Iterator Adaptor

Abstract:
Each specialization of the `iterator_adaptor` class template is derived from a specialization of `iterator_facade`. The core interface functions expected by `iterator_facade` are implemented in terms of the `iterator_adaptor`'s `Base` template parameter. A class derived from `iterator_adaptor` typically redefines some of the core interface functions to adapt the behavior of the `Base` type. Whether the derived class models any of the standard iterator concepts depends on the operations supported by the `Base` type and which core interface functions of `iterator_facade` are redefined in the `Derived` class.

Table of Contents

Overview

Reference

`iterator_adaptor` requirements
`iterator_adaptor` base class parameters
`iterator_adaptor` public operations
`iterator_adaptor` protected member functions
`iterator_adaptor` private member functions

Tutorial Example

Overview

The `iterator_adaptor` class template adapts some `Base` [1] type to create a new iterator. Instantiations of `iterator_adaptor` are derived from a corresponding instantiation of `iterator_facade` and implement the core behaviors in terms of the `Base` type. In essence, `iterator_adaptor` merely forwards all operations to an instance of the `Base` type, which it stores as a member.

[1] The term “Base” here does not refer to a base class and is not meant to imply the use of derivation. We have followed the lead of the standard library, which provides a base() function to access the underlying iterator object of a `reverse_iterator` adaptor.
The user of `iterator_adaptor` creates a class derived from an instantiation of `iterator_adaptor` and then selectively redefines some of the core member functions described in the `iterator_facade` core requirements table. The `Base` type need not meet the full requirements for an iterator; it need only support the operations used by the core interface functions of `iterator_adaptor` that have not been redefined in the user’s derived class.

Several of the template parameters of `iterator_adaptor` default to `use_default`. This allows the user to make use of a default parameter even when she wants to specify a parameter later in the parameter list. Also, the defaults for the corresponding associated types are somewhat complicated, so metaprogramming is required to compute them, and `use_default` can help to simplify the implementation. Finally, the identity of the `use_default` type is not left unspecified because specification helps to highlight that the `Reference` template parameter may not always be identical to the iterator’s `reference` type, and will keep users from making mistakes based on that assumption.

Reference

template <
    class Derived,
    class Base,
    class Value = use_default,
    class CategoryOrTraversal = use_default,
    class Reference = use_default,
    class Difference = use_default
>
class iterator_adaptor
 : public iterator_facade<Derived, V', C', R', D'> // see details
{
    friend class iterator_core_access;

    iterator_adaptor();
    explicit iterator_adaptor(Base iter);
    Base const& base() const;

    protected:
        typedef iterator_adaptor iterator_adaptor_;
        Base const& base_reference() const;
        Base& base_reference();

    private: // Core iterator interface for iterator_facade.
        typename iterator_adaptor::reference dereference() const;

        template <
            class OtherDerived, class OtherIterator,
            class V, class C, class R, class D
        >
            bool equal(iterator_adaptor<OtherDerived, OtherIterator, V, C, R, D> const& x) const;

            void advance(typename iterator_adaptor::difference_type n);
            void increment();
            void decrement();

        template <
            class OtherDerived, class OtherIterator,
            class V, class C, class R, class D
        >
```cpp
> typename iterator_adaptor::difference_type distance_to(
      iterator_adaptor<OtherDerived, OtherIterator, V, C, R, D> const& y) const;

private:
    Base m_iterator; // exposition only
};

iterator_adaptor requirements
static_cast<Derived*>(iterator_adaptor*) shall be well-formed. The Base argument shall be Assignable and Copy Constructible.

iterator_adaptor base class parameters
The V', C', R', and D' parameters of the iterator_facade used as a base class in the summary of iterator_adaptor above are defined as follows:

V' = if (Value is use_default)
      return iterator_traits<Base>::value_type
    else
      return Value

C' = if (CategoryOrTraversal is use_default)
     return iterator_traversal<Base>::type
   else
     return CategoryOrTraversal

R' = if (Reference is use_default)
     if (Value is use_default)
       return iterator_traits<Base>::reference
     else
       return Value&
     else
       return Reference

d' = if (Difference is use_default)
     return iterator_traits<Base>::difference_type
   else
     return Difference

iterator_adaptor public operations
iterator_adaptor();
    Requires: The Base type must be Default Constructible.
    Returns: An instance of iterator_adaptor with m_iterator default constructed.

explicit iterator_adaptor(Base iter);
    Returns: An instance of iterator_adaptor with m_iterator copy constructed from iter.

Base const& base() const;
    Returns: m_iterator
```
iterator_adaptor protected member functions

Base const& base_reference() const;

Returns: A const reference to m_iterator.

Base& base_reference();

Returns: A non-const reference to m_iterator.

iterator_adaptor private member functions

typename iterator_adaptor::reference dereference() const;

Returns: *m_iterator

template <
class OtherDerived, class OtherIterator, class V, class C, class R, class D
>
bool equal(iterator_adaptor<OtherDerived, OtherIterator, V, C, R, D> const& x) const;

Returns: m_iterator == x.base()

void advance(typename iterator_adaptor::difference_type n);

Effects: m_iterator += n;

void increment();

Effects: ++m_iterator;

void decrement();

Effects: --m_iterator;

template <
class OtherDerived, class OtherIterator, class V, class C, class R, class D
>
typename iterator_adaptor::difference_type distance_to(
    iterator_adaptor<OtherDerived, OtherIterator, V, C, R, D> const& y) const;

Returns: y.base() - m_iterator

Tutorial Example

In this section we’ll further refine the node_iter class template we developed in the iterator_facade tutorial. If you haven’t already read that material, you should go back now and check it out because we’re going to pick up right where it left off.

node_base* really is an iterator

It’s not really a very interesting iterator, since node_base is an abstract class: a pointer to a node_base just points at some base subobject of an instance of some other class, and incrementing a node_base* moves it past this base subobject to who-knows-where? The most we can do with that incremented position is to compare another node_base* to it. In other words, the original iterator traverses a one-element array.
You probably didn’t think of it this way, but the node_base* object that underlies node_iterator is itself an iterator, just like all other pointers. If we examine that pointer closely from an iterator perspective, we can see that it has much in common with the node_iterator we’re building. First, they share most of the same associated types (value_type, reference, pointer, and difference_type). Second, even some of the core functionality is the same: operator* and operator== on the node_iterator return the result of invoking the same operations on the underlying pointer, via the node_iterator’s dereference and equal member functions. The only real behavioral difference between node_base* and node_iterator can be observed when they are incremented: node_iterator follows the m_next pointer, while node_base* just applies an address offset.

It turns out that the pattern of building an iterator on another iterator-like type (the Base [1] type) while modifying just a few aspects of the underlying type’s behavior is an extremely common one, and it’s the pattern addressed by iterator_adaptor. Using iterator_adaptor is very much like using iterator_facade, but because iterator_adaptor tries to mimic as much of the Base type’s behavior as possible, we neither have to supply a Value argument, nor implement any core behaviors other than increment. The implementation of node_iter is thus reduced to:

```cpp
template <class Value>
class node_iter
    : public boost::iterator_adaptor<
        node_iter<Value>, // Derived
        Value*, // Base
        boost::use_default, // Value
        boost::forward_traversal_tag // CategoryOrTraversal
    
{
private:
    struct enabler {}; // a private type avoids misuse

public:
    node_iter()
        : node_iter::iterator_adaptor_(0) {}
    explicit node_iter(Value* p)
        : node_iter::iterator_adaptor_(p) {}
    template <class OtherValue>
    node_iter(node_iter<OtherValue> const& other
        , typename boost::enable_if<
            boost::is_convertible<OtherValue*,Value*>,
            enabler
        >::type = enabler())
        : node_iter::iterator_adaptor_(other.base()) {}
    
private:
    friend class boost::iterator_core_access;
    void increment() { this->base_reference() = this->base()->next(); }
};
```

Note the use of node_iter::iterator_adaptor_ here: because iterator_adaptor defines a nested iterator_adaptor_ type that refers to itself, that gives us a convenient way to refer to the complicated base class type of node_iter<Value>. [Note: this technique is known not to work with Borland C++ 5.6.4 and Metrowerks CodeWarrior versions prior to 9.0]
You can see an example program that exercises this version of the node iterators here.

In the case of node_iter, it’s not very compelling to pass boost::use_default as iterator_adaptor’s Value argument; we could have just passed node_iter’s Value along to iterator_adaptor, and that’d even be shorter! Most iterator class templates built with iterator_adaptor are parameterized on another iterator type, rather than on its value_type. For example, boost::reverse_iterator takes an iterator type argument and reverses its direction of traversal, since the original iterator and the reversed one have all the same associated types, iterator_adaptor’s delegation of default types to its Base saves the implementor of boost::reverse_iterator from writing:

    std::iterator_traits<Iterator>::some-associated-type

at least four times.

We urge you to review the documentation and implementations of reverse_iterator and the other Boost specialized iterator adaptors to get an idea of the sorts of things you can do with iterator_adaptor. In particular, have a look at transform_iterator, which is perhaps the most straightforward adaptor, and also counting_iterator, which demonstrates that iterator_adaptor’s Base type needn’t be an iterator.