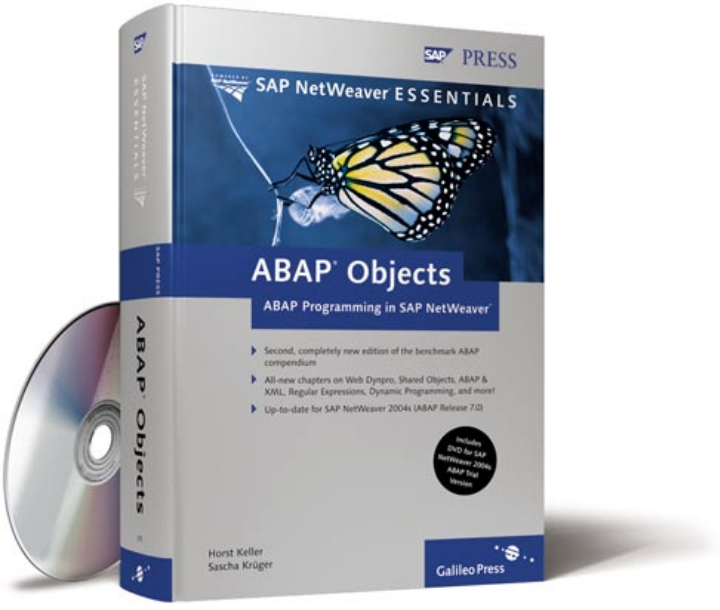
Horst Keller, Sascha Krüger

ABAP® Objects

ABAP Programming in SAP NetWeaver™



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Foreword

This book is the sequel to *ABAP Objects: An Introduction to Programming SAP Applications* from the SAP PRESS series. Instead of producing a reworked second edition of the Introduction, we have written a new book that is based, in part, on the manuscript for the previous book.

The earlier book was the first ABAP book in the SAP PRESS series and was intended to serve both as an introduction to ABAP Objects as well as a general overview of the ABAP language and SAP Basis. Since then, however, SAP PRESS has published dedicated introduction and practice books, as well as a comprehensive ABAP reference book, which is complemented by an ABAP quick reference guide to provide a quick overview. This has allowed us to take a new direction in the current book. This book is much less of a reference guide than its predecessor. Instead, it is intended to function as the programming handbook in the series of ABAP books that have previously appeared at SAP PRESS, grouped between introductory practical books and ABAP reference guides.

In this book, we are therefore offering our readers a compendium of modern ABAP programming and of the key possibilities of the ABAP Application Server in SAP NetWeaver. Modern ABAP programming means programming with ABAP Objects. Contrary to the previous book, ABAP Objects are no longer treated as an addition to classical ABAP, but rather as the underlying programming model. Consistent with all books on object-oriented programming languages, the presentation of the ABAP language in Chapter 4 begins this time with "Classes and Objects." From the start, we have integrated the description of the Class Builder into the description of classes and objects. All remaining language elements and tools have been presented in the same way that they are used in ABAP Objects to implement classes. The classical concepts of ABAP are mentioned where they are still used. We no longer discuss obsolete concepts; and if we do, we only touch on them very briefly.

Whereas in the previous book, we dealt mainly with elementary ABAP language topics, in this book we have also included—in addition to the many new developments that the ABAP language has seen in the meantime—additional topics that are essential for the programming of the ABAP Application Server in SAP NetWeaver. In fact, we devote an entire chapter to the error handling reaching from exception classes to assertions, offer an introduction to Web Dynpro for ABAP, provide a separate chapter on dynamic programming including Run Time Type Creation, and a chapter on the external communication and data interfaces from RFC over ICF to XML, and also provide an overview of all possible tools to use for testing quality assurance.

Because of the large number of new topics, the scope of this book has now passed the magical 1000-page milestone. Therefore, we will at least try to keep the foreword brief, albeit without neglecting to extend our thanks to all of the people who have helped, directly or indirectly, to produce this book.

First we must mention our colleagues in the department "SAP NetWeaver Foundation ABAP." While this organizational unit had a different name in all of the other books that have appeared to date, it is essentially still the "ABAP Language" group, which develops the ABAP language and the ABAP tools, and which now also encompasses the groups "ABAP Workbench" and "ABAP Connectivity." This group's work is the foundation of everything that is described in this book, and we do not exaggerate when we say that the output of this group is the basis of any ABAP developments internationally. In appreciation of all of this team's members, we would here again like to thank the Vice President Andreas Blumenthal, who has supported this book from the very beginning and provided the necessary resources to make it become a reality.

We would specifically like to thank the following colleagues who have made special contributions to producing this book: Kai Baumgarten (information and corrections on Shared Objects), Thomas Becker (information on qRFC), Joachim Bender and Michael Schmitt (proofreading of the section on Web Services), Dirk Feeken and Manfred Lutz (publication of the AS ABAP Trial Version on DVD), Eva Pflug (help in setting up the AS ABAP trial version as a translation system, to ensure that the examples also work when users log

on in English), Susanne Rothaug and Volker Wichers (support with testing the ABAP Web Services on another J2EE Server), Klaus-Dieter Scherer (help and information on ALV print lists), Stefan Seemann (hooked the MaxDB that failed when we tried to install a parallel J2EE Server backup to the AS ABAP trial version), Markus Tolksdorf (information and corrections on JCo), and Doris Vielsack (information and corrections on dynpros).

As a further new feature, this issue of the ABAP Objects book is also based on texts from authors who are responsible for *one* particular contribution: Stefan Bresch (object services), Rupert Hieble (XML), Anne Lanfermann (Web Services), Frank Müller (RFC and ICF), and Stefanie Rohland (Web Dynpro). We would like to thank these authors for their readiness to assist with this project, in addition to their normal responsibilities. The authors' bios are provided at the end of this book.

We would like to thank the publishers at Galileo Press for their collaboration, which was, as always, excellent. Alexandra Müller and Florian Zimniak did an outstanding job correcting and editing the manuscript, even going so far as to find formal errors in the code. For the production, we would like to thank Iris Warkus (Galileo Press) and Dirk Hemke (SatzPro), most especially for the fact that right from the first typesetting for this book, we found nothing of note to grumble about. For the English edition, the authors want to express their gratitude to Nancy Etscovitz from Wellesley Information Services, who did a terrific job in editing the translation, and to Snezhina Gileva from SAP Labs Sofia for proof reading the final manuscript.

Sascha Krüger would especially like to thank his wife Katja for so many things too numerous to mention, both big and small, such as keeping him free from any "distractions," loads of understanding, constant encouragement and motivation, lots of free space, more than a little coffee, and so much more. In this way, she ultimately played a large part in the production of his share of the manuscript.

Horst Keller would like to thank his wife Ute, as always, who again supported the creation of this book with her considerable patience and understanding. Despite the promises made after every previous book—that next time things would be easier—this book, in particular, again proved that such promises cannot always be kept, and con-

sequently much joint free time during the first half of 2006 had to be sacrificed. The fact that Ute never once questioned this project, but just looked forward with Horst to meeting the deadline, proved to be invaluable.

Walldorf, February 2007
Horst Keller
Sascha Krüger

A physician, a civil engineer, and a computer scientist were arguing about what was the oldest profession in the world. The physician remarked, "Well, in the Bible, it says that God created Eve from a rib taken out of Adam. This clearly required surgery, and so I can rightly claim that mine is the oldest profession in the world." The civil engineer interrupted and said, "But even earlier in the book of Genesis, it states that God created the order of the heavens and the earth from out of the chaos. This was the first and certainly the most spectacular application of civil engineering. Therefore, fair doctor, you are wrong; mine is the oldest profession in the world." The computer scientist leaned back in her chair, smiled, and then said confidently, "Ah, but who do you think created the chaos?"
—Grady Booch, Object-Oriented Analysis and Design with Applications

6 Advanced Concepts in ABAP Objects

The above quotation is from a book entitled *Object-Oriented Analysis and Design with Applications* by Grady Booch (Addison-Wesley 1995), where it is used to introduce a chapter discussing "the inherent complexity of software." One advantage of the object-oriented approach is its ability to handle complexity. In Chapter 4, you were introduced to classes and objects as a basis for object orientation, and to attributes and methods as underlying components of these classes and objects. We can sum up what you have already learned as follows:

Basic principles

- Objects constitute the key concept in object-oriented programming. An object is a self-contained unit whose status is determined by the values of its attributes, whose behavior is determined by its methods, and whose identity is defined by its address in the memory. An object is accessed by reference variables,

which refer to this address. An object in a program that performs a certain task should reflect a real object of the task 1:1 as far as possible. With objects, a clear distinction can be made between the public interface and the private and protected components, which are not externally visible. One object can interact with another by accessing its attributes directly in a method, calling methods, or triggering an event (see Section 6.5.2).

- Classes consist of source code containing the definition of possible objects. An object is always an instance of a class, which is addressed by at least one reference variable. All components and properties of its objects are declared in a class. The basis for encapsulation in ABAP Objects is always the class, rather than the object.[1] Classes are either global for all programs or local in a single program. They can be specialized by inheritance (see Section 6.2), and can incorporate standalone interfaces as a public interface (see Section 6.3).
- Attributes describe the status of an object. Technically speaking, attributes (instance attributes) are the local variables of an object, which cannot normally be changed directly from the outside. A class may also contain static attributes, which are jointly used by all objects of the class. Static attributes may be variables or constants.
- Methods allow objects to perform operations. A method (instance method) always works in a specific object. In other words, it reads and changes the status of this object, and interacts with other objects by calling their methods or by triggering events. A method has a parameter interface (see Section 6.1.1), and can pass on exceptions (see Section 8.2). A class may also contain static methods, which only access static attributes, and can only trigger static events.

You may have already realized how powerful these components of ABAP Objects can be when used to program application programs; however, there is more to ABAP Objects than just these basic elements. In this chapter, you'll become familiar with additional concepts that are essential for advanced object-oriented design.

1 The private components of an object of a class are visible to another object of the same class.

- **Method Interfaces and Method Calls**
  Chapter 4 introduced methods in their fundamental role as the operational components of classes. Section 6.1.1 examines the parameter interface of methods in more detail, and focuses in particular on the various options with method calls.
- **Specialization by Inheritance**
  ABAP Objects supports simple inheritance, whereby a class can be declared as the direct subclass of exactly one superclass. All classes of ABAP Objects are part of an inheritance hierarchy tree originating in one common superclass. In addition to its own components, a subclass also contains the components of its superclass. The implementation of superclass methods can be overwritten in subclasses. The concept of inheritance is discussed in Section 6.2.
- **Standalone Interfaces**
  The public visibility section of a class is its external interface. ABAP Objects allows you to create standalone interfaces, which can be used by classes as part of their interface, or even as their complete interface. Objects belonging to various classes that use the same interface can be handled by outside users in the same way. An standalone interface may also comprise several other interfaces. The interface concept is described in Section 6.3.
- **Object Reference Variables and Polymorphism**
  Objects in a program can only be accessed by object references in object reference variables. The type of the object reference variables determines exactly what a program can do with an object. There are both class reference variables and interface reference variables. The latter enable exclusive access to the interface components of a class. The concepts of inheritance and independent interfaces allow you to assign object references between reference variables of different types according to certain rules. This opens up the possibilities of polymorphism, whereby the same reference variable can be used to access objects belonging to different classes with different behavior. This is discussed in Section 6.4.
- **Events and Event Handling**
  A method of an object is normally executed after a direct call. In this case, the calling object and the called object are closely coupled. Events are used to decouple the caller from the called method. In ABAP Objects, events, like attributes and methods, are component type of classes. An object can trigger an event in a

method, and methods of other objects can handle this event. This corresponds to an indirect method call because the calling method does not need to know anything about the possible event handlers. The event concept is described in Section 6.5.

- **Shared Objects**
  Objects as instances of classes exist in the memory area of a program, and are deleted at the latest when the program is exited. As a result, cross-program access to objects is not generally possible. However, ABAP Objects enables cross-program access with shared objects, which are objects in the shared memory of an application server. The concept of shared objects is discussed in Section 6.6.

The basic concepts of ABAP Objects, which were introduced in Chapter 4 (i. e., classes with attributes and methods, objects, and object references), are used in almost all object-oriented programming languages. The advanced concepts introduced in this chapter comprise, on the one hand, a selection of tried and tested advanced techniques adopted by ABAP Objects based on the standards of well-known object-oriented programming languages like Java or C++, and, on the other hand, specialized techniques that are unique to ABAP Objects. When this language was designed, special care was taken to ensure that the focus on business applications was not lost.

ASAP principle

Certain concepts of object-oriented programming, such as multiple inheritance, which is used in C++, for example, would have served only to increase the complexity of the language, without offering any additional benefits for SAP applications. In accordance with the ASAP principle, of "As Simple As Possible," ABAP Objects was made as easy to understand as possible, and only well-established object-oriented concepts were used. Following the example of Java, the interface concept was introduced in place of multiple inheritance. The correct application of inheritance and interfaces represents the crowning achievement of object-oriented programming, and provides a range of options for managing complexity.[2]

The range of options for defining a parameter interface for methods is, in contrast, specific to ABAP. Similarly, the concept of fully inte-

2 However, we do not wish to conceal the fact that the incorrect use of concepts like inheritance may cause major problems. Meticulous object-oriented modeling is essential, particularly when advanced concepts of object orientation are used to manage complex applications.

grating events into the language scope of ABAP Objects as independent components of classes is not a feature of all object-oriented programming languages.

6.1 Method Interfaces and Method Calls

We have defined and called methods on many occasions in the previous chapters. The next two sections discuss the finer points of methods in ABAP Objects.

6.1.1 Parameter Interfaces of Methods

The parameter interface of a method is defined by the additions to the `METHODS` and `CLASS-METHODS` statements when the method is declared, or by the selection of **Parameters** in the Class Builder. No further details of the parameter interface are required in the implementation section between `METHOD` and `ENDMETHOD`. However, you can display the interface during implementation of global classes.

Formal parameters

The parameter interface of a method comprises formal parameters and exceptions. The declaration of exceptions is discussed in Section 8.2. Formal parameters are keyword parameters, to which an actual parameter can or must be assigned when the method is called. Within a method, formal parameters can be used via their names in operand positions. The possible usage kinds depend on the parameter properties. The following properties can be defined for a formal parameter:

- The parameter type
- Kind of parameter passing
- Parameter typing
- Supply type of the parameter

In principle, a parameter interface can contain any number of parameters; however, a small number is recommended. An ideal parameter interface contains only a small number of input parameters or none at all, and a return value.

No overloading

At this point, we should point out that methods in ABAP Objects cannot be overloaded. In other words, you cannot use the same method

names with different parameter interfaces, even when you redefine methods in subclasses.

Parameter Type

You can define the following parameters:

- **Input Parameters**
  Input parameters are specified after the `IMPORTING` addition to the `METHODS` or `CLASS-METHODS` statement, or are declared by selecting **Importing** in the **Type** column on the **Parameters** tab page in the Class Builder. When a method is called, the value of the assigned actual parameter is assigned to the input parameter. Input parameters for which pass by reference is defined cannot be overwritten in the method. Input parameters for which pass by value is defined are not passed to the actual parameter when the procedure is exited.
- **Output Parameters**
  Output parameters are specified after the `EXPORTING` addition to the `METHODS` or `CLASS-METHODS` statement, or are declared by selecting **Exporting** in the **Type** column on the **Parameters** tab page in the Class Builder. When a method is called, the value of the assigned actual parameter is not assigned to an output parameter for which pass by value is defined. Output parameters can be overwritten in the method. If the procedure is exited without errors using `ENDMETHOD` or `RETURN`, the output parameter is passed to the actual parameter.
- **Input/Output Parameters**
  Input/output parameters are specified after the `CHANGING` addition to the `METHODS` or `CLASS-METHODS` statement, or are declared by selecting **Changing** in the **Type** column on the **Parameters** tab page in the Class Builder. When a method is called, the value of the assigned actual parameter is assigned to the input/output parameter, and, if the method is exited without errors using `ENDMETHOD` or `RETURN`, the input/output parameter is passed to the actual parameter. Input/output parameters can be overwritten in the method.

Functional method

- **Return Value**
  A method can have only one return value, for which pass by value must be declared. This return value can be declared after the

RETURNING addition to the METHODS or CLASS-METHODS statement, or by selecting **Returning** in the **Type** column on the **Parameters tab page** in the Class Builder. A return value is handled in the same way that an output parameter is handled in the method; however, a method with a return value is a functional method, which, in addition to the return value, can have only input parameters. A functional method can be used in operand positions. The return value is then used in these positions.[3]

When you declare a parameter, you must always select the type that matches the behavior of that parameter exactly. A parameter that is received but not changed by the method is an input parameter. A parameter that is output but is not received is an output parameter or a return value. A parameter that is received, changed, and output is an input/output parameter.

This may appear to be stating the obvious, but, as you will see, parameters do not have to behave in accordance with their type.

Kind of Parameter Passing

You can define the way a formal parameter is passed either as pass by reference or as pass by value for each individual parameter, with the exception of the return value, for which pass by value is set by default.

The syntax for pass by reference is shown below using the example of an input parameter ipara:

```
METHODS meth IMPORTING ipara ...                                    REFERENCE
```

Equally, you can also use:

```
METHODS meth IMPORTING REFERENCE(ipara) ...
```

The syntax for pass by value is shown below using the example of the return value return:

```
METHODS meth RETURNING VALUE(return) ...                            VALUE
```

3 Functional methods (as opposed to function modules) are the natural extension of integrated functions (see Section 5.2.4) by self-defined functions in the same way as self-defined data types extend the built-in ABAP types.

In the Class Builder, you define the kind of parameter passing by selecting the **Pass by value** check box on the **Parameters** tab page or leaving this blank. Therefore, pass by reference is the standard transfer type, which is used unless a different type is specified, both in the syntax and in the Class Builder. What is the difference between these transfer types?

- **Pass by Reference**
  With pass by reference, a reference to the actual parameter is passed to the method for each formal parameter for which an actual parameter is specified when you call the method, regardless of the parameter type. The method thus uses the actual parameter itself, and changes to formal parameters have a direct effect on the actual parameter.
- **Pass by Value**
  With pass by value, a local data object is created as a copy of the actual parameter for each formal parameter when the method is called. In the case of input parameters and input/output parameters, the value of the actual parameter is assigned to this data object. The value of the formal parameter is only assigned to output parameters, input/output parameters, and return values if the method is exited without errors using `ENDMETHOD` or `RETURN`.

Parameter type and kind of passing

The kind of parameter passing is a technical property, which defines the behavior of a formal parameter. Only with pass by value does the actual behavior always correspond to the behavior defined by the parameter type. The following points apply to pass by reference:

- Output parameters are not necessarily initial at the start of the method (output parameters behave like input/output parameters).
- Changes to output parameters and input/output parameters are effective, even if the method terminates with an exception.
- Input parameters that are passed by reference cannot be explicitly changed in the method. Their values may change, however, if they are linked to global actual parameters and if these parameters are changed during the method is executed.

Therefore, a method should always be programmed in such a way that the behavior of its parameters corresponds to the semantics defined by the parameter type:

- Do not execute read access to an output parameter that is passed by reference because its initial value is not defined.
- If you add lines to an internal table or extend a string that is defined as an output parameter that is passed by reference, you must initialize the parameter before the first access.
- Give due consideration to the value you set for output parameters or input/output parameters that are passed by reference before an exception is triggered to ensure that a calling program can execute adequate exception handling.

Pass by reference and pass by value

A number of precautionary methods are thus required for pass by reference, which do not apply to pass by value. So why is pass by reference even necessary? The answer is performance.

Performance as against robustness

In ABAP, pass by reference always performs better than pass by value, because no data object has to be created when a procedure is called, and no data transport takes place. For performance reasons, pass by reference is usually preferable to pass by value, unless explicit or implicit write access to an input parameter is required, or you want to ensure that an output parameter or an input/output parameter is only returned if the procedure is completed without any errors. If possible, these cases should be limited to the transfer of parameters smaller than approximately 100 bytes.[4]

The example in Listing 6.1 is of a small and probably unexpected situation, which may occur if pass by reference is used without due consideration.

Listing 6.1 Transfer Type of Formal Parameters

```
REPORT z_parameter_passing.

CLASS demo DEFINITION CREATE PRIVATE.
  PUBLIC SECTION.
    CLASS-METHODS main.
  PRIVATE SECTION.
    METHODS: meth1 IMPORTING value(idx)     TYPE i,
             meth2 IMPORTING reference(idx) TYPE i.
```

4 With strings and internal tables, the disadvantage in terms of performance of pass by value compared with pass by reference can even be compensated for by the integrated Copy-on-Write semantics (the concept of sharing, see Section 5.1.7). This is the case for input parameters in particular, provided that they are not changed.

```
    DATA msg TYPE string.
ENDCLASS.

CLASS demo IMPLEMENTATION.
  METHOD main.
    DATA oref TYPE REF TO demo.
    CREATE OBJECT oref.
    DO 2 TIMES.
      oref->meth1( sy-index ).
      oref->meth2( sy-index ).
    ENDDO.
  ENDMETHOD.
  METHOD meth1.
    DO 3 TIMES.
      msg = idx.
      CONCATENATE `meth1: ` msg INTO msg.
      MESSAGE msg TYPE 'I'.
    ENDDO.
  ENDMETHOD.
  METHOD meth2.
    DO 3 TIMES.
      msg = idx.
      CONCATENATE `meth2: ` msg INTO msg.
      MESSAGE msg TYPE 'I'.
    ENDDO.
  ENDMETHOD.
ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

In the `main` method, two methods are called with an identical implementation in a `DO` loop. The first method, `meth1`, outputs the content of `sy-index` , which is passed by value, three times as expected, in other words, "1", "1", "1" during the first call, and "2", "2", "2" during the second call. The second method, `meth2`, outputs "1", "2", "3" during both calls. The `DO` loop in `meth1` and `meth2` sets the global system field `sy-index` and thus also the formal parameter `idx` (passed by reference) in `meth2`.

The method with pass by value is therefore more robust. However, this example also shows that global parameters like system fields—changes to which are not subject to the direct control of a method—should not be simply passed to methods in this way from the calling

program. The expected result is also returned by `meth2` if a local auxiliary variable is implemented in `main`, to which `sy-index` is assigned and which is then passed to `meth2`.

Typing

You must type each formal parameter of a method. Typing simply means that you assign a type to a formal parameter. As with data declaration, the syntax used for this purpose is a `TYPE` or `LIKE` addition, which you must specify after each formal parameter, for example:

```
METHODS meth EXPORTING opara TYPE dtype ...
```

With local classes, any visible type can be specified here. In the Class Builder, fill the **Typing** (**Type**, **Type Ref To** or **Like**) and **Reference type** columns accordingly on the **Parameters** tab page in order to specify the type,. Since the type you specify must also be accessible to all users of the method, you can only specify built-in ABAP types, global types from the ABAP Dictionary, or types from the public visibility section of a global class for public methods. With protected methods, additional types from the protected visibility section of the class can also be used, while types from the private visibility section and local types from the class pool can be used for private method types only.

The main difference between typing and data declaration is that a formal parameter is assigned its actual data type only when it is linked to an actual parameter when a method is called. All technical properties of the actual parameter are then passed to the formal parameter.

Checking typing

In order for an actual parameter to be passed, its data type must match the typing of the formal parameter. To be more precise, its technical type properties must be compatible with the data type used for the typing. The technical properties of an elementary type are the built-in ABAP type (`c`, `d`, `f`, `i`, `n`, `p`, `t`, `string`, `x`, `xstring`), the length (for `c`, `n`, `p`, `x`), and the number of decimal places (for `p`). The technical property of a structured type is its structure, based on substructures and elementary components (the component names are irrelevant). The technical properties of an internal table are the table type (`STANDARD`, `HASHED`, `SORTED`), line type, and table key.

Generic typing

The typing of a formal parameter may be complete or generic. For complete typing, use `TYPE` to refer to a complete data type, or `LIKE` to refer to a data object. For generic typing, you can use the built-in generic types (`any`, `any table`, `c`, `clike`, `csequence`, `data`, `hashed table`, `index table`, `n`, `numeric`, `object`, `simple`, `sorted table`, `standard table`, `table`, `x`, `xsequence`—see Section 5.1.9). Internal table types are also generic if the table key is not fully defined.

Formal parameters that have complete typing can always be regarded as local data objects of this type, with all type properties known inside the method. Generic types differ in terms of static and dynamic access. The type properties used for typing are only used for static access. With dynamic access,[5] the type properties of the assigned actual parameter are used. These properties may differ from the typing in terms of the non-technical properties, such as component names.

Operand position

In addition to checking the data type of an assigned actual parameter, the typing defines how the formal parameter can be used as an operand of statements in the method. With one exception, formal parameters can be used in all operand positions that are not excluded by the typing. For example, a generic formal parameter with the typing `any` can be assigned to any formal parameter that has the same typing. In that case, an exception occurs at runtime if types for which no conversion rules exist (see Section 5.2.2) are assigned. Internal tables constitute the exception to this rule. In this case, table accesses are only permitted to formal parameters that have a corresponding typing.

The example provided in Listing 6.2 shows various typings and their effects on how formal parameters are used in the methods.

Listing 6.2 Typing of Formal Parameters

```
REPORT z_parameter_typing.

CLASS demo DEFINITION.
  PUBLIC SECTION.
    METHODS: meth1 IMPORTING ipar TYPE any,
             meth2 IMPORTING ipar TYPE any table,
             meth3 IMPORTING ipar TYPE index table.
ENDCLASS.
```

5 With dynamic access to a component during an operation on an internal table, for example.

```
CLASS demo IMPLEMENTATION.
  METHOD meth1.
    DATA num TYPE string.
    num = ipar.
    "READ TABLE ipar INDEX 1
    "                TRANSPORTING NO FIELDS.
    "READ TABLE ipar WITH KEY table_line = '...'
    "                TRANSPORTING NO FIELDS.
  ENDMETHOD.
  METHOD meth2.
    DATA num TYPE string.
    "num = ipar.
    "READ TABLE ipar INDEX 1
    "                TRANSPORTING NO FIELDS.
    READ TABLE ipar WITH KEY table_line = '...'
                     TRANSPORTING NO FIELDS.
  ENDMETHOD.
  METHOD meth3.
    DATA num TYPE string.
    "num = ipar.
    READ TABLE ipar WITH KEY table_line = '...'
                     TRANSPORTING NO FIELDS.
    READ TABLE ipar INDEX 1
                     TRANSPORTING NO FIELDS.
  ENDMETHOD.
ENDCLASS.
```

Three conceivable uses of the input parameter are specified in the methods, while the statements that result in syntax errors for the respective typing are commented out:

- The `ipar` input parameter of the `meth1` method is typed as completely generic. It can be assigned to the `num` local variables; however, no read operations can be executed for internal tables. When the method is called, any data objects can be passed to the formal parameter. But, if an internal table is passed, an exception occurs during the assignment to `num`.
- The `ipar` input parameter of the `meth2` method is typed with an internal table that is generic in terms of table type, line type, and table key. It cannot be assigned to the `num` local variable. Only key access can be executed for internal tables because only these accesses are permitted for all table types. When the method is called, any internal tables can be passed to the formal parameter.

- The `ipar` input parameter of the `meth3` method is typed with an index table that is generic in terms of line type and table key. It cannot be assigned to the `num` local variable. However, all accesses can be executed for internal tables because key and index accesses are possible for index tables. When the method is called, only index tables (and no hash tables) can be passed to the formal parameter.

Formal parameters should be as appropriately typed as possible. The typing must comply with both the implementation requirements and the expectations of the calling program. If you want or need to use a generic type, you should always be as specific as possible. Use generic types like `csequence`, `numeric`, `simple`, and `xsequence` instead of `any`. For example, `csequence` is usually an appropriate typing for text processing. The typings `standard table`, `sorted table`, `index table`, or `hashed table` are similarly preferable to `any table`.

Generic or complete

The more generic the typing you use, the more careful you must be when using the formal parameter in the implementation to avoid exceptions. Accordingly, you should avoid assigning formal parameters with a typing that is completely generic if you do not want to first check the type at runtime (see Section 11.2) or handle possible exceptions (see Section 8.2).

Unless generic typing is required, you should always use complete typing. Only formal parameters with complete typing always behave in the same way and can be tested locally. You must be particularly careful to ensure that you don't use generic typing by mistake when you actually intend to use complete typing. This frequently occurs with internal tables with a generic key.

Supply Type

For every formal parameter that awaits a value—input parameters and input/output parameters—by standard, an actual parameter must be specified when the method is called. The assignment of actual parameters to output parameters and return values is always optional.

For input parameters and input/output parameters, this rule can be avoided by declaring the parameter as optional. The syntax is shown below, using the example of an input/output parameter:

```
METHODS meth CHANGING cpara TYPE dtype OPTIONAL ...          OPTIONAL
```

or

```
METHODS meth CHANGING cpara TYPE dtype DEFAULT dobj ...      DEFAULT
```

No actual parameters have to be specified when the method is called for a formal parameter that is declared as optional. An optional formal parameter for which no actual parameter is specified is initialized in accordance with its type. With the addition `DEFAULT`, the value and type of an appropriately specified replacement parameter `dobj` are copied.

In the Class Builder, you can make a formal parameter optional by selecting the **Optional** column, or by entering a value in the **Default value** column.

We recommend that you make all formal parameters optional, with the exception of those for which a different entry is actually required each time the method is called. Otherwise, you force your callers to specify unnecessary actual parameters, for which type-specific auxiliary variables often have to be created.

Ensure that the predefined initialization of optional parameters is sufficient or, if you must initialize such a parameter explicitly, for example, in dependence of other parameters. With the special predicate

```
... IS SUPPLIED ...
```

you can even use a logical expression to react differently in the method, depending on whether an actual parameter is assigned to an optional parameter.

6.1.2 Method Calls

This section discusses the options for calling methods statically. A dynamic method call is also possible (see Section 11.4). When a method is called, actual parameters must be passed to all non-optional formal parameters (in other words, all input parameters and input/output parameters that are not defined as optional). Actual parameters can be connected to optional formal parameters. The actual parameters must match the typing of the formal parameters.

The following sections describe static method with increasing complexity of the method interface.

Static Method Calls

The simplest method has no interface parameters. Accordingly, the method call is also simple. The statement is as follows:

No parameters

```
meth( ).
```

With `meth`, you specify the method as it can be addressed as a component of a class or an object in the current location, that is, directly with its name `meth` in a method of the same class, or with `oref->meth` or `class=>meth` everywhere the method is visible.

If the method has one non-optional input parameter, the statement is as follows:

One input parameter

```
meth( dobj ).
```

The `dobj` data object is passed to the input parameter as an actual parameter. If the method has several non-optional input parameters, the statement is as follows:

Several input parameters

```
meth( i1 = dobj1 i2 = dobj2 ... ).
```

A data object is explicitly assigned to each input parameter. If actual parameters are to be assigned to any formal parameters, the syntax is as follows:

Any parameter

```
meth( EXPORTING i1 = dobj1 i2 = dobj2 ...
      IMPORTING o1 = dobj1 o2 = dobj2 ...
      CHANGING  c1 = dobj1 c2 = dobj2 ... ).
```

With `EXPORTING`, you supply the input parameters defined with `IMPORTING`. With `IMPORTING`, you receive values from output parameters defined with `EXPORTING`. With `CHANGING`, you assign the actual parameters to the input/output parameters defined with `CHANGING`. The equal sign is not an assignment operator in this case. Instead, its function is to bind actual parameters to formal parameters. This syntax includes the previous short forms and can be used instead.

Finally, you can add a `CALL METHOD` to all of the previous syntax forms, for example:

CALL METHOD

```
CALL METHOD meth( i1 = dobj1 i2 = dobj2 ... ).
```

However, this specification is merely unnecessary syntactical noise and can be omitted (as of Release 6.10).[6]

Functional Method Call

You may notice that we haven't mentioned the RETURNING parameter of a functional method[7] in our discussion of method calls. This is because functional methods are intended to be used in operand positions. Nevertheless, there is also a separate statement for calling a functional method:

RETURNING parameter

```
meth( EXPORTING i1 = dobj1 i2 = dobj2 ...
      RECEIVING r  = dobj ).
```

Here, RECEIVING receives the return value in dobj; however, this statement is seldom if ever used in practice. The functional equivalent for the above call is as follows:

```
dobj = meth( i1 = dobj1 i2 = dobj2 ... ).
```

The call of the functional method can be specified in an operand position, which, in this case, is the source field of an assignment, without specifying RECEIVING. When the statement is executed, the method is called and the return value is used as an operand. In the example shown above, it is assigned to dobj. The actual parameters are assigned to input parameters using the three syntax forms described above for no input parameters, one input parameter, or several input parameters.

```
... meth( ) ...
... meth( dobj ) ...
... meth( i1 = dobj1 i2 = dobj2 ... ) ...
```

Functional methods can be used in the same places as built-in functions (see Section 5.2.4). A functional method called with meth(a) hides an built-in function with the same name:

- As the source field of an assignment
- As an operand in an arithmetic expression
- As an operand in a logical expression

6 The CALL METHOD language element is only required for the dynamic method calls still.

7 Remember that a function method can have any number of input parameters and only one return value that is passed by value.

- As an operand in the CASE statement
- As an operand in the WHEN statement
- As an operand in the WHERE condition for internal tables

If a functional method called in an operand position sends a class-based exception, this can be handled within a TRY control structure.[8] As of the next release of SAP NetWeaver, you will be able to use functional methods as well as built-in functions and complete arithmetic expressions in almost all operand positions where it is useful to do so. You will be able to use them, in particular, as actual parameters for input parameters of methods, which will allow you to nest method calls.

In Listing 6.3, we have implemented two functional methods get_area and get_volume, to calculate the circular area and volume of a cylinder in a class called cylinder.

Listing 6.3 Functional Methods

```
REPORT z_functional_method.

SELECTION-SCREEN BEGIN OF SCREEN 100.
PARAMETERS: p_radius TYPE i,
            p_height TYPE i.
SELECTION-SCREEN END OF SCREEN 100.

CLASS demo DEFINITION.
  PUBLIC SECTION.
    CLASS-METHODS main.
ENDCLASS.

CLASS cylinder DEFINITION.
  PUBLIC SECTION.
    METHODS: constructor IMPORTING i_radius TYPE numeric
                                   i_height TYPE numeric,
             get_area    RETURNING value(r_area)   TYPE f,
             get_volume  RETURNING value(r_volume) TYPE f.
  PRIVATE SECTION.
    CONSTANTS pi TYPE f VALUE '3.14159265'.
    DATA: radius TYPE f,
          height TYPE f.
ENDCLASS.

CLASS cylinder IMPLEMENTATION.
  METHOD constructor.
```

8 Classical exceptions cannot be handled in this case.

```
    me->radius = i_radius.
    me->height = i_height.
  ENDMETHOD.
  METHOD get_area.
    r_area = pi * me->radius ** 2.
  ENDMETHOD.
  METHOD get_volume.
    r_volume = me->get_area( ) * me->height.
  ENDMETHOD.
ENDCLASS.

CLASS demo IMPLEMENTATION.
  METHOD main.
    DATA: oref   TYPE REF TO cylinder,
          volume TYPE string.
    CALL SELECTION-SCREEN 100 STARTING AT 10 10.
    IF sy-subrc = 0.
      CREATE OBJECT oref EXPORTING i_radius = p_radius
                                   i_height = p_height.
      volume = oref->get_volume( ).
      CONCATENATE `Volume: ` volume INTO volume.
      MESSAGE volume TYPE 'I'.
    ENDIF.
  ENDMETHOD.
ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

The `main` method of the `demo` class uses a function call to `get_volume` on the right side of an assignment, and assigns the result to the `volume` string. The `get_volume` method calls `get_area` in an arithmetic expression. The calculation type of this expression is `f`.

6.2 Inheritance

In object orientation, inheritance refers to the specialization of classes by deriving subclasses from superclasses.

6.2.1 Basic Principles

Classes provide a construction plan for objects. Suppose you create two classes called "Car" and "Truck". You want to implement methods for both classes, which control the objects or return information

about their location and speed. Even at this stage, you can foresee that some parts of the classes will have to be written twice. The inheritance mechanism of an object-oriented programming language provides options that help you to reuse the same or similar parts of a class, and to create a hierarchy of classes.

Superclasses and subclasses

If we examine the two classes (i. e., "Car" and "Truck") in more detail, it becomes clear that both classes comprise types of vehicles. If you want to create a third class called "Dump truck" it will comprise a specific type of truck. To create a hierarchy relationship between these classes, classes can be derived from each other using inheritance. In our example, "Car" and "Truck" are derived from the "Vehicle" class, while "Dump truck" are derived from the "Truck" class. Derived or more specific classes are referred to as *subclasses*, while more general classes are called *superclasses*.

Simple inheritance

The concept of simple inheritance is implemented in ABAP Objects. According to this concept, each class can have several subclasses but only one superclass.[9] In simple inheritance, inheritance relationships are represented by an inheritance tree. Every class in an object-oriented programming language in which simple inheritance is implemented has a unique position as a node in an inheritance tree. This also applies to all the classes we have dealt with up to now, although we have not yet spoken of them in terms of inheritance. For each class, a unique path can be traced back through their superclasses in the inheritance tree until you reach exactly one root node. This root node is the superclass of all classes in the inheritance tree.

Root class

Figure 6.1 illustrates this relationship. The root node of the inheritance tree in ABAP Objects is the predefined, empty, and abstract class `object`.

Derivation

Inheritance simply means that a subclass inherits all components (attributes, methods, events, etc.) of its superclass and can use them like its own components. In each subclass, new elements can be added or methods can be redefined in order to specialize, without this having any impact on the superclass. Elements can only be added in subclasses. It would go against the inheritance concept to remove elements in a subclass.

9 Other programming languages, such as C++, allow a class to be derived from several classes. This mechanism, which is referred to as *multiple inheritance*, is not implemented in ABAP Objects.

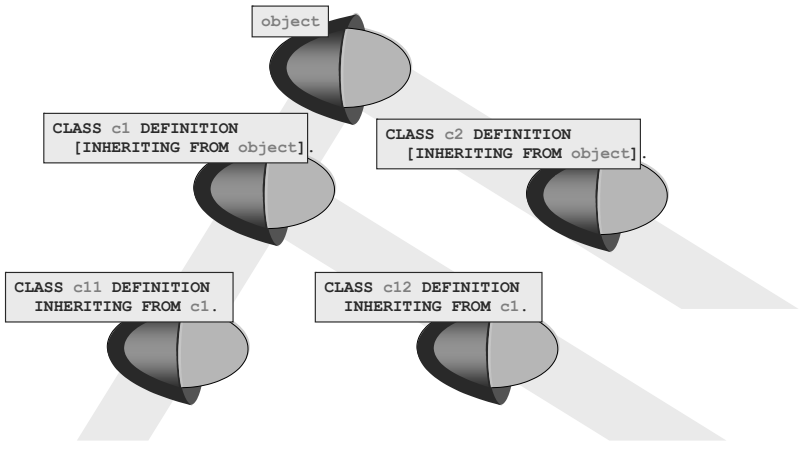

Figure 6.1 Inheritance Tree in ABAP Objects

Implicit subclasses

In accordance with this concept, the direct subclasses of the empty `object` root class do not inherit any components from its superclass. Instead, they can add new components. This situation applies to all our sample classes up to now. All classes in ABAP Objects that do not explicitly inherit from another class are implicit direct subclasses of `object`.

Specialization/ generalization

When subclasses of explicitly defined classes are created, these inherit the components of their superclasses and can add new components. Classes become increasingly specialized the further away you move from the root in the inheritance tree. As you move towards the root node, on the other hand, the classes become more generalized.

Composition

If you look at a class that is located near the bottom of the inheritance tree, you will notice that the inherited components of the class originate in all classes along the path between this class and the root class, which is the superclass of all classes. In other words, the definition of a subclass is composed of the definitions of all of its superclasses right up to `object`. The relationship between a subclass and its superclasses should always be expressed as "is a"; for example, "a cargo plane is a plane is a means of transportation is an object." If this is fulfilled, subclasses can always be handled the same way as superclasses (see polymorphism in Section 6.4).

6.2.2 Creating Subclasses

A superclass has no knowledge of any subclasses it may have. Only a subclass is aware that it is the heir of another class. Therefore, an inheritance relationship can only be defined when a subclass is declared. The syntax for deriving a subclass (`subclass`) from a superclass (`superclass`) is as follows:

INHERITING FROM

```
CLASS subclass DEFINITION INHERITING FROM superclass.
  ...
ENDCLASS.
```

It therefore involves a simple addition to the `CLASS DEFINITION` statement. Any non-final class that is visible at this point can be specified for `superclass`. To create a subclass in the Class Builder, select **Superclass** on the **Properties** tab page. Then enter any non-final, global class as a superclass in the **Inherits from** field. The **Undo inheritance** and **Change inheritance** options allow you to change the inheritance relationship (see Figure 6.2).

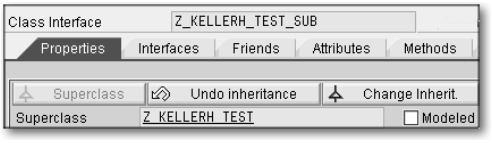

Figure 6.2 Inheritance in the Class Builder

To display the components in a subclass that were inherited from the superclass, select the menu option **Utilities • Settings**, and select the **Display Inherited Components Also** option.

For each class that does not have an explicit `INHERITING FROM` addition, the system implicitly adds the `INHERITING FROM object` addition, which means that any class without an `INHERITING` addition is automatically a direct subclass of the `object` root class.

Listing 6.4 shows the implementation of our example based on vehicles. In this implementation, two classes (`car` and `truck`) are derived from the `vehicle` class.

Listing 6.4 Simple Example of Inheritance

```
REPORT z_inheritance.

CLASS demo DEFINITION.
  PUBLIC SECTION.
```

```
    CLASS-METHODS main.
ENDCLASS.

CLASS vehicle DEFINITION.
  PUBLIC SECTION.
    METHODS: accelerate IMPORTING delta TYPE i,
             show_speed.
  PROTECTED SECTION.
    DATA speed TYPE i.
ENDCLASS.

CLASS car DEFINITION INHERITING FROM vehicle.
ENDCLASS.

CLASS truck DEFINITION INHERITING FROM vehicle.
  PUBLIC SECTION.
    METHODS: load IMPORTING freight TYPE string,
             unload.
  PROTECTED SECTION.
    DATA freight TYPE string.
ENDCLASS.

CLASS vehicle IMPLEMENTATION.
  METHOD accelerate.
    me->speed = me->speed + delta.
  ENDMETHOD.
  METHOD show_speed.
    DATA output TYPE string.
    output = me->speed.
    MESSAGE output TYPE 'I'.
  ENDMETHOD.
ENDCLASS.

CLASS truck IMPLEMENTATION.
  METHOD load.
    me->freight = freight.
  ENDMETHOD.
  METHOD unload.
    CLEAR me->freight.
  ENDMETHOD.
ENDCLASS.

CLASS demo IMPLEMENTATION.
  METHOD main.
    DATA: car_ref   TYPE REF TO car,
          truck_ref TYPE REF TO truck.
    CREATE OBJECT: car_ref,
                   truck_ref.
    car_ref->accelerate( 130 ).
    car_ref->show_speed( ).
```

```
    truck_ref->load( `Beer` ).
    truck_ref->accelerate( 110 ).
    truck_ref->show_speed( ).
    truck_ref->unload( ).
  ENDMETHOD.
ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

The `vehicle` class contains a protected attribute (`speed`) and two public methods (`accelerate` and `show_speed`). Note that we have explicitly specified that `vehicle` inherits from `object`. Normally, we do not specify the `INHERITING` addition for such classes. The `car` and `truck` classes are both derived from `vehicle`. Therefore, they inherit the attribute and methods of the `vehicle` class. Since `speed` is declared in the `PROTECTED SECTION`, it is also visible in the subclasses. The `truck` class is specialized with an additional attribute for freight and additional methods for loading and unloading (`load` and `unload`). In this example, the `car` class receives no additional components. This means that its objects are the same as those of the `vehicle` class. Since no methods have been added, `car` does not require an implementation part.

In the `main` method of the `demo` class, we use the reference variables `car_ref` und `truck_ref` to generate one object each for the two subclasses and call their methods. The `accelerate` and `show_speed` methods can be used in both subclasses; however, the `load` and `unload` methods can be used only in `truck`.

6.2.3 Visibility Sections and Namespaces in Inheritance

There are three different visibility sections in a class, in which the components of the class are declared (see Section 4.3.2). A subclass inherits all components of its superclasses without changing their visibility. For that reason, only the public and protected components of its superclasses are visible in a subclass. In contrast, the private components are contained in the subclass but are invisible.[10] The visibility sections of a subclass therefore contain the following components:

10 Note, however, that the methods inherited from the superclass use the private attributes of the superclass, unless these inherited methods are redefined in the subclass.

- **PUBLIC**
  The public visibility section of a subclass contains all public components of all superclasses, plus its own additional public components. These components can be accessed externally using component selectors.
- **PROTECTED**
  The protected visibility section of a subclass contains all protected components of all superclasses, plus its own additional protected components. These components cannot be accessed externally using component selectors. From an external point of view, "protected" is the same as "private."
- **PRIVATE**
  The private visibility section of a subclass contains only the subclass's own private components. These components can only be accessed in the method implementations of the subclass.

Namespace

Since all visible components in a class must have unique names, all public and protected components of all classes along an inheritance path in the inheritance tree belong to the same namespace and have unique names. Private components, which are only visible within a class and cannot be used in subclasses, must only have unique names within their own class.

The implications of this are as follows: A superclass is not aware of any subclasses it may have. If you create a non-final class in a class library and release it for use, you can never know, as a developer, which subclasses your class will eventually have other than those you define yourself. If you then subsequently add new components to the public or protected section of your class, and any of its subclasses happen to have a component of its own with the same name, this becomes syntactically incorrect. Therefore, it is only secure to add private components. In global classes, not only the external interface but also the interface with any possible subclasses must remain stable.

Therefore, to limit the subclasses of a class to at least the same package, non-final classes should preferably be organized in packages for which the **Package Check as Server** property is activated (see Section 2.3.3).

6.2.4 Method Redefinition

A subclass inherits all public and protected methods additionally to its own components.[11] When a method is called in the subclass, it is executed in the same way it was implemented in the superclass, and even uses the private components of the superclass. However, since the main purpose of inheritance is to specialize classes, the behavior of the method of a superclass may be too general for the more specific purpose of the subclass. In some cases, the implementation of superclass must be enhanced in the subclass, while in other instances, the implementation must be completely changed. However, the semantics of the method must remain stable for the external user, because all this user ever sees is the constant interface (including the documentation) and not the implementation itself.

New implementation

Instance methods can be redefined in subclasses to specialize the behavior of subclass objects. Static methods cannot be redefined. Redefining a method means creating a new implementation of the method in a subclass without changing the interface.[12] The method is still declared in the superclass. Previous implementations of the method in preceding superclasses remain unchanged. When a method is redefined in a subclass, an additional implementation is created, which hides the previous implementation when the subclass and further subclasses are used.

Access

Every reference that refers to an object of the subclass uses the redefined method. This is always the case, regardless of the type of the reference variables (for more details, see Section 6.4). This applies in particular to the self reference `me`. Therefore, if a superclass method (`meth1`) contains the call of a method (`meth2`) belonging to the same class, which is redefined in a subclass, the call of the `meth1` method in an instance of the superclass results in the execution of the original method (`meth2`), while the call of the `meth1` method in an instance of the subclass results in the execution of the redefined method (`meth2`).

11 The private methods are also inherited in principle, but are not visible in the subclass.

12 Some other object-oriented programming languages permit the overloading of functions or methods. This means that a separate, changed parameter interface can be defined for an overwritten or redefined method. ABAP Objects does not currently support this mechanism.

Like the methods belonging to the subclass, a redefined method accesses the private attributes of the subclass.

REDEFINITION

The syntax for redefining an instance method in a subclass is as follows:

```
METHODS meth REDEFINITION.
```

This statement must be specified in the declaration part of the subclass in the same visibility section as the actual declaration of the method in the superclass. The definition of the interface is not repeated.

In the Class Builder, you redefine an inherited method by displaying it on the **Methods** tab. To do so, you must use the **Settings** function of the Class Builder to select the **Display Inherited Components Also** entry. Then, you must highlight the method and select the **Redefine** function (see Figure 6.3).

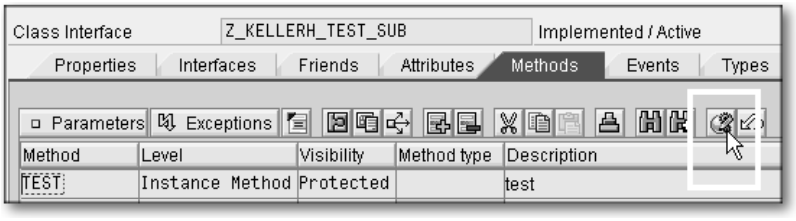

Figure 6.3 Redefinition of an Inherited Method

Implementation

A new implementation must be created for each redefined method in the redefining subclass. In global classes, the Class Builder does this as part of the **Redefine** process, and you can navigate to the implementation in the same way as with normal methods. In local classes, you must enter the implementation yourself in the implementation part as for normal methods.

Pseudo reference

In the implementation of a redefined method, you can use the pseudo reference `super->` to access the original method of the direct superclass. This overrides the hiding of the redefined method. You must always use this pseudo reference if you want to first copy the functionality of the superclass and then enhance it.

We can now apply method redefinition to our example from Listing 6.4. Listing 6.5 shows how this differs from Listing 6.4.

Listing 6.5 Method Redefinition

```
REPORT z_method_redefinition.

...
CLASS car DEFINITION INHERITING FROM vehicle.
  PUBLIC SECTION.
    METHODS show_speed REDEFINITION.
ENDCLASS.
CLASS truck DEFINITION INHERITING FROM vehicle.
  PUBLIC SECTION.
    METHODS: accelerate REDEFINITION,
             show_speed REDEFINITION,
             load IMPORTING freight TYPE string,
             unload.
  PROTECTED SECTION.
    DATA freight TYPE string.
  PRIVATE SECTION.
    CONSTANTS max_speed TYPE i VALUE '80'.
ENDCLASS.
...
CLASS car IMPLEMENTATION.
  METHOD show_speed.
    DATA output TYPE string.
    output = me->speed.
    CONCATENATE `Car, speed: ` output INTO output.
    MESSAGE output TYPE 'I'.
  ENDMETHOD.
ENDCLASS.
CLASS truck IMPLEMENTATION.
  METHOD accelerate.
    super->accelerate( delta ).
    IF me->speed > truck=>max_speed.
      me->speed = truck=>max_speed.
    ENDIF.
  ENDMETHOD.
  METHOD show_speed.
    DATA output TYPE string.
    output = me->speed.
    CONCATENATE `Truck with `
                me->freight
                `, speed: `
                output
      INTO output.
```

```
    MESSAGE output TYPE 'I'.
  ENDMETHOD.
  ...
ENDCLASS.
CLASS demo IMPLEMENTATION.
  METHOD main.
    DATA: car_ref   TYPE REF TO car,
          truck_ref TYPE REF TO truck.
    CREATE OBJECT: car_ref,
                   truck_ref.
    car_ref->accelerate( 130 ).
    car_ref->show_speed( ).
    truck_ref->load( `Beer` ).
    truck_ref->accelerate( 110 ).
    truck_ref->show_speed( ).
    truck_ref->unload( ).
  ENDMETHOD.
ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

We specialize the `accelerate` method in the `truck` class and the `show_speed` method in both subclasses:

- In the `truck` class, we introduced a maximum speed `max_speed` that cannot be exceeded in `accelerate`. In the new implementation, the speed is therefore set by calling `super->accelerate` via the previous implementation, and then checked and adapted, if necessary.
- The `show_speed` method is extended by specific outputs in both subclasses. The previous implementation is not used for this purpose.

All redefined methods keep their original semantics in spite of the new implementation. You will notice that this requires some programming discipline because we can also implement the methods in a completely different way (for more information, see Section 6.4.3). A test tool that might help you check the stability of applications is ABAP Unit (see Section 13.3).

6.2.5 Abstract Classes and Methods

If you want to use a class just as a template for subclasses and don't need any objects of this class, you can define the class as an abstract class. The syntax for defining an abstract class is:

ABSTRACT

```
CLASS class DEFINITION ABSTRACT.
  ...
ENDCLASS.
```

To create an abstract class in the Class Builder, select **Abstract** in the **Instantiation** input field on the **Properties** tab (see Figure 6.4).

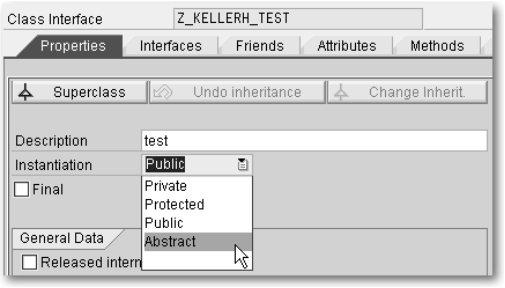

Figure 6.4 Abstract Global Class

Objects cannot be created from an abstract class using `CREATE OBJECT`. Instead, abstract classes are used as a template for subclasses. From an abstract class, actual subclasses can be derived from which objects can then be created.

Single instance methods can be identified as abstract as well. The syntax is:

```
METHODS meth ABSTRACT.
```

In the Class Builder, you can identify a method as **Abstract** in its Detail view (see Figure 6.5).

Implementation

An abstract method cannot be implemented in its own class, but only in a concrete subclass. Therefore, abstract methods can only be created in abstract classes. Otherwise, it would be possible to create an object with an addressable method but without its implementation. To implement an abstract method in a subclass, you use the method definition mechanism discussed in Section 6.2.4. The only difference to a real redefinition is that you cannot use the `super->` pseudo reference in the method.

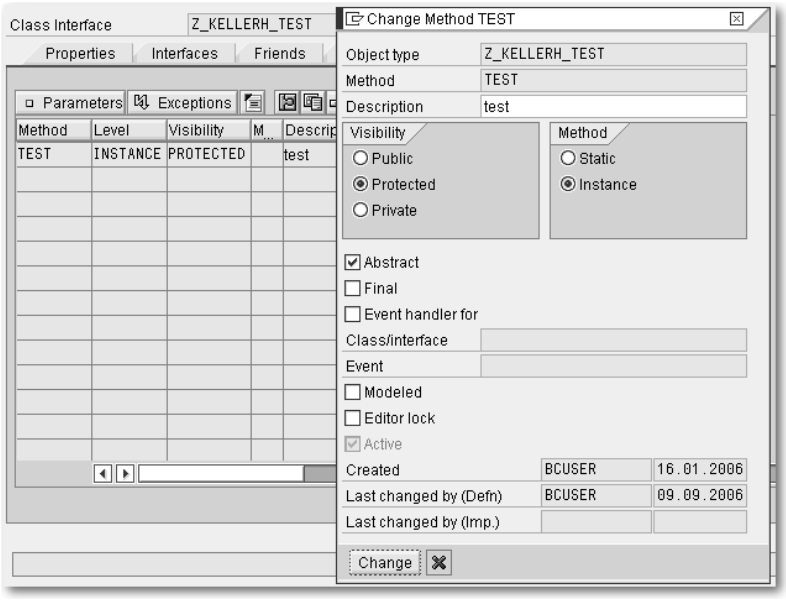

Figure 6.5 Abstract Method

In an abstract class, both concrete and abstract methods can be declared. Concrete methods are declared and implemented as usual. With the exception of instance constructers, concrete methods can even call abstract methods, because names and interfaces are completely known. The behavior of the abstract method, however, is defined during the implementation in a subclass and can therefore vary in different subclasses.

In our example in Listing 6.5, the `vehicle` superclass is rather rudimentary and is not used for creating any objects. To prevent this also syntactically, the class can be defined as abstract, as shown in Listing 6.6. Listing 6.6 only demonstrates the differences in comparison with Listing 6.5.

Listing 6.6 Abstract Class and Method

```
REPORT z_abstract_class.

...
CLASS vehicle DEFINITION ABSTRACT.
  PUBLIC SECTION.
    METHODS: accelerate IMPORTING delta TYPE i,
             show_speed ABSTRACT.
  PROTECTED SECTION.
```

```
    DATA speed TYPE i.
ENDCLASS.
...
CLASS vehicle IMPLEMENTATION.
  METHOD accelerate.
    me->speed = me->speed + delta.
  ENDMETHOD.
ENDCLASS.
...
```

The `vehicle` class only determines the common elements of the subclasses. Because the two subclasses in Listing 6.5 redefine the `show_speed` method anyway, we declared it in Listing 6.6 as abstract as well. It is therefore no longer implemented in the `vehicle` class.

Design

The use of abstract classes and methods can be an important means of object-oriented design. Abstract classes provide a common interface and a partially implemented functionality to their subclasses, but cannot perform any relevant operations on their attributes themselves. In a payroll system, for example, you can imagine a class that already implements many tasks like bank transfers, but only includes the actual payroll function in an abstract manner. It is then the task of various subclasses to perform the correct payroll calculation for different work contracts.

Interfaces

Because ABAP Objects does not support multiple inheritance, the usage of abstraction via abstract classes is always restricted to the subclasses of a specific node of the inheritance tree. Interfaces are another means of solving similar tasks, irrespective of the position in the inheritance hierarchy. They are discussed in Section 6.3.

6.2.6 Final Classes and Methods

Just as abstract classes and methods require a definition of subclasses in order to work with the classes, there can be adverse situations where you want to protect a whole class or a single method from uncontrolled specialization. For this purpose, you can declare a class or an instance method as final. This can make sense particularly if you want to make changes to a class at a later stage without causing any subclasses to become syntactically or semantically incorrect (see the namespace of components in inheritance in Section 6.2.3). If you follow the defensive procedure for programming the AS ABAP using

ABAP Objects, which was introduced in Section 4.9, the declaration of final classes is always recommended.

The syntax for defining a final class is:

FINAL

```
CLASS class DEFINITION FINAL.
  ...
ENDCLASS.
```

In the Class Builder, you create a final class by selecting the **Final** checkbox on the **Properties** tab (see Figure 6.4). You cannot derive any more subclasses from a final class. A final class therefore terminates a path of the inheritance hierarchy. All instance methods of a final class are automatically final.

In a non-final class, individual instance methods can be declared as final. The syntax is:

```
METHODS meth FINAL.
```

In the Class Builder, you can identify an instance method as **Final** in its **Detail view** (see Figure 6.5). A final method cannot be redefined in subclasses. A final method cannot be abstract at the same time. A class can be final and abstract at the same time, but only its static components are usable in this case. Although you can declare instance components in such a class, it is not recommended.

6.2.7 Static Attributes in Inheritance

To use a static component of a class, instances of the class are not required. If instances exist, they share the static components. How does inheritance affect static components, and static attributes in particular?

Inheritance tree

Like all components, a static attribute exists exactly once within a path of the inheritance tree. A subclass can access the contents of the public and protected static attributes of all superclasses. Alternatively, a superclass shares its public and protected static attributes with all subclasses. In inheritance, a static attribute is therefore not assigned to a single class, but to a path of the inheritance tree. It can be accessed from outside via the class component selector (=>) using all class names involved, or from inside in all affected classes where a static attribute is visible. Changes to the value are visible in all relevant classes. Listing 6.7 shows a simple example.

Listing 6.7 Static Attributes in Inheritance

```
REPORT z_static_attributes.

CLASS demo DEFINITION.
  PUBLIC SECTION.
    CLASS-METHODS main.
ENDCLASS.

CLASS c1 DEFINITION.
  PUBLIC SECTION.
    CLASS-DATA a1 TYPE string.
ENDCLASS.

CLASS c2 DEFINITION INHERITING FROM c1.
  ...
ENDCLASS.

CLASS demo IMPLEMENTATION.
  METHOD main.
    c2=>a1 = 'ABAP Objects'.
    MESSAGE c1=>a1 TYPE 'I'.
  ENDMETHOD.
ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

Static constructor

When addressing a static attribute belonging to a path of an inheritance tree, you always address the class in which the attribute is declared, irrespective of the class name used in the class component selector. This is important for calling the static constructor (see Section 6.2.8). A static constructor is executed when a class is addressed for the first time. If a static attribute is addressed via the class name of a subclass but declared in a superclass, only the static constructor of the superclass is executed.

Static methods

Static methods cannot be redefined in ABAP Objects, because static components should occur exactly once (i. e., not more or less) in a path so that they can be shared by all subclasses.

6.2.8 Constructors in Inheritance

Constructors are used for initializing the attributes of a class (see Section 4.7). While instance constructors can set the instance attributes of every single object during the instancing process, the static constructors are responsible for the static attributes of the class before the class is first accessed. Because a subclass inherits all attributes of

its superclasses in inheritance, this automatically begs the question "How can the constructors ensure that the inherited attributes are initialized as well when the subclass is used?"

Instance Constructors

Every class has a predefined instance constructor named `constructor`. Instance constructors thus deviate from the rule that there are only unique component names along a path of the inheritance tree. Consequently, the instance constructors of the individual classes of an inheritance tree must be completely independent of one another. To avoid naming conflicts, the following rules apply:

- Instance constructors of superclasses cannot be redefined in subclasses.
- Instance constructors cannot be explicitly called via the `constructor( )` statement.

super->constructor

After an object has been created with the `CREATE OBJECT` command, the instance constructor is automatically invoked. Because a subclass contains all superclass attributes that are visible to it, the contents of which can be set by instance constructors of these classes, the instance constructor of a subclass must ensure that the instance constructors of all superclasses are executed as well.[13] For this purpose, the instance constructor of every subclass must contain a call

```
super->constructor( ... ).
```

of the instance constructor of the direct superclass, even if the constructor is not explicitly declared. The only exceptions to this rule are the direct subclasses of the root node, `object`. The `super->constructor( ... )` statement is the only exception from the rule that constructors cannot be explicitly called.

In superclasses in which the instance constructor is not explicitly declared and implemented, the implicitly existing implementation of the instance constructor is run. It automatically ensures that the instance constructor of the next higher superclass is called.

Input parameters

Before an instance constructor is run, you must supply its non-optional input parameters. These are searched for as follows:

13 In particular, the private attributes of superclasses can only be initialized in the superclasses' own constructors.

- **Provision in `CREATE OBJECT`**
  Starting with the class of the created object, the first explicitly defined instance constructor is searched for in the corresponding path of the inheritance tree. This is the instance constructor of the class itself, or the first explicitly defined instance constructor of a superclass.
- **Provision in `super->constructor( ... )`**
  Starting with the direct superclass, the first explicitly defined instance constructor is searched for in the corresponding path of the inheritance tree.

In `CREATE OBJECT` or in `super->constructor( ... )`, respectively, the interface of the first explicitly defined instance constructor is provided with values like a normal method:

- If there are no input parameters, no parameters are transferred.
- Optional input parameters can be provided with values.
- Non-optional input parameters must be provided with values.

If there is no explicitly defined instance constructor in the path of the inheritance tree up to the `object` root class, no parameters will be transferred.

Inheritance tree

For both `CREATE OBJECT` and `super->constructor( ... )`, the first explicit instance constructor must therefore be regarded and, if one exists, its interface must be provided with a value. When working with subclasses, you therefore need to know the entire path very well because when creating a subclass object that resides at the lower end of the inheritance tree, a situation can occur whereby parameters must be transferred to the constructor of a superclass positioned much closer to the root node.

The instance constructor of a subclass is split into two parts by the `super->constructor( ... )` call required by the syntax. In the statements before the call, the constructor behaves like a static method. Before the call, it does not have access to the instance attributes of its class, that is, instance attributes cannot be addressed until after the call.

3-phase model

The execution of a subclass instance constructor can therefore be divided into three phases that are presented in the comment lines of Listing 6.8.

Listing 6.8 Three-Phase Model of an Instance Constructor

```
METHOD constructor.
  " Phase 1: Access to static attributes only
  ...
  " Phase 2: Execution of super class constructor(s)
  CALL METHOD super->constructor EXPORTING ...
  " Phase 3: Access to instance attributes only
  ...
ENDMETHOD.
```

In the individual phases, the instance constructor can execute the following tasks:

- **Phase 1**
  Here you can prepare the call of the superclass instance constructor, for example, you can determine the actual parameters for its interface.
- **Phase 2**
  In this phase, the instance constructor of the superclass is executed, which is again divided into three phases, if implemented.
- **Phase 3**
  The attributes of all superclasses are now correctly initialized. Using these values, the necessary initializations for the own instance attributes can be performed.

Therefore, during the instantiation of a subclass, a nested call of the instance constructors from the subclass to the superclasses takes place, where the instance attributes of the highest superclass can be addressed only as of the deepest nesting level. When returning to the constructors of the subclasses underneath, their instance attributes can also be addressed successively.

Self-reference

The methods of subclasses are not visible in constructors. If an instance constructor calls an instance method of the same class via the implicit self-reference `me`, the method is called in the way in which it is implemented in the class of the instance constructor, and not the possibly redefined method of the subclass to be instantiated. This is an exception to the rule that whenever instance methods are called, the implementation is called in the class of the instance to which the reference is pointing.

Listing 6.9 shows the behavior of instance constructors in inheritance using a simple example.

Listing 6.9 Instance Constructors in Inheritance

```
REPORT z_constructor_inheritance.

CLASS demo DEFINITION.
  PUBLIC SECTION.
    CLASS-METHODS main.
ENDCLASS.

CLASS vessel DEFINITION.
  PUBLIC SECTION.
    METHODS constructor IMPORTING i_name TYPE string.
  PROTECTED SECTION.
    DATA name TYPE string.
ENDCLASS.

CLASS ship DEFINITION INHERITING FROM vessel.
  ...
ENDCLASS.

CLASS motorship DEFINITION INHERITING FROM ship.
  PUBLIC SECTION.
    METHODS constructor IMPORTING i_name       TYPE string
                                  i_fuelamount TYPE i.
  PRIVATE SECTION.
    DATA fuelamount TYPE i.
ENDCLASS.

CLASS vessel IMPLEMENTATION.
  METHOD constructor.
    name = i_name.
  ENDMETHOD.
ENDCLASS.

CLASS motorship IMPLEMENTATION.
  METHOD constructor.
    super->constructor( i_name ).
    fuelamount = i_fuelamount.
  ENDMETHOD.
ENDCLASS.

CLASS demo IMPLEMENTATION.
  METHOD main.
    DATA: o_vessel    TYPE REF TO vessel,
          o_ship      TYPE REF TO ship,
          o_motorship TYPE REF TO motorship.
  CREATE OBJECT:
    o_vessel    EXPORTING i_name       = 'Vincent',
    o_ship      EXPORTING i_name       = 'Mia',
    o_motorship EXPORTING i_name       = 'Jules'
                          i_fuelamount = 12000.
```

```
  ENDMETHOD.
ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

This example shows three consecutive classes of the inheritance hierarchy. The `vessel` class has an instance constructor with an input parameter. From `vessel`, we derive the `ship` class that does not explicitly declare and implement the instance constructor. From `ship`, we derive `motorship`. This class again has an explicit instance constructor with two input parameters. We create an object from every class and provide the parameter interface of the constructors with actual parameters. The constructors are called as follows:

- The object created using `o_vessel` is initialized at `CREATE OBJECT` in the explicit instance constructor of `vessel`, where an attribute is set using the passed actual parameter.
- The object created using `o_ship` is also initialized at `CREATE OBJECT` via the instance constructor of `vessel`, because it is called by the implicit instance constructor of `ship`. Its parameter interface needs to be provided with actual parameters.
- The object created using `o_motorship` is initialized in the explicit instance constructor of `motorship`. In this constructor, the instance constructor of the direct superclass must be called via `super->constructor`. The implicit instance constructor of `ship` calls the explicit instance constructor of `vessel`. Its parameter interface needs to be provided with actual parameters.

You can best understand the behavior of the program if you run it line by line in the ABAP Debugger.

Static Constructors

Every class has a static constructor named `class_constructor`. With regard to the namespace along an inheritance tree, the same rules that apply to the instance constructor also apply to the static constructor.

When a subclass is addressed for the first time in a program, its static constructor is run. Before that, however, the preceding static constructors of the entire inheritance tree must have been run. Because

Call

a static constructor should be called only once during the execution of a program, when a subclass is addressed for the first time, the next higher superclass is searched whose static constructor has not yet run. Then this static constructor is executed first, followed by the constructors of all subclasses up to and including the addressed subclass. In contrast to instance constructors, a static constructor does not have to explicitly call the static constructor of its superclass. Instead, the runtime environment automatically ensures that the static constructors are called in the correct order. In a subclass, you can always assume that the static attributes of the superclasses have been correctly initialized.

6.2.9 Instantiation in Inheritance

A subclass includes the object descriptions of all superclasses. The instantiation of a subclass therefore means the instantiation of all superclasses in a single object, where the initialization of the superclass attributes is ensured by calling the superclass constructors, as described in Section 4.3.2.

The additions `CREATE PUBLIC|PROTECTED|PRIVATE` of the `CLASS` statement or the corresponding Class Builder settings, respectively, control for each class who can create an instance of the class or call its instance constructor (see Section 4.3.2). In inheritance, this results in three scenarios whose behavior is defined in ABAP Objects as follows:

- **Superclass with Public Instantiation**
  The instance constructor of the superclass is publicly visible. If the instantiatiability of a subclass is not explicitly specified, it inherits the public instantiation of the superclass. The instantiatiability of a subclass can be explicitly specified in one of the three ways. A subclass can control the visibility of its own instance constructor independently of the superclass.
- **Superclass with Protected Instantiation**
  The instance constructor of the superclass is visible in subclasses. If the instantiatiability of a subclass is not explicitly specified it inherits the protected instantiation of the superclass. The instantiatiability of a subclass can be explicitly specified in one of the three ways. A subclass can control the visibility of its own instance constructor independently of the superclass and can thus also

publish the protected instance constructor of the superclass in the specified section.

- **Superclass with Private Instantiation**
  The instance constructor of the superclass is visible only in the superclass. There are two different scenarios here:
  - The subclass is not a friend of the superclass.
    Because only the superclass itself can call its instance constructor, the subclass cannot be instantiated. Therefore, the subclass has an implicit addition, `CREATE NONE`. The instantiatiability of the subclass cannot be explicitly specified because this would mean a publication of the superclass constructor in the specified section.
  - The subclass is a friend of the superclass.
    If the instantiatiability of the subclass has not been explicitly specified, it inherits the private instantiation of the superclass. The instantiatiability of a subclass can be explicitly specified in one of the three ways. As a friend, a subclass can publish the private constructor of the superclass in the specified section.

Private superclass

If a superclass with private instantiation has been defined in a path of the inheritance tree, no subclass can be instantiated by external users, and a subclass cannot even instantiate itself because it does not have access to the instance constructor of the superclass! The obvious thing to do would be to make a class defined for private instantiation a final class in order to prevent subclasses from being derived.

Exceptions from this rule only exist if a privately instantiatable superclass offers its friendship to its subclasses. This is not often the case, though, because a superclass usually does not know its subclasses. However, a superclass can offer its friendship to an interface as well, which can then be implemented by its subclasses (see Section 6.3.3). As always, when offering friendship, you should proceed very carefully in this case as well, for example, by restricting the usage of the friendly interface to the current package.

6.3 Standalone Interfaces

In ABAP Objects, interfaces of classes can be defined independently from a class as standalone interfaces.

6.3.1 Basic Principles

Point of contact

The only part of a class that is relevant to an external user is its public interface that is made up of the components of its public visibility section. All other components are irrelevant to the user. This aspect becomes clear particularly when using abstract methods in abstract classes (see Section 6.2.5). Basically, such classes are used to define nothing but interfaces that can only be used with objects of subclasses.

No multiple inheritance

Because ABAP Objects does not support multiple inheritance, the usage of abstract classes for defining interfaces is restricted to their subclasses. However, it is also desirable to be able to define generally valid interfaces that can equally be used in several classes.

Decoupling

Such generally valid interfaces can be provided via standalone interfaces. Standalone interfaces are independently definable interfaces without implementation that can be integrated and implemented in classes. Standalone interfaces are used to achieve a looser coupling between a class and a user, because they provide an additional access layer (protocol). Two scenarios are possible:

- A class entirely or partially provides its public interface to the user via one or several standalone interfaces and thus decouples the user from the actual class definition. Every standalone interface describes an independent aspect of the class and only provides this aspect and nothing else to a user. This can positively affect the maintainability of a class.
- A user has an exact idea of how an object should be used and defines an standalone interface containing all wanted components. Every class that is to fulfill this task integrates this interface and provides the functionality.

BAdI

A very nice application example of this decoupling is given by the enhancebility of delivered ABAP application programs in customer systems using Business Add-Ins (BAdIs). BAdIs are based on standalone interfaces that are declared in the original system. The actual functionality of a BAdI is provided only in follow-up systems by implementing the standalone interface in classes.[14]

14 The comprehensive topic of enhancing and modifying ABAP applications of AS ABAP will not yet be discussed in this edition.

Interface reference variables

Because standalone interfaces are just interfaces without implementation, you cannot create any objects from them—similar to abstract classes. Instead, they are integrated and implemented in classes. If a class implements a standalone interface, it can be addressed via this interface. There are specific interface reference variables for this purpose. These can point to objects of all classes that contain the respective standalone interface. Because any classes can integrate the same interface, their objects can be addressed via the same interface reference variable.

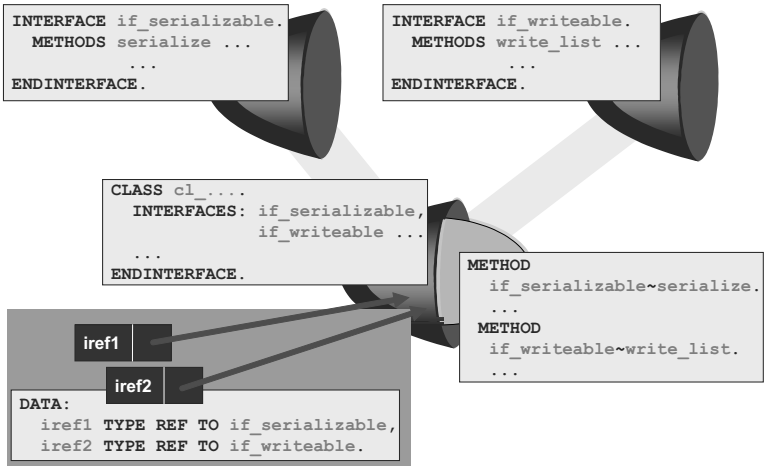

Figure 6.6 Interfaces

Figure 6.6 illustrates the role of interfaces in a graphical way. In our representation of objects with a core that is separated from the external user by a shell, standalone interfaces can be imagined as empty shells that can be used by classes instead of their own shells or as parts of their own shells.[15] For example, if a class wants to provide services like outputting its attributes in a list or serialization, it can implement the corresponding standalone interfaces. Users who are only interested in these different aspects of objects access these via interface reference variables. In the following sections, we will discuss the language elements shown in Figure 6.6 in detail.

15 Compared to Figure 6.1, you can clearly see that the integration of standalone interfaces in classes can also be regarded as a multiple inheritance of interfaces to classes. Because standalone interfaces don't have their own method implementations, there are no conceptual problems like those that occur in multiple inheritance of classes.

6.3.2 Creating Interfaces

With regard to their declaration, interfaces in ABAP Objects play the same role as classes. Just like classes, interfaces are object types that reside in the namespace of all types. While a class describes all aspects of a class, an interface only describes a partial aspect. As mentioned above, standalone interfaces can be regarded as special abstract classes without implementation that can be used in multiple classes.

Accordingly, the declaration of a standalone interface hardly varies from the declaration of a class. As with classes, we distinguish global and local interfaces in the same way that we do global and local classes. Therefore, the same rules apply regarding their usability. Global interfaces can be used in any program if the package assignment of the program permits it. Local interfaces can only be used in the same program.

INTERFACE—ENDINTERFACE

The syntax for declaring a local interface is:

```
INTERFACE intf.
  DATA ...
  CLASS-DATA ...
  METHODS ...
  CLASS-METHODS ...
  ...
ENDINTERFACE.
```

Basically, the declaration of an interface corresponds to the declaration part of a class, where instead of `CLASS—ENDCLASS`, you simply use `INTERFACE—ENDINTERFACE`. Interfaces can contain exactly the same components as classes. Unlike classes, however, interfaces don't need to be divided into different visibility sections because interface components are always integrated in the public visibility section of classes.

To create a global interface, use the Class Builder just as you would for global classes. In the Object Navigator, select **Create • Class Library • Interface**. In Transaction SE24, after selecting **Create**, select the **Interface** object type instead of **Class**.[16]

16 If you observe the naming convention IF_... bzw. ZIF_..., an interface is created automatically.

Class Builder

Figure 6.7 shows the Class Builder for a global interface ZIF_DRIVE_OBJECT. You see the familiar user interface that you know from working with classes. When creating components, you need to specify the same input as you do for classes, except for the assignment to a visibility section. In the shown example, we created the same methods ACCELERATE and SHOW_SPEED as in ZCL_VEHICLE presented in Figure 4.7 in Chapter 4. The shown interface can therefore serve as an interface to objects that can be driven.

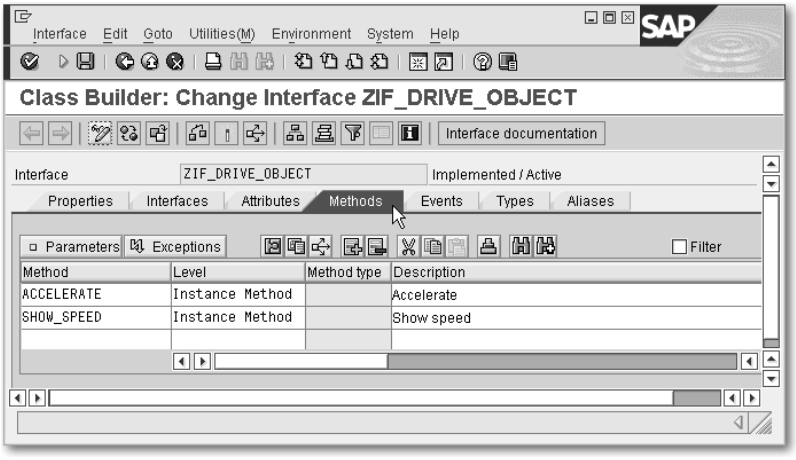

Figure 6.7 Global Interface

The Class Builder generates the corresponding ABAP statements in a program of the interface pool type, the source code of which can also be edited directly via **Goto • Interface Section** (see Figure 6.8). As in class pools, the addition `PUBLIC` identifies the interface as a global interface that can be used in all programs. Apart from the declaration of the global interface, an interface pool cannot contain any local type declarations except for the publication of type groups.[17]

Abstraction

The essential difference between interfaces and classes is that there is no implementation part for an interface. Therefore, it is not necessary to add `DEFINITION` to `INTERFACE`. The methods of an interface are all abstract. They are fully declared, including their parameter interface, but not implemented in the interface. Like the subclasses that

17 In interface pools, declarations like these would not be of any use. They are possible in class pools, but can only be used in the private section of the global class. This section does not exist for interfaces.

implement the abstract methods of their abstract superclasses, all classes that want to use an interface must implement its methods.[18]

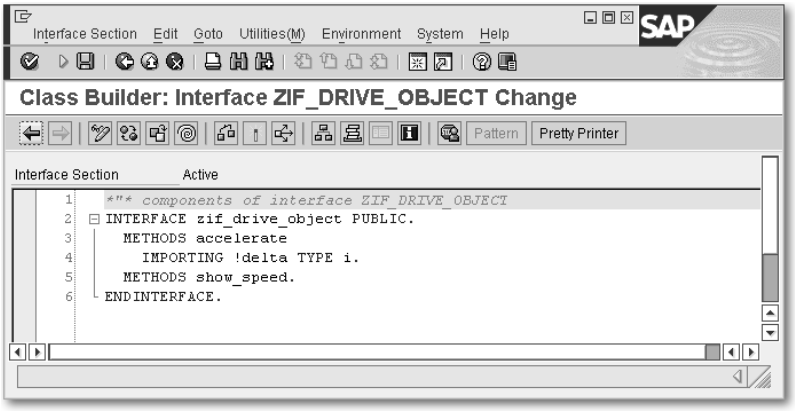

Figure 6.8 Source Code of an Interface Pool

6.3.3 Implementing Interfaces in Classes

Every class can implement one or more interfaces. The essential requirement for implementing an interface is that the interface is known to the implementing class. Therefore, it must be declared globally in the class library or locally in the same program. Additionally, the usage of the interface must be permitted by the package assignment.

INTERFACES The syntax for implementing interfaces is:

```
CLASS class DEFINITION.
  PUBLIC SECTION.
    INTERFACES: intf1, intf2 ...
    ...
  ...
ENDCLASS.
```

Interfaces are therefore integrated using the `INTERFACES` statement in the public visibility section of a class. Only global interfaces can be integrated in the public visibility section of a global class. You can do this on the **Interfaces** tab of Class Builder.

18 Strictly speaking, however, this similarity applies only to instance methods. In interfaces, you can also define static methods without implementation. This is not possible in abstract classes because static methods cannot be redefined.

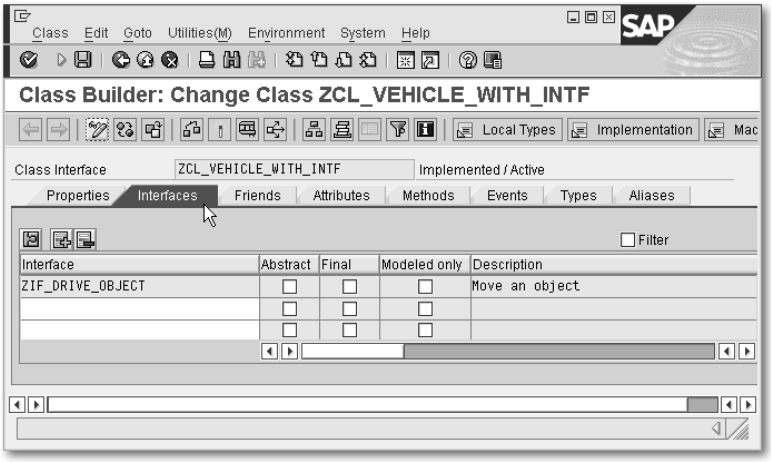

Figure 6.9 Integrating the Interface

In Figure 6.9, we copied the ZCL_VEHICLE class shown in Figure 4.7 to a new class ZCL_VEHICLE_WITH_INTF, deleted its method, and specified the interface ZIF_DRIVE_OBJECT shown in Figure 6.7. In the **Abstract** and **Final** columns, you can specify that all methods of the interface should be either abstract or final in the class. In the `INTERFACES` statement, this is expressed by the optional addition `ALL METHODS ABSTRACT|FINAL`.

intf~comp

Implementing an interface extends the public interface of the class by the interface components. Every `comp` component of an implemented `intf` interface becomes a full component of the class and is identified within the class via the name

```
... intf~comp ...
```

Interface components are inherited to subclasses like class-specific public components. A class can have its own component of the same name like an interface component, or various implemented interfaces can contain components of the same name. All reside in one namespace and are distinguished in the class by different `intf~` prefixes. The tilde sign (~) is the interface component selector.

Figure 6.10 shows how the methods of the interface ZIF_DRIVE_OBJECT are presented in ZCL_VEHICLE_WITH_INTF. In the detailed view (see Figure 6.5), you can specify for every single method if it is to be abstract or final. The `INTERFACES` statement has the optional additions for this purpose, `ABSTRACT METHODS` and `FINAL METHODS`.

Otherwise, however, an interface method can no longer be changed in a class. The same applies to interface attributes. The only property that can be changed when integrating it in a class is the initial value (addition `DATA VALUES` to `INTERFACES`).

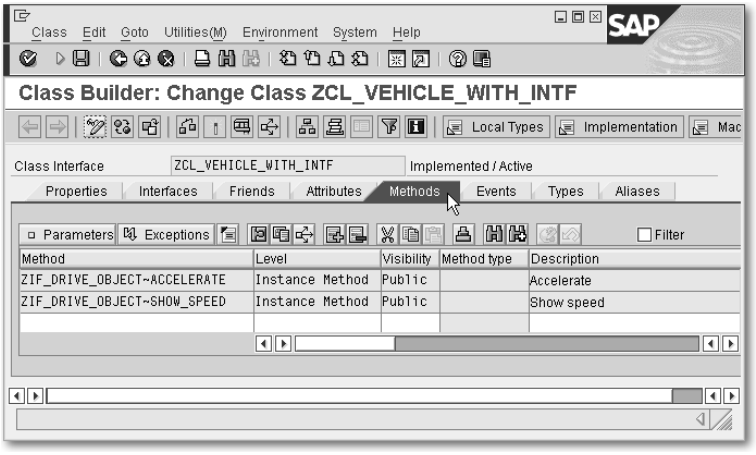

Figure 6.10 Interface Methods

A class must implement all concrete (non-abstract) methods of all integrated interfaces in its implementation part. In the Class Builder, this is achieved via the usual procedure, by selecting **Code** for every interface method. In the ZCL_VEHICLE_WITH_INTF class, we basically used the method implementations of ZCL_VEHICLE (see Listing 6.10).

Listing 6.10 Implementation of Interface Methods

```
CLASS zcl_vehicle_with_intf IMPLEMENTATION.
  METHOD zif_drive_object~accelerate.
    speed = speed + delta.
  ENDMETHOD.
  METHOD zif_drive_object~show_speed.
    DATA output TYPE string.
    output = speed.
    CONCATENATE `Vehicle speed: ` output INTO output.
    MESSAGE output TYPE 'I'.
  ENDMETHOD.
ENDCLASS.
```

If a class does not declare its own components in its public visibility section, but only integrates standalone interfaces, the entire public

interface of the class is defined via standalone interfaces; and standalone interfaces and its public interface are indeed the same for this class. This applies to our sample class ZCL_VEHICLE_WITH_INTF. The interface to the outside world that had so far been built of the class's own components is now completely outsourced to the ZIF_DRIVE_OBJECT interface.

Listing 6.11 summarizes what we have just described using the example of a local interface. The public interface of the `vehicle` class from Listing 4.5 is outsourced to a local standalone interface; however, the local `vehicle` class could just as easily implement the global interface ZIF_DRIVE_OBJECT instead of a local interface `drive_object`.

Listing 6.11 Declaration and Implementation of a Local Interface

```
REPORT z_vehicle_with_intf.

INTERFACE drive_object.
  METHODS: accelerate IMPORTING delta TYPE i,
           show_speed.
ENDINTERFACE.

CLASS vehicle DEFINITION.
  PUBLIC SECTION.
    INTERFACES drive_object.
  PRIVATE SECTION.
    DATA speed TYPE i.
ENDCLASS.

CLASS vehicle IMPLEMENTATION.
  METHOD drive_object~accelerate.
    speed = speed + delta.
  ENDMETHOD.
  METHOD drive_object~show_speed.
    DATA output TYPE string.
    CONCATENATE `Vehicle speed: ` output INTO output.
    output = speed.
    MESSAGE output TYPE 'I'.
  ENDMETHOD.
ENDCLASS.
```

6.3.4 Access to Interfaces of Objects

Objects are always accessed via object reference variables. Until now, we worked with object reference variables that were declared with a reference to a class:

Class reference variable

```
DATA cref TYPE REF TO class.
```

By using these reference variables, you can address all those components of an object's `class` class that are visible at the current position. This kind of object reference variable is therefore referred to as a class *reference variable*.

As you saw in the previous section, the interface components of an interface implemented in a class are handled as full components. You might therefore be tempted to address the interface components of an object as follows:

```
... cref->intf~comp ...
```

In point of fact, this works. You can try this with our ZCL_VEHICLE_WITH_INTF class; however, this kind of access is not recommended. The external user of a class should be able to access its components without having to worry about the technical composition of the interface. Standalone interfaces and the class-specific components both define different sets of components. They should be used directly, but not in mixed forms as shown above. In short, the interface component selector should only be used within classes (and interfaces, see Section 6.3.6).

To access the interface components of objects, ABAP Objects includes interface reference variables. These are object reference variables that are declared with a reference to an interface:

Interface reference variables

```
DATA ref TYPE REF TO intf.
```

An interface reference variable can point to the objects of all classes implementing the `intf` interface. Using such a reference variable, all components of the interface of an object can be addressed directly via

```
... iref->comp ...
```

In contrast to `cref->intf~comp`, the interface reference variable `iref->comp` expresses that components of a class are accessed that are hierarchically on the same level but reside in a different part of the interface. An interface reference variable enables you to address those components of an object that were added to the object's class via the implementation of the `intf` interface that was used to declare the class. Other components—class-specific components or components of other interfaces—cannot be addressed via an interface reference variable (not even dynamically, see Sections 11.1.1 and 11.4.1).

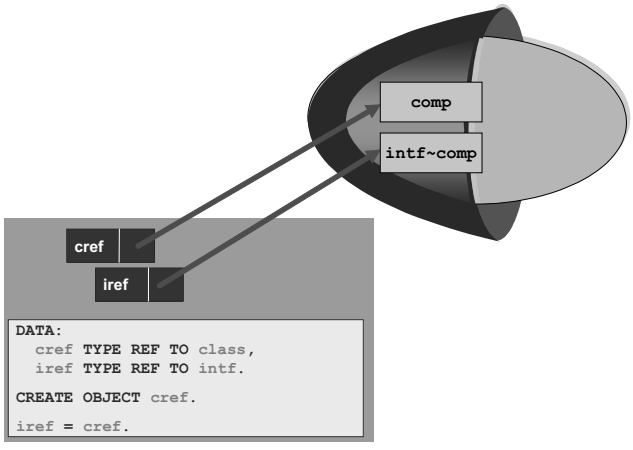

Figure 6.11 Interface Reference Variables

Figure 6.11 shows how class and interface reference variables point to the same object, where the interface reference variable only knows its own interface components, and the class reference variable should only be used to address the non-interface components of the class.

Up Cast

The code in Figure 6.11 already shows how interface reference variables can point to objects. You can simply assign a class reference variable pointing to an object to an interface reference variable. Usually, this is an up cast (see Section 6.4.2 for more information).

This can be accomplished even more comfortably if you're only interested in the interface components of a class. For example, you are naturally only interested in the interface components of a class if the entire public interface of a class is defined via an standalone interface. In these situations, creating the objects of the class via an interface reference variable will suffice:

CREATE OBJECT

```
CREATE OBJECT iref TYPE class EXPORTING ...
```

Via the `TYPE` addition, you specify the class of the object to be created and provide the instance constructor with `EXPORTING`, if necessary. However, you don't need a class reference variable to create the object. The only prerequisite is that the `class` class (or one of its superclasses) contain the `intf` interface.

User view

A user of object reference variables usually works with objects without having to deal with the details of their implementation. In con-

trast to the work with class reference variables, a user of an interface reference variable normally doesn't even need to know from which class the object it is working with originates.

The example shown in Listing 6.12 demonstrates the usage of interface reference variables. The methods `main` and `output` of the `demo` class exclusively work with such object reference variables that were all created with a reference to our sample interface ZIF_DRIVE_OBJECT. For this purpose, an internal table type is declared in `demo` the line type of which is such a reference type. In addition to our global sample class CL_VEHICLE_WITH_INTF, we have also created a local class `electron` that contains the standalone interface as well, but specifically implements the methods by storing the speed in units of the speed of light (c=300.000).

From each of the two classes, an object is created and accelerated, and the object reference is appended to an internal table. Then this table is transferred to the `output` method where the `show_speed` interface method is executed line by line.

Listing 6.12 Standalone Interface Reference Variables

```
REPORT z_drive_many_objects.

CLASS demo DEFINITION.
  PUBLIC SECTION.
    CLASS-METHODS main.
  PRIVATE SECTION.
    TYPES iref_tab_type TYPE TABLE OF
                        REF TO zif_drive_object.
    CLASS-METHODS output IMPORTING iref_tab
                         TYPE iref_tab_type.
ENDCLASS.

CLASS electron DEFINITION.
  PUBLIC SECTION.
    INTERFACES zif_drive_object.
  PRIVATE SECTION.
    CONSTANTS c TYPE i VALUE 300000.
    DATA speed_over_c TYPE p DECIMALS 3.
ENDCLASS.

CLASS electron IMPLEMENTATION.
  METHOD zif_drive_object~accelerate.
    me->speed_over_c = me->speed_over_c + delta / c.
  ENDMETHOD.
  METHOD zif_drive_object~show_speed.
```

```
    DATA output TYPE string.
    output = me->speed_over_c.
    CONCATENATE `Electron speed/c: ` output INTO output.
    MESSAGE output TYPE 'I'.
  ENDMETHOD.
ENDCLASS.

CLASS demo IMPLEMENTATION.

  METHOD main.
    DATA: iref_tab TYPE iref_tab_type,
          iref     LIKE LINE OF iref_tab.
    CREATE OBJECT iref TYPE zcl_vehicle_with_intf.
    iref->accelerate( 100 ).
    APPEND iref TO iref_tab.
    CREATE OBJECT iref TYPE electron.
    iref->accelerate( 250000 ).
    APPEND iref TO iref_tab.
    demo=>output( iref_tab ).
  ENDMETHOD.

  METHOD output.
    DATA iref LIKE LINE OF iref_tab.
    LOOP AT iref_tab INTO iref.
      iref->show_speed( ).
    ENDLOOP.
  ENDMETHOD.

ENDCLASS.

START-OF-SELECTION.
  demo=>main( ).
```

Although the example is similar to the one shown in Listing 4.8, it has a completely new quality. As before, the internal table is a collection of pointers to objects. Because these pointers are interface reference objects, however, the classes and thus the behavior of the objects managed by an internal table can vary.

You should pay special attention to the `output` method. This method is an example of the user mentioned above who works with objects without knowing their classes. The `output` method receives a table with reference variables and knows that it can call a `show_speed` method there. The actual implementation is irrelevant to it. This matches the concept of polymorphism that is illustrated in Figure 6.14 exactly and will be further discussed in the corresponding section. For the moment, it will suffice just to note that syntactically identical method calls in a loop lead to different output.

6.3.5 Access to Static Interface Components

Because interfaces can contain the same components as classes, static components are possible as well. You cannot access the static components of an interface using the name of the interface and the class component selector. The only exceptions are constants declared via CONSTANTS:

```
... intf=>const ...
```

The static components belong to the static components of every implementing class. This means that static attributes have different values depending on the class and that static methods can be differently implemented in every class. To access the static components of interfaces, independently of the instance, you would have to use the name of an implementing class and the interface component selector:

```
... class=>intf~comp ...
```

Alias names

However, this should be the exception for the reasons mentioned in Section 6.3.4. Instead, implementing classes should declare aliases (see Section 6.3.7) for the static components of interfaces and therefore make them addressable via the class name like their own static components. Naturally, you can always use interface reference variables for accessing static components after you created objects from the implementing classes.

6.3.6 Composing Interfaces

In Figure 6.9, it is apparent that the Class Builder provides the **Interfaces** tab as well for an interface as it does for a class. Accordingly, the INTERFACES statement cannot only be used in classes but also in the declaration of an interface:

```
INTERFACE intf1.
  INTERFACES: intf2, intf3, ...
  ...
ENDINTERFACE.
```

Component interface

This mechanism allows you to compose several interfaces into one interface. The composition of interfaces can be useful when modeling complex applications.

The set of components of an interface `intf1` that integrates additional interfaces (i. e., `intf2`, `intf3`, ...) are composed of its own components and the components of the integrated interfaces. The components all reside on the same level. An interface containing at least one other interface is called composite or nested interface. An interface integrated in another interface is called a component interface. A component interface can be composed itself. Let's now look at the nesting of interfaces shown in Listing 6.13.

Listing 6.13 Composite Interfaces

```
INTERFACE intf1.
  ...
ENDINTERFACE.

INTERFACE intf2.
  INTERFACES: intf1 ...
  ...
ENDINTERFACE.

INTERFACE intf3.
  INTERFACES: intf1, intf2 ...
  ...
ENDINTERFACE.
```

The composite interface `intf3` has a component `intf2` that is composed itself. Although it seems like the nesting of several interfaces caused a component hierarchy, this is not the case. All component interfaces of a composite interface are on the same level. A nesting of names like `intf3~intf2~intf1` is not possible.

In the example above, the component interface `intf1` of the composite interface `intf2` becomes a component interface of `intf3`. A composite interface contains each component interface exactly once. Although `intf1` is integrated in `intf3` both directly as a component interface of `intf3` and indirectly via `intf2`, it only occurs once. In `intf3`, it can only be addressed under the name `intf1`, even if it was not integrated directly.

Implementation

If a composite interface is implemented in a class, all interface components of the interface behave as if their interface had been implemented only once. The interface components of the individual component interfaces extend the public interface of the class by its original name. Because every interface is included exactly once in a composite interface, naming conflicts cannot occur. The way an

implemented interface is composed is irrelevant when it is implemented in a class. Next, let's look at the example shown in Listing 6.14:

Listing 6.14 Implementation of Composite Interfaces

```
INTERFACE intf1.
  METHODS meth.
ENDINTERFACE.

INTERFACE intf2.
  INTERFACES intf1.
  METHODS meth.
ENDINTERFACE.

INTERFACE intf3.
  INTERFACES intf1.
  METHODS meth.
ENDINTERFACE.

INTERFACE intf4.
  INTERFACES: intf2, intf3.
ENDINTERFACE.

CLASS class DEFINITION.
  PUBLIC SECTION.
    INTERFACES intf4.
ENDCLASS.

CLASS class IMPLEMENTATION.
  METHOD intf1~meth. ... ENDMETHOD.
  METHOD intf2~meth. ... ENDMETHOD.
  METHOD intf3~meth. ... ENDMETHOD.
ENDCLASS.
```

A method `meth` of the same name is declared in three individual interfaces and thus implemented in three different ways using the interface component selector. The composition of the interfaces does not play any role. The `intf1~meth` method is implemented only once, although it occurs in two interfaces, `intf2` and `intf3`. The name `intf4` does not show up in the implementation part of the class at all.

If you list one or more of the other interfaces—`intf1`, `intf2`, or `intf3`—in addition to `intf4` in the declaration part of the `class` mentioned above, the components and the implementation part of the class do not change at all, because the compiler always ensures for a class as well as in composite interfaces that every component exists only once.

If the class of an object implements a composite interface, the object is accessed in the same way as if the class implemented every interface individually. This means that interface components should be accessed using interface reference variables of the type of the appropriate component interface. This can always be achieved using the corresponding assignments to interface reference variables (up casts, see Section 6.4.2). The interface component selector should not be used for this purpose; however, it can be used in a composite interface to make the components of component interfaces as accessible as native components via aliasing.

Access

6.3.7 Alias Names for Interface Components

The complete name of a component that is added via an interface to a class or another interface is `intf~comp`. For this name, you can define an alias name at the level at which the interface is integrated using the `INTERFACES` statement:

```
ALIASES name FOR intf~comp.
```

ALIASES

Alias names can be assigned when interfaces are implemented in the declaration part of a class or when interfaces are composed in the declaration of an interface. In the Class Builder, you can enter alias names for classes and for interfaces in the **Aliases** tab (see Figure 6.12).

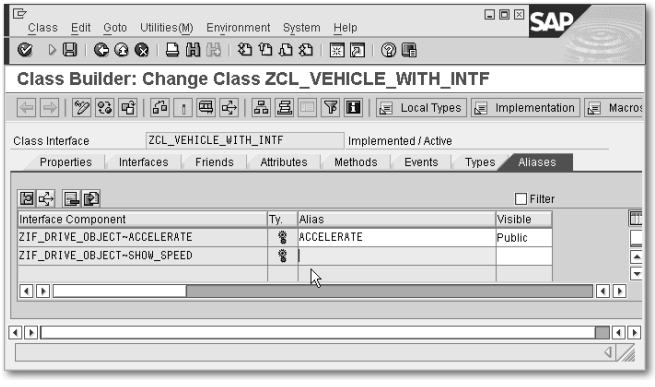

Figure 6.12 Alias Names

Alias Names in Classes

In classes, alias names belong to the namespace of the components of a class and must be assigned to a visibility section just like the other

components. The visibility of an alias name from outside the class depends on its visibility section and not on the visibility section of the assigned interface component.

In Listing 6.15, we modify the example of Listing 6.12 by using alias names. For this purpose, in the local class `electron`, we declare an alias name `accelerate` for the `zif_drive_object~accelerate` interface method as we did for ZCL_VEHICLE_WITH_INTF (see Figure 6.12). Listing 6.15 shows only the differences between it and Listing 6.12.

Listing 6.15 Alias Names in Classes

```
REPORT z_drive_via_aliases.

...
CLASS electron DEFINITION.
  PUBLIC SECTION.
    INTERFACES zif_drive_object.
    ALIASES accelerate FOR zif_drive_object~accelerate.
  PRIVATE SECTION.
    ...
ENDCLASS.
CLASS electron IMPLEMENTATION.
  METHOD accelerate.
    me->speed_over_c = me->speed_over_c + delta / c.
  ENDMETHOD.
  ...
ENDCLASS.
CLASS demo IMPLEMENTATION.
  METHOD main.
    DATA: vehicle  TYPE REF TO zcl_vehicle_with_intf,
          electron TYPE REF TO electron,
          iref_tab TYPE iref_tab_type.
    CREATE OBJECT vehicle.
    vehicle->accelerate( 100 ).
    APPEND vehicle TO iref_tab.
    CREATE OBJECT electron.
    electron->accelerate( 250000 ).
    APPEND electron TO iref_tab.
    demo=>output( iref_tab ).
  ENDMETHOD.
  ...
ENDCLASS.
START-OF-SELECTION.
  demo=>main( ).
```

The interface method can now be implemented in the class via its alias name and called by a user like a direct method of the class. Here, we change the `main` method in which the classes for the object creation must be known, anyway so that the objects are created via class reference variables. Because of the alias name, the class reference variables can be used to call the interface method `accelerate` without using the interface component selector. Nothing is changed in the `output` method, which does not need to know the classes.

Using alias names, a class can publish its interface components as class-specific components, so to speak. In particular, alias names can be used in classes to further on address class-specific components that are outsourced to standalone interfaces in the course of a development cycle using their old name. Then, the users of the class don't need to be adapted to the new names.

In our sample class ZCL_VEHICLE_WITH_INTF, we converted the methods from ZCL_VEHICLE to interface methods. Just imagine if we had made this change directly in ZCL_VEHICLE! All users would have become syntactically incorrect. By introducing alias names simultaneously, however, the class would have remained addressable.

Alias Names in Composite Interfaces

Because names cannot be concatenated in composite interfaces, alias names provide the only means of addressing those components that would otherwise not be available in the composite interface. Let's look at the example shown in Listing 6.16.

Listing 6.16 Alias Names in Interfaces

```
INTERFACE intf1.
  METHODS meth1.
ENDINTERFACE.

INTERFACE intf2.
  INTERFACES intf1.
  ALIASES meth1 FOR intf1~meth1.
ENDINTERFACE.

INTERFACE intf3.
  INTERFACES intf2.
  ALIASES meth1 FOR intf2~meth1.
ENDINTERFACE.
```

The intf3 interface can use the alias name meth1 in intf2 to address the meth1 component of the intf1 interface in its own ALIASES statement. Without alias names in intf2, this would not be possible because the name intf2~intf1~m1 is not permitted. Now the user of intf3 can access the component meth1 in intf1 without having to know anything about the composition of the interface:

```
DATA i_ref TYPE REF TO intf3.
...
i_ref->meth1( ... ).
```

Without alias names in intf3, the access would look as follows:

```
i_ref->intf1~meth1( ... ).
```

The user would have to know that intf3 is composed of intf2, which is composed of intf1. For global interfaces, in particular, the user should not have to look at the composition of an interface in the Class Builder before he can use a method of the interface. Of course, it is not necessary that the alias names always match the original names.

6.3.8 Interfaces and Inheritance

To conclude the description of interfaces, we will discuss the relationship of standalone interfaces to inheritance and compare both concepts in a summary.

The concepts of standalone interfaces and inheritance are independent of each other and totally compatible. Any number of interfaces can be implemented in the classes of an inheritance tree, but every interface can be implemented only once per inheritance tree path. Thus, every interface component has a unique name intf~comp throughout the inheritance tree and is contained in all subclasses of the class implementing the interface. After their implementation, interface methods are full components of a class and can be redefined in subclasses. Although interface methods cannot be identified as abstract or final in the interface declaration, every class can specify these settings when implementing the interface.

Coupling

The usage of inheritance always makes sense when different classes have a generalization/specialization relationship. For example, if we

regard two classes "cargo plane" and "passenger plane", both classes contain components that can be declared in a common "plane" superclass. The big advantage of inheritance is that the subclasses take on and reuse all properties already programmed in the superclass. At the same time, this causes a very tight coupling between superclasses and subclasses. A subclass strongly depends on its superclass, because it often largely consists of the superclass components. A subclass must know its superclass exactly. This became particularly clear, for example, in the discussion of instance constructors in inheritance (see Section 6.2.8). Every change to non-private components of a superclass changes all of its subclasses. Conversely, subclasses can also affect the design of superclasses due to specific requests. If you use inheritance for defining classes, you should ideally have access to all classes involved because only all of the classes in a path of the inheritance tree make a reasonable whole. On the other hand, it is dangerous to just link to some superclass by defining a subclass if the superclass does not belong to the same package, or was explicitly shared as a superclass in the package interface.[19]

Decoupling

The implementation of interfaces is always recommended when interfaces or protocols are to be described without having to use a specific type of implementation. An additional layer is introduced between user and class that decouples the user from an explicit class and therefore makes it much more independent. Interfaces allow the user to handle the most different classes, which don't need to be related to each other. In object-oriented modeling, interfaces provide an abstraction that is independent of classes. Irrespective of the actual implementation, the services required by a user can be described. Additionally, interfaces also implement an aspect of multiple inheritance, because several interfaces can be implemented in a class. If a programming language permits a real multiple inheritance, this multiple inheritance is usually used in the sense of interfaces as well. This means that only abstract classes with exclusively abstract methods are suitable as different superclasses of a single subclass. Otherwise, the question would arise regarding which method implementation is actually used in a subclass if it is already implemented

19 A complete package concept that allows you to predefine and check such specifications in the package interface will only be implemented in the next SAP NetWeaver release.

in several superclasses.[20] As with superclasses in inheritance, you should note that for interfaces as well later changes to an interface might make all classes implementing the interface syntactically incorrect.

6.4 Object References and Polymorphism

Object references are the linchpin when dealing with objects. They are used for creating and addressing objects. As the contents of object reference variables, they can be assigned to other variables or passed to procedures.

Object reference variables are divided into class reference variables and interface reference variables. When using interface reference variables, we already observed that the type of a reference variable does not have to match the type of the referenced object. In this section, we will have a closer look at this fact and at the resulting polymorphic behavior of method calls.

6.4.1 Static and Dynamic Type

In this section, we define two important terms for reference variables, that is, their static *type* and dynamic type.

Static type

The static type of a reference variable `oref` is the type that is specified after

```
... oref TYPE REF TO class|intf ...
```

in the declaration. As with all data objects, the static type is fixed during the entire runtime of a program. For object reference variables, the object types `class` for class reference variables and `intf` for interface reference variables are possible as static types.[21]

20 This is the "diamond" problem of multiple inheritance. A method that is declared in a superclass is redefined in two subclasses, which, in turn, make up the superclass of another subclass. Which implementation is used in this subclass? For interfaces, this problem does not occur, because in the implementation of composite interfaces every interface method exists only once.

21 Accordingly, data types are possible as static types for data reference variables that can point to data objects (see Section 11.1.2).

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