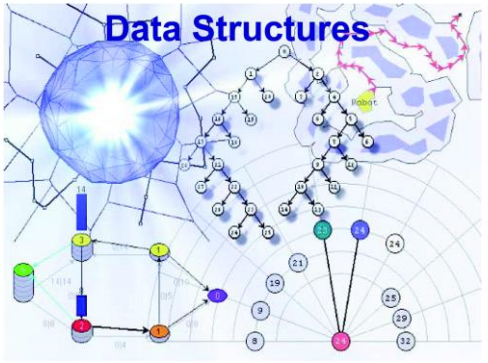
BBM 201
DATA STRUCTURES

Lecture 7:

Introduction to the Lists

(Array-based linked lists)

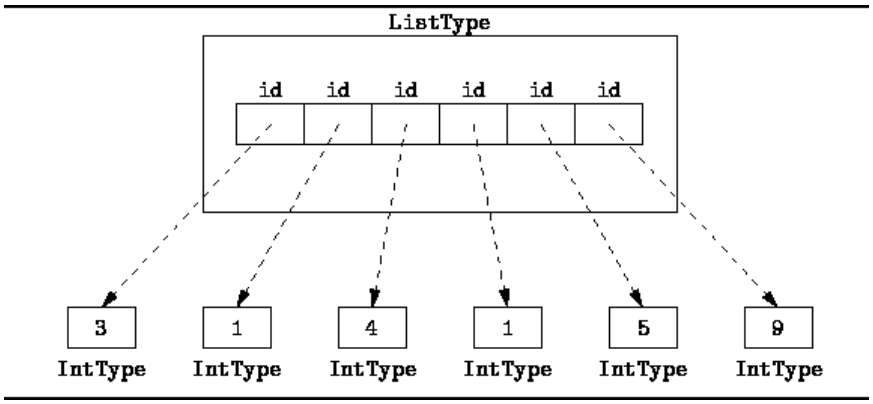


2017-2018 Fall

Lists

Lists

- We used successive data structures up to now:
  - If a_{ij} in the memory location L_{ij}, then a_{ij+1} is in $L_{ij}+c$ (c: constant)
  - In a queue, if the i^{th} item is in L_i, i+1. item is in $(L_i+c)\%n$. (i.e. circular queue)
  - In a stack, if the top item is in L_T, the below item is in L_T-c.



Insertion and deletion: O(1)

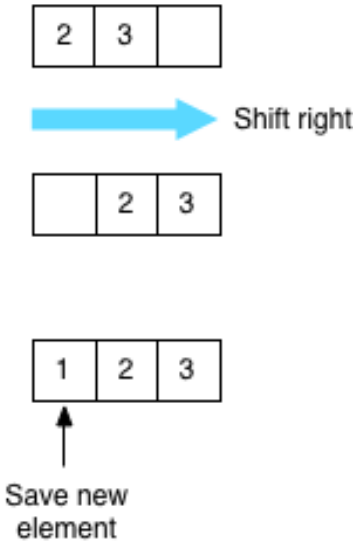
Sequential Access
(ascending or descending)

Example 1:

- Alphabetically ordered lists:

Ape	Butterfly	Cat	Dog	Mouse

- Delete ‘Ape’, what happens?
- Delete ‘Cat’, what happens?
- Add ‘Bear’, what happens?
- Add ‘Chicken’, what happens?



Sequential Access
(ascending or descending)

Example 2:

- The result of the multiplication of two polynomials
  - $(x^7+5x^4-3x2+4)(3x^5-2x^3+x^2+1)$

3	-2	1	1	15	-10	5	5	-9	6	-3	12	…	…
12	10	9	7	9	7	6	4	7	5	4	5	…	…

- Powers are not ordered. So either we need to sort or shift in order to solve this problem.

Sorted items

- We want to keep the items sorted, and we want to avoid the sorting cost.
  - We may need to sort after each insertion of a new item.
  - Or we need to do shifting.

What is the solution?

Towards the Linked List

- Each item has to have a second data field – link.
  - Each item has two fields: **data** and **link**.

Linked List

```
#define MAX_LIST 10
#define TRUE 1
#define FALSE 0
#define NULL -1
```

```
typedef struct{
        char name[5];
        //other fields
        int link;
    }item;

item linkedlist[MAX_LIST];
int free_;
```

Linked List
--make empty list

```
void make emptylist(void)
{
   int i;
   for(i=0;i<MAX_LIST-1;i++)
      list[i].link=i+1;  //every item points the next

    linkedlist [MAX_LIST-1].link=NULL; //last item
    free_=0;
}
```

Linked List
--get item

Returns a free item from the list:

```
int get_item(int* r)
{
  if(free_== NULL) //there is no item to get
    return FALSE;
  else{
    *r=free_;   //get the item which is pointed by free_
    free_=linkedlist[free_].link;//points next free item
    return TRUE;
  }
}
```

Linked List
--return item

Free the item:

```
void return_item(int r)
{
  linkedlist[r].link=free_;       //return item that is pointed by r
  free_=r;  //free the item
}
```

	name	link
[0]		1
[1]		2
[2]		3
[3]		4
[4]		5
[5]		6
[6]		7
[7]		8
…	….	…
…	….	…
		-1

free_ = 0

	name	link
[0]	Arzu	1
[1]	Ayse	2
[2]	Aziz	3
[3]	Bora	4
[4]	Kaan	5
[5]	Muge	6
[6]	Ugur	-1
[7]		8
		…
		-1

free_ = 7
List starts at 0 (*list=0)

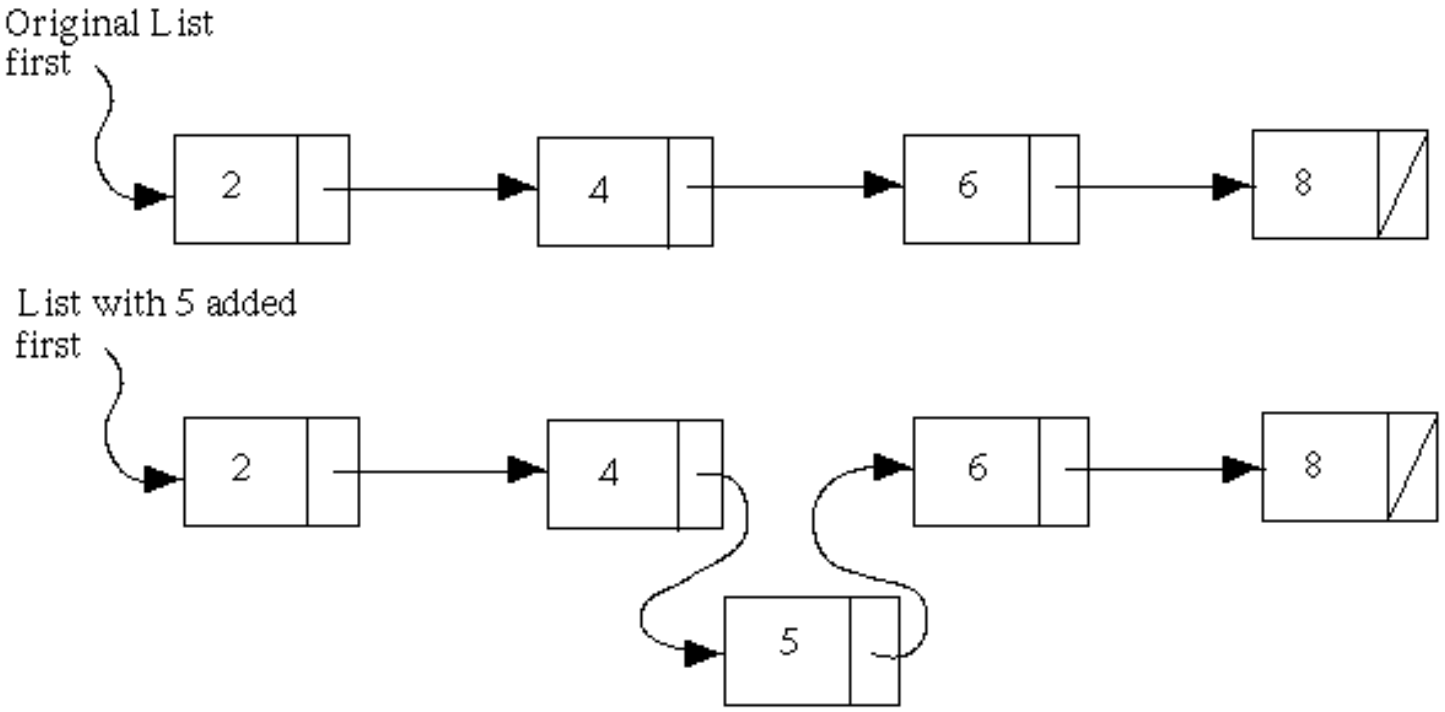
	name	link
[0]	Arzu	1
[1]	Ayse	2
[2]	Aziz	3
[3]	Bora	4
[4]	Kaan	7
[5]	Muge	6
[6]	Ugur	-1
[7]	Leyla	5
[8]	….	9
…	….	…
		-1

free_ = 8 (“Leyla” added)
*list = 0

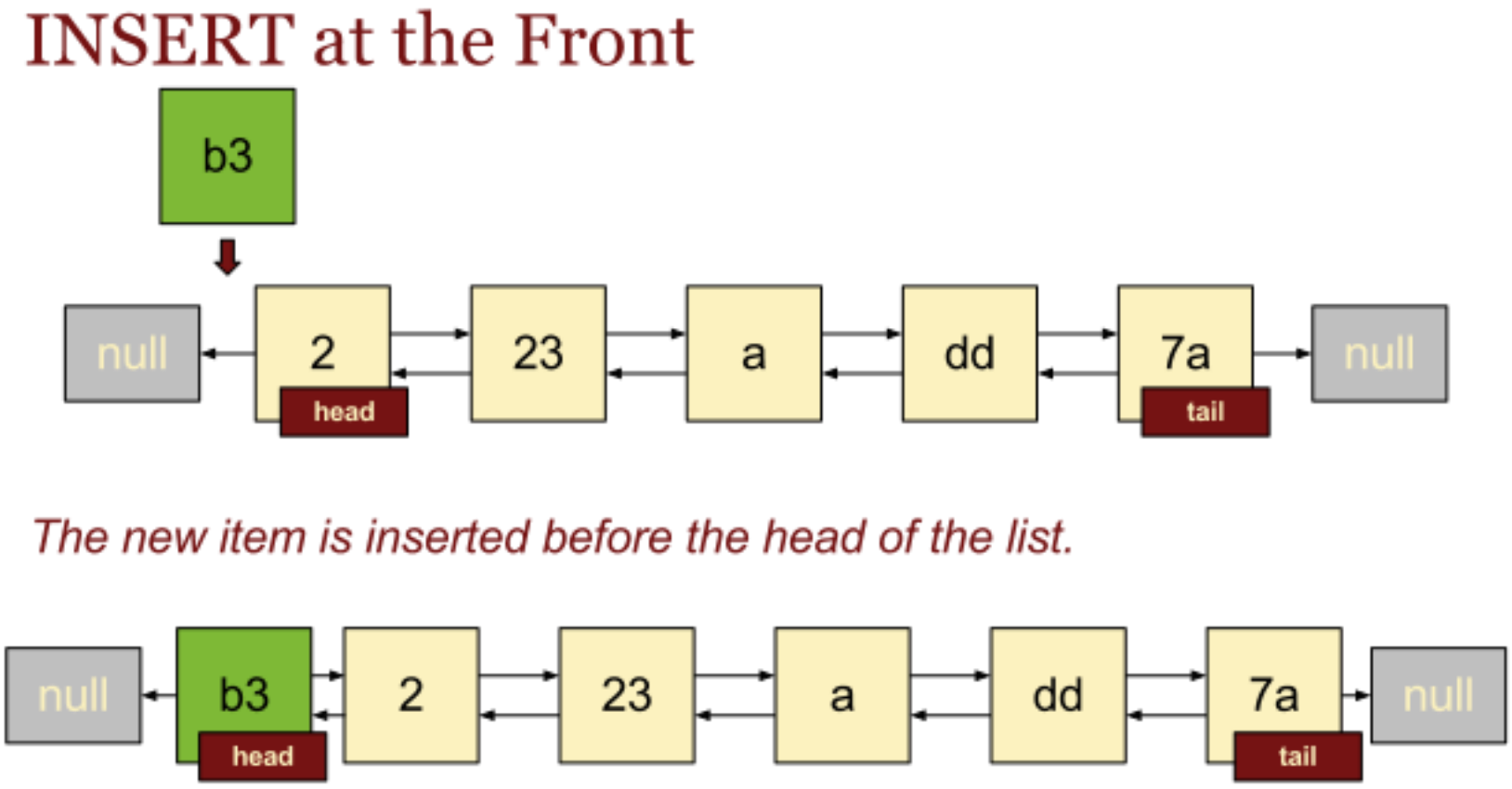
	name	link
[0]	Eyup	4
[1]	Ayse	2
[2]	Aziz	3
[3]	Bora	0
[4]	Kaan	7
[5]	Muge	6
[6]	Ugur	-1
[7]	Leyla	5
[8]		9
		-1

free_ = 0 (“Arzu” deleted)
free_ = 8 (“Eyup” added)
*list = 1

Linked List
--insert item



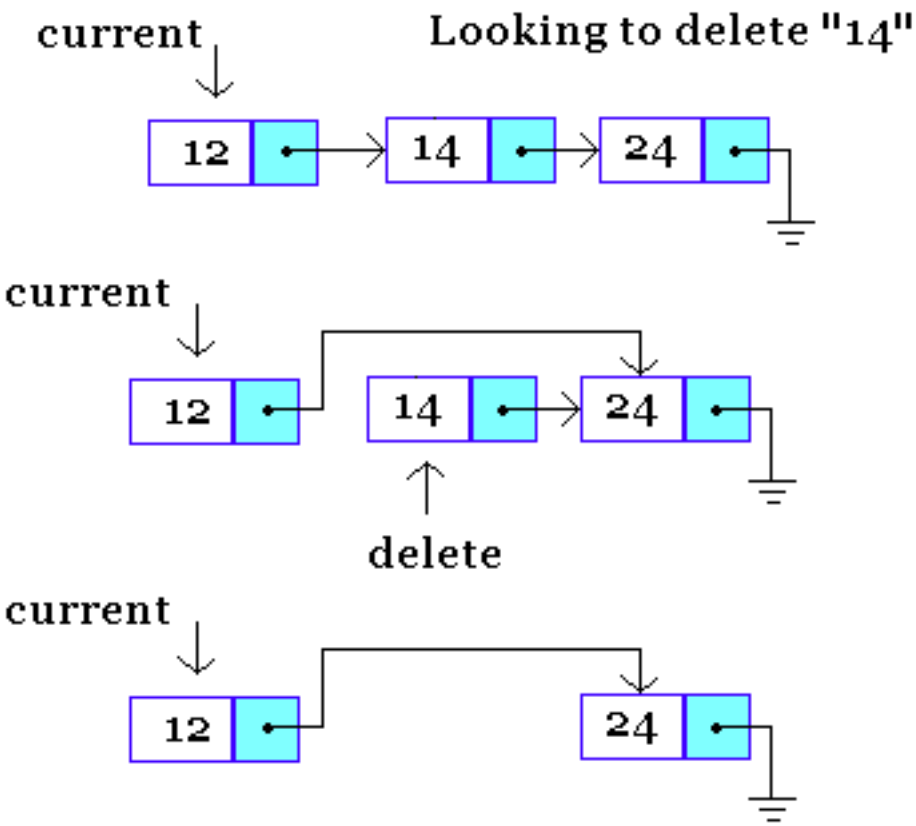
Linked List
--insert item



Linked List
--insert item

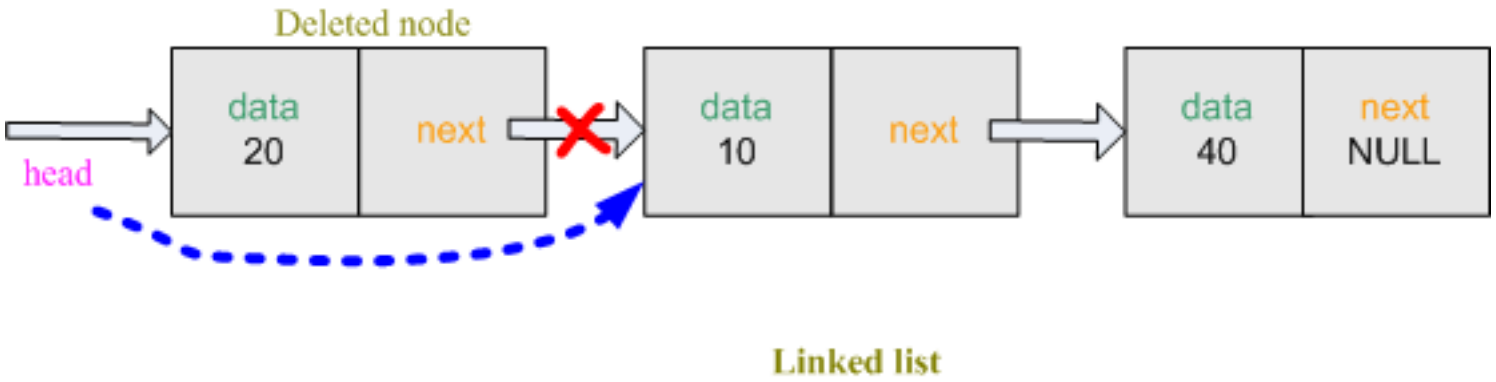
```
void insert_item(char name[], int* list)
{
  int r, q, p;
  if(get_item(&r)){
     strcpy(linkedlist[r].name, name);
     q = NULL;
     p = *list;
     while( p != NULL  &&  strcmp(linkedlist[p].name,  name) < 0) { //search right position
         q = p;
         p = linkedlist [p].link;
     }
      if(q == NULL){  //new item is inserted to the front of the list.
           *list = r;
           linkedlist [r].link = p;
      }
      else{   //new item is inserted in the middle
            linkedlist [q].link = r;
            linkedlist [r].link = p;
       }
  }
  else printf( "\n not enough free space!!");
}
```

Linked List
--delete item



Linked List
--delete item

Deleting from the front:



Linked List
--delete item

```
void delete_item(char name[], int* list)
{
   int q,p;
   q = NULL;
   p = *list;
   int l;
   while( p != NULL  &&  (l = strcmp(linkedlist[p].name, name)) < 0 ) {  //search for the item
       q = p;
       p = linkedlist [p].link;
  }
  if(p == NULL ||  l>0)  //end of the list
       printf( "\n %s cannot be found!! ", name);
  else if( q == NULL){  //the first item of the list will be deleted.
       *list = linkedlist [p].link;
       return_item(p);
  }
  else{   //get the item pointed by 'p'
       linkedlist [q].link = linkedlist [p].link;
       return_item(p);
  }
}
```

References

- Data Structures Notes, Mustafa Ege.
- Fundamentals of Data Structures in C. Ellis Horowitz, Sartaj Sahni, and Susan Anderson-Freed, 1993.