Chapter 3

线性表数据类型

List, Stack, and Queue

- Introduce the concept of Abstract Data Types(ADTS).
- show how to efficiently perform operations on lists.
- Introduce the stack ADT and its use in implementing recursion.
- Introduce the queue ADT and its use in operating systems and algorithm design.

3.1 Abstract Data Types(ADTS)

1. ADT-----a set of objects together with a set of operaions.
   Abstract data types are mathematical abstractions;
   nowhere in an ADT's definition is there any mention of how the set of operations is implemented.

3.1 Abstract Data Types(ADTS)

2. data object---

a set of instances or values

for example:

Boolean={false,true}

Digit={0,1,2,3,4,5,6,7,8,9}

Letter={A,B,……Z,a,b,……z}

NaturalNumber={0,1,2,……}

Integer = {0, +1, -1, +2, -2, +3, -3, …}

String={a,b,……,aa, ab, ac,……}

3.1 Abstract Data Types(ADTS)

3. data structure

is a data object together with the relationships among the instances and among the individual elements that compose an instance

- Data_Structure={D,R}
- D---data object，
- R ---a set of relationships of all the data members in D.

3.2 The List ADT

线性表是逻辑结构
若用链表实现线性表，则 物理结构

逻辑结构影响功能
物理结构影响性能

e.g 语言选择影响性能
影响开发周期，维护成本
而实现的功能可以是一样的

$L = (e_1, e_2, e_3, \ldots, e_n)$

list size is n

if n=0:empty list

if n(finite)>0:

e_1 is the first element

e_n is the last element

e_i precedes e_{i+1}

3.2 The List ADT

Example:

Students =(Jack, Jill, Abe, Henry, Mary, …, Judy)

Exams =(exam1, exam2, exam3)

Days of Week = (S, M, T, W, Th, F, Sa)

Months = (Jan, Feb, Mar, Apr, …, Nov, Dec)

3.2 The List ADT

Operations:

Create a linear list

determine whether the list is empty

determine the length of the list

find the kth of the element

search for a given element

delete the kth element

insert a new element just after the kth

3.2 The List ADT

ADT specification of a linear list

AbstractDateType LinearList

{ instances

ordered finite collections of zero or more elements

operations

Create();	Destroy();
IsEmpty();	Length();
Find(k,x);	Search(x);
Delete(k,x);	Insert(k,x);
Output(out);	

}

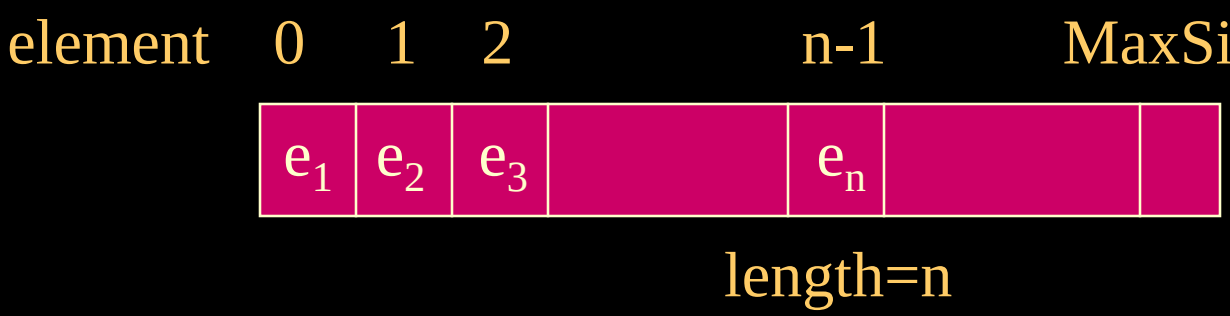
从k这个下标开始

3.2.1. Simple Array Implementation of Lists

数组

1. Use an array to represent the instance of an object

   $(e_1, e_2, \ldots\ldots e_n)$



each position of the array is called a cell or a node

mapping formula: location(i)=i-1 O(1)

已知位置求数据

3.2.1. Simple Array Implementation of Lists

- Search(x)　　O(length)

$L = (a,b,d,b,e)$

Search$(d) = 3$

Search$(a) = 1$

Search$(z) = 0$

线性表下标从1开始

没有是0

Average Compare Number

ACN=(1+2+……+n)/n

=(1+n)*n/(2n)=(n+1)/2

3.2.1. Simple Array Implementation of Lists

- remove(k,x)

  delete the k'th element and return it in x

  L = (a,b,c,d,e)

  delete(2,x) =>

  L=(a,c,d,e), x=b,

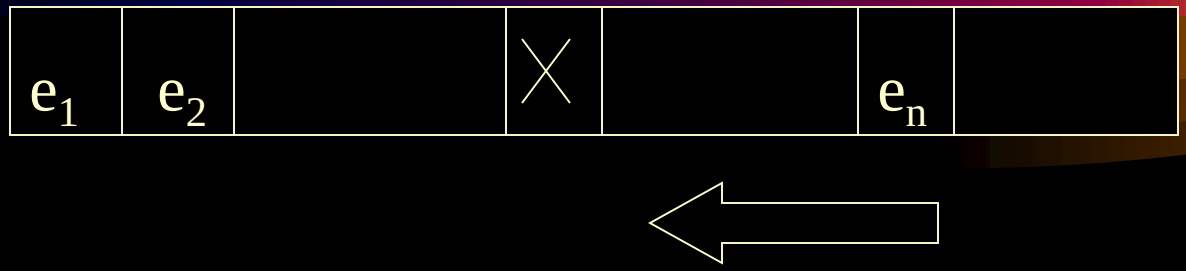
  and index of *c,d,e* decrease by *1*

  delete(0) => error

  delete(20) => error

  O(n)

3.2.1. Simple Array Implementation of Lists



$$AMN=\sum_{i=0}^{n-1}(n-i-1)/n=(n-1+n-2+\ldots\ldots+1+0)/n=(n-1)/2$$

$\Rightarrow O(n)$

Average Moving Number

$\frac{(0+n-1)n}{2}\cdot\frac{1}{n}$

3.2.1. Simple Array Implementation of Lists

- insert (x , i)

insert x after the i'th element

L = (a,b,c,d,e,f,g)

insert(0,h) =>

L = (h,a,b,c,d,e,f,g)

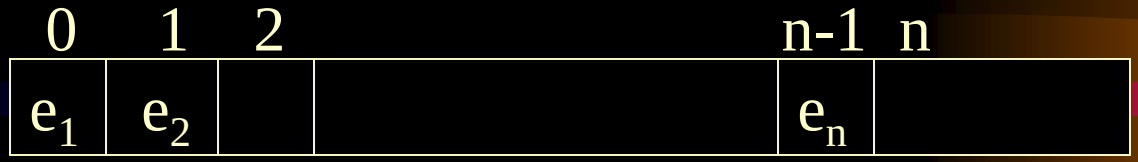
index of *a,b,c,d,e,f,* and *g* increase by *1*

insert(10,h) => error

insert(-6,h) => error

O(n)

3.2.1. Simple Array Implementation of Lists



$$AMN=\sum_{i=0}^{n}(n-i)/(n+1)=(n+n-1+.....+1+0)/(n+1)=n/2$$

$O(n)$

$$\frac{(0+n)n+1}{2}\cdot\frac{1}{n+1}$$

个

情况数变了哈

3.2.1. Simple Array Implementation of Lists

2. Use array Implementation 总结

   merit : easy Search.

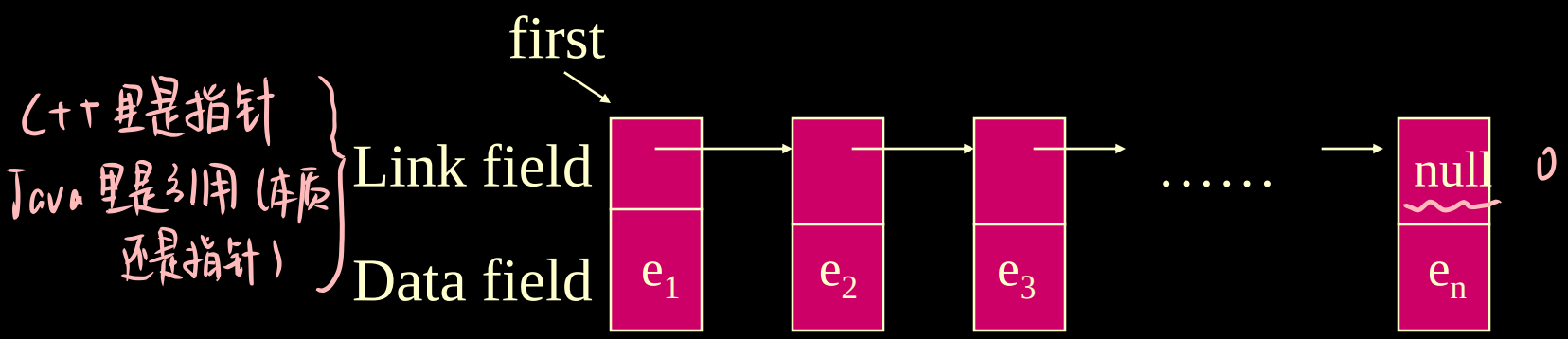
   short coming : Insertion and Removing(Deletion) spend a lot of time.

3.2.2. Linked Lists

In order to avoid the linear cost of insertion and deletion.

1) Each node of a data object keeps a link or a pointer about the location of other relevant nodes

$L=(e_1,e_2,\ldots\ldots\ldots e_n)$



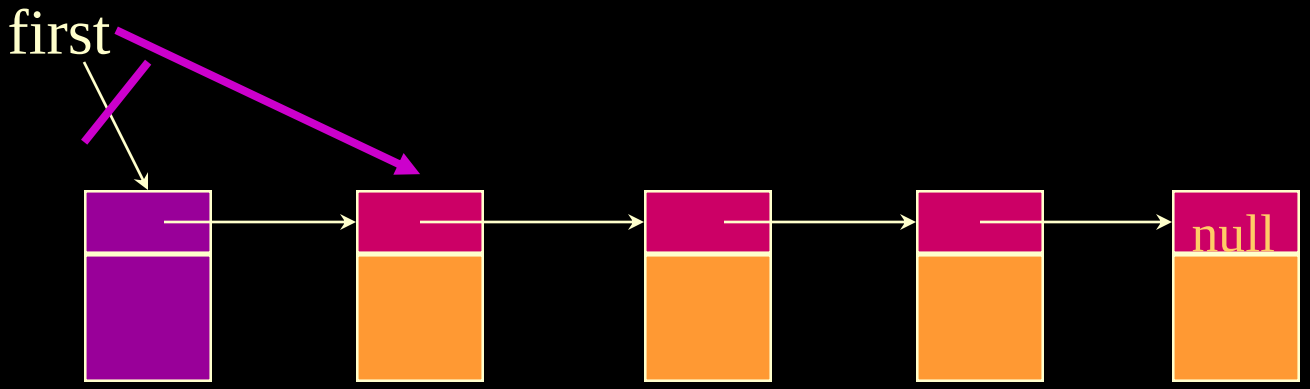
3.2.2. Linked Lists

- The figure above is called a single linked list,and the structure is also called a chain
- A chain is a linked list in which each node represents one element.
- There is a link or pointer from one element to the next.
- The last node has a null pointer.

3.2.2. Linked Lists

- Deletion a element of a chain

  Delete(1,x)



Java

first = first.link;

不需要回收内存.

first是个引用

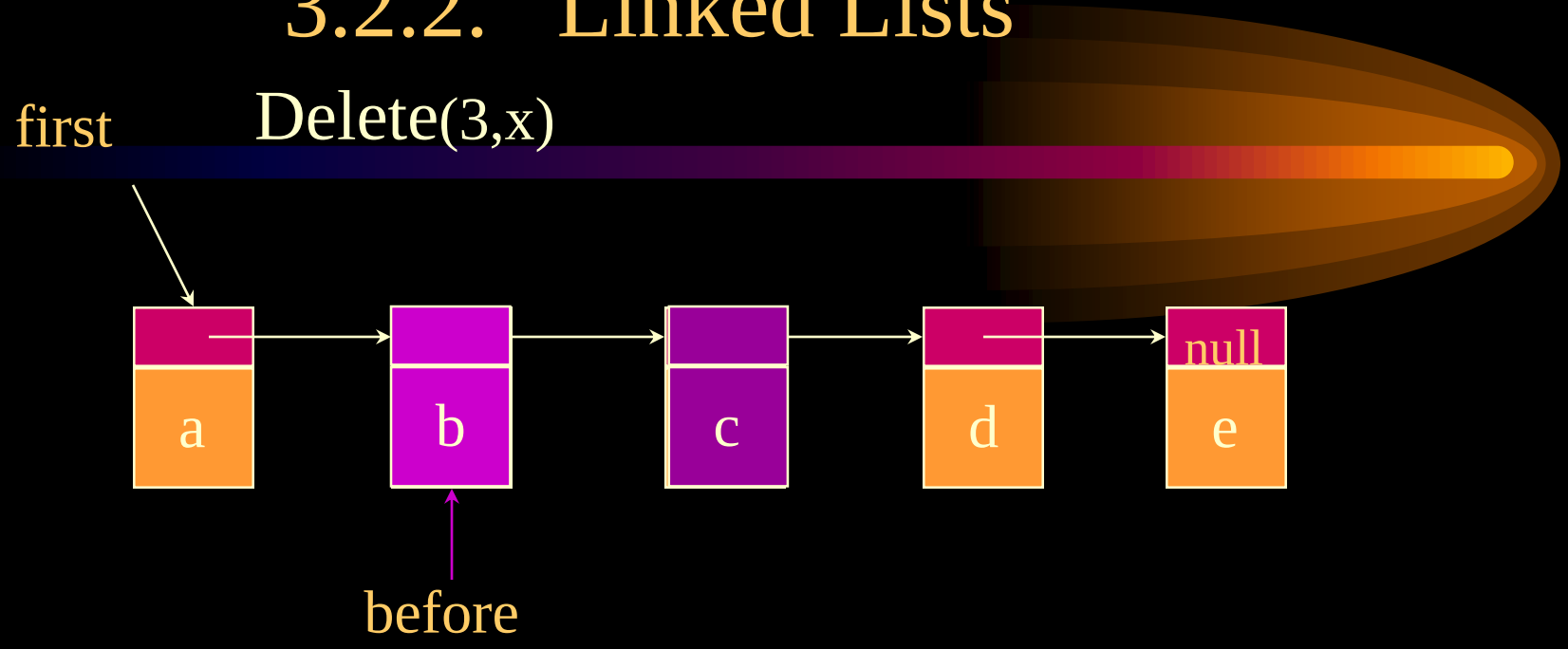
C++

Link * temp = first

first = temp -> next (Link)

free (temp)

3.2.2. Linked Lists

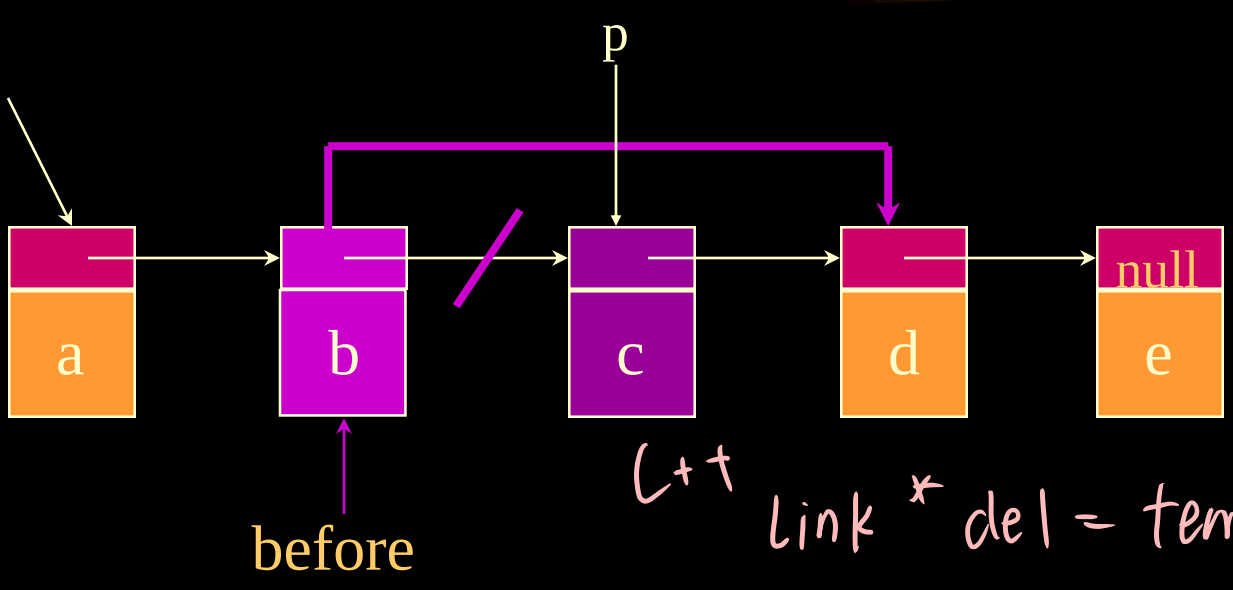


first get to node just before node to be removed

before= first .link;

3.2.2. Linked Lists

now change pointer in before



Java

before .link = before .link .link;

C++

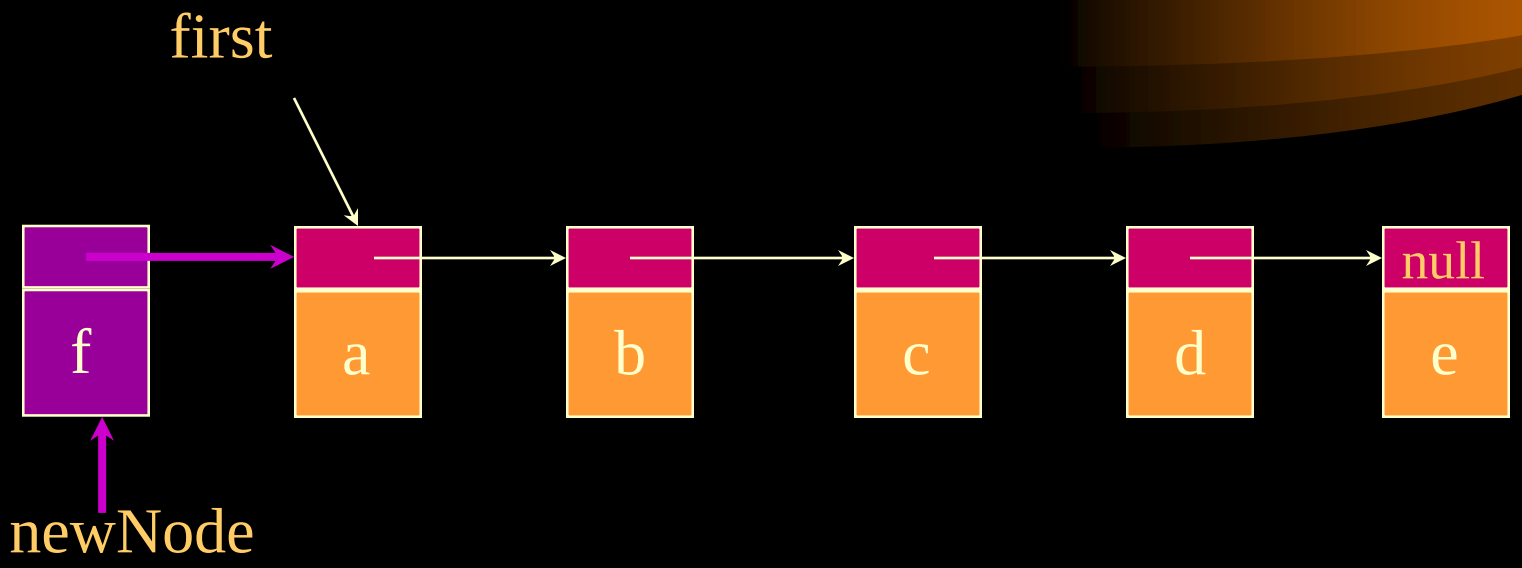
link * del = temp -> link

before -> link = before -> link
-> link

free (del)

3.2.2. Linked Lists

- insert operation ----insert(0,'f')

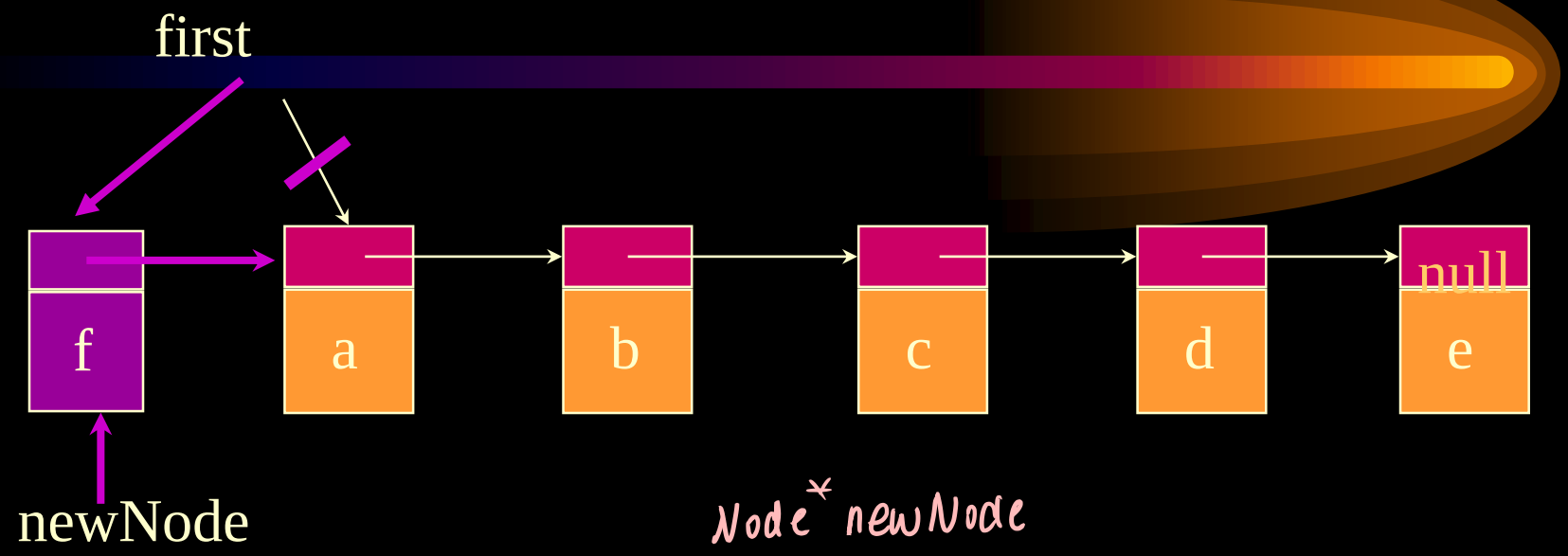


Step 1: get a node, set its data and link fields

Java

```
ChainNode newNode =
        new ChainNode('f', first);
```

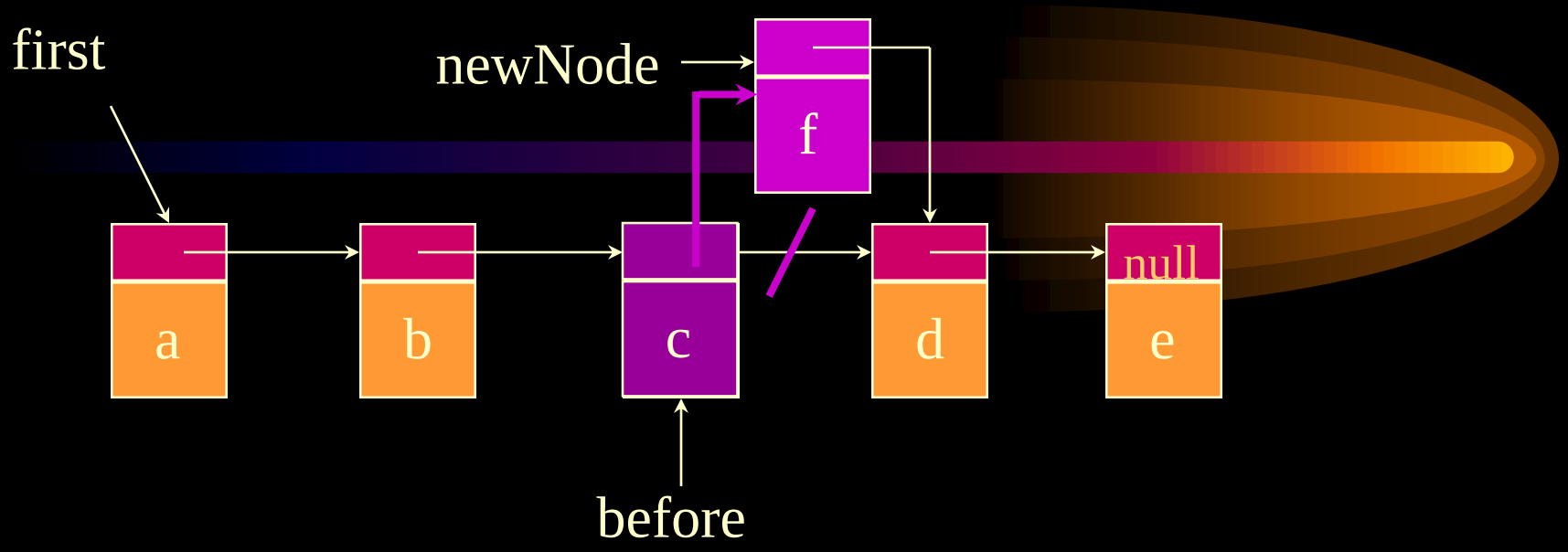
3.2.2. Linked Lists



Step 2: update first

```
first = newNode;
```

insert(3,'f')



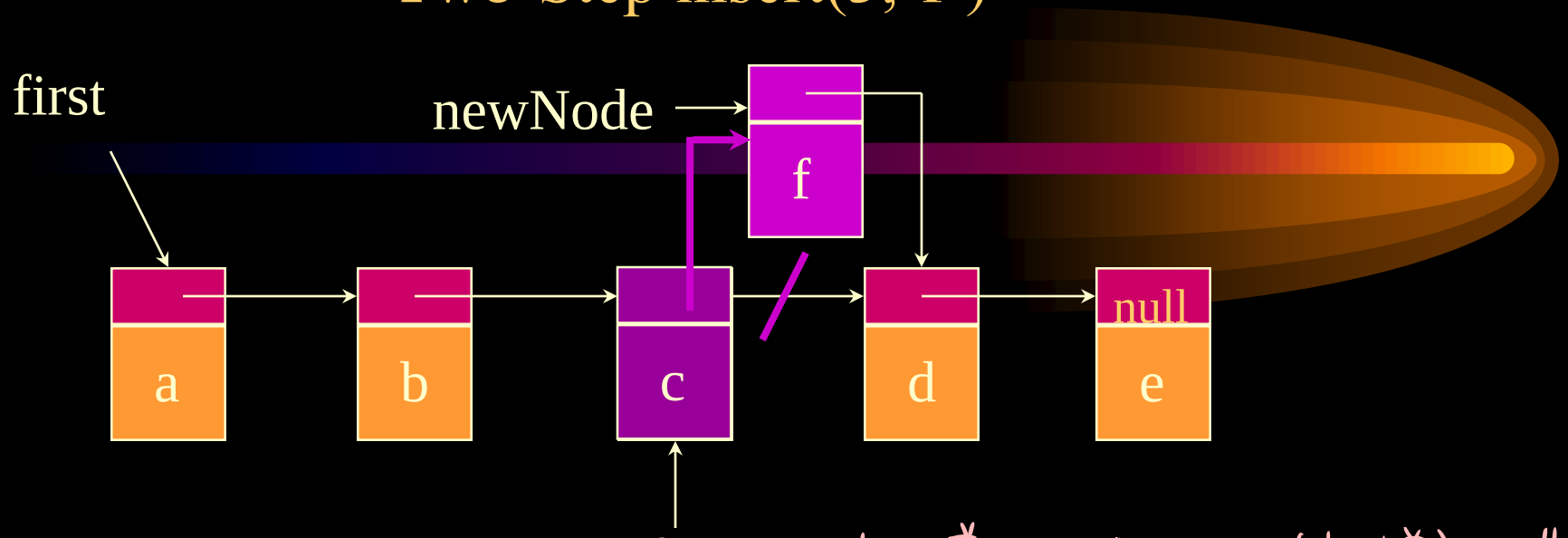
1. first find node whose index is 3
2. next create a node and set its data and link fields

① ChainNode newNode = new ChainNode('f',before .link);

3.finally link before to newNode

② before .link = newNode;

Two-Step insert(3,'f')




```
before = first .link .link;
newNode .link = before .link;
before .link = newNode;
```

```
Link* newNode = (Link*) malloc
    (sizeof(link));
newNode -> elem = 'f';
newNode -> next = before -> next;
before -> next = newNode;
```

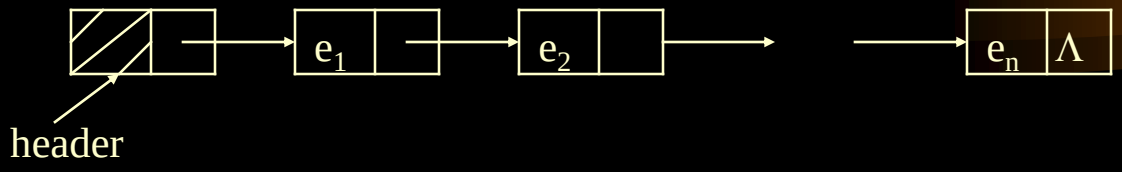
3.2.3 Programming Details

代码简洁(eg.在开头插入结点时相当于插在中间)
易维护

1. Header (dummy node)

带表头结点的单链表

否则有一个 head 指针就行了



header

header

3.2.2. Linked Lists

2. Class definition

ListNode —— 代表结点的类

LinkedList —— 代表表本身的类

LinkedListItr —— 代表位置的类

包含 first 指针

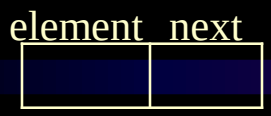
大多编写此类，特别在面向对象的

都是包DataStructures的一部分

↘ 经常不写

3.2.2. Linked Lists

1) ListNode class




```
package DataStructures;
class ListNode
{   ListNode( object theElement)
    {   this( theElement, null);
     }
     ListNode( object theElement, ListNode n)
     {    element = theElement;
          next = n;
      }
     object element;
     ListNode next;
}
```

① ② 构造函数.

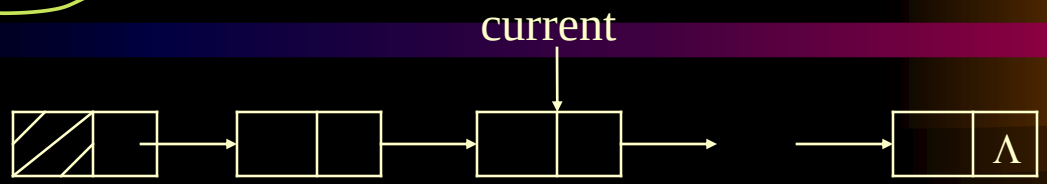
数据.

引用

3.2.2. Linked Lists

2) Iterator class for linked lists

游标类 可以不定义.



```
package DataStructures
public class LinkedListItr
{   LinkedListItr( ListNode  theNode)
    {   current = theNode;
    }
     public boolean isPastEnd( )
     {   return current = = null;
     }
     public object retrieve( )
     {   return isPastEnd( ) ? Null : current.element;
     }
     public void advance( )
     {   if( ! isPastEnd( ) )
             current = current.next;
     }
     ListNode current;
}
```

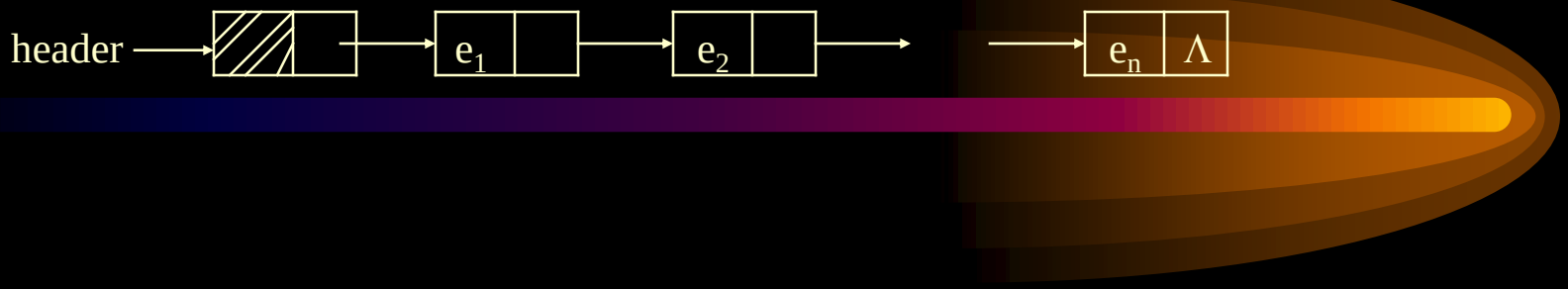
构造函数.

是否是尾(空?)

获得当前node数据.

向后移1次

3) LinkedList class



带表头结点的单链表

```
package DataStructures;
public class LinkedList
{   public LinkedList( )
      {   header = new ListNode( null ) ; }
    public boolean isEmpty( )
      {   return header.next = = null ; }
    public void makeEmpty( )
      {   header.next = null; }
    public LinkedListItr zeroth( )
      {  return new LinkedListItr( header ) ; }
    public LinkedListItr first( )
      {  return new LinkedListItr( header.next ) ; }
    public LinkedListItr find( object x )
    public void remove( object x )
    public LinkedListItr findPrevious( object x )
    public void insert( object x, LinkedListItr p )

    private ListNode header;
}
```

只有 header

Java 自动收集

? 为什么新建 一个指向表头的引用

插到指针 p 的后面

Operation:

- Constructors
- isEmpty
- makeEmpty
- Zeroth and first return iterators corresponding to the header and first element.
- Find(x)

Method to print a list

```
public static void printList( LinkedList theList )
{   if ( theList.isEmpty( ) )
        System.out.print( “Empty list” ) ;
    else
    {   LinkedListItr itr = theList.first( );
        for(  ; ! Itr.isPastEnd( ); itr. Advance( ) )
            System.out.print( itr.retrieve( ) + “ “ ) ;
     }

     System.out.println( );
}
```

此处展示的 itr 没用底层的先后方法..

```
public  LinkedListItr  find (object x)
{    ListNode itr = header.next;
     while ( itr != null && !itr.element.equals( x ) )
             itr = itr.next;
      return new LinkedListItr( itr );
}
```

两个条件

O(N)

和 array 一样

- Remove(x)

```
public void remove( object x )
{   LinkedListItr p = findprevious( x );
    if( p.current.next != null )
        p.current.next = p.current.next.next;
}
```

O(1)

- Findprevious (x)

```
public  LinkedListItr findPrevious( object x )
{    ListNode itr = header;
     while( itr.next !=null && !itr.next.element.equals( x ))
          itr = itr.next;
      return new LinkedListItr( itr );
}
```

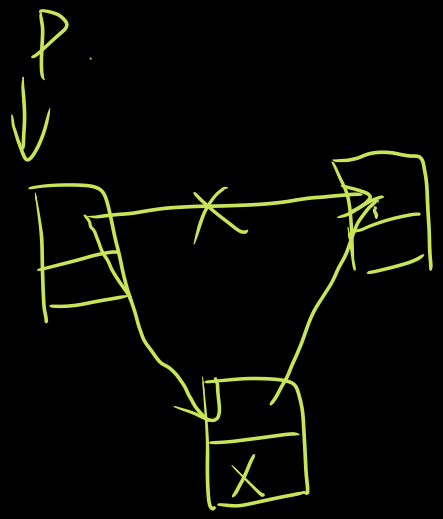
O(N)

```
public  LinkedListItr  find (object x)
{    ListNode itr = header.next;
     while ( itr != null && !itr.element.equals( x ) )
               itr = itr.next;
      return new LinkedListItr( itr );
}
```

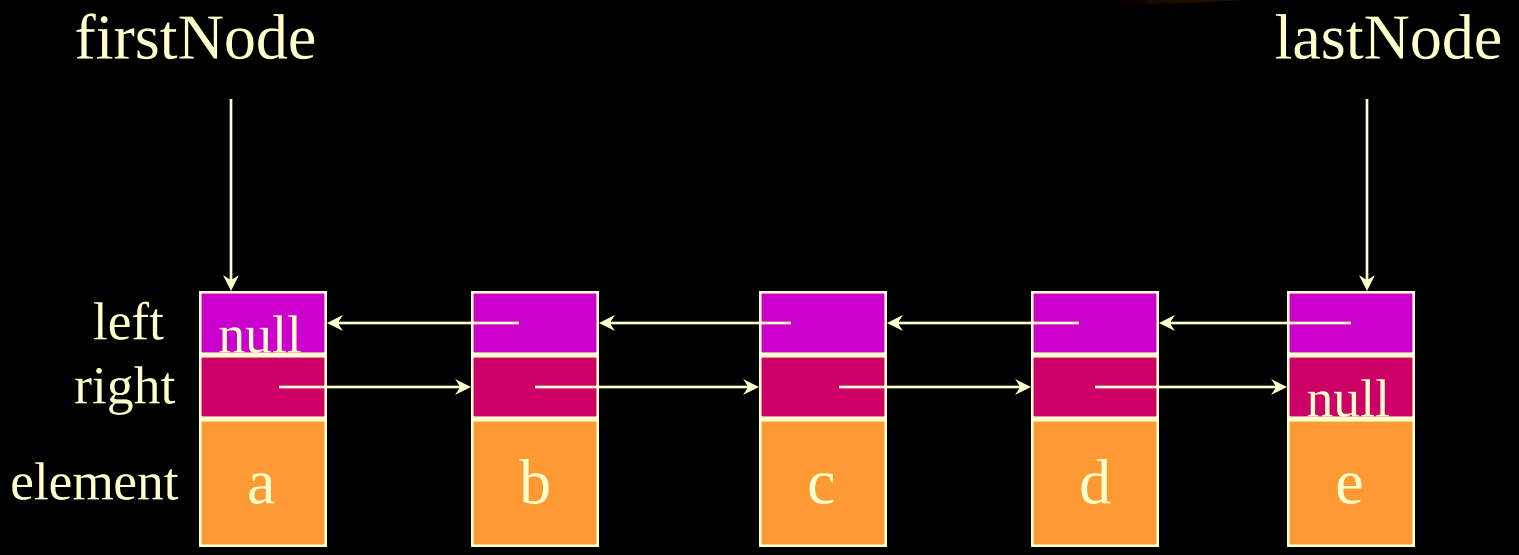
- Insert(x, p)

```
public  void insert( object x, LinkedListItr p)
{   if( p!=null && p.current != null )
        p.current.next = new ListNode( x, p.current.next );
}
```

O(1)

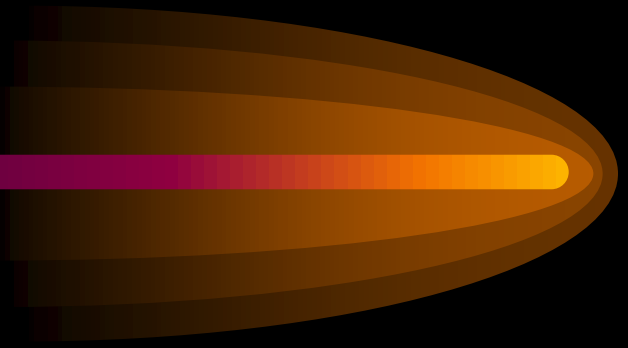


3.2.4. Doubly Linked Lists



单链表+缓存

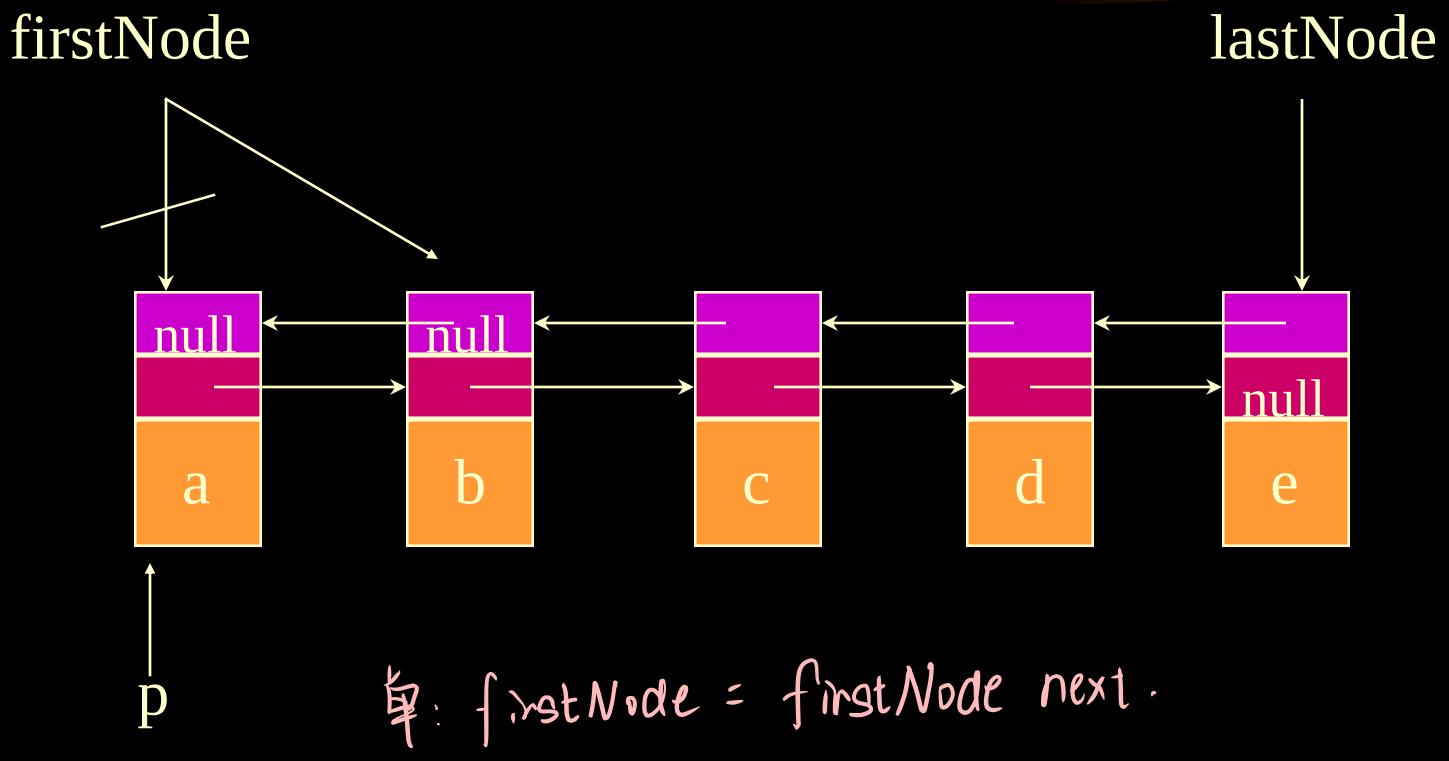
3.2.4. Doubly Linked Lists



operations: insert delete

3.2.4. Doubly Linked Lists

Delete(1)



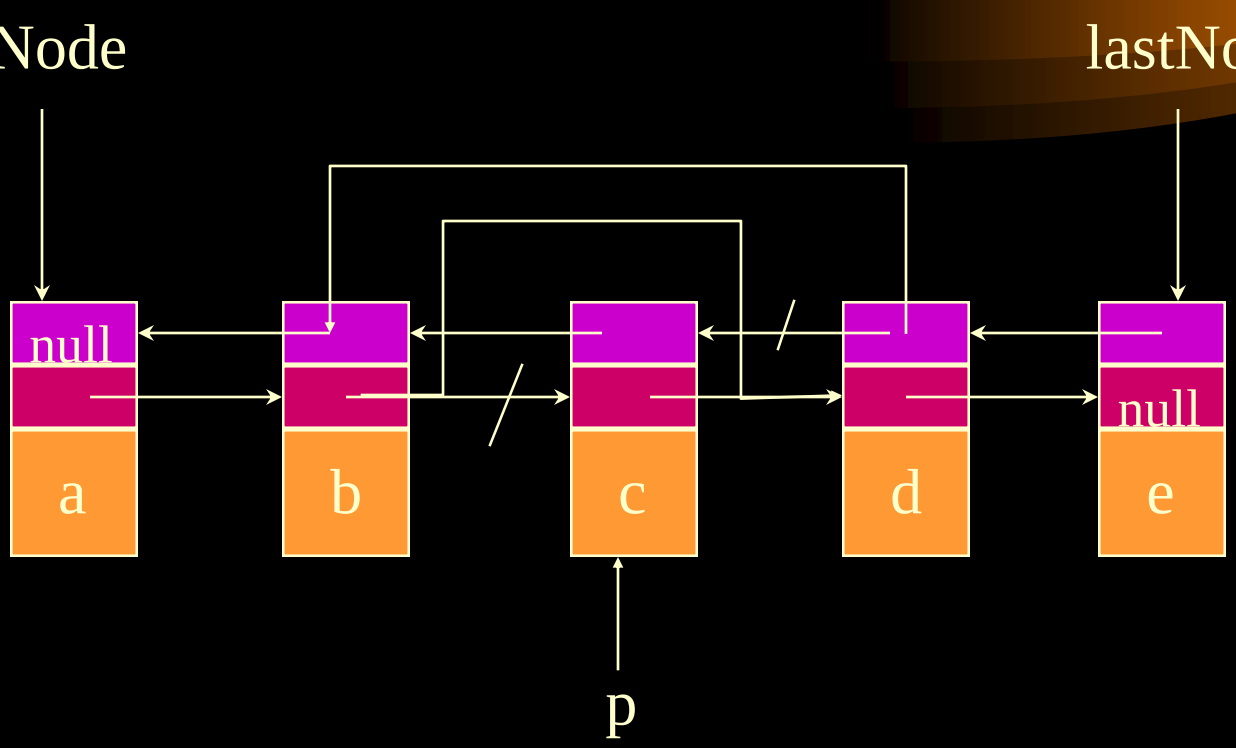
单：firstNode = firstNode.next.

双：① P=firstNode; firstNode=p.right; firstNode.left=null;

② firstNode = firstNode.right; firstNode.left = null;

3.2.4. Doubly Linked Lists

Delete(3)

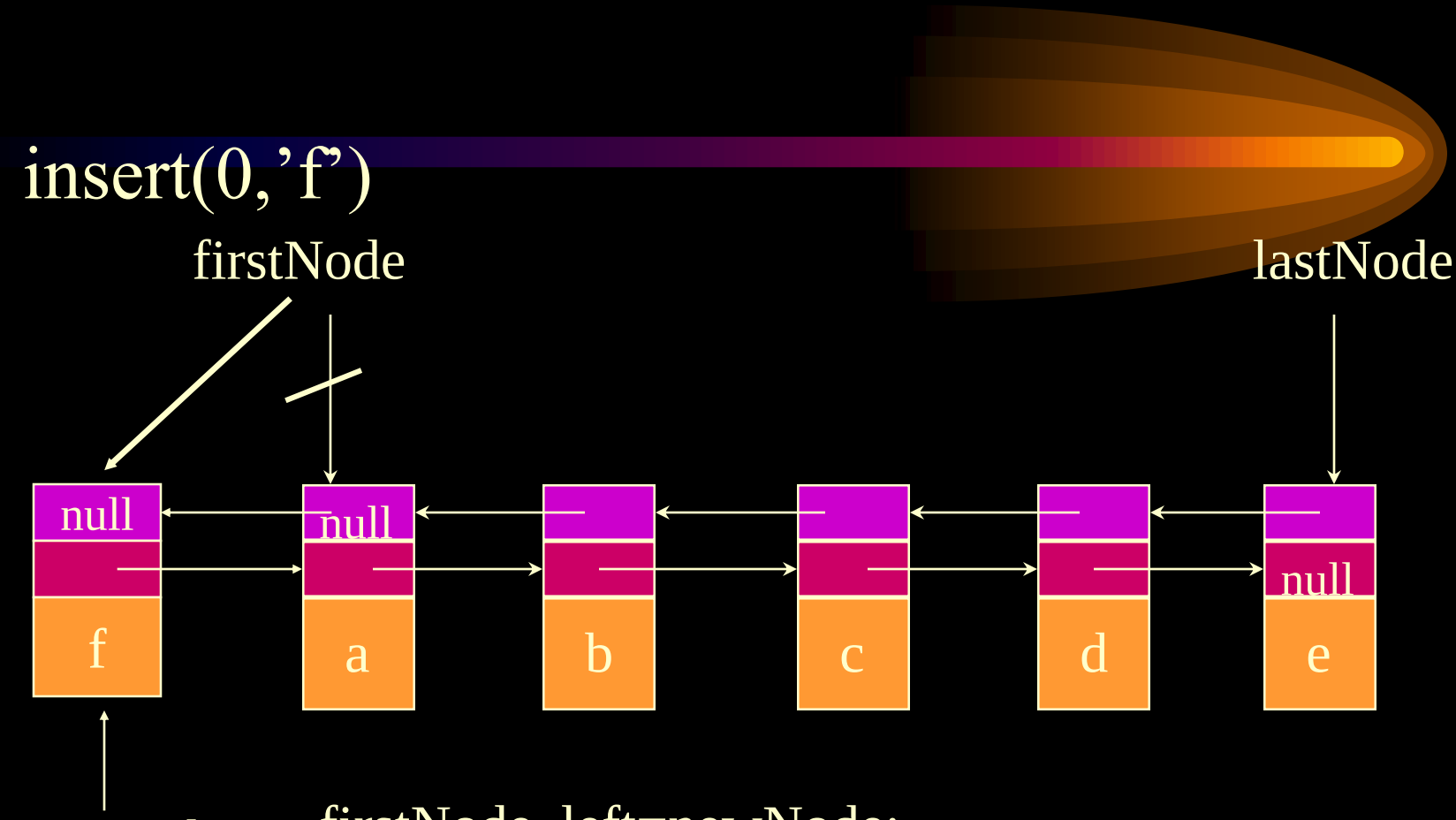


P .left .right=p .right;

P .right .left=p .left;

before.next = before.next.next;

3.2.4. Doubly Linked Lists

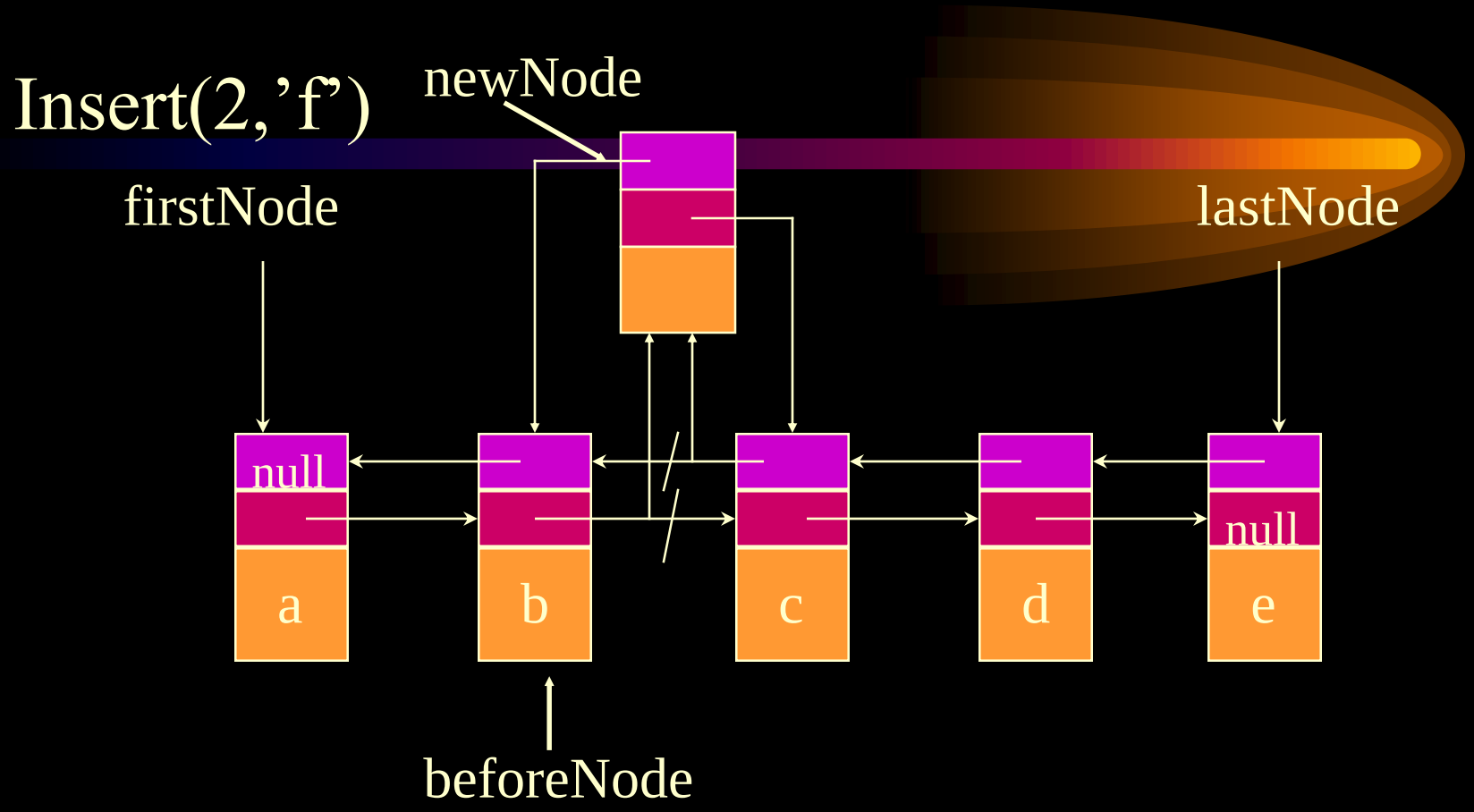


firstNode .left=newNode;

newNode .left=null; newNode .right=firstNode;

firstNode=newNode

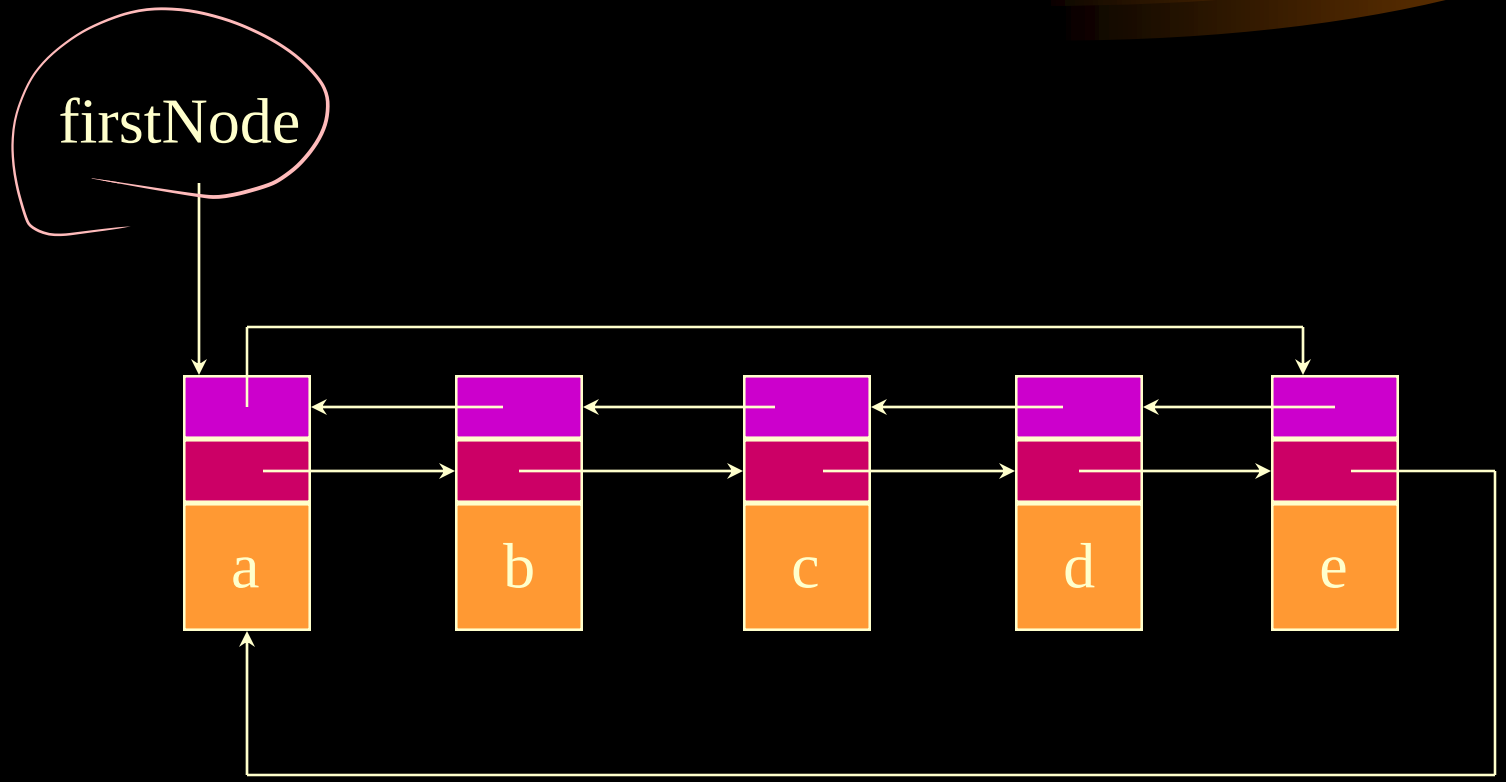
3.2.4. Doubly Linked Lists



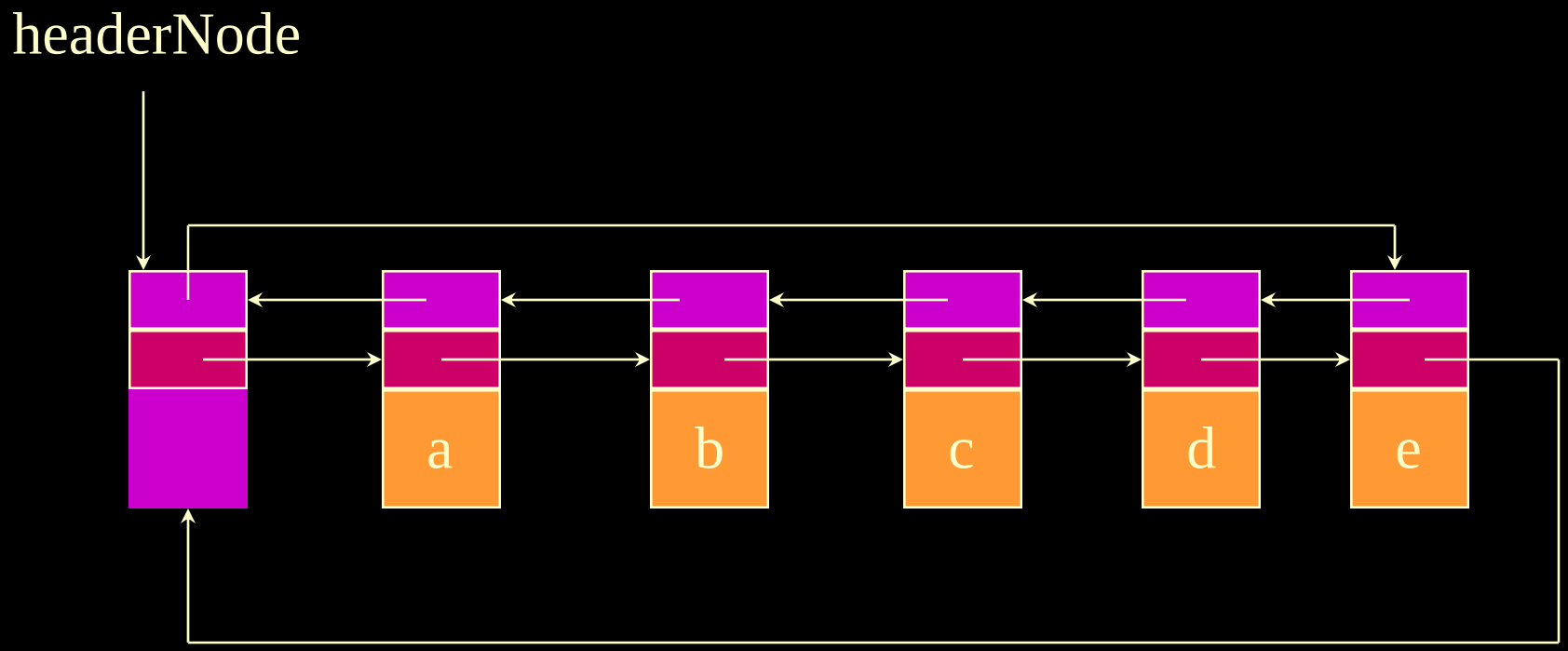
newNode .left=beforeNode; newNode .right=beforeNode .right;

beforeNode .right .left=newNode; beforeNode .right=newNode;

3.2.4. Doubly Linked Circular Lists

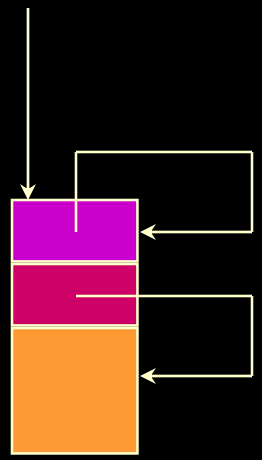


Doubly Linked Circular List With Header Node

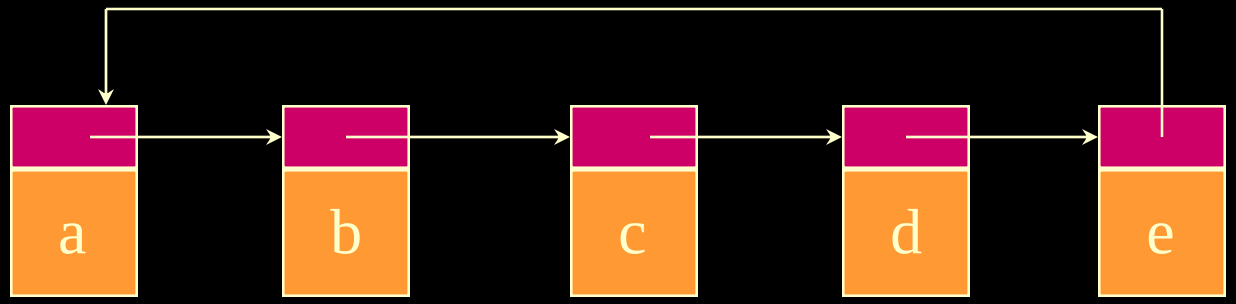


Empty Doubly Linked Circular List With Header Node

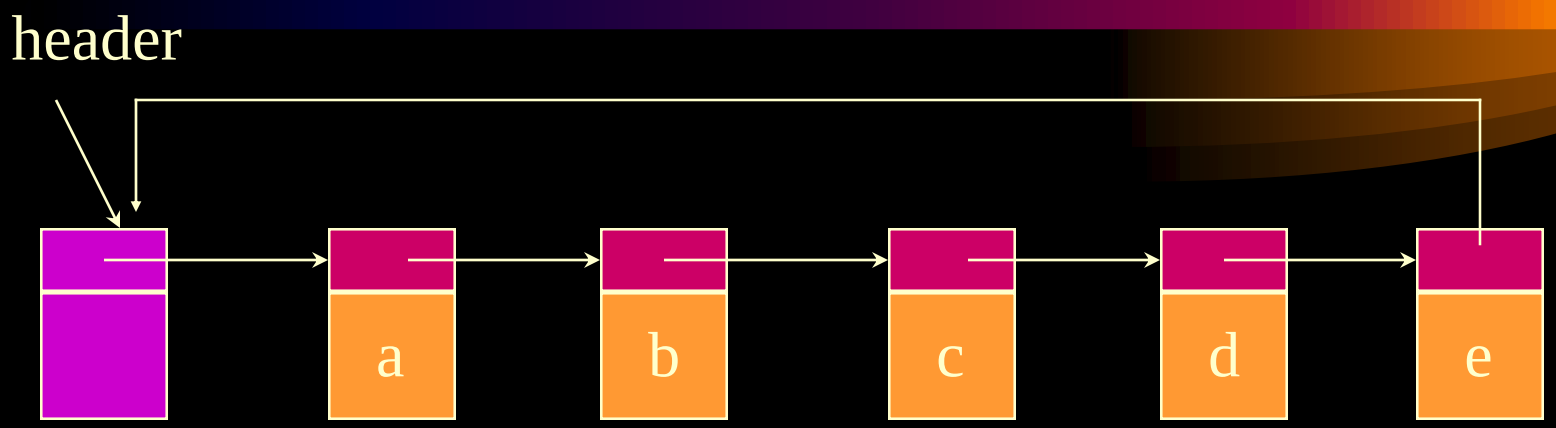
headerNode



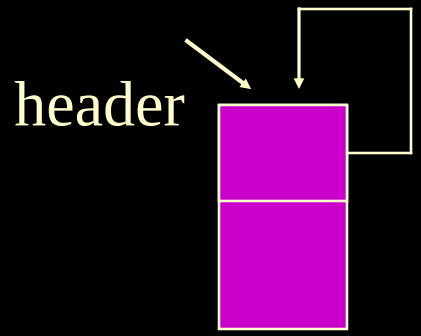
3.2.5. Circular Linked Lists



3.2.5. Circular Linked Lists



headNode



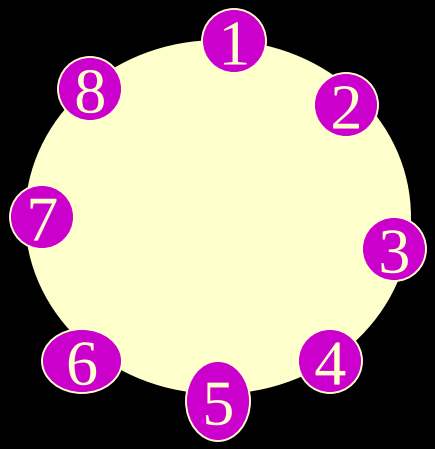
headNode

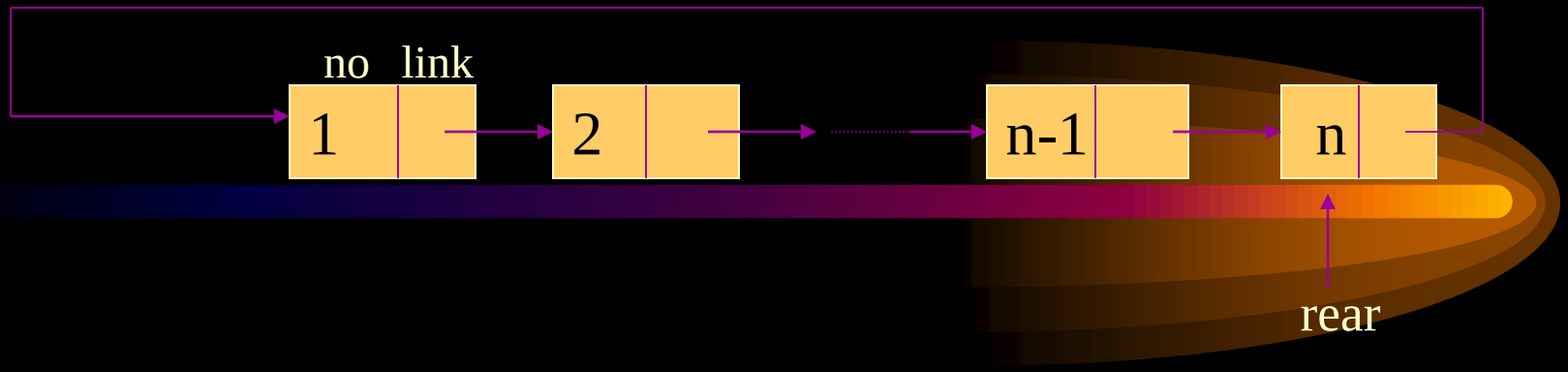
例子:

用循环链表求解约瑟夫(josephus)问题

约瑟夫问题：实际上是一个游戏。书中以旅行社从n个旅客中选出一名旅客，为他提供免费环球旅行服务。

例，n=8, m=3（报数）从1号开始报数出列顺序为：3, 6, 1, 5, 2, 8, 4。最后一个编号7的旅客将赢得环球旅游。





rear: 每次指向要出队列的前一个结点　　初始时指向尾结点

出队列的人也用链表来表示：　　表示出列顺序

head: 指向出队列结点链表的开头结点

p: 指向出队列结点链表的尾结点

以上rear, head, p都是ListNode的一个对象引用。

```
1.  w = m;
2.  for( int i = 1; i<= n-1; i++)
        1) for (int j =1; j<=w-1; j++)  rear = rear.link;
        2) if (i = = 1)
           {  head = rear.link ; p = head;}
           else
              {  p.link = rear.link; p = rear.link; }
        3) rear.link = p.link;
    }
3.  P.link = rear;
    rear.link = null;
```

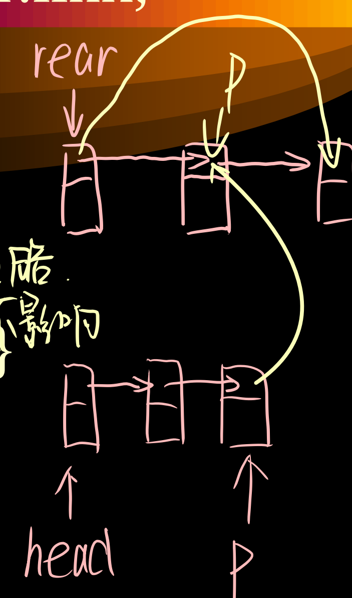
//报数

//将该删的结点连入到出队列链表

//将该结点从原链表删除。

p.link = null; 省略 不影响

P.link = rear; ← 幸存者



rear.link在=的左边：rear指向的内存的link字段（的改动）——"写"

右边：rear指向的内存的link字段指向的内存——"读"

区别。

3.2.6. Examples

1. Polynomial ADT 多项式 抽象数据结构

$p_n(x) = a_0x^{e0}+a_1x^{e1}+a_2x^{e2}+\ldots\ldots+a_nx^{en}$

- Array implementation

example: $p(x) = 3x^4-5x^3+8x^2+2x-1$

coeffArray	3	-5	8	2	-1

也可 -1 2 8 -5 3.

用数组下标代表指数

但在这种情况下，就浪费了大量内存

$p(x) = 2x^{1000}+8x^{50}-2$

⇒ 同时记下指数

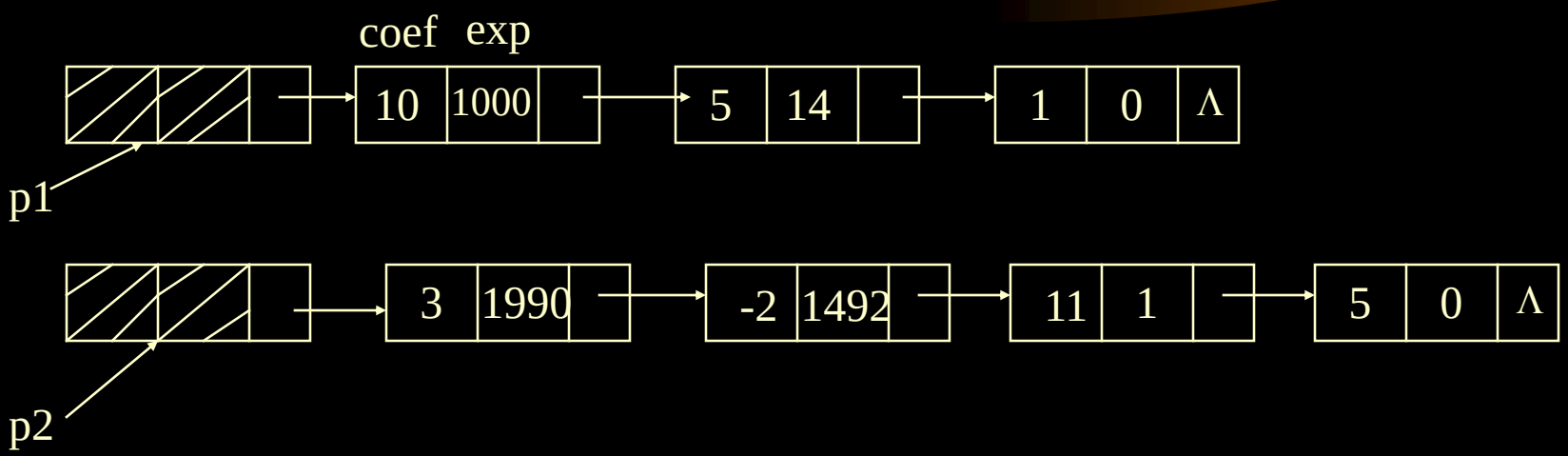
优点 以数小时，节省空间

3.2.6. Examples

- Linked list representations

$p_1(x) = 10x^{1000}+5x^{14}+1$

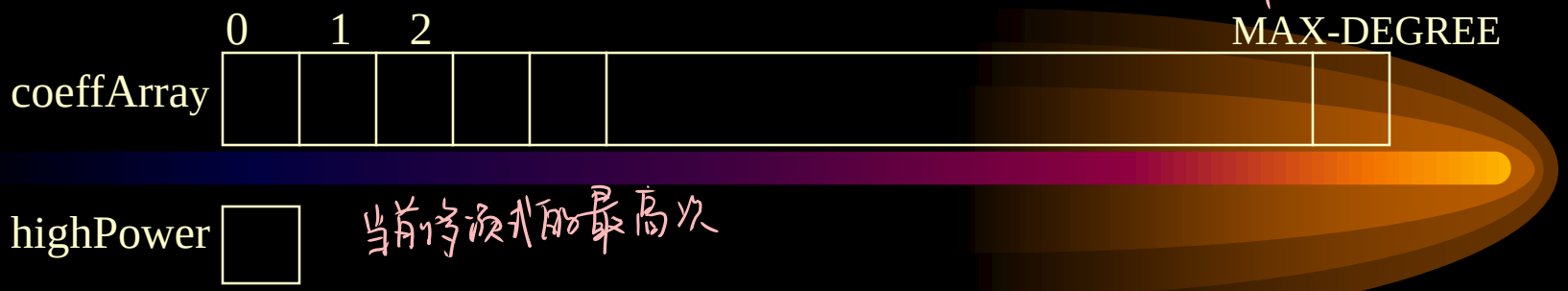
$p_2(x) = 3x^{1990}-2x^{1492}+11x+5$



polynomial operations: addition , multiplication, and so on.

1) Array implementation of the polynomial ADT

允许存储的最高次




```
public class Polynomial
{   public Polynomial( ) { zeroPolynomial( ); }
    public void insertTerm( int coef, int exp )
    public void zeroPolynomial( )
    public Polynomial add( Polynomial rhs )
    public Polynomial multiply( Polynomial rhs ) throws Overflow
    public void print( )

    public static final int MAX-DEGREE = 100;
    private int coeffArray[ ] = new int [MAX-DEGREE + 1];
    private int highPower = 0;
}
```

清0

```
public void zeroPolynomial( )
{    for( int i = 0; i<=MAX-DEGREE; i++)
           coeffArray[i] = 0;
     highPower = 0;
}
```

多項式置0

```
public Polynomial add( Polynomial rhs )
{   Polynomial sum = new Polynomial( );
    sum.highPower = max( highPower, rhs.highPower );
    for( int i = sum.highPower;  i>=0;  i--)
        sum.coeffArray[i] = coeffArray[i] + rhs.coeffArray[i] ;
    return sum;
}
```

$ax^i + bx^i = (a+b)x^i$

Example:

$p_1(x) = 3x^8 – 5x^3 + 3x – 1$

$p_2(x) = 4x^6 + 2x^2 + 2$

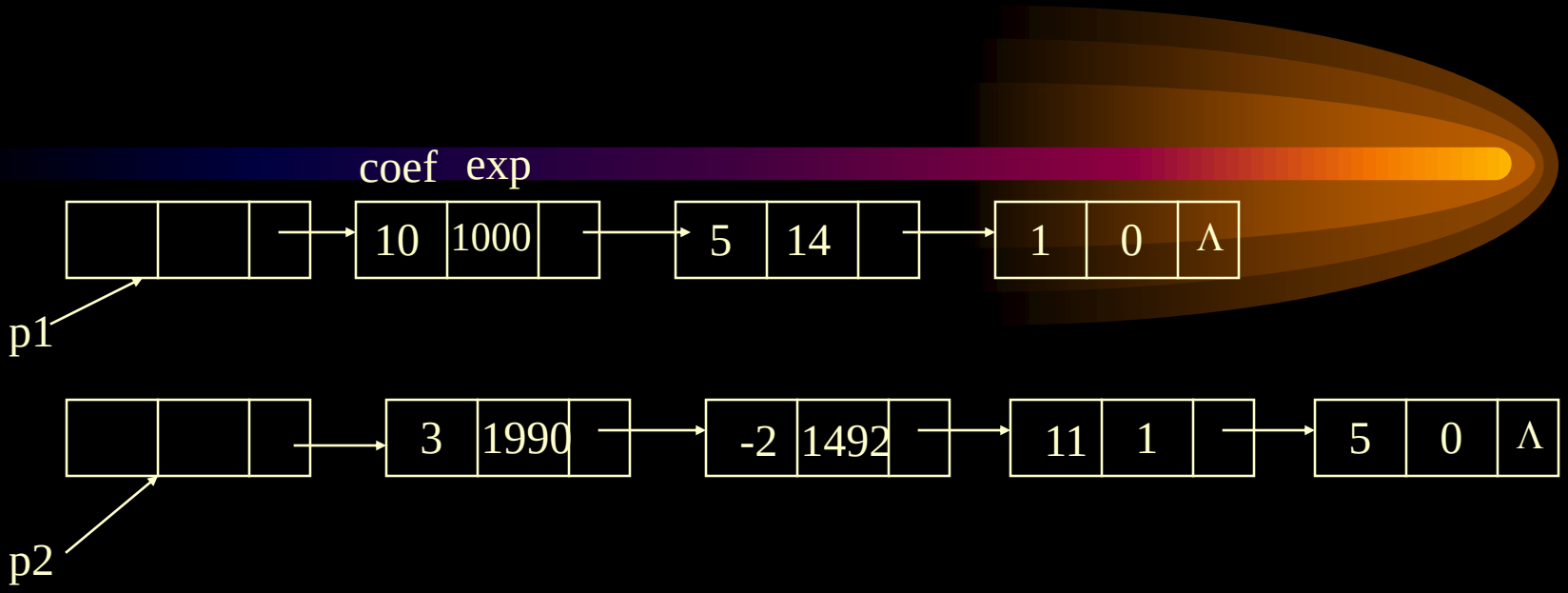
0	1	2	3	4	5	6	7	8
-1	3	0	–5	0	0	0	0	3
2	0	2	0	0	0	4	0	0

```
Public Polynomial multiply( Polynomial rhs ) throws overflow
{    Polynomial product = new Polynomial( );
     product.highPower = highPower + rhs.highPower;
     if( product.highPower > MAX-DEGREE )
          throw new overflow( );
     for( int i = 0; i<= highPower; i++ )
       for( int j = 0; j<= rhs.highPower; j++ )
          product.coeffArray[ i + j ] +=  coeffArray[i] * rhs.coeffArray[j];
      return product;
}
```

$ax^i \times bx^j = abx^{i+j}$

合并同类项

2) Class skeletons for linked list implemetation of the Polynomial ADT



```
public class Literal
{   //Vavious constractors(not shown)
     int coefficient;
     int exponent;
}
public class Polynomial
{   public Polynomial( ) { /* Exercise */ }
    public void insertTerm( int coef, int exp ) { /* Exercise */ }
    public void zeroPolynomial( ) { /* Exercise */ }
    public Polynomial add( Polynomial rhs ) { /* Exercise */ }
    public Polynomial multiply( Polynomial rhs ) { /* Exercise */ }
    public void print( ) { /* Exercise */ }

    private List  terms;  /*  A List of Literals, sorted by exponent */
}
```

构造函数

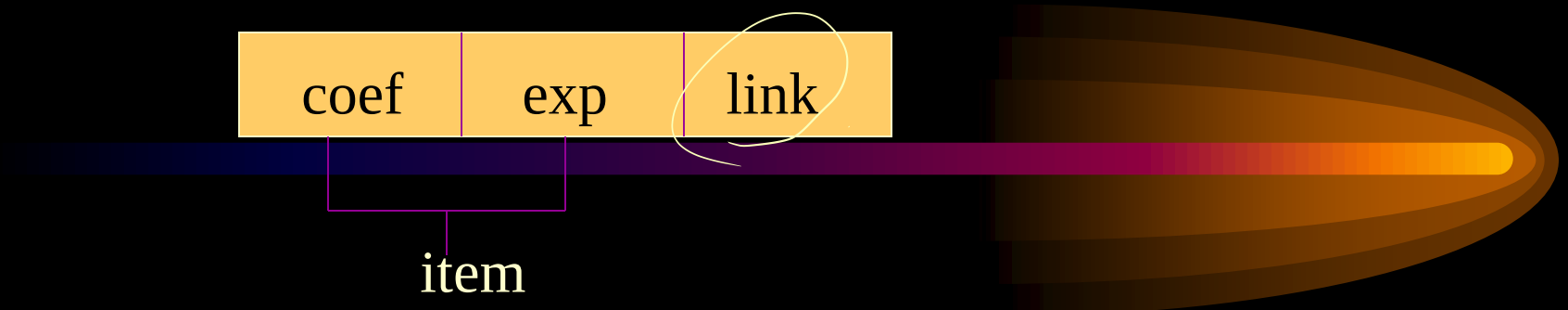
多项式相加：

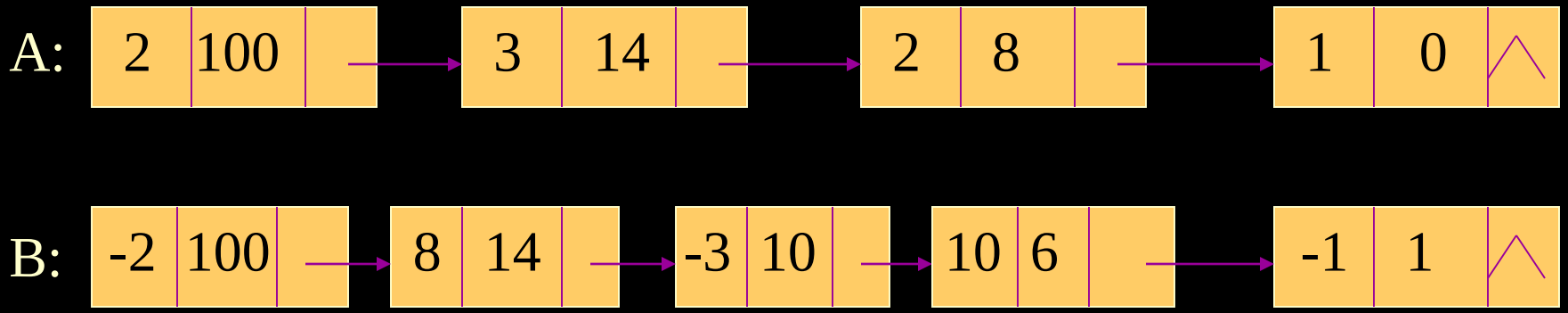
*问题： $A(X)=2X^{100}+3X^{14}+2X^{8}+1$

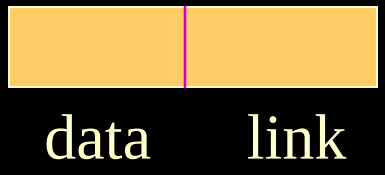
$B(X)=-2X^{100}+8X^{14}-3X^{10}+10X^{6}-X$

$A(X)+B(X)=11X^{14}-3X^{10}+2X^{8}+10X^{6}-X+1$

存放非零指数的系数与指数，因此每个结点有三个域组成。







A(X)+B(X)==》A(X)

具体实现时，并不要再重新申请结点，完全利用原来两个链表的结点。

方法：设4个引用变量：

pa, pb, pc, p(c++需要）

用来释放结点

1)初始化：pc , pa , pb ;

2)当pa和pb都有项时

pc永远指向相加时结果链表的最后一个结点。

a)指数相等(pa. exp= =pb. exp)

对应系数相加：pa. coef=pa. coef + pb. coef ;

p= pb(c++需要） ； pb前进 ；

if (系数相加结果为0){ p=pa; pa前进; }

else { pc. link=pa; pc=pa; pa前进}

b)指数不等 pa. exp< pb.exp //pb要插入结果链表

{pc. link=pb ; pc=pb ; pb前进}

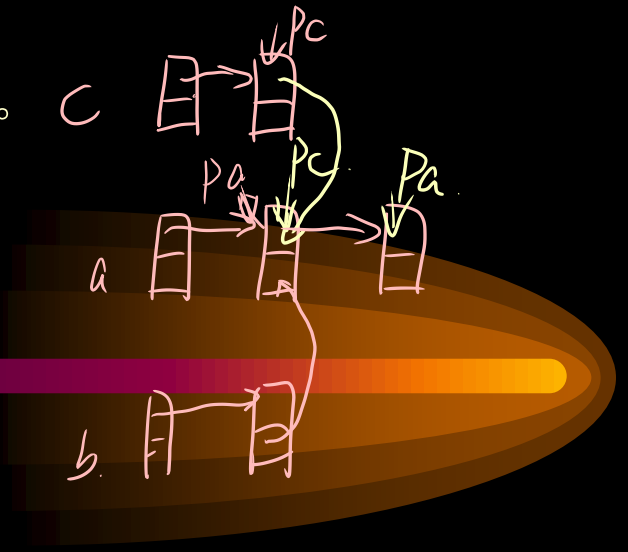
c)指数不等 pa. exp> pb. exp //pa要插入结果链表

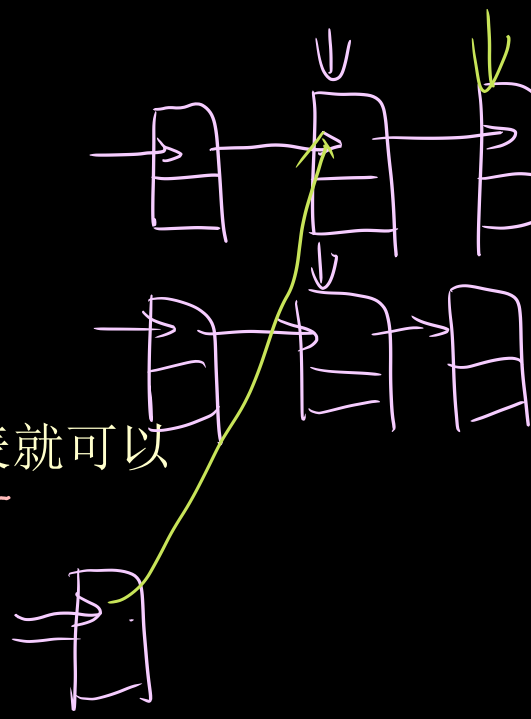
{pc. link=pa ; pc=pa ; pa前进}

3)当两链表中有一链表为空，则将另一链表链入结果链表就可以

if (pb空了){ pc. link=pa;}

else pc. link=pb;





算法分析：设两个多项式的项数分别是m和n，则总的比较次数为O(m+n)

最坏情况下：两个多项式的指数项都不等且交叉递增，如

A(x): $a_5x^5+a_3x^3+a_1x+a_0$ m=4 比较m+n-1次

B(x): $b_4x^4+b_2x^2+b_0$ n=3

2009年考研统考题

(15分)已知一个带有表头结点的单链表,结点结构为 | data | link | ,假设该链表只给出了头指针 list. 在不改变链表的前提下, 请设计一个尽可能高效的算法,查找链表中倒数第k个位置上的结点(k为正整数). 若查找成功,算法输出该结点的data域的值, 并返回1; 否则返回0. 要求:

1) 描述算法的基本设计思想;
2) 描述算法的详细实现步骤;
3) 根据设计思想和实现步骤, 采用程序设计语言描述算法(使用C或C++或JAVA语言实现), 关键之处请给出简要注释.

复杂度为能降到O(n)

"缓存"的思路

静态链表 数组和链表的结合

3.2.6. Cursor implementation of Linked Lists

指针游标

use array to implement linked list:

cursorSpace

	element	next
0		1
1		2
2		3
3		4

		element	next
header →	0		6
	1	30	2
p →	2	50	3
	3	67	8
	4	15	7
	5	81	0
	6	10	4
	7	20	1
	8	78	5

→ 0号结点、或空指针 (由自己定义)

P = p.next ⇒ p = cursorSpace[p].next

p.data cursorSpace[p].data

3.2.6. Cursor implementation of Linked Lists

1)Node and iterator for cursor implemetation of linked lists

```
class CursorNode
{   CursorNode( object theElement )
        {   this( theElement, 0 );  }
     CursorNode( object theElement, int n )
        {   element = theElement;
            next = n;
         }

        object element;
        int next;
}
```

这里0表示单链表的结束，相当于指向3表头结点

3.2.6. Cursor implementation of Linked Lists

```
public class CursorListItr
{   CursorListItr( int theNode ) {  current = theNode; }
    public boolean isPastEnd( ) { return current = = 0; }
    public object retrieve( )
    {  return isPastEnd( ) ? null:
                                CursorList.cursorSpace[ current ].element;
    }
    public void advance( )
    {   if( !isPastEnd( ))
            current = CursorList.cursorSpace[ current ].next;
     }

     int current;
}
```

3.2.6. Cursor implementation of Linked Lists

2) Class skeleton for CursorList

```
public class CursorList
{   private static int alloc( )
    private static void free( int p)
    public CursorList( )
       {  header = alloc( );   cursorSpace[ header ].next = 0; }
    public boolean isEmpty( )
       {  return cursorSpace[ header ].next = = 0; }
    public void makeEmpty( )
    public CursorListItr zeroth( )
       {   return new CursorListItr( header ); }
    public CursorListItr first( )
       {   return new CursorListItr( cursorSpace[ header ].next ); }
```

！：模拟了内存管理

系统给应用软件提供的功能

回去想为什么.

没有static是应用软件的功能

带static：

① 代表类成员变量

类共有

② 类方法

不需创建对象就可调用可类名.方法

~在前面

获得表头

获得第一元素

```
    public CursorListItr find( object x )
    public void insert( object x, CursorListItr p)
    public void remove( object x )
    public CursorListItr findPrevious( object x )

    private int header;
    static CursorNode [ ] cursorSpace;

    private static final int SPACE-SIZE = 100;

    static
    {   cursorSpace = new CursorNode[ SPACE-SIZE ];
        for( int i = 0; i<SPACE-SIZE; i++)
            cursorSpace[ i ] = new CursorNode( null, i + 1 );
        cursorSpace[ SPACE-SIZE-1].next = 0;
     }
}
```

(一个类的实例相当于一个应用软件)
应用软件维护一维护的数据
header 是空闲内存的链表的表头.
是其占用内存的链表的表头

数组(相当于此块内存)做了初始化

3.2.6. Cursor implementation of Linked Lists

Some Routines:

链表代表着空闲的内存空间（节点）

- Alloc and free

```
private static int alloc( )
{   int p = cursorSpace[ 0 ].next;
    cursorSpace[0].next = cursorSpace[p].next;
    if( p = = 0 )
        throw new OutOfMemoryError( );
    return p;
}
```

分配一块内存：0号的next，即p节点，再将p从该链表删除，意味着p不再是空闲内存，p不会再被分配

空间对应那个结点

```
private static void free( int p )
{   cursorSpace[p].element = null;
    cursorSpace[p].next = cursorSpace[0].next;
    cursorSpace[0].next = p;
}
```

系统将p结点再次标注为空闲内存：

将p插入到链表中（0号节点后面）

3.2.6. Cursor implementation of Linked Lists

- Find routine----cursor implementation

```
public CursorListItr find( object x )
{   int itr = cursorSpace[ header ].next;
    while( itr != 0 && !cursorSpace[ itr ].element.equals( x ) )
        itr = cursorSpace[ itr ].next;
     return new CursorListItr( itr );
}
```

3.2.6. Cursor implementation of Linked Lists

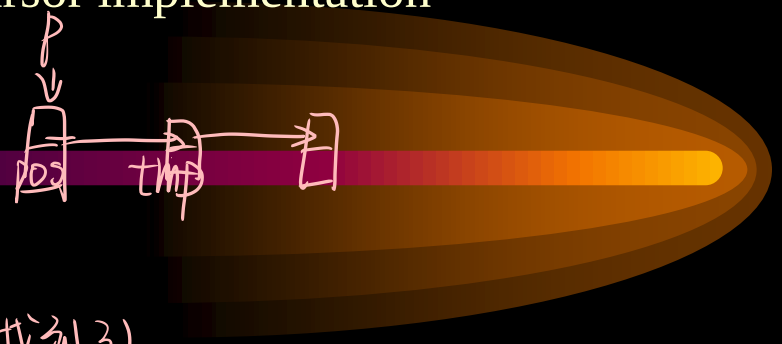
- Insertion routine for linked lists---cursor implementation

```
public void insert( object x, CursorListItr p )
{   if( p != null && p.current != 0)
    {   int pos = p.current;
        int tmp = alloc( );

        cursorSpace[ tmp ].element = x;
        cursorSpace[ tmp ].next = cursorSpace[ pos ].next;
        cursorSpace[ pos ].next = tmp;
      }
}
```

3.2.6. Cursor implementation of Linked Lists

- Deletion routine for linked lists----cursor implementation

```
public void remove( object x )
{   CursorListItr p = findPrevious( x );
    int pos = p.current;

     if( cursorSpace[ pos ].next != 0 )
     {   int tmp = cursorSpace[ pos ].next;
         cursorSpace[ pos ].next = cursorSpace[ tmp ].next;
         free( tmp );
      }
}
```



- makeEmpty for cursor implementation

```
public void makeEmpty( )
{   while( !isEmpty( ) )
        remove( first( ).retrieve( ) );
}
```

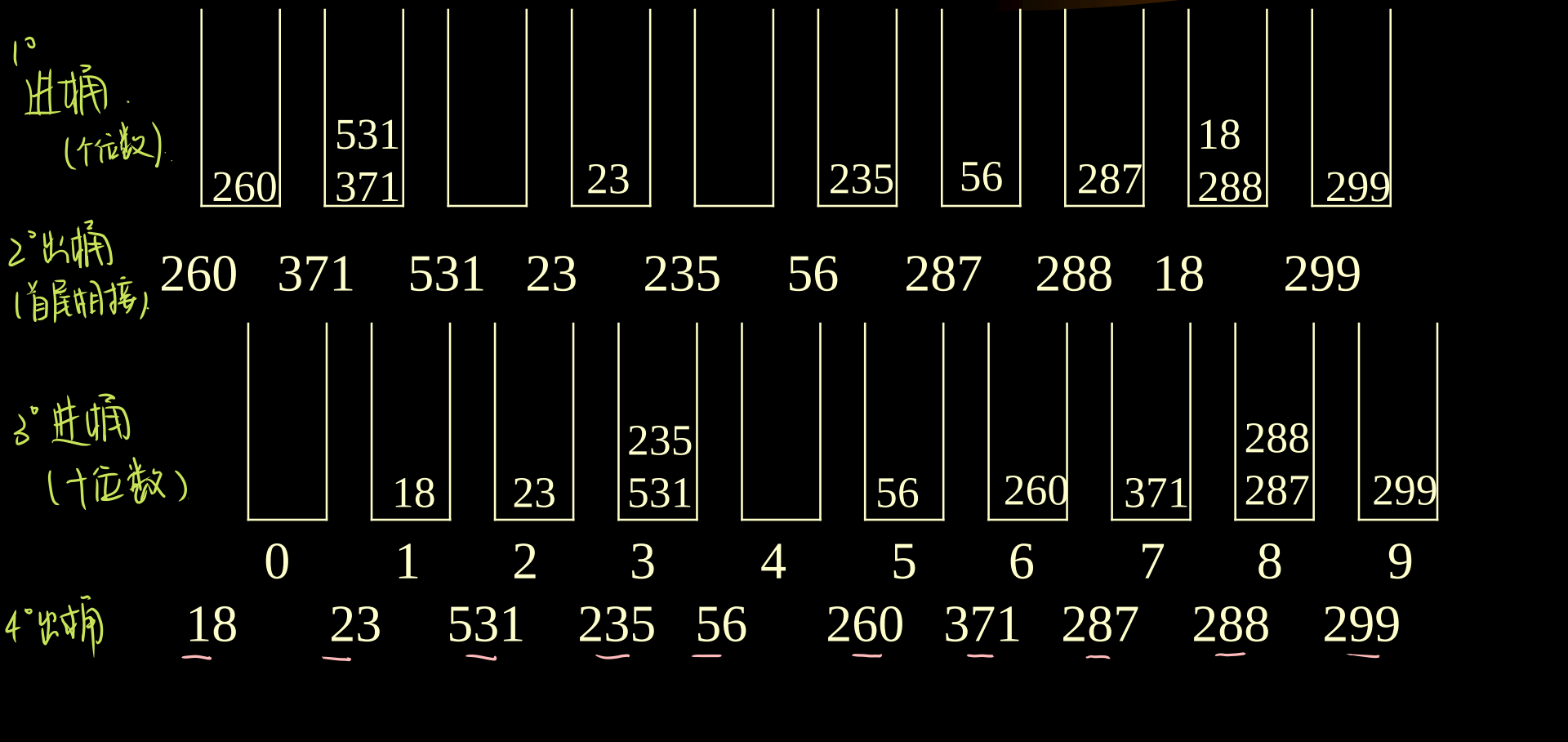
和树状排序 在排序”一章中不会再讲

3.2.7. Examples

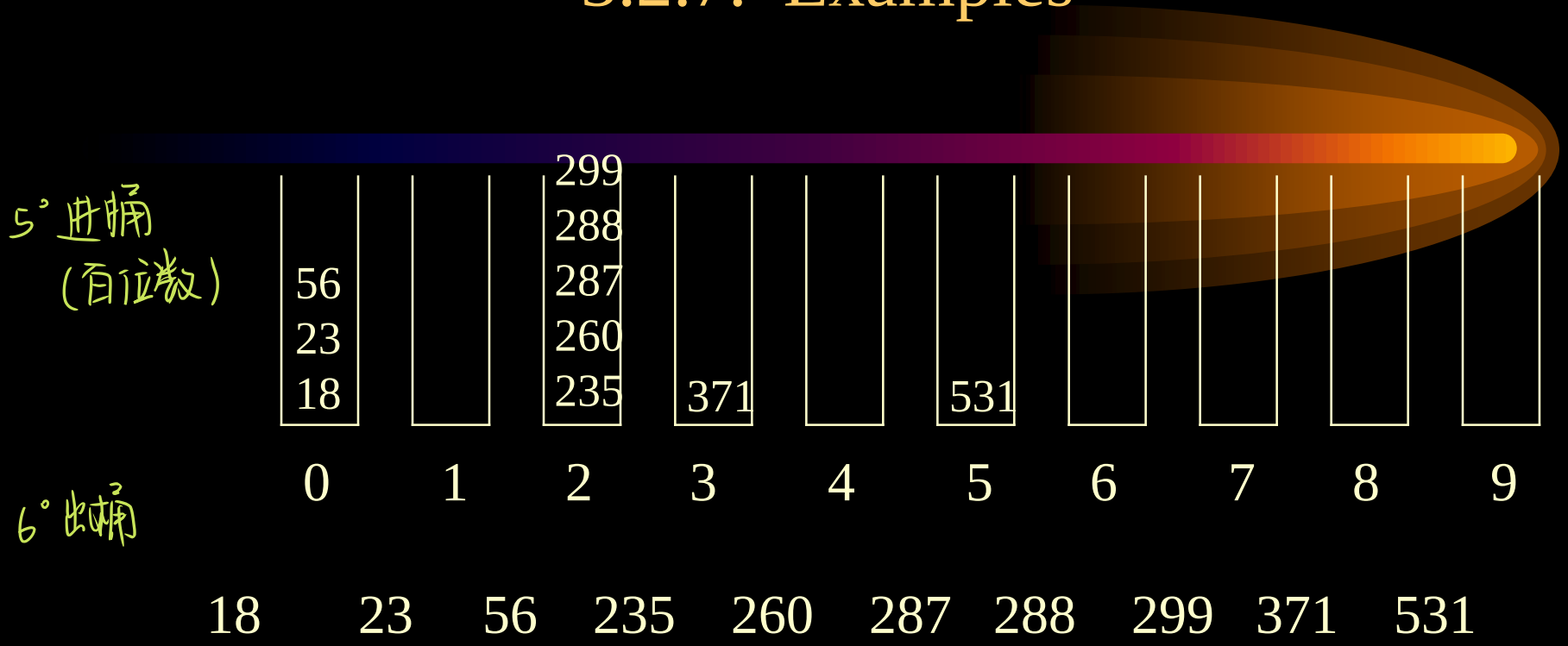
基数排序

Radix Sort

288 371 260 531 287 235 56 299 18 23



3.2.7. Examples



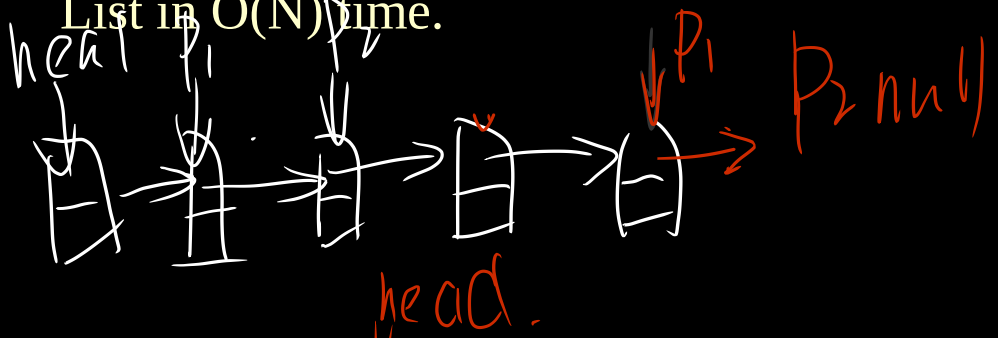
18 23 56 235 260 287 288 299 371 531

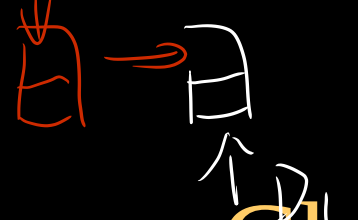
实现：原始要排序的数据、桶中的数据都可以用链表来实现。

Chapter 3

exercises:

1. Swap two adjacent elements by adjusting only the links(and not the data) using:
   a. Singly linked lists.
   b. Doubly linked lists.
2. Given two sorted lists L_1 and L_2,write a procedure to compute $L_1 \cap L_2$ using only the basic list operations.
3. Given two sorted lists, L_1 and L_2, write a procedure to compute $L_1 \cup L_2$ using only the basic list operations.
4. Write a nonrecursive method to reverse a singly linked List in O(N) time.





Chapter 3

上机实习题：

3. 多项式相加， 用链表实现。
4. Josephus(n, m), 用数组、链表实现。