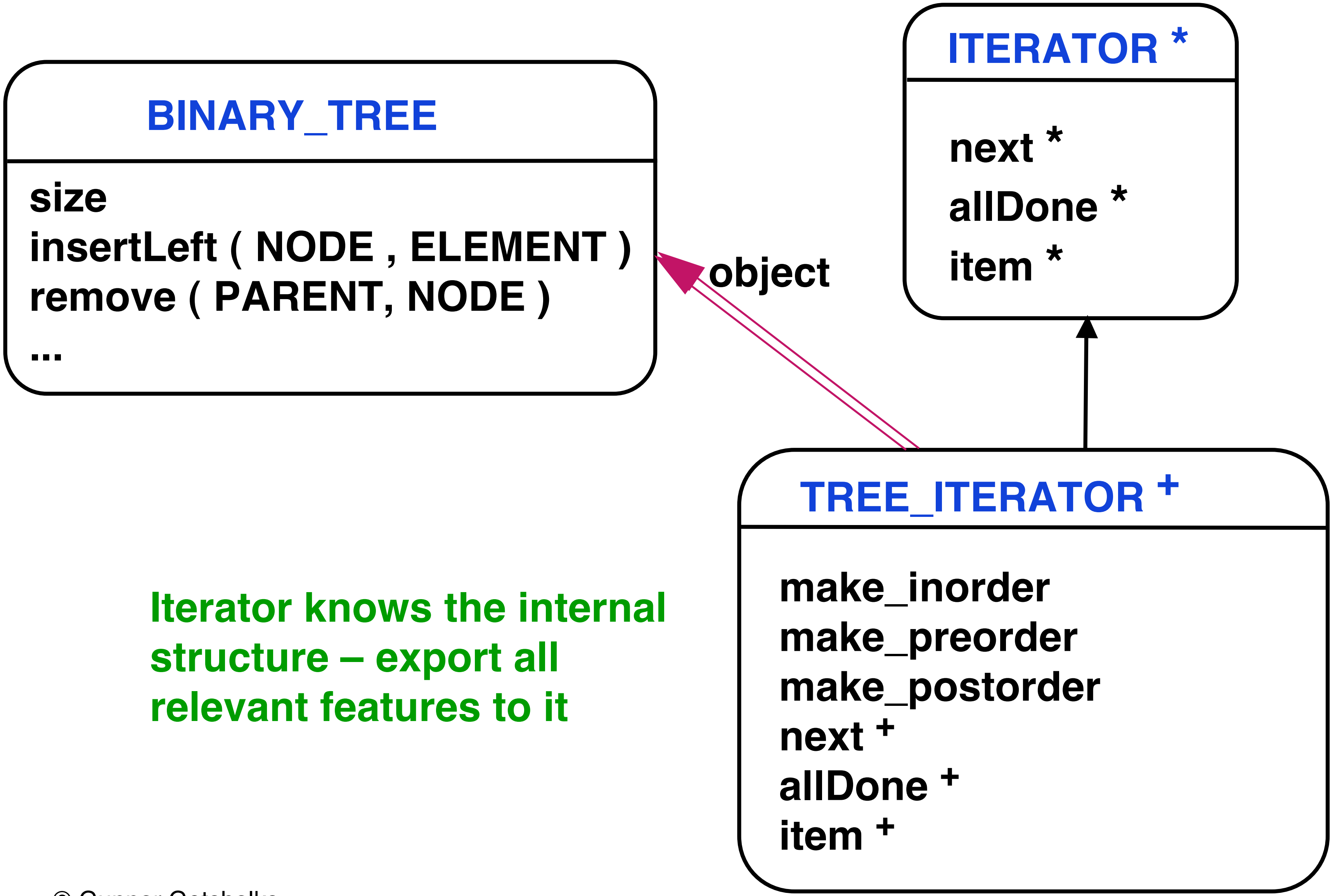
Iterator Pattern – Behavioural

- Intent
  - » Access elements of a container sequentially without exposing the underlying representation
- Motivation
  - » Be able to process all the elements in a container
  - » Different iterators can give different sequential ordering
    - > Binary tree
      - – preorder, inorder, postorder
    - > Do not need to extend container interface

Iterator – Example Architecture



BINARY_TREE

size
insertLeft (NODE , ELEMENT)
remove (PARENT, NODE)
...

object

ITERATOR *

next *
allDone *
item *

TREE_ITERATOR +

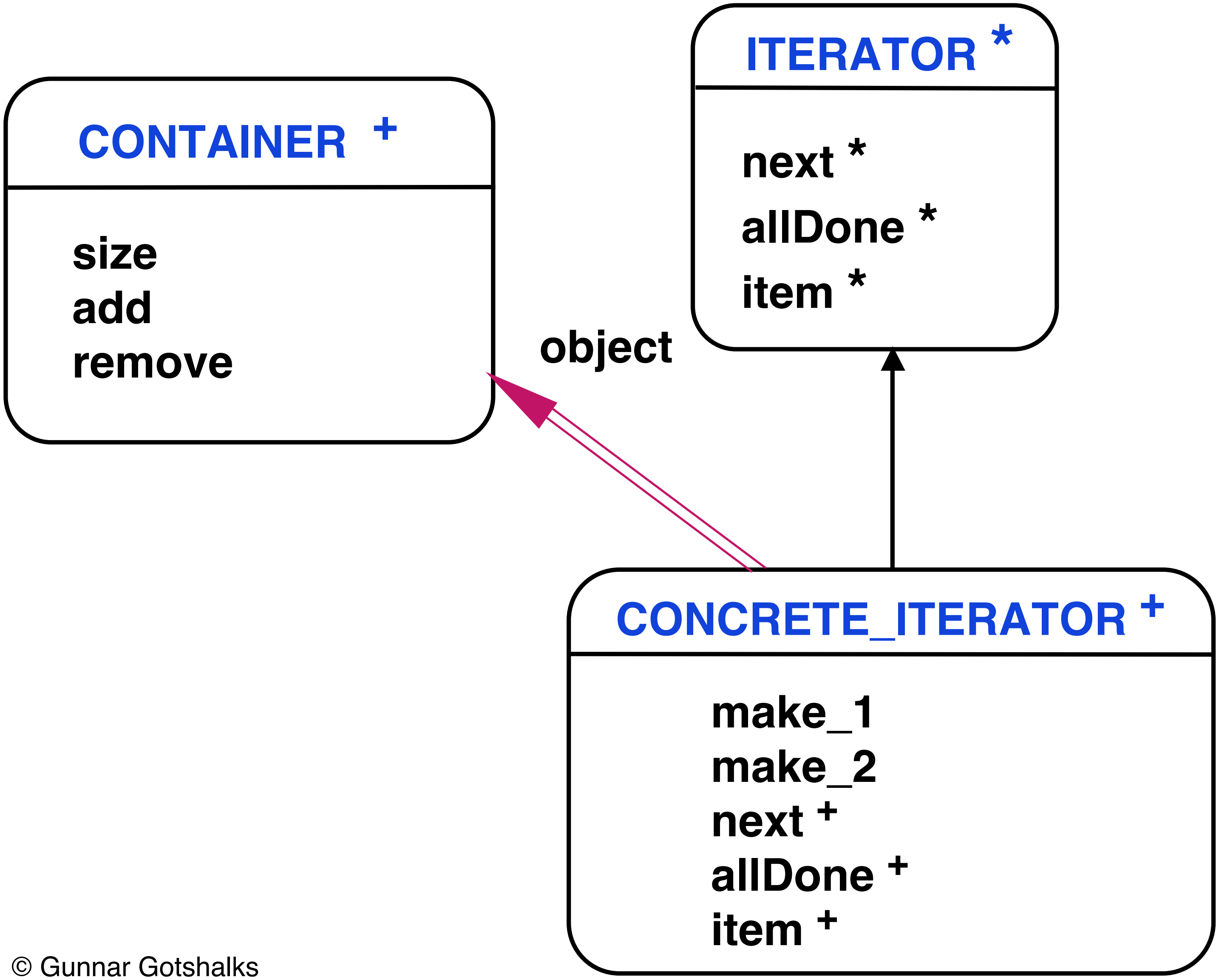
make_inorder
make_preorder
make_postorder
next +
allDone +
item +

Iterator knows the internal structure – export all relevant features to it

Iterator – Example Client

```
tree_items : TREE_ITERATOR
...
from create tree_items.make_inorder ( a_tree )
until tree_items.allDone
loop
    item := tree_items.item
    process ( item )
    tree_items.next
end
```

Iterator – Abstract Architecture



Iterator – Applicability

- Access a container’s contents without knowing about or using its internal representation

- Provide uniform interface for traversing a container’s contents

  Support polymorphic iteration

Iterator – Participants

- Iterator

  Defines interface for accessing and traversing a container's contents

- Concrete iterator
  - » **Implements the iterator interface**
  - » **Keeps track of the current position in the traversal**
  - » **Determines next object in a sequence of the container's objects**

- Container

  Could provide a method to create an instance of an iterator

  Done in Java due to the poor export control

Iterator – Consequences

- Supports variations in the traversal of a container
  - » **Complex containers can be traversed in different ways**

    Trees and graphs
  - » **Easy to change traversal order**

    Replace iterator instance with a different one
- Iterators simplify the container interface

  Do not need iterator interface in container interface
- Multiple simultaneous traversals

  Each iterator keeps track of its own state

Iterator – Implementation

- Can implement null iterators

  allDone is always True

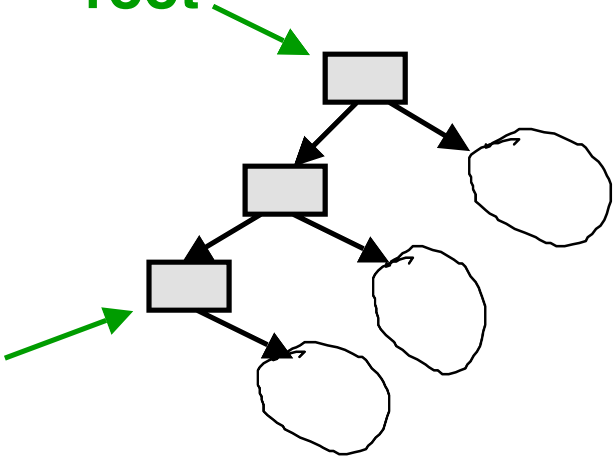
- Useful in traversing tree structures
  - » **At each level use iterator over children**
  - » **At leaf level automatically get a null iterator**
  - » **No exceptions at the boundary**

Inorder Traversal Binary Tree

```
public Enumeration inOrderLRtraversal() {
   return new Enumeration() {
   Declare variables needed by the enumeration
       {
          Initialization program for the enumerator
       }

    public boolean hasMoreElements() {
            Provide the definition
       }
       public Object nextElement() {
            Provide the definition
       }
}
```

Inorder Traversal Binary Tree – 2

```
// Declare variables needed by the enumeration
   private Stack btStack = new Stack();

     { // Initialization program for the enumerator
       // Simulate recursion by programming our own
       // stack.  Need to get to the leftmost node as it
       // is first in the enumeration
          Node node = tree;

          while (node != null) {
               btStack.add(node);
               node = node.left;
          }
     }
```



root

top of stack

Inorder Traversal Binary Tree – 3

```
public boolean hasMoreElements() {
    return ! btStack.isEmpty();
}
```

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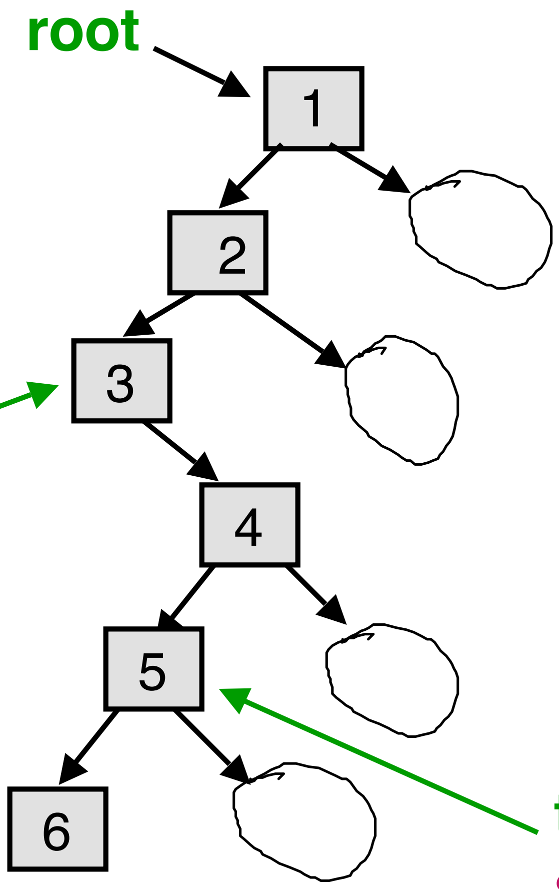
Inorder Traversal Binary Tree – 4



top of stack initially

top of stack after second call to nextElement

top of stack after first call to nextElement

InitStack	after call 1	after call 2
3	6	5
2	5	4
1	4	2
	2	1
	1	

An enumerator is always 1 element ahead of the user

Inorder Traversal Binary Tree – 5

```
public Object nextElement() {
     if (btStack.isEmpty())
                          throw new NoSuchElementException();
     Node node = (Node) btStack.remove();
     Object result = node.datum;   // next data to return
     if (node.right != null) {          // Find next sequence node
        node = node.right;
        do { btStack.add(node);       // Get leftmost node in
          node = node.left;              // right subtree
        } while (node != null);
     }
     return result;
}
```

Notice that an enumerator is always 1 element ahead

Iterator – Related Patterns

- Iterators are frequently applied to Composites