Layering a Component
A Detailed Example
Using the Queue

Part 1 – Public Interface

The Top Part of the File

```
// Filename: Queue2.hpp
#pragma once
#include “List\List1.hpp”

template <class T>
class Queue2
{
public: // Standard Operations
   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

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   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The filename:

- Use the component name for the filename
- Append a number to the end of the component name to distinguish it from other implementations of the same component
- Use the filename extension .hpp for a template class component in C++

The Top Part of the File

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   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The preprocessor directives:

`#pragma once`

- Tells the C preprocessor to only include this file one time into the the target .cpp file that is being compiled
- This eliminates *redefinition* compiler errors
- It is a non-standard but widely supported preprocessor directive
- If this directive is not available, then use `#ifdef .. #endif` directives

The Top Part of the File

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   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The preprocessor directives:

#include

- Include the other component (or components) upon which this current component is going to be layered
- For this example we are going to layer Queue on top of a List component

The Top Part of the File

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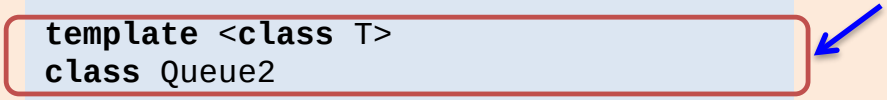
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```



The component definition begins with:

- Template parameters
- Component’s name

The Top Part of the File

```
// Filename: Queue2.hpp
#pragma once
#include "List\List1.hpp"

template <class T>
class Queue2
   //! is modeled by string of T
   //!   exemplar self
{
public: // Standard Operations
   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The component's abstraction introduces the *mathematical model* used for reasoning abstractly about variables declared from the component

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   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
      //! updates self
      //! replaces x
      //! requires: self /= <>
      //! ensures: <x> is prefix of #self and
      //! self = #self[1, |#self|)
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The abstraction also includes the *requires* & *ensures* clauses for each exported operation

dequeue's external contract is shown here

external contract:

- consists of the *requires* and *ensures* clause for an operation
- specifies the behavior required of the calling client (in the *requires* clause) and the service provided by the called operation (*ensures* clause)

For example:

- *dequeue*'s *requires* clause dictates that the client call *dequeue* when the queue is not empty
- the *ensures* clause dictates that the front item on the queue will be removed and produced back to the the caller through parameter *x*

The Exported Operations

```
// Filename: Queue2.hpp
#pragma once
#include “List\List1.hpp”

template <class T>
class Queue2
{
public: // Standard Operations
   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

`public:`

- This keyword tells the compiler that the member functions that follow can be called by the client program
- These are the *exported member functions* – i.e., those operations that are callable by a client program

The Exported Operations

```
// Filename: Queue2.hpp
#pragma once
#include "List\List1.hpp"

template <class T>
class Queue2
{
public: // Standard Operations
   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

member functions:

- *Member function* is the name used in C++ to refer to the operations that are members of a class or a template class
- In this example there are 5 *standard* member functions and 5 *Queue specific* member functions
- In Java, these operations are referred to as *methods*

The Exported Operations

```
// Filename: Queue2.hpp
#pragma once
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template <class T>
class Queue2
{
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   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

member functions – two types:

1. *procedure* – is a member function that has a **void** return type, i.e., does not return a value to the caller
   For example, *enqueue*

1. *function* – is a member function that has a non-**void** return type, and does return a value to the caller
   For example, *length* has a return type of Integer

The Exported Operations

There are two parts to the component's exported operations

- The Standard Operations
- The Component Specific Operations

```
// Filename: Queue2.hpp
#pragma once
#include "List\List1.hpp"

template <class T>
class Queue2
{
public: // Standard Operations
   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
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   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

```
// Filename: Queue2.hpp
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   void clear (void);
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   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The Exported Operations

There are 5 *standard operations* exported by *all* of the components that we will be using

1. constructor
2. destructor
3. clear
4. transferFrom
5. operator =

This *homogenous look and feel* allows one component to more easily be used by other components and is a very important software engineering design technique

```
// Filename: Queue2.hpp
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   Queue2();
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   void clear (void);
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   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   // ...
};
```

The Exported Operations

Component Specific Operations

Typically there are two types of operations:

1. Operations that permit the client to *update* the value of a variable

2. Operations that permit the client client to *inspect* various aspects of a variable

The Exported Operations

```
// Filename: Queue2.hpp
#pragma once
#include "List\List1.hpp"

template <class T>
class Queue2

{

public: // Standard Operations

   ...

// Queue2 Specific Operations

   void enqueue (T& x);
      //! updates self
      //! clears x
      //! ensures: self = #self * <#x>

   void dequeue (T& x);
      //! updates self
      //! replaces x
      //! requires: self /= <>
      //! ensures:  <x> is prefix of #self
      //! and self = #self[1, |#self|)

   void replacefront (T& x);
      //! updates self, x
      //! requires: self /= <>
      //! ensures: <x> is prefix of #self
      //! and self = <#x> * #self[1, |#self|)

   T& front (void);

   Integer length (void);

private: // representation

   // ...

};
```

Operations for updating a Queue variable

- enqueue
- dequeue
- replaceFront

The Exported Operations

```
// Filename: Queue2.hpp
#pragma once
#include “List\List1.hpp”

template <class T>
class Queue2

{

public: // Standard Operations

   ...

// Queue2 Specific Operations

   void enqueue (T& x);

   void dequeue (T& x);

   void replacefront (T& x);

   T& front (void);
      //! restores self
      //! requires: self /= <>
      //! ensures: <front> is prefix of self

   Integer length (void);
      //! restores self
      //! ensures: length = |self|

private: // representation

   // ...

};
```

Operations for inspecting a Queue variable

- length
- front

- Note: Inspecting does not change the abstract value of the variable, i.e., the queue’s value is restored

```
// Filename: Queue2.hpp
#pragma once
#include "List\List1.hpp"

template <class T>
class Queue2

{

public: // Standard Operations

   ...

// Queue2 Specific Operations

   void enqueue (T& x);
      //! updates self
      //! clears x
      //! ensures: self = #self * <#x>

   void dequeue (T& x);
      //! updates self
      //! replaces x
      //! requires: self /= <>
      //! ensures:  <x> is prefix of #self
      //! and self = #self[1, |#self|)

   void replacefront (T& x);

   T& front (void);

   Integer length (void);

private: // representation

   // ...

};
```

Being a Container Component

In order to qualify as a *container component*, the component must export two specific operations for altering a variable:

1. For *inserting* a value into a container variable
2. For *removing* a value from a container variable

For Queue:

- enqueue – for inserting
- dequeue – for removing

The Internal Representation

```
// Filename: Queue2.hpp
#pragma once
#include "List\List1.hpp"

template <class T>
class Queue2
{
public: // Standard Operations
   Queue2();
   ~Queue2();
   void clear (void);
   void transferFrom (Queue2& source);
   Queue2& operator = (Queue2& rhs);
// Queue2 Specific Operations
   void enqueue (T& x);
   void dequeue (T& x);
   void replacefront (T& x);
   T& front (void);
   Integer length (void);
private: // representation
   typedef List1<T> ListOfT;
   ListOfT s;
};
```

In the next set of slides, we dig into the Internal Representation which appears in the component's private part