SFU

Intro to C++ Classes

CMPT 125
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SFU Computing Science
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Lecture 23

Today

- Why not C `struct`? Why C++ `class`?
- C++ Encapsulation
- C++ Information Hiding

Marrying Data and Functions (Review)

Encapsulation

- bundle related data and operations together

Forge a language construct that joins data and operations together

- ~~use a `struct`~~! use a `class`! (C++)
- make the functions part of the data type explicitly
  - called *methods*
- similar idea to an *object* in Python

Adds another level of protection against misuse

```
typedef struct _queue {
    LL_t * intlist;
} queue_t;

queue_t * queue_create(void);
void queue_destroy(queue_t * q);
int queue_isEmpty(queue_t * q);
void queue_enqueue(queue_t * q, int element);
int queue_dequeue(queue_t * q);
```

ORIGINAL

```
typedef struct _queue {
    LL_t * intlist;
    void queue_destroy(queue_t * q);
    int queue_isEmpty(queue_t * q);
    void queue_enqueue(queue_t * q, int element);
    int queue_dequeue(queue_t * q);
} queue_t;

queue_t * queue_create(void);
```

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typedef struct _queue {
    LL_t * intlist;
} queue_t;

queue_t * queue_create(void);
void queue_destroy(queue_t * q);
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int queue_dequeue(queue_t * q);
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ORIGINAL

```
typedef struct _queue {
    LL_t * intlist;
    void queue_destroy(struct _queue * q);
    int queue_isEmpty(struct _queue * q);
    void queue_enqueue(struct _queue * q, int element);
    int queue_dequeue(struct _queue * q);
} queue_t;

queue_t * queue_create(void);
```

```
typedef struct _queue {
    LL_t * intlist;
} queue_t;

queue_t * queue_create(void);
void queue_destroy(queue_t * q);
int queue_isEmpty(queue_t * q);
void queue_enqueue(queue_t * q, int element);
int queue_dequeue(queue_t * q);
```

ORIGINAL

```
typedef struct _queue {
    LL_t * intlist;
    void ( * destroy) (struct _queue * q);
    int ( * isEmpty) (struct _queue * q);
    void ( * enqueue) (struct _queue * q, int element);
    int ( * dequeue) (struct _queue * q);
} queue_t;

queue_t * queue_create(void);
```

Pointer to a function rather than the function itself

Caller's notation:

```
Q->enqueue(Q, x);
```

A Look Ahead to C++

Motivated by these interface issues,

C++ evolved out of C.

- formulated by Bjarne Stroustrop in 1978

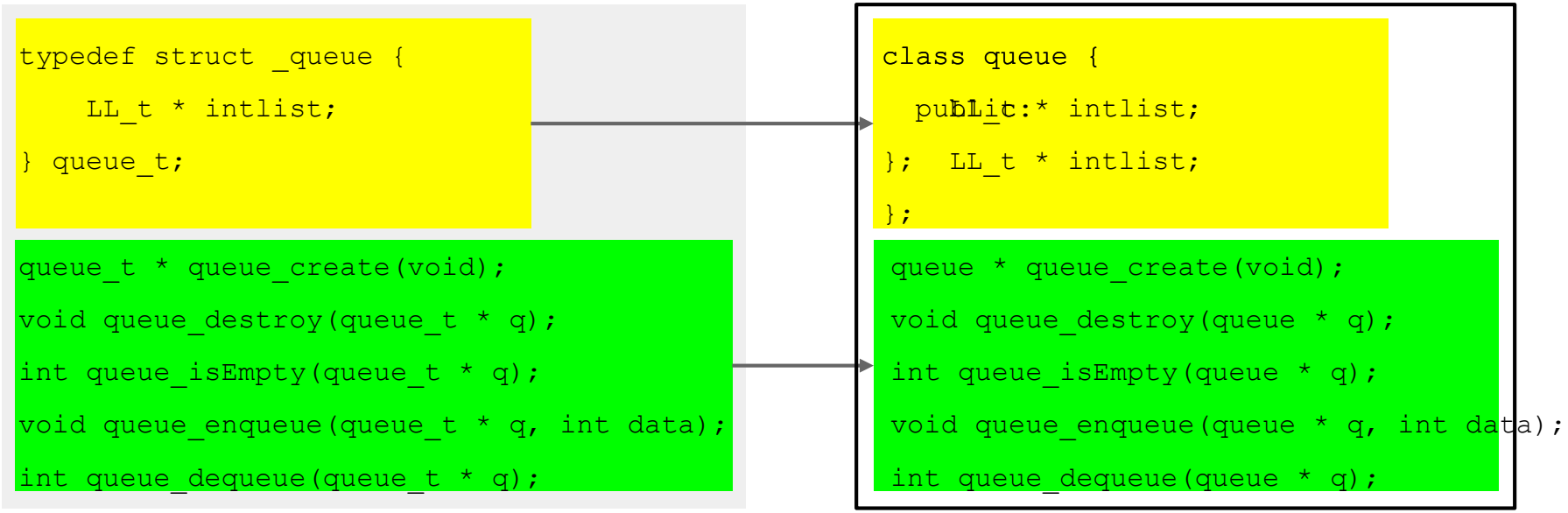
Bjarne Stroustrop

Provides the syntactic sugar for:

- information hiding
- encapsulation of data and methods
- common code re-use situations

Migrate from `struct` → `class`

Step 1: The `class` / `public` Keywords



Instead of: `typedef struct { … } queue_t;`

Use: `class queue { … };`

Adjust types from `queue_t` → `queue`

Add the `public:` keyword (just until we get to Step 4)

Step 2: Add The Methods

```
class queue {
  public:
    LL_t * intlist;
};
queue * queue_create(void);
void queue_destroy(queue * q);
int queue_isEmpty(queue * q);
void queue_enqueue(queue * q, int data);
int queue_dequeue(queue * q);
```

```
class queue {
  public:
    LL_t * intlist;
    int queue_isEmpty(queue * q);
    void queue_enqueue(queue * q, int data);
    int queue_dequeue(queue * q);
};
queue * queue_create(void);
void queue_destroy(queue * q);
```

Migrate the functions into the class definition → *methods*

- except for `_create()` and `_destroy()` which are special cases

Remove the `queue_` prefix from method names

Step 2: Add The Methods

```
class queue {
  public:
    LL_t * intlist;
};
queue * queue_create(void);
void queue_destroy(queue * q);
int queue_isEmpty(queue * q);
void queue_enqueue(queue * q, int data);
int queue_dequeue(queue * q);
```

```
class queue {
  public:
    LL_t * intlist;
    int isEmpty(queue * q);
    void enqueue(queue * q, int data);
    int dequeue(queue * q);
};
queue * queue_create(void);
void queue_destroy(queue * q);
```

Migrate the functions into the class definition → *methods*

- except for `_create()` and `_destroy()` which are special cases

Remove the `queue_` prefix from method names

Remove parameter `queue * q`

Step 2: Add The Methods

```
class queue {
  public:
    LL_t * intlist;
};
queue * queue_create(void);
void queue_destroy(queue * q);
int queue_isEmpty(queue * q);
void queue_enqueue(queue * q, int data);
int queue_dequeue(queue * q);
```

```
class queue {
  public:
    LL_t * intlist;
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
queue * queue_create(void);
void queue_destroy(queue * q);
```

Migrate the functions into the class definition → *methods*

- except for `_create()` and `_destroy()` which are special cases

Remove the `queue_` prefix from method names

Remove parameter `queue * q`

- every method has direct access to all fields

Methods can use the C++ keyword `this` if they need such a pointer

Step 3: The `class::` Syntax

```
class queue {
  public:
    LL_t * intlist;
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
queue * queue_create(void);
void queue_destroy(queue * q);
```

(header file `queue.h`)

```
int queue_isEmpty(queue_t * q) {
    return (q->intlist->head == NULL);
}

void queue_enqueue(queue_t * q, int data) {
    LLappend(q->intlist, data);
}

int queue_dequeue(queue_t * q) {
    return LLremoveHead(q->intlist);
}
```

(part of the implementation file `queue.cpp`)

Edit function specifications so they agree with the header

- remove `queue_t * q` for each method

Step 3: The `class::` Syntax

```
class queue {
  public:
    LL_t * intlist;
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
queue * queue_create(void);
void queue_destroy(queue * q);
```

(header file `queue.h`)

```
int queue_isEmpty() {
    return (q->intlist->head == NULL);
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void queue_enqueue(int data) {
    LLappend(q->intlist, data);
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int queue_dequeue() {
    return LLremoveHead(q->intlist);
}
```

(part of the implementation file `queue.cpp`)

Edit function specifications so they agree with the header

- remove `queue_t * q` for each method
- instead of the prefix `queue_`, use `queue::`

Step 3: The `class::` Syntax

```
class queue {
  public:
    LL_t * intlist;
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
queue * queue_create(void);
void queue_destroy(queue * q);
```

(header file `queue.h`)

```
int queue::isEmpty() {
    return (intlist->head == NULL);
}

void queue::enqueue(int data) {
    LLappend(intlist, data);
}

int queue::dequeue() {
    return LLremoveHead(intlist);
}
```

(part of the implementation file `queue.cpp`)

Edit function specifications so they agree with the header

- remove `queue_t * q` for each method
- instead of the prefix `queue_`, use `queue::`

Remove the usage of `q->`

- `intlist` is a member of the class and is treated like a local variable

Some Terminology

A *class* encapsulates data with its functions

- data members → *properties*
- function members → *methods*

An *object* is a specific instance of a class

- E.g., The **class of all cars** have defining properties:
  - colour, make, year, mileage, oil level, etc.

  but **your car** has specific values:
  - white, Matrix, 2008, 145 000 km, 52% oil, etc.

Creation of an object is known as *instantiation*.

Step 4: `private` Members

```
class queue {
  public:
    LL_t * intlist;
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
```

```
class queue {
  private:
    LL_t * intlist;
  public:
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
```

To protect class members from external access, use the `private:` keyword

Rule: All data members should be kept private.

- Operations on them should be possible only via methods
- This is not merely a matter of style. It's a matter of:
  - information hiding
  - code independence

The Rhythm of `_create()` Functions

Every `_create()` function in C so far has followed two steps:

- *allocate* new space on the heap
- *initialize* the data members

```
queue * queue_create() {
    queue * ret = malloc(sizeof(queue));
    if (ret != NULL) {
        ret->intlist = LLcreate();
    }
    return ret;
}
```

(queue.c)

In C++, these two steps are separate:

- allocate an object on the heap using the `new` keyword OR . . .

  declare an object locally

- All created objects are initialized by running a special method called a *constructor*

```
queue * Q = queue_create();
```

(driver.c)

```
queue * Q = new queue;  // heap decl.
queue Q;  // local declaration
```

(options for `driver.cpp`)

Step 5: Add the Constructor

```
class queue {
  private:
    LL_t * intlist;
  public:
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
queue * queue_create(void);
```

(queue.h)

```
class queue {
  private:
    LL_t * intlist;
  public:
    queue(); // constructor
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
```

(queue.h)

```
queue::queue() {
    intlist = LLcreate();
}
```

(queue.cpp)

The constructor method has the same name as the class.

The constructor is always invoked upon instantiation.

- initialize all data members

A constructor can take parameters.

Step 6: Add the Destructor

```
class queue {
  private:
    LL_t * intlist;
  public:
    queue();
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
queue_destroy(queue * q);
```

(queue.h)

```
class queue {
  private:
    LL_t * intlist;
  public:
    queue();
    ~queue(); // destructor
    int isEmpty();
    void enqueue(int data);
    int dequeue();
};
```

(queue.h)

```
queue::~queue() {
    LLdestroy(intlist);
}
```

(queue.cpp)

Destructor is always invoked upon object's destruction.

- either `delete` ~~operation OR . . .~~
- local variable goes out of scope

`new` and `delete` are the inverses of each other

Clean-up procedure for any resources the object held.