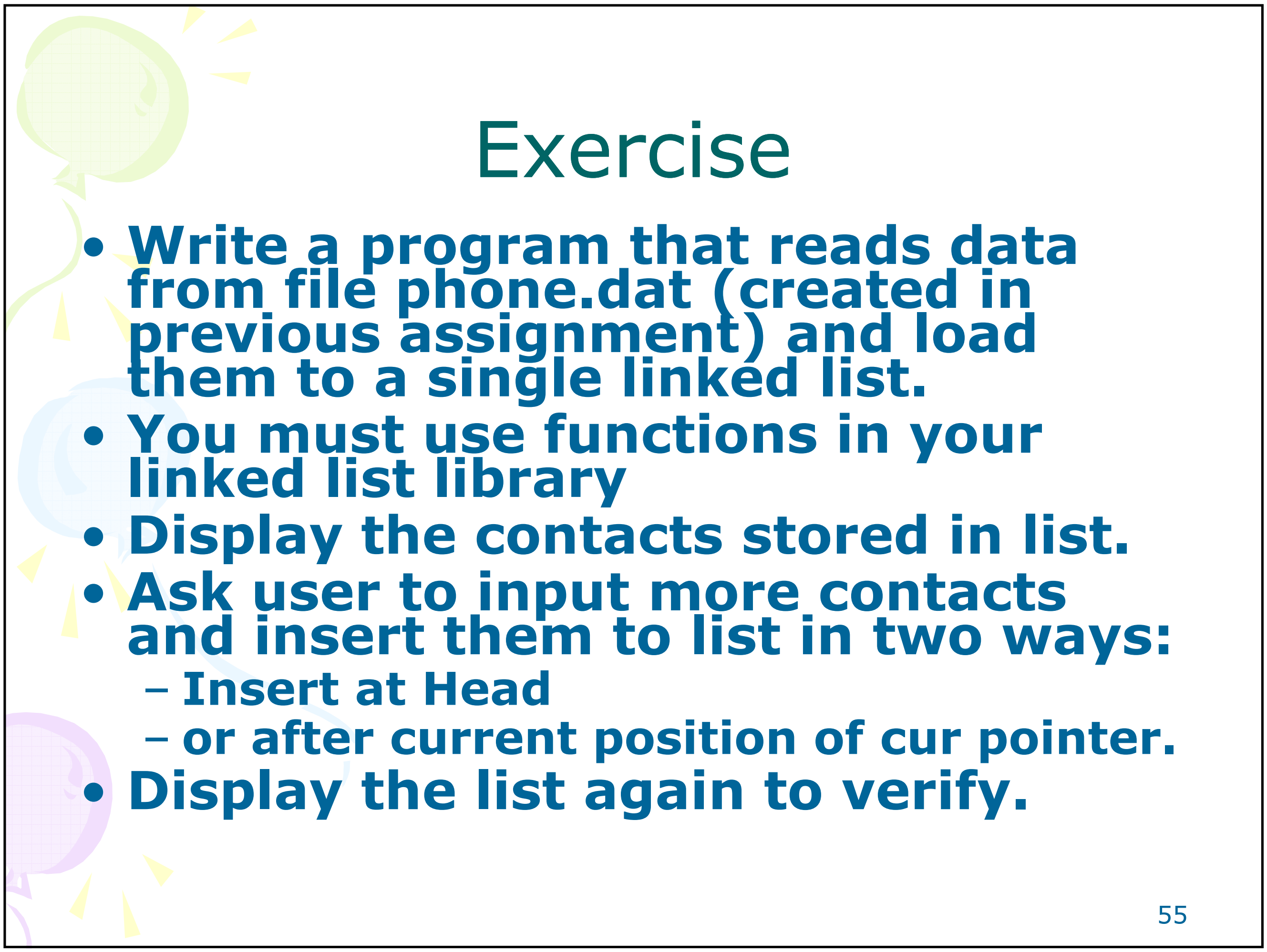
Reverse a list

- Write a function that reverse a list.



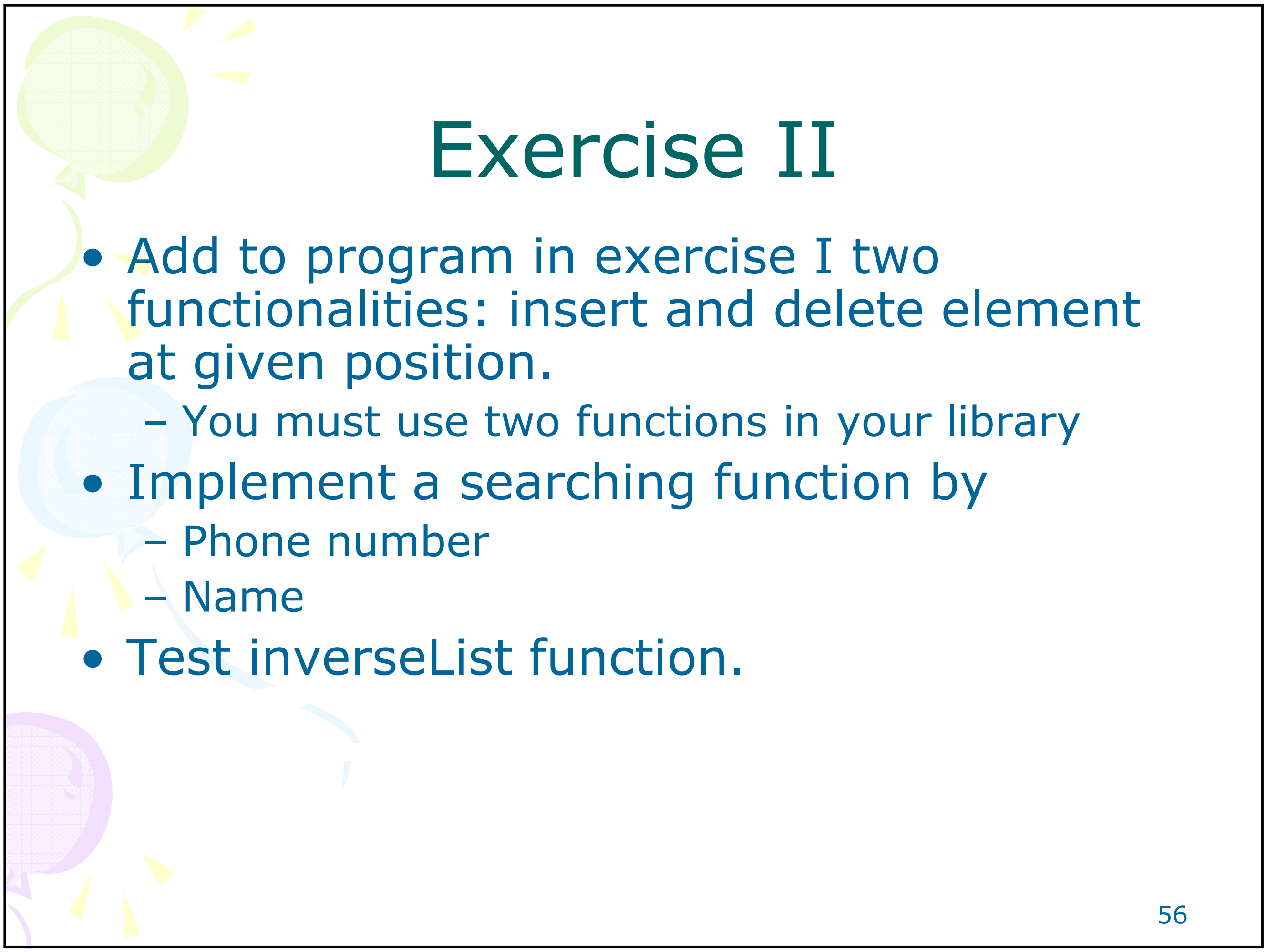
Solution

```
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;
}
```



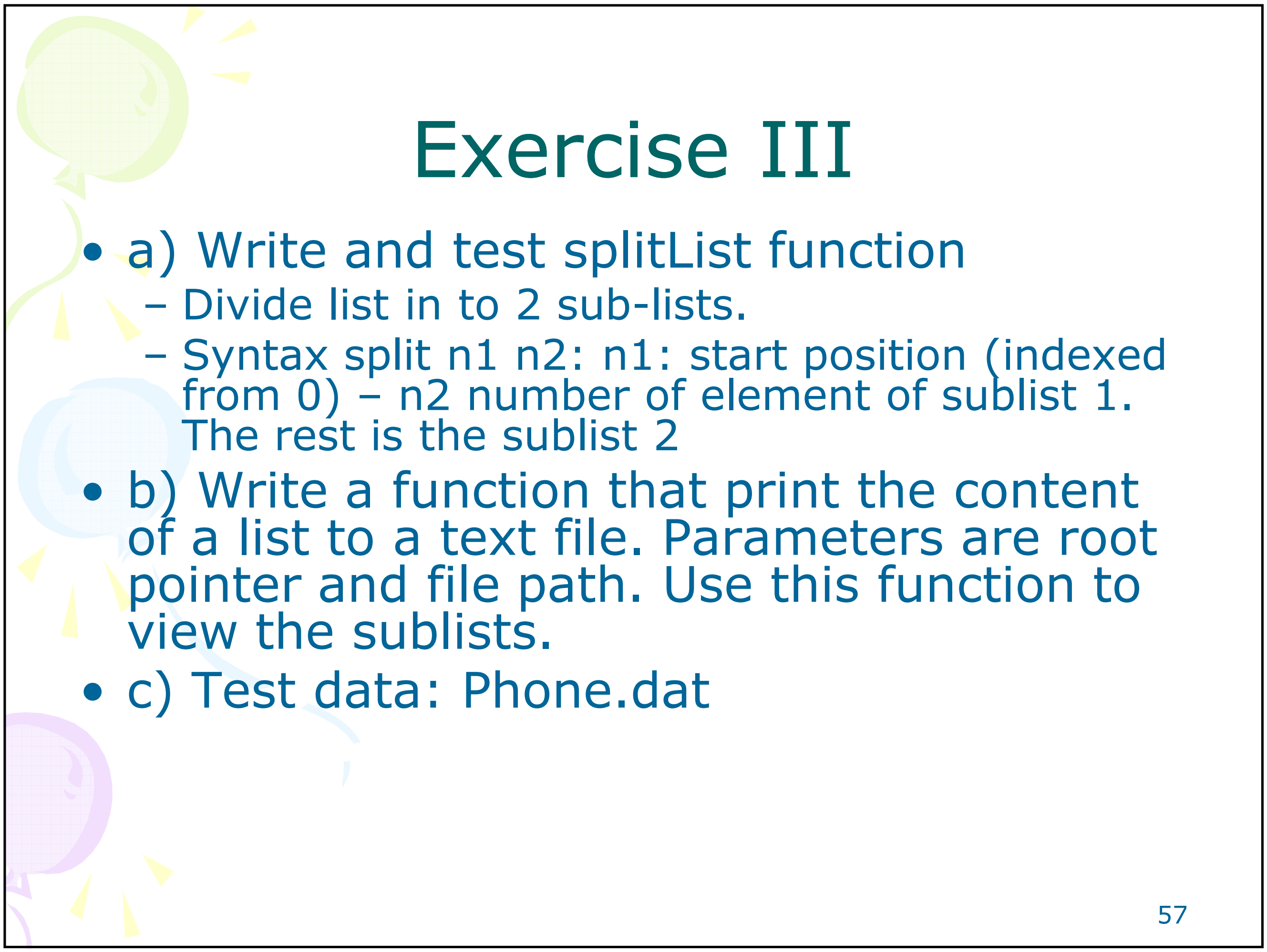
Exercise

- 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.



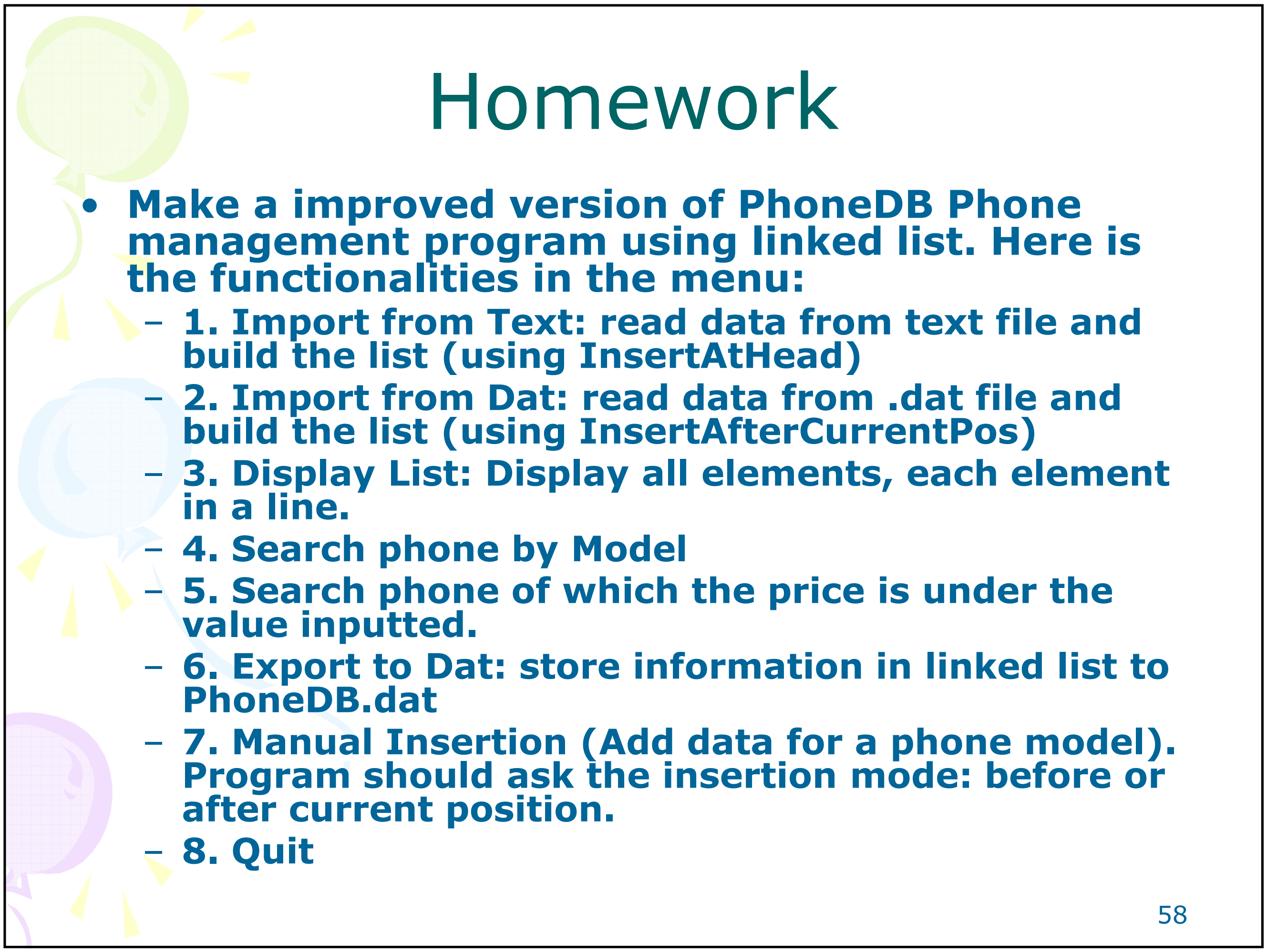
Exercise II

- 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.



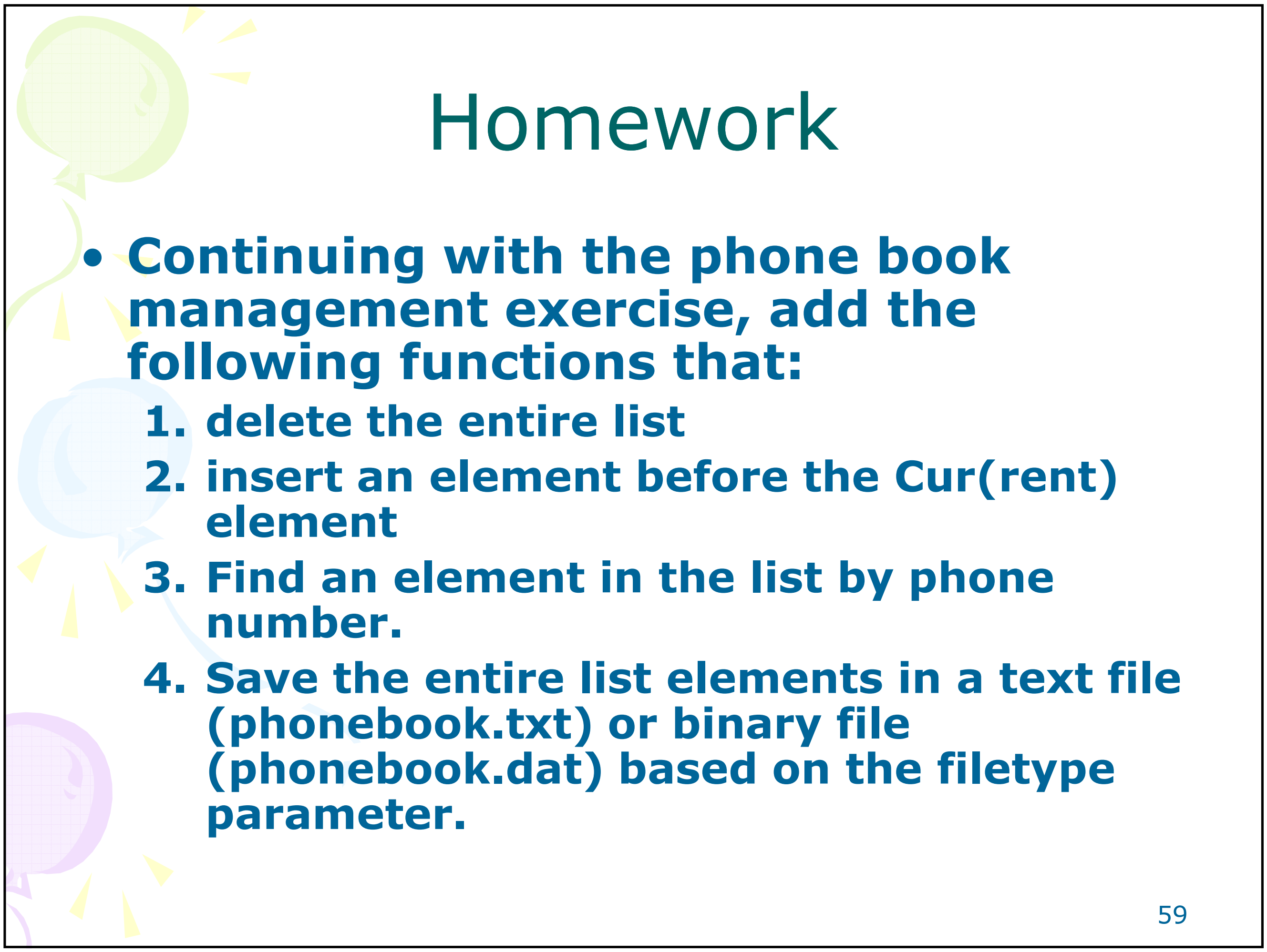
Exercise III

- 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.