CME 112- Programming Languages II

Week 8
Singly Linked Linear Lists

Assist. Prof. Dr. Caner Özcan

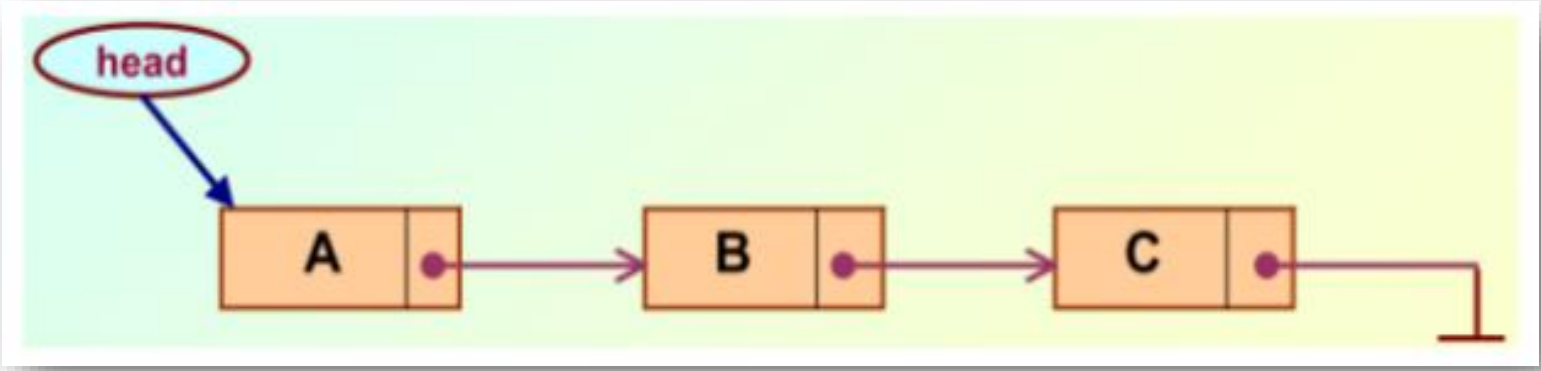
Understanding is the beginning of love. B. Spinoza

Linked Lists

- Linked lists are useful to study for some reasons.
- Most obviously, linked lists are a data structure for real programming.
- Knowing the strengths and weaknesses of linked lists will help you thinking about complexity of processing time and memory space of algorithms.
- Linked lists are a good way of understanding the pointers.
- Linked list problems are a nice combination of algorithms and pointer manipulation.

Linked Lists

- A linked list is a data structure that can be changed during execution.
- Consecutive elements are connected with the pointer.
- Last element points to NULL.
- Size can grow or shrink during the execution of the program (It can be made just as long as required)
- It doesn't made waste memory

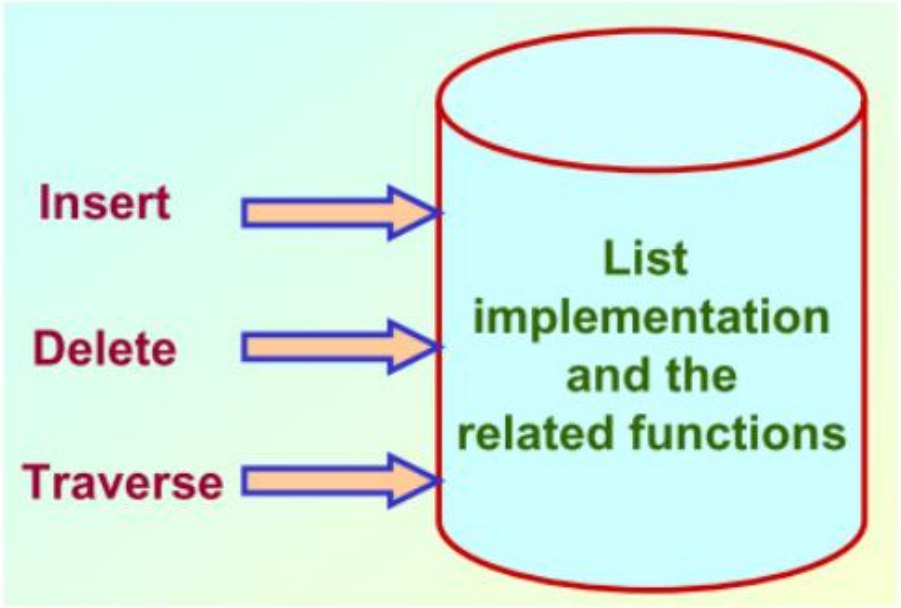


Arrays vs. Linked Lists

- Arrays are suitable for:
  - Inserting/deleting an element at the end.
  - Randomly accessing any element.
  - Searching the array for a particular value.
- Linked lists are suitable for:
  - Inserting an element.
  - Deleting an element.
  - Applications where sequential access is required.
  - In situations where the number of elements can not be predicted beforehand.

Linked Lists

- List is an abstract data type
- This data type is defined by the user.
- Typically more complex than simple data types like int, float, etc.
- Main aim is;



Basic Operations on a List

- Creating a list
- Traversing the list
- Inserting an item to the list
- Deleting an item from the list
- Concatenating two lists into one

Linked Lists

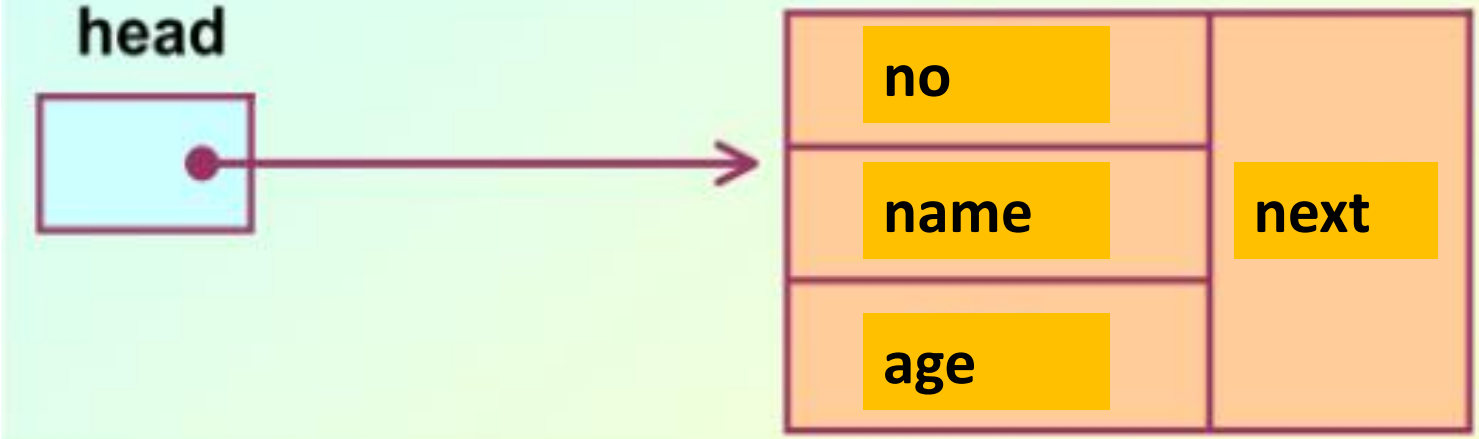
- Consider the structure of a node in the list as follows:

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

struct student{
    int no;
    char name[40];
    int age;
    struct student *next;
};
typedef struct student node;
node *head,*newNode;
```

Creating a Linear List

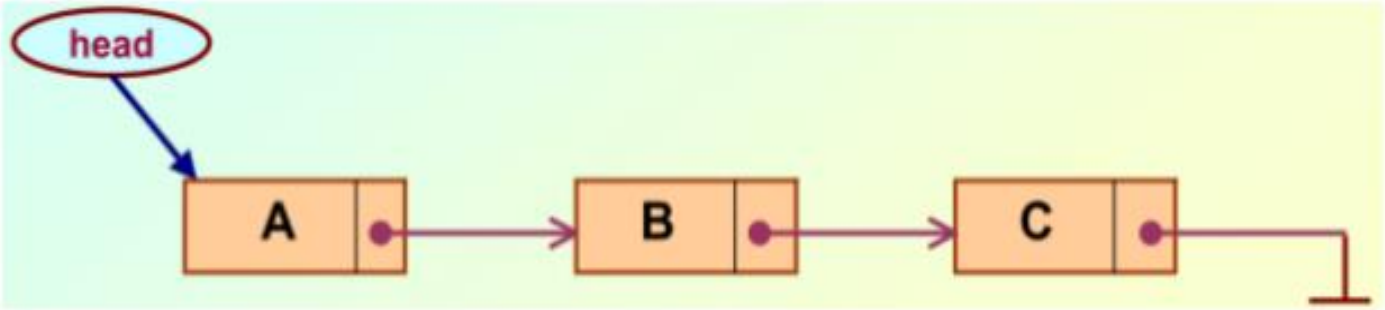
- First, a node must be created and the head must be provided to point that node.

```
head = (node *) malloc(sizeof(node));
```



Creating a Linear List

- If number of nodes is n in the initial linked list:
  - Allocate n records, one by one.
  - Read in the fields of the records.
  - Modify the links of the records so that the chain is formed.



Creating a Linear List


```
node* createList(){
    int n,k;
    node *head,*p;
    printf("How many students in the list?");
    scanf("%d",&n);
    for(k=0;k<n;k++){
        if(k==0){
            head = (node *)malloc(sizeof(node));
            p = head;
        }
        else{
            p->next = (node *) malloc(sizeof(node));
            p = p->next;
        }
        printf("Enter %d. student number: ",k+1); scanf("%d",&p->no);
        printf("Enter %d. student name: ",k+1); scanf("%s",p->name);
        printf("Enter %d. student age: ",k+1); scanf("%d",&p->age);
    }
    p->next = NULL;
    return head;
}
```

Traversing the List

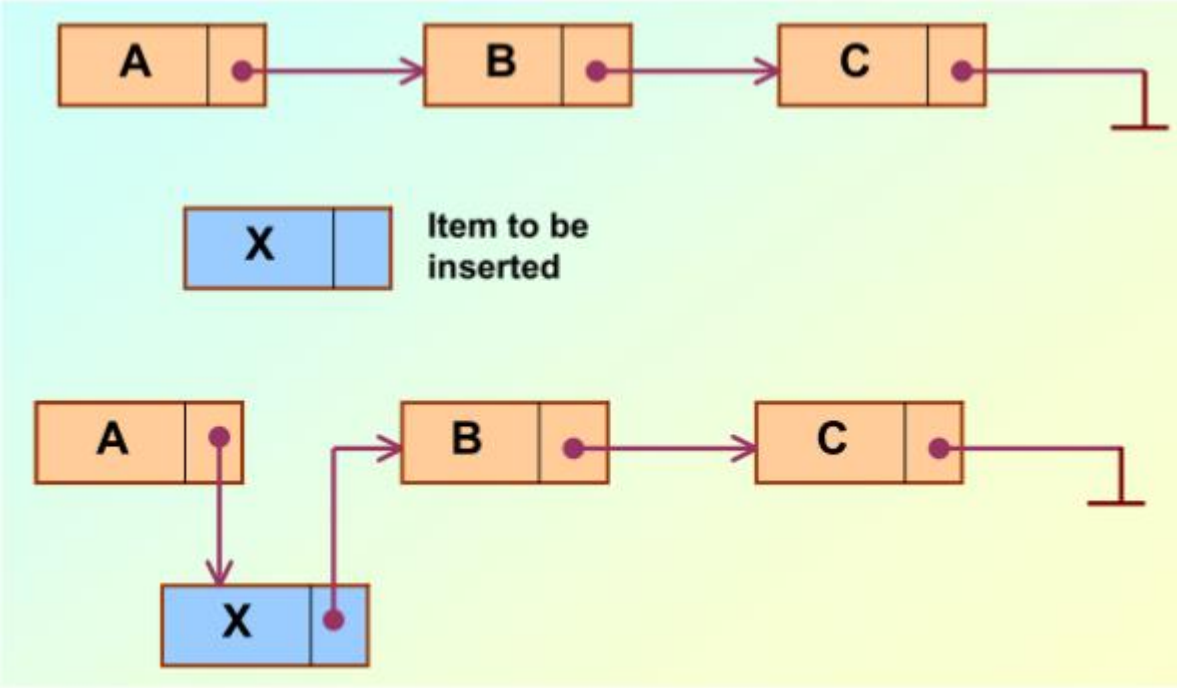
- Once the linked list has been constructed and head points to the first node of the list:
  - Follow the pointers.
  - Display the contents of the nodes as they are traversed.
  - Stop when the next pointer points to NULL

```
void traverseList(node* head){
    int counter =1;
    node *p;
    p = head;
    while(p!=NULL){
        printf("%d- %d %s %d \n",counter,p->no,p->name,p->age);
        p = p->next;
        counter++;
    }
}
```

Adding a Node to a List

- For insertion:
  - A record is created holding the new item.
  - The next pointer of the new record is set to link it to the item which is to follow it in the list.
  - The next pointer of the item which is to precede it must be modified to point to the new item.
- The problem is to insert a node before a specified node.
  - Specified means some value is given for the node (called key).
  - In this example, we consider it to be number.

Adding a Node to a List



Adding a Node to a List

- When a node is added to the beginning,
  - Only one «next» pointer needs to be modified.
    - Head is made to point to the new node.
    - New node points to the previously first element.
- When a node is added to the end,
  - Two «next» pointers need to be modified.
    - Last node now points to the new node.
    - New node points to NULL
- When a node is added to the middle,
  - Two «next» pointers need to be modified.
    - Previous node now points to the new node.
    - New node points to the next node.

Adding a Node to a List

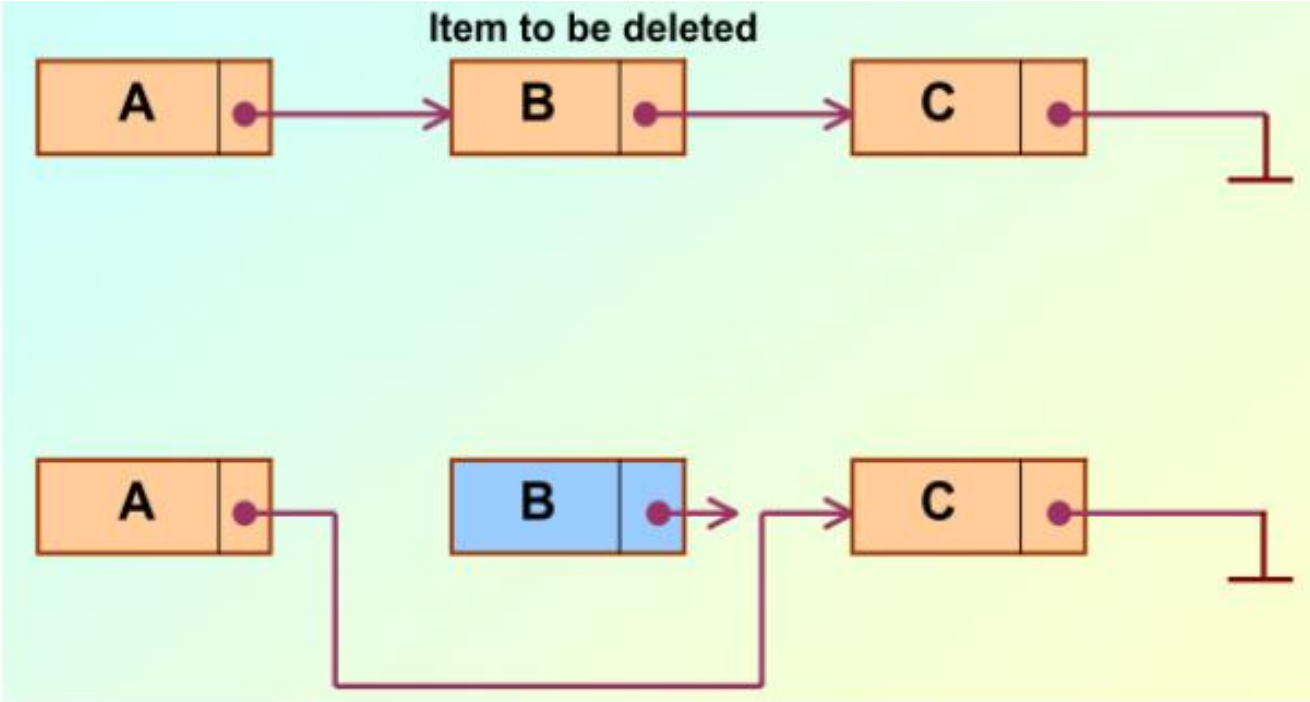

```
node* addNode(node* head){
    int stdNo;
    node *p, *q;
    node *newNode = (node *) malloc(sizeof(node));
    printf("Enter new student number: "); scanf("%d",&newNode->no);
    printf("Enter new student name: "); scanf("%s",newNode->name);
    printf("Enter new student age: "); scanf("%d",&newNode->age);

    printf("Enter std number that new record will be added before: \n");
    printf("Press 0 to add to the end of list\n");
    scanf("%d",&stdNo);

    p = head;
    if(p->no == stdNo){ //add to beginning
        newNode->next = p;
        head = newNode;
    }
```

Adding a Node to a List


```
    p = head;
    if(p->no == stdNo){ //add to beginning
        newNode->next = p;
        head = newNode;
    }
    else{
        while(p->next != NULL && p->no != stdNo){
            q=p;
            p= p->next;
        }
        if(p->no == stdNo){ //Add nor beginning neither end
            q->next = newNode;
            newNode->next = p;
        }
        else if(p->next == NULL){ //Add to end
            p->next = newNode;
            newNode->next = NULL;
        }
    }
    return head;
}
```

Deleting a Node from the List

- The next pointer of the item immediately preceding the one to be deleted is altered, and made to point to the item following the deleted item.



Deleting a Node from the List

- To delete a specified node (give the node whose number field is given)
- Three conditions arise:
  - Deleting the first node.
  - Deleting the last node.
  - Deleting an intermediate node.

Deleting a Node from the List


```
node* deleteNode(node *head){
    int stdNo;
    node *p, *q;

    printf("Enter student number that will be deleted?");
    scanf("%d",&stdNo);

    p = head;
    if(p->no == stdNo){ //delete node at the beginning
        head = p->next;
        free(p);
    }
```

Deleting a Node from the List


```
    p = head;
    if(p->no == stdNo){ //delete node at the beginning
        head = p->next;
        free(p);
    }
    else{
        while(p->next != NULL && p->no != stdNo){
            q=p;
            p= p->next;
        }
        if(p->no == stdNo){ //Delete from nor beginning neither end
            q->next = p->next;
            free(p);
        }
        else if(p->next == NULL){ //No node found to delete
            printf("No node found to delete");
        }
    }
    return head;
}
```

Main Function


```
int main(void)
{
    node *head;
    int selection=0;
    printf("1.Create List 2.Traverse List 3.Add Node 4.Delete Node 5.Exit\r
    while(1)
    {
        printf("Selection [1-5]?");
        scanf("%d",&selection);
        switch(selection)
        {
        case 1: head = createList();printf("Adres: %x\n",head);
            traverseList(head);break;
        case 2: traverseList(head);break;

        case 3: head=addNode(head);
            traverseList(head);break;
        case 4: head=deleteNode(head);
            traverseList(head);break;
        case 5: exit(0);

        }
    }
}
```

Singly Linked List Application-1

- A linear list application that has capability of listing nodes in alphabetical order, inserting nodes, deleting a specified node and finding the record that has maximum number of characters in the list.

Node Structure


```
 5  struct personel
 6  {
 7    char   adi[21];
 8    struct personel *sonraki;
 9  };
10
11  //artık struct personel yerine dugum kullanılacak
12  typedef struct personel dugum;
13  // *head dugum tipinde bir işaretçidir.
14  //Herzaman listenin başını gösterecek
15  dugum *head, *oncekiDugum,*yeni,*silinecek;
```

Searching Record


```
18  void ara(char *aranan) //listede arama yapar
19  {
20    dugum *p;
21    p = head;
22    oncekiDugum = head;
23    while(p->sonraki!=NULL)
24    {
25        p= p->sonraki;
26        if (strcmp(p->adi, aranan) >= 0) break;
27        oncekiDugum = p;
28    }
29  }
```

Adding a New Record


```
30 void ekle(char *s)
31 {
32   yeni = (dugum *) malloc(sizeof(dugum));
33   strcpy(yeni->adi, s);
34   ara(yeni->adi);
35   yeni->sonraki = oncekiDugum->sonraki;  /* listeye ekle */
36   oncekiDugum->sonraki = yeni;
37 }
```

Delete Record


```
38 void sil(char *s)
39 {
40    ara(s);
41    silinecek = oncekiDugum->sonraki;
42    oncekiDugum->sonraki = silinecek->sonraki;
43    free(silinecek);
44 }
```

List Nodes


```
45  void listele(void)
46  {
47      dugum *p;
48      p = head;
49      p = p->sonraki;
50      while (p!= NULL)
51      {
52        printf("%s  \n",p->adi);
53        p = p->sonraki;
54      }
55  }
```

Finding Longest Record


```
56  void enUzunBul(void)
57  {
58      dugum *p, *enuzun;
59      p = head;
60      p= p->sonraki;
61      enuzun=p;
62      while (p != NULL)
63      {
64          if (strlen(p->adi) >= strlen(enuzun->adi))
65          {
66            enuzun = p;
67          }
68          p = p->sonraki;
69      }
70      printf("\nEn uzun :%s  Uzunluk:%d",enuzun->adi,strlen(enuzun->adi));
71      getchar();
72  }
```

Main Function


```
74  void main()
75  {
76    char      sec;
77    char      s[21];
78    head = (dugum *) malloc(sizeof(dugum));
79    strcpy(head->adi," listenin basi");
80    head->sonraki = NULL;
81    do
82      {
83        system("cls");
84        listele();
85        printf("\n\n1 - Ekle\n2 - Sil\n3 - En Uzun isim\n4 - Cikis\n\nSec :");
86        sec = getche();
87        switch (sec)
88          {
89          case '1':printf("\nAdi :"); gets(s);
90            ekle(s);break;
91          case '2':printf("\nAdi ");  gets(s);
92            sil(s);break;
93          case '3':enUzunBul();break;
94          case '4':exit(0);break;
95          }
96      }
97    while (1);
98  }
```

Singly Linked List Application-2

- Do the following operations on a singly linked list application that holds several information about students such as number, name, midterm exam grade and final exam grade:
  - Add / remove record
  - Listing students with their final term grade (Midterm exam %40, Final Exam:%60)
  - List all information of the student who has highest final term grade
  - Calculate the average final term grades of the students in the list

Node Structure

```
1  #include <stdio.h>
2  #include <stdlib.h>
3
4  struct ogrenci{
5      int no;
6      char adi[40];
7      int vize,final;
8      struct ogrenci *sonraki;
9  };
10 typedef struct ogrenci dugum;
11 dugum *head,*yeniDugum,*oncekiDugum,*enBasarili;
12
```

Creating List


```
13  void ogrenciListeOlustur()
14  {
15      int n,k;
16      printf("Kac elamanli liste olusturacaksin");
17      scanf("%d",&n);
18      for(k=0;k<n;k++)
19      {
20          if(k==0) //ilk düğüm ekleniyor
21          {
22              yeniDugum = (dugum *)malloc(sizeof(dugum));
23              head = yeniDugum;
24          }
25          else
26          {
27              yeniDugum->sonraki = (dugum *) malloc(sizeof(dugum));
28              yeniDugum = yeniDugum->sonraki;
29          }
30          printf("Ogrenci No:");scanf("%d",&yeniDugum->no);
31          printf("Ogrenci Adi:");scanf("%s",yeniDugum->adi);
32          printf("Ogrenci Vize:");scanf("%d",&yeniDugum->vize);
33          printf("Ogrenci Final:");scanf("%d",&yeniDugum->final);
34      }
35      yeniDugum->sonraki = NULL;
36  }
```

Listing Students


```
38  void ogrenciListele()
39  {
40      double donemNotu =0;
41      dugum *p;
42      p = head;
43      while(p!=NULL)
44      {
45          printf("\n ************** \n");
46          printf("Ogrenci No:%d\t",p->no);
47          printf("Ogrenci Adi:%s\t",p->adi);
48          printf("Ogrenci Vize:%d\t",p->vize);
49          printf("Ogrenci Final:%d\t",p->final);
50          donemNotu = p->vize*0.4+p->final*0.6;
51          printf("Donem Notu : %.2f\t", donemNotu);
52          printf("\n ************** \n");
53          p = p->sonraki;
54      }
55  }
```

Adding New Student


```
57  void ogrenciEkle()
58  {
59      int kayitNo;
60      dugum *p, *q;
61      yeniDugum = (dugum *) malloc(sizeof(dugum));
62      printf("Ogrenci No:");scanf("%d",&yeniDugum->no);
63      printf("Ogrenci Adi:");scanf("%s",yeniDugum->adi);
64      printf("Ogrenci Vize:");scanf("%d",&yeniDugum->vize);
65      printf("Ogrenci Final:");scanf("%d",&yeniDugum->final);
66
67      printf("Hangi kayittan oncesine eklemek istiyorsunuz");
68      printf("\nListe sonuna eklemek icin 0 gir");
69      scanf("%d",&kayitNo);
70
71      p = head;
72      if(p->no == kayitNo) //başa ekle
73      {
74          yeniDugum->sonraki = p;
75          head = yeniDugum;
76      }
```

Adding New Student


```
80      else
81      {
82          while(p->sonraki !=NULL)
83          {
84              q=p;
85              p=p->sonraki;
86              if(p->no == kayitNo) break;
87          }
88          if(p->no == kayitNo) //araya ekleme
89          {
90              q->sonraki = yeni;
91              yeni->sonraki = p;
92          }
93          else if(p->sonraki == NULL)
94          {
95              p->sonraki = yeni;
96              yeni->sonraki = NULL;
97          }
98      }
99  }
```

Delete Student


```
 97 void ogrenciSil()
 98 {
 99     int kayitNo;
100     dugum *p, *q;
101
102     printf("Silmek istediginiz ogrenci no gir");
103     scanf("%d",&kayitNo);
104
105     p = head;
106     if(p->no == kayitNo) //baştakini sil
107     {
108         head = p->sonraki;
109         free(p);
110     }
```

Delete Student


```
115     else
116     {
117         while(p->sonraki !=NULL)
118         {
119             if(p->no == kayitNo) break;
120             else {
121                 q=p;
122                 p=p->sonraki;
123             }
124         }
125         if(p->no == kayitNo) //araya ekleme
126         {
127             q->sonraki = p->sonraki;
128             free(p);
129         }
130         else if(p->sonraki == NULL)
131         {
132             printf("Silinecek ogrenci no yok\n");
133         }
134     }
135 }
```

Find Student with Highest Final Term Grade


```
130 double basariNotuHesapla(int vize,int final)
131 {
132     return (0.4*vize)+(0.6*final);
133 }
134
135 void enBasariliOgrenci()
136 {
137     double basariNotu = 0;
138
139     dugum *p;
140     p = head;
141     enBasarili = head;
142
143     while(p->sonraki!=NULL)
144     {
145         p=p->sonraki;
146         if(basariNotuHesapla(p->vize,p->final)>basariNotuHesapla(enBasarili->vize,enBasarili->final))
147             enBasarili = p;
148     }
149     printf("En basarili ogrenci:\n");
150     printf("No:%d - Ad: %s  Basari Notu:%.2f\n",enBasarili->no,
151         enBasarili->adi,    basariNotuHesapla(enBasarili->vize,enBasarili->final));
152 }
```

Calculate Final Term Average of the Class


```
154 void sinifBasariOrtalamasi()
155 {
156     double basariNotuOrtalamasi = 0;
157     double toplam =0;
158     int sayac = 0;
159     dugum *p;
160     p = head;
161     if(p==NULL)
162     {
163         printf("Listede kayit yok!");
164     }
165     else
166     {
167         do
168         {
169             toplam += basariNotuHesapla(p->vize,p->final);
170             p=p->sonraki;
171             sayac++;
172         }
173         while(p!=NULL);
174 
175         basariNotuOrtalamasi = toplam/sayac;
176         printf("Basari Notu Ortalamasi: %.2f \n",basariNotuOrtalamasi);
177     }
178 }
```

Main Function


```
180 int main(void)
181 {
182     int secim=0;
183     printf("1-Liste Olustur \n2-Yeni Kayit Ekle \n3-Kayit Sil
184     while(1)
185                                                 \n4-En Yuksek Basari Notu\n5-Sinif Ortalamasi\n");
186     {
187         printf("Secim yap [1-5]?");
188         scanf("%d",&secim);
189         switch(secim)
190         {
191         case 1: ogrenciListeOlustur();
192             ogrenciListele();break;
193         case 2: ogrenciEkle();ogrenciListele();break;
194         case 3: ogrenciSil();ogrenciListele();break;
195         case 4: enBasariliOgrenci();break;
196         case 5: sinifBasariOrtalamasi();break;
197         }
198     }
}
```

Next Week

- String Functions
- Sort and Search Algorithms

References

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Any Questions ?

Thanks for listening

CANER ÖZCAN
canerozcan@karabuk.edu.tr