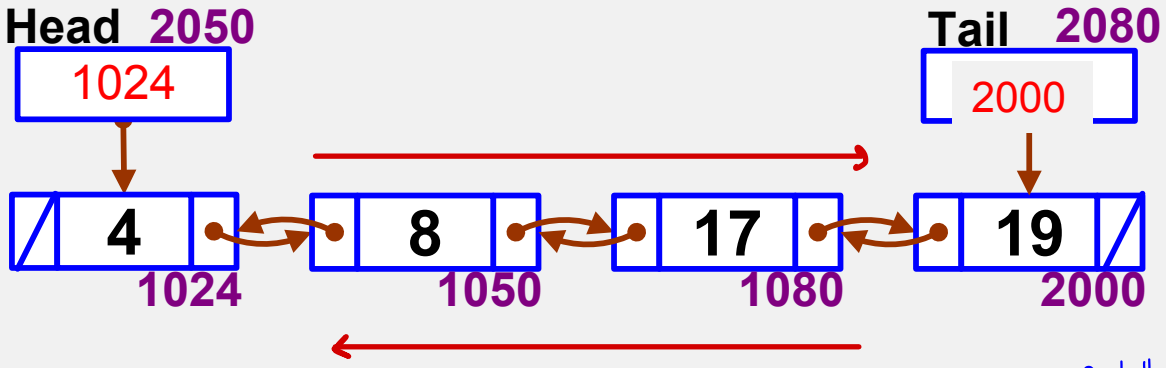
2.4 Doubly Linked Lists

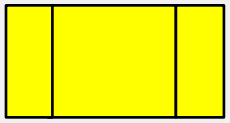
The link list that add extra field to the data structure, containing a pointer to the previous cell.




```
struct record
{    int data;
     struct record *next;
     struct record *prev;
};
```

ไป

กลับ



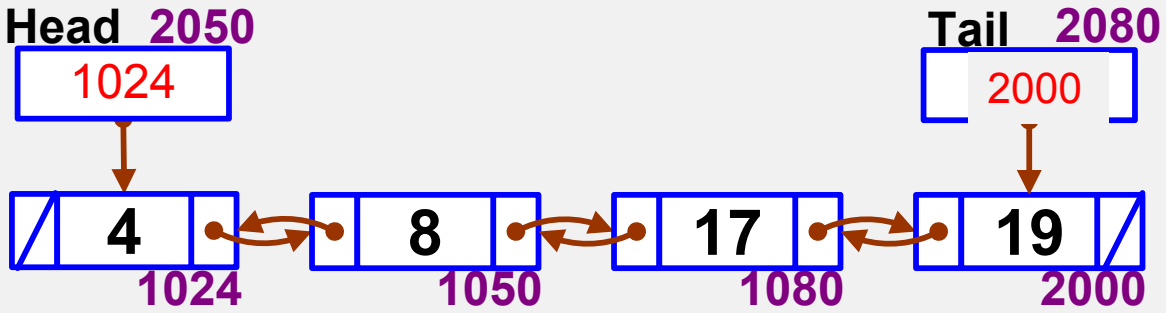
head → tail

tail → head

```
p = tail;
while (p != NULL) {
    cout << p -> value;
    p = p -> prev;
}
```

2.4.1 Insertion (Doubly Linklist)

1. Insert while no data in list
2. Insert first
3. Insert last
4. Insert middle



โครงโปรแกรมในการ insert

```
if(ยังไม่มีข้อมูล ?)
{     ....
}
else
 {    สร้าง node เตรียมไว้
      if ( insert ด้านหน้า ? )
      {
            ......
      }  else if( insert ด้านหลัง ? )
                {
                        ....
                }
                 else   //ตรงกลาง
                {   หาตำแหน่ง
                        ............
                }
}
```

```
if(head==NULL)
{     ....
}
else
{     สร้าง node เตรียมไว้
      if( data ....  head->value?)
      {
            ......
       }  else if(                          )
                {
                        ....
                }
                 else
                {   หาตำแหน่ง
                        ............
                }
}
```

```
                    .....
struct record
{       int value;
        struct record *prev;
        struct record *next;
};
struct record *tail=NULL;

struct record *insert(struct record *head,int data)
{       if(head==NULL)
        {       head=new struct record;
                head->value=data;
                head->next=head->prev=NULL;
                tail=head;
        }
        return head;
}
```

```
int main()
{           struct record *head=NULL;

            head=insert(head,8);
            cout << head->value<< endl;
            cout << tail->value<< endl;
}
```

1. Insert while no data in list

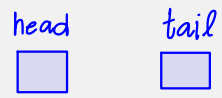
8

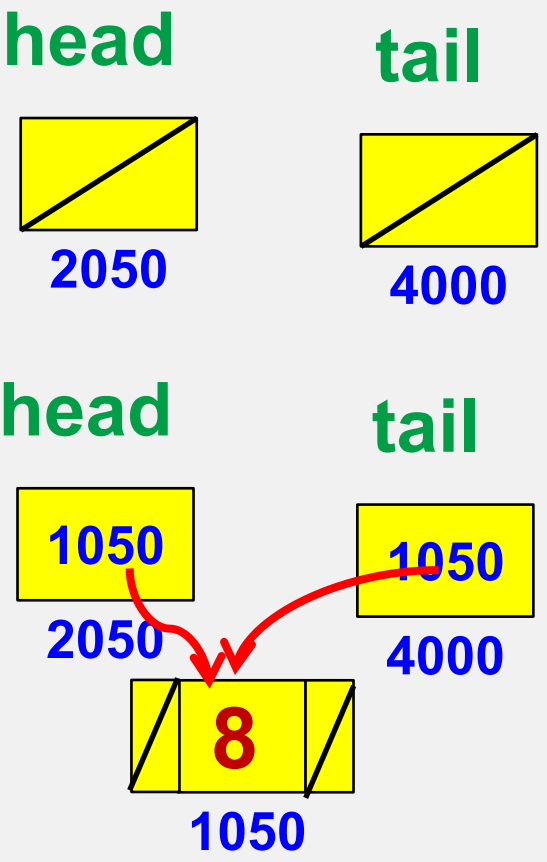
struct record *insert(struct record *head, int data)

.... ประกาศตัวแปรเอง...

```
1. if( head == NULL)
2. {     head=new struct rec;
3.       head->value= data;
4.       head->next=NULL;
5.       head->prev=NULL;
6.      tail=head;
7.  }
8.  return head;
```

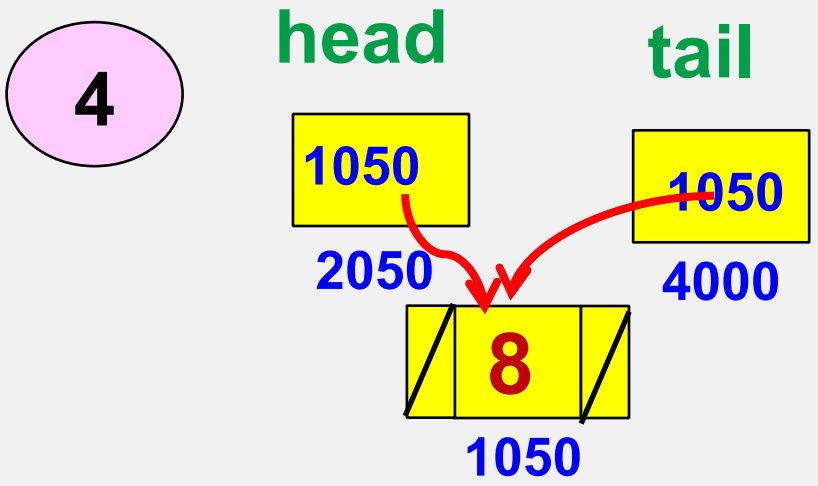
head tail





2. มีข้อมูลแล้วจะ Insert first

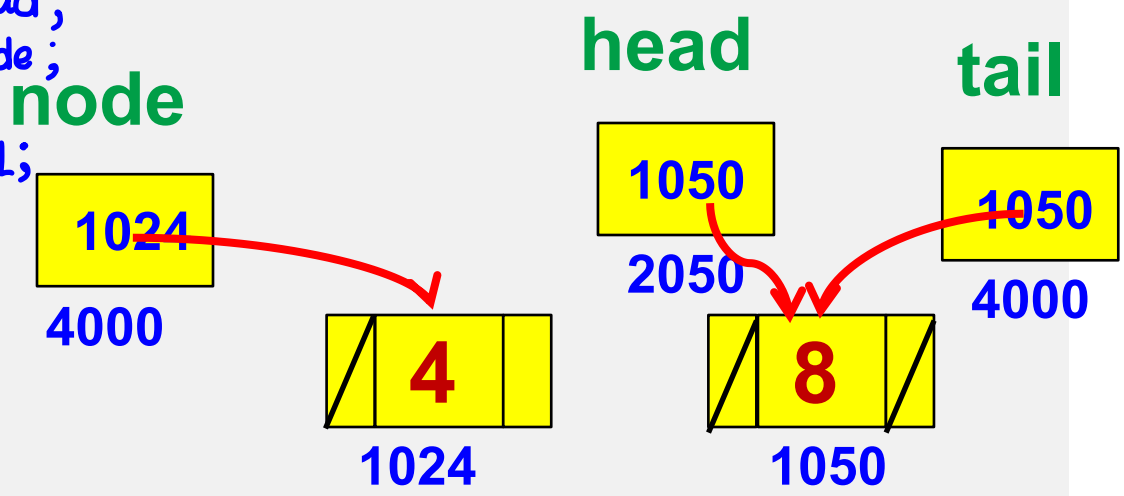
```
struct record *insert(struct record *head, int data)
.... ประกาศตัวแปรเอง...
1. if( head == NULL)
2. {     head=new struct rec;
3.       head->value= data;
4.       head->next=NULL;
5.       head->prev=NULL;
6.      tail=head;
7.  }
```



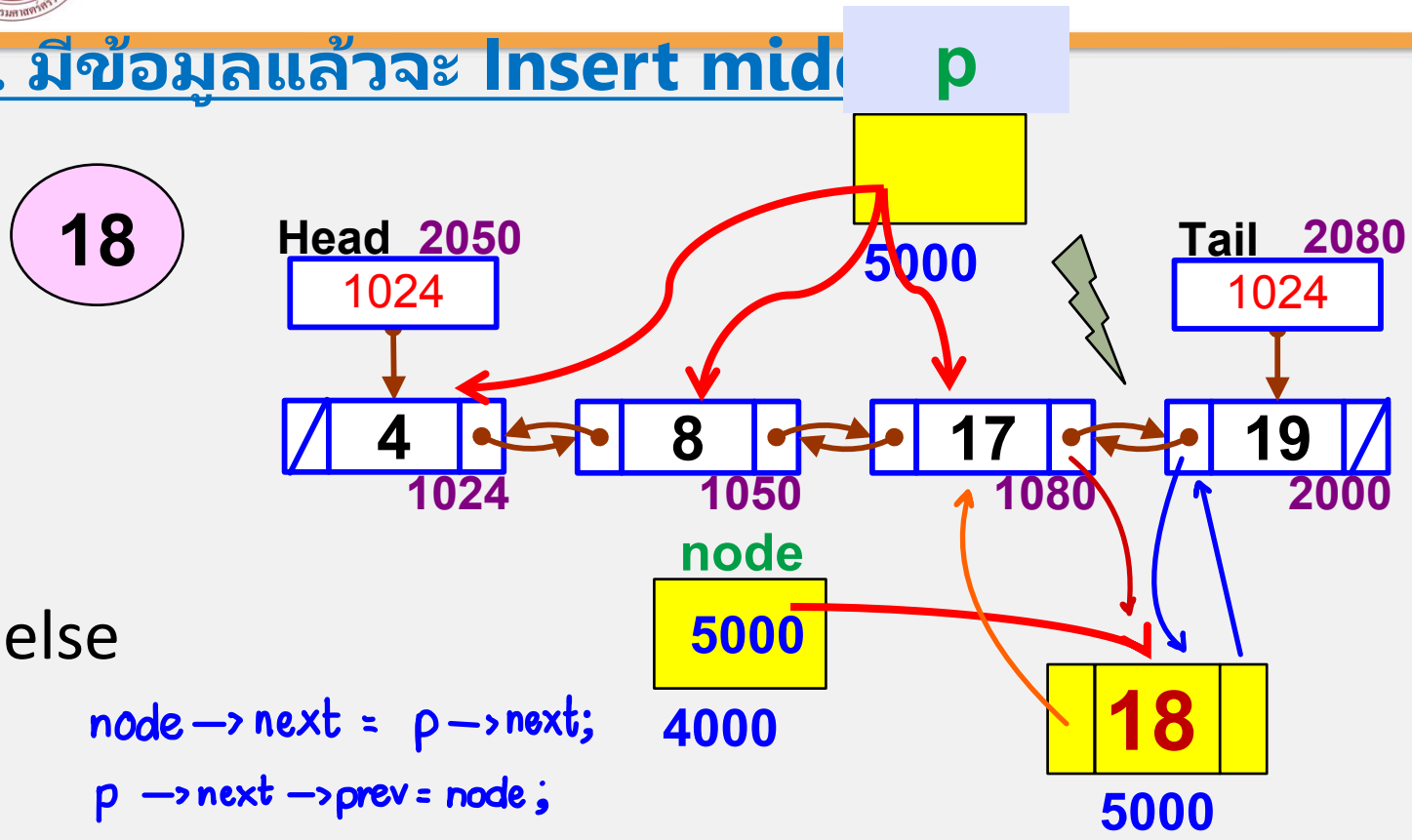
2. มีข้อมูลแล้วจะ Insert first

```
8. else
                = new struct record ;
9. {    node = สร้าง node เก็บข้อมูลใหม่
10.     if (data <= temp->value )
        {
            node -> next = head ;
            head -> prev = node ;
            node -> prev = NULL;
            head = node ;
```

4



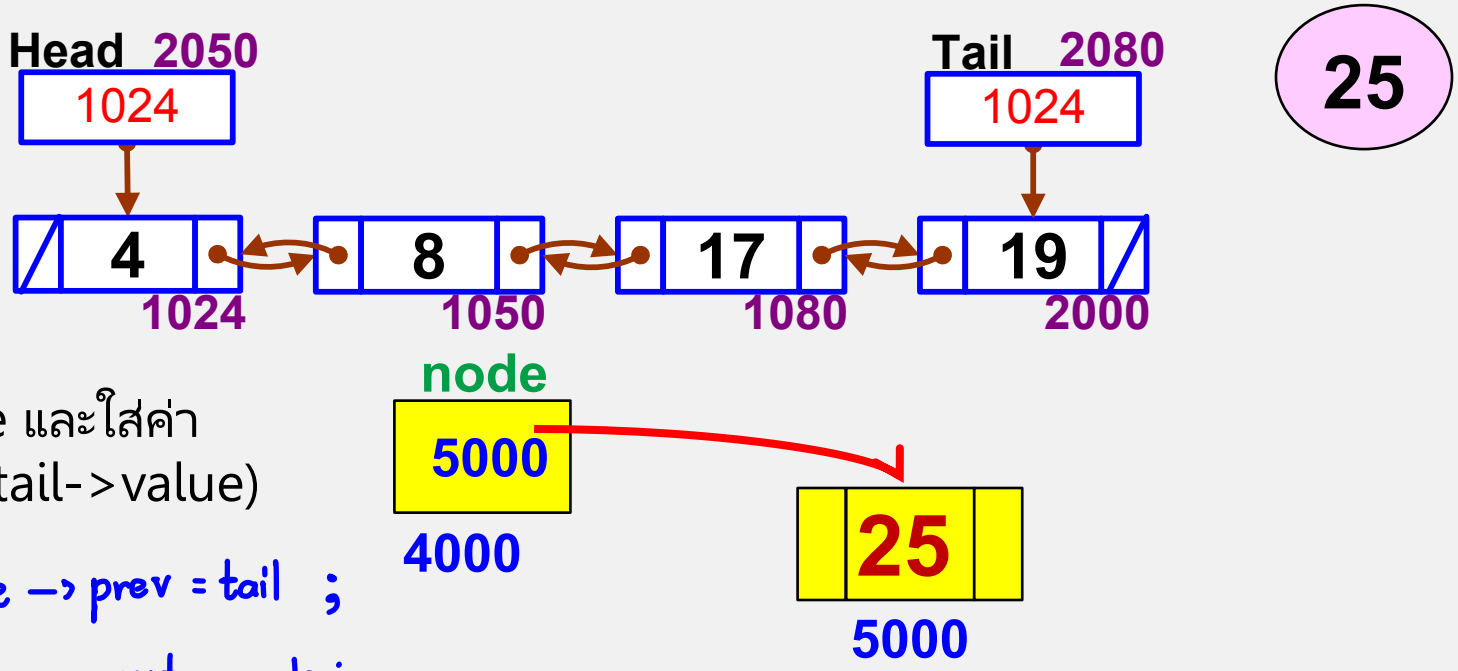
3. มีข้อมูลแล้วจะ Insert mid



else

```
node -> next = p -> next;
p -> next -> prev = node;
p -> next = node;
node -> prev = p;
```

4. มีข้อมูลแล้วจะ Insert last

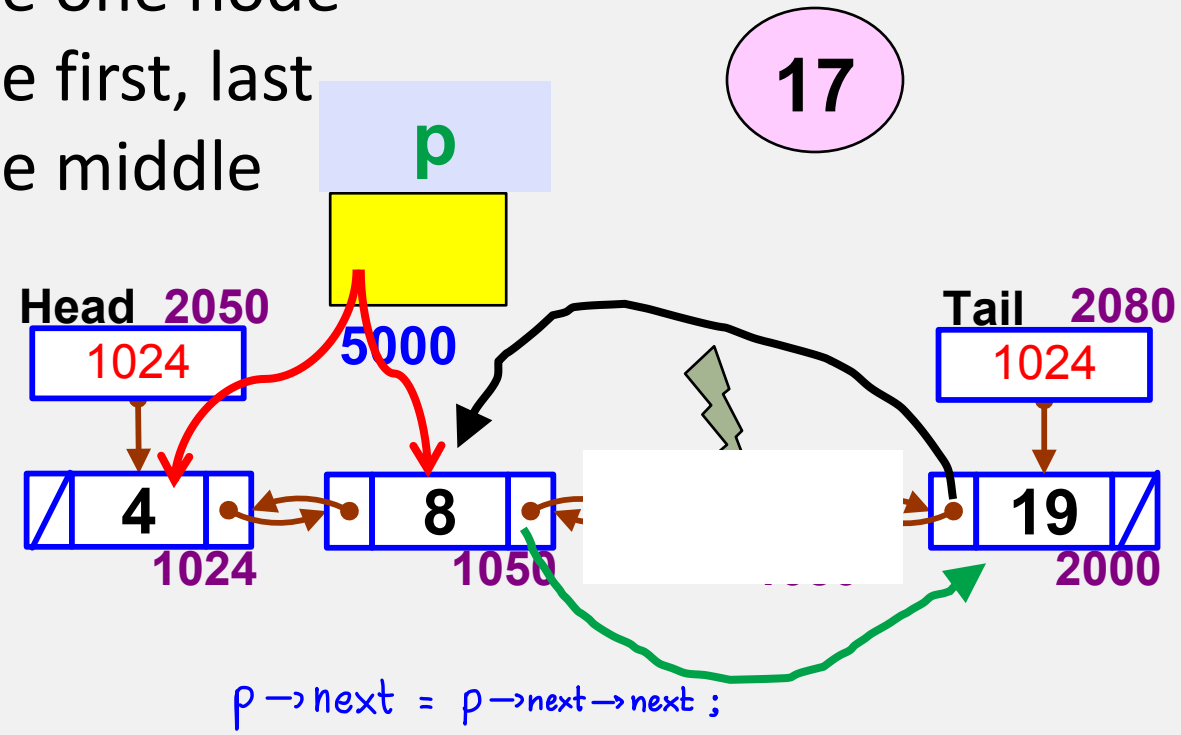


สร้าง node และใส่ค่า
if(data > tail->value)

```
node -> prev = tail ;
tail -> next = node ;
node -> next = NULL;
tail = node ;
```

2.4.2 Delete (Doubly Linklist)

1. Delete while no data in list
2. Delete one node
3. Delete first, last
4. Delete middle



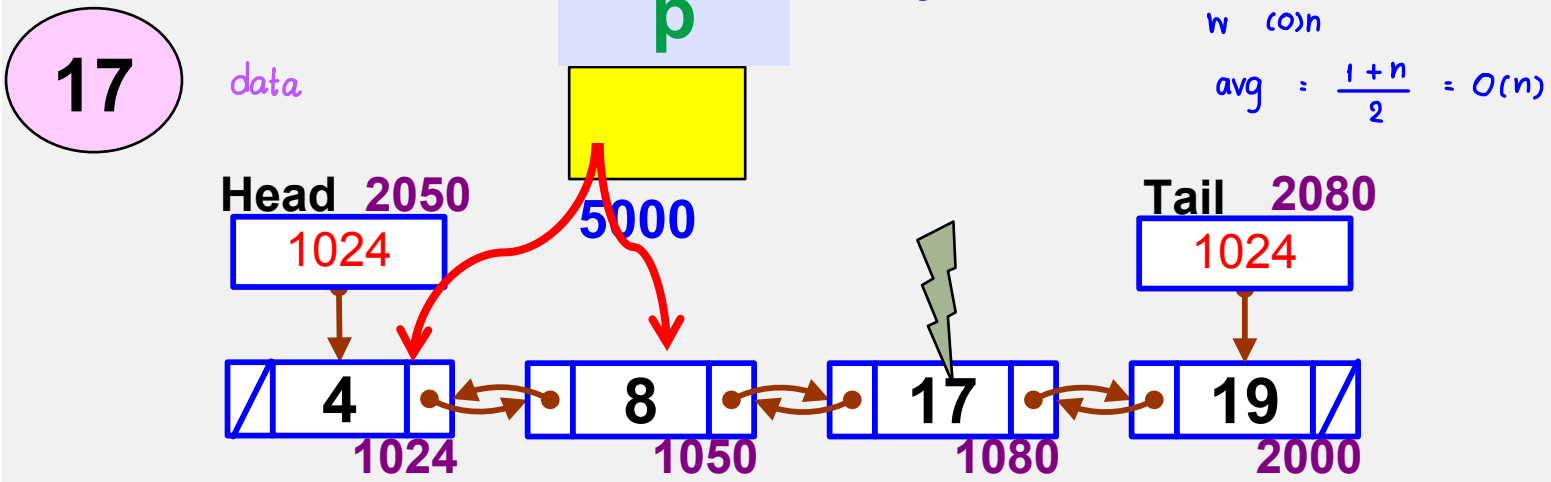
โครงโปรแกรมในการ delete

```
if(มี node เดียว ?)
{    ....
}
else
 {   if ( ลบโหนดแรก ? )
     {
          ......
     }  else if(ลบโหนดท้าย? )
              {
                    ....
              }
               else   //ตรงกลาง
              {  หาตำแหน่ง
                    ............
              }
}
```

```
tmp = head;
head = NULL;
tail = NULL;
delete (tmp);
```

```
tmp = head;
head = head->next;
head->prev = NULL;
delete (tmp);
```

4. Delete middle



big O(n)

b 1

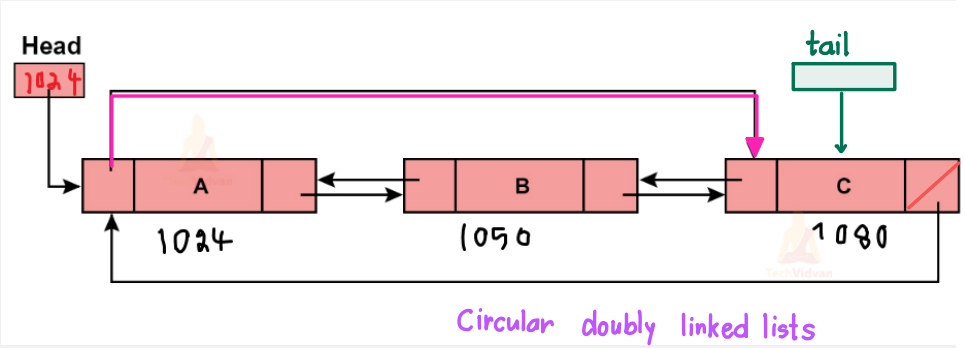
w O(n)

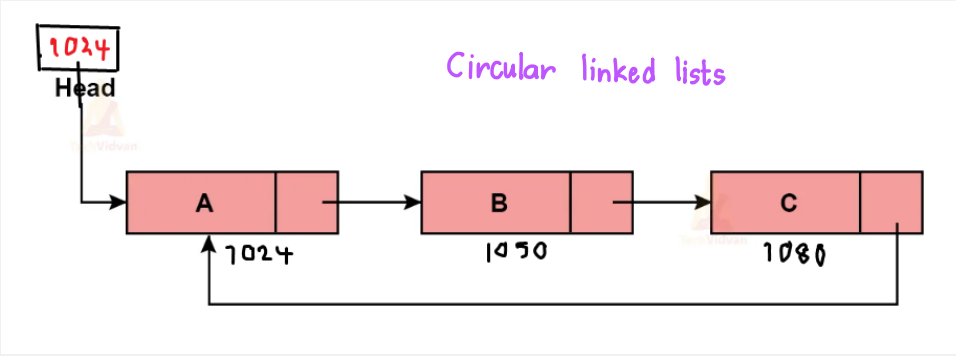
avg : $\frac{1+n}{2}$ = O(n)

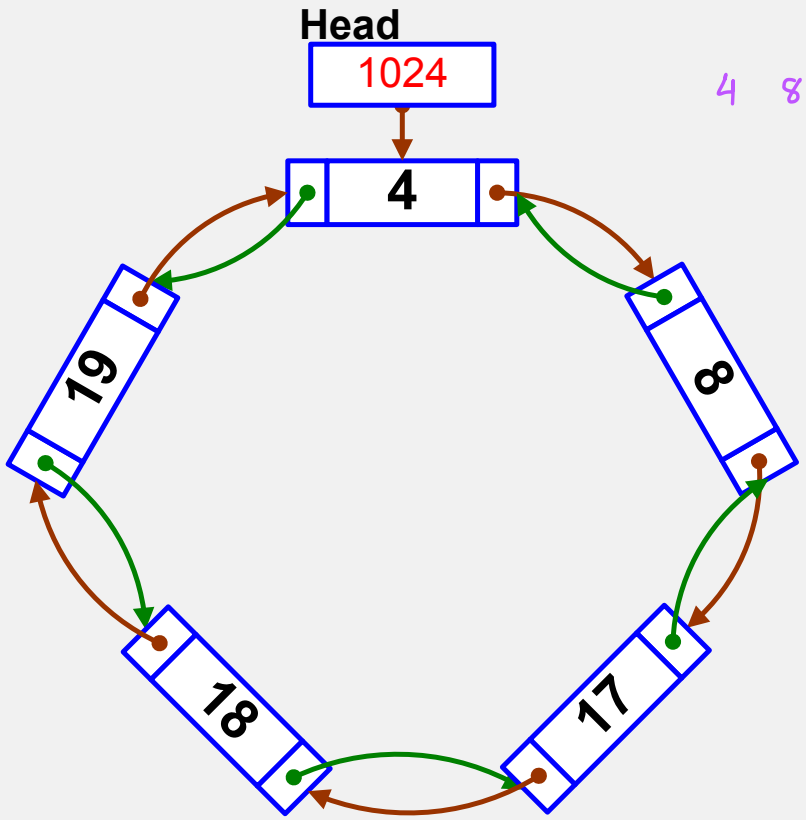
```
p = head;

while ( p != NULL)

{ if (p -> next -> value == data)
    {   tmp  =  p -> next;
        p -> next -> prev  = p ;
        p -> next  = p -> next -> next
        delete (tmp);
  else
      p = p -> next;
}
```

2.5 Circularly doubly linked lists

A popular convention is to have the last cell keep pointer back to the first. This can be done with or without a header (If the header present, the last cell point to it.)







4 8 17 18 19

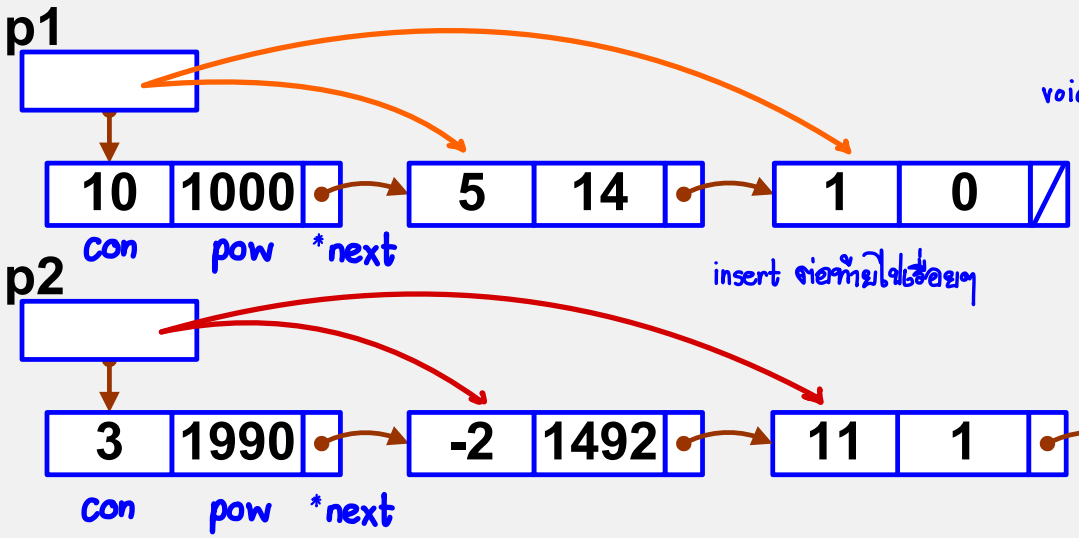
```
p = head;
while ( p != head)
{
```

2.6 Examples

2.6.1 The polynomial ADT

p1(x) = 10x^1000 + 5x^14 + 1

p2(x) = 3x^1990 - 2x^1492 + 11x + 5




```
p->next = node;
p = node;
```

$9x^{100} + 4x^{9} + 3x^{2}$

$8x^{100} + 5x^{11} + 2x^{3} + 9x^{2}$

insert อย่างไปใช่ย่อยๆ

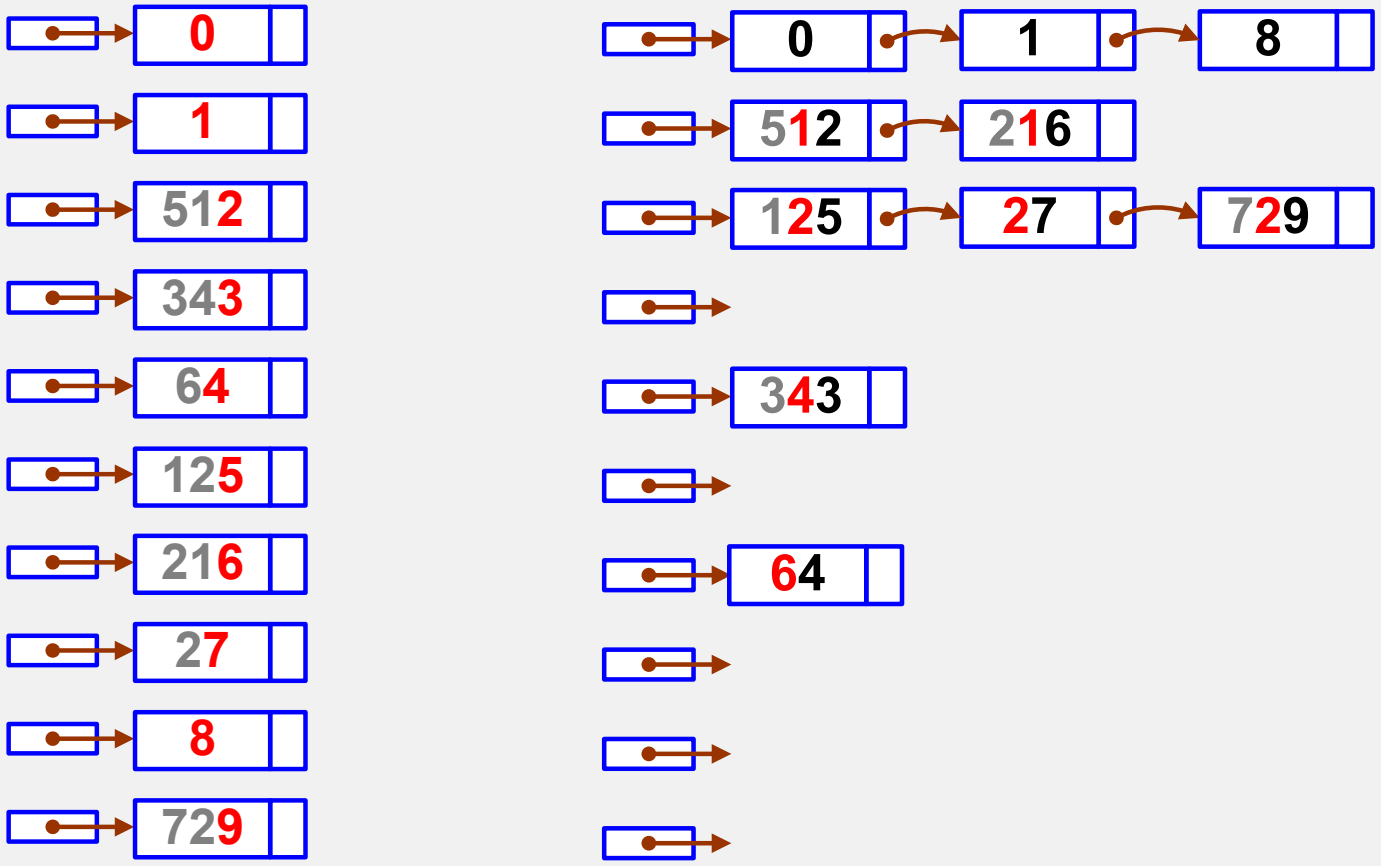
```
void comepare ( struct record *h1 , struct record *h2)
    struct record *p1= h1, *p2 = h2 ;
    if ( p1->value ==p2-> value)
    {   cout << p1->value;
        p1 = p1-> next;
        p2 = p2->next,
    } else {
        if ( p1->value > p2 -> value)
            cout << p1->value ;
            p1 = p1-> next ;
        else
            cout << p2-> value ;
            p2 = p2 -> next;
```

$3x^{1990} + -2x^{1492} + 10x^{1000} + 5x^{14} + \ldots$

2.6.2 Radix Sort

O(n) เร็วที่สุด

Input 64, 8, 216, 512, 27, 729, 0, 1, 343, 125



2.6.3 Multilists

ไม่ค่อยดี

array สี่คน x สี่คน