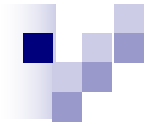


CS10003: Programming & Data Structures

Dept. of Computer Science & Engineering
Indian Institute of Technology Kharagpur

Autumn 2020

Linked Lists

What is ADT?

An abstract data type (**ADT**) is an object with a generic description independent of implementation details.

This description includes a specification of the components from which the object is made and also the behavioral details of the object.

The List ADT

Let us now define a new ADT which is very useful for programming.

We call this ADT the ordered list.

- It is a list of elements, say characters, in which elements are ordered, i.e., there is a zeroth element, a first element, a second element, and so on, and in which repetitions of elements are allowed.

Functions on the List ADT

L = init();

Initialize L to an empty list.

L = insert(L,ch,pos);

Insert the character ch at position pos in the list L and return the modified list. Report error if pos is not a valid position in L.

delete(L,pos);

Delete the character at position pos in the list L. Report error if pos is not a valid position in L.

isPresent(L,ch);

Check if the character ch is present in the list L. If no match is found, return -1, else return the index of the leftmost match.

getElement(L,pos);

Return the character at position pos in the list L. Report error if pos is not a valid position in L.

print(L);

Print the list elements from start to end.

Some functions on the List ADT

```
#include<stdio.h>
#define MAXLEN 100

  typedef struct {
    int len;
    char element[MAXLEN];
  } olist;

olist init()
  {
    olist L;
    L.len = 0;
    return L;
  }

void print(olist L)
  {
    int i;

    for(i = 0; i < L.len; ++i) printf("%c", L.element[i]);
  }
```

```
olist insert(olist L , char ch , int pos)
  {
    int i;

    if ((pos < 0) || (pos > L.len)) {
      fprintf(stderr, "insert: Invalid index %d\n", pos);
      return L;
    }
    if (L.len == MAXLEN) {
      fprintf(stderr, "insert: List already full\n");
      return L;
    }
    for (i = L.len; i > pos; --i)
    L.element[i] = L.element[i-1];
    L.element[pos] = ch;
    ++L.len;
    return L;
  }
```

The main function

```
main()
{
 olist L;
 L=init();
 L=insert(L,'a',0);
 print(L);
 printf("\n");
 L=insert(L,'b',0);
 print(L);
 printf("\n");
 L=insert(L,'c',2);
 print(L);
 printf("\n");
}
```

- a
- ba
- bac

The delete procedure

```
olist delete(olist L, int pos)
  {
    int i;

    if ((pos < 0) || (pos >= L.len)) {
      fprintf(stderr, "delete: Invalid index %d\n", pos);
      return L;
    }
    for (i = pos; i <= L.len - 2; ++i)
     L.element[i] = L.element[i+1];
    --L.len;
    return L;
  }
```

Lists with Linked Lists (using pointers)

Self Referential Structures

```
typedef struct _node {
    int data;
    struct _node *next;
} node;
node *head, *p;
int i;
head = (node *)malloc(sizeof(node)); /* Create the first node */
head->data = 3; /* Set data for the first node */
p = head; /* Next p will navigate down the list */
for (i=1; i<=3; ++i)
{ p->next = (node *)malloc(sizeof(node)); /* Allocate the next node */
  p = p->next; /* Advance p by one node */
  p->data = 2*i+3; /* Set data */
}
p->next = NULL; /* Terminate the list by NULL */
```

Finer Points

An important thing to notice here is that we are always allocating memory to p->next and not to p itself. For example, first consider the allocation of head and subsequently an allocation of p assigned to head->next.

```
head = (node *)malloc(sizeof(node));
   p = head->next;
   p = (node *)malloc(sizeof(node));
```

Finer Points

After the first assignment of p, both this pointer and the next pointer of *head point to the same location.

However, they continue to remain *different pointers*. Therefore, the subsequent memory allocation of p changes p, whereas head->next remains unaffected.

For maintaining the list structure we, on the other hand, want head->next to be allocated memory.

So allocating the running pointer p is an error. One should allocate p->next with p assigned to head (not to head->next).

Now p and head point to the same node and, therefore, both p->next and head->next refer to the same pointer -- the one to which we like to allocate memory in the subsequent step.

This example illustrates that the first node is to be treated separately from subsequent nodes.

- This is the reason why we often maintain a *dummy node* at the head and start the actual data list from the next node.

A Modular Implementation of Linked List using Pointers

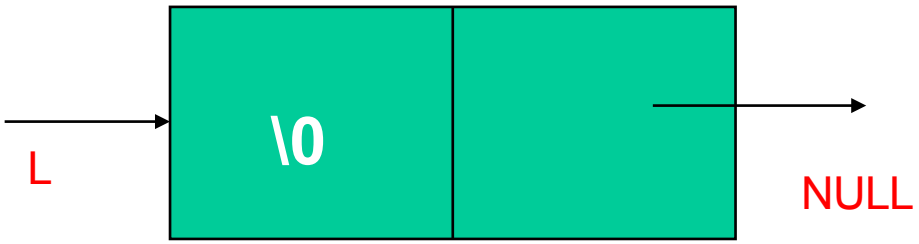
```
#include<stdio.h>
#include<malloc.h>

typedef struct list{
    char value;
    struct list *next;
}node;

typedef node* olist;
```

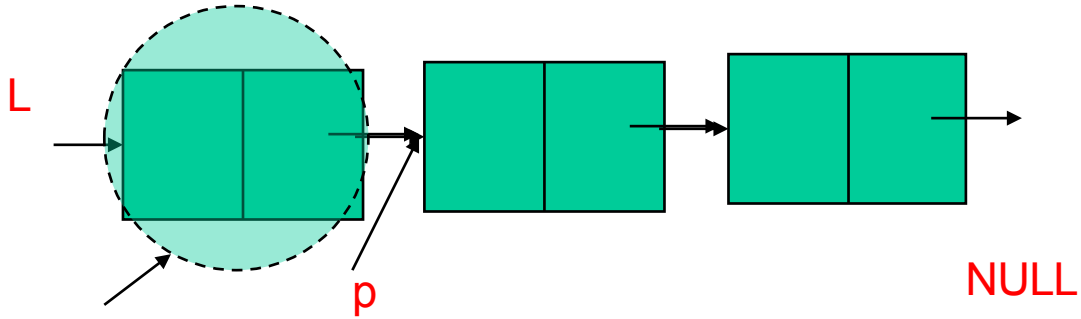
The init function

```
olist init()
{
 olist L;
 L=(olist)malloc(sizeof(node));
 L->value='\0';
 L->next=NULL;
 return(L);
}
```



The print function

```
void print(olist L)
{
 node *p;
 p=L->next;
 while(p!=NULL)
 {
   printf("%c",p->value);
   p=p->next;
 }
 printf("\n");
}
```



The insert function

```
olist insert(olist L, char ch, int pos)
{
 int i;
 node *p;
 node *t;

 if(pos<0)
  {
    fprintf(stderr,"insert: Error in
     index\n");
    return(L);
  }
  p=L;
  i=0;
  while(i<pos){
     p=p->next;
     if(p==NULL){
       fprintf(stderr,"insert: invalid index\n");
       return(L);
      }
     i++;
   }
   t=(node *)malloc(sizeof(node));
   t->value=ch;
   t->next=p->next;
   p->next=t;
   return(L);
}
```

Inserting into an empty list (pos=0)

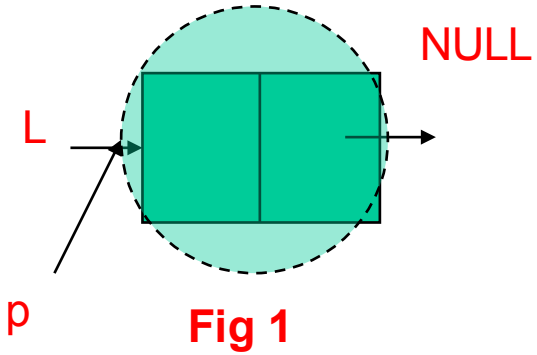
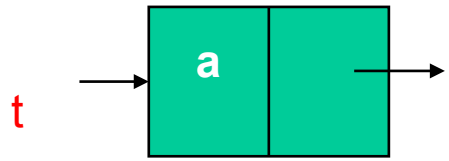


Fig 1



t=(node *)malloc(sizeof(node))

t->value=a;

Fig 2

t->next=p->next

p->next=t

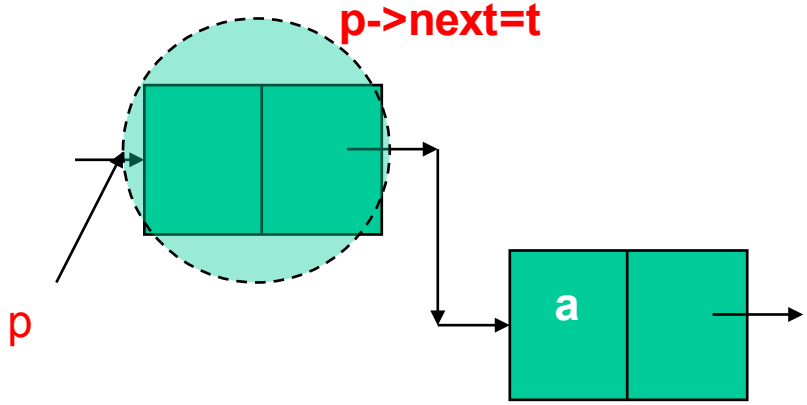


Fig 3

NULL

Inserting into an existing list with 2 nodes at pos=1

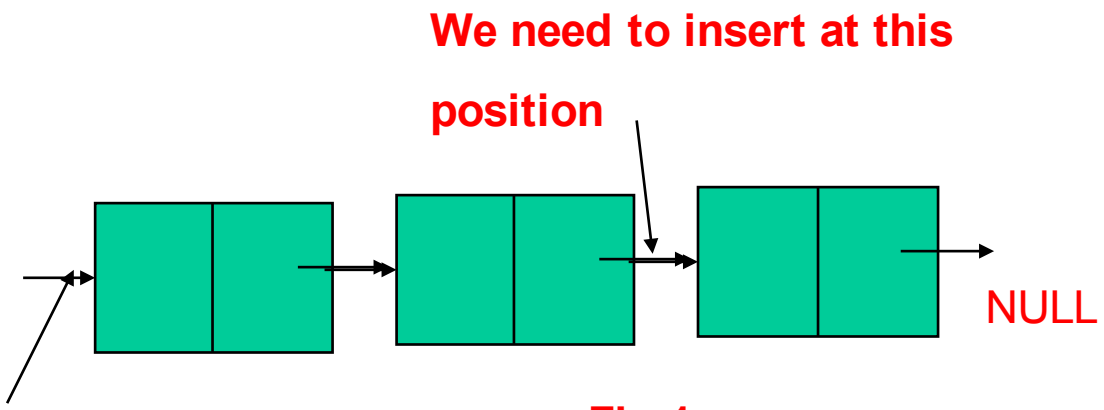


Fig 1

i=0

p=p->next

i=1

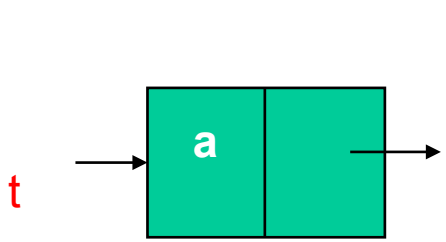


Fig 2

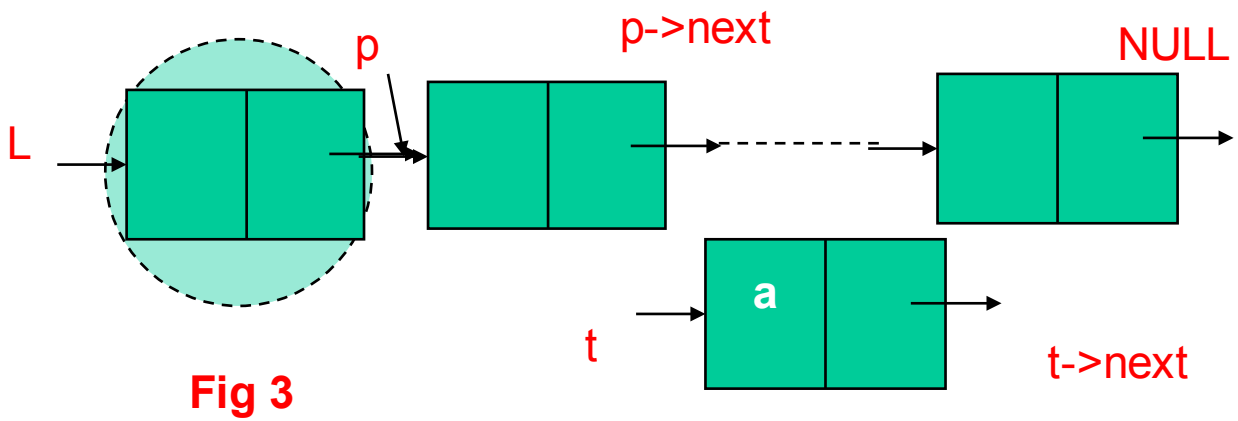
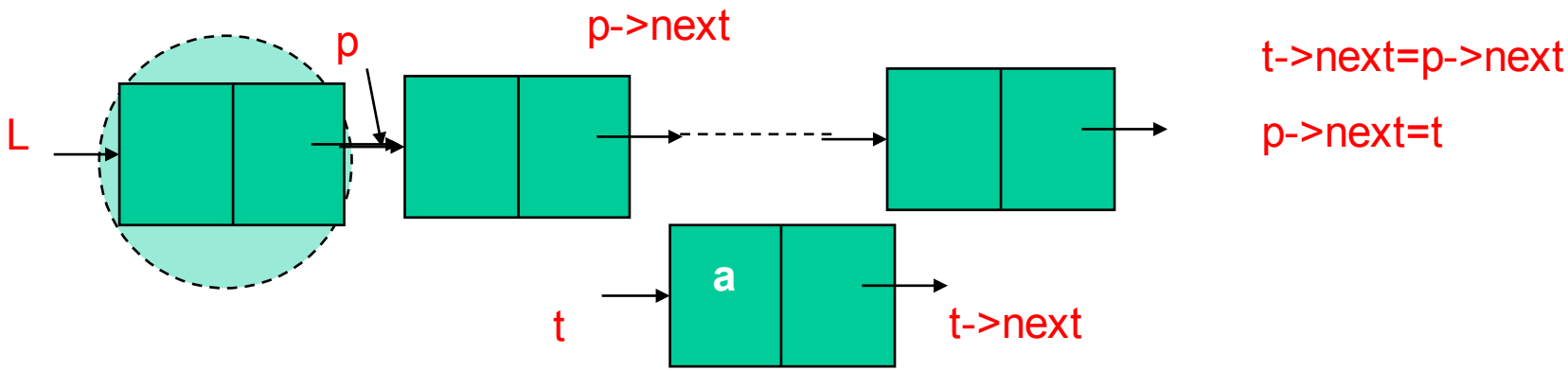


Fig 3

Inserting into an existing list with 2 nodes at pos=1



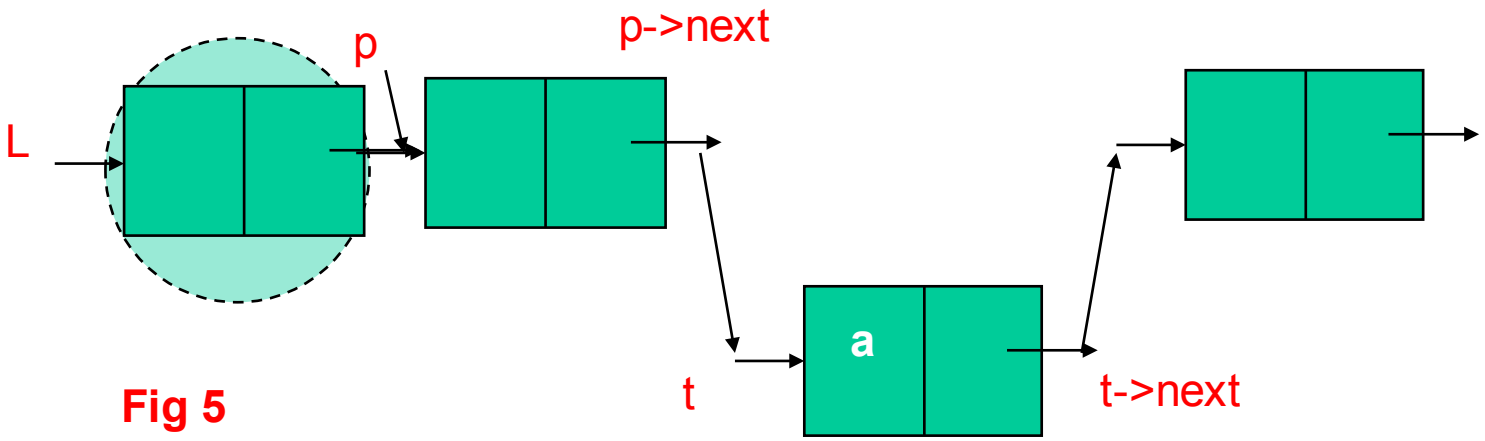


Fig 5

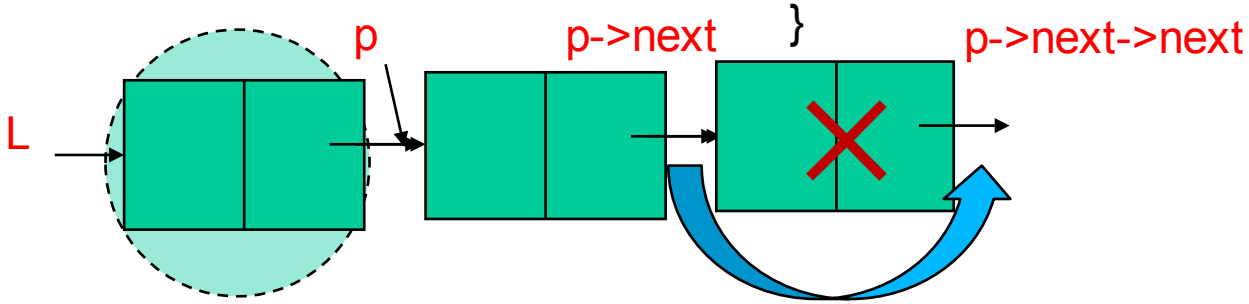
The delete function

```
olist delete(olist L, int pos)
{
 int i=0;
 node *p;
 if(pos<0){
   fprintf(stderr,"delete: invalid
    index\n");
   return(L);
  }
 p=L;
 i=0;
```

```
while(i<pos)
 {
  p=p->next;
    if(p->next==NULL)
    {
      fprintf(stderr,"delete: invalid index\n");
      return(L);
    }
  i++;
  }

p->next=p->next->next;
return(L);


}
```



The main function

```
main()
{
 olist L;
 L=init();
 print(L);
 insert(L,'a',0);
 print(L);
 insert(L,'b',1);
 print(L);
 insert(L,'c',1);
 print(L);
 delete(L,3);
 print(L);
 delete(L,2);
 print(L);
 delete(L,0);
 print(L);
}
```

a

ab

acb

delete: invalid index

acb

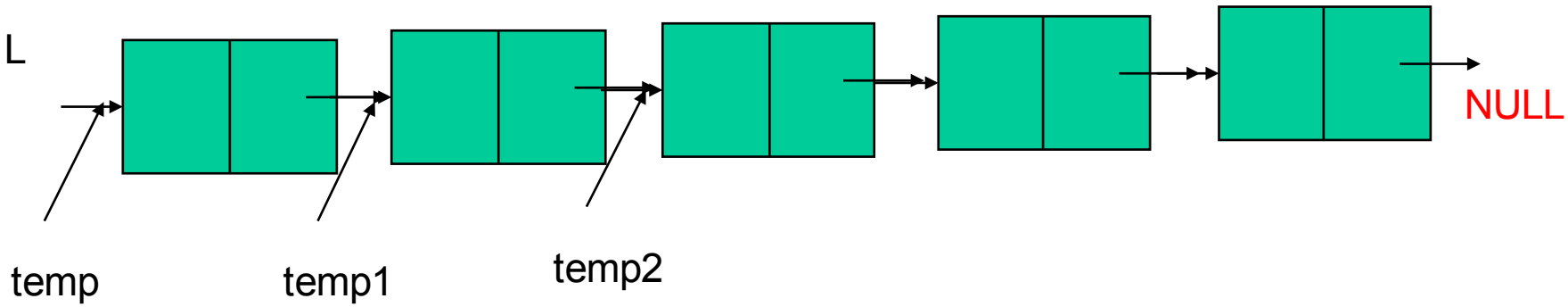
ac

c

Reversing the Linked List

```
void reverse(olist L){
node *temp;
node *temp1; node *temp2;
temp=L;temp1=temp->next;
temp2=temp1->next;
temp->next->next=NULL;
```

```
while(temp2!=NULL) {
    temp=temp1;
    temp1=temp2;
    temp2=temp1->next;
    temp1->next=temp; }
L->next=temp1;
}
```



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```

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while(temp2!=NULL) {
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    temp2=temp1->next;
    temp1->next=temp; }
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}
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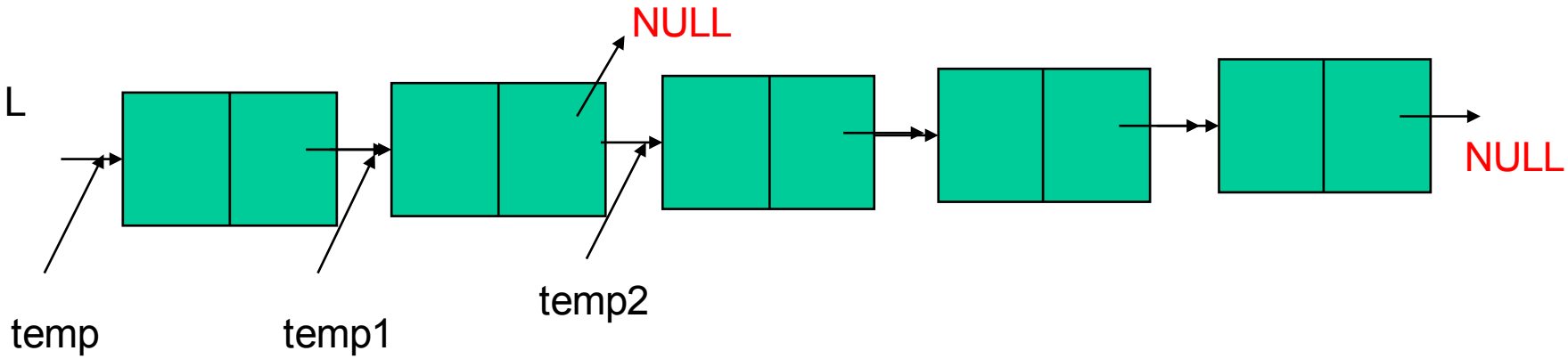

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temp=L;temp1=temp->next;
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```

```
while(temp2!=NULL) {
    temp=temp1;
    temp1=temp2;
    temp2=temp1->next;
    temp1->next=temp; }
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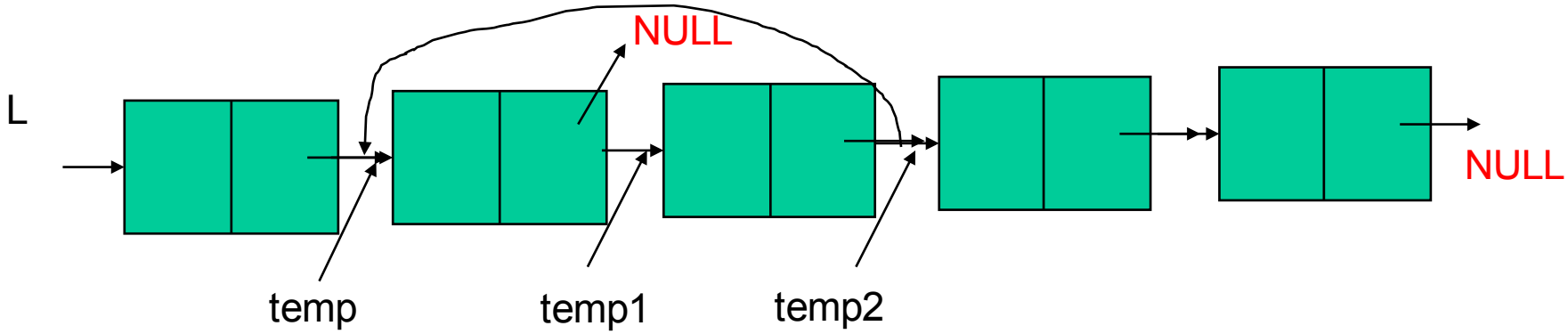
}
```



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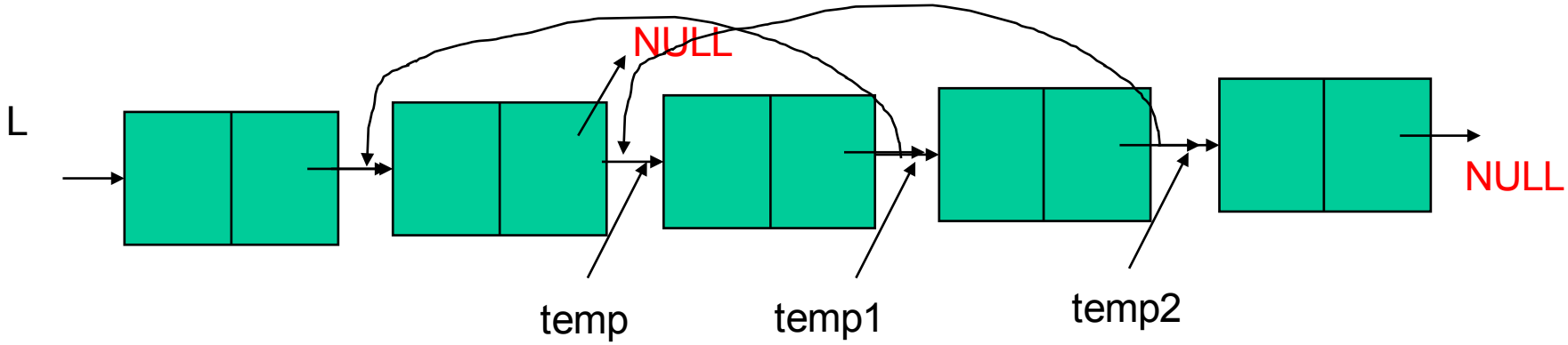

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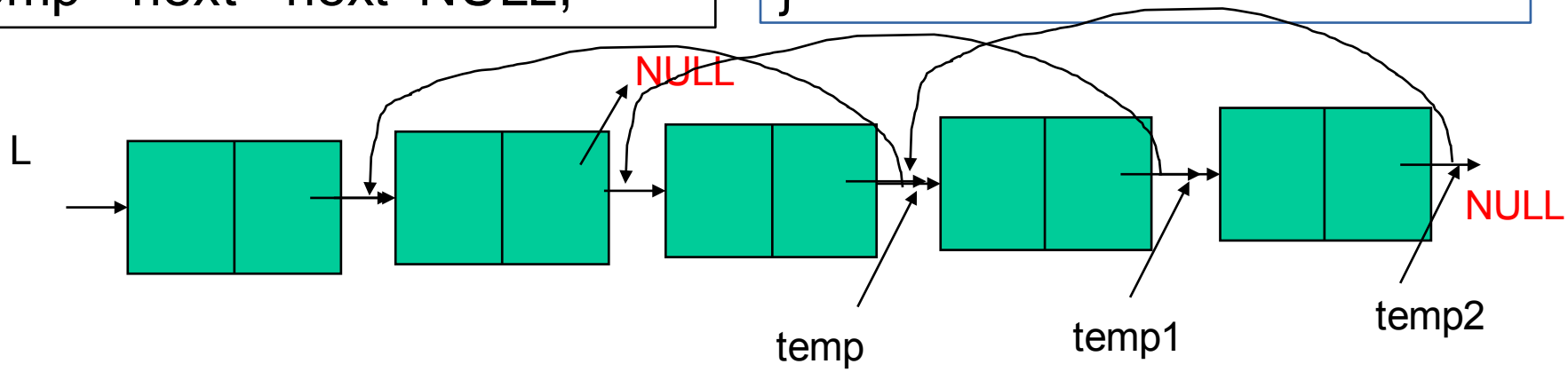

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```

```
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    temp=temp1;
    temp1=temp2;
    temp2=temp1->next;
    temp1->next=temp; }
L->next=temp1;
}
```