FROM STRUCT TO CLASS

UNDERSTANDING C++ ENCAPSULATION

Lecturer：**陈笑沙**

REVIEW

Which line of code has an error in the following program?

```
 1 int a = 100, b = 10;
 2 const int *p1 = &a;
 3 p1 = &b;
 4 *p1 = 0;
 5 int * const p2 = &a;
 6 *p2 = 0;
 7 p2 = &b;
 8 const int * const p3 = &a;
 9 *p3 = 0;
10 p3 = &b
```

REVIEW

Which line of code has an error in the following program?

```
 1 int a = 100, b = 10;
 2 const int *p1 = &a;
 3 p1 = &b;
 4 *p1 = 0;
 5 int * const p2 = &a;
 6 *p2 = 0;
 7 p2 = &b;
 8 const int * const p3 = &a;
 9 *p3 = 0;
10 p3 = &b
```

REVIEW

Which line of code has an error in the following program?

```
 1 int a = 100, b = 10;
 2 const int *p1 = &a;
 3 p1 = &b;
 4 *p1 = 0;
 5 int * const p2 = &a;
 6 *p2 = 0;
 7 p2 = &b;
 8 const int * const p3 = &a;
 9 *p3 = 0;
10 p3 = &b
```

TABLE OF CONTENTS

3.1 CONCEPT AND OPERATION OF STRUCTURES

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.
  - For example: dates, persons, etc.

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.
  - For example: dates, persons, etc.
- Solution: structure

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.
  - For example: dates, persons, etc.
- Solution: structure

```
1 struct Date
2 {
3     int month;
4     int day;
5     int year;
6 }; // Note: semicolon at the end
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.
  - For example: dates, persons, etc.
- Solution: structure

```
1 struct Date
2 {
3     int month;
4     int day;
5     int year;
6 }; // Note: semicolon at the end
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.
  - For example: dates, persons, etc.
- Solution: structure

```
1 struct Date
2 {
3     int month;
4     int day;
5     int year;
6 }; // Note: semicolon at the end
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

- The limitation of single-value data types
  - Object attributes are often not single values, and batch processing is more complex.
  - For example: dates, persons, etc.
- Solution: structure

```
1 struct Date
2 {
3     int month;
4     int day;
5     int year;
6 }; // Note: semicolon at the end
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

First declare the structure type, then define variables of that type.

```
1 struct Student {
2     std::string id;
3     std::string name;
4     char gender; // 'M' or 'F'
5     unsigned int age;
6     double score;
7     std::string address;
8 };
9 Student student1, student2;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

First declare the structure type, then define variables of that type.

```
1 struct Student {
2     std::string id;
3     std::string name;
4     char gender; // 'M' or 'F'
5     unsigned int age;
6     double score;
7     std::string address;
8 };
9 Student student1, student2;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

First declare the structure type, then define variables of that type.

```
1 struct Student {
2     std::string id;
3     std::string name;
4     char gender; // 'M' or 'F'
5     unsigned int age;
6     double score;
7     std::string address;
8 };
9 Student student1, student2;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

First declare the structure type, then define variables of that type.

```
1 struct Student {
2     std::string id;
3     std::string name;
4     char gender; // 'M' or 'F'
5     unsigned int age;
6     double score;
7     std::string address;
8 };
9 Student student1, student2;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

First declare the structure type, then define variables of that type.

```
1 struct Student {
2     std::string id;
3     std::string name;
4     char gender; // 'M' or 'F'
5     unsigned int age;
6     double score;
7     std::string address;
8 };
9 Student student1, student2;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

3.1 CONCEPT AND OPERATION OF STRUCTURES

- Structure type and structure variable are different concepts

3.1 CONCEPT AND OPERATION OF STRUCTURES

- Structure type and structure variable are different concepts
  - What is a type? What is a variable?

3.1 CONCEPT AND OPERATION OF STRUCTURES

- Structure type and structure variable are different concepts
  - What is a type? What is a variable?
  - It can be simply understood that: type is a collection, variable is an element in the collection

3.1 CONCEPT AND OPERATION OF STRUCTURES

- Structure type and structure variable are different concepts
  - What is a type? What is a variable?
  - It can be simply understood that: type is a collection, variable is an element in the collection
- Member names in a structure type can be the same as variable names, but they have different meanings

3.1 CONCEPT AND OPERATION OF STRUCTURES

- Structure type and structure variable are different concepts
  - What is a type? What is a variable?
  - It can be simply understood that: type is a collection, variable is an element in the collection
- Member names in a structure type can be the same as variable names, but they have different meanings
- Member variables can be used individually, and their role and status are equivalent to ordinary variables

3.1 CONCEPT AND OPERATION OF STRUCTURES

```
 1 struct Student {
 2     std::string id;
 3     std::string name;
 4     char gender;
 5     std::string address;
 6 };
 7
 8 Student a = {"10101", "Alice", 'F', "Taiyuan"};
 9 std::cout << a.id << ", "
10           << a.name << ", "
11           << a.gender << ", "
12           << a.address << std::endl;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

```cpp
struct Student {
    std::string id;
    std::string name;
    char gender;
    std::string address;
};

Student a = {"10101", "Alice", 'F', "Taiyuan"};
std::cout << a.id << ", "
          << a.name << ", "
          << a.gender << ", "
          << a.address << std::endl;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

```cpp
struct Student {
    std::string id;
    std::string name;
    char gender;
    std::string address;
};

Student a = {"10101", "Alice", 'F', "Taiyuan"};
std::cout << a.id << ", "
          << a.name << ", "
          << a.gender << ", "
          << a.address << std::endl;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

```
 1 struct Student {
 2     std::string id;
 3     std::string name;
 4     char gender;
 5     std::string address;
 6 };
 7
 8 Student a = {"10101", "Alice", 'F', "Taiyuan"};
 9 std::cout << a.id << ", "
10           << a.name << ", "
11           << a.gender << ", "
12           << a.address << std::endl;
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

Another method (not recommended)

```
1 struct Student {
2   std::string name;
3   char gender;
4 } stu = {"Bob", 'M'};
```

3.1 CONCEPT AND OPERATION OF STRUCTURES

Another method (not recommended)

```
1 struct Student {
2   std::string name;
3   char gender;
4 } stu = {"Bob", 'M'};
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
1  #include <iostream>
2
3  using namespace std;
4
5  struct Person {
6      string name;
7      string id;
8      double salary;
9  };
10
11 int main() {
12     Person person1, person2;
13     Person *ptr1 = &person1;
14     ptr1→name = "Eric";
15     ptr1→id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
1  #include <iostream>
2
3  using namespace std;
4
5  struct Person {
6      string name;
7      string id;
8      double salary;
9  };
10
11 int main() {
12     Person person1, person2;
13     Person *ptr1 = &person1;
14     ptr1->name = "Eric";
15     ptr1->id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
#include <iostream>

using namespace std;

struct Person {
    string name;
    string id;
    double salary;
};

int main() {
    Person person1, person2;
    Person *ptr1 = &person1;
    ptr1->name = "Eric";
    ptr1->id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
#include <iostream>

using namespace std;

struct Person {
    string name;
    string id;
    double salary;
};

int main() {
    Person person1, person2;
    Person *ptr1 = &person1;
    ptr1->name = "Eric";
    ptr1->id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
1  #include <iostream>
2
3  using namespace std;
4
5  struct Person {
6      string name;
7      string id;
8      double salary;
9  };
10
11 int main() {
12     Person person1, person2;
13     Person *ptr1 = &person1;
14     ptr1→name = "Eric";
15     ptr1→id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
1  #include <iostream>
2
3  using namespace std;
4
5  struct Person {
6      string name;
7      string id;
8      double salary;
9  };
10
11 int main() {
12     Person person1, person2;
13     Person *ptr1 = &person1;
14     ptr1->name = "Eric";
15     ptr1->id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

The structure is just a way to organize data: the actual data is stored in member variables. However, there can be pointers to structures

```
1  #include <iostream>
2
3  using namespace std;
4
5  struct Person {
6      string name;
7      string id;
8      double salary;
9  };
10
11 int main() {
12     Person person1, person2;
13     Person *ptr1 = &person1;
14     ptr1->name = "Eric";
15     ptr1->id = "1234004321";
```

3.2 STRUCTURES AND POINTERS

If you need to pass a structure as a function parameter, generally use pointers or references. Otherwise, performance issues may occur.

3.3 STRUCTURES AND ARRAYS

The same usage as basic data types.

```
 1 struct Person {
 2     string name;
 3     unsigned int age;
 4 };
 5
 6 int main() {
 7     Person group[3] = {
 8         {"Bob", 20},
 9         {"Alice", 30},
10         {"Eric", 40}};
11     Person *p = group;
12     return 0;
13 }
```

3.3 STRUCTURES AND ARRAYS

The same usage as basic data types.

```
 1 struct Person {
 2     string name;
 3     unsigned int age;
 4 };
 5
 6 int main() {
 7     Person group[3] = {
 8         {"Bob", 20},
 9         {"Alice", 30},
10         {"Eric", 40}};
11     Person *p = group;
12     return 0;
13 }
```

3.3 STRUCTURES AND ARRAYS

The same usage as basic data types.

```
 1 struct Person {
 2     string name;
 3     unsigned int age;
 4 };
 5
 6 int main() {
 7     Person group[3] = {
 8         {"Bob", 20},
 9         {"Alice", 30},
10         {"Eric", 40}};
11     Person *p = group;
12     return 0;
13 }
```

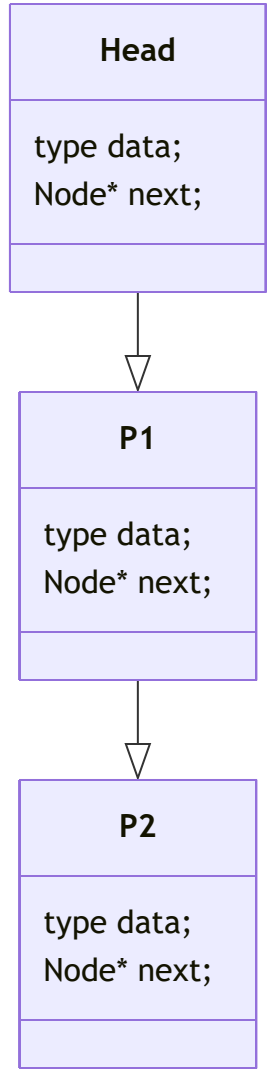
3.3 STRUCTURES AND ARRAYS

The same usage as basic data types.

```
 1 struct Person {
 2     string name;
 3     unsigned int age;
 4 };
 5
 6 int main() {
 7     Person group[3] = {
 8         {"Bob", 20},
 9         {"Alice", 30},
10         {"Eric", 40}};
11     Person *p = group;
12     return 0;
13 }
```

3.4 LINKED LISTS

WHAT IS A LINKED LIST?



3.4 LINKED LISTS

WHAT IS A LINKED LIST?

3.4 LINKED LISTS

WHAT IS A LINKED LIST?

- A linked list consists of several nodes

3.4 LINKED LISTS

WHAT IS A LINKED LIST?

- A linked list consists of several nodes
- Each node contains two members:

3.4 LINKED LISTS

WHAT IS A LINKED LIST?

- A linked list consists of several nodes
- Each node contains two members:
  - Data (can be other structures)

3.4 LINKED LISTS

WHAT IS A LINKED LIST?

- A linked list consists of several nodes
- Each node contains two members:
  - Data (can be other structures)
  - Pointer to the next node

3.4 LINKED LISTS

WHAT IS A LINKED LIST?

- A linked list consists of several nodes
- Each node contains two members:
  - Data (can be other structures)
  - Pointer to the next node
- A null pointer represents an empty linked list

3.4 LINKED LISTS

```
1 struct Node {
2     int data;
3     Node* next;
4 };
```

3.4 LINKED LISTS

```
1 struct Node {
2     int data;
3     Node* next;
4 };
```

3.4 LINKED LISTS

Create a linked list:

```
Node* makeList() {
    return nullptr; // Do Not use NULL
}
```

3.4 LINKED LISTS

prepend:

```
1 Node *prepend(Node *list, const int element) {
2   Node *head = new Node();
3   head→data = element;
4   head→next = list;
5   return head;
6 }
```

3.4 LINKED LISTS

prepend:

```
1 Node *prepend(Node *list, const int element) {
2   Node *head = new Node();
3   head→data = element;
4   head→next = list;
5   return head;
6 }
```

3.4 LINKED LISTS

prepend:

```
1 Node *prepend(Node *list, const int element) {
2   Node *head = new Node();
3   head→data = element;
4   head→next = list;
5   return head;
6 }
```

3.4 LINKED LISTS

prepend:

```
1 Node *prepend(Node *list, const int element) {
2   Node *head = new Node();
3   head→data = element;
4   head→next = list;
5   return head;
6 }
```

3.4 LINKED LISTS

prepend:

```
1 Node *prepend(Node *list, const int element) {
2   Node *head = new Node();
3   head→data = element;
4   head→next = list;
5   return head;
6 }
```

3.4 LINKED LISTS

print:

```
 1 void printList(const Node *list) {
 2   std::cout << "[";
 3   const Node *head = list;
 4   while (head ≠ nullptr) {
 5     std::cout << head→data;
 6     if (head→next ≠ nullptr) {
 7       std::cout << ", ";
 8     }
 9     head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
1  void printList(const Node *list) {
2    std::cout << "[";
3    const Node *head = list;
4    while (head ≠ nullptr) {
5      std::cout << head→data;
6      if (head→next ≠ nullptr) {
7        std::cout << ", ";
8      }
9      head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
1  void printList(const Node *list) {
2    std::cout << "[";
3    const Node *head = list;
4    while (head ≠ nullptr) {
5      std::cout << head→data;
6      if (head→next ≠ nullptr) {
7        std::cout << ", ";
8      }
9      head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
1  void printList(const Node *list) {
2    std::cout << "[";
3    const Node *head = list;
4    while (head ≠ nullptr) {
5      std::cout << head→data;
6      if (head→next ≠ nullptr) {
7        std::cout << ", ";
8      }
9      head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
1  void printList(const Node *list) {
2    std::cout << "[";
3    const Node *head = list;
4    while (head ≠ nullptr) {
5      std::cout << head→data;
6      if (head→next ≠ nullptr) {
7        std::cout << ", ";
8      }
9      head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
 1 void printList(const Node *list) {
 2   std::cout << "[";
 3   const Node *head = list;
 4   while (head ≠ nullptr) {
 5     std::cout << head→data;
 6     if (head→next ≠ nullptr) {
 7       std::cout << ", ";
 8     }
 9     head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
1  void printList(const Node *list) {
2    std::cout << "[";
3    const Node *head = list;
4    while (head ≠ nullptr) {
5      std::cout << head→data;
6      if (head→next ≠ nullptr) {
7        std::cout << ", ";
8      }
9      head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

print:

```
1  void printList(const Node *list) {
2    std::cout << "[";
3    const Node *head = list;
4    while (head ≠ nullptr) {
5      std::cout << head→data;
6      if (head→next ≠ nullptr) {
7        std::cout << ", ";
8      }
9      head = head→next;
10   }
11   std::cout << "]";
12 }
```

3.4 LINKED LISTS

free:

```
1 void freeList(Node *list) {
2   while (list ≠ nullptr) {
3     Node *next = list→next;
4     delete list;
5     list = next;
6   }
7 }
```

3.4 LINKED LISTS

free:

```
1 void freeList(Node *list) {
2   while (list ≠ nullptr) {
3     Node *next = list→next;
4     delete list;
5     list = next;
6   }
7 }
```

3.4 LINKED LISTS

free:

```
1 void freeList(Node *list) {
2   while (list ≠ nullptr) {
3     Node *next = list→next;
4     delete list;
5     list = next;
6   }
7 }
```

3.4 LINKED LISTS

free:

```
1 void freeList(Node *list) {
2   while (list ≠ nullptr) {
3     Node *next = list→next;
4     delete list;
5     list = next;
6   }
7 }
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode→data = element;
7        newNode→next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode->data = element;
7        newNode->next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode→data = element;
7        newNode→next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode→data = element;
7        newNode→next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
 1 Node *insert(Node *list, int element, size_t index) {
 2   if (list == nullptr) {
 3     // empty list
 4     if (index == 0) {
 5       Node *newNode = new Node();
 6       newNode->data = element;
 7       newNode->next = nullptr;
 8       return newNode;
 9     }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode->data = element;
7        newNode->next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode->data = element;
7        newNode->next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode->data = element;
7        newNode->next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode->data = element;
7        newNode->next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

insert:

```
1  Node *insert(Node *list, int element, size_t index) {
2    if (list == nullptr) {
3      // empty list
4      if (index == 0) {
5        Node *newNode = new Node();
6        newNode->data = element;
7        newNode->next = nullptr;
8        return newNode;
9      }
10     return list; // Fail, should thrown exception
11   }
12
13   Node *prev = nullptr;
14   Node *next = list;
15   while (index > 0) {
```

3.4 LINKED LISTS

remove, length, find ...

3.4 LINKED LISTS

remove, length, find ...

- If you need a linked list, it is recommended to use `std::list` (double-linked list)

3.4 LINKED LISTS

remove, length, find ...

- If you need a linked list, it is recommended to use `std::list` (double-linked list)
- If you need to implement it manually, it is recommended to use `std::shared_ptr` (smart pointer)

3.4 LINKED LISTS

remove, length, find ...

- If you need a linked list, it is recommended to use `std::list` (double-linked list)
- If you need to implement it manually, it is recommended to use `std::shared_ptr` (smart pointer)
- Extended reading: Cons List, reference implementation: `demo/consList`

3.4 LINKED LISTS

remove, length, find ...

- If you need a linked list, it is recommended to use `std::list` (double-linked list)
- If you need to implement it manually, it is recommended to use `std::shared_ptr` (smart pointer)
- Extended reading: Cons List, reference implementation: `demo/consList`

`example/lec03/list`

3.4 LINKED LISTS

remove, length, find ...

- If you need a linked list, it is recommended to use `std::list` (double-linked list)
- If you need to implement it manually, it is recommended to use `std::shared_ptr` (smart pointer)
- Extended reading: Cons List, reference implementation: `demo/consList`

`example/lec03/list`

`example/lec03/smartList`

3.5 FROM STRUCTURES TO CLASSES

3.5 FROM STRUCTURES TO CLASSES

- Some functions need to manipulate specific data, and the data needs to be passed in each time:

3.5 FROM STRUCTURES TO CLASSES

- Some functions need to manipulate specific data, and the data needs to be passed in each time:
  - `Node *prepend(Node *list, ...)`

3.5 FROM STRUCTURES TO CLASSES

- Some functions need to manipulate specific data, and the data needs to be passed in each time:
  - `Node *prepend(Node *list, ...)`
  - `Node *insert(Node *list, ...)`

3.5 FROM STRUCTURES TO CLASSES

- Some functions need to manipulate specific data, and the data needs to be passed in each time:
  - `Node *prepend(Node *list, ...)`
  - `Node *insert(Node *list, ...)`
  - `void freeList(Node *list)`

3.5 FROM STRUCTURES TO CLASSES

- Some functions need to manipulate specific data, and the data needs to be passed in each time:
  - `Node *prepend(Node *list, ...)`
  - `Node *insert(Node *list, ...)`
  - `void freeList(Node *list)`
- At the language level, data and its operations are not associated

3.5 FROM STRUCTURES TO CLASSES

3.5 FROM STRUCTURES TO CLASSES

- Some data do not want to be exposed to the caller (internal implementation)

3.5 FROM STRUCTURES TO CLASSES

- Some data do not want to be exposed to the caller (internal implementation)
  - Internal changes do not affect external calls

3.5 FROM STRUCTURES TO CLASSES

- Some data do not want to be exposed to the caller (internal implementation)
  - Internal changes do not affect external calls
  - External errors are easier to debug

3.5 FROM STRUCTURES TO CLASSES

Introducing the concept of classes:

3.5 FROM STRUCTURES TO CLASSES

Introducing the concept of classes:

- Data and operations are bound together

3.5 FROM STRUCTURES TO CLASSES

Introducing the concept of classes:

- Data and operations are bound together
- Control over data access

3.5 FROM STRUCTURES TO CLASSES

```
class Point {
    // data field, default is private
    int x;
    int y;
public:
    // Functions in class (methods)
    void print() {
        cout << '(' << x << ", " << ')';
    }
};
```

3.5 FROM STRUCTURES TO CLASSES

3.5 FROM STRUCTURES TO CLASSES

- A class is a data type, and an object is an instance of the corresponding class

3.5 FROM STRUCTURES TO CLASSES

- A class is a data type, and an object is an instance of the corresponding class
  - An object is a variable of the corresponding data type

3.5 FROM STRUCTURES TO CLASSES

- A class is a data type, and an object is an instance of the corresponding class
  - An object is a variable of the corresponding data type
- A class is a blueprint

3.5 FROM STRUCTURES TO CLASSES

- A class is a data type, and an object is an instance of the corresponding class
  - An object is a variable of the corresponding data type
- A class is a blueprint
  - An object is a specific entity made according to the blueprint

3.5 FROM STRUCTURES TO CLASSES

3.5 FROM STRUCTURES TO CLASSES

- For compatibility reasons, `c++` allows methods to be added to `struct`.

3.5 FROM STRUCTURES TO CLASSES

- For compatibility reasons, `c++` allows methods to be added to `struct`.
- Member variables in `struct` have `public` access by default.

3.6 MEMBER FUNCTIONS

3.6 MEMBER FUNCTIONS

- A class contains member variables and member functions

3.6 MEMBER FUNCTIONS

- A class contains member variables and member functions
- Member variables and member functions are collectively referred to as members of the class

3.6 MEMBER FUNCTIONS

- A class contains member variables and member functions
- Member variables and member functions are collectively referred to as members of the class
- Member variables are sometimes called properties, and member functions are sometimes called methods

3.6 MEMBER FUNCTIONS

- A class contains member variables and member functions
- Member variables and member functions are collectively referred to as members of the class
- Member variables are sometimes called properties, and member functions are sometimes called methods
- They are not required

3.6 MEMBER FUNCTIONS

3.6 MEMBER FUNCTIONS

- In the definition of a class, use the following access range keywords to specify the accessibility of class members:

3.6 MEMBER FUNCTIONS

- In the definition of a class, use the following access range keywords to specify the accessibility of class members:
  - `private`: Private members, can only be accessed within member functions

3.6 MEMBER FUNCTIONS

- In the definition of a class, use the following access range keywords to specify the accessibility of class members:
  - `private`: Private members, can only be accessed within member functions
  - `public` : Public members, can be accessed anywhere

3.6 MEMBER FUNCTIONS

- In the definition of a class, use the following access range keywords to specify the accessibility of class members:
  - `private`: Private members, can only be accessed within member functions
  - `public` : Public members, can be accessed anywhere
  - `protected`: Protected members, will be explained later

3.6 MEMBER FUNCTIONS

- In the definition of a class, use the following access range keywords to specify the accessibility of class members:
  - `private`: Private members, can only be accessed within member functions
  - `public` : Public members, can be accessed anywhere
  - `protected`: Protected members, will be explained later
- The number of occurrences and order of the above three keywords are not limited.

3.6 MEMBER FUNCTIONS

How to define a class?

```
class className {
private:
    // Private properties and methods
public:
    // Public properties and methods
protected:
    // Protected properties and methods
}; // Remember semicolon
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.6 MEMBER FUNCTIONS

```
 1 class Rectangle {
 2 private:
 3     int w, h;
 4 public:
 5     int area() {
 6         return w * h;
 7     }
 8     int perimeter() {
 9         return 2 * (w + h);
10     }
11     void set(int width, int height) {
12         w = width;
13         h = height;
14     }
15 };
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double x, y;
 4 public:
 5     void set(double xCoord, double yCoord) {
 6         x = xCoord;
 7         y = yCoord;
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
1  class Point {
2  private:
3      double x, y;
4  public:
5      void set(double xCoord, double yCoord) {
6          x = xCoord;
7          y = yCoord;
8      }
9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
1  class Point {
2  private:
3      double x, y;
4  public:
5      void set(double xCoord, double yCoord) {
6          x = xCoord;
7          y = yCoord;
8      }
9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
1  class Point {
2  private:
3      double x, y;
4  public:
5      void set(double xCoord, double yCoord) {
6          x = xCoord;
7          y = yCoord;
8      }
9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double x, y;
 4 public:
 5     void set(double xCoord, double yCoord) {
 6         x = xCoord;
 7         y = yCoord;
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double x, y;
 4 public:
 5     void set(double xCoord, double yCoord) {
 6         x = xCoord;
 7         y = yCoord;
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
1  class Point {
2  private:
3      double x, y;
4  public:
5      void set(double xCoord, double yCoord) {
6          x = xCoord;
7          y = yCoord;
8      }
9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double xCoord, double yCoord) {
 6         x = xCoord;
 7         y = yCoord;
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double xCoord, double yCoord) {
 6         x = xCoord;
 7         y = yCoord;
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double x, double y) {
 6         r = std::sqrt(x * x + y * y);
 7         a = std::atan2(y, x);
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double x, double y) {
 6         r = std::sqrt(x * x + y * y);
 7         a = std::atan2(y, x);
 8     }
 9
10     double length() {
11         return std::sqrt(x * x + y * y);
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double x, double y) {
 6         r = std::sqrt(x * x + y * y);
 7         a = std::atan2(y, x);
 8     }
 9
10     double length() {
11         return r;
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double x, double y) {
 6         r = std::sqrt(x * x + y * y);
 7         a = std::atan2(y, x);
 8     }
 9
10     double length() {
11         return r;
12     }
13
14     double angle() {
15         return std::atan2(y, x);
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

```
 1 class Point {
 2 private:
 3     double r, a;
 4 public:
 5     void set(double x, double y) {
 6         r = std::sqrt(x * x + y * y);
 7         a = std::atan2(y, x);
 8     }
 9
10     double length() {
11         return r;
12     }
13
14     double angle() {
15         return a;
```

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

- Internal changes, interface unchanged, will not affect external programs

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

- Internal changes, interface unchanged, will not affect external programs
  - Decoupling

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

- Internal changes, interface unchanged, will not affect external programs
  - Decoupling
- Easier to locate errors

3.7 HIDING THE INTERNAL IMPLEMENTATION OF CLASSES

- Internal changes, interface unchanged, will not affect external programs
  - Decoupling
- Easier to locate errors
  - No need to consider that external programs may have changed private properties without knowing

HOMEWORK

Create a linked list that stores chars with structures.

Need to implement following methods:

- `void display(List*)`
- `void prepend(List*, char c)`
- `void append(List*, char c)`
- `int size(List*)`
- `void remove(List*, int index)`
- `void free(List*)`

Do not use AI, I can tell the differences between AI generate codes and yours. Do not copy.