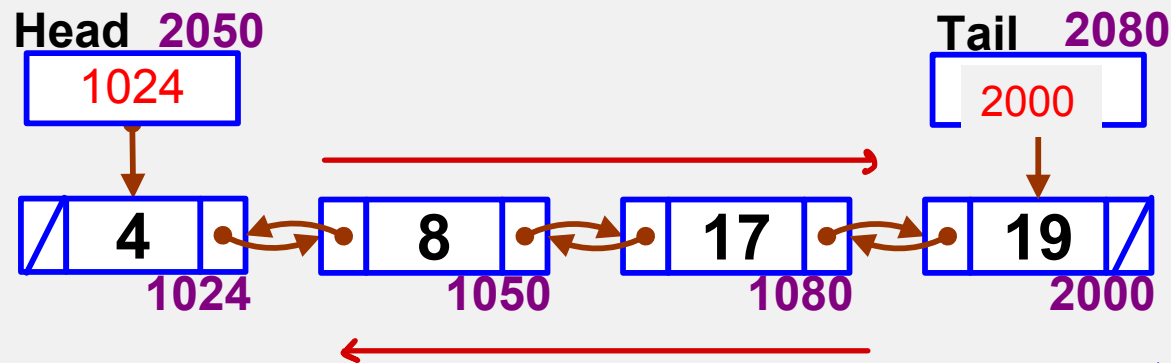


2.4 Doubly Linked Lists

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

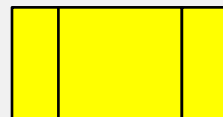


struct record

```
{ int data;
```

```
  struct record *next;
  struct record *prev;
```

```
};
```



head → tail

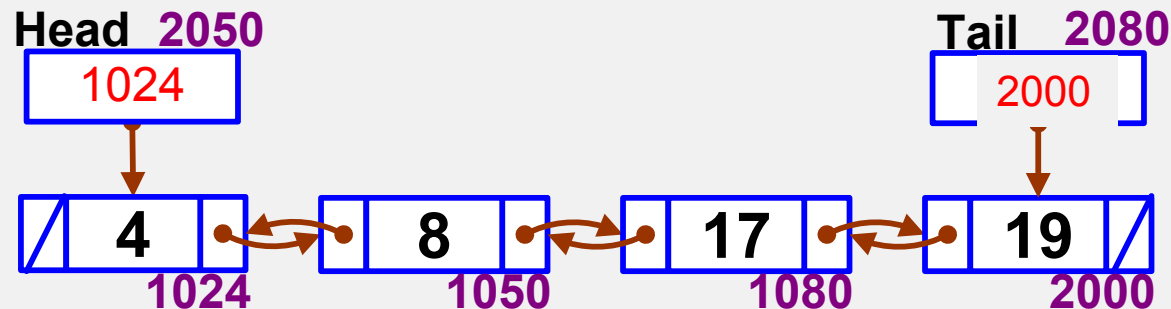
tail → head

```
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;
}
```



03603212 : Module2–List, stack, Queue 5

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

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





8

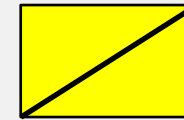
1. Insert while no data in list

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

.... ประกาศตัวแปรเอง...

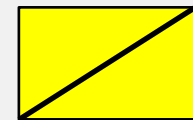
1. if(head == NULL)
2. { head=new struct rec;
3. head->value= data;
4. head->next=NULL;
5. head->prev=NULL;
6. tail=head; head
 tail

7. }
8. return head;

head



2050

tail



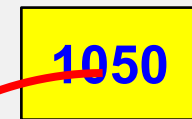
4000

head



2050

tail



4000



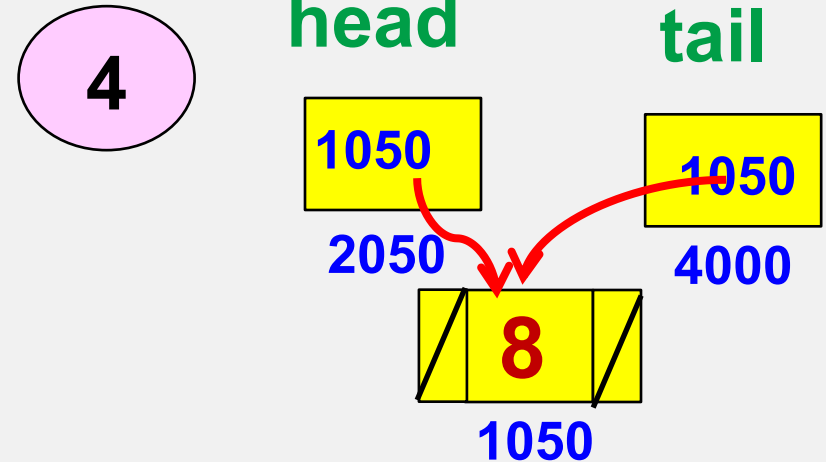
1050

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 ;

node

1024
4000



head

1050
2050



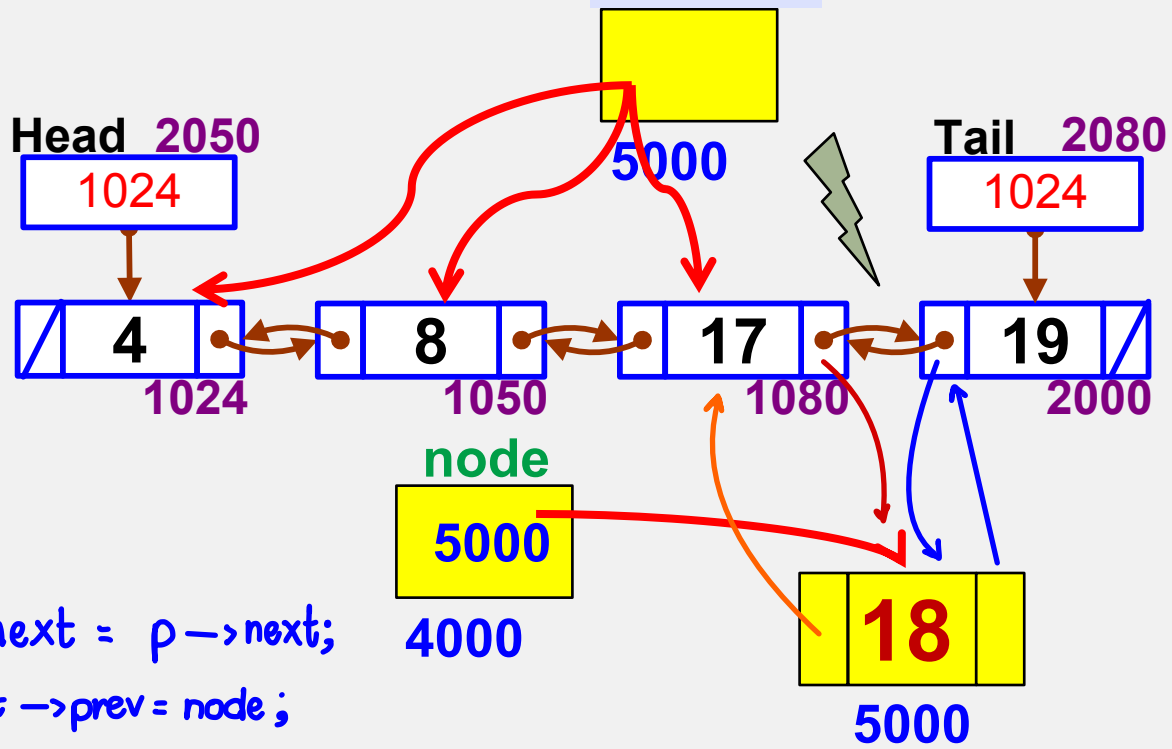
tail

1050
4000

3. มีข้อมูลแล้วจะ Insert mid

p

18

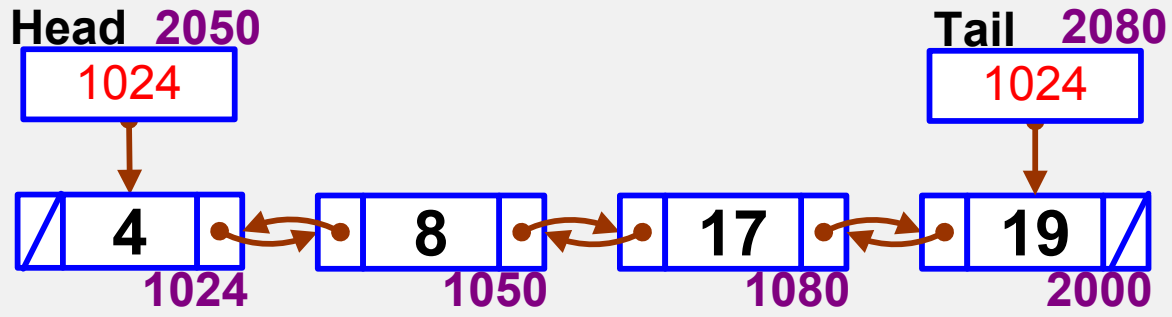


```

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

```

4. มีข้อมูลแล้วจะ Insert last



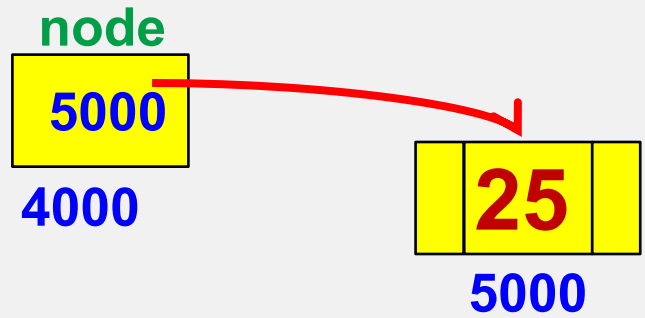
25

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

```

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

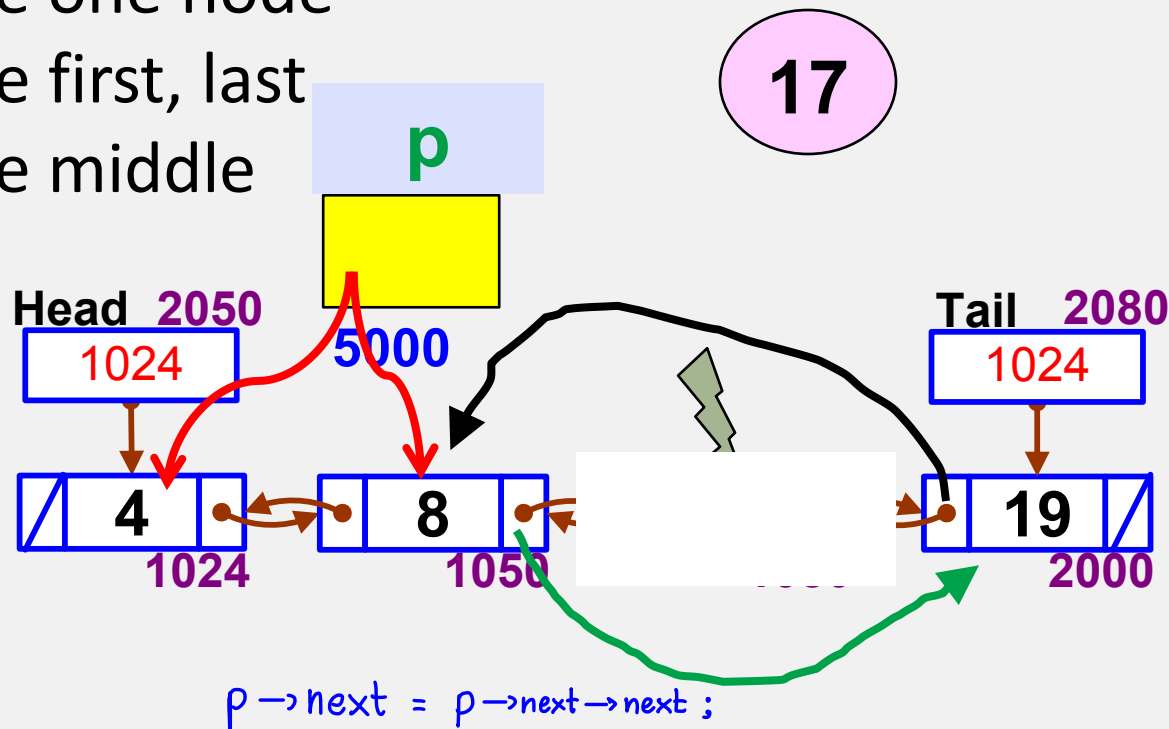
```





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
    {
        หาดำแหน่ง
        .....
    }
}
```

```
tmp = head;
```

```
head = NULL;
```

```
tail = NULL;
```

```
delete (tmp);
```

```
tmp = head;
```

```
head = head->next;
```

```
head->prev = NULL;
```

```
delete (tmp);
```



4. Delete middle

17

data

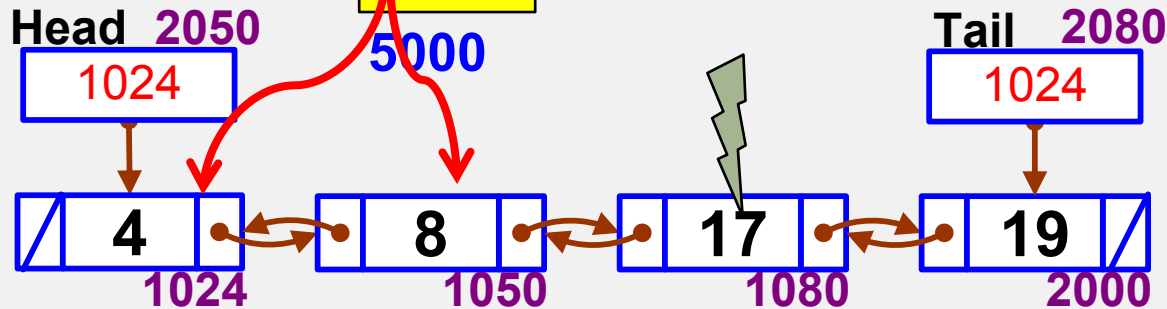
p

big $O(n)$

b 1

w $O(n)$

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



$p = \text{head};$

$\text{while } (p \neq \text{NULL})$

{ if $(p \rightarrow \text{next} \rightarrow \text{value} == \text{data})$

{ tmp = $p \rightarrow \text{next};$
 $p \rightarrow \text{next} \rightarrow \text{prev} = p;$

$p \rightarrow \text{next} = p \rightarrow \text{next} \rightarrow \text{next};$
delete (tmp);

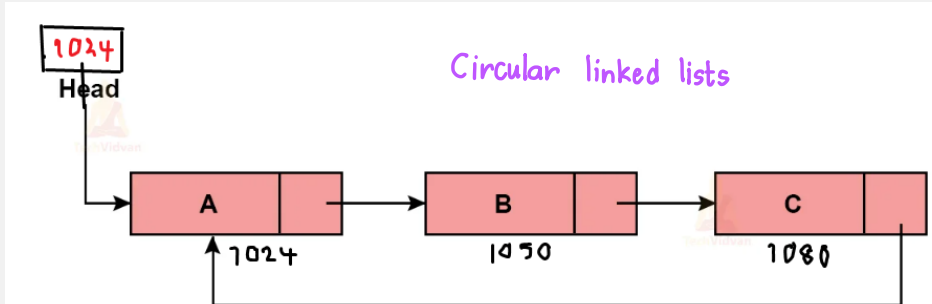
else

$p = p \rightarrow \text{next};$

}

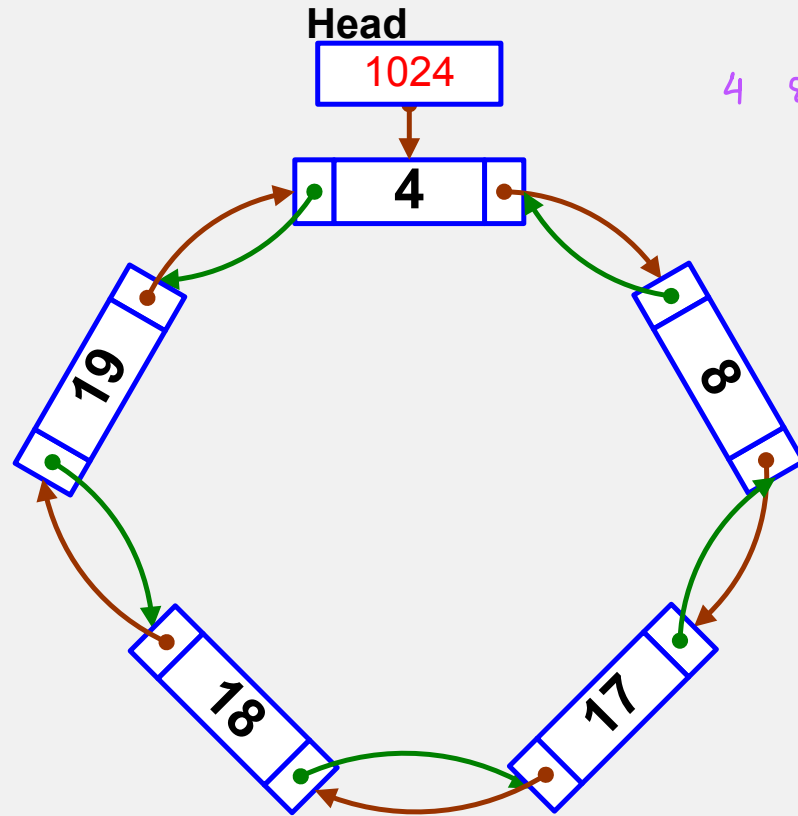


A popular convention is to have the last cell keep pointer back to the first. This can be done with or without a header (If the header present, the last cell point to it.)





03603212 : Module2-List, stack, Queue 15



4 8 17 18 19

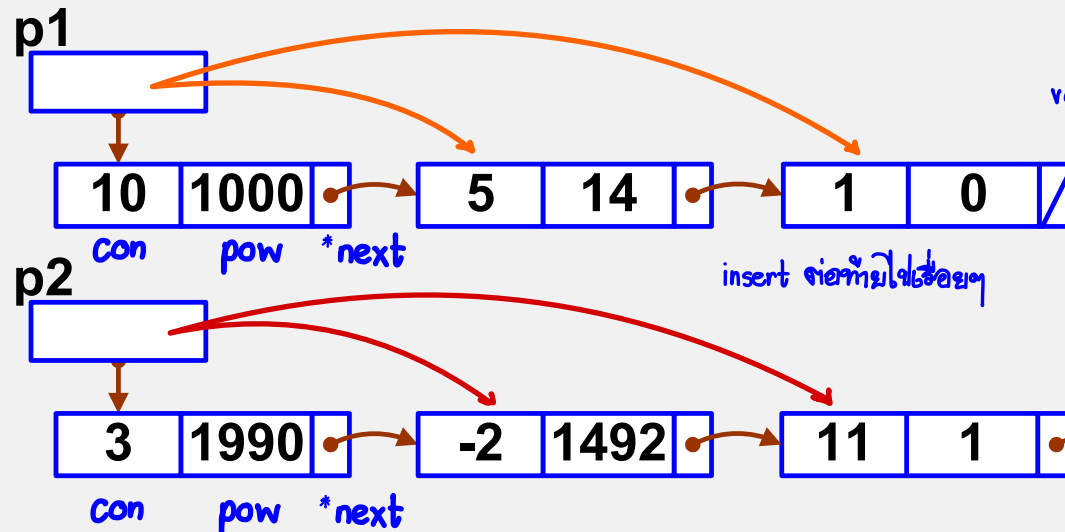
```
p = head;  
while (p != head)  
{
```

2.6 Examples

2.6.1 The polynomial ADT

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

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



$p \rightarrow next = node;$
 $p = node;$

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

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

```

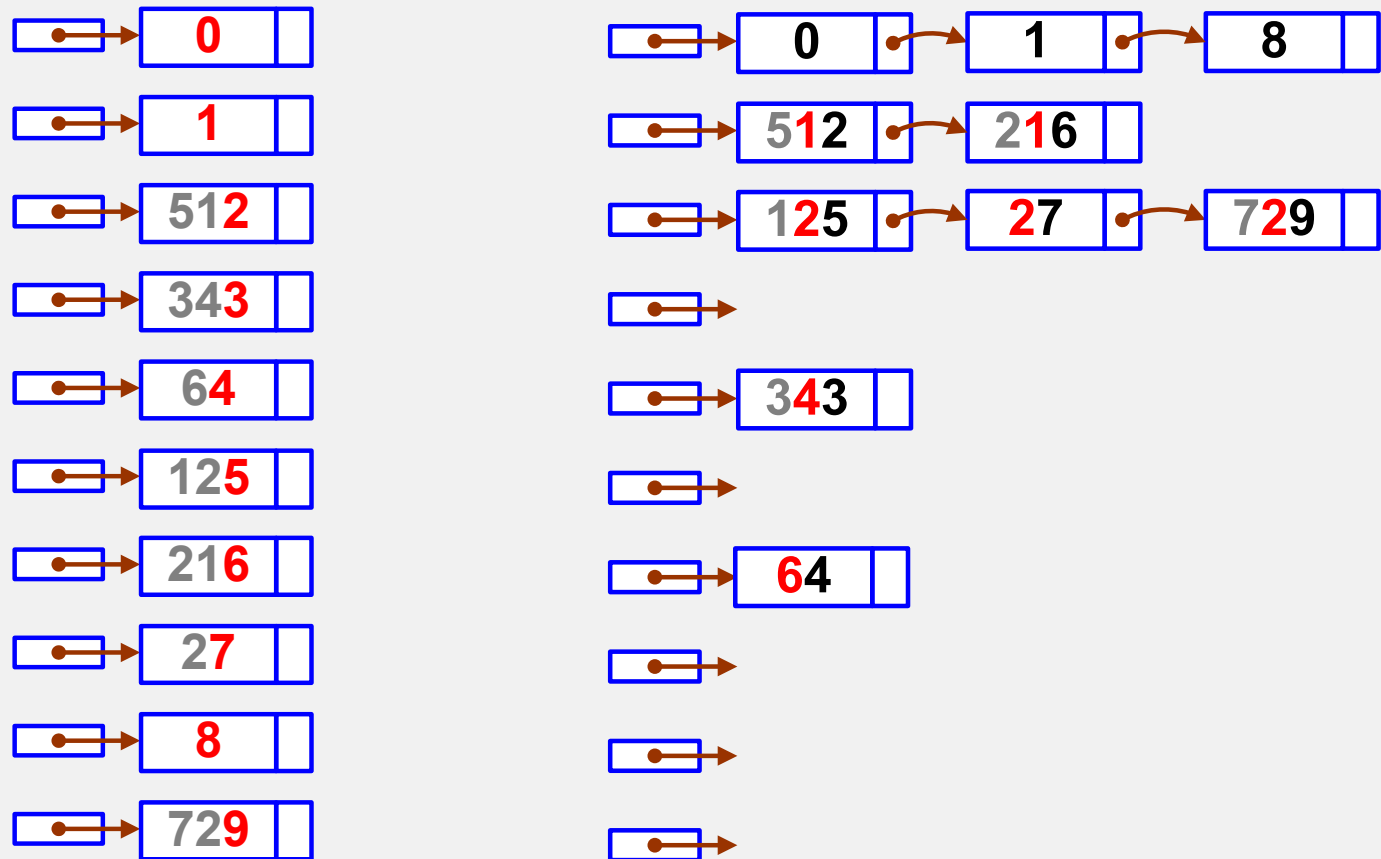
void compare (struct record *h1, struct record *h2)
{
    struct record *p1 = h1, *p2 = h2;
    if (p1->value == p2->value)
    {
        cout << p1->value;
        p1 = p1->next;
        p2 = p2->next;
    } else {
        if (p1->value > p2->value)
        {
            cout << p1->value;
        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

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

2.6.2 Radix Sort

$O(n)$ เรียงทีละค่า

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



2.6.3 Multilists

