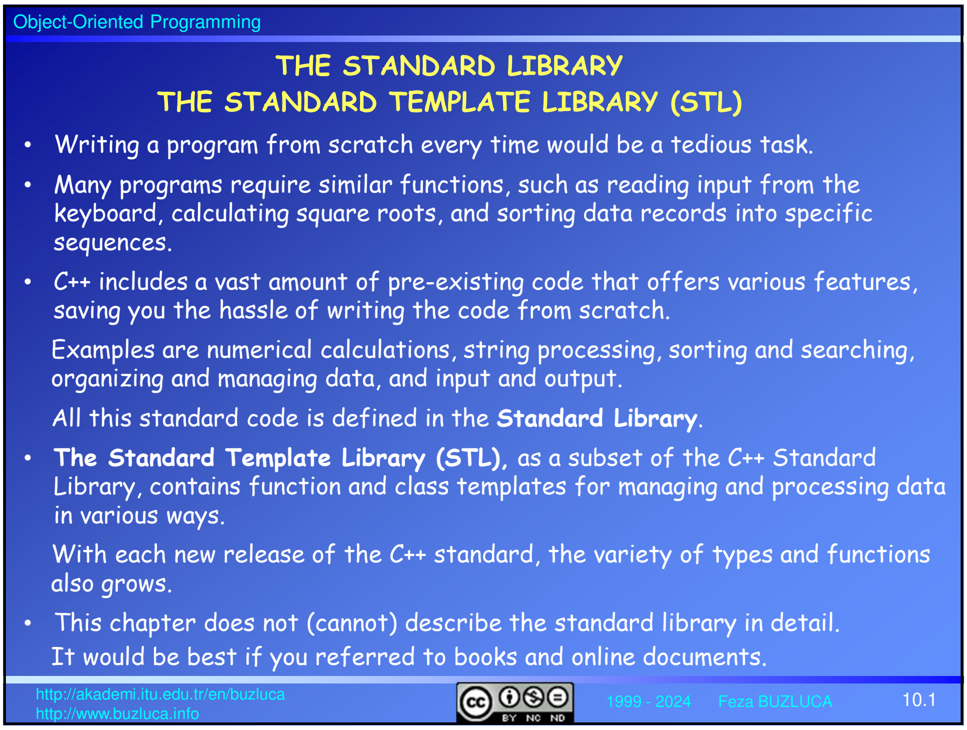


THE STANDARD LIBRARY
THE STANDARD TEMPLATE LIBRARY (STL)

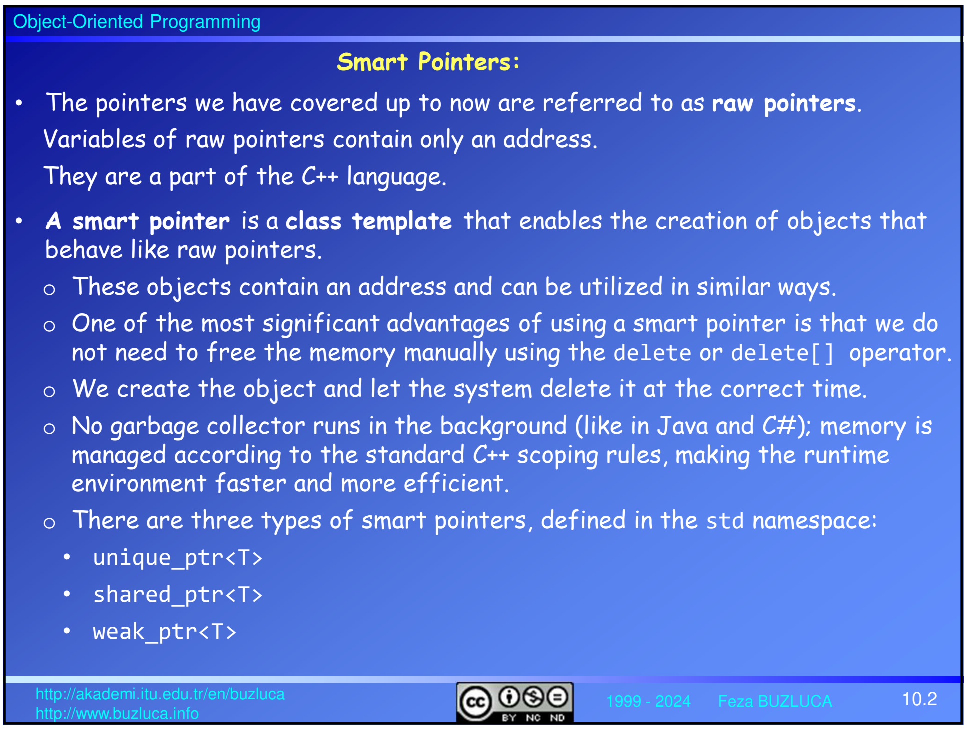
- Writing a program from scratch every time would be a tedious task.
- Many programs require similar functions, such as reading input from the keyboard, calculating square roots, and sorting data records into specific sequences.
- C++ includes a vast amount of pre-existing code that offers various features, saving you the hassle of writing the code from scratch.

  Examples are numerical calculations, string processing, sorting and searching, organizing and managing data, and input and output.

  All this standard code is defined in the **Standard Library**.
- **The Standard Template Library (STL)**, as a subset of the C++ Standard Library, contains function and class templates for managing and processing data in various ways.

  With each new release of the C++ standard, the variety of types and functions also grows.
- This chapter does not (cannot) describe the standard library in detail.

  It would be best if you referred to books and online documents.

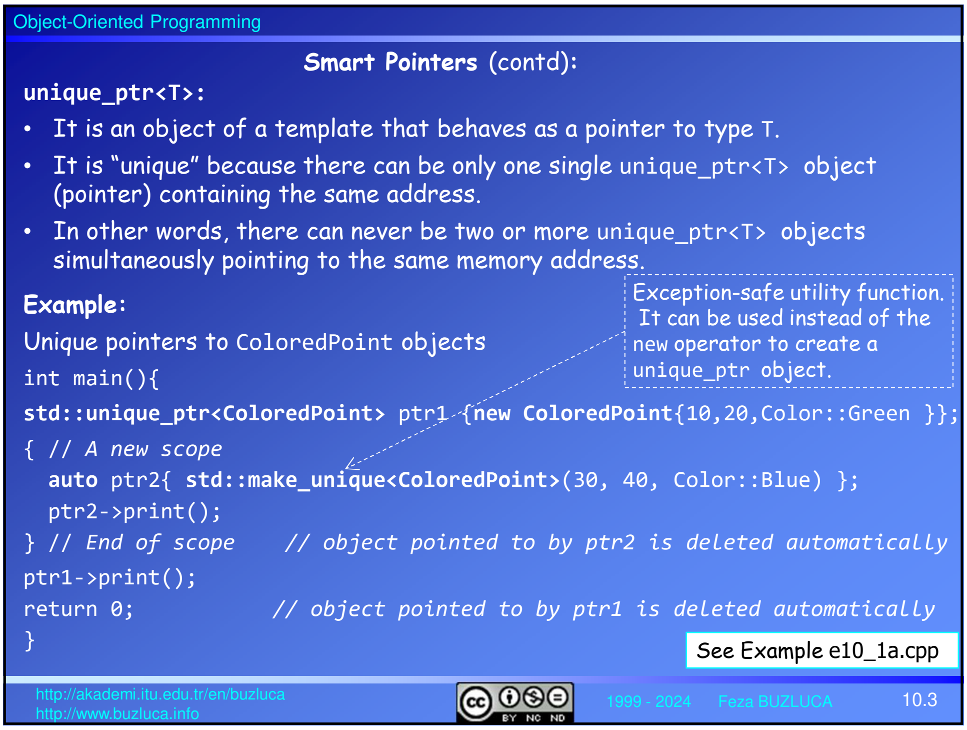


Smart Pointers:

- The pointers we have covered up to now are referred to as **raw pointers**.

  Variables of raw pointers contain only an address.

  They are a part of the C++ language.
- **A smart pointer** is a **class template** that enables the creation of objects that behave like raw pointers.
  - These objects contain an address and can be utilized in similar ways.
  - One of the most significant advantages of using a smart pointer is that we do not need to free the memory manually using the `delete` or `delete[]` operator.
  - We create the object and let the system delete it at the correct time.
  - No garbage collector runs in the background (like in Java and C#); memory is managed according to the standard C++ scoping rules, making the runtime environment faster and more efficient.
  - There are three types of smart pointers, defined in the `std` namespace:
    - `unique_ptr<T>`
    - `shared_ptr<T>`
    - `weak_ptr<T>`



Smart Pointers (contd):

`unique_ptr<T>`:

- It is an object of a template that behaves as a pointer to type T.
- It is "unique" because there can be only one single `unique_ptr<T>` object (pointer) containing the same address.
- In other words, there can never be two or more `unique_ptr<T>` objects simultaneously pointing to the same memory address.

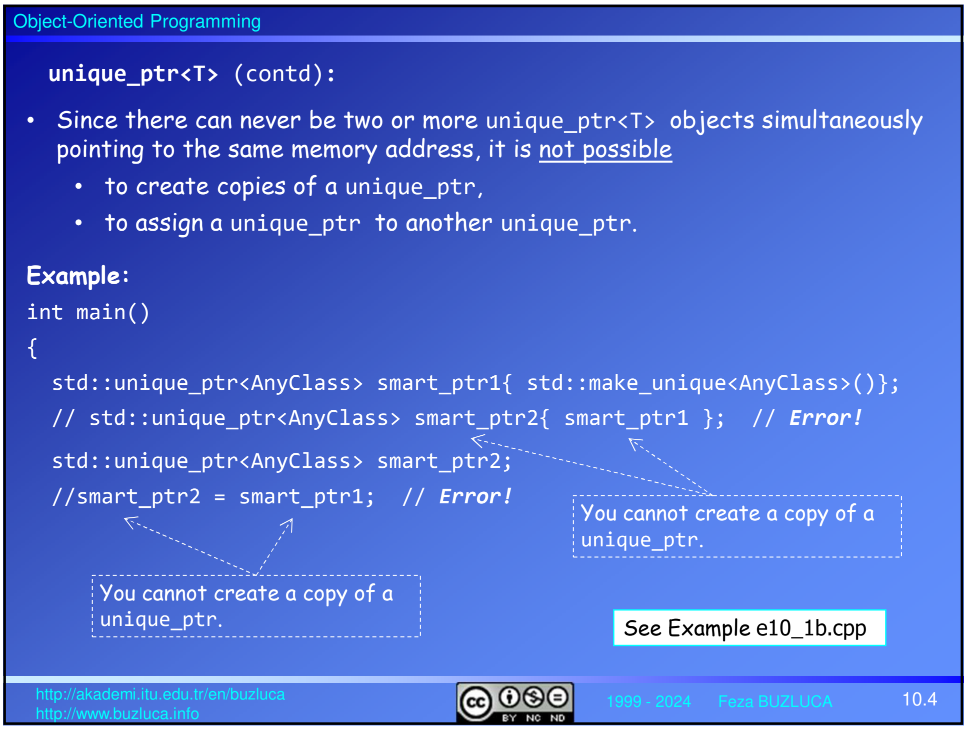
Example:

Unique pointers to ColoredPoint objects

```
int main(){
std::unique_ptr<ColoredPoint> ptr1 {new ColoredPoint{10,20,Color::Green }};
{ // A new scope
  auto ptr2{ std::make_unique<ColoredPoint>(30, 40, Color::Blue) };
  ptr2->print();
} // End of scope    // object pointed to by ptr2 is deleted automatically
ptr1->print();
return 0;           // object pointed to by ptr1 is deleted automatically
}
```

Exception-safe utility function. It can be used instead of the new operator to create a unique_ptr object.

See Example e10_1a.cpp



`unique_ptr<T>` (contd):

- Since there can never be two or more `unique_ptr<T>` objects simultaneously pointing to the same memory address, it is not possible
  - to create copies of a unique_ptr,
  - to assign a unique_ptr to another unique_ptr.

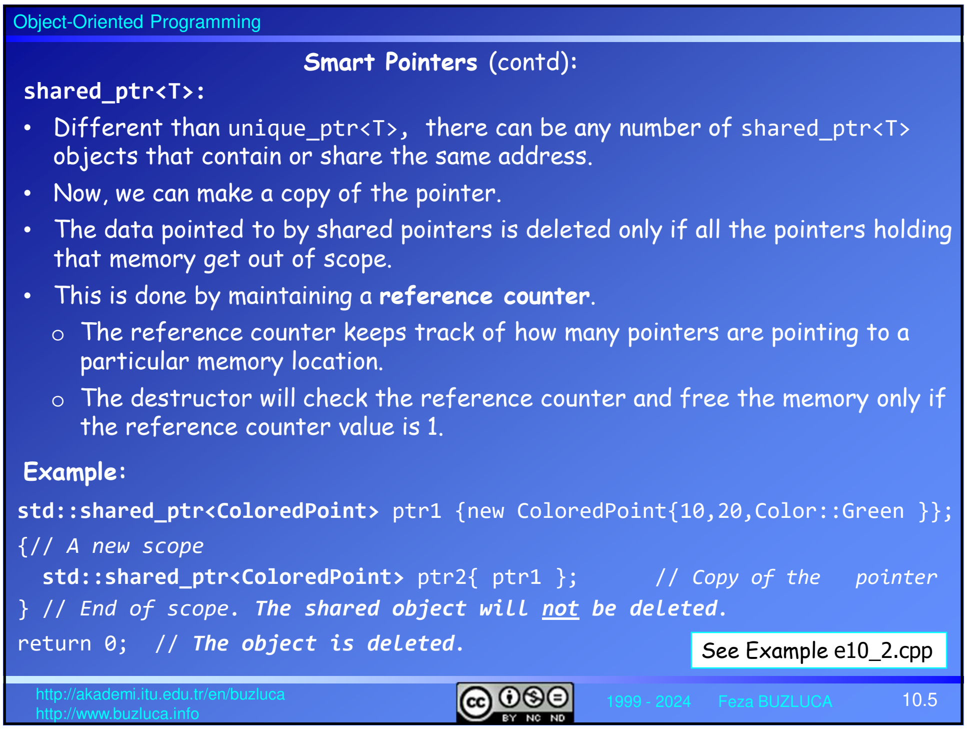
Example:

```
int main()
{
  std::unique_ptr<AnyClass> smart_ptr1{ std::make_unique<AnyClass>()};
  // std::unique_ptr<AnyClass> smart_ptr2{ smart_ptr1 };  // Error!
  std::unique_ptr<AnyClass> smart_ptr2;
  //smart_ptr2 = smart_ptr1;  // Error!
```

You cannot create a copy of a unique_ptr.

You cannot create a copy of a unique_ptr.

See Example e10_1b.cpp



Smart Pointers (contd):

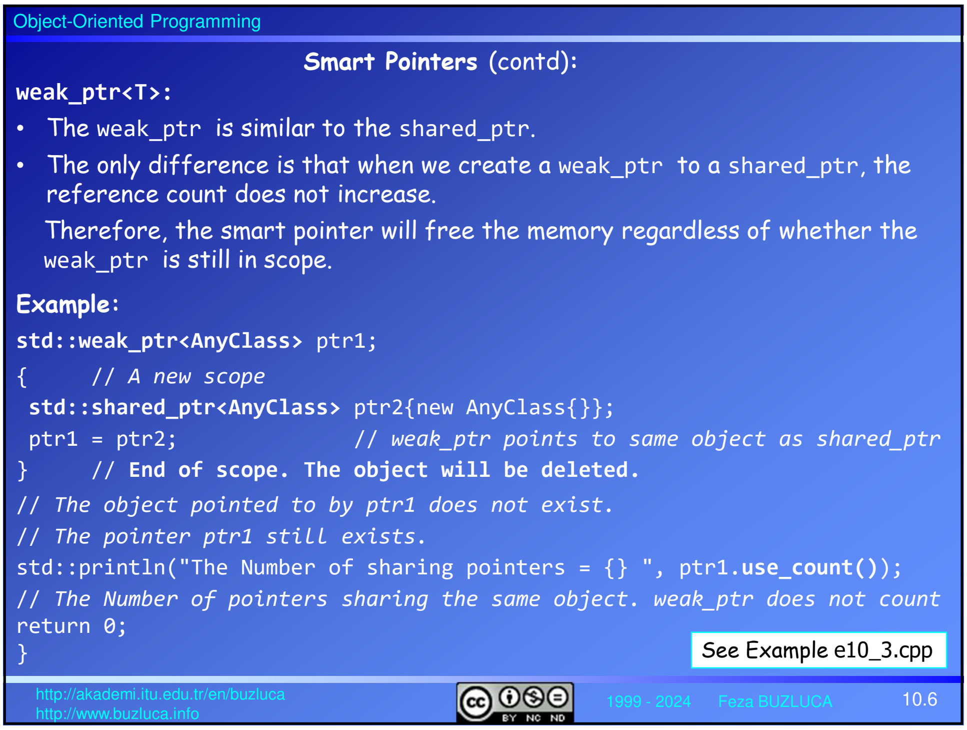
shared_ptr<T>:

- Different than unique_ptr<T>, there can be any number of shared_ptr<T> objects that contain or share the same address.
- Now, we can make a copy of the pointer.
- The data pointed to by shared pointers is deleted only if all the pointers holding that memory get out of scope.
- This is done by maintaining a **reference counter**.
  - The reference counter keeps track of how many pointers are pointing to a particular memory location.
  - The destructor will check the reference counter and free the memory only if the reference counter value is 1.

Example:

```
std::shared_ptr<ColoredPoint> ptr1 {new ColoredPoint{10,20,Color::Green }};
{// A new scope
  std::shared_ptr<ColoredPoint> ptr2{ ptr1 };      // Copy of the   pointer
} // End of scope. The shared object will not be deleted.
return 0;  // The object is deleted.
```

See Example e10_2.cpp



Smart Pointers (contd):

weak_ptr<T>:

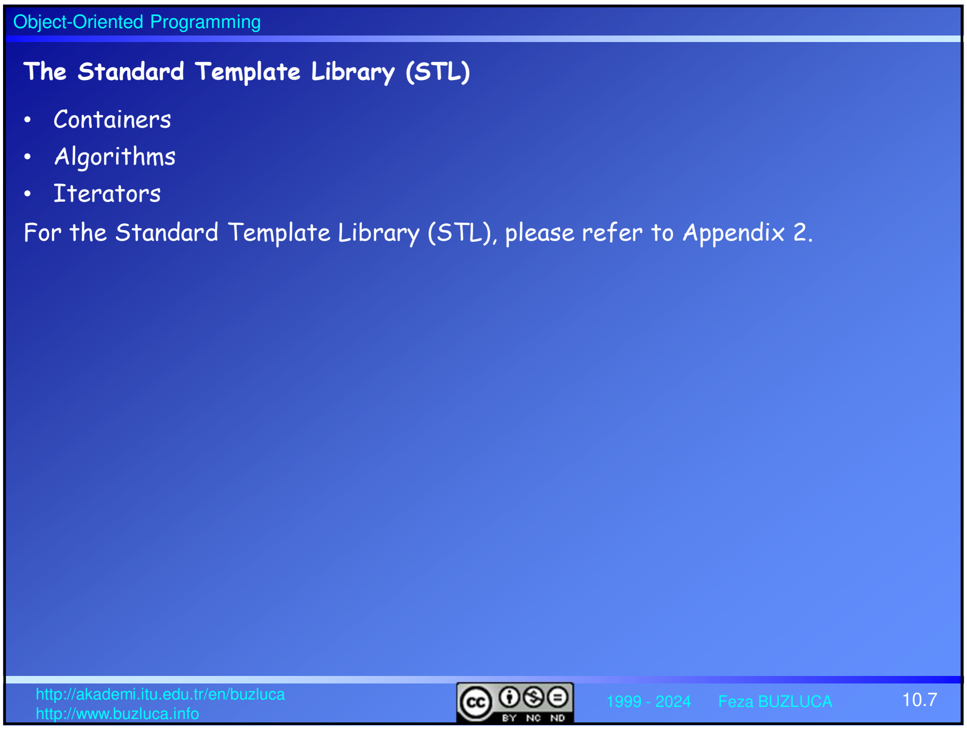
- The weak_ptr is similar to the shared_ptr.
- The only difference is that when we create a weak_ptr to a shared_ptr, the reference count does not increase.

  Therefore, the smart pointer will free the memory regardless of whether the weak_ptr is still in scope.

Example:

```
std::weak_ptr<AnyClass> ptr1;
{     // A new scope
 std::shared_ptr<AnyClass> ptr2{new AnyClass{}};
 ptr1 = ptr2;                // weak_ptr points to same object as shared_ptr
}     // End of scope. The object will be deleted.
// The object pointed to by ptr1 does not exist.
// The pointer ptr1 still exists.
std::println("The Number of sharing pointers = {} ", ptr1.use_count());
// The Number of pointers sharing the same object. weak_ptr does not count
return 0;
}
```

See Example e10_3.cpp



The Standard Template Library (STL)

- Containers
- Algorithms
- Iterators

For the Standard Template Library (STL), please refer to Appendix 2.