Iterator Adaptor

Author:	David Abrahams, Jeremy Siek, Thomas Witt
Contact:	dave@boost-consulting.com, jsiek@osl.iu.edu, witt@ive.uni-hannover.de
Organization:	Boost Consulting, Indiana University Open Systems Lab, University of Hanover Institute for Transport Railway Operation and Construction
Date:	2004-01-12
Copyright:	Copyright David Abrahams, Jeremy Siek, and Thomas Witt 2003. All rights reserved

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

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.

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 table above. 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,

[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 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;
 public:
    iterator_adaptor();
    explicit iterator_adaptor(Base iter);
    Base const& base() const;
 protected:
    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
    >
    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 which 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). However, the `operator++` for `node_iterator` behaves differently than for `node_base*` since it follows the `m_next` pointer.

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:

```
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

    typedef boost::iterator_adaptor<
        node_iter<Value>, Value*, boost::use_default, boost::forward_traversal_tag
    > super_t;

 public:
    node_iter()
      : super_t(0) {}

    explicit node_iter(Value* p)
      : super_t(p) {}
```

```
    template <class OtherValue>
    node_iter(
        node_iter<OtherValue> const& other
      , typename boost::enable_if<
            boost::is_convertible<OtherValue*,Value*>
          , enabler
        >::type = enabler()
    )
      : super_t(other.base()) {}

 private:
    friend class boost::iterator_core_access;
    void increment() { this->base_reference() = this->base()->next(); }
};
```

You can see an example program which 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.