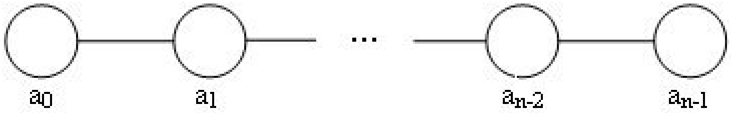
Unit 3 Lists

Array-Based lists

College of Computer Science, CQU



outline

- Definition of ADT
- Array-based List (Sequential List)
- Singly Linked List
- Circular Linked List
- Doubly Linked List
- Applications

1 Definition

- list
- Length of list
- Empty list
- Order

Lists

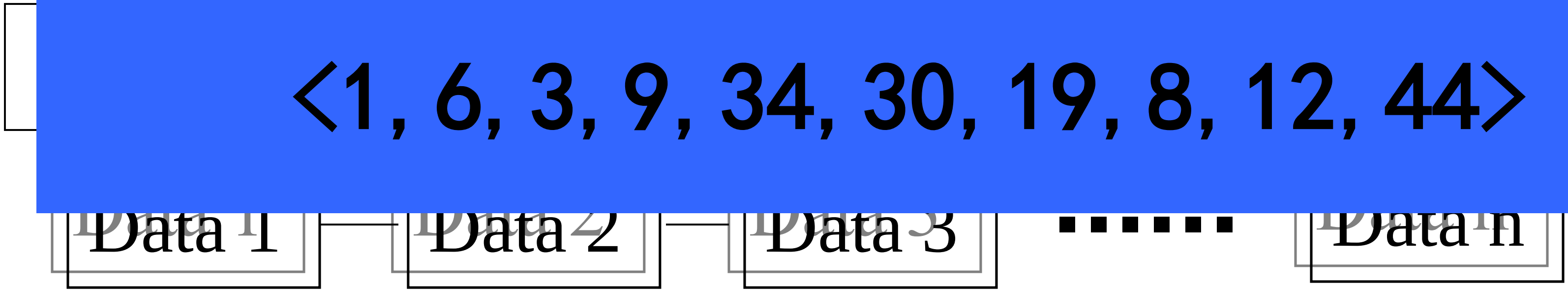
Sorted list

<1, 3, 5, 6, 8, 9, 21, 24, 56, 77>

<98, 65, 43, 23, 11, 10, 9, 6, 5, 4, 2>

Unsorted list

<1, 6, 3, 9, 34, 30, 19, 8, 12, 44>



Terminology

- Length of list

The number of elements currently stored is called the length of the list.

- Empty list

A list is said to be empty when it contains no elements. the empty list would appear as <>.

- Order

Order of a element is it's position in the list.

List Implementation Concepts

Our list implementation will support the concept of a current position.

Operations will act relative to the current position.

- Example: <20, 23 | 12, 15> to indicate the list of four elements, with the current position being to the right of the bar at element 12.

What operations should we implement?

List ADT

```
template <typename E> class List { // List ADT
private:
  void operator =(const List&) {}      // Protect assignment
  List(const List&) {}           // Protect copy constructor
public:
  List() {}          // Default constructor
  virtual ~List() {} // Base destructor

  // Clear contents from the list, to make it empty.
  virtual void clear() = 0;

  // Insert an element at the current location.
  // item: The element to be inserted
  virtual void insert(const E& item) = 0;
```

List ADT

- // Append an element at the end of the list.
- // item: The element to be appended.
- virtual void append(const E& item) = 0;

- // Remove and return the current element.
- // Return: the element that was removed.
- virtual E remove() = 0;

- // Set the current position to the start of the list
- virtual void moveToStart() = 0;

- // Set the current position to the end of the list
- virtual void moveToEnd() = 0;

List ADT

```
// Move the current position one step left. No change  if already at beginning.
 virtual void prev() = 0;
 // Move the current position one step right. No change  if already at end.
 virtual void next() = 0;
 // Return: The number of elements in the list.
 virtual int length() const = 0;

 // Return: The position of the current element.
 virtual int currPos() const = 0;

 // Set current position. pos: The position to make current.
 virtual void moveToPos(int pos) = 0;
 // Return: The current element.
 virtual const E& getValue() const = 0;
};
```

List ADT Examples

List: <12 | 32, 15>

```
L.insert(99);
```

Result: <12 | 99, 32, 15>

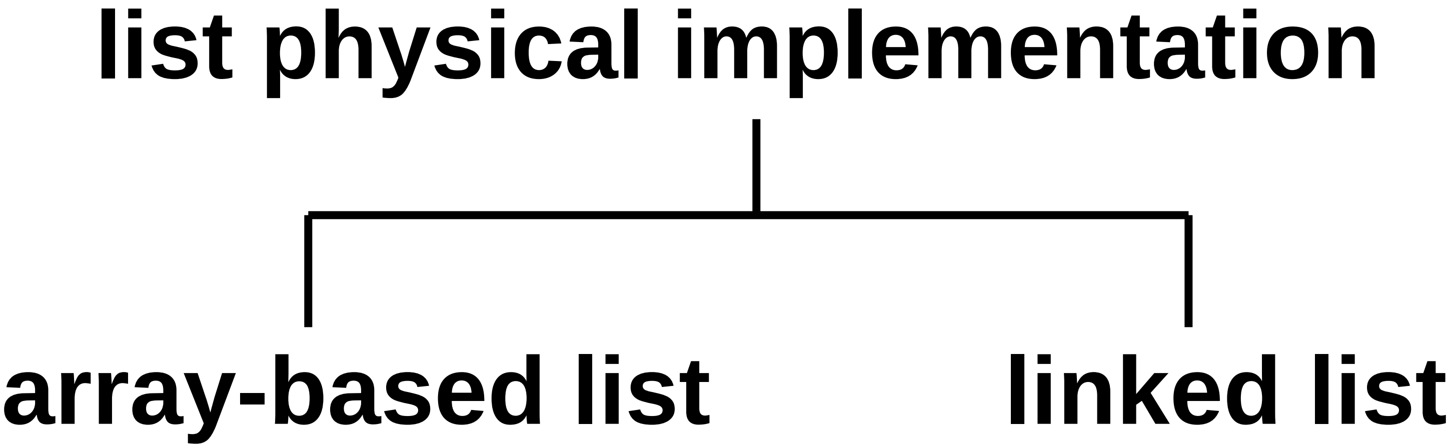
Iterate through the whole list:

```
for (L.moveToStart(); L.currPos()<L.length(); L.next())
{   it = L.getValue();
    doSomething(it);
}
```

List Find Function

```
//return True if k is in list L,
//false otherwise
bool find(List<int>& L, int k) {
    int it;
    for (L.moveToStart();
       L.currPos()<L.length(); L.next())
    {it=L.getValue();
     if (k == it) return true;}
    return false;          // k not found
}
```

Array-Based List

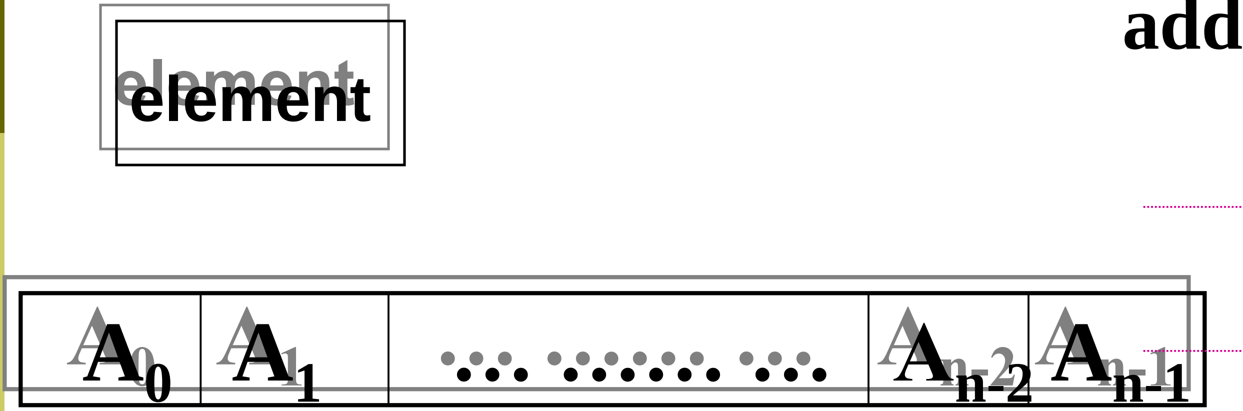


list physical implementation

array-based list

linked list

Array-Based List (cont)



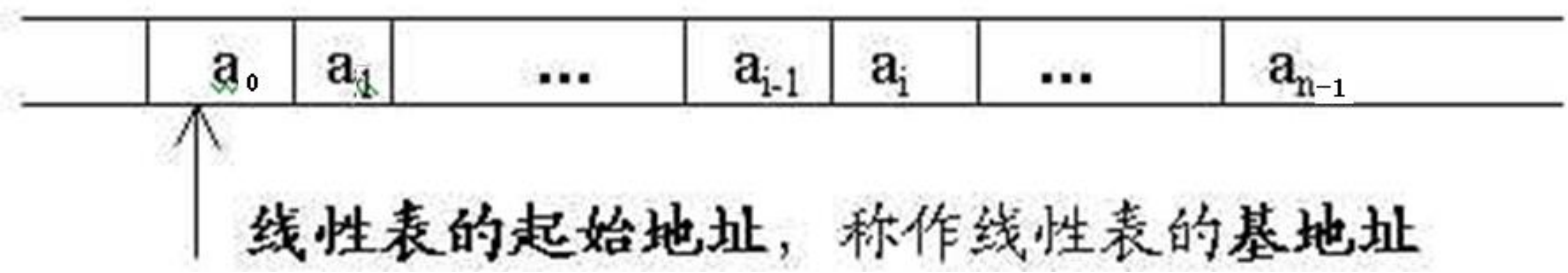
$Loc(a)=L_o+i*m$

Given some position in the list

address	value
L_o	A_0
L_o+m	A_1
	……..
$L_o+(i-1)*m$	A_{i-1}
	……..
L_o+（$n-1)*m$	A_{n-1}

Array-Based List Implementation

Array_Based List : The elements are stored in a consecutive storage area one by one



Notes：

- With ordered pair <a_{i-1} ， a_i> to express “Storage is adjacent to” ， loc（a_i）=loc（a_{i-1}）+c
- Unnecessary to store logic relationship
- First data component location can decide all data elements locations

Array-Based List Class (1)

```
#include "list.h‟
template <typename E> // Array-based list implementation
class AList : public List<E> {
private:
   int maxSize;        // Maximum size of list
   int listSize;       // Number of list items now
   int curr;           // Position of current element
   E* listArray;       // Array holding list elements
```

Array-Based List Class (2)

```
  public:
     AList(int size=defaultSize)
{ // Constructor
     maxSize = size;
     listSize = curr = 0;
     listArray = new E[maxSize];
 }


~AList() { delete [] listArray; } // Destructor
```

Array-Based List Class (3)

```
void clear() {                  // Reinitialize the list
    delete [] listArray;         // Remove the array
    listSize = curr = 0;          // Reset the size
    listArray = new E[maxSize];  // Recreate array
  }
void moveToStart() { curr = 0; }
void moveToEnd() { curr = listSize; }
void prev() { if (curr != 0) curr--; }
void next()      { if (curr < listSize) curr++; }
```

Array-Based List Class (4)

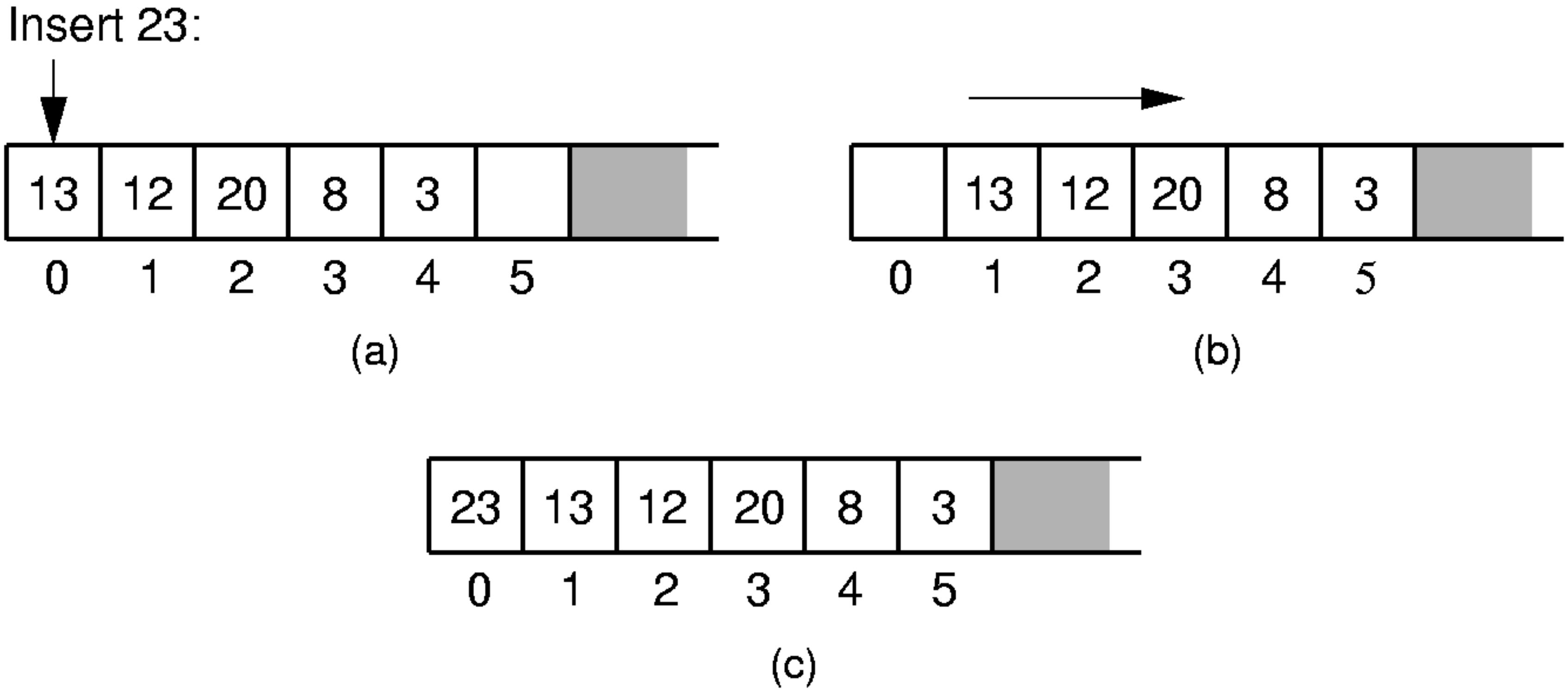
```
// Return list size
 int length() const  { return listSize; }
 // Return current position
 int currPos() const { return curr; }
 // Set current list position to "pos"
 void moveToPos(int pos) {
   Assert ((pos>=0)&&(pos<=listSize), "Pos out of range");
   curr = pos;  }
```

Array-Based List Class (5)

```
// Return current element

 const E& getValue() const
{  Assert((curr>=0)&&(curr<listSize),"No current element");
    return listArray[curr];
 }
```

Array-Based List Insert



Insert 23:

13	12	20	8	3	
0	1	2	3	4	5

(a)

	13	12	20	8	3
0	1	2	3	4	5

(b)

23	13	12	20	8	3
0	1	2	3	4	5

(c)

Insert

```
// Insert "it" at current position
 void insert(const E& it) {
   Assert(listSize < maxSize, "List capacity exceeded");
   for(int i=listSize; i>curr; i--)  // Shift elements up
     listArray[i] = listArray[i-1];  //   to make room
   listArray[curr] = it;
   listSize++;                      // Increment list size
 }
```

Append

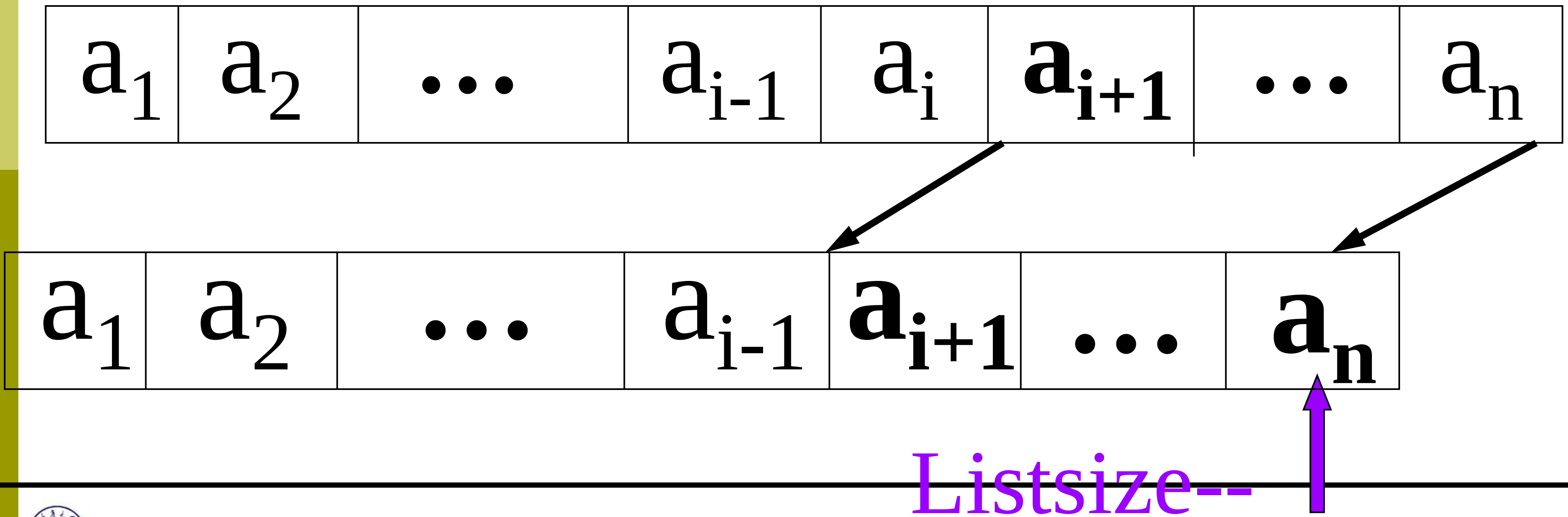
```
void append(const E& it) {      // Append "it"
    Assert(listSize < maxSize, "List capacity exceeded");
    listArray[listSize++] = it;
 }
```

★Remove

$\langle a_1, \ldots, a_{i-1}, a_i, a_{i+1}, \ldots, a_n\rangle$ **change to**

$\langle a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_n\rangle$

$\langle a_{i-1}, a_i\rangle, \langle a_i, a_{i+1}\rangle \longrightarrow \langle a_{i-1}, a_{i+1}\rangle$



a_1	a_2	…	a_{i-1}	a_i	a_{i+1}	…	a_n

a_1	a_2	…	a_{i-1}	a_{i+1}	…	a_n

Listsize--

Remove

```
// Remove and return the current element.
 E remove() {
   Assert((curr>=0) && (curr < listSize), "No element");
   E it = listArray[curr];          // Copy the element
   for(int i=curr; i<listSize-1; i++)  // Shift them down
     listArray[i] = listArray[i+1];
   listSize--;                      // Decrement size
   return it;
 }
```

Exercise：

- 1.To give an example to illustrate data structure idea and describe it in abstract data type form .
- 2.Analyses the time complexity of the following algorithms 。

```
1. i=1;            2. i=n;            3. x=y=1;
  while (s<n)        do {                while(x++ * y++<n);
  { i++;s+=i;}         i++;
                     } while (i<n)
```

- 3.Design an Improve LocateElem's algorithm to look for all the elements matching the relationship 。
- 4.Design an algorithm to reverse an sequential list $(a_1a_2..a_n)$->$(a_na_{n-1}...a_1)$

Summing Up

- Advantages ：
  - Stores a collection of items contiguously.
    - Stores no relations
    - Access randomly
- Disadvantages ：
  - Need to shift many elements in the array whenever there is an insertion or deletion.
  - Need to allocate a fix amount of memory in advance.

Reference

- P95----P103

-End-