C++ Language Mapping

Version 1.3 with change bars

Normative reference: http://www.omg.org/spec/CPP/1.3
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Preface

About the Object Management Group

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Founded in 1989, the Object Management Group, Inc. (OMG) is an open membership, not-for-profit computer industry standards consortium that produces and maintains computer industry specifications for interoperable, portable and reusable enterprise applications in distributed, heterogeneous environments. Membership includes Information Technology vendors, end users, government agencies, and academia.

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  • UML Profile

Modernization Specifications
Platform Independent Model (PIM), Platform Specific Model (PSM), Interface Specifications

- CORBAServices
- CORBAFacilities

OMG Domain Specifications

CORBA Embedded Intelligence Specifications

CORBA Security Specifications

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Helvetica/Arial - 10 pt. Bold: OMG Interface Definition Language (OMG IDL) and syntax elements.


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Note – Terms that appear in italics are defined in the glossary. Italic text also represents the name of a document, specification, or other publication.

Issues

The reader is encouraged to report any technical or editing issues/problems with this specification to http://www.omg.org/report_issue.htm.
1 Scope

1.1 General

The CORBA Language Mapping specifications contain language mapping information for several languages. Each language is described in a separate stand-alone volume. This particular specification explains how OMG IDL constructs are mapped to the constructs of the C++ programming language. It provides mapping information for:

- Interfaces
- Constants
- Basic data types
- Enums
- Types (string, struct, union, fixed, sequence, array, typedefs, any, valuetype, abstract interface, exception)
- Operations and attributes
- Arguments

1.2 Alignment with CORBA

This language mapping is aligned with CORBA, v3.1.

2 Conformance/Compliance

2.1 General

The C++ mapping tries to avoid limiting the implementation freedoms of ORB developers. For each OMG IDL and CORBA construct, the C++ mapping explains the syntax and semantics of using the construct from C++. A client or server program conforms to this mapping (is CORBA-C++ compliant) if it uses the constructs as described in the C++ mapping chapters. An implementation conforms to this mapping if it correctly executes any conforming client or server program. A conforming client or server program is therefore portable across all conforming implementations.

2.2 C++ Implementation Requirements

This mapping assumes that the target C++ environment supports all the features described in The Annotated C++ Reference Manual (ARM) by Ellis and Stroustrup as adopted by the ANSI/ISO C++ standardization committees, including exception handling. In addition, it assumes that the C++ environment supports the namespace construct, but it does provide work-arounds for C++ compilers that do not support namespace.

2.3 No Implementation Descriptions

This mapping does not contain implementation descriptions. It avoids details that would constrain implementations, but still allows clients to be fully source-compatible with any compliant implementation. Some examples show possible implementations, but these are not required implementations.
2.4 Definition of CORBA Compliance

The minimum required for a CORBA-compliant system is adherence to the specifications in CORBA Core and one mapping. Each additional language mapping is a separate, optional compliance point. Optional means users aren’t required to implement these points if they are unnecessary at their site, but if implemented, they must adhere to the CORBA specifications to be called CORBA-compliant. For instance, if a vendor supports C++, their ORB must comply with the OMG IDL to C++ binding specified in this specification.

Interoperability and Interworking are separate compliance points. For detailed information about Interworking compliance, refer to CORBA, v3.1, Part 2: Conformance and Compliance.

As described in the OMA Guide, the OMG’s Core Object Model consists of a core and components. Likewise, the body of CORBA specifications is divided into core and component-like specifications. The CORBA specifications are divided into these volumes:

1. The CORBA/IIOP Specification (Common Object Request Broker Architecture), v3.1 that includes the following parts and clauses:
   - Part I - CORBA Interfaces
     - The Object Model
     - CORBA Overview
     - OMG IDL Syntax and Semantics
     - ORB Interface
     - Value Type Semantics
     - Abstract Interface Semantics
     - Dynamic Invocation Interface
     - Dynamic Management of Any Values
     - The Interface Repository
     - The Portable Object Adapter
     - Portable Interceptors
     - CORBA Messaging
   - Part II - CORBA Interoperability
     - Interoperability Overview
     - ORB Interoperability Architecture
     - Building Inter-ORB Bridges
     - General Inter-ORB Protocol
     - Secure Interoperability
     - Unreliable Multicast Inter-ORB Protocol

2. The Language Mapping Specifications, which are organized into the following stand-alone volumes:
   - Ada Mapping to OMG IDL
   - C Mapping to OMG IDL
   - C++ Mapping to OMG IDL
   - COBOL Mapping to OMG IDL
• IDL Script Mapping
• IDL to Java Mapping
• Java Mapping to OMG IDL
• Lisp Mapping to OMG IDL
• MOF to OMG IDL
• PL/1
• Python Mapping to OMG IDL
• Smalltalk Mapping to OMG IDL
• XML Valuetype Language Mapping

3 Normative References

3.1 General

The following normative documents contain provisions which, through reference in this text, constitute provisions of this specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

• OMG CORBA 3.1 specification (formal/2008-01-04): http://www.omg.org/spec/CORBA/3.1
• ISO IEC 14882-2011 (September 1, 2011), Standard for Programming Language C++

4 Additional Information

4.1 Acknowledgements

The following companies submitted the specification that was approved by the Object Management Group to become the C++ Language Mapping specification:

• Digital Equipment Corporation
• Expersoft Corporation
• Hewlett-Packard Company
• IBM Corporation
• IONA Technologies, Ltd.
• Novell USG
• SunSoft, Inc.
5 C++ Language Mapping Specification

5.1 Scoped Names

Scoped names in OMG IDL are specified by C++ scopes:

- OMG IDL modules are mapped to C++ namespaces.
- OMG IDL interfaces are mapped to C++ classes (as described in “Mapping for Interfaces” on page 7).
- All OMG IDL constructs scoped to an interface are accessed via C++ scoped names. For example, if a type \texttt{mode} were defined in interface \texttt{printer}, then the type would be referred to as \texttt{printer::mode}.

These mappings allow the corresponding mechanisms in OMG IDL and C++ to be used to build scoped names.

For instance

```c++
// IDL
module M
{
    struct E {
        long L;
    };
};
```

is mapped into

```c++
// C++
namespace M
{
    struct E {
        Long L;
    };
}
```

and \texttt{E} can be referred outside of \texttt{M} as \texttt{M::E}. Alternatively, a C++ \texttt{using} statement for namespace \texttt{M} can be used so that \texttt{E} can be referred to simply as \texttt{E}:

```c++
// C++
using namespace M;
E e;
e.L = 3;
```

Another alternative is to employ a \texttt{using} statement only for \texttt{M::E}:

```c++
// C++
using M::E;
```
To avoid C++ compilation problems, every use in OMG IDL of a C++ keyword as an identifier is mapped into the same name preceded by the prefix "_cxx_." For example, an IDL interface named “try” would be named “_cxx_try” when its name is mapped into C++. For consistency, this rule also applies to identifiers that are derived from IDL identifiers. For example, an IDL interface “try” generates the names “_cxx_try_var,” “_cxx_try_ptr,” and “_tc__cxx_try.”

The complete list of C++ keywords can be found in “C++ Keywords” on page 156.

5.2 C++ Type Size Requirements

The sizes of the C++ types used to represent OMG IDL types are implementation-dependent. That is, this mapping makes no requirements as to the `sizeof(T)` for anything except basic types (see “Mapping for Basic Data Types” on page 15) and string (see “Mapping for String Types” on page 17).

5.3 CORBA Module

The mapping relies on some predefined types, classes, and functions that are logically defined in a module named CORBA. The module is automatically accessible from a C++ compilation unit that includes a header file generated from an OMG IDL specification. In the examples presented in this document, CORBA definitions are referenced without explicit qualification for simplicity. In practice, fully scoped names or C++ `using` statements for the CORBA namespace would be required in the application source. See the Common Object Request Broker Architecture, Annex A for standard OMG IDL tags.

5.4 Mapping for Modules

As shown in “Scoped Names” on page 5, a module defines a scope, and as such is mapped to a C++ `namespace` with the same name.

```cpp
// IDL
module M
{
    // definitions
};

// C++
namespace M
{
    // definitions
}
```

Because namespaces were only recently added to the C++ language, few C++ compilers currently support them. Alternative mappings for OMG IDL modules that do not require C++ namespaces are in “Alternative Mappings For C++ Dialects” on page 154.
5.5 Mapping for Interfaces

An interface is mapped to a C++ class that contains public definitions of the types, constants, operations, and exceptions defined in the interface.

A CORBA–C++–compliant program cannot

- create or hold an instance of an interface class, or
- use a pointer (A*) or a reference (A&) to an interface class.

The reason for these restrictions is to allow a wide variety of implementations. For example, interface classes could not be implemented as abstract base classes if programs were allowed to create or hold instances of them. In a sense, the generated class is like a namespace that one cannot enter via a using statement. This example shows the behavior of the mapping of an interface.

// IDL
interface A
{
    struct S { short field; };
};

// C++
// Conformant uses
A::S s; // declare a struct variable
s.field = 3; // field access

// Non-conformant uses:
// one cannot declare an instance of an interface class...
A a;
// ...nor declare a pointer to an interface class...
A *p;
// ...nor declare a reference to an interface class.
void f(A &r);

5.5.1 Object Reference Types

The use of an interface type in OMG IDL denotes an object reference. Because of the different ways an object reference can be used and the different possible implementations in C++, an object reference maps to two C++ types. For an interface A, these types are named A_var and A_ptr. To facilitate template-based programming, typedefs for the A_ptr and A_var types are also provided in the interface class (see “Interface Mapping Example” on page 11). The typedef for A_ptr is named A::_ptr_type and the typedef for A_var is named A::_var_type.

An operation can be performed on an object by using an arrow ("->") on a reference to the object. For example, if an interface defines an operation op with no parameters and obj is a reference to the interface type, then a call would be written obj->op(). The arrow operator is used to invoke operations on both the _ptr and _var object reference types.

Client code frequently will use the object reference variable type (A_var) because a variable will automatically release its object reference when it is deallocated or when assigned a new object reference. The pointer type (A_ptr) provides a more primitive object reference, which has similar semantics to a C++ pointer. Indeed, an implementation may choose to
define A_ptr as A*, but is not required to. Unlike C++ pointers, however, conversion to void*, arithmetic operations, and relational operations, including test for equality, are all non-compliant. A compliant implementation need not detect these incorrect uses because requiring detection is not practical.

For many operations, mixing data of type A_var and A_ptr is possible without any explicit operations or casts. However, one needs to be careful in doing so because of the implicit release performed when the variable is deallocated. For example, the assignment statement in the code below will result in the object reference held by p to be released at the end of the block containing the declaration of a.

```cpp
// C++
A_var a;
A_ptr p = // ...somehow obtain an objref...
a = p;
```

5.5.2 Widening Object References

OMG IDL interface inheritance does not require that the corresponding C++ classes are related, though that is certainly one possible implementation. However, if interface B inherits from interface A, the following implicit widening operations for B must be supported by a compliant implementation:

- B_ptr to A_ptr
- B_ptr to Object_ptr
- B_var to A_ptr
- B_var to Object_ptr

Implicit widening from a B_var to A_var or Object_var is not supported; instead, widening between _var types for object references requires a call to _duplicate (described in “Object Reference Operations” on page 9). An attempt to implicitly widen from one _var type to another must cause a compile-time error. Assignment between two _var objects of the same type is supported, but widening assignments are not and must cause a compile-time error. Widening assignments may be done using _duplicate. The same rules apply for object reference types that are nested in a complex type, such as a structure or sequence.

```cpp
// C++
B_ptr bp = ...
A_ptr ap = bp;       // implicit widening
Object_ptr objp = bp; // implicit widening
objp = ap;           // implicit widening

B_var bv = bp;       // bv assumes ownership of bp
ap = bv;             // implicit widening, bv retains
                    // ownership of bp
objp = bv;           // implicit widening, bv retains
                    // ownership of bp
```

1. When T_ptr is mapped to T*, it is impossible in C++ to provide implicit widening between T_var types while also providing the necessary duplication semantics for T_ptr types.
2. This can be achieved by deriving all T_var types for object references from a base _var class, then making the assignment operator for _var private within each T_var type.
A_var av = bv;         // illegal, compile-time error
A_var av = B::_duplicate(bv); // av, bv both refer to bp
B_var bv2 = bv;          // implicit _duplicate
A_var av2;
   av2 = av;            // implicit _duplicate

5.5.3 Object Reference Operations

Conceptually, the Object class in the CORBA module is the base interface type for all CORBA objects; therefore, any object reference can be widened to the type Object_ptr. As with other interfaces, the CORBA namespace also defines the type Object_var.

CORBA defines three operations on any object reference: duplicate, release, and is_nil. Note that these are operations on the object reference, not the object implementation. Because the mapping does not require that object references to themselves be C++ objects, the "->" syntax cannot be employed to express the usage of these operations. Also, for convenience these operations are allowed to be performed on a nil object reference.

The release and is_nil operations depend only on type Object, so they can be expressed as regular functions within the CORBA namespace as follows.

    // C++
    void release(Object_ptr obj);
    Boolean is_nil(Object_ptr obj);

The release operation indicates that the caller will no longer access the reference so that associated resources may be deallocated. If the given object reference is nil, release does nothing. The is_nil operation returns TRUE if the object reference contains the special value for a nil object reference as defined by the ORB. Neither the release operation nor the is_nil operation may throw CORBA exceptions.

The duplicate operation returns a new object reference with the same static type as the given reference. The mapping for an interface therefore includes a static member function named _duplicate in the generated class.

For example

    // IDL
    interface A { }
    
    // C++
    class A
    {
       public:
          static A_ptr _duplicate(A_ptr obj);
    };

If the given object reference is nil, _duplicate will return a nil object reference. The _duplicate operation can throw CORBA system exceptions.
5.5.4 Narrowing Object References

The mapping for an interface defines a static member function named _narrow that returns a new object reference given an existing reference. Like _duplicate, the _narrow function returns a nil object reference if the given reference is nil. Unlike _duplicate, the parameter to _narrow is a reference of an object of any interface type (Object_ptr). If the actual (runtime) type of the parameter object can be narrowed to the requested interface’s type, then _narrow will return a valid object reference; otherwise, _narrow will return a nil object reference. For example, suppose A, B, C, and D are interface types, and D inherits from C, which inherits from B, which in turn inherits from A. If an object reference to a C object is widened to an A_ptr variable called ap, then:

- A::_narrow(ap) returns a valid object reference
- B::_narrow(ap) returns a valid object reference
- C::_narrow(ap) returns a valid object reference
- D::_narrow(ap) returns a nil object reference

Narrowing to A, B, and C all succeed because the object supports all those interfaces. The D::_narrow returns a nil object reference because the object does not support the D interface.

For another example, suppose A, B, C, and D are interface types. C inherits from B, and both B and D inherit from A. Now suppose that an object of type C is passed to a function as an A_ptr. If the function calls B::_narrow or C::_narrow, a new object reference will be returned. A call to D::_narrow will fail and return nil.

If successful, the _narrow function creates a new object reference and does not consume the given object reference, so the caller is responsible for releasing both the original and new references.

The _narrow operation can throw CORBA system exceptions.

5.5.5 Nil Object Reference

The mapping for an interface defines a static member function named _nil that returns a nil object reference of that interface type. For each interface A, the following call is guaranteed to return TRUE:

// C++
Boolean true_result = is_nil(A::_nil());

A compliant application need not call release on the object reference returned from the _nil function.

As described in “Object Reference Types” on page 7, object references may not be compared using operator==; therefore, is_nil is the only compliant way an object reference can be checked to see if it is nil.

The _nil function may not throw any CORBA exceptions.

A compliant program cannot attempt to invoke an operation through a nil object reference, since a valid C++ implementation of a nil object reference is a null pointer.

5.5.6 Object Reference Out Parameter

When a _var is passed as an out parameter, any previous value it refers to must be implicitly released. To give C++ mapping implementations enough hooks to meet this requirement, each object reference type results in the generation of an _out type that is used solely as the out parameter type. For example, interface A results in the object reference type
A_ptr, the helper type A_var, and the out parameter type A_out. To facilitate template-based programming, a typedef for the A_out type is also provided in the interface class (see “Interface Mapping Example” on page 11). The typedef for A_out is named A::_out_type. The general form for object reference _out types is shown below.

// C++
class A_out
{
  public:
    A_out(A_ptr& p) : ptr_(p) { ptr_ = A::_nil(); }
    A_out(A_var& p) : ptr_(p.ptr_) {
      release(ptr_); ptr_ = A::_nil();
    }
    A_out(const A_out& a) : ptr_(a.ptr_) {}
    A_out& operator=(const A_out& a) {
      ptr_ = a.ptr_; return *this;
    }
    A_out& operator=(const A_var& a) {
      ptr_ = A::_duplicate(A_ptr(a)); return *this;
    }
    A_out& operator=(A_ptr p) { ptr_ = p; return *this; }
    operator A_ptr&() { return ptr_; }
    A_ptr operator->() { return ptr_; }

  private:
    A_ptr& ptr_;  
};

The first constructor binds the reference data member with the A_ptr& argument. The second constructor binds the reference data member with the A_ptr object reference held by the A_var argument, and then calls release() on the object reference. The third constructor, the copy constructor, binds the reference data member to the same A_ptr object reference bound to the data member of its argument. Assignment from another A_out copies the A_ptr referenced by the argument A_out to the data member. The overloaded assignment operator for A_ptr simply assigns the A_ptr object reference argument to the data member. The overloaded assignment operator for A_var duplicates the A_ptr held by the A_var before assigning it to the data member. Note that assignment does not cause any previously-held object reference value to be released; in this regard, the A_out type behaves exactly as an A_ptr. The A_ptr& conversion operator returns the data member. The ptr() member function, which can be used to avoid having to rely on implicit conversion, also returns the data member. The overloaded arrow operator (operator->()) returns the data member to allow operations to be invoked on the underlying object reference after it has been properly initialized by assignment.

5.5.7 Interface Mapping Example

The example below shows one possible mapping for an interface. Other mappings are also possible, but they must provide the same semantics and usage as this example.

// IDL
interface A
{
  A op(in A arg1, out A arg2);
};
// C++
class A;
typedef A *A_ptr;
class A_var;
class A_out;
class A : public virtual Object
{
    public:
        typedef A_ptr _ptr_type;
        typedef A_var _var_type;
        typedef A_out _out_type;

        static A_ptr _duplicate(A_ptr obj);
        static A_ptr _narrow(Object_ptr obj);
        static A_ptr _nil();

        virtual A_ptr op(A_ptr arg1, A_out arg2) = 0;
    
    protected:
        A();
        virtual ~A();

    private:
        A(const A&);
        void operator=(const A&);
    
};

class A_var : public _var
{
    public:
        A_var() : ptr_(A::_nil()) {} 
        A_var(A_ptr p) : ptr_(p) {} 
        A_var(const A_var &a) : ptr_(A::_duplicate(A_ptr(a))
            ~A_var() { free(); }

        A_var &operator=(A_ptr p) {
            reset(p); return *this;
        }
        A_var &operator=(const A_var &a) {
            if (this != &a) {
                free();
                ptr_ = A::_duplicate(A_ptr(a));
            }
            return *this;
        }
        A_ptr in() const { return ptr_; }
        A_ptr& inout() { return ptr_; }

A_ptr& out() {
    reset(A::_nil());
    return ptr_;
}

A_ptr _retn() {
    // yield ownership of managed object reference
    A_ptr val = ptr_;
    ptr_ = A::_nil();
    return val;
}

operator A_ptr() const { return ptr_; }
operator A_ptr&() { return ptr_; }
A_ptr operator->() const { return ptr_; }

protected:
    A_ptr ptr_;
    void free() { release(ptr_); }
    void reset(A_ptr p) { free(); ptr_ = p; }

private:
    // hidden assignment operators for var types
    void operator=(const _var &);
};

The definition for the A_out type is the same as the one shown in “Object Reference Out Parameter” on page 10.

5.6 Mapping for Constants

OMG IDL constants are mapped directly to a C++ constant definition that may or may not define storage depending on the scope of the declaration. In the following example, a top-level IDL constant maps to a file-scope C++ constant whereas a nested constant maps to a class-scope C++ constant. This inconsistency occurs because C++ file-scope constants may not require storage (or the storage may be replicated in each compilation unit), while class-scope constants always take storage. As a side effect, this difference means that the generated C++ header file might not contain values for constants defined in the OMG IDL file.

// IDL
const string name = "testing";

interface A
{
    const float pi = 3.14159;
};
// C++
static const char *const name = "testing";

class A
{
    public:
        static const Float pi;
};

In certain situations, use of a constant in OMG IDL must generate the constant’s value instead of the constant’s name. For example

// IDL
interface A
{
    const long n = 10;
    typedef long V[n];
};

// C++
class A
{
    public:
        static const long n;
        typedef long V[10];
};

5.6.1 Wide Character and Wide String Constants

The mappings for wide character and wide string constants is identical to character and string constants, except that IDL literals are preceded by L in C++. For example, IDL constant:

constant wstring ws = “Hello World”;

would map to

static const WChar *const ws = L"Hello World";

in C++.

5.6.2 Fixed Point Constants

Because C++ does not have a native fixed point type, IDL fixed point literals are mapped to C++ strings without the trailing ‘d’ or ‘D’ in order to guarantee that there is no loss of precision. For example

3. A recent change made to the C++ language by the ANSI/ISO C++ standardization committees allows static integer constants to be initialized within the class declaration, so for some C++ compilers, the code generation issues described here may not be a problem.
// IDL
const fixed F = 123.456D;

// C++
const Fixed F = "123.456";

## 5.7 Mapping for Basic Data Types

The basic data types have the mappings shown in Table 5.1\(^4\). Note that the mapping of the OMG IDL boolean type defines only the values 1 (TRUE) and 0 (FALSE); other values produce undefined behavior.

<table>
<thead>
<tr>
<th>OMG IDL</th>
<th>C++</th>
<th>C++ Out Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>CORBA::Short</td>
<td>CORBA::Short_out</td>
</tr>
<tr>
<td>long</td>
<td>CORBA::Long</td>
<td>CORBA::Long_out</td>
</tr>
<tr>
<td>long long</td>
<td>CORBA::LongLong</td>
<td>CORBA::LongLong_out</td>
</tr>
<tr>
<td>unsigned short</td>
<td>CORBA::UShort</td>
<td>CORBA::UShort_out</td>
</tr>
<tr>
<td>unsigned long</td>
<td>CORBA::ULong</td>
<td>CORBA::ULong_out</td>
</tr>
<tr>
<td>unsigned long long</td>
<td>CORBA::ULongLong</td>
<td>CORBA::ULongLong_out</td>
</tr>
<tr>
<td>float</td>
<td>CORBA::Float</td>
<td>CORBA::Float_out</td>
</tr>
<tr>
<td>double</td>
<td>CORBA::Double</td>
<td>CORBA::Double_out</td>
</tr>
<tr>
<td>long double</td>
<td>CORBA::LongDouble</td>
<td>CORBA::LongDouble_out</td>
</tr>
<tr>
<td>char</td>
<td>CORBA::Char</td>
<td>CORBA::Char_out</td>
</tr>
<tr>
<td>wchar</td>
<td>CORBA::WChar</td>
<td>CORBA::WChar_out</td>
</tr>
<tr>
<td>boolean</td>
<td>CORBA::Boolean</td>
<td>CORBA::Boolean_out</td>
</tr>
<tr>
<td>octet</td>
<td>CORBA::Octet</td>
<td>CORBA::Octet_out</td>
</tr>
</tbody>
</table>

Each OMG IDL basic type is mapped to a typedef in the CORBA module. This is because some types, such as short and long, may have different representations on different platforms, and the CORBA definitions will reflect the appropriate representation. For example, on a 64-bit machine where a long integer is 64 bits, the definition of CORBA::Long would still refer to a 32-bit integer. Requirements for the sizes of basic types are shown in Common Object Request Broker Architecture (CORBA), OMG IDL Syntax and Semantics clause, Basic Types sub clause.

Types boolean, char, and octet may all map to the same underlying C++ type. This means that these types may not be distinguishable for the purposes of overloading.

Type wchar maps to wchar_t in standard C++ environments or, for nonstandard C++ environments, may also map to one of the integer types. This means that wchar may not be distinguishable from integer types for purposes of overloading.

---

4. This mapping assumes that CORBA::LongLong, CORBA::ULongLong, and CORBA::LongDouble are mapped directly to native numeric C++ types (e.g., CORBA::LongLong to a 64-bit integer type) that support the required IDL semantics and can be manipulated via built-in operators. An alternate mapping to C++ classes that provides appropriate creation, conversion, and manipulation operators will be provided in a future version of this specification.
All other mappings for basic types are distinguishable for the purposes of overloading. That is, one can safely write overloaded C++ functions for `Short`, `UShort`, `Long`, `ULong`, `LongLong`, `ULongLong`, `Float`, `Double`, and `LongDouble`.

The `_out` types for the basic types are used to type `out` parameters within operation signatures, as described in “Argument Passing Considerations” on page 91. For the basic types, each `_out` type is a `typedef` to a reference to the corresponding C++ type. For example, the `Short_out` is defined in the CORBA namespace as follows:

```cpp
// C++
typedef Short& Short_out;
```

The `_out` types for the basic types are provided for consistency with other `out` parameter types.

Programmers concerned with portability should use the CORBA types. However, some may feel that using these types with the CORBA qualification impairs readability. If the CORBA module is mapped to a namespace, a C++ `using` statement may help this problem. On platforms where the C++ data type is guaranteed to be identical to the OMG IDL data type, a compliant implementation may generate the native C++ type.

For the `Boolean` type, only the values 1 (representing `TRUE`) and 0 (representing `FALSE`) are defined; other values produce undefined behavior. Since many existing C++ software packages and libraries already provide their own preprocessor macro definitions of `TRUE` and `FALSE`, this mapping does not require that such definitions be provided by a compliant implementation. Requiring definitions for `TRUE` and `FALSE` could cause compilation problems for CORBA applications that make use of such packages and libraries. Instead, we recommend that compliant applications simply use the values 1 and 0 directly.

Alternatively, for those C++ compilers that support the `bool` type, the keywords `true` and `false` may be used.

IDL type `boolean` may be mapped to C++ signed, unsigned, or plain `char`. This mapping is legal for both classic and ANSI C++ environments. In addition, in an ANSI C++ environment, IDL `boolean` can be mapped to C++ `bool`. Mappings to C++ types other than a character type or `bool` are illegal.

### 5.8 Mapping for Enums

An OMG IDL `enum` maps directly to the corresponding C++ type definition. The only difference is that the generated C++ type may need an additional constant that is large enough to force the C++ compiler to use exactly 32 bits for values declared to be of the enumerated type.

```idl
enum Color { red, green, blue };
```

```cpp
enum Color { red, green, blue };
```

In addition, an `_out` type used to type `out` parameters within operation signatures is generated for each enumerated type. For enum `Color` shown above, the `Color_out` type is defined in the same scope as follows:

```cpp
```

5. Examples and descriptions in this specification still use `TRUE` and `FALSE` for purposes of clarity.
// C++
typedef Color& Color_out;

The _out types for enumerated types are generated for consistency with other out parameter types.

5.9 Mapping for String Types

The OMG IDL string type, whether bounded or unbounded, is mapped to char*. String data is NUL-terminated. In addition, the CORBA module defines a class String_var that contains a char* value and automatically frees the pointer when a String_var object is deallocated. When a String_var is constructed or assigned from a char*, the char* is consumed and thus the string data may no longer be accessed through it by the caller. Assignment or construction from a const char* or from another String_var causes a copy. The String_var class also provides operations to convert to and from char* values, as well as subscripting operations to access characters within the string. The full definition of the String_var interface is given in “String_var and String_out Class” on page 137. Calling the out or _retn functions of a String_var has the side effect of setting its internal pointer back to null. An application may also explicitly assign a null pointer to the String_var.

C++ does not have a built-in type that would provide a “close match” for IDL-bounded strings. As a result, the programmer is responsible for enforcing the bound of bounded strings at run time. Implementations of the mapping are under no obligation to prevent assignment of a string value to a bounded string type if the string value exceeds the bound. Implementations may choose to (at run time) detect attempts to pass a string value that exceeds the bound as a parameter across an interface. If an implementation chooses to detect this error, it must raise a BAD_PARAM system exception to signal the error.

Because its mapping is char*, the OMG IDL string type is the only non-basic type for which this mapping makes size requirements. For dynamic allocation of strings, compliant programs must use the following functions from the CORBA namespace:

// C++
namespace CORBA {
    char *string_alloc(ULong len);
    char *string_dup(const char*);
    void string_free(char *);
    ...
}

The string_alloc function dynamically allocates a string, or returns a null pointer if it cannot perform the allocation. It allocates len+1 characters so that the resulting string has enough space to hold a trailing NUL character. The string_dup function dynamically allocates enough space to hold a copy of its string argument, including the NUL character, copies its string argument into that memory, and returns a pointer to the new string. If allocation fails, a null pointer is returned. The string_free function deallocates a string that was allocated with string_alloc or string_dup. Passing a null pointer to string_free is acceptable and results in no action being performed. These functions allow ORB implementations to use special memory management mechanisms for strings if necessary, without forcing them to replace global operator new and operator new[].

The string_alloc, string_dup, and string_free functions may not throw exceptions.

Note that a static array of char in C++ decays to a char*, so care must be taken when assigning one to a String_var, since the String_var will assume the pointer points to data allocated via string_alloc and thus will eventually attempt to string_free it.
// C++
// The following is an error, since the char* should point to
// data allocated via string_alloc so it can be consumed
String_var s = "static string"; // error

// The following are OK, since const char* are copied,
// not consumed
const char* sp = "static string";
s = sp;
s = (const char*)"static string too";

When a String_var is passed as an out parameter, any previous value it refers to must be implicitly freed. To give C++
mapping implementations enough hooks to meet this requirement, the string type also results in the generation of a
String_out type in the CORBA namespace, which is used solely as the string out parameter type. The general form for
the String_out type is shown below.

// C++
class String_out
{
    public:
        String_out(char*& p) : ptr_(p) { ptr_ = 0; }
        String_out(String_var& p) : ptr_(p.ptr_) {
            string_free(ptr_); ptr_ = 0;
        }
        String_out(const String_out& s) : ptr_(s.ptr_) {}
        String_out& operator=(const String_out& s) {
            ptr_ = s.ptr_; return *this;
        }
        String_out& operator=(char* p) {
            ptr_ = p; return *this;
        }
        String_out& operator=(const char* p) {
            ptr_ = string_dup(p); return *this;
        }
        operator char*() { return ptr_; }
        char*& ptr() { return ptr_; }
    
    private:
        char*& ptr_;

        // assignment from String_var disallowed
        void operator=(const String_var&);
};

The first constructor binds the reference data member with the char* & argument. The second constructor binds the
reference data member with the char* held by the String_var argument, and then calls string_free() on the
string. The third constructor, the copy constructor, binds the reference data member to the same char* bound to the data

6. This has changed in ANSI/ISO C++, where string literals are const char*, not char*. However, since most C++ compilers do not yet
implement this change, portable programs must heed the advice given here.
member of its argument. Assignment from another String_out copies the char* referenced by the argument String_out to the char* referenced by the data member. The overloaded assignment operator for char* simply assigns the char* argument to the data member. The overloaded assignment operator for const char* duplicates the argument and assigns the result to the data member. Note that assignment does not cause any previously-held string to be freed; in this regard, the String_out type behaves exactly as a char*. The char*& conversion operator returns the data member. The ptr() member function, which can be used to avoid having to rely on implicit conversion, also returns the data member.

Assignment from String_var to a String_out is disallowed because of the memory management ambiguities involved. Specifically, it is not possible to determine whether the string owned by the String_var should be taken over by the String_out without copying, or if it should be copied. Disallowing assignment from String_var forces the application developer to make the choice explicitly.

// C++
void A::op(String_out arg)
{
    String_var s = string_dup("some string");
    ...  
    arg = s;  // disallowed; either
    arg = string_dup(s);  // 1: copy, or
    arg = s._retn();  // 2: adopt
}

On the line marked with the comment “1,” the application writer is explicitly copying the string held by the String_var and assigning the result to the arg argument. Alternatively, the application writer could use the technique shown on the line marked with the comment “2” in order to force the String_var to give up its ownership of the string it holds so that it may be returned in the arg argument without incurring memory management errors.

A compliant mapping implementation shall provide overloaded operator<< (insertion) and operator>>(extraction) operators for using String_var and String_out directly with C++ iostreams. The operator>> extraction operator has the same semantics as the underlying standard C++ operator>> for extracting strings from an input stream (extracting until whitespace or end of file). Space to store the extracted characters are allocated by calling string_alloc, and the previous contents of the String_var are released by calling string_free.

5.10 Mapping for Wide String Types

Both bounded and unbounded wide string types are mapped to CORBA::WChar* in C++. In addition, the CORBA module defines WString_var and WString_out classes. Each of these classes provides the same member functions with the same semantics as their string counterparts, except of course they deal with wide strings and wide characters.

Dynamic allocation and deallocation of wide strings must be performed via the following functions:

// C++
namespace CORBA {

    // ...
    WCHAR *wstring_alloc(ULONG len);
    WCHAR *wstring_dup(const WCHAR* ws);
    void wstring_free(WCHAR*);
};
These functions have the same semantics as the same functions for the string type, except they operate on wide strings. A compliant mapping implementation provides overloaded operator<< (insertion) and operator>>() (extraction) operators for using WString_var and WString_out directly with C++ iostreams. The operator>>() extraction operator has the same semantics as the underlying standard C++ operator>>() for extracting wide strings from an input stream (extracting until whitespace or end of file). Space to store the extracted characters are allocated by calling wstring_alloc, and the previous contents of the WString_var are released by calling wstring_free.

5.11 Mapping for Structured Types

The mapping for struct, union, and sequence is a C++ struct or class with a default constructor, a copy constructor, an assignment operator, and a destructor. The default constructor initializes object reference members to appropriately-typed nil object references, and string members and wide string members to the empty string ("" and L"", respectively). All other members are initialized via their default constructors. The copy constructor performs a deep-copy from the existing structure to create a new structure, including calling _duplicate on all object reference members and performing the necessary heap allocations for all string members and wide string members. The assignment operator first releases all object reference members and frees all string members and wide string members, and then performs a deep-copy to create a new structure. The destructor releases all object reference members and frees all string members and wide string members.

The mapping for OMG IDL structured types (structs, unions, arrays, and sequences) can vary slightly depending on whether the data structure is fixed-length or variable-length. A type is variable-length if it is one of the following types:

- The type any
- A bounded or unbounded string or wide string
- A bounded or unbounded sequence
- An object reference or reference to a transmissible pseudo-object
- A valuetype
  - A struct or union that contains a member whose type is variable-length
  - An array with a variable-length element type
  - A typedef to a variable-length type

The reason for treating fixed- and variable-length data structures differently is to allow more flexibility in the allocation of out parameters and return values from an operation. This flexibility allows a client-side stub for an operation that returns a sequence of strings (for example, to allocate all the string storage in one area that is deallocated in a single call).

As a convenience for managing pointers to variable-length data types, the mapping also provides a managing helper class for each variable-length type. This type, which is named by adding the suffix “_var” to the original type’s name, automatically deletes the pointer when an instance is destroyed. An object of type T_var behaves similarly to the structured type T, except that members must be accessed indirectly. For a struct, this means using an arrow (“->”) instead of a dot (“.”).

```
// IDL
struct S { string name; float age; };
void f(out S p);
```
// C++
S a;
S_var b;
f(b);
a = b; // deep-copy
cout << "names " << a.name << ", " << b->name << endl;

To facilitate template-based programming, all struct, union, and sequence classes contain nested public typedefs for their associated T_var and T_out types. For example, for an IDL sequence named Seq, the mapped sequence class Seq contains a _var_type and _out_type typedef as follows:

// C++
class Seq_var;
class Seq_out;
class Seq
{
    public:
        typedef Seq_var _var_type;
        typedef Seq_out _out_type;// ...
};

5.11.1 T_var Types

The general form of the T_var types is shown below.

// C++
class T_var
{
    public:
        T_var();
        T_var(T *);
        T_var(const T_var &);
        -T_var();

        T_var &operator=(T *);
        T_var &operator=(const T_var &);

        T* operator->();
        const T* operator->() const;

        /* in parameter type */ in() const;
        /* inout parameter type */ inout();
        /* out parameter type */ out();
        /* return type */ _retn();

        // other conversion operators to support
        // parameter passing
};
The default constructor creates a `T_var` containing a null `T*`. Compliant applications may not attempt to convert a `T_var` created with the default constructor into a `T*` nor use its overloaded `operator->` without first assigning to it a valid `T*` or another valid `T_var`. Due to the difficulty of doing so, compliant implementations are not required to detect this error. Conversion of a null `T_var` to a `T_out` is allowed, however, so that a `T_var` can legally be passed as an `out` parameter. Conversion of a null `T_var` to a `T*&` is also allowed so as to be compatible with earlier versions of this specification.

The `T*` constructor creates a `T_var` that, when destroyed, will `delete` the storage pointed to by the `T*` parameter. It is legal to initialize a `T_var` with a null pointer.

The copy constructor deep-copies any data pointed to by the `T_var` constructor parameter. This copy will be destroyed when the `T_var` is destroyed or when a new value is assigned to it. Compliant implementations may, but are not required to, utilize some form of reference counting to avoid such copies.

The destructor uses `delete` to deallocate any data pointed to by the `T_var`, except for strings and array types, which are deallocated using the `string_free` and `T_free` (for array type `T`) deallocation functions, respectively.

The `T*` assignment operator results in the deallocation of any old data pointed to by the `T_var` before assuming ownership of the `T*` parameter.

The normal assignment operator deep-copies any data pointed to by the `T_var` assignment parameter. This copy will be destroyed when the `T_var` is destroyed or when a new value is assigned to it. Assigning a null pointer to a `T_var` is legal and results in deallocation of the data pointed to by the `T_var`.

The overloaded `operator->` returns the `T*` held by the `T_var`, but retains ownership of it. Compliant applications may not de-reference the return value of this function unless the `T_var` has been initialized with a valid non-null `T*` or `T_var`.

In addition to the member functions described above, the `T_var` types must support conversion functions that allow them to fully support the parameter passing modes shown in Table 5.2. The form of these conversion functions is not specified so as to allow different implementations, but the conversions must be automatic (i.e., they must require no explicit application code to invoke them).

Because implicit conversions can sometimes cause problems with some C++ compilers and with code readability, the `T_var` types also support member functions that allow them to be explicitly converted for purposes of parameter passing.

### Table 5.2 - Parameter Passing Modes

<table>
<thead>
<tr>
<th>To pass a <code>T_var</code> as an:</th>
<th>an application can call the ...</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>in</code> parameter</td>
<td><code>in()</code> member function of the <code>T_var</code></td>
</tr>
<tr>
<td><code>inout</code> parameter</td>
<td><code>inout()</code> member function</td>
</tr>
<tr>
<td><code>out</code> parameter</td>
<td><code>out()</code> member function</td>
</tr>
</tbody>
</table>

To obtain a return value from the `T_var`, an application can call the `_retn()` function.7

---

7. A leading underscore is needed on the `_retn()` function to keep it from clashing with user-defined member names of constructed types, but leading underscores are not needed for the `in()`, `inout()`, and `out()` functions because their names are IDL keywords, so users can’t define members with those names.
For each $T_{\text{var}}$ type, the return types of each of these functions match the types shown in version 2.3 of *The Common Object Request Broker: Architecture and Specifications, Mapping: OLE Automation and CORBA* chapter, *Mapping of Automation Types to OMG IDL Types* table for the `in`, `inout`, `out` and return modes for underlying type $T$ respectively.

For $T_{\text{var}}$ types that return $T*$ from the `out()` member function, the `out()` member function calls `delete` on the $T*$ owned by the $T_{\text{var}}$, sets it equal to the null pointer, and then returns a reference to it. This is to allow for proper management of the $T*$ owned by a $T_{\text{var}}$ when passed as an `out` parameter, as described in “Argument Passing Considerations” on page 91. An example implementation of such an `out()` function is shown below:

```cpp
// C++
T*& T_var::out()
{
    // assume ptr_ is the T* data member of the T_var
    delete ptr_;  
    ptr_ = 0;  
    return ptr_; 
}
```

Similarly, for $T_{\text{var}}$ types whose corresponding type $T$ is returned from IDL operations as $T*$ (see Table 5.3), the `_retn()` function stores the value of the $T*$ owned by the $T_{\text{var}}$ into a temporary pointer, sets the $T*$ to the null pointer value, and then returns the temporary. The $T_{\text{var}}$ thus yields ownership of its $T*$ to the caller of `_retn()` without calling `delete` on it, and the caller becomes responsible for eventually deleting the returned $T*$. An example implementation of such a `_retn()` function is shown below:

```cpp
// C++
T* T_var::_retn()
{
    // assume ptr_ is the T* data member of the T_var
    T* tmp = ptr_;  
    ptr_ = 0;  
    return tmp; 
}
```

This allows, for example, a method implementation to store a $T*$ as a potential return value in a $T_{\text{var}}$ so that it will be deleted if an exception is thrown, and yet be able to acquire control of the $T*$ to be able to return it properly:

```cpp
// C++
T_var t = new T; // t owns pointer to T
if (exceptional_condition) {
    // t owns the pointer and will delete it
    // as the stack is unwound due to throw
    throw AnException();
}
...
return t._retn(); // _retn() takes ownership of
                 // pointer from t
```

After `_retn()` is invoked on a $T_{\text{var}}$ instance, its internal $T*$ pointer is null, so invoking either of its overloaded `operator->` functions without first assigning a valid non-null $T*$ to the $T_{\text{var}}$ will attempt to de-reference the null pointer, which is illegal in C++.
For reasons of consistency, the \texttt{T\_var} types are also produced for fixed-length structured types. These types have the same semantics as \texttt{T\_var} types for variable-length types. This allows applications to be coded in terms of \texttt{T\_var} types regardless of whether the underlying types are fixed- or variable-length. \texttt{T\_var} types for fixed-length structured types have the following general form:

\begin{verbatim}
// C++
class T_var {
public:
  T_var() : m_ptr(0) {}
  T_var(T *t) : m_ptr(t) {}
  T_var(const T& t) : m_ptr(new T(t)) {}
  T_var(const T_var &t) : m_ptr(0) {
    if (t.m_ptr != 0)
      m_ptr = new T(*t.m_ptr);
  }
  ~T_var() { delete m_ptr; }
  T_var &operator=(T *t) {
    if (t != m_ptr) {
      delete m_ptr;
      m_ptr = t;
    }
    return *this;
  }
  T_var &operator=(const T& t) {
    if (&t != m_ptr) {
      T* old_m_ptr = m_ptr;
      m_ptr = new T(t);
      delete old_m_ptr;
    }
    return *this;
  }
  T_var &operator=(const T_var &t) {
    if (this != &t) {
      T* old_m_ptr = m_ptr;
      if (t.m_ptr != 0)
        m_ptr = new T(*t.m_ptr);
      else
        m_ptr = 0;
      delete old_m_ptr;
    }
    return *this;
  }
  T* operator->() { return m_ptr; }
  const T* operator->() const { return m_ptr; }
  const T& in() const { return *m_ptr; }
  T& inout() { return *m_ptr; }
  T& out() {
    if (m_ptr == 0)
      m_ptr = new T;
    return *m_ptr;
  }
};
\end{verbatim}
T_retn() { return *m_ptr; }

private:
    T* m_ptr;
};

Each T_var type must be defined at the same level of nesting as its T type.

T_var types do not work with a pointer to constant T, since they provide no constructor nor operator= taking a const T* parameter. Since C++ does not allow delete to be called on a const T*, the T_var object would normally have to copy the const object; instead, the absence of the const T* constructor and assignment operators will result in a compile-time error if such an initialization or assignment is attempted. This allows the application developer to decide if a copy is really wanted or not. Explicit copying of const T* objects into T_var types can be achieved via the copy constructor for T.

// C++
const T* t = ...;
T_var tv = new T(*t);

5.11.2 T_out Types

When a T_var is passed as an out parameter, any previous value it referred to must be implicitly deleted. To give C++ mapping implementations enough hooks to meet this requirement, each T_var type has a corresponding T_out type that is used solely as the out parameter type. The general form for T_out types for variable-length types is shown below.

// C++
class T_out
{
    public:
        T_out(T*& p) : ptr_(p) { ptr_ = 0; }
        T_out(T_var& p) : ptr_(p.ptr_) {
            delete ptr_;
            ptr_ = 0;
        }
        T_out(const T_out& p) : ptr_(p.ptr_) {}

        T_out( const T_out& p ) : ptr_ ( p.ptr_ ) {}

        T_out& operator=(const T_out& p) {
            ptr_ = p.ptr_;
            return *this;
        }
        T_out& operator=(T* p) { ptr_ = p; return *this; }

};

8. This too has changed in ANSI/ISO C++, but not yet widely implemented by C++ compilers.
The first constructor binds the reference data member with the \texttt{T\&} argument and sets the pointer to the null pointer value. The second constructor binds the reference data member with the pointer held by the \texttt{T\_var} argument, and then calls \texttt{delete} on the pointer (or \texttt{string\_free()} in the case of the \texttt{String\_out} type or \texttt{T\_free()} in the case of a \texttt{T\_var} for an array type \texttt{T}). The third constructor, the copy constructor, binds the reference data member to the same pointer referenced by the data member of the constructor argument. Assignment from another \texttt{T\_out} copies the \texttt{T*} referenced by the \texttt{T\_out} argument to the data member. The overloaded assignment operator for \texttt{T*} simply assigns the pointer argument to the data member. Note that assignment does not cause any previously-held pointer to be deleted; in this regard, the \texttt{T\_out} type behaves exactly as a \texttt{T*}. The \texttt{T\&} conversion operator returns the data member. The \texttt{ptr()} member function, which can be used to avoid having to rely on implicit conversion, also returns the data member. The overloaded arrow operator (\texttt{operator->()}) allows access to members of the data structure pointed to by the \texttt{T\*} data member. Compliant applications may not call the overloaded \texttt{operator->()} unless the \texttt{T\_out} has been initialized with a valid non-null \texttt{T\*}.

Assignment to a \texttt{T\_out} from instances of the corresponding \texttt{T\_var} type is disallowed because there is no way to determine whether the application developer wants a copy to be performed, or whether the \texttt{T\_var} should yield ownership of its managed pointer so it can be assigned to the \texttt{T\_out}. To perform a copy of a \texttt{T\_var} to a \texttt{T\_out}, the application should use \texttt{new}:

```cpp
// C++
T\_var t = ...;
my\_out = new T(t.in()); // heap-allocate a copy
```

The \texttt{in()} function called on \texttt{t} typically returns a \texttt{const T\&}, suitable for invoking the copy constructor of the newly-allocated \texttt{T} instance.

Alternatively, to make the \texttt{T\_var} yield ownership of its managed pointer so it can be returned in a \texttt{T\_out} parameter, the application should use the \texttt{T\_var::\_retn()} function.

```cpp
// C++
T\_var t = ...;
my\_out = t.\_retn(); // t yields ownership, no copy
```

For fixed-length underlying types, no memory management issues arise; however, a compliant mapping must provide the following type definition in the scope of \texttt{T}:

```cpp
operator T\*\&() { return ptr\_; }
T\*\& ptr() { return ptr\_; }
T\* operator->() { return ptr\_; }

private:
T\*\& ptr\_;

// assignment from T\_var not allowed
void operator=(const T\_var\&):
};
```
typedef T &T_out;

Note that the \texttt{T\_out} types are not intended to serve as general-purpose data types to be created and destroyed by applications; they are used only as types within operation signatures to allow necessary memory management side-effects to occur properly.

### 5.12 Mapping for Struct Types

An OMG IDL struct maps to C++ struct, with each OMG IDL struct member mapped to a corresponding member of the C++ struct. The C++ structure members appear in the same order as the corresponding IDL structure members. This mapping allows simple field access as well as aggregate initialization of most fixed-length structs. To facilitate such initialization, C++ structs must not have user-defined constructors, assignment operators, or destructors, and each struct member must be of self-managed type. With the exception of strings and object references, the type of a C++ struct member is the normal mapping of the OMG IDL member’s type.

For a string, wide string, or object reference member, the name of the C++ member’s type is not specified by the mapping; therefore, a compliant program cannot create an object of that type. The behavior of the type is the same as the normal mapping (\texttt{char*} for string, \texttt{WChar*} for wide string, and \texttt{A\_ptr} for an interface \texttt{A}) except the type’s copy constructor copies the member’s storage and its assignment operator releases the member’s old storage. These types must also provide the \texttt{in()}, \texttt{inout()}, \texttt{out()}, and \texttt{\_retn()} functions that their corresponding \texttt{T\_var} types provide to allow them to support the parameter passing modes specified in Table 5.2. A compliant mapping implementation also provides overloaded \texttt{operator<<} (insertion) and \texttt{operator>>} (extraction) operators for using string members and wide string members directly with C++ iostreams.

For anonymous sequence members (required for recursive structures), a type name is required for the member. This name is generated by prepending an underscore to the member name, and appending “\_seq”.

For example

```c++
// IDL
struct node {
    long value;
    sequence<node, 2> operand;
};
```

This results in the following C++ code

```c++
// C++
struct node {
    typedef ... _operand_seq;
    Long value;
    _operand_seq operand;
};
```

In the C++ code shown above, the “...” in the \_operand_seq typedef refers to an implementation-specific sequence type. The name of this type is not standardized.

Assignment between a string, wide string, or object reference member and a corresponding \texttt{T\_var} type (\texttt{String\_var}, \texttt{WString\_var}, or \texttt{A\_var}) always results in copying the data, while assignment with a pointer does not. The one exception to the rule for assignment is when a \texttt{const char*} or \texttt{const WChar*} is assigned to a member, in which case the storage is copied.
When the old storage must not be freed (for example, it is part of the function’s activation record), one can access the member directly as a pointer using the _ptr field accessor. This usage is dangerous and generally should be avoided.

```cpp
struct FixedLen { float x, y, z; }

FixedLen x1 = {1.2, 2.4, 3.6};
FixedLen_var x2 = new FixedLen;
x2->y = x1.z;
```

The example above shows usage of the T and T_var types for a fixed-length struct. When it goes out of scope, x2 will automatically free the heap-allocated FixedLen object using delete.

The following examples illustrate mixed usage of T and T_var types for variable-length types, using the following OMG IDL definition.

```idl
interface A;
struct Variable { string name; }
```

```cpp
Variable str1;       // str1.name is initially empty
Variable_var str2 = new Variable;  // str2->name is
                                  // initially empty

c char *non_const;
const char *const2;
String_var string_var;
const char *const3 = "string 1";
const char *const4 = "string 2";

str1.name = const3;       // 1: free old storage, copy
str2->name = const4;      // 2: free old storage, copy
```

In the example above, the name components of variables str1 and str2 both start out as empty strings. On the line marked 1, const3 is assigned to the name component of str1. This results in the previous str1.name being freed, and since const3 points to const data, the contents of const3 being copied. In this case, str1.name started out as an empty string, so it must be freed before the copying of const3 takes place. Line 2 is similar to line 1, except that str2 is a T_var type.

Continuing with the example

```cpp
non_const = str1.name;   // 3: no free, no copy
const2 = str2->name;     // 4: no free, no copy
```

On the line marked 3, str1.name is assigned to non_const. Since non_const is a pointer type (char*), str1.name is not freed, nor are the data it points to copied. After the assignment, str1.name and non_const effectively point to the same storage, with str1.name retaining ownership of that storage. Line 4 is identical to line 3, even though const2 is a pointer to const char; str2->name is neither freed nor copied because const2 is a pointer type.
Line 5 involves assignment of a `char*` to `str1.name`, which results in the old `str1.name` being freed and the value of the `non_const` pointer, but not the data it points to, being copied. In other words, after the assignment `str1.name` points to the same storage as `non_const` points to. Line 6 is the same as line 5 except that because `const2` is a `const char*`, the data it points to are copied.

On line 7, assignment is performed to a member from another member, so the original value is of the left-hand member is freed and the new value is copied. Similarly, lines 8 and 9 involve assignment to or from a `String_var`, so in both cases the original value of the left-hand side is freed and the new value is copied.

Finally, line 10 uses the `_ptr` field accessor, so no freeing or copying takes place. Such usage is dangerous and generally should be avoided.

Compliant programs use `new` to dynamically allocate structs and `delete` to free them.

### 5.13 Mapping for Fixed Types

The C++ mapping for `fixed` is defined by the following class.

```cpp
// C++
class Fixed 
{ 
    public:
        // Constructors
        Fixed(int val = 0);
        Fixed(unsigned val);
        Fixed(Long val);
        Fixed(ULONG val);
        Fixed(LongLong val);
        Fixed(ULONGLong val);
        Fixed(Double val);
        Fixed(LongDouble val);
        Fixed(const Fixed& val);
        Fixed(const char*);
    ~Fixed();

        // Conversions
        operator LongLong() const;
        operator LongDouble() const;
        Fixed round(USHort scale) const;
};
```
Fixed truncate(UShort scale) const;
char *to_string() const;

// Operators
Fixed& operator=(const Fixed& val);
Fixed& operator+=(const Fixed& val);
Fixed& operator-=(const Fixed& val);
Fixed& operator*=(const Fixed& val);
Fixed& operator/=(const Fixed& val);

Fixed& operator++();
Fixed operator++(int);
Fixed& operator--();
Fixed operator--(int);
Fixed operator+() const;
Fixed operator-() const;
Boolean operator!() const;

// Other member functions
UShort fixed_digits() const;
UShort fixed_scale() const;

}

istream& operator>>(istream& is, Fixed& val);
ostream& operator<<(ostream& os, const Fixed& val);

Fixed operator + (const Fixed& val1, const Fixed& val2);
Fixed operator - (const Fixed& val1, const Fixed& val2);
Fixed operator * (const Fixed& val1, const Fixed& val2);
Fixed operator / (const Fixed& val1, const Fixed& val2);

Boolean operator > (const Fixed& val1, const Fixed& val2);
Boolean operator < (const Fixed& val1, const Fixed& val2);
Boolean operator >= (const Fixed& val1, const Fixed& val2);
Boolean operator <= (const Fixed& val1, const Fixed& val2);
Boolean operator == (const Fixed& val1, const Fixed& val2);
Boolean operator != (const Fixed& val1, const Fixed& val2);

The `Fixed` class is used directly by the C++ mapping for IDL fixed-point constant values and for all intermediate results of arithmetic operations on fixed-point values. For fixed-point parameters of IDL operations or members of IDL structured datatypes, the implementation may use the `Fixed` type directly, or alternatively, may use a different type, with an effectively constant digits and scale, that provides the same C++ interface and can be implicitly converted from/to the `Fixed` class. The name(s) of this alternative class is not defined by this mapping. Since fixed-point types used as parameters of IDL operations must be named via an IDL `typedef` declaration, the mapping must use the `typedef` to define the type of the operation parameter to make sure that server-side operation signatures are portable. Below is an example of the mapping.

// IDL
typedef fixed<5,2> F;

interface A
```cpp
{  
    void op(in F arg);
};

// C++
typedef Implementation_Defined_Class F;
class A
{
  public:
    ...
    void op(const F& arg);
    ...
};
```

The `Fixed` class has a number of constructors to guarantee that a fixed value can be constructed from any of the IDL standard integer and floating point types. The `Fixed(char*)` constructor converts a string representation of a fixed-point literal, with an optional leading sign (+ or -) and an optional trailing ‘d’ or ‘D,’ into a real fixed-point value. The `Fixed` class also provides conversion operators back to the `LongLong` and `LongDouble` types. For conversion to integral types, digits to the right of the decimal point are truncated. If the magnitude of the fixed-point value does not fit in the target conversion type, then the `DATA_CONVERSION` system exception is thrown.

The `round` and `truncate` functions convert a fixed value to a new value with the specified scale. If the new scale requires the value to lose precision on the right, the `round` function will round away from zero values that are halfway or more to the next absolute value for the new fixed precision. The `truncate` function always truncates the value towards zero. If the value currently has fewer digits on the right than the new scale, `round` and `truncate` return the argument unmodified.

For example

```cpp
// C++
Fixed f1 = "0.1";
 Fixed f2 = "0.05";
 Fixed f3 = "-0.005;
```

In this example, `f1.round(0)` and `f1.truncate(0)` both return 0, `f2.round(1)` returns 0.1, `f2.truncate(1)` returns 0.0, `f3.round(2)` returns -0.01 and `f3.truncate(2)` returns 0.00.

`to_string()` converts a fixed value to a string. Leading zeros are dropped, but trailing fractional zeros are preserved. (For example, a `fixed<4,2>` with the value 1.1 is converted “1.10”.) The caller of `Fixed::to_string()` must deallocate the return value by calling `CORBA::string_free()` or assigning the return value to a `String_var`.

The `fixed_digits` and `fixed_scale` functions return the smallest digits and scale value that can hold the complete fixed-point value. If the implementation uses alternative classes for operation parameters and structured type members, then `fixed_digits` and `fixed_scale` return the constant digits and scale values defined by the source IDL fixed-point type.

Arithmetic operations on the `Fixed` class must calculate the result exactly, using an effective double precision (62 digit) temporary value. The results are then truncated at run time to fit in a maximum of 31 digits using the method defined in version 2.3 of the `Common Object Request Broker Architecture (CORBA), OMG IDL Syntax and Semantics` clause, `Semantics` sub clause to determine the new digits and scale. If the result of any arithmetic operation produces more than
31 digits to the left of the decimal point, the DATA_CONVERSION exception will be thrown. If a fixed-point value, used as an actual operation parameter or assigned to a member of an IDL structured datatype, exceeds the maximum absolute value implied by the digits and scale, the DATA_CONVERSION exception will be thrown.

The stream insertion and extraction operators << and >> convert a fixed-point value to/from a stream. The exact definition of these operators may vary depending on the level of standardization of the C++ environment. These operators insert and extract fixed-point values into the stream using the same format as for C++ floating point types. In particular, the trailing ‘d’ or ‘D’ from the IDL fixed-point literal representation is not inserted or extracted from the stream. These operators use all format controls appropriate to floating point defined by the stream classes except that they never use the scientific format.

5.13.1 Fixed T_var and T_out Types

Because fixed-point types are always passed by reference as operation parameters and returned by value, there is no need for a _var type for a fixed-point type. For each IDL fixed-point typedef a corresponding _out type is defined as a reference to the fixed-point type.

// IDL
typedef fixed<5,2> F;

// C++
typedef Implementation_Defined_Name F;
typedef F& F_out;

5.14 Mapping for Union Types

Unions map to C++ classes with access functions for the union members and discriminant. Some member functions only provide read access to a member. Such functions are called “accessor functions” or “accessors” for short. For example

// C++
Long x() const;

Here, \texttt{x()} is an accessor that returns the value of the member \texttt{x} of a union (of type \texttt{Long} in this example).

Other member functions only provide write access to a union member. Such functions are called “modifier functions” or “modifiers” for short. For example

// C++
void x(Long val);

Here, \texttt{x()} is a modifier that sets the value of the member \texttt{x} of a union (of type \texttt{Long} in this example).

Still other union member functions provide read-write access to a union member by returning a reference to that member. Such functions are called “reference functions” or “referents” for short. For example

// C++
S& w();

Here, \texttt{w()} is a referent to the member \texttt{w} (of type \texttt{S}) of a union.
The default union constructor performs no application-visible initialization of the union. It does not initialize the discriminator, nor does it initialize any union members to a state useful to an application. (The implementation of the default constructor can do whatever type of initialization it wants to, but such initialization is implementation-dependent. No compliant application can count on a union ever being properly initialized by the default constructor alone.) Assigning, copying, and the destruction of default-constructed unions are safe. Assignment from or copying a default-constructed union results in the target of the assignment or copy being initialized the same as a default-constructed union.

It is therefore an error for an application to access the union before setting it, but ORB implementations are not required to detect this error due to the difficulty of doing so. The copy constructor and assignment operator both perform a deep-copy of their parameters, with the assignment operator releasing old storage if necessary. The destructor releases all storage owned by the union.

The union discriminant accessor and modifier functions have the name \_d to both be brief and to avoid name conflicts with the union members. The \_d discriminator modifier can only be used to set the discriminant to a value within the same union member. In addition to the \_d accessor and modifier, a union with an implicit default member provides a \_default() modifier function that sets the discriminant to a legal default value. A union has an implicit default member if it does not have a default case and not all permissible values of the union discriminant are listed. Assigning, copying, and the destruction of a union immediately after calling \_default() are safe. Assignment from or copying of such a union results in the target of the assignment or copy having the same safe state as it would if its \_default() function were invoked.

Setting the union value through a modifier function automatically sets the discriminant and may release the storage associated with the previous value. Attempting to get a value through an accessor that does not match the current discriminant results in undefined behavior. If a modifier for a union member with multiple legal discriminant values is used to set the value of the discriminant, the union implementation is free to set the discriminant to any one of the legal values for that member. The actual discriminant value chosen under these circumstances is implementation-dependent. Calling a referent for a member that does not match the current discriminant results in undefined behavior.

The following example helps illustrate the mapping for union types.

```idl
typedef octet Bytes[64];
struct S { long len; }
interface A;
valuetype Val;
union U switch (long) {
  case 1: long x;
  case 2: Bytes y;
  case 3: string z;
  case 4:
  case 5: S w;
  case 6: Val v;
  default: A obj;
}
```

```cpp
typedef Octet Bytes[64];
typedef Octet Bytes_slice;
class Bytes_forany { ... };
struct S { Long len; }
typedef ... A_ptr;
```
class Val ...
class U
{

    public:

    U();
    U(const U&);
    ~U();
    U &operator=(const U&);

    void _d(Long);
    Long _d() const;

    void x(Long);
    Long x() const;

    void y(Bytes);
    Bytes_slice *y() const;

    void z(char*); // free old storage, no copy
    void z(const char*); // free old storage,
    void z(const String_var &); // free old storage, copy
    const char *z() const;

    void w(const S &); // deep copy
    const S &w() const; // read-only access
    S &w(); // read-write access

    void v(Val*); // _remove_ref old valuetype,
        // _add_ref argument
    Val* v() const; // no _add_ref of return value

    void obj(A_ptr); // release old objref,
        // duplicate
    A_ptr obj() const; // no duplicate

    }

Accessor and modifier functions for union members provide semantics similar to that of struct data members. Modifier functions perform the equivalent of a deep-copy of their parameters, and their parameters should be passed by value (for small types) or by reference to const (for larger types). Referents can be used for read-write access, but are only provided for the following types: **struct, union, sequence, any, and fixed**.

The reference returned from a reference function continues to denote that member only for as long as the member is active. If the active member of the union is subsequently changed, the reference becomes invalid, and attempts to read or write the member via the reference result in undefined behavior.

For an array union member, the accessor returns a pointer to the array slice, where the slice is an array with all dimensions of the original except the first (array slices are described in detail in “Mapping For Array Types” on page 43). The array slice return type allows for read-write access for array members via regular subscript operators. For members of an anonymous array type, supporting typedefs for the array must be generated directly into the union.

For example
// IDL
union U switch (long) {
    default: long array[20][20];
};

// C++
class U
{
    public:
        void array(long arg[20][20]);
        typedef long _array_slice[20];
        _array_slice * array();
};

The name of the supporting array slice typedef is created by prepending an underscore and appending “_slice” to the union member name. In the example above, the array member named “array” results in an array slice typedef called “_array_slice” nested in the union class.

For string union members, the char* modifier results in the freeing of old storage before ownership of the pointer parameter is assumed, while the const char* modifier and the String_var modifier\(^9\) both result in the freeing of old storage before the parameter’s storage is copied. The accessor for a string member returns a const char* to allow examination but not modification of the string storage.\(^10\) The union will also provide modifier functions that take the unnamed string struct member, array member, and sequence member types as a parameter, with the same semantics as the String_var modifier.

For object reference union members, object reference parameters to modifier functions are duplicated after the old object reference is released. An object reference return value from an accessor function is not duplicated because the union retains ownership of the object reference.

For anonymous sequence union members (required for recursive unions), a type name is required. This name is generated by prepending an underscore to the member name, and appending “_seq.”

For example

// IDL
union node switch (long) {
    case 0: long value;
    case 1: sequence<node, 2> operand;
};

This results in the following C++

\(^9\) A separate modifier for String_var is needed because it can automatically convert to both a char* and a const char*; since unions provide modifiers for both of these types, an attempt to set a string member of a union from a String_var would otherwise result in an ambiguity error at compile time.

\(^10\) A return type of char* allowing read-write access could mistakenly be assigned to a String_var, resulting in the String_var and the union both assuming ownership for the string’s storage.
// C++
class node {
  public:
    typedef ... _operand_seq;
    ...
    // Member functions dealing with the operand
    // member use _operand_seq for its type.
    ...
};

In the C++ code shown above, the “…” in the _operand_seq typedef refers to an implementation-specific sequence type. The name of this type is not standardized.

The restrictions for using the _d discriminator modifier function are shown by the following examples, based on the definition of the union U shown above.

// C++
S s = {10};
U u;
u.w(s); // member w selected
u._d(4); // OK, member w selected
u._d(5); // OK, member w selected
u._d(1); // error, different member selected
A_ptr a = ...;
u.obj(a); // member obj selected
u._d(7); // OK, member obj selected
u._d(1); // error, different member selected
s = u.w(); // error, member w not active

As shown here, neither the _d modifier function nor the w referent can be used to implicitly switch between different union members. The following shows an example of how the _default() member function is used.

// IDL
union Z switch(boolean) {
  case TRUE: short s;
};

// C++
Z z;
z._default(); // implicit default member selected
Boolean disc = z._d(); // disc == FALSE
U u; // union U from previous example
u._default(); // error, no _default() provided

For union Z, calling the _default() modifier function causes the union’s value to be composed solely of the discriminator value of FALSE, since there is no explicit default member. For union U, calling _default() causes a compilation error because U has an explicitly declared default case and thus no _default() member function. A _default() member function is only generated for unions with implicit default members.

Compliant programs use new to dynamically allocate unions and delete to free them.
### 5.15 Mapping for Sequence Types

A sequence is mapped to a C++ class that behaves like an array with a current length and a maximum length. For a bounded sequence, the maximum length is implicit in the sequence’s type and cannot be explicitly controlled by the programmer. For an unbounded sequence, the initial value of the maximum length can be specified in the sequence constructor to allow control over the size of the initial buffer allocation. The length of a sequence never changes without an explicit call to the length() member function.

For an unbounded sequence, setting the length to a larger value than the current length may reallocate the sequence data. Reallocation is conceptually equivalent to creating a new sequence of the desired new length, copying the old sequence elements zero through length-1 into the new sequence, and then assigning the old sequence to be the same as the new sequence. Setting the length to a smaller value than the current length does not affect how the storage associated with the sequence is manipulated. Note, however, that the elements orphaned by this reduction are no longer accessible and that their values cannot be recovered by increasing the sequence length to its original value.

For a bounded sequence, attempting to set the current length to a value larger than the maximum length given in the OMG IDL specification produces undefined behavior.

For each different typedef naming an anonymous sequence type, a compliant mapping implementation provides a separate C++ sequence type. To facilitate template-based programming, a nested public typedef _size_type is delivered as the type representing the length and maximum of the sequence.

For example

```idl
typedef sequence<long> LongSeq;
typedef sequence<LongSeq, 3> LongSeqSeq;
```

```cpp
class LongSeq // unbounded sequence
{
    public:
        typedef ULong _size_type;
        LongSeq(); // default constructor
        LongSeq(ULong max); // maximum constructor
        LongSeq(ULong max,
                ULong length,
                Long *value,
                Boolean release = FALSE);
        LongSeq(const LongSeq &);
        ~LongSeq();
        ...
};

class LongSeqSeq // bounded sequence
{
    public:
        typedef ULong _size_type;
        LongSeqSeq(); // default constructor
        LongSeqSeq( // T *data constructor
            ...]
```
ULong length,
LongSeq *value,
    Boolean release = FALSE);
LongSeqSeq(const LongSeqSeq&);
    -LongSeqSeq();
...

For both bounded and unbounded sequences, the default constructor (as shown in the example above) sets the sequence length equal to 0. For bounded sequences, the maximum length is part of the type and cannot be set or modified, while for unbounded sequences, the default constructor also sets the maximum length to 0. Default constructors for bounded and unbounded sequences need not allocate buffers immediately.

Unbounded sequences provide a constructor that allows only the initial value of the maximum length to be set (the “maximum constructor” shown in the example above). This allows applications to control how much buffer space is initially allocated by the sequence. This constructor also sets the length to 0 and the release flag to FALSE.

The “T *data” constructor (as shown in the example above) allows the length and contents of a bounded or unbounded sequence to be set. For unbounded sequences, it also allows the initial value of the maximum length to be set. For this constructor, ownership of the buffer is determined by the release parameter—FALSE means the caller owns the storage for the buffer and its elements, while TRUE means that the sequence assumes ownership of the storage for the buffer and its elements. If release is TRUE, the buffer is assumed to have been allocated using the sequence allocbuf function, and the sequence will pass it to freebuf when finished with it. The allocbuf and freebuf functions are described on “Additional Memory Management Functions” on page 42.

The copy constructor creates a new sequence with the same maximum and length as the given sequence, copies each of its current elements (items zero through length–1), and sets the release flag to TRUE.

The assignment operator deep-copies its parameter, releasing old storage if necessary. It behaves as if the original sequence is destroyed via its destructor and then the source sequence copied using the copy constructor.

If release=TRUE, the destructor destroys each of the current elements (items zero through length–1), and destroys the underlying sequence buffer.

For an unbounded sequence, if a reallocation is necessary due to a change in the length and the sequence was created using the release=TRUE parameter in its constructor, the sequence will deallocate the old storage for all elements and the buffer. If release is FALSE under these circumstances, old storage will not be freed for either the elements or for the buffer before the reallocation is performed. After reallocation, the release flag is always set to TRUE.

For an unbounded sequence, the maximum() accessor function returns the total number of sequence elements that can be stored in the current sequence buffer. This allows applications to know how many items they can insert into an unbounded sequence without causing a reallocation to occur. For a bounded sequence, maximum() always returns the bound of the sequence as given in its OMG IDL type declaration.

The length() functions can be used to access and modify the length of the sequence. Increasing the length of a sequence adds new elements at the tail. The newly-added elements behave as if they are default-constructed when the sequence length is increased. However, a sequence implementation may delay actual default construction until a newly-added element is first accessed. For sequences of strings and wide strings, default element construction requires initialization of each element to the empty string or wide string. For sequences of object references, default element construction requires initialization of each element to a suitably-typed nil reference. For sequences of valuetypes, default element construction requires initialization of each element to a null pointer. The elements of sequences of other complex
types, such as structs and sequences, are initialized by their default constructors. Union sequences elements do not have any application-visible initialization; in particular, a default-constructed union element is not safe for marshaling or access. Sequence elements of a basic type, such as `ULong`, have undefined default values.

The overloaded subscript operators (operator[]) return the item at the given index. The non-const version must return something that can serve as an lvalue (i.e., something that allows assignment into the item at the given index), while the const version must allow read-only access to the item at the given index.

The overloaded subscript operators may not be used to access or modify any element beyond the current sequence length. Before either form of operator[] is used on a sequence, the length of the sequence must first be set using the `length(ULong)` modifier function, unless the sequence was constructed using the `T*data` constructor.

For strings, wide strings, and object references, operator[] for a sequence must return a type with the same semantics as the types used for string, wide string, and object reference members of structs and arrays, so that assignment to the string, wide string, or object reference sequence member via operator=() will release old storage when appropriate.

Note that whatever these special return types are, they must honor the setting of the release parameter in the `T*data` constructor with respect to releasing old storage. A compliant mapping implementation also provides overloaded operator<<(insertion) and operator>>(extraction) operators for using string sequence elements and wide string sequence elements directly with C++ iostreams.

The release() accessor function returns the state of the sequence release flag.

The overloaded get_buffer() accessor and reference functions allow direct access to the buffer underlying a sequence. This can be very useful when sending large blocks of data as sequences, such as sending image data as a sequence of octet, and the per-element access provided by the overloaded subscript operators is not sufficient.

The non-const get_buffer() reference function allows read-write access to the underlying buffer. If its orphan argument is FALSE (the default), the sequence returns a pointer to its buffer, allocating one if it has not yet done so. The size of the buffer can be determined using the maximum() accessor. For bounded sequences, the size of the returned buffer is equal to the sequence bound. The number of elements in the buffer can be determined from the sequence length() accessor. The sequence maintains ownership of the underlying buffer. Elements in the returned buffer may be directly replaced by the caller. For sequences of strings, wide strings, and object references, the caller must use the sequence release() accessor to determine whether elements should be freed (using string_free, wstring_free, or CORBA::release for string, wide strings, and object references, respectively) before being directly assigned to.

Because the sequence maintains a notion of the length and size of the buffer, the caller of get_buffer() shall not lengthen or shorten the sequence by directly adding elements to the buffer or directly removing elements from the buffer. Changing the length of the sequence shall be performed only by invoking the sequence length() modifier function.

Alternatively, if the orphan argument to get_buffer() is TRUE, the sequence yields ownership of the buffer to the caller. If orphan is TRUE and the sequence does not own its buffer (i.e., its release flag is FALSE), the return value is a null pointer. If the buffer is taken from the sequence using this form of get_buffer(), the sequence reverts to the same state it would have if constructed using its default constructor. The caller becomes responsible for eventually freeing each element of the returned buffer (for strings, wide string, and object references), and then freeing the returned buffer itself using freebuf.

The const get_buffer() accessor function allows read-only access to the sequence buffer. The sequence returns its buffer, allocating one if one has not yet been allocated. No direct modification of the returned buffer by the caller is permitted.

For the non-const get_buffer() reference function with an orphan argument of FALSE, and for the const get_buffer() accessor function, the return value remains valid until another non-const member function of the sequence is invoked, or until the sequence is destroyed, whichever occurs first.
The `replace()` function allows the buffer underlying a sequence to be replaced. The parameters to `replace()` are identical in type, order, and purpose to those for the `T *data` constructor for the sequence.

Access to the underlying sequences buffers seems to imply that a sequence implementation must use contiguous memory to hold the elements, but this need not be the case. A compliant sequence implementation could keep its elements in several separate memory buffers and relocate them to a single buffer only if the application called the `get_buffer()` accessors. In fact, for applications that never invoke these accessors, such an implementation would very likely be better suited to handling large sequences than one using a large single contiguous buffer.

For the `T *data` sequence constructor and for the buffer parameter of the `replace()` function, the type of `T` for strings, wide strings, and object references is `char*`, `CORBA::WChar*`, and `T_ptr`, respectively. In other words, string buffers are passed as `char**`, wide string buffers as `CORBA::WChar**`, and object reference buffers as `T_ptr*`. The return type of the non-const `get_buffer()` reference function for sequences of strings is `char**`, `CORBA::WChar**` for sequences of wide strings, and `T_ptr*` for sequences of object references. The return type of the const `get_buffer()` accessor function for sequences of strings is `const char* const*`, `const CORBA::WChar* const*` for sequences of wide strings, and `const T_ptr*` for sequences of object reference.

### 5.15.1 Sequence Example

The example below shows full declarations for both a bounded and an unbounded sequence.

```plaintext
// IDL
typedef sequence<T> V1; // unbounded sequence
typedef sequence<T, 2> V2; // bounded sequence

// C++
class V1 // unbounded sequence
{
public:
    typedef ULong _size_type;
    V1();
    V1(ULong max);
    V1(ULong max, ULong length, T *data,
       Boolean release = FALSE);
    V1(const V1&);
    ~V1();
    V1 &operator=(const V1&);

    ULong maximum() const;
    void length(ULong);
    ULong length() const;

    T &operator[](ULong index);
    const T &operator[](ULong index) const;

    Boolean release() const;

    void replace(ULong max, ULong length, T *data,
                 Boolean release = FALSE);
```
```cpp
T* get_buffer(Boolean orphan = FALSE);
const T* get_buffer() const;
};

class V2 //bounded sequence
{
public:
    typedef ULong _size_type;
    V2();
    V2(ULong length, T *data, Boolean release = FALSE);
    V2(const V2&);
    ~V2();
    V2 &operator=(const V2&);

    ULong maximum() const;
    void length(ULong);
    ULong length() const;

    T &operator[](ULong index);
    const T &operator[](ULong index) const;

    Boolean release() const;
    void replace(ULong length, T *data,
                 Boolean release = FALSE);

    T* get_buffer(Boolean orphan = FALSE);
    const T* get_buffer() const;
};

5.15.2 Using the “release” Constructor Parameter

Consider the following example

// IDL
typedef sequence<string, 3> StringSeq;

// C++
char *static_arr[] = {"one", "two", "three"};
char **dyn_arr = StringSeq::allocbuf();
dyn_arr[0] = string_dup("one");
dyn_arr[1] = string_dup("two");
dyn_arr[2] = string_dup("three");

StringSeq seq1(3, static_arr);
StringSeq seq2(3, dyn_arr, TRUE);

seq1[1] = "2"; // no free, no copy
```
char *str = string_dup("2");
seq2[1] = str; // free old storage, no copy

In this example, both seq1 and seq2 are constructed using user-specified data, but only seq2 is told to assume management of the user memory (because of the release=TRUE parameter in its constructor). When assignment occurs into seq1[1], the right-hand side is not copied, nor is anything freed because the sequence does not manage the user memory. When assignment occurs into seq2[1], however, the old user data must be freed before ownership of the right-hand side can be assumed, since seq2 manages the user memory. When seq2 goes out of scope, it will call string_free for each of its elements and then call freebuf on the buffer given to it in its constructor.

When the release flag is set to TRUE and the sequence element type is either a string or an object reference type, the sequence will individually release each element before releasing the contents buffer. It will release strings using string_free, and it will release object references using the release function from the CORBA namespace.

In general, assignment should never take place into a sequence element via operator[] unless release=TRUE due to the possibility for memory management errors. In particular, a sequence constructed with release=FALSE should never be passed as an inout parameter because previous versions of this specification provided no means for the callee to determine the setting of the sequence release flag, and thus the callee always had to assume that release was set to TRUE. Code that creates a sequence with release=FALSE and then knowingly and correctly manipulates it in that state, as shown with seq1 in the example above, is compliant, but care should always be taken to avoid memory leaks under these circumstances.

For a sequence passed to an operation as an in parameter, the operation must not assign to the sequence if its release flag is FALSE and the sequence has variable-length elements.

For a sequence passed to a client as an out parameter or return value, the client must not assign to the sequence if its release flag is FALSE and the sequence has variable-length elements.

When a sequence is constructed with release=TRUE, a compliant application should make no assumptions about the continued lifetime of the data buffer passed to the constructor, since a compliant sequence implementation is free to copy the buffer and immediately free the original pointer.

5.15.3 Additional Memory Management Functions

Compliant programs use new to dynamically allocate sequences and delete to free them.

Sequences also provide additional memory management functions for their buffers. For an unbounded sequence of type T, the following static member functions are provided in the sequence class public interface.

// C++
static T *allocbuf(ULong nelems);
static void freebuf(T *);

The allocbuf function allocates a vector of T elements that can be passed to the T *data constructor and to the replace() member function. The length of the vector is given by the nelems function argument. The allocbuf function initializes each element using its default constructor, except for strings and wide strings, which are initialized to pointers to empty string, and object references, which are initialized to suitably-typed nil object references. A null pointer is returned if for some reason allocbuf cannot allocate the requested vector.

For bounded sequences, the following static member functions are provided in the sequence class public interface.
For bounded sequences, the first (zero parameter) version of allocatebuf allocates a buffer of maximum() elements. A null pointer is returned if the function cannot allocate the requested vector.

Note that the version of allocatebuf that accepts an element count is deprecated for bounded sequences and will be removed in a future version of the mapping. Calls to the deprecated version with an argument value other than the sequence maximum have implementation-dependent behavior.

Vectors allocated by allocatebuf must be freed using the freebuf function. The freebuf function ensures that the destructor for each element is called before the buffer is destroyed, except for string and wide string elements, which are freed using string_free() andwstring_free(), respectively, and object reference elements, which are freed using CORBA::release(). The freebuf function will ignore null pointers passed to it. Neither allocatebuf nor freebuf may throw CORBA exceptions.

A call to allocatebuf with a zero-value argument causes allocatebuf to allocate a zero-length buffer and return a pointer to it. Like any buffer returned from allocatebuf, this buffer must be freed using the corresponding freebuf function.

5.15.4 Sequence T_var and T_out Types

In addition to the regular operations defined for T_var and T_out types, the T_var and T_out for a sequence type also supports an overloaded operator[] that forwards requests to the operator[] of the underlying sequence. This subscript operator should have the same return type as that of the corresponding operator on the underlying sequence type.

5.16 Mapping For Array Types

Arrays are mapped to the corresponding C++ array definition, which allows the definition of statically-initialized data using the array. If the array element is a string, wide string, or an object reference, then the mapping uses the same type as for structure members. That is, the default constructor for string elements and wide string elements initializes them to the empty string ("" and L""), respectively, and assignment to an array element that is a string, wide string, or object reference will release the storage associated with the old value.

// IDL
typedef float F[10];
typedef string V[10];
typedef string M[1][2][3];
void op(out F p1, out V p2, out M p3);

11. Note that since T_var and T_out types do not handle const T*, there is no need to provide the const version of operator[] for Sequence_var and Sequence_out types.
// C++
typedef Float F[10];
typedef ... V[10];       // underlying type not shown because
typedef ... M[1][2][3];  // it is implementation-dependent
F f1; F_var f2;
V v1; V_var v2;
M m1; M_var m2;
f(f2, v2, m2);
f1[0] = f2[1];
v1[1] = v2[1];          // free old storage, copy
m1[0][1][2] = m2[0][1][2];  // free old storage, copy

In the above example, the last two assignments result in the storage associated with the old value of the left-hand side
being automatically released before the value from the right-hand side is copied.

As shown in Table 5.3, out and return arrays are handled via pointer to array slice, where a slice is an array with all the
dimensions of the original specified except the first one. As a convenience for application declaration of slice types, the
mapping also provides a typedef for each array slice type. The name of the slice typedef consists of the name of the array
type followed by the suffix "_slice."

For example

// IDL
typedef long LongArray[4][5];

// C++
typedef Long LongArray[4][5];
typedef Long LongArray_slice[5];

Both the T_var type and the T_out type for an array should overload operator[] instead of operator->. The use
of array slices also means that the T_var type and the T_out type for an array should have a constructor and assignment
operator that each take a pointer to array slice as a parameter, rather than T*. The T_var for the previous example would be

// C++
class LongArray_var
{
  public:
    LongArray_var();
    LongArray_var(LongArray_slice*);
    LongArray_var(const LongArray_var &);
    ~LongArray_var();
    LongArray_var &operator=(LongArray_slice*);
    LongArray_var &operator=(const LongArray_var &);
    LongArray_slice &operator[](Ulong index);
    const LongArray_slice &operator[](Ulong index) const;

    const LongArray_slice* in() const;
    LongArray_slice* inout();
    LongArray_slice* out();
    LongArray_slice* _retn();
Because arrays are mapped into regular C++ arrays, they present special problems for the type-safe any mapping described in “Mapping for the Any Type” on page 47. To facilitate their use with the any mapping, a compliant implementation must also provide for each array type a distinct C++ type whose name consists of the array name followed by the suffix _forany. These types must be distinct so as to allow functions to be overloaded on them. Like Array_var types, Array_forany types allow access to the underlying array type, but unlike Array_var, the Array_forany type does not delete the storage of the underlying array upon its own destruction. This is because the Any mapping retains storage ownership, as described in “Extraction from any” on page 51.

The interface of the Array_forany type is identical to that of the Array_var type, but it may not be implemented as a typedef to the Array_var type by a compliant implementation since it must be distinguishable from other types for purposes of function overloading. Also, the Array_forany constructor taking an Array_slice* parameter also takes a Boolean nocopy parameter, which defaults to FALSE.

The nocopy flag allows for a non-copying insertion of an Array_slice* into an Any.

Each Array_forany type must be defined at the same level of nesting as its Array type.

For dynamic allocation of arrays, compliant programs must use special functions defined at the same scope as the array type. For array T, the following functions will be available to a compliant program.

The T_alloc function dynamically allocates an array, or returns a null pointer if it cannot perform the allocation. The T_dup function dynamically allocates a new array with the same size as its array argument, copies each element of the argument array into the new array, and returns a pointer to the new array. If allocation fails, a null pointer is returned. The T_copy function copies the contents of the from array to the to array. If either argument is a null pointer, T_copy does not attempt a copy and results in no action being performed. The T_free function deallocates an array that was allocated with T_alloc or T_dup. Passing a null pointer to T_free is acceptable and results in no action being performed. The T_alloc, T_dup, and T_free functions allow ORB implementations to utilize special memory management mechanisms for array types if necessary, without forcing them to replace global operator new and operator new[].

The T_alloc, T_dup, T_copy, and T_free functions may not throw CORBA exceptions.
5.17 Mapping For Typedefs

A typedef creates an alias for a type. If the original type maps to several types in C++, then the typedef creates the corresponding alias for each type. The example below illustrates the mapping.

// IDL
typedef long T;
interface A1;
typedef A1 A2;
typedef sequence<long> S1;
typedef S1 S2;

// C++
typedef Long T;
// ...definitions for A1...

typedef A1 A2;
typedef A1_ptr A2_ptr;
typedef A1_var A2_var;

// ...definitions for S1...
class S1 { ... };

typedef S1 S2;
typedef S1_var S2_var;

For a typedef of an IDL type that maps to multiple C++ types, such as arrays, the typedef maps to all of the same C++ types and functions that its base type requires.

For example

// IDL
typedef long array[10];
typedef array another_array;

// C++
// ...C++ code for array not shown...
typedef array another_array;
typedef array_var another_array_var;
typedef array_slice another_array_slice;
typedef array_forany another_array_forany;

inline another_array_slice *another_array_alloc() {
    return array_alloc();
}

inline another_array_slice* another_array_dup(another_array_slice *a) {
    return array_dup(a);
}

inline void
another_array_copy(another_array_slice* to,  
    const another_array_slice* from)  
{
    array_copy(to, from);
}

inline void another_array_free(another_array_slice *a) {
    array_free(a);
}

5.18 Mapping for the Any Type

A C++ mapping for the OMG IDL type **any** must fulfill two different requirements:

1. Handling C++ types in a type-safe manner.
2. Handling values whose types are not known at implementation compile time.

The first item covers most normal usage of the **any** type—the conversion of typed values into and out of an **any**. The second item covers situations such as those involving the reception of a request or response containing an **any** that holds data of a type unknown to the receiver when it was created with a C++ compiler.

5.18.1 Handling Typed Values

To decrease the chances of creating an **any** with a mismatched **TypeCode** and value, the C++ function overloading facility is utilized. Specifically, for each distinct type in an OMG IDL specification, overloaded functions to insert and extract values of that type are provided by each ORB implementation. Overloaded operators are used for these functions so as to completely avoid any name space pollution. The nature of these functions, which are described in detail below, is that the appropriate **TypeCode** is implied by the C++ type of the value being inserted into or extracted from the **any**.

Since the type-safe **any** interface described below is based upon C++ function overloading, it requires C++ types generated from OMG IDL specifications to be distinct. However, there are special cases in which this requirement is not met:

- As noted in “Mapping for Basic Data Types” on page 15, the **boolean**, **octet**, **char**, and **wchar** OMG IDL types are not required to map to distinct C++ types, which means that a separate means of distinguishing them from each other for the purpose of function overloading is necessary. The means of distinguishing these types from each other is described in “Distinguishing boolean, octet, char, wchar, bounded string, and bounded wstring” on page 53.

- Since all strings and wide strings are mapped to **char** and **WChar***, respectively, regardless of whether they are bounded or unbounded, another means of creating or setting an **any** with a bounded string or wide string value is necessary. This is described in “Distinguishing boolean, octet, char, wchar, bounded string, and bounded wstring” on page 53.

- In C++, arrays within a function argument list decay into pointers to their first elements. This means that function overloading cannot be used to distinguish between arrays of different sizes. The means for creating or setting an **any** when dealing with arrays is described below and in “Mapping For Array Types” on page 43.
5.18.2 Insertion into any

To allow a value to be set in an any in a type-safe fashion, an ORB implementation must provide the following overloaded operator function for each separate OMG IDL type T.

// C++
void operator<<=(Any&, T);

This function signature suffices for types that are normally passed by value:

- Enumerations
- Unbounded strings and wide strings (char* and WChar* passed by value)
- Object references (T_ptr)
- Pointers to valuetype (T*)

For values of type T that are too large to be passed by value efficiently, such as structs, unions, sequences, Any, and exceptions, two forms of the insertion function are provided.

// C++
void operator<<=(Any&, const T&); // copying form
void operator<<=(Any&, T*);       // non-copying form

Note that the copying form is largely equivalent to the first form shown, as far as the caller is concerned.

These “left-shift-assign” operators are used to insert a typed value into an any as follows:

// C++
Long value = 42;
Any a;
a <<= value;

In this case, the version of operator<<= overloaded for type Long must be able to set both the value and the TypeCode properly for the any variable.

Setting a value in an any using operator<<= means that:

- For the copying version of operator<<=, the lifetime of the value in the any is independent of the lifetime of the value passed to operator<<=. The implementation of the any may not store its value as a reference or pointer to the value passed to operator<<=.

- For the non-copying version of operator<<=, the inserted T* is consumed by the any. The caller may not use the T* to access the pointed-to data after insertion, since the any assumes ownership of it, and it may immediately copy the pointed-to data and destroy the original.

- With both the copying and non-copying versions of operator<<=, any previous value held by the Any is properly deallocated. For example, if the Any(TypeCode_ptr, void*, TRUE) constructor was called to create the Any, the Any is responsible for de-allocating the memory pointed to by the void* before copying the new value.

Copying insertion of a string type or wide string type causes one of the following functions to be invoked:
void operator<<=(Any&, const char*);
void operator<<=(Any&, const WChar*);

Since all string types are mapped to char*, and all wide string types are mapped to WChar*, these insertion functions assume that the values being inserted are unbounded. “Distinguishing boolean, octet, char, wchar, bounded string, and bounded wstring” on page 53 describes how bounded strings and bounded wide strings may be correctly inserted into an Any. Note that insertion of wide strings in this manner depends on standard C++, in which wchar_t is a distinct type. Code that must be portable across standard and older C++ compilers must use the Any::from_wstring helper. Noncopying insertion of both bounded and unbounded strings can be achieved using the Any::from_string helper type. Similarly, noncopying insertion of bounded and unbounded wide strings can be achieved using the Any::from_wstring helper type. Both of these helper types are described in “Distinguishing boolean, octet, char, wchar, bounded string, and bounded wstring” on page 53.

Note that the following code has undefined behavior in nonstandard C++ environments:

// C++
Any a = ...;
WChar wc;
a >>= wc;  // undefined behavior

This code may erroneously extract an integer type in environments where wchar_t is not a distinct type.

Because valuetype may be represented legally using null pointers, a conforming application may insert a null valuetype pointer into an Any.

Type-safe insertion of arrays uses the Array_forany types described in “Mapping For Array Types” on page 43. Compliant implementations must provide a version of operator<<= overloaded for each Array_forany type.

For example

// IDL
typedef long LongArray[4][5];

// C++
typedef Long LongArray[4][5];
typedef Long LongArray_slice[5];
class LongArray_forany { ... };

void operator<<=(Any &, const LongArray_forany &);

The Array_forany types are always passed to operator<<= by reference to const. The nocopy flag in the Array_forany constructor is used to control whether the inserted value is copied (nocopy == FALSE) or consumed (nocopy == TRUE). Because the nocopy flag defaults to FALSE, copying insertion is the default.

Because of the type ambiguity between an array of T and a T*, it is highly recommended that portable code explicitly12 use the appropriate Array_forany type when inserting an array into an Any.

12. A mapping implementor may use the new C++ keyword “explicit” to prevent implicit conversions through the Array_forany constructor, but this feature is not yet widely available in current C++ compilers.
// IDL
struct S {...};
typedef S SA[5];

// C++
struct S { ... };
typedef S SA[5];
typedef S SA_slice;
class SA_forany { ... };

SA s;
// ...initialize s...
Any a;
a <<= s; // line 1
a <<= SA_forany(s); // line 2

Line 1 results in the invocation of the noncopying operator<<=(Any&, S*) due to the decay of the SA array type into a pointer to its first element, rather than the invocation of the copying SA_forany insertion operator. Line 2 explicitly constructs the SA_forany type and thus results in the desired insertion operator being invoked.

The noncopying version of operator<<= for object references takes the address of the T_ptr type.

// IDL
interface T {...};

// C++
void operator<<=(Any&, T_ptr); // copying
void operator<<=(Any&, T_ptr*); // non-copying

The noncopying object reference insertion consumes the object reference pointed to by T_ptr*; therefore after insertion the caller may not access the object referred to by T_ptr since the any may have duplicated and then immediately released the original object reference. The caller maintains ownership of the storage for the T_ptr itself.

The noncopying version of operator<<= for valuetypes takes the address of the T* pointer type.

// IDL
valuetype T {...};

// C++
void operator<<=(Any&, T*); // copying
void operator<<=(Any&, T**); // non-copying

The noncopying valuetype insertion consumes the valuetype pointed to by the pointer that T** points to. After insertion, the caller may not access the valuetype instance pointed to by the pointer that T* points to. The caller maintains ownership of the storage for the pointed-to T* itself.

In general, the copying versions of operator<<= are also supported on the Any_var type. Note that due to the conversion operators that convert Any_var to Any& for parameter passing, only those operator<<= functions defined as member functions of any need to be explicitly defined for Any_var.
5.18.3 Extraction from any

To allow type-safe retrieval of a value from an any, the mapping provides the following operators for each OMG IDL type T:

// C++
Boolean operator >>= (const Any&, T&);

This function signature suffices for primitive types that are normally passed by value. For values of type T that are too large to be passed by value efficiently (such as structs, unions, sequences, Any, valuetype, and exceptions) this function may be prototyped as follows:

// C++
Boolean operator >>= (const Any&, T*); // deprecated
Boolean operator >>= (const Any&, const T*);

The non-constant version of the operator will be deprecated in a future version of the mapping and should not be used.
The first form of this function is used only for the following types:

- Enumerations
- Unbounded strings and wide strings (const char* and const WChar* passed by reference (i.e., const char* & and const WChar* &))
- Object references (T_ptr)

For all other types, the second form of the function is used.

All versions of operator >>= implemented as member functions of class Any, such as those for primitive types, should be marked as const.

This “right-shift-assign” operator is used to extract a typed value from an any as follows:

// C++
Long value;
 Any a;
a <<= Long(42);
if (a >>= value) {
    // ... use the value ...
}

In this case, the version of operator >>= for type Long must be able to determine whether the Any truly does contain a value of type Long and, if so, copy its value into the reference variable provided by the caller and return TRUE. If the Any does not contain a value of type Long, the value of the caller’s reference variable is not changed, and operator >>= returns FALSE.

---

13. Note that extraction of wide strings in this manner depends on standard C++, in which wchar_t is a distinct type. Code that must be portable across standard and older C++ compilers must use the to_wstring helper type.
For non-primitive types, such as struct, union, sequence, exception, and Any, extraction is done by pointer to const (valuetypes are extracted by pointer to non-const because valuetype operations do not support const). For example, consider the following IDL struct:

```
// IDL
struct MyStruct {
    long lmem;
    short smem;
};
```

Such a struct could be extracted from an Any as follows:

```
// C++
Any a;
// ... a is somehow given a value of type MyStruct ...
const MyStruct *struct_ptr;
if (a >>= struct_ptr) {
    // ... use the value ...
}
```

If the extraction is successful, the caller’s pointer will point to storage managed by the Any, and operator >>= will return TRUE. The caller must not try to delete or otherwise release this storage. The caller also should not use the storage after the contents of the Any variable are replaced via assignment, insertion, or the replace function, or after the Any variable is destroyed. An attempt to extract to a T_var type is non-conforming and must cause a compile-time error.

If the extraction is not successful, the value of the caller’s pointer is set equal to the null pointer, and operator >>= returns FALSE. Note that because valuetypes may legally be represented as null pointers, however, a pointer to T extracted from an Any, where T is a valuetype, may be null even when extraction is successful if the Any holds a null valuetype pointer.

Correct extraction of array types relies on the Array_forany types described in “Mapping For Array Types” on page 43.

```
// IDL
typedef long A[20];
typedef A B[30][40][50];
```

```
// C++
typedef Long A[20];
typedef Long A_slice;
class A_forany { ... }

typedef A B[30][40][50];
typedef A B_slice[40][50];
class B_forany { ... }

Boolean operator >>= (const Any &, A_forany &); // for type A
Boolean operator >>= (const Any &, B_forany &); // for type B
```

The Array_forany types are always passed to operator >>= by reference.
For strings, wide strings, and arrays, applications are responsible for checking the `TypeCode` of the `any` to be sure that they do not overstep the bounds of the array, string, or wide string object when using the extracted value.

The operator `>>=` is also supported on the `Any_var` type. Note that due to the conversion operators that convert `Any_var` to `const Any&` for parameter passing, only those `operator>>=` functions defined as member functions of `any` need to be explicitly defined for `Any_var`.

### 5.18.4 Distinguishing boolean, octet, char, wchar, bounded string, and bounded wstring

Since the boolean, octet, char, and wchar OMG IDL types are not required to map to distinct C++ types, another means of distinguishing them from each other is necessary so that they can be used with the type-safe `any` interface. Similarly, since both bounded and unbounded strings map to `char*`, both bounded and unbounded wide strings map to `WChar*`, and all fixed-point types map to the `Fixed` class, another means of distinguishing them must be provided. This is done by introducing several new helper types nested in the `any` class interface. For example, this can be accomplished as shown next.

```c++
// C++
class Any
{
  public:
    // special helper types needed for boolean, octet, char, // and bounded string insertion
    struct from_boolean {
      from_boolean(Boolean b) : val(b) {} 
      Boolean val;
    };
    struct from_octet {
      from_octet(Octet o) : val(o) {}  
      Octet val;
    };
    struct from_char {
      from_char(Char c) : val(c) {}  
      Char val;
    };
    struct from_wchar {
      from_wchar(WChar wc) : val(wc) {}
      WChar val;
    };
    struct from_string {
      from_string(char* s, ULong b, 
        Boolean n = FALSE) :
        val(s), bound(b), nocopy(n) {}
      from_string(const char* s, ULong b) :
        val (const_cast<char*>(s)), bound(b),
        nocopy (0) {}
      char *val;
      ULong bound;
      Boolean nocopy;
    };
    struct from_wstring {
```
from_wstring(WChar* s, ULong b,
    Boolean n = FALSE) :
    val(s), bound(b), nocopy(n) {} 
from_wstring(const WChar* s, ULong b) :
    val(const_cast<WChar*>(s)), bound(b),
    nocopy(0) {} 
WChar *val;
ULong bound;
Boolean nocopy;
};
struct from_fixed {
    from_fixed(const Fixed& f, UShort d, UShort s)
        : val(f), digits(d), scale(s) {}
    const Fixed& val;
    UShort digits;
    UShort scale;
};

void operator<<=(from_boolean);
void operator<<=(from_char);
void operator<<=(from_wchar);
void operator<<=(from_octet);
void operator<<=(from_string);
void operator<<=(from_wstring);
void operator<<=(from_fixed);
// special helper types needed for boolean, octet, 
// char, and bounded string extraction
struct to_boolean {
    to_boolean(Boolean &b) : ref(b) {} 
    Boolean &ref;
};
struct to_char {
    to_char(Char &c) : ref(c) {} 
    Char &ref;
};
struct to_wchar {
    to_wchar(WChar &wc) : ref(wc) {} 
    WChar &ref;
};
struct to_octet {
    to_octet(Octet &o) : ref(o) {} 
    Octet &ref;
};
struct to_string {
    to_string(const char *&s, ULong b)
        : val(s), bound(b) {}
    const char *&val;
    ULong bound;

    // the following constructor is deprecated
An ORB implementation provides the overloaded `operator<<` and `operator>>=` functions for these special helper types. These helper types are used as shown next.

// C++
Boolean b = TRUE;
Any any;
any <<= Any::from_boolean(b);
// ...
if (any >>= Any::to_boolean(b)) {
    // ...any contained a Boolean...
}

const char* p = "bounded";
A bound value of zero passed to the appropriate helper type indicates an unbounded string or wide string.

For noncopying insertion of a bounded or unbounded string into an `any`, the `nocopy` flag on the `from_string` constructor should be set to `TRUE`.

```cpp
// C++
char* p = string_alloc(8);
// ...initialize string p...
any <<= Any::from_string(p, 8, 1); // any consumes p
```

The same rules apply for bounded and unbounded wide strings and the `from_wstring` helper type. Note that the non-constant versions of the `to_string` and `to_wstring` constructors will be removed in a future version of the mapping and should not be used.

Assuming that `boolean`, `char`, and `octet` all map the C++ type `unsigned char`, the private and unimplemented `operator<<=` and `operator>>=` functions for `unsigned char` will cause a compile-time error if straight insertion or extraction of any of the `boolean`, `char`, or `octet` types is attempted.

```cpp
// C++
Octet oct = 040;
Any any;
any <<= oct;   // this line will not compile
any <<= Any::from_octet(oct);// but this one will
```

It is important to note that the previous example is only one possible implementation for these helpers, not a mandated one. Other compliant implementations are possible, such as providing them via in-lined static `any` member functions if `boolean`, `char`, and `octet` are in fact mapped to distinct C++ types. All compliant C++ mapping implementations must provide these helpers, however, for purposes of portability.

In standard C++ environments, the mapping implementation must declare the constructors of the `from_` and `to_` helper classes as `explicit`. This prevents undesirable conversions via temporaries.

### 5.18.5 Widening to Object

Sometimes it is desirable to extract an object reference from an `Any` as the base `Object` type. This can be accomplished using a helper type similar to those required for extracting `Boolean`, `Char`, and `Octet`.

```cpp
// C++
class Any
{
    public:
        ...
        struct to_object {
            to_object(Object_out obj) : ref(obj) {}
            Object_ptr &ref;
        };
```
Boolean operator>>(to_object) const;
...
};

The `to_object` helper type is used to extract an object reference from an `Any` as the base `Object` type. If the `Any` contains a value of an object reference type as indicated by its `TypeCode`, the extraction function
`operator>>(to_object)` explicitly widens its contained object reference to `Object` and returns true, otherwise it returns false. This is the only object reference extraction function that performs widening on the extracted object reference. Unlike for regular object reference extraction, the lifetime of an object reference extracted using `to_object` is independent of that of the `Any` that it is extracted from, and so the responsibility for invoking `release` on it becomes that of the caller.

### 5.18.6 Widening to Abstract Interface

The `CORBA::Any::to_abstract_base` type allows the contents of an `Any` to be extracted as an `AbstractBase` if the entity stored in the `Any` is an object reference type or a `valuetype` directly or indirectly derived from the `AbstractBase` base class. The `to_abstract_base` type is shown below.

```
// C++
class Any {
public:
    ...
    struct to_abstract_base {
        to_abstract_base(AbstractBase_ptr& base) : ref(base) {}
        AbstractBase_ptr& ref;
    };
    Boolean operator>>(to_abstract_base val) const;
    ...
};
```

The caller is responsible for releasing the returned `AbstractBase_ptr`. See “Abstract Interface Base” on page 83 for a description of `AbstractBase`.

### 5.18.7 Widening to ValueBase

The `CORBA::Any::to_value` type allows the contents of an `Any` to be extracted as a `ValueBase*` if the entity stored in the `Any` is a `valuetype`. The `to_value` type is shown below.

```
// C++
class Any {
public:
    ...
    struct to_value {
        to_value(ValueBase*& base) : ref(base) {}
        ValueBase*& ref;
    };
    Boolean operator>>(to_value val) const;
    ...
};
```
The caller is responsible for calling \_remove\_ref on the returned \texttt{ValueBase} pointer. See “ValueBase and Reference Counting” on page 64 for a description of \texttt{ValueBase}.

### 5.18.8 TypeCode Replacement

The \texttt{type} accessor function returns a \texttt{TypeCode\_ptr} pseudo-object reference to the \texttt{TypeCode} associated with the \texttt{Any}. Like all object reference return values, the caller must release the reference when it is no longer needed, or assign it to a \texttt{TypeCode\_var} variable for automatic management.

\begin{verbatim}
TypeCode\_ptr type() const;
\end{verbatim}

Because C++ \texttt{typedef}s are only aliases and do not define distinct types, inserting a type with a \texttt{tk\_alias TypeCode} into an \texttt{Any} while preserving that \texttt{TypeCode} is not possible.

For example

// IDL
typedef long LongType;

// C++
Any any;
LongType val = 1234;
any <<= val;
TypeCode\_var tc = any.type();
assert(tc->kind() == tk\_alias); // assertion failure!
assert(tc->kind() == tk\_long); // assertion OK

In this code, the \texttt{LongType} is an alias for \texttt{CORBA::Long}. Therefore, when the value is inserted, standard C++ overloading mechanisms cause the insertion operator for \texttt{CORBA::Long} to be invoked. In fact, because \texttt{LongType} is an alias for \texttt{CORBA::Long}, an overloaded \texttt{operator\texttt{<\texttt{<}}} for \texttt{LongType} cannot be generated anyway.

In cases where the \texttt{TypeCode} in the \texttt{Any} must be preserved as a \texttt{tk\_alias TypeCode}, the application can use the \texttt{type} modifier function on the \texttt{Any} to replace its \texttt{TypeCode} with an equivalent one.

\begin{verbatim}
void type(TypeCode\_ptr);
\end{verbatim}

Revising the previous example

// C++
Any any;
LongType val = 1234;
any <<= val;
any.type(_tc\_LongType); // replace TypeCode
TypeCode\_var tc = any.type();
assert(tc->kind() == tk\_alias); // assertion OK

The \texttt{type} modifier function invokes the \texttt{TypeCode\_::equivalent} operation on the \texttt{TypeCode} in the target \texttt{Any}, passing the \texttt{TypeCode} it received as an argument. If \texttt{TypeCode\_::equivalent} returns true, the \texttt{type} modifier function replaces the original \texttt{TypeCode} in the \texttt{Any} with its argument \texttt{TypeCode}. If the two \texttt{TypeCode}s are not equivalent, the \texttt{type} modifier function raises the \texttt{BAD\_TYPECODE} exception.
5.18.9 Any Constructors, Destructor, Assignment Operator

The default constructor creates an Any with a TypeCode of type tk_null, and no value. The copy constructor calls _duplicate on the TypeCode_ptr of its Any parameter and deep-copies the parameter’s value. The assignment operator releases its own TypeCode_ptr and deallocates storage for the current value if necessary, then duplicates the TypeCode_ptr of its Any parameter and deep-copies the parameter’s value. The destructor calls release on the TypeCode_ptr and deallocates storage for the value, if necessary.

Compliant programs use new to dynamically allocate anys and delete to free them.

5.18.10 The Any Class

The full definition of the Any class can be found in “Any Class” on page 140.

5.18.11 The Any_var and Any_out Classes

Because Anys are returned via pointer as out and return parameters (see Table 5.3), there exists an Any_var class similar to the T_var classes for object references. Any_var obeys the rules for T_var classes described in “Mapping for Structured Types” on page 20, calling delete on its Any* when it goes out of scope or is otherwise destroyed. The full interface of the Any_var class is shown in “Any_var Class” on page 144. An Any_out class is also available that is similar in form to the T_out class described in “T_out Types” on page 25.

5.19 Mapping for Valuetypes

The IDL valuetype has features that make its C++ mapping unlike that of any other IDL type. Specifically, from an application perspective all other IDL types comprise either pure state or pure interface, but a valuetype may include both. Because of this, the C++ mapping for the valuetype is necessarily more restrictive in terms of implementation than other parts of the C++ mapping.

An IDL valuetype is mapped to a C++ class with the same name as the IDL valuetype. This class is an abstract base class (ABC), with pure virtual accessor and modifier functions corresponding to the state members of the valuetype, and pure virtual functions corresponding to the operations of the valuetype.

A C++ class whose name is formed by prepending the string “OBV_” to the fully-scoped name of the valuetype provides default implementations for the accessors and modifiers of the ABC base class. The application developer then overrides the pure virtual functions corresponding to valuetype operations in a concrete class derived directly or indirectly from the OBV_ base class.

Applications are responsible for the creation of valuetype instances, and after creation, they deal with those instances only via C++ pointers. Unlike object references, which map to C++ _ptr types that may be implemented either as actual C++ pointers or as C++ pointer-like objects, “handles” to C++ valuetype instances are actual C++ pointers. This helps to distinguish them from object references.

Because valuetype supports the sharing of instances within other constructed types (such as graphs), the lifetimes of C++ valuetype instances are managed via reference counting. Unlike the semantics of object reference counting, where neither duplicate nor release actually affect the object implementation, reference counting operations for C++ valuetype instances are directly implemented by those instances. Reference counting mix-in classes are provided by ORB implementations for use by valuetype implementors (see “Reference Counting Mix-in Classes” on page 66).
As for most other types in the C++ mapping, each `valuetype` also has an associated C++ `_var` type that automates its reference counting. To facilitate template-based programming, typedefs for the `_ptr`, `_out`, and `_var` types are provided in the valuetype class. The typedef for `_ptr` is named `_ptr_type`, the typedef for `_out` is named `_out_type`, and the typedef for `_var` is named `_var_type`. All `init` initializers declared for a `valuetype` are mapped to pure virtual functions on a separate abstract C++ factory class. The class is named by appending “-_init” to the name of the `valuetype` (e.g., type `A` has a factory class named `A_init`).

5.19.1 Valuetype Data Members

The C++ mapping for `valuetype` data members follows the same rules as the C++ mapping for unions, except that the accessors and modifiers are pure virtual. Public state members are mapped to public pure virtual accessor and modifier functions of the C++ `valuetype` base class, and private state members are mapped to protected pure virtual accessor and modifier functions (so that derived concrete classes may access them). Portable applications that use `OBV_` classes, including derived value type classes, shall not access the actual data members of `OBV_` classes, and ORB implementations are free to make such members private. The only requirement on the actual data members in a concrete or partially-concrete class such as an `OBV_` class is that they be self-managing so that derived classes can correctly implement copying without needing direct access to them.

Like C++ unions, the accessor and modifier functions for `valuetype` state members do not follow the regular C++ parameter passing rules. This is because they allow local program access to the state stored inside the `valuetype` instance. Modifier functions perform the equivalent of a deep-copy of their parameters, and accessors that return a reference or pointer to a state member can be used for read-write access.

For example

```idl
typedef octet Bytes[64];
struct S { ... };
interface A { ... };

valuetype Val {
    public Val t;
    private long v;
    public Bytes w;
    public string x;
    private S y;
    private A z;
};
```

```cpp
typedef Octet Bytes[64];
typedef Octet Bytes_slice;
...
struct S { ... };

typedef ... A_ptr;
typedef ... Val_ptr;
class Val_out;
class Val_var;
```
class Val : public virtual ValueBase {
public:
  ...
  typedef Val_ptr _ptr_type;
  typedef Val_var _var_type;
  typedef Val_out _out_type;

  virtual Val* t() const = 0;
  virtual void t(Val*) = 0;

  virtual const Bytes_slice* w() const = 0;
  virtual Bytes_slice* w() = 0;
  virtual void w(const Bytes) = 0;

  virtual const char* x() const = 0;
  virtual void x(char*) = 0;
  virtual void x(const char*) = 0;
  virtual void x(const String_var&) = 0;

protected:
  virtual Long v() const = 0;
  virtual void v(Long) = 0;

  virtual const S& y() const = 0;
  virtual S& y() = 0;
  virtual void y(const S&) = 0;

  virtual A_ptr z() const = 0;
  virtual void z(A_ptr) = 0;
...
};

The following rules apply to the accessor and modifier functions shown in the above example:

- The \( t \) accessor function does not increment the reference count of the returned \texttt{valuetype}. This implies that the caller of \( t \) does not adopt the return value.
- The \( t \) modifier function increments the reference count of its argument, then decrements the reference count of the \( t \) member it is replacing before returning.
- The \( x(\text{char*}) \) modifier function frees the old string member and adopts its argument.
- The \( x(\text{const char*}) \) modifier function frees the old string member and copies its argument.
- The \( x(\text{const String_var&}) \) modifier function frees the old string member and copies its argument.
- By returning a reference to a const \( S \), the first \( y \) accessor function provides read-only access to the \( y \) member.
- By returning a reference to an \( S \), the second \( y \) accessor function provides read-write access to the \( y \) member.
- The \( y \) modifier function deep-copies its \( S \) argument.
- The \( z \) accessor function does not invoke \texttt{_duplicate} on the object reference it returns. This implies that the caller of \( z \) is not responsible for invoking \texttt{release} on the return value.
• The z modifier function releases its old object reference corresponding to the z member, then duplicates its argument before returning.

These rules correspond directly to the parameter passing rules for union accessors and modifiers as explained in “Mapping for Union Types” on page 32.

State members of anonymous array and sequence types require the same supporting C++ typedefs as required for union members of anonymous array and sequence types; see “Mapping for Union Types” on page 32 for more details.

5.19.2 Constructors, Assignment Operators, and Destructors

A C++ valuetype class defines a protected default constructor and a protected virtual destructor. The default constructor is protected to allow only derived class instances to invoke it, while the destructor is protected to prevent applications from invoking delete on pointers to value instances instead of using reference counting operations. The destructor is virtual to provide for proper destruction of derived value class instances when their reference counts drop to zero.

For the same reasons, a C++ OBV_ class defines a protected default constructor, a protected constructor that takes an initializer for each valuetype data member, and a protected destructor. The parameters of the constructor that takes an initializer for each member appear in the same order as the data members appear, top to bottom, in the IDL valuetype definition, regardless of whether they are public or private. If the valuetype inherits from a concrete valuetype, then parameters for the data members of the inherited valuetype appear first. All parameters for the member initializer constructor follow the C++ mapping parameter passing rules for in arguments of their respective types. For valuetypes that have no operations other than factory initializers, the same constructors and destructors are generated, but with public access so that they can be called directly by application code.

Portable applications shall not invoke a valuetype class copy constructor or default assignment operator. Due to the required value reference counting, the default assignment operator for a valuetype class shall be private and preferably unimplemented to completely disallow assignment of valuetype instances.

5.19.3 Valuetype Operations

Operations declared on a valuetype are mapped to public pure virtual member functions in the corresponding valuetype C++ class. (Note that state member accessor and modifier functions are not considered to be operations—they have different parameter passing rules than operations and so they are always referred to as accessor and modifier functions.) None of the pure virtual member functions corresponding to operations shall be declared const because unlike C++, IDL provides no way to distinguish between operations that change the state of an object and those that merely access that state. This choice, similar to the choice made for the C++ mapping for operations declared in IDL interface types, has an impact on parameter passing rules, as described in “Argument Passing Considerations” on page 91. The alternative, declaring all pure virtual member functions as const, is less desirable because it would not allow member functions inherited from interface classes to be invoked on const value instances, since all such member functions are already mapped as non-const.

The C++ signatures and memory management rules for valuetype operations (but not state member accessor and modifier functions) are identical to those described in “Argument Passing Considerations” on page 91 for client-side interface operations.

A static _downcast function is provided by each valuetype class to provide a portable way for applications to cast down the C++ inheritance hierarchy. This is especially required after an invocation of the _copy_value function (see “ValueBase and Reference Counting” on page 64). If a null pointer is passed to _downcast, it returns a null pointer.
Otherwise, if the `valuetype` instance pointed to by the argument is an instance of the `valuetype` class being downcast to, a pointer to the downcast-to class type is returned. If the `valuetype` instance pointed to by the argument is not an instance of the `valuetype` class being downcast to, a null pointer is returned. The `_downcast` function does not increment the reference count of the valuette.

5.19.4 Valuetype Example

For example, consider the following IDL `valuetype`:

```idl
// IDL
valuetype Example {
    short op1();
    long op2(in Example x);
    private short val1;
    public long val2;

    private string val3;
    private float val4;
    private Example val5;
};
```

The C++ mapping for this `valuetype` is

```cpp
// C++
class Example : public virtual ValueBase {
public:
    virtual Short op1() = 0;
    virtual Long op2(Example*) = 0;

    virtual Long val2() const = 0;
    virtual void val2(Long) = 0;

    static Example* _downcast(ValueBase*);

protected:
    Example();
    virtual ~Example();

    virtual Short val1() const = 0;
    virtual void val1(Short) = 0;

    virtual const char* val3() const = 0;
    virtual void val3(char*) = 0;
    virtual void val3(const char*) = 0;
    virtual void val3(const String_var&) = 0;

    virtual Float val4() const = 0;
    virtual void val4(Float) = 0;

    virtual Example* val5() const = 0;
};
```
virtual void val5(Example*) = 0;

private:
   // private and unimplemented
   void operator=(const Example&);
};

class OBV_Example : public virtual Example {
public:
   virtual Long val2() const;
   virtual void val2(Long);

protected:
   OBV_Example();
   OBV_Example(Short init_val1, Long init_val2,
               const char* init_val3, Float init_val4,
               Example* init_val5);
   virtual ~OBV_Example();

   virtual Short val1() const;
   virtual void val1(Short);

   virtual const char* val3() const;
   virtual void val3(char*);
   virtual void val3(const char*);
   virtual void val3(const String_var&);

   virtual Float val4() const;
   virtual void val4(Float);

   virtual Example* val5() const;
   virtual void val5(Example*);

   // ...
};

5.19.5 ValueBase and Reference Counting

The C++ mapping for the ValueBase IDL type serves as an abstract base class for all C++ valuetype classes. ValueBase provides several pure virtual reference counting functions inherited by all valuetype classes.

// C++
namespace CORBA {
   class ValueBase {
      public:
         virtual void _add_ref() = 0;
         virtual void _remove_ref() = 0;
         virtual ValueBase* _copy_value() = 0;
         virtual ULong _refcount_value() = 0;
   }
static ValueBase* _downcast(ValueBase*);

protected:
    ValueBase();
    ValueBase(const ValueBase&);
    virtual ~ValueBase();

private:
    void operator=(const ValueBase&);
};

The names of these operations begin with underscore to keep them from clashing with user-defined operations in derived valuetype classes.

ValueBase also provides a protected default constructor, a protected copy constructor, and a protected virtual destructor. The copy constructor is protected to disallow copy construction of derived valuetype instances except from within derived class functions, and the destructor is protected to prevent direct deletion of instances of classes derived from ValueBase.

With respect to reference counting, ValueBase is intended to introduce only the reference counting interface. Depending upon the inheritance hierarchy of a valuetype class, its instances may require different reference counting mechanisms. For example, the reference counting mechanisms needed for a valuetype class that supports an interface are likely to be different from those needed for a regular concrete valuetype class, since the former has object adapter issues to consider. Therefore, ValueBase normally serves as a virtual base class multiply inherited into a valuetype class. One inheritance path is through the IDL inheritance hierarchy for the valuetype, since all valuetypes inherit from ValueBase, which provides the reference counting interface. The other inheritance path is through the reference counting implementation mix-in base class (see “Reference Counting Mix-in Classes” on page 66), which itself also inherits from ValueBase.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>_add_ref</td>
<td>Used to increment the reference count of a valuetype instance.</td>
</tr>
<tr>
<td>_remove_ref</td>
<td>Used to decrement the reference count of a valuetype instance and delete the instance when the reference count drops to zero. Note that the use of delete to destroy instances requires that all valuetype instances be allocated using new.</td>
</tr>
<tr>
<td>_copy_value</td>
<td>Used to make a deep copy of the valuetype instance. The copy has no connections with the original instance and has a lifetime independent of that of the original. Since C++ supports covariant return types, derived classes can override the _copy_value function to return a pointer to the derived class rather than ValueBase*, but since covariant return types are still not commonly supported by commercial C++ compilers, the return value of _copy_value can also be ValueBase*, even for derived classes. A compliant ORB implementation may use either approach. For now, portable applications will not rely on covariant return types and will instead use downcasting&lt;sup&gt;a&lt;/sup&gt; to regain the most derived type of a copied valuetype.</td>
</tr>
<tr>
<td>_refcount_value</td>
<td>Returns the value of the reference count for the valuetype instance on which it is invoked.</td>
</tr>
</tbody>
</table>

<sup>a</sup> The C++ dynamic_cast<> operator may also be used to cast down the value hierarchy, but it too is still not available in all C++ compilers and thus its use is still not portable at this time.

The names of these operations begin with underscore to keep them from clashing with user-defined operations in derived valuetype classes.
5.19.5.1 CORBA Module Additions

The C++ mapping also adds two additional reference counting functions to the CORBA namespace, as shown below:

```cpp
// C++
namespace CORBA {
    void add_ref(ValueBase* vb)
    {
        if (vb != 0) vb->_add_ref();
    }

    void remove_ref(ValueBase* vb)
    {
        if (vb != 0) vb->_remove_ref();
    }

    // ...
}
```

These functions are provided for consistency with object reference counting functions. They are similar in that unlike the `_add_ref` and `_remove_ref` member functions, they can be called with null `valuetype` pointers. The CORBA::add_ref function increments the reference count of the `valuetype` instance pointed to by the function argument if non-null, or does nothing if the argument is a null pointer. The CORBA::remove_ref function behaves the same except it decrements the reference count. (The implementations shown above are intended to specify the required semantics of the functions, not to imply that conforming implementations must inline the functions.)

5.19.6 Reference Counting Mix-in Classes

The C++ mapping provides two standard reference counting implementation mix-in base classes:

1. **CORBA::DefaultValueRefCountBase**, which can serve as a base class for any application-provided concrete `valuetype` class whose corresponding IDL value type does not derive from any IDL interfaces. For these types of `valuetype` classes, applications are also free to use their own reference-counting implementation mix-ins as long as they fulfill the `ValueBase` reference counting interface.

2. **PortableServer::ValueRefCountBase**, which must serve as a base class for any application-provided concrete `valuetype` class whose corresponding IDL `valuetype` does derive from one or more IDL interfaces, and whose instances will be registered with the POA as servants. If IDL interface inheritance is present, but instances of the application-provided concrete `valuetype` class will not be registered with the POA, the CORBA::DefaultValueRefCountBase or an application-specific reference counting implementation mix-in may be used as a base class instead.

Each of these classes shall be fully concrete and shall completely fulfill the `ValueBase` reference counting interface, except that since they provide implementation, not interface, they shall not provide support for downcasting. In addition, each of these classes shall provide a protected default constructor that sets the reference count of the instance to one, a protected virtual destructor, and a protected copy constructor that sets the reference count of the newly-constructed instance to one. Just as with the `ValueBase` base class, the default assignment operator should be private and preferably unimplemented to completely disallow assignment.
Note that it is the application-supplied concrete `valuetype` classes that must derive from these mix-in classes, not the `valuetype` classes generated by the IDL compiler. This is to avoid the need to inherit these mix-ins as virtual bases, or to avoid inheriting multiple copies of the mix-ins (and thus multiple reference counts) if virtual bases are not employed. Also, only the final implementor of a `valuetype` knows whether it will ever be used as a POA servant or not, and thus the implementor must specify the desired reference counting mix-in.

5.19.7 Value Boxes

A value box class essentially provides a reference-counted version of its underlying type. Unlike normal `valuetype` classes, C++ classes for value boxes can be concrete since value boxes do not support methods, inheritance, or interfaces. Value box classes differ depending upon their underlying types.

To fulfill the `ValueBase` interface, all value box classes are derived from `CORBA::DefaultValueRefCountBase`.

5.19.7.1 Parameter Passing for Underlying Boxed Type

All value box classes provide `_boxed_in`, `_boxed_inout`, and `_boxed_out` member functions that allow the underlying boxed value to be passed to functions taking parameters of the underlying boxed type. The signatures of these functions depend on the parameter passing modes of the underlying boxed type. The return values of the `_boxed_inout` and `_boxed_out` functions shall be such that the boxed value is referenced directly, allowing it to be replaced or set to a new value. For example, invoking `_boxed_out` on a boxed string allows the actual string owned by the value box to be replaced.

```cpp
// IDL
valuetype StringValue string;
interface X {
    void op(out string s);
};

// C++
StringValue* sval = new StringValue("string val");
X_var x = ...
x->op(sval->_boxed_out()); // boxed string is replaced
                           // by op() invocation
```

Assume the implementation of `op` is as follows:

```cpp
// C++
void MyXImpl::op(String_out s)
{
    s = string_dup("new string val");
}
```

The return value of the `_boxed_out` function shall be such that the string value boxed in the instance pointed to by `sval` is set to "new string val" after `op` returns, with the instance pointed to by `sval` maintaining ownership of the string.

5.19.7.2 Basic Types, Enums, and Object References

For all the signed and unsigned integer types except for the `fixed` type, and for `boolean`, `octet`, `char`, `wchar`, `float`, `double`, `long double`, and enumerated types, and for typedefs of all of these, value box classes provide:
A public default constructor. Note that except for the object reference case, the value of the underlying boxed value will be indeterminate after this constructor runs (i.e., the default constructor does not initialize the boxed value to a given value). This is because the built-in constructors for each of the basic types and enumerations do not initialize instances of their types to particular values, either. For boxed object references, this constructor sets the underlying boxed object reference to nil.

A public constructor that takes one argument of the underlying type. This argument is used to initialize the value of the underlying boxed type.

A public assignment operator that takes one argument of the underlying type. This argument is used to replace the value of the underlying boxed type.

Public accessor and modifier functions for the boxed value. The accessor and modifier functions are always named _value. For boxed object references, the return value of the accessor is not a duplicate.

Explicit conversion functions that allow the boxed value to be passed where its underlying type is called for. These functions are named boxed_in, boxed_inout, and boxed_out, and their return types match the in, inout, and out parameter passing modes, respectively, of the underlying boxed type. Implicit conversions to the underlying type are not provided because values are normally handled by pointer.

A public copy constructor.

A public static _downcast function.

A protected destructor.

A private and preferably unimplemented default assignment operator.

Value box classes for object references maintain a private managed copy of the object reference. The constructor, assignment operator, and _value modifier methods for these classes call _duplicate on the object reference argument; the destructor calls CORBA::release on the boxed reference.

An example value box class for an enumerated type is shown below:

```
// IDL
enum Color { red, green, blue };  
valuetype ColorValue Color;

// C++
class ColorValue : public DefaultValueRefCountBase {
  public:
    ColorValue();
    ColorValue(Color val);
    ColorValue(const ColorValue& val);
    ColorValue& operator=(Color val);

    Color _value() const; // accessor
    void _value(Color val); // modifier

    // explicit conversion functions for underlying boxed type
    // Color boxed_in() const;
```
Color& _boxed_inout();
Color& _boxed_out();
static ColorValue* _downcast(ValueBase* base);

protected:
-ColorValue();

private:
  void operator=(const ColorValue& val);
};

5.19.7.3 Struct Types

Value box classes for struct types map to classes that provide accessor and modifier functions for each struct member. Specifically, the classes provide:

- A public default constructor. The underlying boxed struct type is initialized as it would be by its own default constructor.
- A public constructor that takes a single argument of type \texttt{const T&}, where \texttt{T} is the underlying boxed struct type.
- A public assignment operator that takes a single argument of type \texttt{const T&}, where \texttt{T} is the underlying boxed struct type.
- Public accessor and modifier functions, all named \texttt{_value}, for the underlying boxed struct type. Two accessor are provided: one a const member function returning \texttt{const T&}, and the other a non-const member function returning a \texttt{T&}. The modifier function takes a single argument of type \texttt{const T&}.
- The \texttt{boxed_in}, \texttt{boxed_inout}, and \texttt{boxed_out} functions that allow access to the boxed value to pass it in signatures expecting the underlying boxed struct type. The return values of these functions correspond to the \texttt{in}, \texttt{inout}, and \texttt{out} parameter passing modes for the underlying boxed struct type, respectively.
- For each struct member, a set of accessor and modifier functions. These functions have the same signatures as accessor and modifier functions for union members.
  - A public copy constructor.
  - A public static \texttt{_downcast} function.
  - A protected destructor.
  - A private and preferably unimplemented default assignment operator.

As with other value box classes, no implicit conversions to the underlying boxed type are provided since values are normally handled by pointer.

For example

```
// IDL
struct S {
  string str;
  long len;
};
value type BoxedS S;
```
// C++
class BoxedS : public DefaultValueRefCountBase {
    public:
        BoxedS();
        BoxedS(const S& val);
        BoxedS(const BoxedS& val);

        BoxedS& operator=(const S& val);

        const S& _value() const;
        S& _value();
        void _value(const S& val);

        const S& _boxed_in() const;
        S& _boxed_inout();
        S*& _boxed_out();

        static BoxedS* _downcast(ValueBase* base);

        const char* str() const;
        void str(char* val);
        void str(const char* val);
        void str(const String_var& val);

        Long len() const;
        void len(Long val);

    protected:
        ~BoxedS();

    private:
        void operator=(const BoxedS& val);
    }

5.19.7.4 String and WString Types

In order to allow boxed strings to be treated as normal strings where appropriate, value box classes for strings provide largely the same interface as the String_var class. The only differences from the interface of the String_var class are:

- The value box class interface does not provide the in, inout, out, and _retn functions that String_var provides. Rather, the value box class provides replacements for these functions called _boxed_in, _boxed_inout, and _boxed_out. They have mostly the same semantics and signatures as their String_var counterparts, but their names have been changed to make it clear that they provide access to the underlying string, not to the value box itself.

- There are no overloaded operators for implicit conversion to the underlying string type because values are normally handled by pointer.

In addition to most of the String_var interface, value box classes for strings provide:
• Public accessor and modifier functions for the boxed string value. These functions are all named _value. The single accessor function takes no arguments and returns a const char*. There are three modifier functions, each taking a single argument. One takes a char* argument that is adopted by the value box class, one takes a const char* argument that is copied, and one takes a const String_var& from which the underlying string value is copied.

• A public default constructor that initializes the underlying string to an empty string.

• Three public constructors that take string arguments. One takes a char* argument that is adopted, one takes a const char* that is copied, and one takes a const String_var& from which the underlying string value is copied. If the String_var holds no string, the boxed string value is initialized to the empty string.

• Three public assignment operators: one that takes a parameter of type char* which is adopted, one that takes a parameter of type const char* that is copied, and one that takes a parameter of type const String_var& from which the underlying string value is copied. Each returns a reference to the object being assigned to. If the String_var holds no string, the boxed string value is set equal to the empty string.

• A public copy constructor.

• A public static _downcast function.

• A protected destructor.

• A private and preferably unimplemented default assignment operator.

An example of a value box class for a string is shown below.

// IDL
typedef StringValue string;

// C++
class StringValue : public DefaultValueRefCountBase {
public:
  // constructors
  //
  StringValue();
  StringValue(const StringValue& val);
  StringValue(char* str);
  StringValue(const char* str);
  StringValue(const String_var& var);

  // assignment operators
  //
  StringValue& operator=(char* str);
  StringValue& operator=(const char* str);
  StringValue& operator=(const String_var& var);

  // accessor
  //
  const char* _value() const;

  // modifiers
  //
  void _value(char* str);
void _value(const char* str);
void _value(const String_var& var);

// explicit argument passing conversions for
// the underlying string
//
const char* _boxed_in() const;
char*& _boxed_inout();
char*& _boxed_out();

// ...other String_var functions such as overloaded
// subscript operators, etc....

static StringValue* _downcast(ValueBase* base);

protected:
  -StringValue();

private:
  void operator=(const StringValue& val);
};

Note that even though value box classes for strings provide overloaded subscript operators, the fact that values are normally handled by pointer means that they must be dereferenced before the subscript operators can be used.

5.19.7.5 Union, Sequence, Fixed, and Any Types

Value boxes for these types map to classes that have exactly the same public interfaces as the underlying boxed types, except that each has:

- In addition to the constructors provided by the class for the underlying boxed type, a public constructor that takes a single argument of type const T& where T is the underlying boxed type.

- An assignment operator that takes a single argument of type const T& where T is the underlying boxed type.

- Accessor and modifier functions for the underlying boxed value. All such functions are named _value. There are two accessor functions, one a const member function returning a const T& and the other a non-const member function returning T&. The modifier function takes a single argument of type const T&.

- The _boxed_in, _boxed_inout, and _boxed_out functions that allow access to the boxed value to pass it in signatures expecting the underlying boxed value type. The return values of these functions correspond to the in, inout, and out parameter passing modes for the underlying boxed type, respectively.

- A protected destructor.

- A private and preferably unimplemented default assignment operator.

As with other value box classes, no implicit conversions to the underlying boxed type are provided since values are normally handled by pointer.

Note that the value box class for sequence types provides overloaded subscript operators (operator[]) just as a sequence class does. However, since values are normally handled by pointer, the value instance must be dereferenced before the overloaded subscript operator can be applied to it.
Value box instances for the **any** type can be passed to the overloaded operators for insertion and extraction by invoking the appropriate explicit conversion function.

```
// C++
AnyValueBox* val = ...
val->_boxed_inout() <<= something;
if (val->_boxed_in() >>= something_else) ...
```

Below is an example value box along with its corresponding C++ class.

```
// IDL
typedef sequence<long> LongSeq;
valuetype LongSeqValue LongSeq;

// C++
class LongSeqValue : public DefaultValueRefCountBase {
   public:
      LongSeqValue();
      LongSeqValue(ULong max);
      LongSeqValue(ULong max,
                     ULong length,
                     Long* buf,
                     Boolean release = 0);
      LongSeqValue(const LongSeq& init);
      LongSeqValue(const LongSeqValue& val);

      LongSeqValue& operator=(const LongSeq& val);
      const LongSeq& _value() const;
      LongSeq& _value();
      void _value(const LongSeq&);

      const LongSeq& _boxed_in() const;
      LongSeq& _boxed_inout();
      LongSeq*& _boxed_out();

      static LongSeqValue* _downcast(ValueBase*);

      ULong maximum() const;
      ULong length() const;
      void length(ULong len);

      Long& operator[](ULong index);
      Long operator[](ULong index) const;

   protected:
      ~LongSeqValue();

   private:
      void operator=(const LongSeqValue&);
};
```
5.19.7.6 Array Types

In order to allow boxed arrays to be treated as normal arrays where appropriate, value box classes for arrays provide largely the same interface as the corresponding array _var class. The only differences from the interface of the _var class are:

- The value box class interface does not provide the in, inout, out, and _retn functions that _var provides. Rather, the value box class provides replacements for these functions called _boxed_in, _boxed_inout, and _boxed_out. They have mostly the same semantics and signatures as their _var counterparts, but their names have been changed to make it clear that they provide access to the underlying array, not to the value box itself.

- There are no overloaded operators for implicit conversion to the underlying array type because values are normally handled by pointer.

In addition to most of the _var interface, value box classes for arrays provide:

- Public accessor and modifier functions for the boxed array value. These functions are named _value. The single accessor function takes no arguments and returns a pointer to array slice. The modifier function takes a single argument of type const array.
- A public default constructor.
- A public constructor that takes a const array argument.
- A public assignment operator that takes a const array argument.
- A public copy constructor.
- A public static _downcast function.
- A protected destructor.
- A private and preferably unimplemented default assignment operator.

An example of a value box class for an array is shown below.

// IDL
typedef long LongArray[3][4];
valuetype ArrayValue LongArray;

// C++
typedef Long LongArray[3][4];
typedef Long LongArray_slice[4];
class ArrayValue : public DefaultValueRefCountBase {
   public:
      ArrayValue();
      ArrayValue(const ArrayValue& val);
      ArrayValue(const LongArray val);
      ArrayValue& operator=(const LongArray val);
      const LongArray_slice* _value() const;
      LongArray_slice* _value();
      void _value(const LongArray val);
};
// explicit argument passing conversions for
// the underlying array
//
const LongArray_slice* _boxed_in() const;
LongArray_slice* _boxed_inout();
LongArray_slice* _boxed_out();

// ...overloaded subscript operators...

static ArrayValue* _downcast(ValueBase* base);

protected:
-ArrayValue();

private:
  void operator=(const ArrayValue& val);
};

Note that even though value box classes for arrays provide overloaded subscript operators, the fact that values are
normally handled by pointer means that they must be de-referenced before the subscript operators can be used.

5.19.8 Abstract Valuetypes

Abstract IDL `valuetype` follow the same C++ mapping rules as concrete IDL `valuetype`, except that because they have
no data members, the IDL compiler does not generate `OBV_` classes for them.

5.19.9 Valuetype Inheritance

For an IDL `valuetype` derived from other `valuetype`s or that supports `interface` types, several C++ inheritance scenarios
are possible:

- **Concrete value base classes** are inherited as public virtual bases to allow for “ladder style” implementation
  inheritance.

- **Abstract value base classes** are inherited as public virtual base classes, since they may be multiply inherited in IDL.

- **Interface classes** supported by the IDL `valuetype` are not inherited. Instead, the operations on the interface (and base
  interfaces, if any) are mapped to pure virtual functions in the generated C++ base value class. In addition to this
abstract base value class and the `OBV_` class, the IDL compiler generates a POA skeleton for this value type; the name
of this skeleton is formed by prepending the string “POA_” to the fully-scoped name of the `valuetype`. The base value
class and the POA skeleton of the interface type are public virtual base classes of this skeleton. No tie skeleton class is
generated for the `valuetype` because the tie for the supported class can be used instead.

The reason that `interface` classes are not inherited is that `valuetype` instances, like POA servants, are themselves `not`
object references. Providing this inheritance would allow for error-prone code that implicitly widened pointers to
`valuetype` instances to C++ object references for the supported interfaces, but without first obtaining valid object
references for those `valuetype` instances from the POA. When such an application attempted to use an invalid object
reference obtained in this manner, it would encounter errors that could be difficult to track back to the implicit widening
of the pointer to `valuetype` to object reference. The C++ language provides no hooks into the implicit pointer-to-class
widening mechanism by which an application might guard against this type of error.
Avoiding the derivation of `valuetype` classes from `interface` classes also separates the lifetimes of `valuetype` instances from the lifetimes of object reference instances. It would be surprising to an application if a valid object reference that had not yet been released unexpectedly became invalid because another part of the program had decremented the `valuetype` part of the object reference instance to zero. This scenario could be solved by the provision of an appropriate reference counting mix-in class. However, given that such an approach breaks local/remote transparency by having object reference release operations affect the servant, and given the associated problems described in the preceding paragraphs, deriving `valuetype` classes from `interface` classes is best avoided.

An example of the mapping for a `valuetype` that supports an `interface` is shown below.

```idl
interface A {
    void op();
};

valuetype B supports A {
    public short data;
};
```

```c++
// C++
class B : public virtual ValueBase {
    public:
        virtual void op();

        virtual Short data() const = 0;
        virtual void data(Short) = 0;

    // ...
};

class POA_B : public virtual POA_A, public virtual B {
    public:
        virtual void op();

    // ...
};
```

### 5.19.10 Valuetype Factories

Because concrete `valuetype` classes are provided by the application developer, the creation of values is problematic under certain circumstances. These circumstances include:

- **Unmarshaling.** The ORB cannot know *a priori* about all potential concrete value classes supplied by the application, and so the ORB unmarshaling mechanisms do not possess the capability to directly create instances of those classes.

- **Component Libraries.** Portions of an application, such as parts of a framework, may be limited to only manipulating `valuetype` instances while leaving creation of those instances to other parts of the application.

#### 5.19.10.1 ValueFactoryBase Class

Just as they provide concrete C++ `valuetype` classes, applications must also provide factories for those concrete classes. The base of all value factory classes is the C++ `CORBA::ValueFactoryBase` class:
// C++
namespace CORBA {
    class ValueFactoryBase;
    typedef ValueFactoryBase* ValueFactory;

    class ValueFactoryBase
    {
    public:
        virtual ~ValueFactoryBase();
        virtual void _add_ref();
        virtual void _remove_ref();

        static ValueFactory _downcast(ValueFactory vf);
    }

    protected:
        ValueFactoryBase();

    private:
        virtual ValueBase* create_for_unmarshal() = 0;
    };

The C++ mapping for the IDL `CORBA::ValueFactory` native type is a pointer to a `ValueFactoryBase` class, as shown above. Applications derive concrete factory classes from `ValueFactoryBase`, and register instances of those factory classes with the ORB via the `ORB::register_value_factory` function. If a factory is registered for a given value type and no previous factory was registered for that type, the `register_value_factory` function returns a null pointer.

When unmarshaling value instances, the ORB needs to be able to call up to the application to ask it to create those instances. Value instances are normally created via their type-specific value factories (see “Valuetype Factories” on page 76) so as to preserve any invariants they might have for their state. However, creation for unmarshaling is different because the ORB has no knowledge of application-specific factories, and in fact in most cases may not even have the necessary arguments to provide to the type-specific factories.

To allow the ORB to create value instances required during unmarshaling, the `ValueFactoryBase` class provides the `create_for_unmarshal` pure virtual function. The function is private so that only the ORB, through implementation-specific means (e.g., via a friend class), can invoke it. Applications are not expected to invoke the `create_for_unmarshal` function. Derived classes shall override the `create_for_unmarshal` function and shall implement it such that it creates a new value instance and returns a pointer to it. The caller assumes ownership of the returned instance and shall ensure that `_remove_ref` is eventually invoked on it. Since the `create_for_unmarshal` function returns a pointer to `ValueBase`, the caller may use the downcasting functions supplied by value types to downcast the pointer back to a pointer to a derived value type.

Once the ORB has created a value instance via the `create_for_unmarshal` function, it can use the value data member modifier functions to set the state of the new value instance from the unmarshaled data. How the ORB accesses the protected value data member modifiers of the value is implementation-specific and does not affect application portability.
The `ValueFactoryBase` uses reference counting to prevent itself from being destroyed while still in use by the application. A `ValueFactoryBase` initially has a reference count of one. Invoking `add_ref` on a `ValueFactoryBase` increases its reference count by one. Invoking `remove_ref` on a `ValueFactoryBase` decrements its reference count by one, and if the resulting reference count equals zero, `remove_ref` invokes `delete` on its `this` pointer in order to destroy the factory. For ORBs that operate in multi-threaded environments, the implementations of `ValueFactoryBase::add_ref` and `ValueFactoryBase::remove_ref` are thread-safe.

When a `valuetype` factory is registered with the ORB, the ORB invokes `add_ref` once on the factory before returning from `register_value_factory`. When the ORB is done using that factory, the reference count is decremented once. This can occur in any of the following circumstances:

- If the factory is explicitly unregistered via `unregister_value_factory`, the ORB invokes `remove_ref` once on the factory.
- If the factory is implicitly unregistered due to `ORB::shutdown`, the ORB is responsible for invoking `remove_ref` once on each registered factory.
- If the factory is replaced with a new invocation of `register_value_factory`, the previously registered factory is returned to the caller who assumes ownership of one reference to that factory. When the caller is done with the factory, it invokes `remove_ref` once on that factory.

The caller of `lookup_value_factory` assumes ownership of one reference to the factory. When the caller is done with the factory, it invokes `remove_ref` once on that factory.

The `downcast` function on the factory allows the return type of the `ORB::lookup_value_factory` function to be downcast to a pointer to a type-specific factory (see “Valuetype Factories” on page 76). It is important to note that the return value of the factory `downcast` does not become the memory management responsibility of the caller, and thus `remove_ref` is not called on it.

### 5.19.10.2 ValueFactoryBase_var Class

For the convenience of automatically managing `valuetype` factory reference counts, the `CORBA` namespace provides the `ValueFactoryBase_var` class. This class behaves similarly to the `PortableServer::ServantBase_var` class for servant memory management (see “ServantBase_var Class” on page 122).

```cpp
// C++
namespace CORBA
{
  class ValueFactoryBase_var
  {
    public:
      ValueFactoryBase_var() : _ptr(0) {}
      ValueFactoryBase_var(ValueFactoryBase* p) :
        _ptr(p) {}
      ValueFactoryBase_var(const ValueFactoryBase_var& b) :
        _ptr(b._ptr)
      {
        if (_ptr != 0) _ptr->add_ref();
      }
      ~ValueFactoryBase_var()
      {
        if (_ptr != 0) _ptr->remove_ref();
      }
  }
}
```
The implementation shown above for the `ValueFactoryBase_var` is intended only as an example that conveys required semantics. Variations of this implementation are conforming as long as they provide the same semantics as the implementation shown here.

5.19.10.3 Type-Specific Value Factories

All `valuetype`s that have initializer operations declared for them also have type-specific C++ value factory classes generated for them. For a `valuetype A`, the name of the factory class, which is generated at the same scope as the value class, shall be `A_init`. Each initializer operation maps to a pure virtual function in the factory class, and each of these
initializers defined in IDL is mapped to an initializer function of the same name. Base `valuetype` initializers are not inherited, and so do not appear in the factory class. The initializer parameters are mapped using normal C++ parameter passing rules for `in` parameters. The return type of each `initializer` function is a pointer to the created `valuetype`.

For example, consider the following `valuetype`:

```idl
valuetype V {
    factory create_bool(boolean b);
    factory create_char(char c);
    factory create_octet(octet o);
    factory create_short(short s, string p);
    ...
};
```

The factory class for the example given above will be generated as follows:

```cpp
// C++
class V_init : public ValueFactoryBase {
    public:
        virtual ~V_init();
        virtual V* create_bool(Boolean val) = 0;
        virtual V* create_char(Char val) = 0;
        virtual V* create_octet(Octet val) = 0;
        virtual V* create_other(Short s, const char* p) = 0;
        static V_init* _downcast(ValueFactory vf);
    protected:
        V_init();
};
```

Each generated factory class has a public virtual destructor, a protected default constructor, and a public `_downcast` function allowing downcasting from a pointer to the base `ValueFactoryBase` class. Each also supplies a public pure virtual `create` function corresponding to each initializer. Applications derive concrete factory classes from these classes and register them with the ORB. Note that since each generated value factory derives from the base `ValueFactoryBase`, all derived concrete factory classes shall also override the private pure virtual `create_for_unmarshal` function inherited from `ValueFactoryBase`.

For `valuetypes` that have no operations or initializers, a concrete type-specific factory class is generated whose implementation of the `create_for_unmarshal` function simply constructs an instance of the `OBV_` class for the `valuetype` using `new` and the default constructor. The constructor for a concrete factory is public, not protected.

For `valuetypes` that have operations, but no initializers, there are no type-specific abstract factory classes, but applications must still supply concrete factory classes. These classes, which are derived directly from `ValueFactoryBase`, need not supply `_downcast` functions, and only need to override the `create_for_unmarshal` function.
5.19.10.4 Unmarshaling Issues

When the ORB unmarshals a `valuetype` for a request handled via C++ static stubs or skeletons, it tries to find a factory for the `valuetype` via the `ORB::lookup_value_factory` operation. If the factory lookup fails, the client application receives a `CORBA::MARSHAL` exception. Thus, applications utilizing static stubs or skeletons must ensure that a `valuetype` factory is registered for every `valuetype` it expects to receive via static invocation mechanisms.

Because of their dynamic nature, applications using the DII or DSI are not expected to have compile-time information for all the `valuetypes` they might receive. For these applications, `valuetype` instances are represented as `CORBA::Any`, and so value factories are not required to be registered with the ORB to allow such `valuetypes` to be unmarshaled. However, value factories must be registered with the ORB and available for lookup if the application attempts extraction of the `valuetypes` via the statically-typed `Any` extraction functions. See “Extraction from any” on page 51 for more details.

5.19.11 Custom Marshaling

The C++ mappings for the IDL `CORBA::CustomerMarshal`, `CORBA::DataOutputStream`, and `CORBA::DataInputStream` types follow normal C++ `valuetype` mapping rules.

5.19.12 Another Valuetype Example

```plaintext
// IDL
valuetype Node {
    public long data;
    public Node next;
    void print();

    Node change(in Node inval,
                inout Node ioval,
                out Node outval);
};

// C++
class Node : public virtual ValueBase
{
    public:
        virtual Long data() const = 0;
        virtual void data(Long) = 0;
        virtual Node* next() const = 0;
        virtual void next(Node*) = 0;
        virtual void print() = 0;
        virtual Node* change(Node* inval,
                             Node*& ioval,
                             Node_out outval) = 0;
        static Node* _downcast(ValueBase*);
}
```

14. Since the factory class hierarchy has virtual functions in it, a C++ dynamic_cast can always be used to traverse the factory inheritance hierarchy, but it is not portable since all C++ compilers do not yet support it.
protected:
    Node();
    virtual ~Node();

private:
    // private and unimplemented
    void operator=(const Node&);
};

class OBV_Node : public virtual Node
{
    public:
        virtual Long data() const;
        virtual void data(Long);

        virtual Node* next() const;
        virtual void next(Node*);

    protected:
        OBV_Node();
        OBV_Node(Long data_init, Node* next_init);
        virtual ~OBV_Node();

    private:
        // private and unimplemented
        void operator=(const OBV_Node&);
};

5.19.13 Valuetype Members of Structs

As described in “Mapping for Structured Types” on page 20, struct members are required to be self-managing. This results in the need for manager types for both strings and object references. Since valuetypes are handled by pointer, similar to the way strings and object references are handled, they too require manager types to represent them when they are used as struct members.

The valuetype instance manager types have semantics similar to that of the manager types for object references:

- Any assignment to a managed valuetype member causes that member to decrement the reference count of the valuetype it is managing, if any.

- A valuetype pointer assigned to a managed valuetype member is adopted by the member.

- A valuetype _var assigned to a managed valuetype member results in the reference count of the instance being incremented. The _var types and valuetype member manager types follow the same rules for widening assignment that those for object references do.

- If the constructed type holding the managed valuetype member is assigned to another constructed type (for example, an instance of a struct with a valuetype member is assigned to another instance of the same struct), the reference count of the managed valuetype instance in the struct on the right-hand side of the assignment is incremented, while the reference count of the managed instance on the left-hand side is decremented. As usual in C++, assignment to self must be guarded against to avoid any mishandling of the reference count.
When it is destroyed, the managed `valuetype` member decrements the reference count of the managed `valuetype` instance.

The semantics of `valuetype` managers described here provide for sharing of `valuetype` instances across constructed types by default. Each C++ `valuetype` also provides an explicit copy function that can be used to avoid sharing when desired.

### 5.20 Mapping for Abstract Interfaces

The C++ mapping for abstract interfaces is almost identical to the mapping for regular interfaces. Rather than defining a complete C++ mapping for abstract interfaces, which would only duplicate much of the specification of the mapping for regular interfaces found in “Mapping for Interfaces” on page 7, only the ways in which the abstract interface mapping differs from the regular interface mapping are described here.

#### 5.20.1 Abstract Interface Base

C++ classes for abstract interfaces are not derived from the `CORBA::Object` C++ class. In IDL, abstract interfaces have no common base. However, to facilitate narrowing from an abstract interface base class down to derived abstract interfaces, derived interfaces, and derived `valuetype` types, all abstract interface base classes that have no other base abstract interfaces derive directly from `CORBA::AbstractBase`. This base class provides the following:

- a protected default constructor
- a protected copy constructor
- a protected pure virtual destructor
- a public static `_duplicate` function
- a public static `_narrow` function
- a public static `_nil` function

The `AbstractBase` class is shown below:

```cpp
// C++
class AbstractBase;
typedef ... AbstractBase_ptr; // either pointer or class
class AbstractBase {
  public:
    static AbstractBase_ptr _duplicate(AbstractBase_ptr);
    static AbstractBase_ptr _narrow(AbstractBase_ptr);
    static AbstractBase_ptr _nil();

    Object_ptr _to_object();
    ValueBase* _to_value();

  protected:
    AbstractBase();
    AbstractBase(const AbstractBase& val);
    virtual ~AbstractBase() = 0;
};
```
The _duplicate function operates polymorphically over both object references and _valuetype types. If an _AbstractBase_ptr that actually refers to an object reference is passed to the _duplicate function, the object reference is duplicated and a duplicate object reference is returned. Otherwise, the argument refers to a _valuetype instance, so the _add_ref function is called on the _valuetype and the argument is returned. If the argument is a nil _AbstractBase_ptr, the return value is nil.

The implementation of _AbstractBase::_narrow merely passes its argument to _duplicate and uses the value it returns as its own return value. Strictly speaking, the _narrow function is not needed in the _AbstractBase interface because it is of little use to narrow an _AbstractBase to its own type, but it is required by all conforming implementations to make writing C++ templates that deal with abstract interfaces easier (_AbstractBase does not present a special case).

As with regular object references, the _nil function returns a typed _AbstractBase nil reference.

Both the is_nil and release functions in the CORBA namespace are overloaded to handle abstract interface references.

    // C++
    namespace CORBA {
        Boolean is_nil(_AbstractBase_ptr);
        void release(_AbstractBase_ptr);
    }

These behave the same as their object reference counterparts. Note that release is expected to operate polymorphically over both _valuetype types and object reference types. If its argument is nil, it does nothing. If its argument refers to a _valuetype instance, it invokes _remove_ref on that instance. Otherwise, its argument refers to an object reference, on which it invokes CORBA::release for object references.

If the concrete type of an abstract interface instance is a normal object reference, the _to_object function returns a reference to that object, otherwise it returns a nil reference. If the concrete type is a _valuetype, _to_value returns a pointer to that _valuetype, otherwise it returns a null pointer. The caller of _to_object or _to_value is responsible for properly releasing the returned reference or pointer.

5.20.2 Client Side Mapping

The client side mapping for abstract interfaces is almost identical to the mapping for object references, except:

- C++ classes for abstract interfaces derive from CORBA::AbstractBase, not CORBA::Object.
- Because abstract interface classes can serve as base classes for application-supplied concrete _valuetype classes, they shall provide a protected default constructor, a protected copy constructor, and a protected destructor (which is virtual by virtue of inheritance from AbstractBase).
- The mapping for object reference classes does not specify the type of inheritance used for base object reference classes. However, because abstract interfaces can serve as base classes for application-supplied concrete _valuetype classes, which themselves can be derived from regular interface classes, abstract interface classes shall always be inherited as public virtual base classes.
- Normal Any insertion and extraction operators are generated for abstract interfaces. The Any::to_object, Any::to_abstract_base, and Any::to_value types can be used to extract the contents of an Any as a generic object reference, abstract object reference, or _valuetype respectively.
Other than that, the mapping for abstract interfaces is identical to that for regular interfaces, including the provision of _var types, _out types, manager types for struct, sequence, and array members, identical memory management, and identical C++ signatures for operations.

Both interfaces that are derived from one or more abstract interfaces, and _valuetype_ that support one or more abstract interfaces support implicit widening to the _ptr_ type for each abstract interface base class. Specifically, the _T* for _valuetype_ _T_ and the _T_ptr_ type for interface type _T_ support implicit widening to the _Base_ptr_ type for abstract interface type _Base_. The only exception to this rule is for _valuetype_ that only support an abstract interface indirectly via support for a regular interface type (see “Valuetype Inheritance” on page 75). In this case, it is the object reference for the _valuetype_, not the pointer to the _valuetype_, that supports widening to the abstract interface base. If a _valuetype_ supports an abstract interface directly (or inherits that support via derivation from another _valuetype_) and at the same time supports a normal interface that inherits from the same abstract interface, then either the _valuetype_ pointer or the object reference may be widened to the abstract interface.

### 5.21 Mapping for Exception Types

- An OMG IDL exception is mapped to a C++ class that derives from the standard _UserException_ class defined in the CORBA module (see “CORBA Module” on page 6). The generated class is like a variable-length struct, regardless of whether or not the exception holds any variable-length members. Just as for variable-length structs, each exception member must be self-managing with respect to its storage. String and wide string exception members must be initialized to the empty string ("" and L"", respectively) by the default constructor for the exception.

- The copy constructor, assignment operator, and destructor automatically copy or free the storage associated with the exception. For convenience, the mapping also defines a constructor with one parameter for each exception member—this constructor initializes the exception members to the given values. For exception types that have a string member, this constructor should take a _const char* parameter, since the constructor must copy the string argument. Similarly, constructors for exception types that have an object reference member must call _duplicate_ on the corresponding object reference constructor parameter. The default constructor performs no explicit member initialization.

```cpp
// C++
class Exception {
  public:
    virtual ~Exception();
    virtual void _raise() const = 0;
    virtual const char * _name() const;
    virtual const char * _rep_id() const;
  protected:
    Exception();
    Exception(const Exception &);
    Exception &operator=(const Exception &);
};
```

The _Exception_ base class is abstract and may not be instantiated except as part of an instance of a derived class. It supplies one pure virtual function to the exception hierarchy: the _raise_() function. This function can be used to tell an exception instance to _throw_ itself so that a _catch_ clause can catch it by a more derived type. Each class derived from _Exception_ implements _raise_() as follows:
void SomeDerivedException::_raise() const
{
    throw *this;
}

For environments that do not support exception handling, please refer to “Without Exception Handling” on page 154 for information about the _raise() function.

The _name() function returns the unqualified (unscoped) name of the exception. The _rep_id() function returns the repository ID of the exception. The return value from _name() and _rep_id() must not be deallocated.

The UserException class is derived from a base Exception class, which is also defined in the CORBA module.

All standard exceptions are derived from a SystemException class, also defined in the CORBA module. Like UserException, SystemException is derived from the base Exception class. The SystemException class interface is shown below.

```cpp
// C++
enum CompletionStatus {
    COMPLETED_YES,
    COMPLETED_NO,
    COMPLETED_MAYBE
};

class SystemException : public Exception
{
    public:
        ~SystemException();
        ULong minor() const;
        void minor(ULong);
        virtual void _raise() const = 0;
        CompletionStatus completed() const;
        void completed(CompletionStatus);
    protected:
        SystemException();
        SystemException(const SystemException &);
        SystemException(ULong minor, CompletionStatus status);
        SystemException &operator=(const SystemException &);
};
```

The default constructor for SystemException causes minor() to return 0 and completed() to return COMPLETED_NO.

Each specific system exception is derived from SystemException.
class UNKNOWN : public SystemException { ... };

class BAD_PARAM : public SystemException { ... };
// etc.

All specific system exceptions are defined within the CORBA module.

This exception hierarchy allows any exception to be caught by simply catching the Exception type.

try {
...
} catch (const Exception &exc) {
...
}

Alternatively, all user exceptions can be caught by catching the UserException type, and all system exceptions can be caught by catching the SystemException type.

try {
...
} catch (const UserException &ue) {
...
} catch (const SystemException &se) {
...
}

Naturally, more specific types can also appear in catch clauses.

Exceptions are normally thrown by value and caught by reference. This approach lets the exception destructor release storage automatically.

The Exception class provides for downcasting within the exception hierarchy.

class UserException : public Exception
{
  public:
    static UserException * _downcast(Exception *);
    static const UserException * _downcast(
        const Exception *
    );

    virtual void _raise() const = 0;

    // ...
};

class SystemException : public Exception
{
public:
    static SystemException * _downcast(Exception *);
    static const SystemException * _downcast(const Exception *);

    virtual void _raise() const = 0;

    // ...
};

Each exception class supports an overloaded static member function named _downcast. The parameter to the _downcast calls is a pointer to a const or non-const instance of the base class Exception. If the parameter is a null pointer, the return type of _downcast is a null pointer. If the actual (run time) type of the parameter exception can be widened to the requested exception’s type, then _downcast will return a valid pointer to the parameter Exception. Otherwise, _downcast will return a null pointer. The version of _downcast overloaded to take a pointer to a const Exception returns a pointer to const in order to preserve const-correctness.

Unlike the _narrow operation on object references, the _downcast operation on exceptions is equivalent to the C++ dynamic_cast operator in that it returns a suitably-typed pointer to the same exception parameter, not a pointer to a new exception. If the original exception goes out of scope or is otherwise destroyed, the pointer returned by _downcast is no longer valid. The semantics for _downcast are thus the same as for valuetype as described in “Valuetype Operations” on page 62.

For application portability, conforming C++ mapping implementations built using C++ compilers that support the standard C++ Run Time Type Information (RTTI) mechanisms still need to support downcasting for the Exception hierarchy. RTTI supports, among other things, determination of the run-time type of a C++ object. In particular, the dynamic_cast<T*> operator allows for downcasting from a base pointer to a more derived pointer if the object pointed to really is of the more derived type. This operator is not useful for narrowing object references, since it cannot determine the actual type of remote objects, but it can be used by the C++ mapping implementation to downcast within the exception hierarchy.

Previous versions of this mapping provided support for downcasting via a static member function called _narrow, which had exactly the same semantics as _downcast. Due to confusion over memory management differences between object reference _narrow functions and exception _narrow functions, the exception _narrow function is now deprecated in favor of _downcast. Portable applications shall use _downcast for exception downcasting, not _narrow. ORB implementations that provide _narrow functions for exceptions for purposes of backwards compatibility shall provide overloaded _narrow functions for both const and non-const Exception*, same as for _downcast.

5.21.1 ostream Inserters

Conforming implementations shall provide ostream inserters with the following signatures:

    // C++
    ostream& operator<<(ostream &, const CORBA::Exception &);
    ostream& operator<<(ostream &, const CORBA::Exception *);

15. It is unlikely that a compiler would support RTTI without supporting exceptions, since much of a C++ exception handling implementation is based on RTTI mechanisms.
These inserters print information about an exception on an ostream. The format and amount of detail of the printed information is implementation dependent. To guarantee that applications can control formatting of exceptions by providing custom overloaded inserters for more derived exception types, a conforming implementation must never provide overloaded inserters for \texttt{SystemException}, \texttt{UserException} or other more derived exception types.

5.21.2 UnknownUserException

Request invocations made through the DII may result in user-defined exceptions that cannot be fully represented in the calling program because the specific exception type was not known at compile-time. The mapping provides the \texttt{UnknownUserException} so that such exceptions can be represented in the calling process.

\begin{verbatim}
// C++
class UnknownUserException : public UserException
{
    public:
        Any &exception();
};
\end{verbatim}

As shown here, \texttt{UnknownUserException} is derived from \texttt{UserException}. It provides the \texttt{exception()} accessor that returns an \texttt{Any} holding the actual exception. Ownership of the returned \texttt{Any} is maintained by the \texttt{UnknownUserException}—the \texttt{Any} merely allows access to the exception data. Conforming applications should never explicitly throw exceptions of type \texttt{UnknownUserException}—it is intended for use with the DII.

5.21.3 Any Insertion and Extraction for Exceptions

Conforming implementations shall generate \texttt{Any} insertion and extraction operators (\texttt{operator<<=} and \texttt{operator>>=}, respectively) that allow all system and user exceptions to be correctly inserted into and extracted from \texttt{Any}. Both copying and non-copying forms of the \texttt{Any} insertion operator shall be provided for all system and user exceptions.

In addition, conforming mapping implementations must support \texttt{Any} insertion (but not extraction) for \texttt{CORBA::Exception}. This is required to allow DSI-based applications to catch exceptions as \texttt{CORBA::Exception&} and store them into a \texttt{ServerRequest}.

\begin{verbatim}
// C++
try {
    // ...
} catch (Exception& exc) {
    Any any;
    any <<= exc;
    server_request->set_exception(any);
}
\end{verbatim}

Note that this shall result in both the \texttt{TypeCode} and value for the actual derived exception type being stored into the \texttt{Any}. Both copying and non-copying forms of \texttt{Any} insertion for \texttt{CORBA::Exception} shall be provided.

\begin{verbatim}
// C++
void operator<<=(Any&, const Exception&);
void operator<<=(Any&, const Exception*);
\end{verbatim}
For applications using the DII or portable interceptors, it is useful to be able to extract system exceptions generically. The mapping provides the following operator to do this:

```
// C++
Boolean operator>>(const SystemException*& se) const;
```

The operator returns true if the Any on which it is invoked contains a system exception and the ORB has static type information for the actual system exception contained in the Any. In that case, se points at the base part of the actual exception after the operator returns. If the ORB does not have static type information for the system exception, the operator returns true and se points at an instance of CORBA::UNKNOWN. Otherwise, the operator returns false and the value of se is unchanged.

### 5.22 Mapping For Operations and Attributes

An operation maps to a C++ function with the same name as the operation. Each read-write attribute maps to a pair of overloaded C++ functions (both with the same name), one to set the attribute’s value and one to get the attribute’s value. The set function takes an in parameter with the same type as the attribute, while the get function takes no parameters and returns the same type as the attribute. An attribute marked “readonly” maps to only one C++ function, to get the attribute’s value. Parameters and return types for attribute functions obey the same parameter passing rules as for regular operations.

OMG IDL oneway operations are mapped the same as other operations; that is, there is no way to know by looking at the C++ whether an operation is oneway or not.

Operation and attribute signatures do not have exception specifications.

```
// IDL
interface A
{
    void f();
    oneway void g();
    attribute long x;
};
```

```
// C++
A_var a;
a->f();
a->g();
Long n = a->x();
a->x(n + 1);
```

C++ operations do not require an additional Environment parameter for passing exception information—real C++ exceptions are used for this purpose. See “Mapping for Exception Types” on page 85 for more details.
5.23 Implicit Arguments to Operations

If an operation in an OMG IDL specification has a context specification, then a **Context_ptr** input parameter (see “Context” on page 109) follows all operation-specific arguments. In an implementation that does not support real C++ exceptions, an output **Environment** parameter is the last argument following all operation-specific arguments, and following the context argument if present. The parameter passing mode for **Environment** is described in “Without Exception Handling” on page 154.

5.24 Argument Passing Considerations

The mapping of parameter passing modes attempts to balance the need for both efficiency and simplicity. For primitive types, enumerations, and object references, the modes are straightforward, passing the type **P** for primitives and enumerations and the type **A_ptr** for an interface type **A**.

Aggregate types are complicated by the question of when and how parameter memory is allocated and deallocated. Mapping **in** parameters is straightforward because the parameter storage is caller-allocated and read-only. The mapping for **out** and **inout** parameters is more problematic. For variable-length types, the callee must allocate some if not all of the storage. For fixed-length types, such as a **Point** type represented as a struct containing three floating point members, caller allocation is preferable (to allow stack allocation).

To accommodate both kinds of allocation, avoid the potential confusion of split allocation, and eliminate confusion with respect to when copying occurs, the mapping is **T&** for a fixed-length aggregate **T** and **T*&** for a variable-length **T**. This approach has the unfortunate consequence that usage for structs depends on whether the struct is fixed- or variable-length; however, the mapping is consistently **T_var&** if the caller uses the managed type **T_var**.

The mapping for **out** and **inout** parameters additionally requires support for deallocating any previous variable-length data in the parameter when a **T_var** is passed. Even though their initial values are not sent to the operation, we include **out** parameters because the parameter could contain the result from a previous call. There are many ways to implement this support. The mapping does not require a specific implementation, but a compliant implementation must free the inaccessible storage associated with a parameter passed as a **T_var** managed type. The provision of the **T_out** types is intended to give implementations the hooks necessary to free the inaccessible storage while converting from the **T_var** types.

The following examples demonstrate the compliant behavior:

```c++
// IDL
struct S { string name; float age; };
void f(out S p);

// C++
S_var s;
f(s);
// use s
f(s); // first result will be freed

S *sp; // need not initialize before passing to out
f(sp);
// use sp
```
delete sp; // cannot assume next call will free old value
f(sp);

Note that implicit deallocation of previous values for **out** and **inout** parameters works only with **T_var** types, not with other types.

// IDL
void q(out string s);

// C++
char *s;
for (int i = 0; i < 10; i++)
    q(s); // memory leak!

Each call to the **q** function in the loop results in a memory leak because the caller is not invoking **string_free** on the **out** result. There are two ways to fix this, as shown below:

// C++
char *s;
String_var svar;
for (int i = 0 ; i < 10; i++) {
    q(s);
    string_free(s); // explicit deallocation
    // OR:
    q(svar); // implicit deallocation
}

Using a plain **char** for the **out** parameter means that the caller must explicitly deallocate its memory before each reuse of the variable as an **out** parameter, while using a **String_var** means that any deallocation is performed implicitly upon each use of the variable as an **out** parameter.

If strings or wide strings are passed as **inout** parameters, the callee may modify the contents of the string or wide string in place. However, if the new string or wide string is longer than the initial string or wide string, reallocation becomes necessary. For a new string or wide string that is shorter than the original string or wide string, reallocation may also be used to conserve memory. However, shortening the string or wide string by replacing a character that is part of the initial string or wide string with the appropriate NUL character is also legal.

For **inout** object references, reallocation is necessary whenever the callee needs to change the initial value of the reference. The example below illustrates this.

For **in valuetype**s, the callee shall receive a copy of each **valuetype** argument passed to it even if the caller and callee are collocated in the same process. The callee is allowed to invoke operations and modifier functions that modify the state of the **valuetype** instance, but the state of the caller’s copy of that **valuetype** instance shall not be affected by the callee’s state changes. This is required to preserve location transparency for interface operations.

For **inout valuetype**s, the callee may either modify the incoming **valuetype** instance, or may replace the incoming pointer with a pointer to a different **valuetype** instance. The callee shall invoke **_remove_ref** on the **valuetype** instance passed in before replacing it with a **valuetype** instance to be passed back out. The caller shall eventually invoke **_remove_ref** on the **valuetype** instance it receives back as either an **inout**, **out**, or return value.

The example below illustrates the replacement of **inout** arguments. For the operation **f**, **s1** is an **inout** string that is modified in place and whose length is not changed by the callee, **s2** is an **inout** string that is grown by the callee, **obj** is an **inout** object reference that is changed by the callee, **val1** is an **inout valuetype** that is changed in place by the callee,
and val2 is an **inout valuetype** that is replaced by the callee. The example code uses local `T_var` variables to ensure automatic deallocation, but explicit calls to `CORBA::string_free` and `CORBA::release` could have been used instead.

Example

```idl
valuetype V { public long state; };
interface A {
    void f(inout string s1, inout string s2, inout A obj,
           inout V val1, inout V val2);
};
```

```c++
void Aimpl::f(char *&s1, char *&s2, A_ptr &obj,
              V *&val1, V *&val2)
{
    // Convert s1 to uppercase in place
    while (*s1 != '\0') upper(*s1++);

    // Return a different string value for s2
    String_var s2_tmp = s2;
    s2 = string_dup("new s2");

    // Assign new value to obj
    A_ptr newobj = ...;
    A_var obj_tmp = obj;
    obj = A::_duplicate(newobj);

    // Change value of val1 in place
    if (val1 != 0) val1->state(42);

    // Replace val2 entirely
    CORBA::remove_ref(val2);
    val2 = new MyVImpl(1234);
}
```

For parameters that are passed or returned as a pointer (`T*`) or reference to pointer (`T*&`), except for `valuetype`, a compliant program is not allowed to pass or return a null pointer; the result of doing so is undefined. In particular, a caller may not pass a null pointer under any of the following circumstances:

- **in** and **inout** string
- **in** and **inout** array (pointer to first element)

A caller may pass a reference to a pointer with a null value for **out** parameters, however, since the callee does not examine the value but rather just overwrites it. Furthermore, conforming applications may also pass and return null pointers for all `valuetype` parameters and return types, and may embed null `valuetype` pointers within constructed types that are passed as parameters or return values, such as structs, unions, arrays, sequences, Any, and other valuetypes.
A callee may not return a null pointer under any of the following circumstances:

- **out** and return variable-length struct
- **out** and return variable-length union
- **out** and return string
- **out** and return sequence
- **out** and return variable-length array, return fixed-length array
- **out** and return any

Since OMG IDL has no concept of pointers in general or null pointers in particular, except for `valuetype`, allowing the passage of null pointers to or from an operation would project C++ semantics onto OMG IDL operations. A compliant implementation is allowed but not required to raise a `BAD_PARAM` exception if it detects such an error.

### 5.24.1 Operation Parameters and Signatures

Table 5.3 displays the mapping for the basic OMG IDL parameter passing modes and return type according to the type being passed or returned, while Table 5.3 displays the same information for `T_var` types. Table 5.4 is merely for informational purposes; it is expected that operation signatures for both clients and servers will be written in terms of the parameter passing modes shown in Table 5.3, with the exception that the `T_out` types will be used as the actual parameter types for all `out` parameters. It is also expected that `T_var` types will support the necessary conversion operators to allow them to be passed directly. Callers should always pass instances of either `T_var` types or the base types shown in Table 5.3, and callees should treat their `T_out` parameters as if they were actually the corresponding underlying types shown in Table 5.3.

In Table 5.3, fixed-length arrays are the only case where the type of an `out` parameter differs from a return value, which is necessary because C++ does not allow a function to return an array. The mapping returns a pointer to a slice of the array, where a slice is an array with all the dimensions of the original specified except the first one.

A caller is responsible for providing storage for all arguments passed as `in` arguments.

**Table 5.3 - Basic Argument and Result Passing**

<table>
<thead>
<tr>
<th>Data Type</th>
<th>In</th>
<th>Inout</th>
<th>Out</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>Short</td>
<td>Short&amp;</td>
<td>Short&amp;</td>
<td>Short</td>
</tr>
<tr>
<td>long</td>
<td>Long</td>
<td>Long&amp;</td>
<td>Long&amp;</td>
<td>Long</td>
</tr>
<tr>
<td>unsigned short</td>
<td>UShort</td>
<td>UShort&amp;</td>
<td>UShort&amp;</td>
<td>UShort</td>
</tr>
<tr>
<td>unsigned long</td>
<td>ULong</td>
<td>ULong&amp;</td>
<td>ULong&amp;</td>
<td>ULong</td>
</tr>
<tr>
<td>unsigned long long</td>
<td>ULongLong</td>
<td>ULongLong&amp;</td>
<td>ULongLong&amp;</td>
<td>ULongLong</td>
</tr>
<tr>
<td>float</td>
<td>Float</td>
<td>Float&amp;</td>
<td>Float&amp;</td>
<td>Float</td>
</tr>
<tr>
<td>double</td>
<td>Double</td>
<td>Double&amp;</td>
<td>Double&amp;</td>
<td>Double</td>
</tr>
<tr>
<td>long double</td>
<td>LongDouble</td>
<td>LongDouble&amp;</td>
<td>LongDouble&amp;</td>
<td>LongDouble</td>
</tr>
</tbody>
</table>

---

16. When real C++ exceptions are not available, however, it is important that null pointers are returned whenever an `Environment` containing an exception is returned; see “Without Exception Handling” on page 154 for more details.
### Table 5.3 - Basic Argument and Result Passing (Continued)

<table>
<thead>
<tr>
<th>Data Type</th>
<th>In</th>
<th>Inout</th>
<th>Out</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean</td>
<td>Boolean</td>
<td>Boolean&amp;</td>
<td>Boolean&amp;</td>
<td>Boolean</td>
</tr>
<tr>
<td>char</td>
<td>Char</td>
<td>Char&amp;</td>
<td>Char&amp;</td>
<td>Char</td>
</tr>
<tr>
<td>wchar</td>
<td>WChar</td>
<td>WChar&amp;</td>
<td>WChar&amp;</td>
<td>WChar</td>
</tr>
<tr>
<td>octet</td>
<td>Octet</td>
<td>Octet&amp;</td>
<td>Octet&amp;</td>
<td>Octet</td>
</tr>
<tr>
<td>enum</td>
<td>enum</td>
<td>enum&amp;</td>
<td>enum&amp;</td>
<td>enum</td>
</tr>
<tr>
<td>object reference ptr&lt;sup&gt;a&lt;/sup&gt;</td>
<td>objref_ptr</td>
<td>objref_ptr&amp;</td>
<td>objref_ptr&amp;</td>
<td>objref_ptr</td>
</tr>
<tr>
<td>struct, fixed</td>
<td>const struct&amp;</td>
<td>struct&amp;</td>
<td>struct&amp;</td>
<td>struct</td>
</tr>
<tr>
<td>struct, variable</td>
<td>const struct&amp;</td>
<td>struct&amp;</td>
<td>struct* &amp;</td>
<td>struct*</td>
</tr>
<tr>
<td>union, fixed</td>
<td>const union&amp;</td>
<td>union&amp;</td>
<td>union&amp;</td>
<td>union</td>
</tr>
<tr>
<td>union, variable</td>
<td>const union&amp;</td>
<td>union&amp;</td>
<td>union* &amp;</td>
<td>union*</td>
</tr>
<tr>
<td>string</td>
<td>const char*</td>
<td>char* &amp;</td>
<td>char* &amp;</td>
<td>char*</td>
</tr>
<tr>
<td>wstring</td>
<td>const WChar*</td>
<td>WChar* &amp;</td>
<td>WChar* &amp;</td>
<td>WChar*</td>
</tr>
<tr>
<td>sequence</td>
<td>const sequence&amp;</td>
<td>sequence&amp;</td>
<td>sequence* &amp;</td>
<td>sequence*</td>
</tr>
<tr>
<td>array, fixed</td>
<td>const array</td>
<td>array</td>
<td>array</td>
<td>array slice&lt;sup&gt;4b&lt;/sup&gt;</td>
</tr>
<tr>
<td>array, variable</td>
<td>const array</td>
<td>array</td>
<td>array slice* &amp;&lt;sup&gt;2&lt;/sup&gt;</td>
<td>array slice*&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>any</td>
<td>const any&amp;</td>
<td>any&amp;</td>
<td>any* &amp;</td>
<td>any*</td>
</tr>
<tr>
<td>fixed</td>
<td>const fixed&amp;</td>
<td>fixed&amp;</td>
<td>fixed&amp;</td>
<td>fixed</td>
</tr>
<tr>
<td>valuetype&lt;sup&gt;c&lt;/sup&gt;</td>
<td>valuetype*</td>
<td>valuetype* &amp;</td>
<td>valuetype* &amp;</td>
<td>valuetype*</td>
</tr>
</tbody>
</table>

- **a.** Including pseudo-object references.
- **b.** A slice is an array with all the dimensions of the original except the first one.
- **c.** Including value boxes.

### Table 5.4 - T_var Argument and Result Passing<sup>a</sup>

<table>
<thead>
<tr>
<th>Data Type</th>
<th>In</th>
<th>Inout</th>
<th>Out</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>object reference var&lt;sup&gt;b&lt;/sup&gt;</td>
<td>const objref_var&amp;</td>
<td>objref_var&amp;</td>
<td>objref_var&amp;</td>
<td>objref_var</td>
</tr>
<tr>
<td>struct_var</td>
<td>const struct_var&amp;</td>
<td>struct_var&amp;</td>
<td>struct_var&amp;</td>
<td>struct_var</td>
</tr>
<tr>
<td>union_var</td>
<td>const union_var&amp;</td>
<td>union_var&amp;</td>
<td>union_var&amp;</td>
<td>union_var</td>
</tr>
<tr>
<td>string_var</td>
<td>const string_var&amp;</td>
<td>string_var&amp;</td>
<td>string_var&amp;</td>
<td>string_var</td>
</tr>
<tr>
<td>sequence_var</td>
<td>const sequence_var&amp;</td>
<td>sequence_var&amp;</td>
<td>sequence_var&amp;</td>
<td>sequence_var</td>
</tr>
<tr>
<td>array_var</td>
<td>const array_var&amp;</td>
<td>array_var&amp;</td>
<td>array_var&amp;</td>
<td>array_var</td>
</tr>
<tr>
<td>any_var</td>
<td>const any_var&amp;</td>
<td>any_var&amp;</td>
<td>any_var&amp;</td>
<td>any_var</td>
</tr>
<tr>
<td>valuetype_var&lt;sup&gt;c&lt;/sup&gt;</td>
<td>const valuetype_var&amp;</td>
<td>valuetype_var&amp;</td>
<td>valuetype_var&amp;</td>
<td>valuetype_var</td>
</tr>
</tbody>
</table>

- **a.** Fixed types have no corresponding var type and are therefore not shown in this table.
- **b.** Including pseudo-object references.
- **c.** Including value boxes.
Table 5.5 and Table 5.6 describe the caller’s responsibility for storage associated with **inout** and **out** parameters and for return results.

**Table 5.5 - Caller Argument Storage Responsibilities**

<table>
<thead>
<tr>
<th>Type</th>
<th>Inout Param</th>
<th>Out Param</th>
<th>Return Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>long</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>long long</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>unsigned short</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>unsigned long</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>unsigned long long</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>float</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>double</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>long double</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>boolean</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>char</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>wchar</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>octet</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>enum</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>object reference ptr</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>struct, fixed</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>struct, variable</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>union, fixed</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>union, variable</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>string</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>wstring</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>sequence</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>array, fixed</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>array, variable</td>
<td>1</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>any</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>fixed</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>valuetype</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Case</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Caller allocates all necessary storage, except that which may be encapsulated and managed within the parameter itself. For inout parameters, the caller provides the initial value, and the callee may change that value. For out parameters, the caller allocates the storage but need not initialize it, and the callee sets the value. Function returns are by value.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Caller allocates storage for the object reference. For inout parameters, the caller provides an initial value; if the callee wants to reassign the inout parameter, it will first call CORBA::release on the original input value. To continue to use an object reference passed in as an inout, the caller must first duplicate the reference. The callee is responsible for the release of all out and return object references. Release of all object references embedded in other structures is performed automatically by the structures themselves.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>For out parameters, the caller allocates a pointer and passes it by reference to the callee. The callee sets the pointer to point to a valid instance of the parameter’s type. For returns, the callee returns a similar pointer. The callee is not allowed to return a null pointer in either case. In both cases, the caller is responsible for releasing the returned storage. To maintain local/remote transparency, the caller must always release the returned storage, regardless of whether the callee is located in the same address space as the caller or is located in a different address space.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>For inout strings, the caller provides storage for both the input string and the char* or wchar* pointing to it. Since the callee may deallocate the input string and reassign the char* or wchar* to point to new storage to hold the output value, the caller should allocate the input string using string_alloc() or wstring_alloc(). The size of the out string is therefore not limited by the size of the in string. The callee is responsible for deleting the storage for the out using string_free() or wstring_free(). The callee is not allowed to return a null pointer for an inout, out, or return value.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>For inout sequences and anys, assignment or modification of the sequence or any may cause deallocation of owned storage before any reallocation occurs, depending upon the state of the Boolean release parameter with which the sequence or any was constructed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>For out parameters, the caller allocates a pointer to an array slice, which has all the same dimensions of the original array except the first, and passes the pointer by reference to the callee. The callee sets the pointer to point to a valid instance of the array. For returns, the callee returns a similar pointer. The callee is not allowed to return a null pointer in either case. In both cases, the caller is responsible for releasing the returned storage. To maintain local/remote transparency, the callee must always release the returned storage, regardless of whether the callee is located in the same address space as the caller or is located in a different address space.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Caller allocates storage for the valuetype instance. For inout parameters, the caller provides an initial value; if the callee wants to reassign the inout pointer value to point to a different valuetype instance, it will first call _remove_ref on the original input valuetype. To continue to use a valuetype instance passed in as an inout after the invoked operation returns, the caller must first invoke _add_ref on the valuetype instance. The callee is responsible for invoking _remove_ref on all out and return valuetype instances. The reduction of reference counts via _remove_ref for all valuetype instances embedded in other structures is performed automatically by the structures themselves.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.25 Mapping of Pseudo Objects to C++

CORBA pseudo objects may be implemented either as normal CORBA objects or as serverless objects. In the CORBA specification, the fundamental differences between these strategies are:

- Serverless object types do not inherit from `CORBA::Object`.
- Individual serverless objects are not registered with any ORB.
- Serverless objects do not necessarily follow the same memory management rules as for regular IDL types.

References to serverless objects are not necessarily valid across computational contexts; for example, address spaces. Instead, references to serverless objects that are passed as parameters may result in the construction of independent functionally-identical copies of objects used by receivers of these references. To support this, the otherwise hidden representational properties (such as data layout) of serverless objects are made known to the ORB. Specifications for achieving this are not contained in this chapter. Making serverless objects known to the ORB is an implementation detail.

This sub clause provides a standard mapping algorithm for all pseudo object types. This avoids the need for piecemeal mappings for each of the nine CORBA pseudo object types, and accommodates any pseudo object types that may be proposed in future revisions of CORBA.

5.26 Usage

Rather than C-PIDL, this mapping uses an augmented form of full OMG IDL to describe serverless object types. Interfaces for pseudo object types follow the exact same rules as normal OMG IDL interfaces, with the following exceptions:

- They are prefaced by the keyword `pseudo`.
- Their declarations may refer to other serverless object types that are not otherwise necessarily allowed in OMG IDL.

As explained in “Mapping of Pseudo Objects to C++” on page 98, the `pseudo` prefix means that the interface may be implemented in either a normal or serverless fashion. That is, apply either the rules described in the following sub clauses or the normal mapping rules described in this clause.

5.27 Mapping Rules

Serverless objects are mapped in the same way as normal interfaces, except for the differences outlined in this sub clause. Classes representing serverless object types are not subclasses of `CORBA::Object`, and are not necessarily subclasses of any other C++ class. Thus, they do not necessarily support, for example, the `Object::create_request` operation.

For each class representing a serverless object type T, overloaded versions of the following functions are provided in the `CORBA` namespace:

17. In particular, `exception` used as a data type and a function name.
The mapped C++ classes are not guaranteed to be usefully subclassable by users, although subclasses can be provided by implementations. Implementations are allowed to make assumptions about internal representations and transport formats that may not apply to subclasses.

The member functions of classes representing serverless object types do not necessarily obey the normal memory management rules. This is due to the fact that some serverless objects, such as `CORBA::NVList`, are essentially just containers for several levels of other serverless objects. Requiring callers to explicitly free the values returned from accessor functions for the contained serverless objects would be counter to their intended usage.

All other elements of the mapping are the same. In particular:

1. The types of references to serverless objects, `T_ptr`, may or may not simply be a typedef of `T*`.
2. Each mapped class supports the following static member functions:

```c++
// C++
static T_ptr _duplicate(T_ptr p);
static T_ptr _nil();
```

Legal implementations of `_duplicate` include simply returning the argument or constructing references to a new instance. Individual implementations may provide stronger guarantees about behavior.

1. The corresponding C++ classes may or may not be directly instantiable or have other instantiation constraints. For portability, users should invoke the appropriate constructive operations.
2. As with normal interfaces, assignment operators are not supported.
3. Although they can transparently employ “copy-style” rather than “reference-style” mechanics, parameter passing signatures and rules as well as memory management rules are identical to those for normal objects, unless otherwise noted.

## 5.28 Relation to the C PIDL Mapping

All serverless object interfaces and declarations that rely on them have direct analogs in the C mapping. Differences between the pseudo object specifications for C-PIDL and C++ PIDL are as follows:

- C++-PIDL calls for removal of representation dependencies through the use of interfaces rather than structs and typedefs.
- C++-PIDL calls for placement of operations on pseudo objects in their interfaces, including a few cases of redesignated functionality as noted.
- In C++-PIDL, the `release` performs the role of the associated `free` and `delete` operations in the C mapping, unless otherwise noted.

Brief descriptions and listings of each pseudo-interface and its C++ mapping are provided in the following sub clauses. Further details, including definitions of types referenced but not defined below, may be found in the relevant clauses of this specification.

Some of the pseudo-interfaces shown in this clause rely on a user-defined exception supplied in the `CORBA` module by ORB implementations. This exception is called `Bounds` and is defined as follows:

```c++
// C++
void release(T_ptr);
Boolean is_nil(T_ptr p);
```
module CORBA
{
    exception Bounds {};
    // ...
};

Note that this exception is not the same as the CORBA::TypeCode::Bounds exception.

5.29 Environment

Environment provides a vehicle for dealing with exceptions in those cases where true exception mechanics are unavailable or undesirable (for example in the DII). They may be set and inspected using the exception attribute.

As with normal OMG IDL attributes, the exception attribute is mapped into a pair of C++ functions used to set and get the exception. The semantics of the set and get functions, however, are somewhat different than those for normal OMG IDL attributes. The set C++ function assumes ownership of the Exception pointer passed to it. The Environment will eventually call delete on this pointer, so the Exception it points to must be dynamically allocated by the caller. The get function returns a pointer to the Exception, just as an attribute for a variable-length struct would, but the pointer refers to memory owned by the Environment. Once the Environment is destroyed, the pointer is no longer valid. The caller must not call delete on the Exception pointer returned by the get function. The Environment is responsible for deallocating any Exception it holds when it is itself destroyed. If the Environment holds no exception, the get function returns a null pointer.

The clear() function causes the Environment to delete any Exception it is holding. It is not an error to call clear() on an Environment holding no exception. Passing a null pointer to the set exception function is equivalent to calling clear(). If an Environment contains exception information, the caller is responsible for calling clear() on it before passing it to an operation.

5.29.1 Environment Interface

pseudo interface Environment
{
    attribute exception exception;
    void clear();
};

5.29.2 Environment C++ Class

class Environment
{
    public:
    void exception(Exception*);
    Exception *exception() const;
    void clear();
};
5.29.3 Differences from C-PIDL

The C++-PIDL specification differs from the C-PIDL specification as follows:

- Defines an interface rather than a struct.
- Supports an attribute allowing operations on exception values as a whole rather than on major numbers and/or identification strings.
- Supports a `clear()` function that is used to destroy any `Exception` the `Environment` may be holding.
- Supports a default constructor that initializes it to hold no exception information.

5.29.4 Memory Management

`Environment` has the following special memory management rules:

- The `void exception(Exception*)` member function adopts the `Exception*` given to it.
- Ownership of the return value of the `Exception *exception()` member function is maintained by the `Environment`; this return value must not be freed by the caller.

5.30 NamedValue

`NamedValue` is used only as an element of `NVList` and for return values in the `CORBA::Object::create_request` operation. `NamedValue` maintains an (optional) name, an `any` value, and labeling flags. Legal flag values are `ARG_IN`, `ARG_OUT`, and `ARG_INOUT`.

The value in a `NamedValue` may be manipulated via standard operations on `any`.

5.30.1 NamedValue Interface

```
// IDL
pseudo interface NamedValue
{
    readonly attribute Identifier name;
    readonly attribute any value;
    readonly attribute Flags flags;
};
```

5.30.2 NamedValue C++ Class

```
// C++
class NamedValue
{
    public:
        const char *name() const;
        Any *value() const;
        Flags flags() const;
};
```
5.30.3 Differences from C-PIDL

The C++-PIDL specification differs from the C-PIDL specification as follows:

- Defines an interface rather than a struct.
- Provides no analog of the len field.

5.30.4 Memory Management

NamedValue has the following special memory management rules:

- Ownership of the return values of the name() and value() functions is maintained by the NamedValue; these return values must not be freed by the caller.

5.31 NVList

NVList is a list of NamedValues. A new NVList is constructed using the ORB::create_list operation (see “ORB” on page 111). New NamedValues may be constructed as part of an NVList, in any of these ways:

- add—creates an unnamed value, initializing only the flags.
  - add_item—initializes name and flags.
  - add_value—initializes name, value, and flags.
  - add_item_consume—initializes name and flags, taking over memory management responsibilities for the char* name parameter.
  - add_value_consume—initializes name, value, and flags, taking over memory management responsibilities for both the char* name parameter and the Any* value parameter. Each of these operations returns the new item.

Elements may be accessed and deleted via zero-based indexing. The add, add_item, add_value, add_item_consume, and add_value_consume functions lengthen the NVList to hold the new element each time they are called. The item function can be used to access existing elements.

5.31.1 NVList Interface

// IDL
pseudo interface NVList
{
    readonly attribute unsigned long count;
    NamedValue add(in Flags flags);
    NamedValue add_item(in Identifier item_name, in Flags flags);
    NamedValue add_value(  in Identifier item_name,
                            in any val,
                            in Flags flags);
    NamedValue item(in unsigned long index) raises(Bounds);
    void remove(in unsigned long index) raises(Bounds);
};
5.31.2 NVList C++ Class

// C++
class NVList
{
    public:
        ULong count() const;
        NamedValue_ptr add(Flags);
        NamedValue_ptr add_item(const char*, Flags);
        NamedValue_ptr add_value(
            const char*,
            const Any&,
            Flags
        );
        NamedValue_ptr add_item_consume(
            char*,
            Flags
        );
        NamedValue_ptr add_value_consume(
            char*,
            Any *,
            Flags
        );
        NamedValue_ptr item(ULong);
        void remove(ULong);
};

5.31.3 Differences from C-PIDL

The C++-PIDL specification differs from the C-PIDL specification as follows:

- Defines an interface rather than a typedef.
- Provides different signatures for operations that add items in order to avoid representation dependencies.
- Provides indexed access methods.

5.31.4 Memory Management

NVList has the following special memory management rules:

- Ownership of the return values of the add, add_item, add_value, add_item_consume, add_value_consume, and item functions is maintained by the NVList; these return values must not be freed by the caller.
• The char* parameters to the `add_item_consume` and `add_value_consume` functions and the Any* parameter to the `add_value_consume` function are consumed by the NVList. The caller may not access these data after they have been passed to these functions because the NVList may copy them and destroy the originals immediately. The caller should use the `NamedValue::value()` operation in order to modify the value attribute of the underlying NamedValue, if desired.

• The `remove` function also calls `CORBA::release` on the removed NamedValue.

### 5.32 Request

`Request` provides the primary support for DII. A new request on a particular target object may be constructed using the short version of the request creation operation shown in “Object” on page 115.

```c++
// C++
Request_ptr Object::_request(Identifier operation);
```

Arguments and contexts may be added after construction via the corresponding attributes in the Request interface. Results, output arguments, and exceptions are similarly obtained after invocation. The following C++ code illustrates usage:

```c++
// C++
Request_ptr req = anObj->_request("anOp");
*(req->arguments()->add(ARG_IN)->value()) <<= anArg;
// ...
req->invoke();
if (req->env()->exception() == 0) {
    *(req->result()->value()) >>= aResult;
}
```

While this example shows the semantics of the attribute-based accessor functions, the following example shows that it is much easier and preferable to use the equivalent argument manipulation helper functions:

```c++
// C++
Request_ptr req = anObj->_request("anOp");
req->add_in_arg() <<= anArg;
// ...
req->invoke();
if (req->env()->exception() == 0) {
    req->return_value() >>= aResult;
}
```

Alternatively, requests can be constructed using one of the long forms of the creation operation shown in the Object interface in “Object” on page 115:

```c++
// C++
void Object::_create_request(
    Context_ptr ctx,
    const char *operation,
    NVList_ptr arg_list,
    NamedValue_ptr result,
    Request_out request,
    ...);
```
Flags req_flags
);
void Object::create_request(
    Context_ptr ctx,
    const char *operation,
    NVList_ptr arg_list,
    NamedValue_ptr result,
    ExceptionList_ptr,
    ContextList_ptr,
    Request_out request,
    Flags req_flags
);

Usage is the same as for the short form except that all invocation parameters are established on construction. Note that the OUT_LIST_MEMORY and IN_COPY_VALUE flags can be set as flags in the req_flags parameter, but they are meaningless and thus ignored because argument insertion and extraction are done via the Any type.

Request also allows the application to supply all information necessary for it to be invoked without requiring the ORB to utilize the Interface Repository. In order to deliver a request and return the response, the ORB requires:

- a target object reference
- an operation name
- a list of arguments (optional)
- a place to put the result (optional)
- a place to put any returned exceptions
  - a Context (optional)
    - a list of the user-defined exceptions that can be thrown (optional)
    - a list of Context strings that must be sent with the operation (optional)

Since the Object::create_request operation allows all of these except the last two to be specified, an ORB may have to utilize the Interface Repository in order to discover them. Some applications, however, may not want the ORB performing potentially expensive Interface Repository lookups during a request invocation, so two new serverless objects have been added to allow the application to specify this information instead:

- ExceptionList: allows an application to provide a list of TypeCodes for all user-defined exceptions that may result when the Request is invoke.
- ContextList: allows an application to provide a list of Context strings that must be supplied with the Request invocation.

The ContextList differs from the Context in that the former supplies only the context strings whose values are to be looked up and sent with the request invocation (if applicable), while the latter is where those values are obtained.

The IDL descriptions for ExceptionList, ContextList, and Request are shown below.
5.32.1 Request Interface

// IDL
pseudo interface ExceptionList
{
    readonly attribute unsigned long count;
    void add(in TypeCode exc);
    TypeCode item(in unsigned long index) raises(Bounds);
    void remove(in unsigned long index) raises(Bounds);
}

pseudo interface ContextList
{
    readonly attribute unsigned long count;
    void add(in string ctxt);
    string item(in unsigned long index) raises(Bounds);
    void remove(in unsigned long index) raises(Bounds);
}

pseudo interface Request
{
    readonly attribute Object target;
    readonly attribute Identifier operation;
    readonly attribute NVList arguments;
    readonly attribute NamedValue result;
    readonly attribute Environment env;
    readonly attribute ExceptionList exceptions;
    readonly attribute ContextList contexts;

    attribute context ctx;

    void invoke();
    void send_oneway();
    void send_deferred();
    void get_response();
    boolean poll_response();
}
5.32.2 Request C++ Class

// C++
class ExceptionList
{
    public:
        ULong count();
        void add(TypeCode_ptr tc);
        void add_consume(TypeCode_ptr tc);
        TypeCode_ptr item(ULong index);
        void remove(ULong index);
};

class ContextList
{
    public:
        ULong count();
        void add(const char* ctxt);
        void add_consume(char* ctxt);
        const char* item(ULong index);
        void remove(ULong index);
};
class Request
{
    public:
        Object_ptr target() const;
        const char *operation() const;
        NVList_ptr arguments();
        NamedValue_ptr result();
        Environment_ptr env();
        ExceptionList_ptr exceptions();
        ContextList_ptr contexts();

        void ctx(Context_ptr);
        Context_ptr ctx() const;

        // argument manipulation helper functions
        Any &add_in_arg();
        Any &add_in_arg(const char* name);
        Any &add_inout_arg();
        Any &add_inout_arg(const char* name);
        Any &add_out_arg();
        Any &add_out_arg(const char* name);
        void set_return_type(TypeCode_ptr tc);
        Any &return_value();
void invoke();
void send_oneway();
void send_deferred();
void get_response();
Boolean poll_response();

};

5.32.3 Differences from C-PIDL

The C++-PIDL specification differs from the C-PIDL specification as follows:

- Replacement of add_argument, and so forth, with attribute-based accessors.
- Use of env attribute to access exceptions raised in DII calls.
- The invoke operation does not take a flag argument, since there are no flag values that are listed as legal in CORBA.
- The send_oneway and send_deferred operations replace the single send operation with flag values, in order to clarify usage.
- The get_response operation does not take a flag argument. If invoked before the request has completed, get_response blocks until the request completes; if invoked after the request has completed, get_response returns immediately. The poll_response operation returns immediately. A true return value indicates that the request has completed. A false return value indicates that the reply for the request is still outstanding.
- The add_*_arg, set_return_type, and return_value member functions are added as shortcuts for using the attribute-based accessors.

5.32.4 Memory Management

Request has the following special memory management rules:

- Ownership of the return values of the target, operation, arguments, result, env, exceptions, contexts, and ctx functions is maintained by the Request; these return values must not be freed by the caller.

ExceptionList has the following special memory management rules:

- The add_consume function consumes its TypeCode_ptr argument. The caller may not access the object referred to by the TypeCode_ptr after it has been passed in because the add_consume function may copy it and release the original immediately.
- Ownership of the return value of the item function is maintained by the ExceptionList; this return value must not be released by the caller.

ContextList has the following special memory management rules:

- The add_consume function consumes its char* argument. The caller may not access the memory referred to by the char* after it has been passed in because the add_consume function may copy it and free the original immediately.
- Ownership of the return value of the item function is maintained by the ContextList; this return value must not be released by the caller.
5.33 Context

A Context supplies optional context information associated with a method invocation.

5.33.1 Context Interface

// IDL
pseudo interface Context
{
    readonly attribute Identifier context_name;
    readonly attribute context parent;

    void create_child(in Identifier child_ctx_name, out Context child_ctx);

    void set_one_value(in Identifier propname, in any propvalue);
    void set_values(in NVList values);
    void delete_values(in Identifier propname);
    void get_values(
        in Identifier start_scope, 
        in Flags op_flags, 
        in Identifier pattern, 
        out NVList values 
    );
};

5.33.2 Context C++ Class

// C++
class Context
{
    public:
        const char *context_name() const;
        Context_ptr parent() const;

        void create_child(const char *, Context_out);

        void set_one_value(const char *, const Any &);
        void set_values(NVList_ptr);
        void delete_values(const char *);
        void get_values(
            const char*,
            Flags,
            const char*,
            NVList_out
        );
};
5.33.3 Differences from C-PIDL

The C++-PIDL specification differs from the C-PIDL specification as follows:

- Introduction of attributes for context name and parent.
- The signatures for values are uniformly set to `any`.
- The `release` operation frees child contexts.

5.33.4 Memory Management

`Context` has the following special memory management rules:

- Ownership of the return values of the `context_name` and `parent` functions is maintained by the `Context`; these return values must not be freed by the caller.

5.34 TypeCode

A `TypeCode` represents OMG IDL type information.

No constructors for `TypeCode`s are defined. However, in addition to the mapped interface, for each basic and defined OMG IDL type, an implementation provides access to a `TypeCode` pseudo object reference (`TypeCode_ptr`) of the form `_tc_<type>` that may be used to set types in `Any`, as arguments for `equal`, and so on. In the names of these `TypeCode` reference constants, `<type>` refer to the local name of the type within its defining scope. Each C++ `_tc_<type>` constant must be defined at the same scoping level as its matching type.

In all C++ `TypeCode` pseudo object reference constants, the prefix “_tc_” should be used instead of the “TC_” prefix prescribed in “TypeCode” on page 110.

Like all other serverless objects, the C++ mapping for `TypeCode` provides a `_nil()` operation that returns a nil object reference for a `TypeCode`. This operation can be used to initialize `TypeCode` references embedded within constructed types. However, a nil `TypeCode` reference may never be passed as an argument to an operation, since `TypeCode`s are effectively passed as values, not as object references.

5.34.1 TypeCode Interface

The `TypeCode` IDL interface is fully defined in version 2.3 of Common Object Request Broker Architecture, Interface Repository clause, The TypeCode Interface sub clause and is thus not duplicated here.

5.34.2 TypeCode C++ Class

```cpp
// C++
class TypeCode
{
    public:
        class Bounds : public UserException { ... };
        class BadKind : public UserException { ... };

        Boolean equal(TypeCode_ptr) const;
```
Boolean equivalent(TypeCode_ptr) const;
TCKind kind() const;

TypeCode_ptr get_compact_typecode() const;
const char* id() const;
const char* name() const;

ULong member_count() const;
const char* member_name(ULong index) const;

TypeCode_ptr member_type(ULong index) const;
Any *member_label(ULong index) const;
TypeCode_ptr discriminator_type() const;
Long default_index() const;

ULong length() const;

TypeCode_ptr content_type() const;

USHort fixed_digits() const;
Short fixed_scale() const;

Visibility member_visibility(ULong index) const;
ValueModifier type_modifier() const;
TypeCode_ptr concrete_base_type() const;

};

5.34.3 Differences from C-PIDL

For C++, use of prefix “_tc_” instead of “TC_” for constants.

5.34.4 Memory Management

TypeCode has the following special memory management rules:

- Ownership of the return values of the id, name, and member_name functions is maintained by the TypeCode; these return values must not be freed by the caller.

5.35 ORB

An ORB is the programmer interface to the Object Request Broker.
5.35.1 ORB Interface

// IDL
pseudo interface ORB
{
    typedef sequence<Request> RequestSeq;
    string object_to_string(in Object obj);
    Object string_to_object(in string str);

    void create_list(in long count, out NVList new_list);
    void create_operation_list(in OperationDef oper, out NVList new_list);

    void create_named_value(out NamedValue nmval);
    void create_exception_list(out ExceptionList exclist);
    void create_context_list(out ContextList ctxtlist);

    void get_default_context(out Context ctx);
    void create_environment(out Environment new_env);

    void send_multiple_requests_oneway(in RequestSeq req);
    void send_multiple_requests_deferred(in RequestSeq req);
    boolean poll_next_response();
    void get_next_response(out Request req);

    Boolean work_pending();
    void perform_work();
    void shutdown(in Boolean wait_for_completion);
    void destroy();
    void run();

    Boolean get_service_information (
        in ServiceType service_type,
        out ServiceInformation service_information
    );

    typedef string ObjectId;
    typedef sequence<ObjectId> ObjectIdList;
    Object resolve_initial_references(in ObjectId id) raises(InvalidName);
    ObjectIdList list_initial_services();

    Policy create_policy(in PolicyType type, in any val)
        raises(PolicyError);
};
5.35.2 ORB C++ Class

// C++
class ORB
{
    public:
        class RequestSeq {...};
        char *object_to_string(Object_ptr);
        Object_ptr string_to_object(const char *);
        void create_list(Long, NVList_out);
        void create_operation_list(OperationDef_ptr, NVList_out);
        void create_named_value(NamedValue_out);
        void create_exception_list(ExceptionList_out);
        void create_context_list(ContextList_out);
        void get_default_context(Context_out);
        void create_environment(Environment_out);
        void send_multiple_requests_oneway(const RequestSeq&);
        void send_multiple_requests_deferred(const RequestSeq &);
        Boolean poll_next_response();
        void get_next_response(Request_out);
        Boolean work_pending();
        void perform_work();
        void shutdown(Boolean wait_for_completion);
        void run();
        Boolean get_service_information(
            ServiceType svc_type,
            ServiceInformation_out svc_info);
        typedef char* ObjectId;
        class ObjectIdList { ... }; 
        Object_ptr resolve_initial_references(const char* id);
        ObjectIdList* list_initial_services();
        Policy_ptr create_policy(PolicyType type, const Any& val);
    }

5.35.3 Differences from C-PIDL

- Added create_environment. Unlike the struct version, Environment requires a construction operation. (Since this is overly constraining for implementations that do not support real C++ exceptions, these implementations may allow Environment to be declared on the stack. See “Without Exception Handling” on page 154 for details.)
- Assigned multiple request support to ORB, made usage symmetrical with that in Request, and used a sequence type rather than otherwise illegal unbounded arrays in signatures.
- Added `create_named_value`, which is required for creating `NamedValue` objects to be used as return value parameters for the `Object::create_request` operation.

- Added `create_exception_list` and `create_context_list` (see “Request” on page 104 for more details).

### 5.35.4 Mapping of ORB Initialization Operations

The following PIDL specifies initialization operations for an ORB; this PIDL is part of the CORBA module (not the ORB interface) and is described in version 2.3 of *Common Object Request Broker Architecture, ORB Interface* clause, *ORB Initialization* sub clause.

```plaintext
// PIDL
module CORBA {
    typedef string ORBid;
    typedef sequence <string> arg_list;
    ORB ORB_init (inout arg_list argv, in ORBid orb_identifier);
};
```

The mapping of the preceding PIDL operations to C++ is as follows:

```plaintext
// C++
namespace CORBA {
    typedef char* ORBid;
    static ORB_ptr ORB_init(
        int& argc,
        char** argv,
        const char* orb_identifier = ""
    );
}
```

The C++ mapping for `ORB_init` deviates from the OMG IDL PIDL in its handling of the `arg_list` parameter. This is intended to provide a meaningful PIDL definition of the initialization interface, which has a natural C++ binding. To this end, the `arg_list` structure is replaced with `argv` and `argc` parameters.

The `argv` parameter is defined as an unbound array of strings (**char**) and the number of strings in the array is passed in the `argc` (**int**) parameter.

If an empty ORBid string is used, then `argc` arguments can be used to determine which ORB should be returned. This is achieved by searching the `argv` parameters for one tagged `ORBid` (e.g., `-ORBid "ORBid_example"`). If an empty ORBid string is used and no ORB is indicated by the `argv` parameters, the default ORB is returned.

Regardless of whether an empty or non-empty ORBid string is passed to `ORB_init`, the `argv` arguments are examined to determine if any ORB parameters are given. If a non-empty ORBid string is passed to `ORB_init`, all `-ORBid` parameters in the `argv` are ignored. All other `-ORB<suffix>` parameters may be of significance during the ORB initialization process.

For C++, the order of consumption of `argv` parameters may be significant to an application. In order to ensure that applications are not required to handle `argv` parameters they do not recognize the ORB initialization function must be called before the remainder of the parameters is consumed. Therefore, after the `ORB_init` call the `argv` and `argc` parameters will have been modified to remove the ORB understood arguments. It is important to note that the `ORB_init`
call can only reorder or remove references to parameters from the argv list, this restriction is made in order to avoid potential memory management problems caused by trying to free parts of the argv list or extending the argv list of parameters. This is why `argv` is passed as a `char**` and not a `char**&`.

5.36 Object

The rules in this section apply to OMG IDL interface `Object`, the base of the OMG IDL interface hierarchy. Interface `Object` defines a normal CORBA object, not a pseudo object. However, it is included here because it references other pseudo objects.

5.36.1 Object Interface

```idl
// IDL
interface Object
{
    boolean is_nil();
    Object duplicate();
    void release();
    ImplementationDef get_implementation();
    InterfaceDef get_interface();
    boolean is_a(in string logical_type_id);
    boolean non_existent();
    boolean is_equivalent(in Object other_object);
    unsigned long hash(in unsigned long maximum);
    void create_request(
        in Context ctx,
        in Identifier operation,
        in NVList arg_list,
        in NamedValue result,
        out Request request,
        in Flags req_flags);

    void create_request2(
        in Context ctx,
        in Identifier operation,
        in NVList arg_list,
        in NamedValue result,
        in ExceptionList exclist,
        in ContextList ctxtlist,
        out Request request,
        in Flags req_flags);

    Policy get_policy(in PolicyType policy_type);
    DomainManagerList get_domain_managers();
    Object set_policy_overrides(in PolicyList policies,
        in SetOverrideType set_or_add);
    Policy get_client_policy(in PolicyType type);
    PolicyList get_policy_overrides(in PolicyTypeSeq types);
    boolean validate_connection(out PolicyList inconsistent_policies );
}```
string repository_id();
Object get_component();
ORB get_ORB();

};

5.36.2 Object C++ Class

In addition to other rules, all operation names in interface Object have leading underscores in the mapped C++ class. Also, the mapping for create_request is split into three forms, corresponding to the usage styles described in “Request” on page 104 of this specification. The is_nil and release functions are provided in the CORBA namespace, as described in “Object Reference Operations” on page 9.

// C++
class Object
{
    public:
        static Object_ptr _duplicate(Object_ptr obj);
        static Object_ptr _nil();
        ImplementationDef_ptr _get_implementation();
        InterfaceDef_ptr _get_interface();
        Boolean _is_a(const char* logical_type_id);
        Boolean _non_existent();
        Boolean _is_equivalent(Object_ptr other_object);
        ULong _hash(ULong maximum);
        void _create_request(
            Context_ptr ctx,
            const char* operation,
            NVList_ptr arg_list,
            NamedValue_ptr result,
            Request_out request,
            Flags req_flags
        );
        void _create_request(
            Context_ptr ctx,
            const char* operation,
            NVList_ptr arg_list,
            NamedValue_ptr result,
            ExceptionList_ptr,
            ContextList_ptr,
            Request_out request,
            Flags req_flags
        );
        Request_ptr _request(const char* operation);
        Policy_ptr _get_policy(PolicyType policy_type);
        DomainManagerList* _get_domain_managers();
        Object_ptr _set_policyOverrides(const PolicyList&,
                                      SetOverrideType);
        Policy_ptr _get_client_policy(PolicyType type);
PolicyList* _get_policy_overrides(const PolicyTypeSeq& types);
Boolean _validate_connection(PolicyList_out inconsistent_policies);
char* _repository_id();
Object_ptr _get_component();
ORB_ptr _get_ORB();
};

5.37 Local Object

The C++ mapping of LocalObject is a class derived from CORBA::Object that is used as a base class for locality constrained object implementations. A locality constrained object is implemented by a class derived both from the class mapping the interface and from CORBA::LocalObject.

namespace CORBA
{
    class LocalObject : public virtual Object
    {
        public:
            virtual void _add_ref();
            virtual void _remove_ref();
            virtual ULong _refcount_value() const;

            // ...other pseudo ops not shown...

        protected:
            LocalObject();
            ~LocalObject();
    }
};

Member functions and any data members needed to implement the Object pseudo-operations and any other ORB support functions shall also be supplied but are not shown.

The IDL compiler will generate appropriate conversion operations to allow a pointer to a local object implementation to automatically be converted to the corresponding _ptr or _var type.

Local object instances implement reference counting to prevent themselves from being destroyed while the application is still using them. The constructor and copy constructor initialize the reference count member to one. The assignment operator returns *this and does not affect the reference count.

_refcount_value returns the current value of the reference count member.

_add_ref increments the reference count member by one.

_remove_ref decrements the reference count member by one; if the resulting reference count equals ezero, _remove_ref invokes delete on its this pointer in order to destroy the local object.

For ORBs that operate in multi-threaded environments, the implementations of _refcount_value, _add_ref, and _remove_ref shall be thread-safe.
Local objects can be allocated on the stack even though they are reference-counted: because the constructor sets the initial reference count to one, and the program makes an equal number of calls to _add_ref and _remove_ref, when the local object is popped off the stack, the destructor simply destroys a local object with a reference count of one (that is, the reference count never drops to zero).

Note that reference counting can be disabled completely by providing no-op implementations of _add_ref and _remove_ref in the derived local object implementation.

Here is an example of how to implement a local interface.

```c++
// IDL
local interface LocalIF {
  void an_op(in long an_arg);
};

// C++
class MyLocalIF : public LocalIF, public CORBA::LocalObject {
public:
  MyLocalIF(...);
  ~MyLocalIF();
  void an_op(CORBA::Long an_arg);
};
```

### 5.38 Server-Side Mapping

Server-side mapping refers to the portability constraints for an object implementation written in C++. The term server is not meant to restrict implementations to situations in which method invocations cross address space or machine boundaries. This mapping addresses any implementation of an OMG IDL interface.

### 5.39 Implementing Interfaces

To define an implementation in C++, one defines a C++ class with any valid C++ name. For each operation in the interface, the class defines a non-static member function with the mapped name of the operation (the mapped name is the same as the OMG IDL identifier except when the identifier is a C++ keyword, in which case the string “_cxx_” is prepended to the identifier). Note that the ORB implementation may allow one implementation class to derive from another, so the statement “the class defines a member function” does not mean the class must explicitly define the member function—it could inherit the function.

The mapping specifies two alternative relationships between the application-supplied implementation class and the generated class or classes for the interface. Specifically, the mapping requires support for both inheritance-based relationships and delegation-based relationships. CORBA-compliant ORB implementations are required to provide both of these alternatives. Conforming applications may use either or both of these alternatives.

#### 5.39.1 Mapping of PortableServer::Servant

The PortableServer module for the Portable Object Adapter (POA) defines the native Servant type. The C++ mapping for Servant is as follows:
namespace PortableServer
{
    class ServantBase
    {
    public:
        virtual ~ServantBase();

        virtual POA_ptr _default_POA();

        virtual InterfaceDef_ptr _get_interface();

        virtual Boolean _is_a(const char* logical_type_id);

        virtual Boolean _non_existent();

        virtual void _add_ref();
        virtual void _remove_ref();
        virtual ULong _refcount_value();

    protected:
        ServantBase() : _ref_count(1) {}
        ServantBase(const ServantBase &): _ref_count(1) {}
        ServantBase& operator=(const ServantBase&);
        // ...all other constructors...

    private:
        ULong _ref_count;
    };

typedef ServantBase* Servant;
}

The ServantBase destructor is public and virtual to ensure that skeleton classes derived from it can be properly destroyed. The default constructor, along with other implementation-specific constructors, must be protected so that instances of ServantBase cannot be created except as sub-objects of instances of derived classes. A default constructor (a constructor that either takes no arguments or takes only arguments with default values) must be provided so that derived servants can be constructed portably. Both copy construction and a protected default assignment operator must be supported so that application-specific servants can be copied if necessary. Note that copying a servant that is already registered with the object adapter, either by assignment or by construction, does not mean that the target of the assignment or copy is also registered with the object adapter. Similarly, assigning to a ServantBase or a class derived from it that is already registered with the object adapter does not in any way change its registration.

The default implementation of the _default_POA function provided by ServantBase returns an object reference to the root POA of the default ORB in this process—the same as the return value of an invocation of ORB::resolve_initial_references("RootPOA") on the default ORB. Classes derived from ServantBase can override this definition to return the POA of their choice, if desired.
ServantBase provides default implementations of the _get_interface, _is_a, and _non_existent object reference operations that can be overridden by derived servants if the default behavior is not adequate. The POA invokes these just like normal skeleton operations, thus allowing overriding definitions in derived servant classes to use _this and the PortableServer::Current interface within their function bodies.

For static skeletons, the default implementation of the _get_interface and _is_a functions provided by ServantBase use the interface associated with the skeleton class to determine their respective return values. For dynamic skeletons (see Section 5.42, “Mapping of DSI to C++,” on page 134), these functions use the _primary_interface function to determine their return values.

The default implementation of _non_existent simply returns false.

Servant instances implement reference counting to prevent themselves from being destroyed while the application is still using them. The constructor and copy constructor initialize the _ref_count member to one. The assignment operator returns *this and does not affect the reference count. _refcount_value returns the current value of the _ref_count member. _add_ref increments the _ref_count member by one. _remove_ref decrements the _ref_count member by one; if the resulting reference count equals zero, _remove_ref invokes delete on its this pointer in order to destroy the servant. For ORBs that operate in multi-threaded environments, the implementations of _refcount_value, _add_ref, and _remove_ref shall be thread-safe.

```cpp
// C++
void PortableServer::ServantBase::_add_ref()
{
    ++_ref_count;
}

void PortableServer::ServantBase::_remove_ref()
{
    if (--_ref_count == 0)
        delete this;
}

ULong PortableServer::ServantBase:: _refcount_value()
{
    return _ref_count;
}
```

Servants can be allocated on the stack even though they are reference-counted: because the constructor sets the initial reference count to one, and the ORB makes an equal number of calls to _add_ref and _remove_ref, when the servant is popped off the stack, the destructor simply destroys a servant with a reference count of one (that is, the reference count never drops to zero).

Note that reference counting can be disabled completely by providing no-op implementations of _add_ref and _remove_ref in the derived servant implementation.

### 5.39.2 Servant Reference Counting Mix-In

The PortableServer namespace provides a RefCountServantBase class. This class exists for backward compatibility reasons; its use is deprecated and the class will be removed in a future revision of the C++ mapping. The RefCountServantBase class is defined as follows:
// C++
namespace PortableServer
{
    struct RefCountServantBase {};
}

5.40 Servant Memory Management Considerations

Portable memory management of servants requires an exact specification of when and how a servant may be deleted:

- The POA ensures that a servant will not be deleted while invocations are currently outstanding on that servant by maintaining a reference to the servant until the invocations have completed. For example, the POA may increment the reference count of the servant before invoking the implementation (but after `preinvoke`) and decrement the reference count after the invocation (but before `postinvoke`).

- Beware that explicit deletion of a servant will cause memory access violations if that servant is still in use by some other part of the application. For example, if the same servant instance was obtained from `POA::reference_to_servant` or `POA::id_to_servant` (perhaps in another thread), the caller that obtained the servant instance may still be using it. Also, explicit deletion may cause problems if the same servant instance is registered in multiple POAs.

For each POA, `ServantActivator`, or `ServantLocator` operation that either passes a `Servant` as a parameter or returns a `Servant`, the following rules described caller and callee memory management responsibilities:

- `ServantActivator::incarnate`—returns a `Servant`. The POA may use this `Servant` until it is passed to `etherealize`.

- `ServantActivator::etherealize`—has an `in Servant` argument. The POA assumes that `etherealize` consumes the `Servant` argument, and does not access a `Servant` in any way after it has been passed to `etherealize`. A conforming implementation of `etherealize` may invoke `_remove_ref` on the `Servant`.

- `ServantLocator::preinvoke`—returns a `Servant`. The POA may use this `Servant` until it is passed to `postinvoke`.

- `ServantLocator::postinvoke`—has an `in Servant` argument. The POA assumes that `postinvoke` consumes the `Servant` argument, and does not access a `Servant` in any way after it has been passed to `postinvoke`. A conforming implementation invoke `_remove_ref` on the `Servant`.

- `POA::get_servant`—returns a `Servant`. The POA invokes `_add_ref` once on the `Servant` before returning it; the caller of `get_servant` is responsible for invoking `_remove_ref` once on the returned `Servant` when it is finished with it.

- `POA::set_servant`—has an `in Servant` argument. The implementation of `set_servant` will invoke `_add_ref` at least once on the `Servant` argument before returning. When the POA no longer needs the `Servant`, it will invoke `_remove_ref` on it the same number of times.

- `POA::activate_object`—has an `in Servant` argument. The implementation of `activate_object` will invoke `_add_ref` at least once on the `Servant` argument before returning. When the POA no longer needs the `Servant`, it will invoke `_remove_ref` on it the same number of times.

- `POA::activate_object_with_id`—has an `in Servant` argument. The implementation of `activate_object_with_id` will invoke `_add_ref` at least once on the `Servant` argument before returning. When the POA no longer needs the `Servant`, it will invoke `_remove_ref` on it the same number of times.
• **POA::servant_to_id**—has an **in** _Servant_ argument. If this operation causes the object to be activated, _add_ref_ is invoked at least once on the _Servant_ argument before returning. Otherwise, the POA does not increment or decrement the reference count of the _Servant_ passed to this function.

• **POA::servant_to_reference**—has an **in** _Servant_ argument. If this operation causes the object to be activated, _add_ref_ is invoked at least once on the _Servant_ argument before returning. Otherwise, the POA does not increment or decrement the reference count of the _Servant_ passed to this function.

• **POA::reference_to_servant**—returns a _Servant_. The POA invokes _add_ref_ once on the _Servant_ before returning it; the caller of _reference_to_servant_ is responsible for invoking _remove_ref_ once on the returned _Servant_ when it is finished with it.

• **POA::id_to_servant**—returns a _Servant_. The POA invokes _add_ref_ once on the _Servant_ before returning it; the caller of _id_to_servant_ is responsible for invoking _remove_ref_ once on the returned _Servant_ when it is finished with it.

The following operations do not receive or return _Servants_ in their signatures, but have behavior that may require invocations of _add_ref_ or _remove_ref_:

• **_this**—invoked on a _Servant_ to obtain an object reference for an object implemented by that _Servant_. If this operation causes the object to be activated, _add_ref_ is invoked at least once on the _Servant_ argument before returning. Otherwise, the POA does not increment or decrement the reference count of the _Servant_ passed to this function.

• **POA::deactivate_object**—upon activation, _add_ref_ is invoked on the _Servant_. Therefore, the act of deactivation must cause _remove_ref_ to be invoked. If the POA has no _ServantActivator_ associated with it, the POA implementation calls _remove_ref_ when all operation invocations have completed. If there is a _ServantActivator_, the Servant is consumed by the call to _ServantActivator::etherealize_ instead.

• **POA::destroy**—upon activation of a servant or registration of a default servant, _add_ref_ is invoked on the _Servant_. Therefore, the destruction of a POA must cause _remove_ref_ to be invoked. The POA implementation invokes _remove_ref_ on any default servant. If the POA has no _ServantActivator_ associated with it, the POA implementation calls _remove_ref_ on each _Servant_ in the Active Object Map when all operation invocations have completed. If there is a _ServantActivator_, each _Servant_ is consumed by the call to _ServantActivator::etherealize_ instead.

• **POAManager::deactivate**—upon activation of a servant or registration of a default servant, _add_ref_ is invoked on the _Servant_. Therefore, the destruction of a POA must cause _remove_ref_ to be invoked. If _etherealize_objects_ is true, the POA implementation invokes _remove_ref_ on any default servant. If _etherealize_objects_ is true and a managed POA does not have a _ServantActivator_ associated with it, the POA implementation invokes _remove_ref_ on each Servant in that POA's Active Object Map after all dispatched operations have completed. If there is a _ServantActivator_, each _Servant_ is consumed by the call to _ServantActivator::etherealize_ instead.

Note that in those cases where the caller becomes responsible for invoking _remove_ref_ on a _Servant_ returned to it, the caller can assign the return value to a _ServantBase_var_ instance for automatic reference count management.

### 5.40.1 ServantBase_var Class

For the convenience of automatically managing servant reference counts, the PortableServer namespace also provides the _ServantBase_var_ class. This class behaves similarly to _var_ classes for object references (see “Object Reference Types” on page 7). Class _ServantBase_var_ is a type definition of the _Servant_var_ template for type _ServantBase_.
namespace PortableServer
{
    class ServantBase { /* ... */};
    typedef Servant_var<ServantBase> ServantBase_var;
}

The definition of the Servant_var template is as follows:

namespace PortableServer
{
    template<typename Servant>
    class Servant_var
    {
        protected:
            void swap(Servant* lhs, Servant* rhs)
            {
                Servant *tmp = lhs;
                lhs = rhs;
                rhs = tmp;
            }

        public:
            Servant_var() : _ptr(0) {}
            Servant_var(Servant* p) : _ptr(p) {}
            Servant_var(const Servant_var& b)
                : _ptr(b._ptr)
            {
                if (_ptr != 0) _ptr->_add_ref();
            }
            ~Servant_var()
            {
                if (_ptr != 0) {
                    try {
                        _ptr->_remove_ref();
                    } catch (...) {
                        // swallow exceptions
                    }
                }
            }

            Servant_var& operator=(Servant* p)
            {
                if (_ptr != p) {
                    Servant_var<Servant> tmp = p;
                    swap(_ptr, p);
                }
                return *this;
            }
        }
    }
operator=(const Servant_var& b) {
    if (_ptr != b._ptr) {
        Servant_var<Servant> tmp = b;
        swap(_ptr, tmp._ptr);
    }
    return *this;
}

Servant* operator->() const { return _ptr; }
Servant* in() const { return _ptr; }
Servant& inout() { return _ptr; }
Servant*& out() {
    if (_ptr != 0) {
        Servant_var<Servant> tmp;
        swap(_ptr, tmp._ptr);
    }
    return _ptr;
}
Servant* _retn() {
    Servant* retval = _ptr;
    _ptr = 0;
    return retval;
}

private:
    Servant* _ptr;
};

The implementation shown above for the ServantBase_var is intended only as an example that conveys required semantics. Variations of this implementation are possible as long as they provide the same semantics as the implementation shown here.

The Servant_var template can be used to write exception-safe and type-safe code for heap-allocated servants. For example:

```cpp
Foo* some_function(/*...*/) {
    Servant_var<Foo_impl> foo_servant = new Foo_impl;
    foo_servant->do_something(); // might throw...
    some_poa->activate_object_with_id(...);
    return foo_servant->_this();
}
```

5.40.2 Skeleton Operations

All skeleton classes provide a _this() member function. This member function has three purposes:
1. Within the context of a request invocation on the target object represented by the servant, it allows the servant to obtain the object reference for the target CORBA object it is incarnating for that request. This is true even if the servant incarnates multiple CORBA objects. In this context, \_this() can be called regardless of the policies used to create the dispatching POA.

2. Outside the context of a request invocation on the target object represented by the servant, it allows a servant to be implicitly activated if its POA allows implicit activation. This requires the activating POA to have been created with the \_IMPLICIT\_ACTIVATION policy. If the POA was not created with the \_IMPLICIT\_ACTIVATION policy, the PortableServer::WrongPolicy exception is thrown. The POA used for implicit activation is gotten by invoking \_default\_POA() on the servant.

3. Outside the context of a request invocation on the target object represented by the servant, it will return the object reference for a servant that has already been activated, as long as the servant is not incarnating multiple CORBA objects. This requires the POA with which the servant was activated to have been created with the UNIQUE\_ID and RETAIN policies. If the POA was created with the \_MULTIPLE\_ID or \_NON\_RETAIN policies, the PortableServer::WrongPolicy exception is thrown. The POA is gotten by invoking \_default\_POA() on the servant.

For example, for interface A defined as follows:

\[
// IDL
interface A {
  short op1();
  void op2(in long val);
};
\]

The return value of \_this() is a typed object reference for the interface type corresponding to the skeleton class. For example, the \_this() function for the skeleton for interface A would be defined as follows:

\[
// C++
class POA_A : public virtual ServantBase {
  public:
    A\_ptr \_this();
  ...}
\]

The \_this() function follows the normal C++ mapping rules for returned object references, so the caller assumes ownership of the returned object reference and must eventually call CORBA\::\_release() on it.

The \_this() function can be virtual if the C++ environment supports covariant return types, otherwise the function must be non-virtual so the return type can be correctly specified without compiler errors. Applications use \_this() the same way regardless of which of these implementation approaches is taken.

Assuming A\_impl is a class derived from POA_A that implements the A interface, and assuming that the servant’s POA was created with the appropriate policies, a servant of type A\_impl can be created and implicitly activated as follows:
// C++
A_impl my_a;
A_var a = my_a._this();

5.40.3 Inheritance-Based Interface Implementation

Implementation classes can be derived from a generated base class based on the OMG IDL interface definition. The generated base classes are known as skeleton classes, and the derived classes are known as implementation classes. Each operation of the interface has a corresponding virtual member function declared in the skeleton class. The signature of the member function is identical to that of the generated client stub class. The implementation class provides implementations for these member functions. The object adapter typically invokes the methods via calls to the virtual functions of the skeleton class.

Assume that IDL interface A is defined as follows:

// IDL
interface A
{
    short op1();
    void op2(in long val);
};

For IDL interface A as shown above, the IDL compiler generates an interface class A. This class contains the C++ definitions for the typedefs, constants, exceptions, attributes, and operations in the OMG IDL interface. It has a form similar to the following:

// C++
class A : public virtual Object
{
    public:
        virtual Short op1() = 0;
        virtual void op2(Long val) = 0;
        ...
};

Some ORB implementations might not use public virtual inheritance from CORBA::Object, and might not make the operations pure virtual, but the signatures of the operations will be the same.

On the server side, a skeleton class is generated. This class is partially opaque to the programmer, though it will contain a member function corresponding to each operation in the interface. For the POA, the name of the skeleton class is formed by prepending the string “POA_” to the fully-scoped name of the corresponding interface, and the class is either directly or indirectly derived from the servant base class PortableServer::ServantBase. The PortableServer::ServantBase class must be a virtual base class of the skeleton to allow portable implementations to multiply inherit from both skeleton classes and implementation classes for other base interfaces without error or ambiguity.

The skeleton class for interface A shown above would appear as follows:
// C++
class POA_A : public virtual PortableServer::ServantBase
{
    public:
        // ...server-side implementation-specific detail
        // goes here...
        virtual Short op1();
        virtual void op2(Long val);
        ...
};

If interface A were defined within a module rather than at global scope, e.g., Mod::A, the name of its skeleton class would be POA_Mod::A. This helps to separate server-side skeleton declarations and definitions from C++ code generated for the client.

To implement this interface using inheritance, a programmer must derive from this skeleton class and implement each of the operations in the OMG IDL interface. An implementation class declaration for interface A would take the form:

// C++
class A_impl : public POA_A
{
    public:
        Short op1();
        void op2(Long val);
        ...
};

Note that the presence of the _this() function implies that C++ servants must only be derived directly from a single skeleton class. Direct derivation from multiple skeleton classes could result in ambiguity errors due to multiple definitions of _this(). This should not be a limitation, since CORBA objects have only a single most-derived interface. Servants that are intended to support multiple interface types can utilize the delegation-based interface implementation approach, described below in “Delegation-Based Interface Implementation,” or can be registered as DSI-based servants, as described in “Mapping of DSI to C++” on page 134.

For interfaces that inherit from one or more base interfaces, the generated POA skeleton class uses virtual inheritance:

// IDL
interface A { ... };
interface B : A { ... };
interface C : A { ... };
interface D : B, C { ... };

// C++
class POA_A : public virtual PortableServer::ServantBase
{ ... }
class POA_B : public virtual POA_A { ... };
class POA_C : public virtual POA_A { ... };
class POA_D : public virtual POA_B, public virtual POA_C
{ ... };

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This guarantees that the POA skeleton class inherits only one version of each operation, and also allows optional inheritance of implementations. In this example, the implementation of interface B reuses the implementation of interface A:

```cpp
// C++
class A_impl: public virtual POA_A { ... }
class B_impl: public virtual POA_B, public virtual A_impl
{};
```

For interfaces that inherit from an abstract interface, the POA skeleton class is also virtually derived directly from the abstract interface class, but with protected access:

```idl
abstract interface A { ... }
interface B : A { ... };
```

```cpp
// C++
class A { ... };
class POA_B : public virtual PortableServer::ServantBase,
protected virtual A { ... };
```

The abstract interface is inherited with protected access to prevent accidental conversion of the POA skeleton pointer to an abstract interface reference, for ORBs that implement object references as pointers. This also allows implementation classes and valuetypes to share an implementation of the abstract interface:

```idl
valuetype V : supports A { ... };
```

```cpp
// C++
class MyA : virtual A { ... };
class MyB : public virtual POA_B, protected virtual MyA
{ ... };
class MyV : public virtual V, public virtual MyA { ... };
```

### 5.40.4 Delegation-Based Interface Implementation

Inheritance is not always the best solution for implementing servants. Using inheritance from the OMG IDL-generated classes forces a C++ inheritance hierarchy into the application. Sometimes, the overhead of such inheritance is too high, or it may be impossible to compile correctly due to defects in the C++ compiler. For example, implementing objects using existing legacy code might be impossible if inheritance from some global class were required, due to the invasive nature of the inheritance.

In some cases delegation can be used to solve this problem. Rather than inheriting from a skeleton class, the implementation can be coded as required for the application, and a wrapper object will delegate upcalls to that implementation. This sub clause describes how this can be achieved in a type-safe manner using C++ templates.

For the examples in this sub clause, the OMG IDL interface from “Inheritance-Based Interface Implementation” on page 126 will again be used.
// IDL
interface A
{
    short op1(); void op2(in long val);
};

In addition to generating a skeleton class, the IDL compiler generates a delegating class called a tie. This class is partially opaque to the application programmer, though like the skeleton, it provides a method corresponding to each OMG IDL operation. The name of the generated tie class is the same as the generated skeleton class with the addition that the string "_tie" is appended to the end of the name.

For example

// C++
template<class T>
class POA_A_tie : public POA_A
{
    public:
        ...
};

An instance of this template class performs the task of delegation. When the template is instantiated with a class type that provides the operations of A, then the POA_A_tie class will delegate all operations to an instance of that implementation class. A reference or pointer to the actual implementation object is passed to the appropriate tie constructor when an instance of the tie class is created. When a request is invoked on it, the tie servant will just delegate the request by calling the corresponding method in the implementation object.

// C++
template<class T>
class POA_A_tie : public POA_A
{
    public:
        POA_A_tie(T& t)
            : _ptr(&t), _poa(POA::_nil()), _rel(0) {}
        POA_A_tie(T& t, POA_ptr poa)
            : _ptr(&t),
              _poa(POA::_duplicate(poa)), _rel(0) {}
        POA_A_tie(T* tp, Boolean release = 1)
            : _ptr(tp), _poa(POA::_nil()), _rel(release) {}
        POA_A_tie(T* tp, POA_ptr poa,
              Boolean release = 1)
            : _ptr(tp), _poa(POA::_duplicate(poa)),
              _rel(release) {}
    ~POA_A_tie()
    {
        CORBA::release(_poa);
        if (_rel) delete _ptr;
    }

    // tie-specific functions
    T* _tied_object() { return _ptr; }

C++ Language Mapping, v1.3
void _tied_object(T& obj)
{
    if (_rel) delete _ptr;
    _ptr = &obj;
    _rel = 0;
}

void _tied_object(T* obj, Boolean release = 1)
{
    if (_rel) delete _ptr;
    _ptr = obj;
    _rel = release;
}

Boolean _is_owner() { return _rel; }
void _is_owner(Boolean b) { _rel = b; }

// IDL operations
Short op1()
{
    return _ptr->op1();
}
void op2(Long val)
{
    _ptr->op2(val);
}

// override ServantBase operations
POA_ptr _default_POA()
{
    if (!CORBA::is_nil(_poa)) {
        return PortableServer::POA::_duplicate(_poa);
    } else {
        // return root POA
    }
}

private:
    T* _ptr;
    POA_ptr _poa;
    Boolean _rel;

    // copy and assignment not allowed
    POA_A_tie(const POA_A_tie&);
    void operator=(const POA_A_tie&);
};

It is important to note that the tie example shown above contains sample implementations for all of the required functions. A conforming implementation is free to implement these operations as it sees fit, as long as they conform to the semantics in the paragraphs described below. A conforming implementation is also allowed to include additional implementation-specific functions if it wishes.
The T& constructors cause the tie servant to delegate all calls to the C++ object bound to reference t. Ownership for the object referred to by t does not become the responsibility of the tie servant.

The T* constructors cause the tie servant to delegate all calls to the C++ object pointed to by tp. The release parameter dictates whether the tie takes on ownership of the C++ object pointed to by tp; if release is TRUE, the tie adopts the C++ object, otherwise it does not. If the tie adopts the C++ object being delegated to, it will delete it when its own destructor is invoked, as shown above in the ~POA_A_tie() destructor.

The _tied_object() accessor function allows callers to access the C++ object being delegated to. If the tie was constructed to take ownership of the C++ object (release was TRUE in the T* constructor), the caller of _tied_object() should never delete the return value.

The _is_owner() accessor function returns TRUE if the tie owns the C++ object it is delegating to, or FALSE if it does not. The _is_owner() modifier function allows the state of the tie’s release flag to be changed. This is useful for ensuring that memory leaks do not occur when transferring ownership of tied objects from one tie to another, or when changing the tied object a tie delegates to.

For delegation-based implementations it is important to note that the servant is the tie object, not the C++ object being delegated to by the tie object. This means that the tie servant is used as the argument to those POA operations that require a Servant argument. This also means that any operations that the POA calls on the servant, such as ServantBase::default_POA(), are provided by the tie servant, as shown by the example above. The value returned by _default_POA() is supplied to the tie constructor.

It is also important to note that by default, a delegation-based implementation (the “tied” C++ instance) has no access to the _this() function, which is available only on the tie. One way for this access to be provided is by informing the delegation object of its associated tie object. This way, the tie holds a pointer to the delegation object, and vice-versa. However, this approach only works if the tie and the delegation object have a one-to-one relationship. For a delegation object tied into multiple tie objects, the object reference by which it was invoked can be obtained within the context of a request invocation by calling PortableServer::Current::get_object_id(), passing its return value to PortableServer::POA::id_to_reference(), and then narrowing the returned object reference appropriately.

In the tie class shown above, all the operations are shown as being inline. In practice, it is likely that they will be defined out of line, especially for those functions that override inherited virtual functions. Either approach is allowed by conforming implementations.

The use of templates for tie classes allows the application developer to provide specializations for some or all of the template’s member functions for a given instantiation of the template. This allows the application to control how the tied object is invoked. For example, the POA_A_tie<T>::op2() operation is normally defined as follows:

```c++
// C++
template<class T>
void
POA_A_tie<T>::op2(Long val)
{
    _ptr->op2(val);
}
```
This implementation assumes that the tied object supports an op2() operation with the same signature. However, if the application wants to use legacy classes for tied object types, it is unlikely they will support these capabilities. In that case, the application can provide its own specialization. For example, if the application already has a class named Foo that supports a log_value() function, the tie class op2() function can be made to call it if the following specialization is provided:

```cpp
// C++
void POA_A_tie<Foo>::op2(Long val)
{
   _tied_object()->log_value(val);
}
```

Portable specializations like the one shown above should not access tie class data members directly, since the names of those data members are not standardized.

For C++ implementations that do not support namespaces or the definition of template classes inside other classes, tie template classes must be defined at global scope. For these environments, the names of tie template classes shall be formed by “flattening” the normal tie name, i.e., replacing all occurrences of “::” with “_”. For example, in such an environment the name of the tie template class for interface A::B::C would be POA_A_B_C_tie.

5.41 Implementing Operations

The signature of an implementation member function is the mapped signature of the OMG IDL operation.

For example

```idl
interface A
{
   exception B {};
   void f() raises(B);
};
```

```cpp
class MyA : public virtual POA_A
{
   public:
      void f();
      ...
};
```

Within a member function, the “this” pointer refers to the implementation object’s data as defined by the class. In addition to accessing the data, a member function may implicitly call another member function defined by the same class.

For example
```cpp
// IDL
interface A
{
    void f();
    void g();
};

// C++
class MyA : public virtual POA_A
{
    public:
        void f();
        void g();
    private:
        long x_;
};

void MyA::f()
{
    this->x_ = 3;
    this->g();
}

However, when a servant member function is invoked in this manner, it is being called simply as a C++ member function, not as the implementation of an operation on a CORBA object. In such a context, any information available via the POA_Current object refers to the CORBA request invocation that performed the C++ member function invocation, not to the member function invocation itself.

5.41.1 Skeleton Derivation From Object

In several existing ORB implementations, each skeleton class derives from the corresponding interface class. For example, for interface Mod::A, the skeleton class POA_Mod::A is derived from class Mod::A. These systems therefore allow an object reference for a servant to be implicitly obtained via normal C++ derived-to-base conversion rules:

```cpp
// C++
MyImplOfA my_a; // declare impl of A
A_ptr a = &my_a; // obtain its object reference
// by C++ derived-to-base
// conversion
```

Such code can be supported by a conforming ORB implementation, but it is not required, and is thus not portable. The equivalent portable code invokes _this() on the implementation object in order to implicitly register it if it has not yet been registered, and to get its object reference.
5.42 Mapping of DSI to C++

The Common Object Request Broker Architecture (CORBA) specification, Dynamic Skeleton Interface clause, DSI: Language Mapping sub clause contains general information about mapping the Dynamic Skeleton Interface to programming languages.

This sub clause contains the following information:

- Mapping of the Dynamic Skeleton Interface’s ServerRequest to C++
- Mapping of the Portable Object Adapter’s Dynamic Implementation Routine to C++

5.42.1 Mapping of ServerRequest to C++

The ServerRequest pseudo object maps to a C++ class in the CORBA namespace that supports the following operations and signatures:

```cpp
// C++
class ServerRequest
{
    public:
        const char* operation() const;
        void arguments(NVList_ptr& parameters);
        Context_ptr ctx();
        void set_result(const Any& value);
        void set_exception(const Any& value);
};
```

Note that, as with the rest of the C++ mapping, ORB implementations are free to make such operations virtual and modify the inheritance as needed.

All of these operations follow the normal memory management rules for data passed into skeletons by the ORB. That is, the DIR is not allowed to modify or change the string returned by operation(), in parameters in the NVList returned from arguments(), or the Context returned by ctx(). Similarly, data allocated by the DIR and handed to the ORB (the NVList parameters) are freed by the ORB rather than by the DIR.

5.42.2 Handling Operation Parameters and Results

The ServerRequest provides parameter values when the DIR invokes the arguments() operation. The NVList provided by the DIR to the ORB includes the TypeCodes and direction Flags (inside NamedValues) for all parameters, including out ones for the operation. This allows the ORB to verify that the correct parameter types have been provided before filling their values in, but does not require it to do so. It also relieves the ORB of all responsibility to consult an Interface Repository, promoting high-performance implementations.
The NVList provided to the ORB then becomes owned by the ORB. It becomes deallocated after the DIR returns. This allows the DIR to pass the out values, including the return side of inout values, to the ORB by modifying the NVList after arguments() has been called. Therefore, if the DIR stores the NVList_ptr into an NVList_var, it should pass it to the arguments() function by invoking the _retn() function on it, in order to force it to release ownership of its internal NVList_ptr to the ORB.

5.42.3 Mapping of PortableServer Dynamic Implementation Routine

In C++, DSI servants inherit from the standard DynamicImplementation class. This class inherits from the ServantBase class and is also defined in the PortableServer namespace. The Dynamic Skeleton Interface (DSI) is implemented through servants that are members of classes that inherit from dynamic skeleton classes.

```cpp
// C++
namespace PortableServer
{
    class DynamicImplementation : public virtual ServantBase
    {
        public:
            Object_ptr _this();
            virtual void invoke(
                ServerRequest_ptr request
            ) = 0;
            virtual RepositoryId _primary_interface(
                const ObjectId& oid,
                POA_ptr poa
            ) = 0;
    }
}
```

The _this() function returns a CORBA::Object_ptr for the target object. Unlike _this() for static skeletons, its return type is not interface-specific because a DSI servant may very well incarnate multiple CORBA objects of different types. If DynamicImplementation::_this() is invoked outside of the context of a request invocation on a target object being served by the DSI servant, it raises the PortableServer::WrongPolicy exception.

The invoke() method receives requests issued to any CORBA object incarnated by the DSI servant and performs the processing necessary to execute the request. Requests for the standard object operations (_get_interface, _is_a, and _non_existent) do not call invoke(), but call the corresponding functions defined in ServantBase instead.

The _primary_interface() method receives an ObjectId value and a POA_ptr as input parameters and returns a valid RepositoryId representing the most-derived interface for that oid.

It is expected that the invoke() and _primary_interface() methods will be invoked only by the POA in the context of serving a CORBA request. Invoking this method in other circumstances may lead to unpredictable results.

5.43 PortableServer Functions

Objects registered with POAs use sequences of octet, specifically the PortableServer::POA::ObjectId type, as object identifiers. However, because C++ programmers will often want to use strings as object identifiers, the C++ mapping provides several conversion functions that convert strings to ObjectId and vice-versa:
These functions follow the normal C++ mapping rules for parameter passing and memory management.

If conversion of an ObjectId to a string would result in illegal characters in the string (such as a NUL), the first two functions throw the CORBA::BAD_PARAM exception.

## 5.44 Mapping for PortableServer::ServantManager

### 5.44.1 Mapping for Cookie

Since PortableServer::ServantLocator::Cookie is an IDL native type, its type must be specified by each language mapping. In C++, Cookie maps to void*.

```cpp
// C++
namespace PortableServer
{
    class ServantLocator {
        typedef void* Cookie;
    }
}
```

For the C++ mapping of the PortableServer::ServantLocator::preinvoke() operation, the Cookie parameter maps to a Cookie*, while for the postinvoke() operation, it is passed as a Cookie.

### 5.44.2 ServantManagers and AdapterActivators

Portable servants that implement the PortableServer::AdapterActivator, the PortableServer::ServantActivator, or PortableServer::ServantLocator interfaces are implemented just like any other servant. They may use either the inheritance-based approach or the tie approach.

### 5.44.3 Server Side Mapping for Abstract Interfaces

The only circumstances under which an IDL compiler should generate C++ code for abstract interfaces for the server side are when either an interface is derived from an abstract interface, or when a valuetype supports an abstract interface indirectly through one or more intermediate regular interface types. Abstract interfaces by themselves cannot be directly implemented or instantiated by portable applications. Because of this, standard C++ skeleton classes for abstract interfaces are not necessary.
5.45 C++ Definitions for CORBA

This sub clause provides a partial set of C++ definitions for the CORBA module. The definitions appear within the C++ namespace named CORBA.

// C++
namespace CORBA { ... }

Any implementations shown here are merely sample implementations: they are not the required definitions for these types. Furthermore, in some cases these types do not define the complete interfaces of their IDL counterparts; if any type is missing one or more operations, those operations are assumed to follow normal C++ mapping rules for their signatures, parameter passing rules, memory management rules, etc.

5.45.1 Primitive Types

typedef unsigned char Boolean;
typedef unsigned char Char;
typedef wchar_t WChar;
typedef unsigned char Octet;
typedef short Short;
typedef unsigned short UShort;
typedef long Long;
typedef LongLong;
typedef unsigned long ULong;
typedef ULongLong;
typedef float Float;
typedef double Double;
typedef long double LongDouble;
typedef Boolean& Boolean_out;
typedef Char& Char_out;
typedef WChar& WChar_out;
typedef Octet& Octet_out;
typedef Short& Short_out;
typedef UShort& UShort_out;
typedef Long& Long_out;
typedef LongLong& LongLong_out;
typedef ULong& ULong_out;
typedef ULongLong& ULongLong_out;
typedef Float& Float_out;
typedef Double& Double_out;
typedef LongDouble& LongDouble_out;

5.45.2 String_var and String_out Class

class String_var
{
  public:
    String_var();
    String_var(char *p);
String_var(const char *p);
String_var(const String_var &s);
~String_var();

String_var &operator=(char *p);
String_var &operator=(const char *p);
String_var &operator=(const String_var &s);

operator char*();
operator const char*() const;
const char * operator();
const char* in() const;
char*& inout();
char* out();
char* _retn();

char &operator[](ULong index);
char operator[](ULong index) const;

class String_out
{
public:
    String_out(char*& p);
    String_out(String_var& p);
    String_out(const String_out& s);
    String_out& operator=(const String_out& s);
    String_out& operator=(char* p);
    String_out& operator=(const char* p)

    operator char*();
    char*& ptr();

private:
    // assignment from String_var disallowed
    void operator=(const String_var&);
};

5.45.3 WString_var and WString_out

The WString_var and WString_out types are identical to String_var and String_out, respectively, except that they operate on wide string and wide character types.

5.45.4 Fixed Class

class Fixed
{
    public:
        // Constructors
        Fixed(int val = 0);
Fixed(unsigned val);
Fixed(Long val);
Fixed(ULong val);
Fixed(LongLong val);
Fixed(ULongLong val);
Fixed(Double val);
Fixed(LongDouble val);
Fixed(const Fixed& val);
Fixed(const char *);
~Fixed();

// Conversions
operator LongLong() const;
operator LongDouble() const;
Fixed round(UShort scale) const;
Fixed truncate(UShort scale) const;
char *to_string() const;

// Operators
Fixed& operator=(const Fixed& val);
Fixed& operator+=(const Fixed& val);
Fixed& operator-=(const Fixed& val);
Fixed& operator*=(const Fixed& val);
Fixed& operator/=(const Fixed& val);

Fixed& operator++();
Fixed operator++(int);
Fixed& operator--();
Fixed operator--(int);
Fixed operator+() const;
Fixed operator-() const;
Boolean operator!() const;

// Other member functions
UShort fixed_digits() const;
UShort fixed_scale() const;

};

istream& operator>>(istream& is, Fixed& val);
ostream& operator<<(ostream& os, const Fixed& val);

Fixed operator + (const Fixed& val1, const Fixed& val2);
Fixed operator - (const Fixed& val1, const Fixed& val2);
Fixed operator * (const Fixed& val1, const Fixed& val2);
Fixed operator / (const Fixed& val1, const Fixed& val2);

Boolean operator > (const Fixed& val1, const Fixed& val2);
Boolean operator < (const Fixed& val1, const Fixed& val2);
Boolean operator >= (const Fixed& val1, const Fixed& val2);
Boolean operator <= (const Fixed& val1, const Fixed& val2);
Boolean operator == (const Fixed& val1, const Fixed& val2);
Boolean operator != (const Fixed& val1, const Fixed& val2);

5.45.5 Any Class

class Any
{
    public:
    Any();
    Any(const Any&);
    ~Any();

    Any &operator=(const Any&);

    // special types needed for boolean, octet, char,
    // and bounded string insertion
    // these are suggested implementations only
    struct from_boolean {
        from_boolean(Boolean b) : val(b) {}
        Boolean val;
    };
    struct from_octet {
        from_octet(Octet o) : val(o) {}
        Octet val;
    };
    struct from_char {
        from_char(Char c) : val(c) {}
        Char val;
    };
    struct from_wchar {
        from_char(WChar c) : val(c) {}
        WChar val;
    };
    struct from_string {
        from_string(char* s, ULong b,
                    Boolean n = FALSE) :
            val(s), bound(b), nocopy(n) {}
        from_string(const char* s, ULong b) :
            val(const_cast<char*>(s)), bound(b),
            nocopy(0) {}
        char *val;
        ULong bound;
    };
}
Boolean nocopy;
}
struct from_wstring {
   from_wstring(WChar* s, ULong b,
         Boolean n = FALSE) :
      val(s), bound(b), nocopy(n) {}
   from_wstring(const WChar*, ULong b) :
      val(const_cast<WChar*>(s)), bound(b),
         nocopy(0) {}
      WChar *val;
   ULong bound;
   Boolean nocopy;
};
struct from_fixed {
   from_fixed(const Fixed& f, UShort d, UShort s)
      : val(f), digits(d), scale(s) {}
   const Fixed& val;
   UShort digits;
   UShort scale;
};

void operator<<(from_boolean);
void operator<<(from_char);
void operator<<(from_wchar);
void operator<<(from_octet);
void operator<<(from_string);
void operator<<(from_wstring);
void operator<<(from_fixed);

// special types needed for boolean, octet,
// char extraction
// these are suggested implementations only
struct to_boolean {
   to_boolean(Boolean &b) : ref(b) {}
   Boolean &ref;
};
struct to_char {
   to_char(Char &c) : ref(c) {}
   Char &ref;
};
struct to_wchar {
   to_wchar(WChar &c) : ref(c) {}
   WChar &ref;
};
struct to_octet {
    to_octet(Octet &o) : ref(o) {}
    Octet &ref;
};
struct to_object {
    to_object(Object_out obj) : ref(obj) {}
    Object_ptr &ref;
};
struct to_string {
    to_string(const char *&s, ULong b) : val(s), bound(b) {}
    const char *&val;
    ULong bound;

    // the following constructor is deprecated
    to_string(char *&s, ULong b) : val(s), bound(b) {}
};
struct to_wstring {
    to_wstring(const WChar *&s, ULong b) : val(s), bound(b) {}
    const WChar *&val;
    ULong bound;

    // the following constructor is deprecated
    to_wstring(WChar *&s, ULong b) : val(s), bound(b) {}
};
struct to_fixed {
    to_fixed(Fixed& f, UShort d, UShort s) : val(f), digits(d), scale(s) {}
    Fixed& val;
    UShort digits;
    UShort scale;
};
struct to_abstract_base {
    to_abstract_base(AbstractBase_ptr& base) : ref(base) {}
    AbstractBase_ptr& ref;
};
struct to_value {
    to_value(ValueBase*& base) : ref(base) {}
    ValueBase*& ref;
};

Boolean operator>>(to_boolean) const;
Boolean operator>>(to_char) const;
Boolean operator>>(to_wchar) const;
Boolean operator>>(to_octet) const;
Boolean operator>>(to_object) const;
Boolean operator>>(to_string) const;
Boolean operator>>(to_wstring) const;
Boolean operator>>(to_fixed) const;
Boolean operator>>(to_abstract_base) const;
Boolean operator>>(to_value) const;

TypeCode_ptr type() const;
void type(TypeCode_ptr);

private:
// these are hidden and should not be implemented
// so as to catch erroneous attempts to insert
// or extract multiple IDL types mapped to unsigned char
void operator<<(unsigned char);
Boolean operator>>(unsigned char&) const;

void operator<<(Any&, Short);
void operator<<(Any&, UShort);
void operator<<(Any&, Long);
void operator<<(Any&, ULong);
void operator<<(Any&, Float);
void operator<<(Any&, Double);
void operator<<(Any&, LongLong);
void operator<<(Any&, ULongLong);
void operator<<(Any&, LongDouble);
void operator<<(Any&, const Any&); // copying
void operator<<(Any&, Any*); // non-copying
void operator<<(Any&, const char*);
void operator<<(Any&, const WChar*);

Boolean operator>>(const Any&, Short&);
Boolean operator>>(const Any&, UShort&);
Boolean operator>>(const Any&, Long&);
Boolean operator>>(const Any&, ULong&);
Boolean operator>>(const Any&, Float&);
Boolean operator>>(const Any&, Double&);
Boolean operator>>(const Any&, LongLong&);
Boolean operator>>(const Any&, ULongLong&);
Boolean operator>>(const Any&, LongDouble&);
Boolean operator>>(const Any&, const Any*);
Boolean operator>>(const Any&, const char*);
Boolean operator>>(const Any&, const WChar*);
5.45.6 Any_var Class

class Any_var
{
    public:
        Any_var();
        Any_var(Any *a);
        Any_var(const Any_var &a);
        ~Any_var();
        Any_var &operator=(Any *a);
        Any_var &operator=(const Any_var &a);
        Any *operator->();
        const Any& in() const;
        Any& inout();
        Any** out();
        Any* _retn();

        // other conversion operators for parameter passing
};

5.45.7 Exception Class

// C++
class Exception
{
    public:
        Exception(const Exception &);  
        virtual ~Exception();
        Exception &operator=(const Exception &);

        virtual void _raise() const = 0;
        virtual const char * _name() const;
        virtual const char * _rep_id() const;

    protected:
        Exception();
};

5.45.8 SystemException Class

// C++
enum CompletionStatus { COMPLETED_YES, COMPLETED_NO, COMPLETED_MAYBE };
class SystemException : public Exception
{
public:
~SystemException();

ULong minor() const;
void minor(ULong);

CompletionStatus completed() const;
void completed(CompletionStatus);

virtual void _raise() const = 0;

static SystemException* _downcast(Exception*);
static const SystemException* _downcast(
    const Exception*);

protected:
SystemException();
SystemException(const SystemException &);
SystemException(ULong minor, CompletionStatus status);
SystemException &operator=(const SystemException &);

};

5.45.9 UserException Class

// C++
class UserException : public Exception
{
public:
~UserException();

virtual void _raise() const = 0;

static UserException* _downcast(Exception*);
static const UserException* _downcast(
    const Exception*);

protected:
UserException();
UserException(const UserException &);
UserException &operator=(const UserException &);
};
5.45.10 UnknownUserException Class

// C++
class UnknownUserException : public UserException
{
  public:
    Any &exception();

    static UnknownUserException* _downcast(Exception*);
    static const UnknownUserException* _downcast(  
      const Exception*);
  
  virtual void raise();
};

5.45.11 release and is_nil

// C++
namespace CORBA {
  void release(Object_ptr);
  void release(Environment_ptr);
  void release(NamedValue_ptr);
  void release(NVList_ptr);
  void release(Request_ptr);
  void release(Context_ptr);
  void release(TypeCode_ptr);
  
  void release(ORB_ptr);

  Boolean is_nil(Object_ptr);
  Boolean is_nil(Environment_ptr);
  Boolean is_nil(NamedValue_ptr);
  Boolean is_nil(NVList_ptr);
  Boolean is_nil(Request_ptr);
  Boolean is_nil(Context_ptr);
  Boolean is_nil(TypeCode_ptr);
  Boolean is_nil(ORB_ptr);
  ...
}

5.45.12 Object Class

// C++
class Object
{
    public:
        static Object_ptr _duplicate(Object_ptr obj);
        static Object_ptr _nil();
        InterfaceDef_ptr _get_interface();
        Boolean _is_a(const char* logical_type_id);
        Boolean _non_existent();
        Boolean _is_equivalent(Object_ptr other_object);
        ULong _hash(ULong maximum);
        void _create_request(
            Context_ptr ctx,
            const char *operation,
            NVList_ptr arg_list,
            NamedValue_ptr result,
            Request_out request,
            Flags req_flags
        );

        void _create_request(
            Context_ptr ctx,
            const char *operation,
            NVList_ptr arg_list,
            ExceptionList_ptr result,
            ContextList_ptr ptr,
            Request_out request,
            Flags req_flags
        );
        Request_ptr _request(const char* operation);
        Policy_ptr _get_policy(PolicyType policy_type);
        DomainManagerList* _get_domain_managers();
        Object_ptr _set_policy_overrides(
            const PolicyList& policies,
            SetOverrideType set_or_add
        );
};
5.45.13 Environment Class

// C++
class Environment
{
    public:
        void exception(Exception*);
        Exception *exception() const;
        void clear();

        static Environment_ptr _duplicate(Environment_ptr ev);
        static Environment_ptr _nil();
};

5.45.14 NamedValue Class

// C++
class NamedValue
{
    public:
        const char *name() const;
        Any *value() const;
        Flags flags() const;

        static NamedValue_ptr _duplicate(NamedValue_ptr nv);
        static NamedValue_ptr _nil();
};

5.45.15 NVList Class

// C++
class NVList
{
    public:
        ULong count() const;
        NamedValue_ptr add(Flags);
        NamedValue_ptr add_item(const char*, Flags);
        NamedValue_ptr add_value(const char*, const Any&, Flags);
        NamedValue_ptr add_item_consume(char*, Flags);
        NamedValue_ptr add_value_consume(char*, Any*, Flags);
    };
5.45.16 ExceptionList Class

// C++
class ExceptionList
{
public:
  ULong count();
  void add(TypeCode_ptr tc);
  void add_consume(TypeCode_ptr tc);
  TypeCode_ptr item(ULong index);
  void remove(ULong index);
};

5.45.17 ContextList Class

class ContextList
{
public:
  ULong count();
  void add(const char* ctxt);
  void add_consume(char* ctxt);
  const char* item(ULong index);
  void remove(ULong index);
};

5.45.18 Request Class

// C++
class Request
{
public:
  Object_ptr target() const;
  const char *operation() const;
  NVList_ptr arguments();
  NamedValue_ptr result();
  Environment_ptr env();
  ExceptionList_ptr exceptions();
  ContextList_ptr contexts();

  void ctx(Context_ptr);
  Context_ptr ctx() const;
};


5.45.19 Context Class

// C++
class Context
{
    public:
        const char *context_name() const;
        Context_ptr parent() const;

        void create_child(const char*, Context_out);
        void set_one_value(const char*, const Any&);
        void set_values(NVList_ptr);

        void delete_values(const char*);
        void get_values(const char*, Flags, const char*,
                        NVList_out);

        static Context_ptr _duplicate(Context_ptr ctx);
        static Context_ptr _nil();
};
5.45.20 TypeCode Class

// C++
class TypeCode
{
   public:
      class Bounds : public UserException { ... };
      class BadKind : public UserException { ... };

      TCKind kind() const;
      Boolean equal(TypeCode_ptr) const;
      Boolean equivalent(TypeCode_ptr) const;
      TypeCode_ptr get_compact_typecode() const;

      const char* id() const;
      const char* name() const;

      ULong member_count() const;
      const char* member_name(ULong index) const;

      TypeCode_ptr member_type(ULong index) const;
      Any *member_label(ULong index) const;
      TypeCode_ptr discriminator_type() const;
      Long default_index() const;

      ULong length() const;

      TypeCode_ptr content_type() const;

      UShort fixed_digits() const;
      Short fixed_scale() const;

      Visibility member_visibility(ULong index) const;
      ValuetypeModifier type_modifier() const;
      TypeCode_ptr concrete_base_type() const;

      static TypeCode_ptr _duplicate(TypeCode_ptr tc);
      static TypeCode_ptr _nil();
};
5.45.21 ORB Class

// C++
class ORB
{
   public:
   typedef sequence<Request_ptr> RequestSeq;
   char *object_to_string(Object_ptr);
   Object_ptr string_to_object(const char*);
   void create_list(Long, NVList_out);
   void create_operation_list(OperationDef_ptr,
                               NVList_out);
   void create_named_value(NamedValue_out);
   void create_exception_list(ExceptionList_out);
   void create_context_list(ContextList_out);
   void get_default_context(Context_out);
   void create_environment(Environment_out);
   void send_multiple_requests_oneway(const RequestSeq&);
   void send_multiple_requests_deferred(const RequestSeq&);
   Boolean poll_next_response();
   void get_next_response(Request_out);

   // Obtaining initial object references
   typedef char* ObjectId;
   class ObjectIdList {...};
   class InvalidName : public UserException {...};
   ObjectIdList *list_initial_services();
   Object_ptr resolve_initial_references(const char *identifier);

   Boolean work_pending();
   void perform_work();
   void shutdown(Boolean wait_for_completion);
   void destroy();
   void run();

   Boolean get_service_information(
      ServiceType svc_type,
      ServiceInformation_out svc_info);;

   typedef char* ObjectId;
   class ObjectIdList {...};
   Object_ptr resolve_initial_references(const char* id);
   ObjectIdList* list_initial_services();

   Policy_ptr create_policy(PolicyType type, const Any& val);

   static ORB_ptr _duplicate(ORB_ptr orb);
   static ORB_ptr _nil();
};
5.45.22 ORB Initialization

// C++
typedef char* ORBid;
static ORB_ptr ORB_init(
    int& argc,
    char** argv,
    const char* orb_identifier = ""
);

5.45.23 General T_out Types

// C++
class T_out
{
    public:
        T_out(T*& p) : ptr_(p) { ptr_ = 0; }
        T_out(T_var& p) : ptr_(p.ptr_) {
            delete ptr_;  // assignment from T_var not allowed
            ptr_ = 0;
        }
        T_out(T_out& p) : ptr_(p.ptr_) {}
        T_out& operator=(T_out& p) {
            ptr_ = p.ptr_;  // assignment from T_var not allowed
            return *this;
        }
        T_out& operator=(T* p) { ptr_ = p; return *this; }
        T_out operator-() { return ptr_; }
    
        operator T*() { return ptr_; }
        T* ptr() { return ptr_; }
        T* operator->() { return ptr_; }

    private:
        T*& ptr_;

    void operator=(const T_var&):
};
5.46 Alternative Mappings For C++ Dialects

5.46.1 Without Namespaces

If the target environment does not support the namespace construct but does support nested classes, then a module should be mapped to a C++ class. If the environment does not support nested classes, then the mapping for modules should be the same as for the CORBA C mapping (concatenating identifiers using an underscore (“_”) character as the separator). Note that module constants map to file-scope constants on systems that support namespaces and class-scope constants on systems that map modules to classes.

5.46.2 Without Exception Handling

For those C++ environments that do not support real C++ exception handling, referred to here as non-exception handling (non-EH) C++ environments, an Environment parameter passed to each operation is used to convey exception information to the caller.

As shown in “Environment” on page 100, the Environment class supports the ability to access and modify the Exception it holds.

As shown in “Mapping for Exception Types” on page 85, both user-defined and system exceptions form an inheritance hierarchy that normally allow types to be caught either by their actual type or by a more general base type. When used in a non-EH C++ environment, the narrowing functions provided by this hierarchy allow for examination and manipulation of exceptions.

```
// IDL
interface A
{
    exception Broken {...};
    void op() raises(Broken);
};

// C++
Environment ev;
A_ptr obj = ...
obj->op(ev);
if (Exception *exc = ev.exception()) {
    if (A::Broken *b = A::Broken::_narrow(exc)) {
        // deal with user exception
    } else {
        // must have been a system exception
        SystemException *se = SystemException::_narrow(exc);
        ...
    }
}
```

“ORB” on page 111 specifies that Environment must be created using ORB::create_environment, but this is overly constraining for implementations requiring an Environment to be passed as an argument to each method invocation. For implementations that do not support real C++ exceptions, Environment may be allocated as a static, automatic, or heap variable. For example, all of the following are legal declarations on a non-EH C++ environment:
// C++
Environment global_env;  // global
static Environment static_env;  // file static

class MyClass
{
    public:
        ...
    private:
        static Environment class_env;  // class static
};

void func()
{
    Environment auto_env;  // auto
    Environment *new_env = new Environment;  // heap
    ...
}

For ease of use, Environment parameters are passed by reference in non-EH environments.

// IDL
interface A
{
    exception Broken { ... };
    void op() raises(Broken);
};
// C++
class A ...
{
    public:
        void op(Environment &);
    ...
};

For additional ease of use in non-EH environments, Environment should support copy construction and assignment from other Environment objects. These additional features are helpful for propagating exceptions from one Environment to another under non-EH circumstances.

When an exception is “thrown” in a non-EH environment, object implementors and ORB runtimes must ensure that all out and return pointers are returned to the caller as null pointers. If non-initialized or “garbage” pointer values are returned, client application code could experience runtime errors due to the assignment of bad pointers to T_var types. When a T_var goes out of scope, it attempts to delete the T given to it; if this pointer value is garbage, a runtime error will almost certainly occur. Exceptions in non-EH environments need not support the virtual _raise() function, since the only useful implementation of it in such an environment would be to abort the program.
### 5.47 C++ Keywords

Table 5.7 lists all C++ keywords from the ISO/IEC 14822:2011 (September 1, 2011), Standard for Programming Language C++.

<table>
<thead>
<tr>
<th></th>
<th>and</th>
<th>and_eq</th>
<th>alignas</th>
<th>alignof</th>
<th>asm</th>
<th>auto</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>bitand</code></td>
<td><code>bitand</code></td>
<td><code>bool</code></td>
<td><code>break</code></td>
<td><code>case</code></td>
<td><code>catch</code></td>
<td></td>
</tr>
<tr>
<td><code>char</code></td>
<td><code>char</code></td>
<td><code>char16_t</code></td>
<td><code>char32_t</code></td>
<td><code>class</code></td>
<td><code>compl</code></td>
<td><code>const</code></td>
</tr>
<tr>
<td><code>constexpr</code></td>
<td><code>constexpr</code></td>
<td><code>continue</code></td>
<td><code>decltype</code></td>
<td><code>default</code></td>
<td><code>delete</code></td>
<td></td>
</tr>
<tr>
<td><code>do</code></td>
<td><code>double</code></td>
<td><code>dynamic_cast</code></td>
<td><code>else</code></td>
<td><code>enum</code></td>
<td><code>explicit</code></td>
<td></td>
</tr>
<tr>
<td><code>export</code></td>
<td><code>extern</code></td>
<td><code>false</code></td>
<td><code>float</code></td>
<td><code>for</code></td>
<td><code>friend</code></td>
<td></td>
</tr>
<tr>
<td><code>goto</code></td>
<td><code>if</code></td>
<td><code>inline</code></td>
<td><code>int</code></td>
<td><code>long</code></td>
<td><code>mutable</code></td>
<td></td>
</tr>
<tr>
<td><code>namespace</code></td>
<td><code>new</code></td>
<td><code>nothrow</code></td>
<td><code>not</code></td>
<td><code>not_eq</code></td>
<td><code>nullptr</code></td>
<td></td>
</tr>
<tr>
<td><code>operator</code></td>
<td><code>or</code></td>
<td><code>or_eq</code></td>
<td><code>private</code></td>
<td><code>protected</code></td>
<td><code>public</code></td>
<td></td>
</tr>
<tr>
<td><code>register</code></td>
<td><code>reinterpret_cast</code></td>
<td><code>return</code></td>
<td><code>short</code></td>
<td><code>signed</code></td>
<td><code>sizeof</code></td>
<td></td>
</tr>
<tr>
<td><code>static</code></td>
<td><code>static_assert</code></td>
<td><code>static_cast</code></td>
<td><code>struct</code></td>
<td><code>switch</code></td>
<td><code>template</code></td>
<td></td>
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<tr>
<td><code>this</code></td>
<td><code>thread_local</code></td>
<td><code>throw</code></td>
<td><code>true</code></td>
<td><code>true</code></td>
<td><code>typedef</code></td>
<td></td>
</tr>
<tr>
<td><code>typeid</code></td>
<td><code>typename</code></td>
<td><code>union</code></td>
<td><code>unsigned</code></td>
<td><code>using</code></td>
<td><code>virtual</code></td>
<td></td>
</tr>
<tr>
<td><code>void</code></td>
<td><code>volatile</code></td>
<td><code>wchar_t</code></td>
<td><code>while</code></td>
<td><code>xor</code></td>
<td><code>xor_eq</code></td>
<td></td>
</tr>
</tbody>
</table>