CHAPTER 3

Lists, Stacks, and Queues

§ 1 Abstract Data Type (ADT)

【Definition】 Data Type = { Objects } ∪ { Operations }

〖Example〗 int = { 0, ±1, ±2, · · ·, INT_MAX, INT_MIN }
∪ { +, −, ×, ÷, %, · · · }

【Definition】 An Abstract Data Type (ADT) is a data type that is organized in such a way that the specification on the objects and specification of the operations on the objects are separated from the representation of the objects and the implementation on the operations.

§ 2 The List ADT

❖ **ADT:**

Objects: ($\text{item}_0, \text{item}_1, \cdots, \text{item}_{N-1}$)

Operations:

- Finding the length, N, of a list.
- Printing all the items in a list.
- Making an empty list.
- Finding the k-th item from a list, $0 \le k < N$.
- Inserting a new item after the k-th item of a list, $0 \le k < N$.
- Deleting an item from a list.
- Finding next of the current item from a list.
- Finding previous of the current item from a list.

Why after?

1. Simple Array implementation of Lists

array[*i*] = item$_i$

Sequential mapping

Address	Content
……	……
array+*i*	item$_i$
array+*i*+1	item$_{i+1}$
……	……

MaxSize has to be estimated.

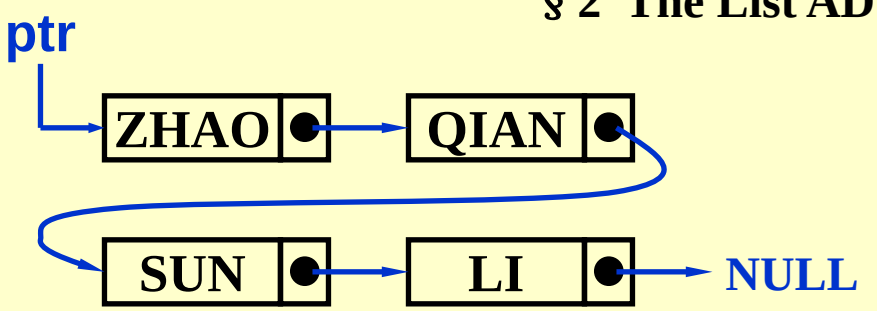
Find_Kth takes O(1) time.

Insertion and Deletion not only take O(*N*) time, but also involve a lot of data movements which takes time.

2. Linked Lists

Address	Data	Pointer
0010	SUN	1011
0011	QIAN	0010
0110	ZHAO	0011
1011	LI	NULL

Head pointer ptr = 0110



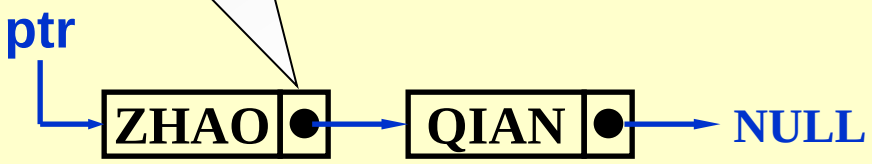
To link 'ZHAO' and 'QIAN':

```
                                    izeof(struct list_node));
                                    of(struct list_node));
ptr = 
```

Initialization:

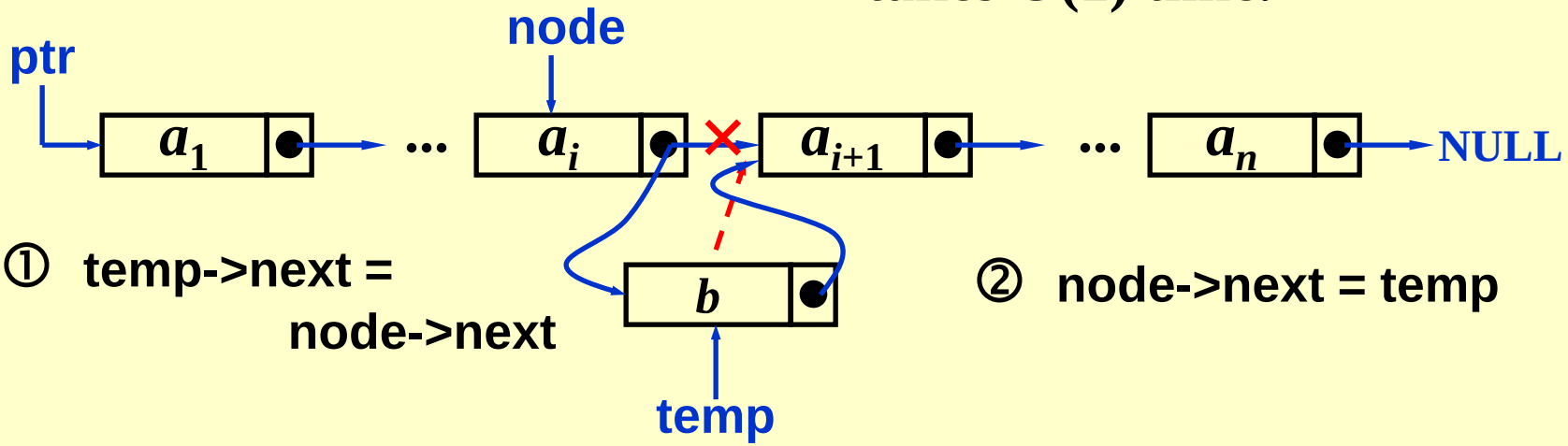
```
typedef  struct  list_node  *li
typedef  struct  list_node  {
     char        data [ 4 ] ;
     list_ptr    next ;
} ;
list_ptr   ptr ;
```

Locations of the nodes may change on different runs.



Insertion

takes O(1) time.

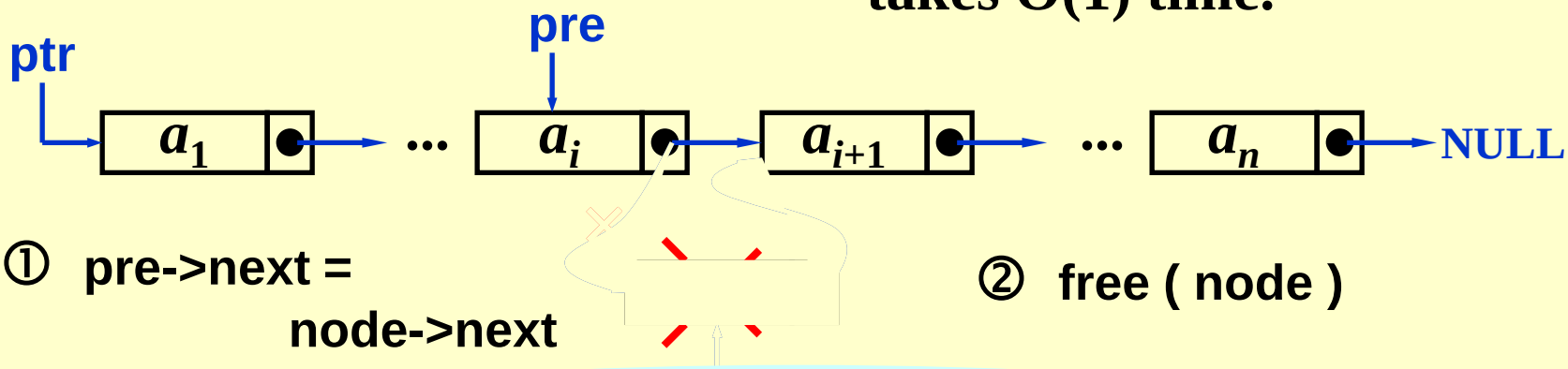


Question: What will happen if the order of the two steps is reversed?

Question: How can we insert a new first item?

Deletion

takes O(1) time.



① pre->next = node->next

② free (node)

Question: How can we delete the first node from a list?

Answer: We can add a dummy head node to a list.

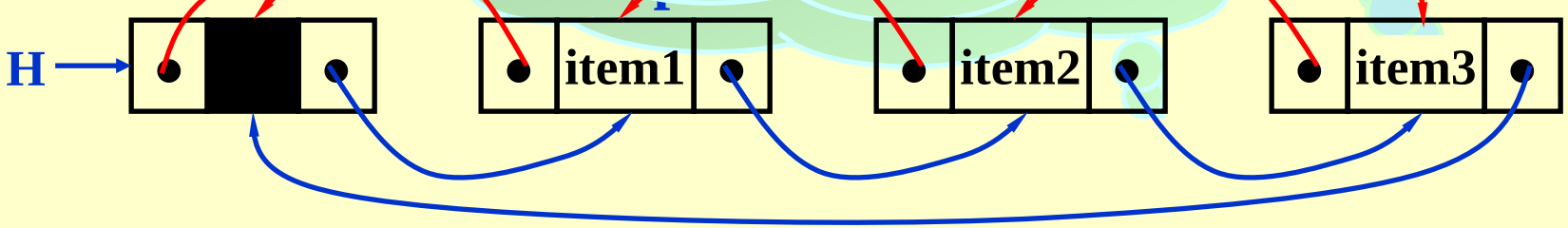
Read programs in Figures 3.6-3.15 for detailed implementations of operations.

Doubly Linked Circular Lists

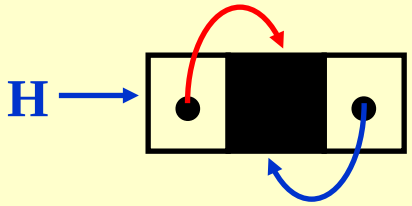
```
typedef  struct  node  *node_ptr ;
typedef  struct  node  {
      node_ptr  llink;
      element    item;
      node_ptr  rlink;
} ;
```

... Then I'll have to
the 1st node again.
ptr = ptr->llink->rlink
ptr = ptr->rlink->llink
, why do I wanna
de?
ode
Why do you ask me? :-)
Maybe you wanna delete
the *m*-th node?
ue.
1?

A doubly linked circular list with head node:



An empty list :



Two Applications

The Polynomial ADT

Objects : $P(x) = a_1 x^{e1} + \cdots + a_n x^{en}$; a set of ordered pairs of $< e_i , a_i >$ where a_i is the coefficient and e_i is the exponent. e_i are nonnegative integers.

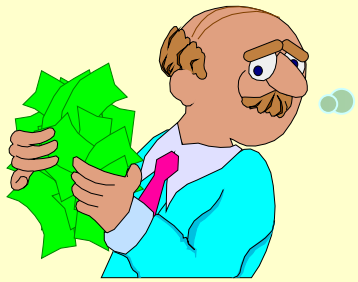
Operations:

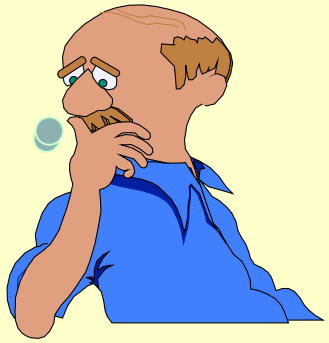
- Finding degree, max { e_i }, of a polynomial.
- Addition of two polynomials.
- Subtraction between two polynomials.
- Multiplication of two polynomials.
- Differentiation of a polynomial.

【Representation 1】

```
typedef struct {
        int    CoeffArray [ MaxDegree + 1 ] ;
        int    HighPower;
} *Polynomial ;
```

Try to apply MultPolynomial (p.47)
On $P_1(x) = 10x^{1000}+5x^{14}+1$ and
$P_2(x) = 3x^{1990}-2x^{1492}+11x+5$
-- now do you see my point?





【Representation 2】

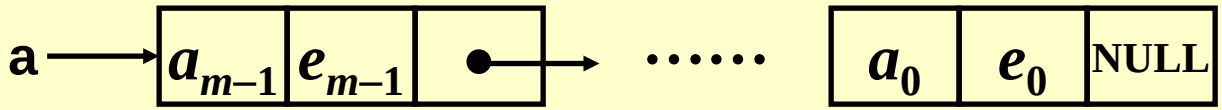
Given: $A(x) = a_{m-1}x^{e_{m-1}} + \cdots + a_0 x^{e_0}$

where $e_{m-1} > e_{m-2} > \cdots > e_0 \geq 0$ and $a_i \neq 0$ for $i = 0, 1, \cdots, m-1$.

We represent each term as a node

Declaration:

```
typedef  struct  poly_node   *poly_ptr;
struct  poly_node  {
     int       Coefficient ;  /* assume coefficients are integers */
     int       Exponent;
     poly_ptr    Next ;
} ;
typedef  poly_ptr   a ;    /* nodes sorted by exponent */
```



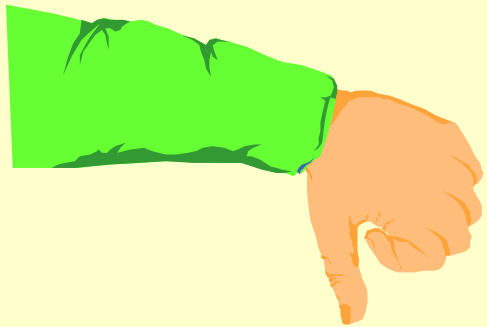
Multilists

〖Example〗 Suppose that we have 40,000 students and 2,500 courses. Print the students' name list for each course, and print the registered classes' list for each student.

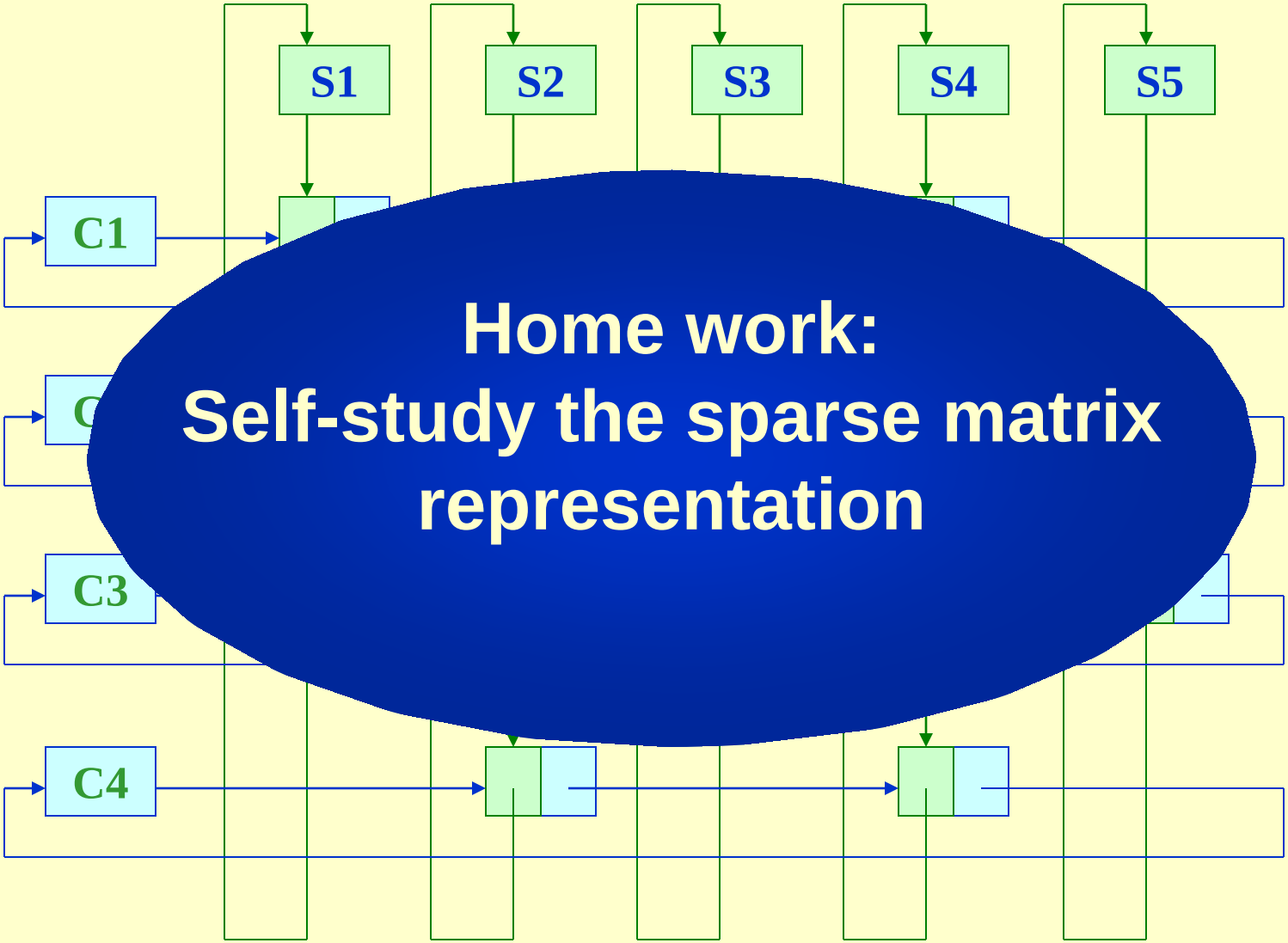
【Representation 1】

```
int Array[40000][2500];
```

$$\text{Array}[i][j] = \begin{cases} 1 & \text{if student } i \text{ is registered for course } j \\ 0 & \text{otherwise} \end{cases}$$



【Representation 2】

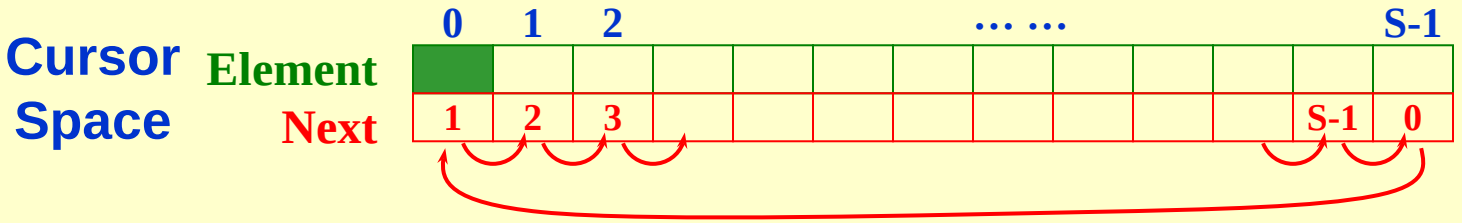


3. Cursor Implementation of Linked Lists (no pointer)

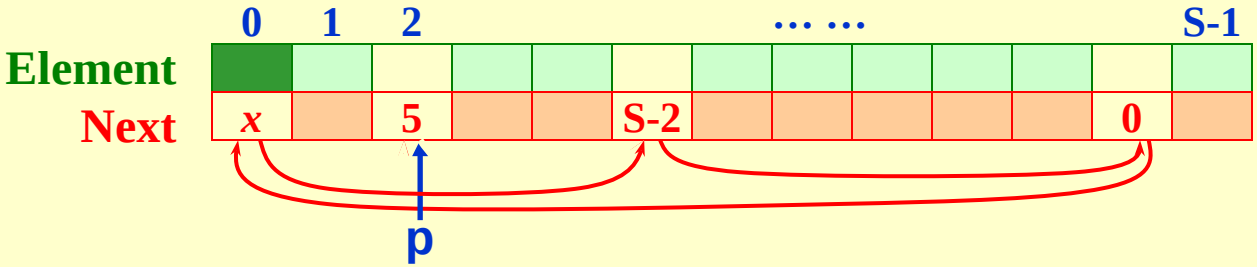
☞ Features that a linked list must have:

a) The data are stored in a collection of structures. Each structure contains data and a pointer to the next structure.

b) A new structure can be obtained from the system's global memory by a call to malloc and released by a call to free.

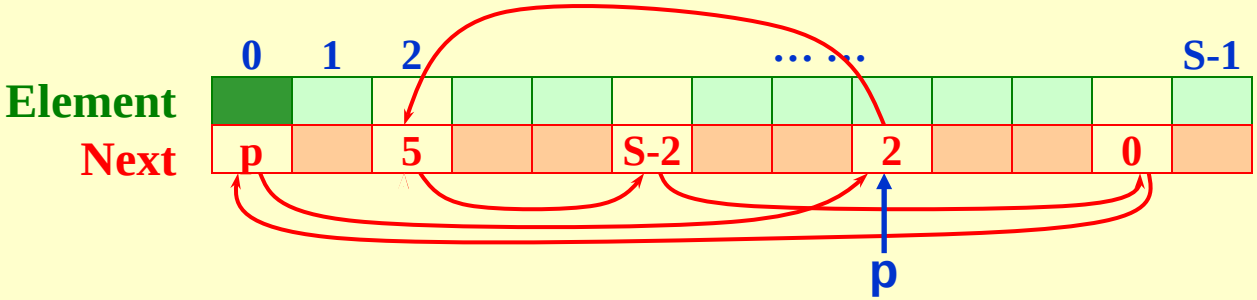


Note: The interface for the cursor implementation (given in Figure 3.27 on p. 52) is identical to the pointer implementation (given in Figure 3.6 on p. 40).



malloc: p = CursorSpace[0].Next ;

CursorSpace[0].Next = CursorSpace[p].Next ;



free(p): CursorSpace[p].Next = CursorSpace[0].Next ;

CursorSpace[0].Next = p ;

Read operation implementations given in Figures 3.31-3.35

Note: The cursor implementation is usually significantly faster because of the lack of memory management routines.