



Orientation Guide for Server-Side Programming

Version 2019.1
2019-03-19

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InterSystems IRIS Data Platform Version 2019.1 2019-03-19

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About This Book

This book presents background material that is important to know when writing server-side code for an InterSystems IRIS™ application. It consists of the following topics:

- [Introduction to InterSystems IRIS™ Programming](#)
- [A Closer Look at ObjectScript](#)
- [Classes](#)
- [Objects](#)
- [Persistent Objects and InterSystems IRIS SQL](#)
- [Namespaces and Databases](#)
- [InterSystems IRIS Security](#)
- [Localization Support](#)
- [Server Configuration Options](#)
- [What's That?](#)
- [Rules and Guidelines for Identifiers](#)
- [General System Limits](#)
- [Numeric Computing in InterSystems Applications](#)

For a detailed outline, see the [table of contents](#).

For information about related topics, see the following documents:

- [Defining and Using Classes](#) describes how to create and work with classes and objects.
- [Using ObjectScript](#) describes concepts and how to use the ObjectScript language.
- [Using InterSystems SQL](#) describes how to use InterSystems SQL and where you can use this language.
- [Using Globals](#) describes how to work with multidimensional arrays and globals.
- [InterSystems Programming Tools Index](#) is a directory of the InterSystems classes, routines, bindings, and other programming tools, grouped by topic.

For demonstration purposes, this book refers to the Samples-Data sample (<https://github.com/interSystems/Samples-Data>). You might find it helpful to download and set up this sample, but doing so is not necessary. If you do download the sample, InterSystems recommends that you create a dedicated namespace called SAMPLES (for example) and load samples into that namespace. For the general process, see [Downloading Samples for Use with InterSystems IRIS](#).

1

Introduction to InterSystems IRIS Programming

This book is an orientation guide for programmers. It is not a tutorial but rather a survey of the basic features of server-side programming.

This chapter provides a high-level overview of the language elements you can use in InterSystems IRIS™ server-side programs. It discusses the following topics:

- [Introduction](#)
- [Routines](#)
- [Classes](#)
- [Globals](#)
- [InterSystems SQL](#)
- [Macros](#)
- [Include files](#)
- [How these elements work together](#)

1.1 Introduction

InterSystems IRIS is a high-performance object database with a built-in general-purpose programming language. It supports multiple processes and provides concurrency control. Each process has direct, efficient access to the data.

In InterSystems IRIS, you can write routines, classes, or a mix of these, as suits your preferences. In all cases, stored data is ultimately contained in structures known as globals (a later section in this chapter discusses these). InterSystems IRIS programming has the following features:

- Routines and classes can be used interchangeably.
- Routines and classes can call each other.
- Classes provide object-oriented features.
- Database storage is integrated into the programming language.

- Classes can persist data in a way that simplifies programming. If you use persistent classes, data is simultaneously available as objects, SQL tables, and globals.
- You can access globals directly from either routines or classes, which means that you have the flexibility to store and access data exactly how you want.

You can choose the approach that is appropriate for your needs.

1.2 Routines

When you create routines in InterSystems IRIS, you use ObjectScript. The following shows part of a routine written in ObjectScript:

```
SET text = ""
FOR i=1:5:$LISTLENGTH(attrs)
{
    IF ($ZCONVERT($LIST(attrs, (i + 1)), "U") = "XREFLABEL")
    {
        SET text = $LIST(attrs, (i + 4))
        QUIT
    }
}

IF (text = "")
{
    QUIT $$$ERROR($$$GeneralError,$$$T("Missing xreflabel value"))
}
```

The [next chapter](#) provides an introduction to ObjectScript.

1.3 Classes

InterSystems IRIS also supports classes. You can use the system classes and you can define your own classes.

In InterSystems IRIS, a class can include familiar class elements such as properties, methods, and parameters (known as constants in other class languages). It can also include items not usually defined in classes, including triggers, queries, and indices.

The following shows a class definition:

```
Class Sample.Employee Extends Person
{
    // The employee's job title.
    Property Title As %String(MAXLEN = 50);

    // The employee's current salary.
    Property Salary As %Integer(MAXVAL = 100000, MINVAL = 0);

    // A character stream containing notes about this employee.
    Property Notes As %Stream.GlobalCharacter;

    // A picture of the employee
    Property Picture As %Stream.GlobalBinary;

    // This method overrides the method in the Person class.
    Method PrintPerson()
    {
        Write !,"Name: ", ..Name, ?30, "Title: ", ..Title
        Quit
    }
}
```

You can use classes from within routines. For example, the following shows part of a routine, in which we refer to the `Sample.Person` class:

```
//get details of requested person; print them
showperson() public {
  set rand=$RANDOM(10)+1      ; rand is an integer in the range 1-10
  write "Your random number: "_rand
  set person=##class(Sample.Person).%OpenId(rand)
  write !,"This person's name: "_person.Name
  write !,"This person's age: "_person.Age
  write !,"This person's home city: "_person.Home.City
}
```

Similarly, a method can invoke a label in a routine. For example:

```
Method DemoRoutineCall(input) as %String
{
  Set value=$$function^myroutine(input)
  Quit value
}
```

Later chapters discuss [classes in InterSystems IRIS](#) and the unique capabilities of [persistent classes](#) in InterSystems IRIS.

1.4 Introduction to Globals

InterSystems IRIS supports a special kind of variable that is not seen in other programming languages; this is a *global variable*, which is usually just called a *global*. In InterSystems IRIS, the term *global* indicates that this data is available to all processes accessing this database. This usage is different from other programming languages in which *global* means “available to all code in this module.”

The contents of a global are stored in an InterSystems IRIS database. The [next chapter](#) introduces these more thoroughly; for now, it is important just to know the following points:

- A global consists of a set of nodes (in some cases, only one node), identified by subscripts. Each node can contain a value.
- ObjectScript includes functions to iterate through the nodes of a global and quickly access values.
- A global is automatically stored in the database. When you assign a value to a node of a global variable, the data is written immediately to the database.
- You can see the contents of a global via an ObjectScript command or via the Management Portal.

1.4.1 Ways to Access Data

In InterSystems IRIS, a database contains globals and nothing else; even code is stored in globals, as described later in this book. At the lowest level, all access to data is done via *direct global access* — that is, by using commands and functions that work directly with globals.

When you use persistent classes, discussed later in this book, you can create, modify, and delete stored data in either of the following ways:

- By using methods such as `%New()`, `%Save()`, `%Open()`, and `%Delete()`.
- By using InterSystems SQL.

Internally, the system always uses direct global access.

1.5 InterSystems SQL

InterSystems IRIS provides an implementation of SQL, known as InterSystems SQL.

You can use InterSystems SQL within routines and within methods. To use SQL in these contexts, you can use either or both of the following tools:

- *Dynamic SQL* (the %SQL.Statement and %SQL.StatementResult classes), as in the following example:

```
SET myquery = "SELECT TOP 5 Name,Home_City FROM Sample.Person ORDER BY Age"
SET tStatement = ##class(%SQL.Statement).%New()
SET tStatus = tStatement.%Prepare(myquery)
SET rset = tStatement.%Execute()
DO rset.%Display()
WRITE !,"End of data"
```

You can use dynamic SQL in any context.

- *Embedded SQL*, as in the following example:

```
&sql(SELECT COUNT(*) INTO :myvar FROM Sample.Person)
Write myvar
```

The first line is embedded SQL, which executes an InterSystems SQL query and writes a value into a *host variable* called myvar.

The next line is ordinary ObjectScript; it simply writes the value of the variable myvar.

You can use embedded SQL in ObjectScript routines and in methods written in ObjectScript.

1.6 Macros

ObjectScript also supports *macros*, which define substitutions. The definition can either be a value, an entire line of code, or (with the ##Continue directive) multiple lines. You use macros to ensure consistency. For example:

```
#define StringMacro "Hello, World!"
write $$$StringMacro
```

To give you an idea of what can be done in macros, the following example shows the definition of a macro that is used internally:

```
#define output1(%str,%lf,%indent) do output^%fm2class(%str,%lf,%indent,$$display)
```

This macro accepts an argument, as many of them do. It also refers to another macro.

You can use macros in routines as well as in classes. Some of the system classes use them extensively.

1.7 Include Files

You can define macros in a routine and use them later in the same routine. More commonly, you define them in a central place. To do this, you create and use *include files*. An include file defines macros and can include other include files.

The following shows parts of a system include file:

```

/// Create a success %Status code
#define OK 1

/// Return true if the %Status code is success, and false otherwise
/// %sc - %Status code
#define ISOK(%sc) (+%sc)

/// Return true if the %Status code if an error, and false otherwise
/// %sc - %Status code
#define ISERR(%sc) ('%sc)

```

Then you can do the following:

- Include the include file at the start of any routine. That routine can refer to the macros defined in the include file.
- Include the include file at the start of any class. Methods in that class can refer to the macros.
- Include the include file at the start of any method. That method can refer to the macros.

Note that you use slightly different syntax to include an include file within a class definition. See “[Macros and Include Files in Class Definitions](#),” later in this book.

1.8 How These Code Elements Work Together

It is useful to understand how InterSystems IRIS uses the code elements introduced in this chapter.

The reason that you can use a mix of ObjectScript, InterSystems SQL, macros, class definitions, routines, and so on is that InterSystems IRIS does not *directly* use the code that you write. Instead, when you compile your code, the system generates the code that it uses, which is OBJ code, used by the InterSystems IRIS virtual machine.

There are multiple steps. It is not necessary to know the steps in detail, but the following points are good to remember:

- The *class compiler* uses the class definitions and generates INT code.

In some cases, the compiler generates and saves additional classes, which you should not edit. This occurs, for example, when you compile classes that define web services and web clients.

The class compiler also generates the class descriptor for each class. The system code uses this at runtime.

- A *preprocessor* (sometimes called the *macro preprocessor* or *MPP*) uses the include files (not shown in the figure) and replaces the macros. It also handles the embedded SQL in the ObjectScript routines.

These changes occur in a temporary work area, and your code is not changed.

- Additional compilers create INT code for the ObjectScript routines. This layer is known as intermediate code. In this layer, all access to the data is done via direct global access.

INT code is compact but human-readable.

- INT code is used to generate OBJ code.

The InterSystems IRIS virtual machine uses this code. Once you have compiled your code, the routines and INT code are no longer necessary for code execution.

- After you compile your classes, you can put them into *deployed* mode. InterSystems IRIS has a utility that removes the class internals and the intermediate code for a given class; you can use this utility when you deploy your application.

If you examine the InterSystems IRIS system classes, you might find that some classes cannot be seen because they are in deployed mode.

Note: All routines and class definitions are stored in the same InterSystems IRIS databases as the generated code. This fact makes the code easier to manage. InterSystems IRIS provides a robust set of source control hooks that InterSystems developers have used for many years. You can use these hooks as well.

2

A Closer Look at ObjectScript

Most methods and most routines are written in ObjectScript. This chapter gives an overview of this language, if you intend to use it or if you need to understand code that other people have written. This chapter discusses the following topics:

- [Routines](#)
- [Procedures, functions, and subroutines](#)
- [Variables](#)
- [Variable availability and scope](#)
- [Multidimensional arrays](#)
- [Operators](#)
- [Commands](#)
- [Special variables](#)
- [Locking and concurrency control](#)
- [Functions](#)
- [Date and time values](#)
- [Macros and include files](#)
- [How to use routines, procedures, functions, and subroutines](#)
- [Potential pitfalls](#)
- [Other sources of information on these topics](#)

A method can contain the same statements, labels, and comments as routines do. That is, all the information here about the contents of a routine also applies to the contents of a method.

If you are writing classes rather than routines, start with the section “[Variables](#).”

2.1 Routines

The following shows an example routine named `demoroutine` that is written in ObjectScript. This example gives us an opportunity to see some common commands, operators, and functions, and to see how code is organized within a routine.

```
; this is demoroutine
write "Use one of the following entry points:"
write !,"random"
write !,"input"
write !,"interesting"
quit

//this procedure can be called from outside the routine
random() public {
  set rand=$RANDOM(10)+1      ; rand is an integer in the range 1-10
  write "Your random number: "_rand
  set name=$$getnumbername(rand)
  write !, "Name of this number: "_name
}

//this procedure can be called from outside the routine
input() public {
  read "Enter a number from 1 to 10: ", input
  set name=$$getnumbername(input)
  write !, "Name of this number: "_name
}

//this procedure can be called only from within this routine
getnumbername(number) {
  set name=$CASE(number,1:"one",2:"two",3:"three",
  4:"four",5:"five",6:"six",7:"seven",8:"eight",
  9:"nine",10:"ten",:"other")
  quit name
}

/* write some interesting values
this procedure can be called from outside the routine
*/
interesting() public {
  write "Today's date: "_$ZDATE($HOROLOG,3)
  write !,"Your installed version: "_$ZVERSION
  write !,"Your username: "_$USERNAME
  write !,"Your security roles: "_$ROLES
}
```

Note the following highlights:

- The only identifier that actually starts with a caret (^) is the name of a global; these are discussed later in this chapter. However, in running text and in code comments, it is customary to refer to a routine as if its name started with a caret, because you use the caret when you invoke the routine (as shown later in this chapter). For example, the routine `demoroutine` is usually called `^demoroutine`.
- The routine name does not have to be included within the routine. However, many programmers include the routine name as a comment at the start of the routine or as the first label in the routine.
- The routine has multiple *labels*: `random`, `input`, `getnumbername`, and `interesting`.

Labels are used to indicate the starting point for procedures (as in this example), functions, and subroutines; these terms are defined [later in this chapter](#). You can also use them as a destination for certain commands.

Labels are common in routines, but you can also use them within methods.

Labels are also called *entry points* or *tags*.

- The `random` and `input` subroutines invoke the `getnumbername` subroutine.
- **WRITE**, **QUIT**, **SET**, and **READ** are commands. The language includes other commands to remove variables, commands to control program flow, commands to control I/O devices, commands to manage transactions (possibly nested), and so on.

The names of commands are not case-sensitive, although they are shown in running text in all upper case by convention.

- The sample includes two operators. The plus sign (+) performs addition, and the underscore (_) performs string concatenation.

ObjectScript provides the usual operators and some special operators not seen in other languages.

- **\$RANDOM**, **\$CASE**, and **\$ZDATE** are functions.

The language provides functions for string operations, conversions of many kinds, formatting operations, mathematical operations, and others.

- **\$HOROLOG**, **\$ZVERSION**, **\$USERNAME**, and **\$ROLES** are system variables (called *special variables* in InterSystems IRIS). Most special variables contain values for aspects of the InterSystems IRIS operating environment, the current processing state, and so on.
- ObjectScript supports comment lines, block comments, and comments at the end of statements.

We can execute parts of this routine in the Terminal, as a demonstration. First, the following shows a Terminal session, in which we run the routine itself. In these examples, `TESTNAMESPACE>` is the prompt shown in the Terminal. The text after the prompt on the same line is the entered command. The lines after that show the values that the system writes to the Terminal in response.

```
TESTNAMESPACE>do ^demoroutine
Use one of the following entry points:
random
input
TESTNAMESPACE>
```

When we run the routine, we just get help information, as you can see. It is not required to write your routines in this way, but it is common. Note that the routine includes a **QUIT** before the first label, to ensure that when a user invokes the routine, processing is halted before that label. This practice is also not required, but is also common.

Next, the following shows how a couple of the subroutines behave:

```
TESTNAMESPACE>do input^demoroutine
Enter a number from 1 to 10: -7
Name of this number: other
TESTNAMESPACE>d interesting^demoroutine
Today's date: 2018-02-06
Your installed version: IRIS for Windows (x86-64) 2018.1 (Build 513U) Fri Jan 26 2018 18:35:11 EST
Your username: _SYSTEM
Your security roles: %All
TESTNAMESPACE>
```

2.2 Procedures, Functions, and Subroutines

Within an ObjectScript routine, a label defines the starting point for one of the following units of code:

- *Procedure* (optionally returns a value). The variables defined in a procedure are private to that procedure, which means that they are not available to other code. This is not true for functions and subroutines.

A procedure is also called a *procedure block*.

- *Function* (returns a value).
- *Subroutine* (does not return a value).

InterSystems recommends that you use procedures, because this simplifies the task of controlling the scope of variables. In existing code, however, you might also see functions and subroutines, and it is useful to be able to recognize them. The following list shows what all these forms of code look like.

procedure

```
label(args) scopekeyword {
    zero or more lines of code
    QUIT returnvalue
}
```

Or:

```
label(args) scopekeyword {
    zero or more lines of code
}
```

label is the identifier for the procedure.

args is an optional comma-separated list of arguments. Even if there are no arguments, you must include the parentheses.

The optional *scopekeyword* is one of the following (not case-sensitive):

- **Public**. If you specify `Public`, then the procedure is *public* and can be invoked outside of the routine itself.
- **Private** (the default for procedures). If you specify `Private`, the procedure is *private* and can be invoked only by other code in the same routine. If you attempt to access the procedure from another routine, a `<NOLINE>` error occurs.

returnvalue is an optional, single value to return. To return a value, you must use the **QUIT** command. If you do not want to return a value, you can omit the **QUIT** command, because the curly braces indicate the end of the procedure.

A procedure can declare variables as public variables, although this practice is not considered modern. To do this, you include a comma-separated list of variable names in square brackets immediately before *scopekeyword*. For details, see “[User-defined Code](#)” in *Using ObjectScript*.

function

```
label(args) scopekeyword
    zero or more lines of code
    QUIT optionalreturnvalue
```

args is an optional comma-separated list of arguments. Even if there are no arguments, you must include the parentheses.

The optional *scopekeyword* is either `Public` (the default for functions) or `Private`.

subroutine

```
label(args) scopekeyword
    zero or more lines of code
    QUIT
```

args is an optional comma-separated list of arguments. If there are no arguments, the parentheses are optional.

The optional *scopekeyword* is either `Public` (the default for subroutines) or `Private`.

The following table summarizes the differences among routines, subroutines, functions, and procedures:

	Routine	Subroutine	Function	Procedure
Can accept arguments	no	yes	yes	yes
Can return a value	no	no	yes	yes
Can be invoked outside the routine (by default)	yes	yes	yes	no
Variables defined in it are available after the code finishes execution	yes	yes	yes	depends on nature of the variable

The section “[Variable Availability and Scope](#),” later in this chapter, has further details on variable scope.

Note: In casual usage, the term *subroutine* can mean procedure, function, or subroutine (as defined formally here).

2.3 Variables

In ObjectScript, there are two kinds of variables, as categorized by how they hold data:

- *Local variables*, which hold data in memory.
Local variables can have public or private scope.
- *Global variables*, which hold data in a database. These are also called *globals*. All interactions with a global affect the database immediately. For example, when you set the value of a global, that change immediately affects what is stored; there is no separate step for storing values. Similarly, when you remove a global, the data is immediately removed from the database.

There are special kinds of globals not discussed here; see “[Caret \(^\)](#)” in the appendix “[What’s That?](#)”

2.3.1 Variable Names

The names of variables follow these rules:

- For most local variables, the first character is a letter, and the rest of the characters are letters or numbers. Valid names include `myvar` and `i`.
- For most global variables, the first character is always a caret (^). The rest of the characters are letters, numbers, or periods. Valid names include `^myvar` and `^my.var`.

InterSystems IRIS also supports a special kind of variable known as a *percent variable*; these are less common. The name of a percent variable starts with a percent character (%). Percent variables are special in that they are always public; that is they are visible to all code within a process. This includes all methods and all procedures within the calling stack.

When you define percent variables, use the following rules:

- For a local percent variable, start the name with `%Z` or `%z`. Other names are reserved for system use.
- For a global percent variable, start the name with `^%Z` or `^%z`. Other names are reserved for system use.

For details on percent variables and variable scope, see “[Variable Availability and Scope](#),” later in this chapter; also see “[Callable User-defined Code Modules](#)” in *Using ObjectScript*.

For further details on names and for variations, see “[Syntax Rules](#)” in *Using ObjectScript*. Or see “[Rules and Guidelines for Identifiers](#),” later in this book.

2.3.2 Variable Types

Variables in ObjectScript are weakly, dynamically typed. They are dynamically typed because you do not have to declare the type for a variable, and variables can take any legal value — that is, any legal literal value or any legal ObjectScript expression. They are weakly typed because usage determines how they are evaluated.

A legal literal value in ObjectScript has one of the following forms:

- Numeric. Examples: `100`, `17.89`, and `1e3`
- Quoted string, which is a set of characters contained within a matched set of quotation marks ("). For example: `"my string"`

To include a double quote character within a string literal, precede it with another double quote character. For example: `"This string has ""quotes"" in it."`

Depending on the context, a string can be treated as a number and vice versa. Similarly, in some contexts, a value may be interpreted as a boolean (true or false) value; anything that evaluates to zero is treated as false; anything else is treated as true.

When you create classes, you can specify types for properties, for arguments to methods, and so on. The InterSystems IRIS class mechanisms enforce these types as you would expect. [A later section of this book](#) provides an overview of InterSystems IRIS data type classes.

2.3.3 Variable Length

The length of a value of a variable must be less than 3,641,144 characters.

2.3.4 Variable Existence

You usually define a variable with the **SET** command. As noted earlier, when you define a global variable, that immediately affects the database.

A global variable becomes undefined only when you *kill* it (which means to remove it via the **KILL** command). This also immediately affects the database.

A local variable can become undefined in one of three ways:

- It is killed.
- The process (in which it was defined) ends.
- It goes out of scope within that process.

To determine whether a variable is defined, you use the **\$DATA** function. For example, the following shows a Terminal session that uses this function:

```
TESTNAMESPACE>write $DATA(x)
0
TESTNAMESPACE>set x=5
TESTNAMESPACE>write $DATA(x)
1
```

In the first step, we use **\$DATA** to see if a variable is defined. The system displays 0, which means that the variable is not defined. Then we set the variable equal to 5 and try again. Now the function returns 1.

In this example and in previous examples, you may have noticed that it is not necessary to declare the variable in any way. The **SET** command is all that you need.

If you attempt to access an undefined variable, you get the <UNDEFINED> error. For example:

```
TESTNAMESPACE>WRITE testvar
WRITE testvar
^
<UNDEFINED> *testvar
```

2.4 Variable Availability and Scope

ObjectScript supports the following program flow, which is similar (in most ways) to what other programming languages support:

1. A user invokes a procedure, perhaps from a user interface.
2. The procedure executes some statements and then invokes another procedure.

3. The procedure defines local variables A, B, and C.
Variables A, B, and C are *in scope* within this procedure. They are *private* to this procedure.
The procedure also defines the global variable ^D.
4. The second procedure ends, and control returns to the first procedure.
5. The first procedure resumes execution. This procedure cannot use variables A, B, and C, which are no longer defined. It can use ^D, because that variable was immediately saved to the database.

The preceding program flow is quite common. InterSystems IRIS provides other options, however, of which you should be aware.

2.4.1 Summary of Variable Scope

Several factors control whether a variable is available outside of the unit of code that defines it. Before discussing those, it is necessary to point out the following environmental details:

- An InterSystems IRIS instance includes multiple namespaces, including multiple system namespaces and probably multiple namespaces that you define.
A namespace is the environment in which any code runs. Namespaces are discussed [later](#) in more detail.
- You can run multiple processes simultaneously in a namespace. In a typical application, many processes are running at the same time.

The following table summarizes where variables are available:

Variable availability, broken out by kind of variable...	Outside of unit of code that defines it (but in the same process)	In other processes in the same namespace	In other namespaces within same InterSystems IRIS instance
Local variable, private scope [*]	No	No	No
Local variable, public scope	Yes	No	No
Local percent variable	Yes	No	No
Global variable (not percent)	Yes	Yes	Not unless global mappings permit this†
Global percent variable	Yes	Yes	Yes

^{*}By default, variables defined in a procedure are private to the procedure, as noted before. Also, in a procedure, you can declare variables as public variables, although this practice is not preferred. See “[User-defined Code](#)” in *Using ObjectScript*.

†Each namespace has default databases for specific purposes and can have mappings that give access to additional databases. Consequently, a global variable can be available to multiple namespaces, even if it is not a global percent variable. See the chapter “[Namespaces and Databases](#).”

2.4.2 The NEW Command

InterSystems IRIS provides another mechanism to enable you to control the scope of a variable: the **NEW** command. The argument to this command is one or more variable names, in a comma-separated list. The variables must be public variables and cannot be global variables.

This command establishes a new, limited context for the variable (which may or may not already exist). For example, consider the following routine:

```
; demonew
; routine to demo NEW
NEW var2
set var1="abc"
set var2="def"
quit
```

After you run this routine, the variable `var1` is available, and the variable `var2` is not, as shown in the following example Terminal session:

```
TESTNAMESPACE>do ^demonew

TESTNAMESPACE>write var1
abc
TESTNAMESPACE>write var2

write var2
^
<UNDEFINED> *var2
```

If the variable existed before you used **NEW**, the variable still exists after the scope of **NEW** has ended, and it retains its previous value. For example, consider the following Terminal session, which uses the routine defined previously:

```
TESTNAMESPACE>set var2="hello world"

TESTNAMESPACE>do ^demonew

TESTNAMESPACE>write var2
hello world
```

2.5 Multidimensional Arrays

In ObjectScript, any variable can be an InterSystems IRIS *multidimensional array* (also called an *array*). A multidimensional array is generally intended to hold a set of values that are related in some way. ObjectScript provides [commands](#) and [functions](#) that provide convenient and fast access to the values; these are discussed in later sections.

You may or may not work directly with multidimensional arrays, depending on the system classes that you use and your own preferences. InterSystems IRIS provides a class-based alternative to use when you want a container for sets of related values; see “[Collection Classes](#),” later in this book.

2.5.1 Basics

A multidimensional array consists of any number of *nodes*, defined by subscripts. The following example sets several nodes of an array and then prints the contents of the array:

```
set myarray(1)="value A"
set myarray(2)="value B"
set myarray(3)="value C"
zwrite myarray
```

This example shows a typical array. Notes:

- This array has one subscript. In this case, the subscripts are the integers 1, 2, and 3.
- There is no need to declare the structure of the array ahead of time.
- `myarray` is the name of the array itself.
- ObjectScript provides commands and functions that can act on an entire array or on specific nodes. For example:

```
kill myarray
```

You can also kill a specific node and its child nodes.

- The following variation sets several subscripts of a global array named `^myglobal`; that is, these values are written to disk:

```
set ^myglobal(1)="value A"
set ^myglobal(2)="value B"
set ^myglobal(3)="value C"
```

- There is a limit to the possible length of a global reference. This limit affects the length of the global name and the length and number of any subscripts. If you exceed the limit, you get a `<SUBSCRIPT>` error. See the section “[Maximum Length of a Global Reference](#)” in *Using Globals*.
- The length of a value of a node must be less than 3,641,144 characters.

A multidimensional array has one reserved memory location for each defined node and no more than that. For a global, all the disk space that it uses is dynamically allocated.

2.5.2 Structure Variations

The preceding examples show a common form of array. Note the following possible variations:

- You can have any number of subscripts. For example:

```
Set myarray(1,1,1)="grandchild of value A"
```

- A subscript can be a string. The following is valid:

```
set myarray("notes to self","2 Dec 2010")="hello world"
```

2.5.3 Use Notes

For those who are learning ObjectScript, a common mistake is to confuse globals and arrays. It is important to remember that any variable is either local or global, *and* may or may not have subscripts. The following table shows the possibilities:

		Example and Notes
<i>Local</i>	<i>No subscripts</i>	<pre>Set MyVar=10</pre> Variables like this are quite common. The majority of the variables you see might be like this.
	<i>Has subscripts</i>	<pre>Set MyVar(1)="alpha" Set MyVar(2)="beta" Set MyVar(3)="gamma"</pre> A local array like this is useful when you want to pass a set of related values.
<i>Global</i>	<i>No subscripts</i>	<pre>Set ^MyVar="saved note"</pre> In practice, globals usually have subscripts.
	<i>Has subscripts</i>	<pre>Set ^MyVar(\$USERNAME,"Preference 1")=42</pre>

2.6 Operators

This section provides an overview of the operators in ObjectScript; some are [familiar](#), and others are [not](#).

Operator precedence in ObjectScript is strictly left-to-right; within an expression, operations are performed in the order in which they appear. You can use explicit parentheses within an expression to force certain operations to be carried out ahead of others.

Typically you use parentheses even where you do not strictly need them. It is useful to other programmers (and to yourself at a later date) to do this because it makes the intent of your code clearer.

2.6.1 Familiar Operators

ObjectScript provides the following operators for common activities:

- Mathematical operators: addition (+), subtraction (-), division (/), multiplication (*), integer division (\), modulus (#), and exponentiation (**)
- Unary operators: positive (+) and negative (-)
- String concatenation operator (⏟)
- Logical comparison operators: equals (=), greater than (>), greater than or equal to (>=), less than (<), less than or equal to (<=)
- Logical complement operator (')

You can use this immediately before any logical value as well as immediately before a logical comparison operator.

- Operators to combine logical values: AND (&&), OR (||)

Note that ObjectScript also supports an older, less efficient form of each of these: & is a form of the && operator, and ! is a form of the || operator. You might see these older forms in existing code.

2.6.2 Unfamiliar Operators

ObjectScript also includes operators that have no equivalent in some languages. The most important ones are as follows:

- The pattern match operator (?) tests whether the characters in its left operand use the pattern in its right operand. You can specify the number of times the pattern is to occur, specify alternative patterns, specify pattern nesting, and so on.

For example, the following writes the value 1 (true) if a string (`testthis`) is formatted as a U.S. Social Security Number and otherwise writes 0.

```
Set testthis="333-99-0000"
Write testthis ?3N1"- "2N1"- "4N
```

This is a valuable tool for ensuring the validity of input data, and you can use it within the definition of class properties.

- The binary contains operator (I) returns 1 (true) or 0 (false) depending on whether the sequence of characters in the right operand is a substring of the left operand. For example:

```
Set L="Steam Locomotive",S="Steam"
Write L[I S
```

- The binary follows operator (J) tests whether the characters in the left operand come after the characters in the right operand in ASCII collating sequence.
- The binary sorts after operator (J) tests whether the left operand sorts after the right operand in numeric subscript collation sequence.
- The indirection operator (@) allows you to perform dynamic runtime substitution of part or all of a command argument, a variable name, a subscript list, or a pattern. InterSystems IRIS performs the substitution before execution of the associated command.

2.7 Commands

This section provides an overview of the commands that you are most likely to use and to see in ObjectScript. These include commands that are similar to those in other languages, as well as others that have no equivalent in other languages.

The names of commands are not case-sensitive, although they are shown in running text in all upper case by convention.

2.7.1 Familiar Commands

ObjectScript provides commands to perform familiar tasks such as the following:

- To define variables, use **SET** as shown previously.
- To remove variables, use **KILL** as shown previously.
- To control the flow of logic, use the following commands:
 - **IF**, **ELSEIF**, and **ELSE**, which work together
 - **FOR**
 - **WHILE**, which can be used on its own
 - **DO** and **WHILE**, which can be used together
 - **QUIT**, which can also return a value

There are other commands for flow control, but they are used less often.

- To trap errors, use **TRY** and **CATCH**, which work together.
- To write a value, use **WRITE**. This writes values to the current device (for example, the Terminal or a file).

Used without an argument, this command writes the values of all local variables. This is particularly convenient in the Terminal.

This command can use a small set of format control code characters that position the output. In existing code, you are likely to see the exclamation point, which starts a new line. For example:

```
write "hello world",!,"another line"
```

- To read a value from the current device (for example, the Terminal), use **READ**.
- To work with devices other than the principal device, use the following commands:
 - **OPEN** makes a device available for use.
 - **USE** specifies an open device as the current device for use by **WRITE** and **READ**.
 - **CLOSE** makes a device no longer available for use.
- To control concurrency, use **LOCK**. Note that the InterSystems IRIS lock management system is different from analogous systems in other languages. It is important to review how it works; see “[Locking and Concurrency Control](#),” later in this chapter.

You use this command in cases where multiple processes can potentially access the same variable or other item.

- To manage transactions, use **TSTART**, **TCOMMIT**, **TROLLBACK**, and related commands.
- For debugging, use **ZBREAK** and related commands.
- To suspend execution, use **HANG**.

2.7.2 Commands for Use with Multidimensional Arrays

In ObjectScript, you can work with multidimensional arrays in the following ways:

- To define nodes, use the **SET** command.
- To remove individual nodes or all nodes, use the **KILL** command.

For example, the following removes an entire multidimensional array:

```
kill myarray
```

In contrast, the following removes the node `myarray("2 Dec 2010")` and all its children:

```
kill myarray("2 Dec 2010")
```

- To delete a global or a global node but none of its descendent subnodes, use **ZKILL**.
- To iterate through all nodes of a multidimensional array and write them all, use **ZWRITE**. This is particularly convenient in the Terminal. The following sample Terminal session shows what the output looks like:

```
TESTNAMESPACE>ZWRITE ^myarray
^myarray(1)="value A"
^myarray(2)="value B"
^myarray(3)="value C"
```

This example uses a global variable rather than a local one, but remember that both can be multidimensional arrays.

- To copy a set of nodes from one multidimensional array into another, preserving existing nodes in the target if possible, use **MERGE**. For example, the following command copies an entire in-memory array (`sourcearray`) into a new global (`^mytestglobal`):

```
MERGE ^mytestglobal=sourcearray
```

This can be a useful way of examining the contents of an array that you are using, while debugging your code.

2.8 Special Variables

This section introduces some InterSystems IRIS *special variables*. The names of these variables are not case-sensitive.

Some special variables provide information about the environment in which the code is running. These include the following:

- **\$HOROLOG**, which contains the date and time for the current process, as given by the operating system. See “[Date and Time Values](#),” later in this chapter.
- **\$USERNAME** and **\$ROLES**, which contain information about the username currently in use, as well as the roles to which that user belongs.

```
write "You are logged in as: ", $USERNAME, !, "And you belong to these roles: ", $ROLES
```

- **\$ZVERSION**, which contains a string that identifies the currently running version of InterSystems IRIS.

Others include **\$JOB**, **\$TIMEZONE**, **\$IO**, and **\$ZDEVICE**.

Other variables provide information about the processing state of the code. These include **\$STACK**, **\$TLEVEL**, **\$NAMESPACE**, and **\$ZERROR**.

2.8.1 \$SYSTEM Special Variable

The special variable **\$SYSTEM** provides easy access to a large set of utility methods.

The special variable **\$SYSTEM** is an alias for the **%SYSTEM** package, which contains classes that provide class methods that address a wide variety of needs. The customary way to refer to methods in **%SYSTEM** is to build a reference that uses the **\$SYSTEM** variable. For example, the following command executes the **SetFlags()** method in the **%SYSTEM.OBJ** class:

```
DO $SYSTEM.OBJ.SetFlags("ck")
```

Because names of special variables are not case-sensitive (unlike names of classes and their members), the following commands are all equivalent:

```
DO ##class(%SYSTEM.OBJ).SetFlags("ck")
DO $System.OBJ.SetFlags("ck")
DO $SYSTEM.OBJ.SetFlags("ck")
DO $system.OBJ.SetFlags("ck")
```

The classes all provide the **Help()** method, which can print a list of available methods in the class. For example:

```
TESTNAMESPACE>d $system.OBJ.Help()
'Do $system.OBJ.Help(method)' will display a full description of an individual method.

Methods of the class: %SYSTEM.OBJ

CloseObjects()
  Deprecated function, to close objects let them go out of scope.

Compile(classes, qspec, &errorlog, recurse)
  Compile a class.

CompileAll(qspec, &errorlog)
  Compile all classes within this namespace
....
```

You can also use the name of a method as an argument to **Help()**. For example:

```
TESTNAMESPACE>d $system.OBJ.Help("Compile")
Description of the method:class Compile:%SYSTEM.OBJ

Compile(classes:%String="",qspec:%String="",&errorlog:%String,recurse:%Boolean=0)
Compile a class.
<p>Compiles the class <var>classes</var>, which can be a single class, a comma separated list,
a subscripted array of class names, or include wild cards. If <var>recurse</var> is true then
do not output the initial 'compiling' message or the compile report as this is being called inside
another compile loop.<br>
<var>qspec</var> is a list of flags or qualifiers which can be displayed with
'Do $system.OBJ.ShowQualifiers()'
and 'Do $system.OBJ.ShowFlags()'
```

2.9 Locking and Concurrency Control

An important feature of any multi-process system is *concurrency control*, the ability to prevent different processes from changing a specific element of data at the same time, resulting in corruption. Consequently, ObjectScript provides a lock management system. This section provides a brief summary.

Also see “[Locks, Globals, and Namespaces](#),” later in this book.

2.9.1 Basics

The basic locking mechanism is the **LOCK** command. The purpose of this command is to delay activity in one process until another process has signaled that it is OK to proceed.

It is important to understand that a lock does not, by itself, prevent other processes from modifying the associated data; that is, InterSystems IRIS does not enforce unilateral locking. Locking works only by convention: it requires that mutually competing processes all implement locking with the same lock names.

You can use the **LOCK** command to create locks (replacing all previous locks owed by the process), to add locks, to remove specific locks, and to remove all locks owned by the process.

For the purpose of this simple discussion, the **LOCK** command uses the following arguments:

- The lock name. Lock names are arbitrary, but by universal convention, programmers use lock names that are identical to the names of the item to be locked. Usually the item to be locked is a global or a node of a global.
- The optional lock type (to create a non-default type of lock). There are several lock types, with different behaviors.
- An optional timeout argument, which specifies how long to wait before the attempted lock operation times out. By default, InterSystems IRIS waits indefinitely.

The following describes a common lock scenario: Process A issues the **LOCK** command, and InterSystems IRIS attempts to create a lock. If process B already has a lock with the given lock name, process A pauses. Specifically, the **LOCK** command in process A does not return, and no successive lines of code can be executed. When the process B releases the lock, the **LOCK** command in process A finally returns and execution continues.

The system automatically uses the **LOCK** command internally in many cases, such as when you work with persistent objects (discussed later in this book) or when you use certain InterSystems SQL commands.

2.9.2 The Lock Table

InterSystems IRIS maintains a system-wide, in-memory table that records all current locks and the processes that own them. This table — the lock table — is accessible via the Management Portal, where you can view the locks and (in rare cases, if needed) remove them. Note that any given process can own multiple locks, with different lock names (or even multiple locks with the same lock name).

When a process ends, the system automatically releases all locks that the process owns. Thus it is not generally necessary to remove locks via the Management Portal, except in the case of an application error.

The lock table cannot exceed a fixed size, which you can specify. For information, see “[Monitoring Locks](#)” in the *Monitoring Guide*. Consequently, it is possible for the lock table to fill up, such that no further locks are possible. If this occurs, InterSystems IRIS writes the following message to the messages.log file:

```
LOCK TABLE FULL
```

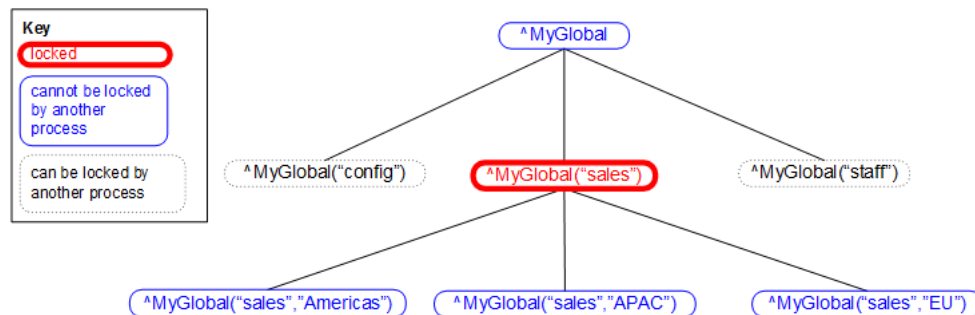
Filling the lock table is *not* generally considered to be an application error; InterSystems IRIS also provides a lock queue, and processes wait until there is space to add their locks to the lock table.

However, if two processes each assert an incremental lock on a variable already locked by the other process, that is a condition called *deadlock* and it *is* considered an application programming error. For details, see “[Avoiding Deadlock](#)” in the chapter “Lock Management” in *Using ObjectScript*.

2.9.3 Locks and Arrays

When you lock an array, you can lock either the entire array or one or more nodes in the array. When you lock an array node, other processes are blocked from locking any node that is subordinate to that node. Other processes are also blocked from locking the direct ancestors of the locked node.

The following figure shows an example:



2.9.4 Introduction to Lock Types

When you create a lock, you specify a combination of lock type codes, which control the nature of the lock. This section discusses some of the key concepts of lock types.

Depending on the lock type, it is possible to create multiple locks with the same lock name. These locks can be owned by the same process or different processes, again depending on the lock type. The lock table displays information for all of them.

Any lock is either *exclusive* (the default) or *shared*. These types have the following significance:

- While one process has an exclusive lock (with a given lock name), no other process can acquire any lock with that lock name.
- While one process has a shared lock (with a given lock name), other processes can acquire shared locks with that lock name, but no other process can acquire an exclusive lock with that lock name.

In general, the purpose of an exclusive lock is to indicate that you intend to modify a value and that other processes should not attempt to read or modify that value. The purpose of a shared lock is to indicate that you intend to read a value and that other processes should not attempt to modify that value; they can, however, read the value.

Any lock is also either *non-escalating* (the default) or *escalating*. The purpose of escalating locks is to make it easier to manage large numbers of locks, which consume memory and which increase the chance of filling the [lock table](#). You use

escalating locks when you lock multiple nodes of the same array. For escalating locks, if a given process has created more than a specific number (by default, 1000) of locks on sibling nodes of a given array, InterSystems IRIS removes all the individual lock names and replaces them with a new lock at the parent level. For example, you might have 1000 locks of the form `^MyGlobal("sales", "EU", salesdate)` where *salesdate* represents dates. When the same process attempts to create another lock of this form (and these locks are all escalating), InterSystems IRIS removes all these locks and replaces them with a lock of the name `^MyGlobal("sales", "EU")`. The lock table maintains the lock count for this new lock. This lock count is currently 1001, but when you add additional lock names of the same form, the lock table increments the lock count for the lock name `^MyGlobal("sales", "EU")`. Similarly, when you remove lock names of the same form, the lock table decrements this lock count.

There are additional subtypes of locks that InterSystems IRIS treats in specific ways within transactions. For details on these and for more information on locks in general, see [LOCK](#) in the *ObjectScript Reference*. For information on specifying the lock threshold (which by default is 1000), see “[LockThreshold](#)” in the *Configuration Parameter File Reference*.

2.10 System Functions

This section highlights some of the most commonly used system functions in ObjectScript.

The names of these functions are not case-sensitive.

The InterSystems IRIS class library also provides a large set of utility methods that you can use in the same way that you use functions. To find a method for a particular purpose, use the *InterSystems Programming Tools Index*.

See also “[Date and Time Values](#),” later in this chapter.

2.10.1 Value Choice

You can use the following functions to choose a value, given some input:

- **\$CASE** compares a given test expression to a set of comparison values and then returns the return value associated with the matching comparison value. For example:

```
TESTNAMESPACE>set myvar=1
TESTNAMESPACE>write $CASE(myvar,0:"zero",1:"one",:"other")
one
```

- **\$SELECT** examines a set of expressions and returns the return value associated with the first true expression. For example:

```
TESTNAMESPACE>set myvar=1
TESTNAMESPACE>write $SELECT(myvar=0:"branch A",1=1:"branch B")
branch B
```

2.10.2 Existence Functions

You can use the following functions to test for the existence of a variable or of a node of a variable.

- To test if a specific variable exists, use the **\$DATA** function.
For a variable that contains multiple nodes, this function can indicate whether a given node exists, and whether a given node has a value and child nodes.
- To get the value of a variable (if it exists) or get a default value (if not), use the **\$GET** function.

2.10.3 List Functions

ObjectScript provides a native list format. You can use the following functions to create and work with these lists:

- **\$LISTBUILD** returns a special kind of string called a *list*. Sometimes this is called *\$LIST format*, to distinguish this kind of list from other kinds (such as comma-separated lists).

The only supported way to work with a **\$LIST** list is to use the ObjectScript list functions. The internal structure of this kind of list is not documented and is subject to change without notice.

- **\$LIST** returns a list element or can be used to replace a list element.
- **\$LISTLENGTH** returns the number of elements in a list.
- **\$LISTFIND** returns the position of a given element, in a given list.

There are additional list functions as well.

If you use a list function with a value that is not a list, you receive the <LIST> error.

Note: The system class %Library.List is equivalent to a list returned by **\$LISTBUILD**. That is, when a class has a property of type %Library.List, you use the functions named here to work with that property. You can refer to this class by its short name, %List.

InterSystems IRIS provides other list classes that are *not* equivalent to a list returned by **\$LISTBUILD**. These are useful if you prefer to work with classes. For an introduction, see “[Collection Classes](#),” later in this book.

2.10.4 String Functions

ObjectScript also has an extensive set of functions for using strings efficiently:

- **\$EXTRACT** returns or replaces a substring, using a character count.
- **\$FIND** finds a substring by value and returns an integer specifying its end position in the string.
- **\$JUSTIFY** returns a right-justified string, padded on the left with spaces.
- **\$ZCONVERT** converts a string from one form to another. It supports both case translations (to uppercase, to lowercase, or to title case) and encoding translation (between various character encoding styles).
- **\$TRANSLATE** modifies the given string by performing a character-by-character replacement.
- **\$REPLACE** performs string-by-string replacement within a string and returns a new string.
- **\$PIECE** returns a substring from a character-delimited string (often called a *pieced string*). The following demonstrates how to extract a substring:

```
SET mystring="value 1^value 2^value 3"
WRITE $PIECE(mystring,"^",1)
```

- **\$LENGTH** returns the number of characters in a specified string or the number of delimited substrings in a specified string, depending on the parameters used.

For example:

```
SET mystring="value 1^value 2^value 3"
WRITE !, "Number of characters in this string: "
WRITE $LENGTH(mystring)
WRITE !, "Number of pieces in this string: "
WRITE $LENGTH(mystring,"^")
```

2.10.5 Working with Multidimensional Arrays

You can use the following functions to work with a multidimensional array as a whole:

- **\$ORDER** allows you to sequentially visit each node within a multidimensional array.
- **\$QUERY** enables you to visit every node and subnode within an array, moving up and down over subnodes.

To work with an individual node in an array, you can use any of the functions described previously. In particular:

- **\$DATA** can indicate whether a given node exists and whether a given node has child nodes.
- **\$GET** gets the value of a given node or gets a default value otherwise.

2.10.6 Character Values

Sometimes when you create a string, you need to include characters that cannot be typed. For these, you use **\$CHAR**.

Given an integer, **\$CHAR** returns the corresponding ASCII or Unicode character. Common uses:

- **\$CHAR(9)** is a tab.
- **\$CHAR(10)** is a line feed.
- **\$CHAR(13)** is a carriage return.
- **\$CHAR(13,10)** is a carriage return and line feed pair.

The function **\$ASCII** returns the ASCII value of the given character.

2.11 Date and Time Values

This section provides a quick overview of date and time values in ObjectScript.

2.11.1 Local Time

To access the date and time for the current process, you use the **\$HOROLOG** special variable. Because of this, in many InterSystems IRIS applications, dates and times are stored and transmitted in the format used by this variable. This format is often called *\$H format* or *\$HOROLOG format*.

\$HOROLOG retrieves the date and time from the operating system and is thus always in the local time zone.

The InterSystems IRIS class library includes data type classes to represent dates in more common formats such as ODBC, and many applications use these instead of \$H format. Note that InterSystems supports POSIX time via the `%Library.PosixTime` data type class, which new applications should use to represent date/time values.

2.11.2 UTC Time

InterSystems IRIS also provides the **\$ZTIMESTAMP** special variable, which contains the current date and time as a Coordinated Universal Time value in \$H format. This is a worldwide time and date standard; this value is very likely to differ from your local time (and date) value.

2.11.3 Date and Time Conversions

ObjectScript includes functions for converting date and time values.

- Given a date in \$H format, the function **\$ZDATE** returns a string that represents the date in your specified format.

For example:

```
TESTNAMESPACE>WRITE $ZDATE($HOROLOG,3)
2010-12-03
```

- Given a date and time in \$H format, the function **\$ZDATETIME** returns a string that represents the date and time in your specified format.

For example:

```
TESTNAMESPACE>WRITE $ZDATETIME($HOROLOG,3)
2010-12-03 14:55:48
```

- Given string dates and times in other formats, the functions **\$ZDATEH** and **\$ZDATETIMEH** convert those to \$H format.
- The functions **\$ZTIME** and **\$ZTIMEH** convert times from and to \$H format.

2.11.4 Details of the \$H Format

The \$H format is a pair of numbers separated by a comma. For example: 54321,12345

- The first number is the number of days since December 31st, 1840. That is, day number 1 is January 1st, 1841. This number is always an integer.
- The second number is the number of seconds since midnight on the given day.
Some functions, such as **\$NOW()**, provide a fractional part.

For additional details, including an explanation of the starting date, see [\\$HOROLOG](#) in the *ObjectScript Reference*.

2.12 Using Macros and Include Files

As noted earlier, you can define macros and use them later in the same routine. More commonly, you define them in include files. An include file is a document with the extension .inc in Atelier.

To define a macro, use the **#define** directive or other preprocessor directive. For example:

```
#define mymacro "hello world"
```

To include an include file in a routine, use the **#Include** directive. For example:

```
#Include myincludefile
```

(Note that the [syntax](#) is slightly different in class definitions.)

To refer to a macro, use the following syntax:

```
$$macroname
```

Or:

```
$$macroname(arguments)
```

The preprocessor directives are documented in “[ObjectScript Macros and the Macro Preprocessor](#)” in Using ObjectScript.

Note: The Management Portal lists the include files with the routines. Include files are not, however, actually routines because they are not executable.

2.13 Using Routines and Subroutines

To execute a routine, you use the DO command, as follows:

```
do ^routinename
```

To execute a procedure, function, or subroutine (without accessing its return value), you use the following command:

```
do label^routinename
```

Or:

```
do label^routinename(arguments)
```

To execute a procedure, function, or subroutine and refer to its return value, you use an expression of the form `$$label^routinename` or `$$label^routinename(arguments)`. For example:

```
set myvariable=$$label^routinename(arguments)
```

In all cases, if the label is within the same routine, you can omit the caret and routine name. For example:

```
do label
do label(arguments)
set myvariable=$$label(arguments)
```

In all cases, the arguments that you pass can be either literal values, expressions, or names of variables.

2.13.1 Passing Variables by Value or by Reference

When you invoke code, you can pass values of variables to that code either by value or by reference. In most cases, these variables are local variables with no subscripts, so this section discusses those first.

As with other programming languages, InterSystems IRIS has a memory location that contains the value of each local variable. The name of the variable acts as the address to the memory location.

When you pass a local variable with no subscripts to procedure, function, or subroutine, you pass the variable *by value*. This means that the system makes a copy of the value, so that the original value is not affected. To pass the memory address instead, place a period immediately before the name of the variable in the argument list. For example:

```
do ^myroutine(.myarg)
```

To demonstrate this, consider the following procedure:

```
square(input) public
{
  set answer=input*input
  set input=input + 10
  quit answer
}
```

Suppose that you define a variable and pass it by value to this procedure:

```
TESTNAMESPACE>set myvariable=5
TESTNAMESPACE>write $$square^demobyref(myvariable)
25
TESTNAMESPACE>write myvariable
5
```

In contrast, suppose that you pass the variable by reference:

```
TESTNAMESPACE>set myvariable=5
TESTNAMESPACE>write $$square^demobyref(.myvariable)
25
TESTNAMESPACE>write myvariable
15
```

There are other variations of variables in addition to local variables with no subscripts. The following table summarizes all the possibilities:

Kind of Variable	Passing by Value	Passing by Reference
Local variable with no subscripts	The default way in which these variables are passed	Allowed
Local variable (with subscripts)	Cannot be passed this way (only the top node would be passed)	Required
Global variable (with or without subscripts)	Required	Cannot be passed this way (data for a global is not in memory)

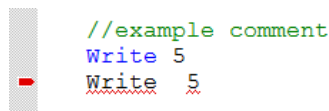
2.14 Potential Pitfalls

The following items can confuse programmers who are new to ObjectScript, particularly if those who are responsible for maintaining code written by other programmers:

- Within a routine or a method, every line must be indented by at least one space or one tab unless that line contains a label. That is, if there is text of any kind in the first character position, the compiler and Atelier treat it as a label. Note that Studio displays labels in red, as seen in previous examples.

There is one exception: A curly brace is accepted in the first character position.

- There must be exactly one space (not a tab) between a command and its first argument. Otherwise, Studio indicates that you have a syntax error:



```
//example comment
Write 5
Write 5
```

Similarly, the Terminal displays a syntax error as follows:

```
TESTNAMESPACE>write 5
WRITE 5
^
<SYNTAX>
TESTNAMESPACE>
```

- Operator precedence in ObjectScript is strictly left-to-right; within an expression, operations are performed in the order in which they appear. You can use explicit parentheses within an expression to force certain operations to be carried ahead of others.

Typically you use parentheses even where you do not strictly need them. It is useful to other programmers (and to yourself at a later date) to do this because it makes the intent of your code clearer.

- For reasons of history, ObjectScript does not consider an empty string (" ") to equal the ASCII NULL value. To represent the ASCII NULL value, use `$CHAR(0)`. (**\$CHAR** is a system function that returns an ASCII character, given its decimal-based code.) For example:

```
write "" = $char(0)
```

Similarly, when ObjectScript values are projected to SQL or XML, the values " " and `$CHAR(0)` are treated differently. For information on the SQL projections of these values, see “[Null and the Empty String](#)” in the chapter “Language Elements” in *Using InterSystems SQL*. For information on the XML projections of these values, see the chapter “[Handling Empty Strings and Null Values](#)” in *Projecting Objects to XML*.

- Some parts of ObjectScript are case-sensitive while others are not. The case-insensitive items include names of commands, functions, special variables, namespaces, and users.

The case-sensitive items include names of most of the elements that you define: routines, variables, classes, properties, and methods. For more details, see “[Syntax Rules](#)” in *Using ObjectScript*.

- Most command names can be represented by an abbreviated form. Therefore, `WRITE`, `Write`, `write`, `W`, and `w` are all valid forms of the **WRITE** command. For a list, see “[Table of Abbreviations](#)” in the *ObjectScript Reference*.
- For many of the commands, you can include a *postconditional expression* (often simply called a *postconditional*).

This expression controls whether InterSystems IRIS executes the command. If the postconditional expression evaluates to true (nonzero), InterSystems IRIS executes the command. If the expression evaluates to false (zero), InterSystems IRIS ignores the command and continues with the next command.

For example:

```
Set count = 6
Write:count<5 "Print this if count is less than five"
Write:count>5 "Print this if count is greater than five"
```

The preceding generates the following output: `Print this if count is greater than five`

Note: If postconditionals are new to you, you might find the phrase “postconditional expression” somewhat misleading, because it suggests (incorrectly) that the expression is executed *after* the command. Despite the name, a postconditional is executed *before* the command.

- You can include multiple commands on a single line. For example:

```
set myval="hello world" write myval
```

When you do this, beware that you must use two spaces after any command that does not take arguments, if there are additional commands on that line; if you do not do so, a syntax error occurs.

- The **IF**, **ELSE**, **FOR**, and **DO** commands are available in two forms:
 - A newer block form, which uses curly braces to indicate the block. For example:

```
if (testvalue=1) {
    write "hello world"
}
```

InterSystems recommends that you use the block form in all new code.

- An older line-based form, which does not use curly braces. For example:

```
if (testvalue=1) write "hello world"
```

- As a result of the preceding items, ObjectScript can be written in a very compact form. For example:

```
s:$g(%d(3))'=" " %d(3)=$$fdN3(%d(3)) q
```

The class compiler automatically generates compact code of the form shown above (although not necessarily with abbreviated commands as in this example). Sometimes it is useful to look at this generated code, to track down the source of a problem or to understand how something works.

- There are no truly reserved words in ObjectScript, so it is theoretically possible to have a variable named `set`, for example. However, it is prudent to avoid names of commands, functions, SQL reserved words, and certain system items; see “[Syntax Rules](#)” in *Using ObjectScript*.
- InterSystems IRIS allocates a fixed amount of memory to hold the results of string operations. If a string expression exceeds the amount of space allocated, a `<MAXSTRING>` error results. The limit is 3,641,144 characters.

For class definitions, the string operation limit affects the size of string properties. InterSystems IRIS provides a system object (called a *stream*) that you can use when you need to work with strings that exceed this limit. A later section of this book explains how to use the [stream interface classes](#).

2.15 For More Information

The chapters after this provide more detail on the topics covered in this chapter. This information is taken from the following books:

- *Using ObjectScript* provides details on ObjectScript.
- *Using Globals* provides details on multidimensional arrays and globals.
- *ObjectScript Reference* provides reference information for the operators, commands, functions, special variables, and other parts of ObjectScript.

3

Classes

This chapter discusses the basic rules for defining and working with classes in InterSystems IRIS™. It discusses the following topics:

- [Class names and packages](#)
- [Basic contents of a class definition](#)
- [Shortcuts for class names](#)
- [Parameters](#)
- [Properties](#)
- [Properties based on data types](#)
- [Methods](#)
- [Method arguments](#)
- [Special kinds of methods](#)
- [Class queries](#)
- [XData blocks](#)
- [Macros and include files](#)
- [Inheritance rules in InterSystems IRIS](#)
- [Other sources of information on these topics](#)

The [next chapter](#) discusses objects and object classes. Namespaces are discussed [later](#) in this book.

3.1 Class Names and Packages

Each InterSystems IRIS class has a name, which must be unique within the [namespace](#) where it is defined. A *full class name* is a string delimited by one or more periods, as in the following example:

`package.subpackage.subpackage.class`. The *short class name* is the part after the final period within this string; the part preceding the final period is the *package name*.

The package name is simply a string, but if it contains periods, the InterSystems IRIS development tools treat each period-delimited piece as a *subpackage*. Atelier and other tools display these subpackages as a hierarchy of folders, for convenience.

3.2 Basic Contents of a Class Definition

An InterSystems IRIS class definition can include the following items, all known as *class members*:

- Parameters — A parameter defines a constant value for use by this class. The value is set at compilation time.
- Methods — There are two kinds of methods: instance methods and class methods (called static methods in other languages). In most cases, a method is a subroutine.
- Properties — A property contains data for an instance of the class.
- Class queries — A class query defines an SQL query that can be used by the class and specifies a class to use as a container for the query.
- XData blocks — An XData block is a well-formed XML document within the class, for use by the class. These have many possible applications.
- Other kinds of class members that are relevant only for persistent classes; these are discussed in the [next chapter](#).

A class definition can include *keywords*; these affect the behavior of the class compiler. You can specify some keywords for the entire class, and others for specific class members. These keywords affect the code that the class compiler generates and thus control the behavior of the class.

The following shows a simple InterSystems IRIS class definition:

```
Class MyApp.Main.SampleClass Extends %RegisteredObject
{
Parameter CONSTANTMESSAGE [Internal] = "Hello world!" ;
Property VariableMessage As %String [ InitialExpression = "How are you?"];
Property MessageCount As %Numeric [Required];
ClassMethod HelloWorld() As %String
{
    Set x=..#CONSTANTMESSAGE
    Quit x
}
Method WriteIt() [ ServerOnly = 1]
{
    Set count=..MessageCount
    For i=1:1:count {
        Write !,..#CONSTANTMESSAGE," ",..VariableMessage
    }
}
}
```

Note the following points:

- The first line gives the name of the class. `MyApp.Main.SampleClass` is the full class name, `MyApp.Main` is the package name, and `SampleClass` is the short class name. Atelier and other user interfaces treat each package as a folder. For example:
- `Extends` is a compiler keyword. The `Extends` keyword specifies that this class is a superclass of `%RegisteredObject`, which is a system class, discussed in the next chapter. This class extends only one class, but it is possible to extend multiple other classes. Those classes, in turn, can extend other classes.
- `CONSTANTMESSAGE` is a parameter. By convention, all parameters in InterSystems IRIS system classes have names in all capitals. This is a convenient convention, but you are not required to follow it.

The `Internal` keyword is a compiler keyword. It marks this parameter as internal, which suppresses it from display in the class documentation. This parameter has a string value.

- `VariableMessage` and `MessageCount` are properties. The item after `As` indicates the types for these properties. `InitialExpression` and `Required` are compiler keywords.

- `HelloWorld()` is a class method and it returns a string; this is indicated by the item after `As`.

This method uses the value of the class parameter.

- `WriteIt()` is an instance method and it does not return a value.

This method uses the value of the class parameter and values of two properties.

The `ServerOnly` compiler keyword means that this method will not be projected to Java or C++ clients.

The following Terminal session shows how we can use this class:

```
TESTNAMESPACE>write ##class(MyApp.Main.SampleClass).HelloWorld()
Hello world!
TESTNAMESPACE>set x=##class(MyApp.Main.SampleClass).%New()

TESTNAMESPACE>set x.MessageCount=3

TESTNAMESPACE>do x.WriteIt()

Hello world! How are you?
Hello world! How are you?
Hello world! How are you?
```

3.3 Class Name Shortcuts

When referring to a class, you can omit the package (or the higher level packages) in the following scenarios:

- The reference is within a class, and the referenced class is in the same package or subpackage.
- The reference is within a class, and the class uses the `IMPORT` directive to import the package or subpackage that contains the referenced class.
- The reference is within a method, and the method uses the `IMPORT` directive to import the package or subpackage that contains the referenced class.
- You are referring to a class in the `%Library` package, which is specially handled. You can refer to the class `%Library.ClassName` as `%ClassName`. For example, you can refer to `%Library.String` as `%String`.
- You are referring to a class in the `User` package, which is specially handled. For example, you can refer to `User.MyClass` as `MyClass`.

`InterSystems` does not provide any classes in the `User` package, which is reserved for your use.

3.4 Class Parameters

A class parameter defines a value that is the same for all objects of a given class. This value is established when the class is compiled and cannot be altered at runtime. You use class parameters for the following purposes:

- To define a value that should not be changed at runtime.
- To define user-specific information about a class definition. A class parameter is simply an arbitrary name-value pair; you can use it to store any information you like about a class.

- To customize the behavior of the various data type classes (such as providing validation information) when used as properties; this is discussed in the next section.
- To provide parameterized values for [method generator](#) methods to use.

The following shows a class with several parameters:

```
Class GSOP.DivideWS Extends %SOAP.WebService
{
Parameter USECLASSNAMESPACES = 1;

/// Name of the Web service.
Parameter SERVICENAME = "Divide";

/// SOAP namespace for the Web service
Parameter NAMESPACE = "http://www.mynamespace.org";

/// let this Web service understand only SOAP 1.2
Parameter SOAPVERSION = "1.2";

  ///further details omitted
}
```

3.5 Properties

Formally, there are two kinds of properties in InterSystems IRIS:

- Attributes, which hold values. The value can be any of the following:
 - A single, literal value, usually based on a data type.
 - An object value (this includes collection objects and stream objects, both introduced in the next chapter).
 - A multidimensional array. This is less common.

The word *property* often refers just to properties that are attributes, rather than properties that hold associations.

- Relationships, which hold associations between objects.

This section shows a sample class that contains property definitions that show some of these variations:

```
Class MyApp.Main.Patient Extends %Persistent
{
Property PatientID As %String [Required];
Property Gender As %String(DISPLAYLIST = ",Female,Male", VALUELIST = ",F,M");
Property BirthDate As %Date;
Property Age As %Numeric [Transient];
Property MyTempArray [MultiDimensional];
Property PrimaryCarePhysician As Doctor;
Property Allergies As list Of PatientAllergy;
Relationship Diagnoses As PatientDiagnosis [ Cardinality = children, Inverse = Patient ];
}
```

Note the following:

- In each definition, the item after *As* is the type of the property. Each type is a class. The syntax *As List Of* is shorthand for a specific collection class; these are discussed in the next chapter.

%String, %Date, and %Numeric are data type classes.

%String is the default type.

- Diagnoses is a relationship property; the rest are attribute properties.
- PatientID, Gender, BirthDate, and Age can contain only simple, literal values.
- PatientID is required because it uses the Required keyword. This means that you cannot save an object of this class if you do not specify a value for this property.
- Age is not saved to disk, unlike the other literal properties. This is because it uses the Transient keyword.
- MyTempArray is a *multidimensional property* because it uses the MultiDimensional keyword. This property is not saved to disk by default.
- PrimaryCarePhysician and Allergies are *object-valued properties*.
- The Gender property definition includes values for property parameters. These are parameters in the data type class that this property uses.

This property is restricted to the values M and F. When you display the logical values (as in the Management Portal), you see Male and Female instead. Each data type class provides methods such as **LogicalToDisplay()**.

Object-valued properties and relationship properties are discussed in the next chapter.

3.5.1 Specifying Property Keywords

In a property definition, you can include optional property keywords that affect how the property is used. The following list shows some of the most commonly seen keywords:

Required

Specifies that the value of the property set before an instance of this class can be stored to disk. By default, properties are not required. In a subclass, you can mark an optional property as required, but you cannot do the reverse.

InitialExpression

Specifies an initial value for the property. By default, properties have no initial value. Subclasses inherit the value of the InitialExpression keyword and can override it. The value specified must be a valid ObjectScript expression (this applies even if the class is written in another language).

Transient

Specifies that the property is not stored in the database. By default, properties are not transient. Subclasses inherit the value of the Transient keyword and cannot override it.

Private

Specifies that the property is private. Subclasses inherit the value of the Private keyword and cannot override it.

By default, properties are public and can be accessed anywhere. You can mark a property as private (via the Private keyword). If so, it can only be accessed by methods of the object to which it belongs.

In InterSystems IRIS, private properties are always inherited and visible to subclasses of the class that defines the property.

In other programming languages, these are often called *protected properties*.

Calculated

Specifies that the property has no in-memory storage allocated for it when the object containing it is instantiated. By default, a property is not calculated. Subclasses inherit the Calculated keyword and cannot override it.

MultiDimensional

Specifies that the property is multidimensional. This property is different from other properties as follows:

- It does not have associated methods (see the following topics).
- It is ignored when the object is validated or saved.
- It is not saved to disk, unless your application includes code to save it specifically.
- It cannot be exposed to client technologies.
- It cannot be stored in or exposed through SQL tables.

Multidimensional properties are rare but are occasionally useful to temporarily contain object state information.

3.6 Properties Based on Data Types

When you define a property and you specify its type as a data type class, you have special options for defining and working with that property, as described in this section.

3.6.1 Data Type Classes

Data type classes enable you to enforce sets of rules about the values of properties.

InterSystems IRIS provides data type classes which include %Library.String, %Library.Integer, %Library.Numeric, %Library.Date, and many others. Because the names of classes of the %Library package can be abbreviated, you can abbreviate many of these; for example, %Date is an abbreviation for %Library.Date.

Each data type class has the following features:

- It specifies values for compiler keywords. For a property, a compiler keyword can do things like the following:
 - Make the property required
 - Specify an initial value for the property
 - Control how the property is projected to SQL, ODBC, and Java clients
- It specifies values for parameters that affect the details such as the following:
 - Maximum and minimum allowed logical value for the data type
 - Maximum and minimum number of characters the string can contain
 - Number of digits following the decimal point
 - Whether to truncate the string if it exceeds the maximum number of characters
 - Display format
 - How to escape any special XML or HTML characters
 - Enumerated lists of logical values and display values to use in any user interface
 - Pattern that the string must match (automatically uses the InterSystems IRIS pattern-matching operator)
 - Whether to respect or ignore the UTC time zone when importing or exporting to XML
- It provides a set of methods to translate literal data among the stored (on disk), logical (in memory), and display formats.

You can add your own data type classes. For example, the following shows a custom subclass of `%Char`:

```
Class MyApp.MyType Extends %Library.Char
{
  /// The maximum number of characters the string can contain.
  Parameter MAXLEN As INTEGER = 2000;
}
```

3.6.2 Overriding Parameters of Data Type Classes

When you define a property and you specify its type as a data type class, you can override any parameters defined by the data type class.

For example, the `%Integer` data type class defines the class parameter (`MAXVAL`) but provides no value for this parameter. You can override this in a property definition as follows:

```
Property MyInteger As %Integer(MAXVAL=10);
```

For this property, the maximum allowed value is 10.

(Internally, this works because the validation methods for the data type classes are method generators; the parameter value you provide is used when the compiler generates code for your class. Method generators are discussed later in “[Special Kinds of Methods](#).”)

Similarly, every property of type `%String` has a collation type, which determines how values are ordered (such as whether capitalization has effects or not). The default collation type is `SQLUPPER`. For more details on collations, see the section “[Data Collation](#)” in the chapter “[InterSystems IRIS SQL Basics](#)” in *Using InterSystems SQL*.

For another example, the data type classes define the `DISPLAYLIST` and `VALUELIST` parameters, which you can use to specify choices to display in a user interface and their corresponding internal values:

```
Property Gender As %String(DISPLAYLIST = ",Female,Male", VALUELIST = ",F,M");
```

3.6.3 Using Instance Variables

To access the in-memory value of a property from within an instance method of an object, you can use the following in-memory value syntax:

```
Set i%Name = "Carl"
```

This directly sets “Carl” as the in-memory value of the property `Name`, bypassing the `NameSet` accessor method (if present). The variable `i%Name` is an *instance variable*; see “[i%<PropertyName> syntax](#)” in *Defining and Using Classes*. For information on accessor methods, see the chapter “[Using and Overriding Property Methods](#)” in the same book.

3.6.4 Using Other Property Methods

Properties have a number of methods associated with them automatically. These methods are generated by the data type classes.

For example, if we define a class `Person` with three properties:

```
Class MyApp.Person Extends %Persistent
{
  Property Name As %String;
  Property Age As %Integer;
  Property DOB As %Date;
}
```

The names of each generated method is the property name concatenated with the name of the method from the inherited class. For example, some of the methods associated with the DOB property are:

```
Set x = person.DOBIsValid(person.DOB)
Write person.DOBLogicalToDisplay(person.DOB)
```

where **IsValid** is a method of the property class and **LogicalToDisplay** is a method of the %Date data type class.

3.7 Methods

There are two kinds of methods: instance methods and class methods (called static methods in other languages). In most cases, a method is a procedure.

3.7.1 Specifying Method Keywords

In a method definition, you can include optional compiler keywords that affect how the method behaves. The following list shows some of the most commonly seen method keywords:

ProcedureBlock

By default, the variables used in a method are private to that method, because by default all methods are [procedure blocks](#). To define a method as a non-procedure block, specify the ProcedureBlock keyword as 0. For example:

```
Method MyMethod() [ ProcedureBlock = 0 ]
{
    //implementation details
}
```

In this case, the variables in this method would be public variables.

Private

Specifies that the method is private. Subclasses inherit the value of the Private keyword and cannot override it.

By default, methods are public and can be accessed anywhere. You can mark a method as private (via the Private keyword). If you do:

- It can only be accessed by methods of the class to which it belongs.
- It does not appear in the InterSystems Class Reference.

It is, however, inherited and available in subclasses of the class that defines the method.

Other languages often call such methods *protected methods*.

3.7.2 References to Other Class Members

Within a method, use the syntax shown here to refer to other class members:

- To refer to a parameter, use an expression like this:

```
.. #PARAMETERNAME
```

In classes provided by InterSystems, all parameters are defined in all capitals, by convention, but your code is not required to do this.

- To refer to another method, use an expression like this:


```
..methodName(arguments)
```

Note that you cannot use this syntax within a class method to refer to an instance method.

- (Within an instance method only) To refer to a property of the instance, use an expression like this:

```
..PropertyName
```

Similarly, to refer to a property of an object-valued property, use an expression like this:

```
..PropertyNameA.PropertyNameB
```

This is known as *InterSystems IRIS dot syntax*.

Also, you can invoke an instance method of an object-valued property. For example:

```
do ..PropertyName.MyMethod()
```

3.7.3 References to Methods of Other Classes

Within a method (or within a routine), use the syntax shown here to refer to a method in some other class:

- To invoke a class method and access its return value, use an expression like the following:

```
##class(Package.Class).MethodName(arguments)
```

For example:

```
Set x=##class(Util.Utils).GetToday()
```

Or, if you are not interested in the return value, use **DO** as follows:

```
Do ##class(Util.Utils).DumpValues()
```

Note: `##class` is not case-sensitive.

- To invoke an instance method, create an instance (as described in the next chapter) and then use an expression like the following to invoke the method and access its return value:

```
instance.MethodName(arguments)
```

For example:

```
Set x=instance.GetName()
```

Or, if you are not interested in the return value, use **DO** as follows:

```
Do instance.InsertItem("abc")
```

Not all methods have return values, so choose the syntax appropriate for your case.

3.7.4 References to Current Instance

Within an instance method, sometimes it is necessary to refer to the current instance itself, rather than to a property of method of the instance. For example, you might need to pass the current instance as an argument when invoking some other code. In such a case, use the special variable **\$THIS** to refer to the current instance.

For example:

```
Set sc=header.ProcessService($this)
```

3.7.5 Method Arguments

A method can take positional arguments in a comma-separated list. For each argument, you can specify a type and the default value.

For instance, here is the partial definition of a method that takes three arguments:

```
Method Calculate(count As %Integer, name, state As %String = "CA") as %Numeric
{
    // ...
}
```

Notice that two of the arguments have explicit types, and one has a default value. Generally it is a good idea to explicitly specify the type of each argument.

3.7.5.1 Skipping Arguments

In ObjectScript, when you invoke a method, you can skip arguments, if there are suitable defaults for them. For example, the following is valid:

```
set myval=##class(mypackage.myclass).GetValue(,,,,,4)
```

3.7.5.2 Passing Variables by Value or by Reference

When you invoke a method, you can pass values of variables to that method either by value or by reference, in just the same way that you do with routines and subroutines; see “[Passing Variables by Value or by Reference](#),” earlier in this book:

The signature of a method usually indicates whether you are intended to pass arguments by reference. For example:

```
Method MyMethod(argument1, ByRef argument2, Output argument3)
```

The `ByRef` keyword indicates that you should pass this argument by reference. The `Output` keyword indicates that you should pass this argument by reference and that the method ignores any value that you initially give to this argument.

Similarly, when you define a method, you use the `ByRef` and `Output` keywords in the method signature to inform other users of the method how it is meant to be used.

Important: The `ByRef` and `Output` keywords provide information for the benefit of anyone using the InterSystems Class Reference. They do not affect the behavior of the code. It is the responsibility of the writer of the method to enforce any rules about how the method is to be invoked.

3.7.5.3 Variable Numbers of Arguments

You can define a method so that it accepts a variable number of arguments. For example:

```
ClassMethod MultiArg(Arg1... As %List)
{
    Write "Invocation has ",
        $GET(Arg1, 0),
        " element",
        $SELECT(($GET(Arg1, 0)=1):" ", 1:"s"),
        !
    For i = 1 : 1 : $GET(Arg1, 0)
    {
        Write:($DATA(Arg1(i))>0) "Argument[" , i , "]:",
            ?15, $GET(Arg1(i), "<NULL>"), !
    }
    Quit
}
```

Because methods are procedures, they support the `...` syntax to accept variable numbers of arguments. This syntax is described in the “[Variable Numbers of Arguments](#)” section of the “[User-defined Code](#)” chapter of *Using ObjectScript*.

3.7.5.4 Specifying Default Values

To specify an argument's default value, use syntax as shown in the following example:

```
Method Test(flag As %Integer = 0)
{
  //method details
}
```

When a method is invoked, it uses its default values (if specified) for any missing arguments.

Another option is to use the **\$GET** function. For example:

```
Method Test(flag As %Integer)
{
  set flag=$GET(flag,0)
  //method details
}
```

This technique, however, does not affect the class signature.

3.8 Special Kinds of Methods

The CodeMode keyword enables you to define other, special kinds of methods:

3.8.1 Call Methods

A call method is a special mechanism to create method wrappers around existing InterSystems IRIS routines. The syntax for a call method is as follows:

```
Method Call() [ CodeMode = call ]
{
  Label^Routine
}
```

where “Label^Routine” specifies a label within a routine.

3.8.2 Method Generators

A method generator is a program that is invoked by the class compiler during class compilation. Its output is the actual runtime implementation of the method. Method generators provide a means of inheriting methods that can produce high performance, specialized code that is customized to the needs of the inheriting class or property. Within the InterSystems IRIS library, method generators are used extensively by the data type and storage classes.

For details, refer to the “[Method Generators](#)” chapter of *Using ObjectScript*.

3.9 Class Queries

An InterSystems IRIS class can contain class queries. A *class query* defines an SQL query that can be used by the class and specifies a class to use as a container for the query. The following shows an example:

```
Query QueryName(Parameter As %String) As %SQLQuery
{
  SELECT MyProperty, MyOtherProperty FROM MyClass
  WHERE (MyProperty = "Hello" AND MyOtherProperty = :Parameter)
  ORDER BY MyProperty
}
```

You define class queries to provide predefined lookups for use in your application. For example, you can look up instances by some property, such as by name, or provide a list of instances that meet a particular set of conditions, such as all the flights from Paris to Madrid. The example shown here uses a parameter, which is a common way to provide a flexible query. Note that you can define class queries within any class; there is no requirement to include class queries within persistent classes, which are introduced later in this book.

3.10 XData Blocks

Because XML is often a useful way to represent structured data, InterSystems IRIS classes include a mechanism that allow you to include well-formed XML documents, for any need you might have. To do this, you include an *XData block*, which is another kind of class member.

InterSystems IRIS uses XData blocks for certain specific purposes, and these might give you ideas for your own applications:

- WS-Policy support for InterSystems IRIS web service services and web clients. See *Creating Web Services and Web Clients*. In this case, an XData block describes the security policy.
- In Business Intelligence, you use XData blocks to define cubes, subject areas, KPIs, and other elements.

3.11 Macros and Include Files in Class Definitions

In an InterSystems IRIS class definition, you can define macros in a method and use them in that method. More often, however, you define them in an [include file](#), which you can include at the start of any class definition. For example:

```
Include (%assert, %callout, %occInclude, %occSAX)

/// Implements an interface to the XSLT Parser. XML contained in a file or binary stream
/// may be transformed
Class %XML.XSLT.Transformer Extends %RegisteredObject ...
```

Then your methods in that class can refer to any macros defined in that include file, or in its included include files.

Macros are inherited. That is, a subclass has access to all the same macros as its superclasses.

3.12 Inheritance Rules in InterSystems IRIS

As with other class-based languages, you can combine multiple class definitions via inheritance. An InterSystems IRIS class definition can *extend* (or *inherit from*) multiple other classes. Those classes, in turn, can extend other classes.

The following subsections provide the basic rules for inheritance of classes in InterSystems IRIS.

3.12.1 Inheritance Order

InterSystems IRIS uses the following rules for inheritance order:

1. By default, if a class member of a given name is defined in multiple superclasses, the subclass takes the definition from the left-most class in the superclass list.
2. If the class definition contains `Inheritance = right`, then the subclass takes the definition from the right-most class in the superclass list.

For reasons of history, most InterSystems IRIS classes contain `Inheritance = right`.

3.12.2 Primary Superclass

Any class that extends other classes has a single *primary superclass*.

No matter which inheritance order a class uses, the primary superclass is the first one, reading left to right.

For any class-level compiler keywords, a given class uses the values specified in its primary superclass.

For a persistent class, the primary superclass is especially important; see “[Classes and Extents](#),” later in this book.

3.12.3 Most-Specific Type Class

Although an object can be an instance belonging to the extents of more than one class — such as that of various superclasses — it always has a *most-specific type class (MSTC)*. A class is the most specific type of an object when that object is an instance of that class, but is not an instance of any subclass of that class.

3.12.4 Overriding Methods

A class inherits methods (both class and instance methods) from its superclass or superclasses, which you can override. If you do so, you must ensure that the signature in your method definition matches the signature of the method you are overriding. This even includes that any argument of a subclass’s method cannot have a data type specified if the matching argument of the superclass’s method has no data type specified. The method in the subclass can, however, specify additional arguments that are not defined in the superclass.

Within a method in a subclass, you can refer to the method that it overrides in a superclass. To do so, use the `##super()` syntax. For example:

```
//overrides method inherited from a superclass
Method MyMethod()
{
    //execute MyMethod as implemented in the superclass
    do ##super()
    //do more things....
}
```

Note: `##super` is not case-sensitive.

3.13 For More Information

For more information on the topics covered in this chapter, see the following books:

- [Defining and Using Classes](#) describes how to define classes and class members in InterSystems IRIS.
- [Class Definition Reference](#) provides reference information for the compiler keywords that you use in class definitions.
- The InterSystems Class Reference provides details on all non-internal classes provided with InterSystems IRIS.

4

Objects

This chapter discusses objects in InterSystems IRIS™. It discusses the following topics:

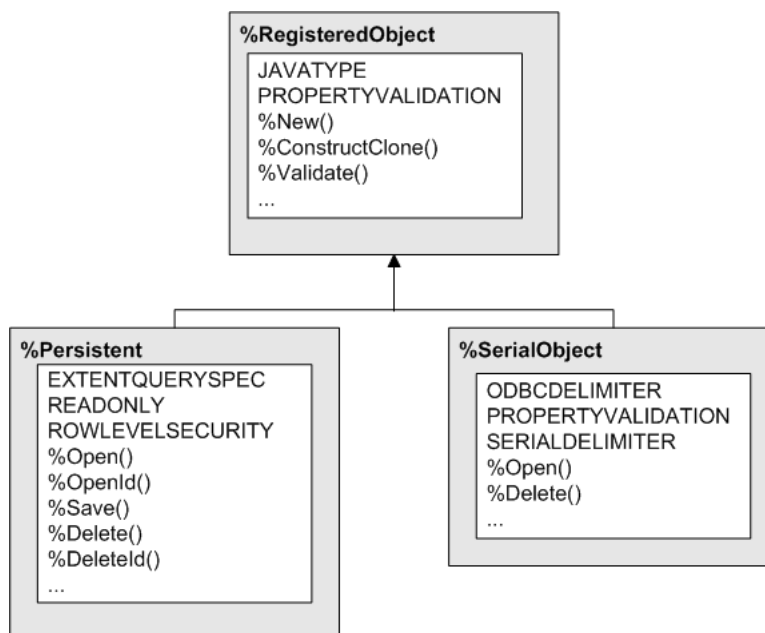
- [Introduction to InterSystems IRIS object classes](#)
- [Basic features of object classes](#)
- [OREFs](#)
- [Stream classes](#)
- [Collection classes](#)
- [Functions that are especially useful with classes](#)
- [Other sources of information on these topics](#)

The samples shown in this chapter are from the Samples-Data sample (<https://github.com/interSystems/Samples-Data>). InterSystems recommends that you create a dedicated namespace called SAMPLES (for example) and load samples into that namespace. For the general process, see [Downloading Samples for Use with InterSystems IRIS](#).

4.1 Introduction to InterSystems IRIS Object Classes

InterSystems IRIS provides object technology by means of the following object classes: %Library.RegisteredObject, %Library.Persistent, and %Library.SerialObject.

The following figure shows the inheritance relationships among these classes, as well as some of their parameters and methods. The names of classes of the %Library package can be abbreviated, so that (for example) %Persistent is an abbreviation for %Library.Persistent. Here, the items in all capitals are parameters and the items that start with percent signs are methods.



In a typical class-based application, you define classes based on these classes (and on specialized system subclasses). All objects inherit directly or indirectly from one of these classes, and every object is one of the following types:

- A *registered object* is an instance of `%RegisteredObject` or a subclass. You can create these objects but you cannot save them. The other two classes inherit from `%RegisteredObject` and thus include all the parameters, methods, and so on of that class.
- A *persistent object* is an instance of `%Persistent` or a subclass. You can create, save, open, and delete these objects. A persistent class is automatically projected to a table that you can access via InterSystems SQL. The [following chapter](#) discusses persistent classes in detail.
- A *serial object* is an instance of `%SerialObject` or a subclass. A serial class is meant for use as a property of another object. You can create and delete these objects, but you cannot save them or open them independently of the object that contains them.

When contained in persistent objects, these objects have an automatic projection to SQL.

Note: Via the classes `%DynamicObject` and `%DynamicArray`, InterSystems IRIS also provides the ability to work with objects and arrays that have no schema. These classes are not discussed in this book. For details, see [Using JSON](#).

4.2 Basic Features of Object Classes

With the object classes, you can perform the following tasks, among others:

- You can create an object (an *instance* of a class). To do so, you use the `%New()` method of that class, which it inherits from `%RegisteredObject`.

For example:

```
set myobj=##class(Sample.Person).%New()
```

- You can use properties.

You can define properties in any class, but they are useful only in object classes, because only these classes enable you to create instances.

Any property contains a single literal value, an object (possibly a collection object), or a multidimensional array (rare). The following example shows the definition of an object-valued property:

```
Property Home As Sample.Address;
```

`Sample.Address` is another class. The following shows one way to set the value of the `Home` property:

```
Set myaddress=##class(Sample.Address).%New()
Set myaddress.City="Louisville"
Set myaddress.Street="15 Winding Way"
Set myaddress.State="Georgia"

Set myperson=##class(Sample.Person).%New()
Set myperson.Home=myaddress
```

- You can invoke methods of an instance of the class, if the class or its superclasses define instance methods. For example:

```
Method PrintPerson()
{
    Write !, "Name: ", ..Name
    Quit
}
```

If `myobj` is an instance of the class that defines this method, you can invoke this method as follows:

```
Do myobj.PrintPerson()
```

- You can validate that the property values comply with the rules given in the property definitions.
 - All objects inherit the instance method **%NormalizeObject()**, which normalizes all the object's property values. Many data types allow different representations of the same value. Normalization converts a value to its canonical, or normalized, form. **%NormalizeObject()** returns true or false depending on the success of this operation.
 - All objects inherit the instance method **%ValidateObject()**, which returns true or false depending on whether the property values comply with the property definitions.
 - All persistent objects inherit the instance method **%Save()**. When you use the **%Save()** instance method, the system automatically calls **%ValidateObject()** first.

In contrast, when you work at the routine level and do not use classes, your code must include logic to check the type and other input requirements.

- You can define *callback methods* to add additional custom behavior when objects are created, modified, and so on.

For example, to create an instance of a class, you invoke the **%New()** method of that class. If that class defines the **%OnNew()** method (a *callback method*), then InterSystems IRIS automatically also calls that method. The following shows a simple example:

```
Method %OnNew() As %Status
{
    Write "hi there"
    Quit $$$OK
}
```

In realistic scenarios, this callback might perform some required initialization. It could also perform logging by writing to a file or perhaps to a global.

4.3 OREFs

The `%New()` method of an object class creates an internal, in-memory structure to contain the object's data and returns an *OREF* (*object reference*) that points to that structure. An OREF is a special kind of value in ObjectScript. You should remember the following points:

- In the Terminal, when you display an OREF, you see a string that consists of a number, followed by an at sign, followed by the name of the class. For example:

```
TESTNAMESPACE>set myobj=##class(Sample.Person).%New()
TESTNAMESPACE>w myobj
3@Sample.Person
```

- InterSystems IRIS returns an error if you do not use an OREF where an OREF is expected:

```
TESTNAMESPACE>set myobj.Name="Fred Parker"
SET myobj.Name="Fred Parker"
^
<INVALID OREF>
```

Similarly:

```
TESTNAMESPACE>do myobj.PrintPerson()
DO myobj.PrintPerson()
^
<INVALID OREF>
```

It is helpful to be able to recognize this error. It means that the variable is not an OREF but should be.

- There is only one way to create an OREF: Use a method that returns an OREF. The methods that return OREFs are defined in the object classes or their subclasses.

The following does not create an OREF, but rather a string that *looks* like an OREF:

```
TESTNAMESPACE>set testthis="4@Sample.Person"
```

- You can determine programmatically whether a variable contains an OREF. The function `$IsObject` returns 1 (true) if the variable contains an OREF; and it returns 0 (false) otherwise.

Note: For persistent classes, described in the [next chapter](#), methods such as `%OpenId()` also return OREFs.

4.4 Stream Interface Classes

As [noted earlier](#), InterSystems IRIS allocates a fixed amount of space to hold the results of string operations. If a string expression exceeds the amount of space allocated, a `<MAXSTRING>` error results. The limit is 3,641,144 characters.

If you need to pass a value whose length exceeds this limit, or you need a property whose value might exceed this limit, you use a stream. A *stream* is an object that can contain a single value whose size is larger than the string size limit. (Internally InterSystems IRIS creates and uses a temporary global to avoid the memory limitation.)

You can use stream fields with InterSystems SQL, with some restrictions. For details and a more complete introduction, see [Defining and Using Classes](#); also see the InterSystems Class Reference for these classes.

4.4.1 Stream Classes

The main InterSystems IRIS stream classes use a common stream interface defined by the `%Stream.Object` class. You typically use streams as properties of other objects, and you save those objects. Stream data may be stored in either an external file or an InterSystems IRIS global, depending on the class you choose:

- The `%Stream.FileCharacter` and `%Stream.FileBinary` classes are used for streams written to external files.
(Binary streams contain the same kind of data as type `%Binary`, and can hold large binary objects such as pictures. Character streams contain the same kind of data as type `%String`, and are intended for storing large amounts of text.)
- The `%Stream.GlobalCharacter` and `%Stream.GlobalBinary` classes are used for streams stored in globals.

To work with a stream object, you use its methods. For example, you use the **Write()** method of these classes to add data to a stream, and you use **Read()** to read data from it. The stream interface includes other methods such as **Rewind()** and **MoveTo()**.

4.4.2 Example

For example, the following code creates a global character stream and writes some data into it:

```
Set mystream=##class(%Stream.GlobalCharacter).%New()
Do mystream.Write("here is some text to store in the stream ")
Do mystream.Write("here is some more text")
Write "this stream has this many characters: ",mystream.Size,!
Write "this stream has the following contents: ",!
Write mystream.Read()
```

4.5 Collection Classes

When you need a container for sets of related values, you can use `$LIST` format lists and multidimensional arrays, as described earlier in this book.

If you prefer to work with classes, InterSystems IRIS provides list classes and array classes; these are called *collections*.

4.5.1 List and Array Classes for Use As Standalone Objects

To create list objects, you can use the following classes:

- `%Library.ListOfDataTypes` — Defines a list of literal values.
- `%Library.ListOfObjects` — Defines a list of objects (persistent or serial).

To manipulate a list object, use its methods. For example:

```
Set Colors=##class(%Library.ListOfDataTypes).%New()
Do Colors.Insert("Red")
Do Colors.Insert("Green")
Do Colors.Insert("Blue")
Write "Number of items in this list: ", Colors.Count()
Write !, "Second item in the list: ", Colors.GetAt(2)
```

Similarly, to create array objects, you can use the following classes:

- `%Library.ArrayOfDataTypes` — Defines an array of literal values. Each array item has a key and a value.
- `%Library.ArrayOfObjects` — Defines an array of objects (persistent or serial). Each array item has a key and an object value.

To manipulate an array object, use its methods. For example:

```
Set ItemArray=##class(%Library.ArrayOfDataTypes).%New()
Do ItemArray.SetAt("example item","alpha")
Do ItemArray.SetAt("another item","beta")
Do ItemArray.SetAt("yet another item","gamma")
Do ItemArray.SetAt("still another item","omega")
Write "Number of items in this array: ", ItemArray.Count()
Write !, "Item that has the key gamma: ", ItemArray.GetAt("gamma")
```

4.5.2 List and Arrays as Properties

You can also define a property as a list or array.

To define a property as a list, use the following form:

```
Property MyProperty As list of Classname;
```

If *Classname* is a data type class, then InterSystems IRIS uses the interface provided by %Collection.ListOfDT. If *Classname* is an object class, then it uses the interface provided by %Collection.ListOfObj.

To define a property as an array, use the following form:

```
Property MyProperty As Array of Classname;
```

If *Classname* is a data type class, then InterSystems IRIS uses the interface provided by %Collection.ArrayOfDT. If *Classname* is an object class, then it uses the interface provided by %Collection.ArrayOfObj.

4.6 Useful ObjectScript Functions

ObjectScript provides the following functions for use with object classes:

- **\$CLASSMETHOD** enables you to run a class method, given as class name and method name. For example:

```
TESTNAMESPACE>set class="Sample.Person"
TESTNAMESPACE>set obj=$CLASSMETHOD(class,"%OpenId",1)
TESTNAMESPACE>w obj.Name
Van De Griek,Charlotte M.
```

This function is useful when you need to write generic code that executes a class method, but the class name (or even the method name) is not known in advance. For example:

```
//read name of class from imported document
Set class=$list(headerElement,1)
// create header object
Set headerObj=$classmethod(class,"%New")
```

The other functions are useful in similar scenarios.

- **\$METHOD** enables you to run an instance method, given an instance and a method name. For example:

```
TESTNAMESPACE>set obj=##class(Sample.Person).%OpenId(1)
TESTNAMESPACE>do $METHOD(obj,"PrintPerson")
Name: Van De Griek,Charlotte M.
```

- **\$PROPERTY** gets or sets the value of the given property for the given instance. For example:

```
TESTNAMESPACE>set obj=##class(Sample.Person).%OpenId(2)
TESTNAMESPACE>write $property(obj,"Name")
Edison,Patrick J.
```

- **\$PARAMETER** gets the value of the given class parameter, given an instance. For example:

```
TESTNAMESPACE>set obj=##class(Sample.Person).%OpenId(2)
TESTNAMESPACE>write $parameter(obj,"EXTENTQUERYSPEC")
Name,SSN,Home.City,Home.State
```

- **\$CLASSNAME** returns the class name for a given instance. For example:

```
TESTNAMESPACE>set obj=##class(Sample.Person).%OpenId(1)
TESTNAMESPACE>write $CLASSNAME(obj)
Sample.Person
```

With no argument, this function returns the class name of the current context. This can be useful in instance methods.

4.7 For More Information

For more information on the topics covered in this chapter, see the following books:

- [Defining and Using Classes](#) describes how to define classes and class members in InterSystems IRIS.
- [Class Definition Reference](#) provides reference information for the compiler keywords that you use in class definitions.
- The InterSystems Class Reference provides details on all non-internal classes provided with InterSystems IRIS.

5

Persistent Objects and InterSystems IRIS SQL

A key feature in InterSystems IRIS™ is its combination of object technology and SQL. You can use the most convenient access mode for any given scenario. This chapter describes how InterSystems IRIS provides this feature and gives an overview of your options for working with stored data. It discusses the following topics:

- [Introduction](#)
- [InterSystems SQL](#)
- [Options for persistent classes](#)
- [SQL projection of persistent classes](#)
- [Object IDs](#)
- [Storage](#)
- [How to create classes and tables](#)
- [How to access stored data](#)
- [A look at stored data](#)
- [Other sources of information on these topics](#)

The samples shown in this chapter are from the Samples-Data sample (<https://github.com/interSystems/Samples-Data>). InterSystems recommends that you create a dedicated namespace called SAMPLES (for example) and load samples into that namespace. For the general process, see [Downloading Samples for Use with InterSystems IRIS](#).

5.1 Introduction

InterSystems IRIS provides what is sometimes called an *object database*: a database combined with an object-oriented programming language. As a result, you can write flexible code that does all of the following:

- Perform a bulk insert of data via SQL.
- Open an object, modify it, and save it, thus changing the data in one or more tables without using SQL.
- Create and save new objects, adding rows to one or more tables without using SQL.

- Use SQL to retrieve values from a record that matches your given criteria, rather than iterating through a large set of objects.
- Delete an object, removing records from one or more tables without using SQL.

That is, you can choose the access mode that suits your needs at any given time.

Internally, all access is done via direct global access, and you can access your data that way as well when appropriate. (If you have a class definition, it is not recommended to use direct global access to make changes to the data.)

5.2 InterSystems SQL

InterSystems IRIS provides an implementation of SQL, known as InterSystems SQL.

InterSystems SQL supports the complete entry-level SQL-92 standard with a few exceptions and several special extensions. InterSystems SQL also supports indices, triggers, BLOBs, and stored procedures (these are typical RDBMS features but are not part of the SQL-92 standard). For a complete list, see [Using InterSystems SQL](#).

5.2.1 Where You Can Use InterSystems SQL

You can use InterSystems SQL within routines and within methods. To use SQL in these contexts, you can use either or both of the following tools:

- *Embedded SQL*, as in the following example:

```
&sql(SELECT COUNT(*) INTO :myvar FROM Sample.Person)
Write myvar
```

You can use embedded SQL in ObjectScript routines and in methods written in ObjectScript.

- *Dynamic SQL* (the %SQL.Statement and %SQL.StatementResult classes), as in the following example:

```
SET myquery = "SELECT TOP 5 Name,DOB FROM Sample.Person"
SET tStatement = ##class(%SQL.Statement).%New()
SET tStatus = tStatement.%Prepare(myquery)
SET rset = tStatement.%Execute()
//now use properties of rset object
```

You can use dynamic SQL in any context.

Also, you can execute InterSystems SQL directly within the SQL Shell (in the Terminal) and in the Management Portal. Each of these includes an option to view the query plan, which can help you identify ways to make a query more efficient.

5.2.2 Object Extensions to SQL

To make it easier to use SQL within object applications, InterSystems IRIS includes a number of object extensions to SQL.

One of the most interesting of these extensions is ability to follow object references using the reference (“->”) operator. For example, suppose you have a Vendor class that refers to two other classes: Contact and Region. You can refer to properties of the related classes using the reference operator:

```
SELECT ID,Name,ContactInfo->Name
FROM Vendor
WHERE Vendor->Region->Name = 'Antarctica'
```

Of course, you can also express the same query using SQL JOIN syntax. The advantage of the reference operator syntax is that it is succinct and easy to understand at a glance.

5.3 Special Options for Persistent Classes

In InterSystems IRIS, all persistent classes extend `%Library.Persistent` (also referred to as `%Persistent`). This class provides much of the framework for the object-SQL correspondence in InterSystems IRIS. Within persistent classes, you have options like the following:

- Methods to open, save, and delete objects.

When you open a persistent object, you specify the degree of *concurrency locking*, because a persistent object could potentially be used by multiple users or multiple processes.

When you open an object instance and you refer to an object-valued property, the system automatically opens that object as well. This process is referred to as *swizzling* (also known as *lazy loading*). Then you can work with that object as well. For example:

```
Set person=##class(Sample.Person).%OpenId(10)
Set person.Name="Andrew Park"
Set person.Address.City="Birmingham"
Do person.%Save()
```

Similarly, when you save an object, the system automatically saves all its object-valued properties as well; this is known as a *deep save*. There is an option to perform a *shallow save* instead.

- Default query (the Extent query) that is an SQL result set that contains the data for the objects of this class.

In this class (or in other classes), you can define additional queries; see “[Class Queries](#),” earlier in this book.

- Ability to define relationships between classes that are projected to SQL as foreign keys.

A relationship is a special type of object-valued property that defines how two or more object instances are associated with each other. Every relationship is two-sided: for every relationship definition, there is a corresponding inverse relationship that defines the other side. InterSystems IRIS automatically enforces referential integrity of the data, and any operation on one side is immediately visible on the other side. Relationships automatically manage their in-memory and on-disk behavior. They also provide superior scaling and concurrency over object collections (see “[Collection Classes](#)” in the previous chapter).

- Ability to define foreign keys. In practice, you add foreign keys to add referential integrity constraints to an existing application. For a new application, it is simpler to define relationships instead.
- Ability to define indices in these classes.

Indices provide a mechanism for optimizing searches across the instances of a persistent class; they define a specific sorted subset of commonly requested data associated with a class. They are very helpful in reducing overhead for performance-critical searches.

Indices can be sorted on one or more properties belonging to their class. This allows you a great deal of specific control of the order in which results are returned.

In addition, indices can store additional data that is frequently requested by queries based on the sorted properties. By including additional data as part of an index, you can greatly enhance the performance of the query that uses the index; when the query uses the index to generate its result set, it can do so without accessing the main data storage facility.

- Ability to define triggers in these classes to control what occurs when rows are inserted, modified, or deleted.
- Ability to project methods and class queries as SQL stored procedures.
- Ability to fine-tune the projection to SQL (for example, specifying the table and column names as seen in SQL queries).
- Ability to fine-tune the structure of the globals that store the data for the objects.

5.4 SQL Projection of Persistent Classes

For any persistent class, each instance of the class is available as a row in a table that you can query and manipulate via SQL. To demonstrate this, this section uses the Management Portal and the Terminal, which are introduced later in this book.

5.4.1 Demonstration of the Object-SQL Projection

Consider the `Sample.Person` class in `SAMPLES`. If we use the Management Portal to display the contents of the table that corresponds to this class, we see something like the following:

Refresh Close Window

Sample.Person in namespace SAMPLES

#	ID	Age	DOB	FavoriteColors	Name	SSN	Spouse	Home_City	Home_State	Home_Street
1	1	14	03/20/2000	Red	Newton,Dave R.	384-10-8538		Pueblo	AK	6977 First Street
2	2	17	05/30/1997	Green	Waterman,Danielle C.	944-39-5991		Oak Creek	ID	1648 Maple Street
3	3	86	04/01/1928		DeSantis,Christen N.	336-13-6311		Boston	AZ	8572 Maple Street
4	4	55	02/29/1960	Purple	Baker,Marvin Z.	198-22-7709		Queensbury	NV	1243 First Blvd
5	5	80	12/13/1934	Black	Diavolo,Ralph A.	586-13-9662		Hialeah	NY	3880 Maple Plaza
6	6	38	10/13/1976		Russell,Paul S.	572-40-8824		Denver	CA	7269 Main Plaza
7	7	33	11/26/1981	Purple Purple	Pascal,John X.	468-82-7179		Zanesville	AR	872 Elm Street

(This is not the same data that you see, because this sample is repopulated at each release.) Note the following points:

- The values shown here are the display values, not the logical values as stored on disk.
- The first column (**#**) is the row number in this displayed page.
- The second column (**ID**) is the unique identifier for a row in this table; this is the identifier to use when opening objects of this class. (In this class, these identifiers are integers, but that is not always true.)

These numbers happen to be the same in this case because this table is freshly populated each time the `SAMPLES` database is built. In a real application, it is possible that some records have been deleted, so that there are gaps in the **ID** values and these values do not match the row numbers.

In the Terminal, we can use a series of commands to look at the first person:

```
SAMPLES>set person=##class(Sample.Person).%OpenId(1)

SAMPLES>write person.Name
Van De Griek,Charlotte M.
SAMPLES>write person.FavoriteColors.Count()
1
SAMPLES>write person.FavoriteColors.GetAt(1)
Red
SAMPLES>write person.SSN
571-15-2479
```

These are the same values that we see via SQL.

5.4.2 Basics of the Object-SQL Projection

Because inheritance is not part of the relational model, the class compiler projects a “flattened” representation of a persistent class as a relational table. The following table lists how some of the various object elements are projected to SQL:

Object Concept	SQL Concept
Package	Schema
Class	Table
Data type property	Field
Embedded object	Set of fields
List property	List field
Array property	Child table
Stream property	BLOB
Index	Index
Class method marked as stored procedure	Stored procedure

The projected table contains all the appropriate fields for the class, including those that are inherited.

5.4.3 Classes and Extents

InterSystems IRIS uses an unconventional and powerful interpretation of the object-table mapping.

All the stored instances of a persistent class compose what is known as the *extent* of the class, and an instance belongs to the extent of *each* class of which it is an instance. Therefore:

- If the persistent class `Person` has the subclass `Student`, the `Person` extent includes all instances of `Person` and all instances of `Student`.
- For any given instance of class `Student`, that instance is included in the `Person` extent and in the `Student` extent.

Indices automatically span the entire extent of the class in which they are defined. The indices defined in `Person` contain both `Person` instances and `Student` instances. Indices defined in the `Student` extent contain only `Student` instances.

The subclass can define additional properties not defined in its superclass. These are available in the extent of the subclass, but not in the extent of the superclass. For example, the `Student` extent might include the `FacultyAdvisor` field, which is not included in the `Person` extent.

The preceding points mean that it is comparatively easy in InterSystems IRIS to write a query that retrieves all records of the same type. For example, if you want to count people of all types, you can run a query against the `Person` table. If you want to count only students, run the same query against the `Student` table. In contrast, with other object databases, to count people of all types, it would be necessary to write a more complex query that combined the tables, and it would be necessary to update this query whenever another subclass was added.

5.5 Object IDs

Each object has a unique ID within each extent to which it belongs. In most cases, you use this ID to work with the object. This ID is the argument to the following commonly used methods of the `%Persistent` class:

- `%DeleteId()`
- `%ExistsId()`
- `%OpenId()`

The class has other methods that use the ID, as well.

5.5.1 How an ID Is Determined

InterSystems IRIS assigns the ID value when you first save an object. The assignment is permanent; you cannot change the ID for an object. Objects are not assigned new IDs when other objects are deleted or changed.

Any ID is unique within its extent.

The ID for an object is determined as follows:

- For most classes, by default, IDs are integers that are assigned sequentially as objects of that class are saved.
- For a class that is used as the child in a parent-child relationship, the ID is formed as follows:

```
parentID | | childID
```

Where *parentID* is the ID of the parent object and *childID* is the ID that the child object would receive if it were not being used in a parent-child relationship. Example:

```
104 | | 3
```

This ID is the third child that has been saved, and its parent has the ID 104 in its own extent.

- If the class has an index of type `IdKey` and the index is on a specific property, then that property value is used as the ID.

```
SKU-447
```

Also, the property value cannot be changed.

- If the class has an index of type `IdKey` and that index is on multiple properties, then those property values are concatenated to form the ID. For example:

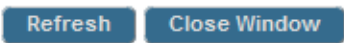
```
CATEGORY12 | | SUBCATEGORYA
```

Also, these property values cannot be changed.

5.5.2 Accessing an ID

To access the ID value of an object, you use the `%Id()` instance method that the object inherits from `%Persistent`.

In SQL, the ID value of an object is available as a pseudo-field called `%id`. Note that when you browse tables in the Management Portal, the `%id` pseudo-field is displayed with the caption ID:



Sample.Person in namespace SAMPLES

#	ID	Age	DOB	FavoriteColors	Name	SSN	Spouse	Home_City	Home_State	Home_Street
1	1	14	03/20/2000	Red	Newton,Dave R.	384-10-6538		Pueblo	AK	6977 First Street
2	2	17	05/30/1997	Green	Waterman,Danielle C.	944-39-5991		Oak Creek	ID	1648 Maple Street
3	3	88	04/01/1928		DeSantis,Christen N.	336-13-6311		Boston	AZ	8572 Maple Street
4	4	55	02/29/1960	Purple	Baker,Marvin Z.	198-22-7709		Queensbury	NV	1243 First Blvd
5	5	80	12/13/1934	Black	Diavolo,Ralph A.	586-13-9662		Hialeah	NY	3880 Maple Place
6	6	38	10/13/1976		Russell,Paul S.	572-40-8824		Denver	CA	7269 Main Place
7	7	33	11/26/1981	Purple Purple	Pascal,John X.	468-82-7179		Zanesville	AR	872 Elm Street

Despite this caption, the name of the pseudo-field is `%id`.

5.6 Storage

Each persistent class definition includes information that describes how the class properties are to be mapped to the globals in which they are actually stored. The class compiler generates this information for the class and updates it as you modify and recompile.

5.6.1 A Look at a Storage Definition

It can be useful to look at this information, and on rare occasions you might want to change some of the details (very carefully). For a persistent class, Studio displays something like the following as part of your class definition:

```
<Storage name="Default">
<Data name="PersonDefaultData"><Value name="1">
<Value>%%CLASSNAME</Value>
</Value>
<Value name="2">
<Value>Name</Value>
</Value>
<Value name="3">
<Value>SSN</Value>
</Value>
<Value name="4">
<Value>DOB</Value>
</Value>
...
</Storage>
```

5.6.2 Globals Used by a Persistent Class

The storage definition includes several elements that specify the globals in which the data is stored:

```
<DataLocation>^Sample.PersonD</DataLocation>
<IdLocation>^Sample.PersonD</IdLocation>
<IndexLocation>^Sample.PersonI</IndexLocation>
...
<StreamLocation>^Sample.PersonS</StreamLocation>
```

By default, with default storage:

- The class data is stored in the *data global* for the class. Its name starts with the complete class name (including package name). A “D” is appended to the name. For example: `Sample.PersonD`
- The index data is stored in the *index global* for the class. Its name starts with the class name and ends with an “I”. For example: `Sample.PersonI`
- Any saved stream properties are stored in the *stream global* for the class. Its name starts with the class name and ends with an “S”. For example: `Sample.PersonS`

Important: If the complete class name is long, the system automatically uses a hashed form of the class name instead. So when you view a storage definition, you might sometimes see global names like `^package1.pC347.VeryLongCl1a4F4AD`. If you plan to work directly with the data global for a class for any reason, make sure to examine the storage definition so that you know the actual name of the global.

Informally, these globals are sometimes called the *class globals*, but this can be a misleading phrase. The class definitions are not stored in these globals.

For more information on how global names are determined, see “[Globals](#)” in *Defining and using Classes*.

5.6.3 Default Structure for a Stored Object

For a typical class, most data is contained in the data global, which includes nodes as follows:

Node	Node Contents
<code>^full_class_name("id")</code> Where <i>full_class_name</i> is the complete class name including package, hashed if necessary to keep the length to 31 characters. Also, <i>id</i> is the object ID as described in “ Object IDs .”	List of the format returned by \$ListBuild . In this list, stored properties are listed in the order given by the <code>name</code> attribute of the <code><Value></code> element in the storage definition. By definition, transient properties are not stored. Stream properties are stored in the stream global for the class.

For an example, see “[A Look at Stored Data](#),” later in this chapter.

5.6.4 Notes

Note the following points:

- Never redefine or delete storage for a class that has stored data. If you do so, you will have to recreate the storage manually, because the new default storage created when you next compile the class might not match the required storage for the class.
- During development, you may want to reset the storage definition for a class. You can do this if you also delete the data and later reload or regenerate it.
- By default, as you add and remove properties during development, the system automatically updates the storage definition, via a process known as *schema evolution*.

The exception is if you use a non-default storage class for the `<Type>` element. The default is `%Storage.Persistent`; if you do not use this storage class, InterSystems IRIS does not update the storage definition.

5.7 Options for Creating Persistent Classes and Tables

To create a persistent class and its corresponding SQL table, you can do any of the following:

- Use Atelier to define a class based on `%Persistent`. When you compile the class, the system creates the table.
- In the Management Portal, you can use the Data Migration Wizard, which reads an external table, prompts you for some details, generates a class based on `%Persistent`, and then loads records into the corresponding SQL table.
You can run the wizard again later to load more records, without redefining the class.
- In the Management Portal, you can use the Link Table Wizard, which reads an external table, prompts you for some details, and generates a class that is linked to the external table.
This is a special case and is not discussed further in this book.
- In InterSystems SQL, use `CREATE TABLE` or other DDL statements. This also creates a class.
- In the Terminal (or in code), use the `CSVTOCLASS()` method of `%SQL.Util.Procedures`. For details, see the Class Reference for `%SQL.Util.Procedures`.

5.8 Accessing Data

To access, modify, and delete data associated with a persistent class, your code can do any or all of the following:

- Open instances of persistent classes, modify them, and save them.
- Delete instances of persistent classes.
- Use embedded SQL.
- Use dynamic SQL (the SQL statement and result set interfaces).
- Use low-level commands and functions for direct global access. Note that this technique is not recommended *except* for retrieving stored values, because it bypasses the logic defined by the object and SQL interfaces.

InterSystems SQL is suitable in situations like the following:

- You do not initially know the IDs of the instances to open but will instead select an instance or instances based on input criteria.
- You want to perform a bulk load or make bulk changes.
- You want to view data but not open object instances.

(Note, however, that when you use object access, you can control the degree of concurrency locking. If you know that you do not intend to change the data, you can use minimal concurrency locking.)

- You are fluent in SQL.

Object access is suitable in situations like the following:

- You are creating a new object.
- You know the ID of the instance to open.
- You find it more intuitive to set values of properties than to use SQL.

5.9 A Look at Stored Data

This section demonstrates that for any persistent object, the same values are visible via object access, SQL access, and direct global access.

In Atelier, if we view the `Sample.Person` class, we see the following property definitions:

```

/// Person's name.
Property Name As %String(POPSPEC = "Name()") [ Required ];

...

/// Person's age.<br>
/// This is a calculated field whose value is derived from <property>DOB</property>.
Property Age As %Integer [ details removed for this example ];

/// Person's Date of Birth.
Property DOB As %Date(POPSPEC = "Date()");

```

In the Terminal, we can open a stored object and write its property values:

```
SAMPLES>set person=##class(Sample.Person).%OpenId(1)

SAMPLES>w person.Name
Newton,Dave R.
SAMPLES>w person.Age
14
SAMPLES>w person.DOB
58153
```

Note that here we see the literal, stored value of the DOB property. We could instead call a method to return the display value of this property:

```
SAMPLES>write person.DOBLogicalToDisplay(person.DOB)
03/20/2000
```

In the Management Portal, we can browse the stored data for this class, which looks as follows:

Refresh
Close Window

Sample.Person in namespace SAMPLES

#	ID	Age	DOB	FavoriteColors	Name	SSN	Spouse	Home_City	Home_State	Home_Street
1	1	14	03/20/2000	Red	Newton,Dave R.	384-10-6538		Pueblo	AK	6977 First Street
2	2	17	05/30/1997	Green	Waterman,Danielle C.	944-39-5991		Oak Creek	ID	1648 Maple Street
3	3	88	04/01/1928		DeSantis,Christen N.	336-13-6311		Boston	AZ	8572 Maple Street
4	4	55	02/29/1960	Purple	Baker,Marvin Z.	198-22-7709		Queensbury	NV	1243 First Blvd
5	5	80	12/13/1934	Black	Diavolo,Ralph A.	586-13-9662		Hialeah	NY	3880 Maple Plaza
6	6	38	10/13/1976		Russell,Paul S.	572-40-8824		Denver	CA	7269 Main Plaza
7	7	33	11/26/1981	Purple Purple	Pascal,John X.	468-82-7179		Zanesville	AR	872 Elm Street

Notice that in this case, we see the display value for the DOB property. (In the Portal, there is another option to execute queries, and with that option you can control whether to use logical or display mode for the results.)

In the Portal, we can also browse the global that contains the data for this class:

Global Search Mask: Display Cancel

Search History: Maximum Rows: 100 Allow Edit

```

1: ^Sample.PersonD = 200
2: ^Sample.PersonD(1) = $lb("", "Newton,Dave R.", "384-10-6538", 58153, $lb("6977 First Street", "Pueblo", "AK", 63163), $lb("9984 Second Blvd", "Washington", "MN", 42829), "", $lb("Red"))
3: ^Sample.PersonD(2) = $lb("", "Waterman,Danielle C.", "944-39-5991", 57128, $lb("1648 Maple Street", "Oak Creek", "ID", 63163), $lb("1243 First Blvd", "Queensbury", "NV", 43523), "", $lb("Black"))
4: ^Sample.PersonD(3) = $lb("", "DeSantis,Christen N.", "336-13-6311", 31867, $lb("8572 Maple Street", "Boston", "AZ", 63163), $lb("1243 First Blvd", "Queensbury", "NV", 43523), "", $lb("Purple Purple"))
5: ^Sample.PersonD(4) = $lb("", "Baker,Marvin Z.", "198-22-7709", 43523, $lb("1243 First Blvd", "Queensbury", "NV", 43523), $lb("1243 First Blvd", "Queensbury", "NV", 43523), "", $lb("Purple"))

```

Or, in the Terminal, we can write the value of the global node that contains this instance:

```
zw ^Sample.PersonD("1")
^Sample.PersonD(1)=$lb("", "Newton,Dave R.", "384-10-6538", 58153, $lb("6977 First Street", "Pueblo", "AK", 63163), $lb("9984 Second Blvd", "Washington", "MN", 42829), "", $lb("Red"))
```

For reasons of space, the last example contains an added line break.

5.10 Storage of Generated Code for InterSystems SQL

For InterSystems SQL (except when used as embedded SQL), the system generates reusable code to access the data.

When you first execute an SQL statement, InterSystems IRIS optimizes the query and generates and stores code that retrieves the data. It stores the code in the *query cache*, along with the optimized query text. Note that this cache is a cache of code, not of data.

Later when you execute an SQL statement, InterSystems IRIS optimizes it and then compares the text of that query to the items in the query cache. If InterSystems IRIS finds a stored query that matches the given one (apart from minor differences such as whitespace), it uses the code stored for that query.

You can view the query cache and delete any items in it.

5.11 For More Information

For more information on the topics covered in this chapter, see the following:

- [Defining and Using Classes](#) describes how to define classes and class members in InterSystems IRIS.
- [Class Definition Reference](#) provides reference information for the compiler keywords that you use in class definitions.
- [Using InterSystems SQL](#) describes how to use InterSystems SQL and where you can use it.
- [InterSystems SQL Reference](#) provides reference information on InterSystems SQL.
- [Using Globals](#) provides details on how InterSystems IRIS stores persistent objects in globals.
- The InterSystems Class Reference has information on all non-internal classes provided by InterSystems IRIS.

6

Namespaces and Databases

This chapter describes how InterSystems IRIS™ organizes data and code. It discusses the following:

- [Introduction](#)
- [Database basics](#)
- [System-supplied databases](#)
- [%SYS namespace](#)
- [IRISSYS database](#)
- [What is accessible in your namespaces](#)
- [Stream directory for a namespace](#)
- [Other sources of information on these topics](#)

6.1 Introduction to Namespaces and Databases

In InterSystems IRIS, any code runs in a *namespace*, which is a logical entity. A namespace provides access to data and to code, which is stored (typically) in multiple databases. A *database* is a file — an IRIS.DAT file. InterSystems IRIS provides a set of namespaces and databases for your use, and you can define additional ones.

In a namespace, the following options are available:

- A namespace has a default database in which it stores code; this is the *routine database* for this namespace.
When you write code in a namespace, the code is stored in its routine database unless other considerations apply. Similarly, when you invoke code, InterSystems IRIS looks for it in this database unless other considerations apply.
- A namespace also has a default database to contain data for persistent classes and any globals you create; this is the *global database* for this namespace.

So, for example, when you access data (in any manner), InterSystems IRIS retrieves it from this database unless other considerations apply.

The global database can be the same as the routine database, but it is often desirable to separate them for maintainability.

- A namespace has a default database for temporary storage.
- A namespace can include *mappings* that provide access to additional data and code that is stored in other databases. Specifically, you can define mappings that refer to routines, class packages, entire globals, and specific global nodes

in non-default databases. (These kinds of mappings are called, respectively, *routine mappings*, *package mappings*, *global mappings*, and *subscript-level mappings*.)

When you provide access to a database via a mapping, you provide access to only a part of that database. The namespace cannot access the non-mapped parts of that database, not even in a read-only manner.

Also, it is important to understand that when you define a mapping, that affects only the configuration of the namespace. It does not change the current location of any code or data. Thus when you define a mapping, it is also necessary to move the code or data (if any exists) from its current location to the one expected by the namespace.

Defining mappings is a database administration task and requires no change to class/table definitions or application logic.

- Any namespace you create has access to most of the InterSystems IRIS code library. This code is available because InterSystems IRIS automatically establishes specific mappings for any namespace you create.

This book has mentioned some of these classes; to find tools for a particular purpose, see the *InterSystems Programming Tools Index*.

- When you define a namespace, you can cause it to be *interoperability-enabled*. This means that you can define a production in this namespace. A production is a program that uses InterSystems IRIS Interoperability features and integrates multiple separate software systems; to read about this, see *Introducing Interoperability Productions*.

Mappings provide a convenient and powerful way to share data and code. Any given database can be used by multiple namespaces. For example, there are several system databases that all customer namespaces can access, as discussed later in this chapter.

You can change the configuration of a namespace after defining it, and InterSystems IRIS provides tools for moving code and data from one database to another. Thus you can reorganize your code and data during development, if you discover the need to do so. This makes it possible to reconfigure InterSystems IRIS applications (such as for scaling) with little effort.

6.1.1 Locks, Globals, and Namespaces

Because a global can be accessed from multiple namespaces, InterSystems IRIS provides automatic cross-namespace support for its locking mechanism. A lock on a given global applies automatically to *all* namespaces that use the database that stores the global.

For an introduction to locking, see “[Locking and Concurrency Control](#),” earlier in this book.

6.2 Database Basics

An InterSystems IRIS *database* is an IRIS.DAT file. You create a database via the Management Portal. Or if you have an existing InterSystems IRIS database, you can configure InterSystems IRIS to become aware of it.

6.2.1 Database Configuration

For any database, InterSystems IRIS requires the following configuration details:

- Logical name for the database.
- Directory in which the IRIS.DAT file resides. When you create a database in the Management Portal, you are prompted to choose or create a subdirectory within the *system manager’s directory* (*install-dir/Mgr*), but you can store the database file in any convenient directory.

Tip: It is convenient to use the same string for the logical name and for the directory that contains the IRIS.DAT file. The system-provided InterSystems IRIS databases follow this convention.

Additional options include the following:

- Default directory to use for file streams used by this database.
This is important because your users will need write access to this directory; if not, your code will not be able to create file streams.
- Collation of new globals.
- Initial size and other physical characteristics.
- Option to enable or disable *journaling*. Journaling tracks changes made to an InterSystems IRIS database, for up-to-the-minute recovery after a crash or restoring your data during system recovery.
In most cases, it is best to enable journaling. However, you might want to disable journaling for designated temporary work spaces; for example, the IRISTEMP database is not journaled.
- Option to mount this database for read-only use.
If a user tries to set a global in a read-only database, InterSystems IRIS returns a <PROTECT> error.

In most cases, you can create, delete, or modify database attributes while the system is running.

6.2.2 Database Features

With each database, InterSystems IRIS provides physical integrity guarantees for both the actual data and the metadata that organizes it. This integrity is guaranteed even if an error occurs during writes to the database.

The databases are automatically extended as needed, without manual intervention. If you expect a particular database to grow and you can determine how large it will become, you can “pre-expand” it by setting its initial size to be near the expected eventual size. If you do so, the performance is better.

InterSystems IRIS provides a number of strategies that allow high availability and recoverability. These include:

- Journaling — Introduced earlier.
- Mirroring — Provides rapid, reliable, robust, automatic failover between two InterSystems IRIS systems, making mirroring the ideal automatic failover high-availability solution for the enterprise.
- Clustering — There is full support of clustering on operating systems that provide it.

InterSystems IRIS has a technology for distributing data and application logic and processing among multiple systems. It is called the Enterprise Cache Protocol (ECP). On a multiserver system, a network of InterSystems IRIS database servers can be configured as a common resource, sharing data storage and application processing, with the data distributed seamlessly among them. This provides increased scalability as well as automatic failover and recovery.

6.2.3 Database Portability

InterSystems IRIS databases are portable across platforms and across versions, with the following caveat:

- On different platforms, any file is either *big-endian* (that is, most-significant byte first) or *little-endian* (least-significant byte first).

InterSystems IRIS provides a utility to convert the byte order of an InterSystems IRIS database; it is called *cvendian*. This is useful when moving a database among platforms of the two types. For details, see the section “[Using cvendian to Convert Between Big-endian and Little-endian Systems](#)” in *Specialized System Tools and Utilities*.

6.3 System-Supplied Databases

InterSystems IRIS provides the following databases:

- **IRISLIB** — This is a read-only database that includes the object, data type, stream, and collection classes and many other class definitions. It also includes the system include files, generated INT code (for most classes), and generated OBJ code.
- **ENSLIB** — This is a read-only database contains additional code needed for InterSystems IRIS Interoperability features, specifically the ability to create productions, which integrate separate software systems.

If you create a namespace that is interoperability-enabled, that namespace has access to the code in this database.

- **IRISSYS** (the *system manager's database*) — This database includes utilities and data related to system management. It is intended to contain specific custom code and data of yours and to preserve that code and data upon upgrades.

This database contains or can contain:

- Users, roles, and other security elements (both predefined items and ones that you add).

For reasons of security, the Management Portal handles this data differently than other data; for example, you cannot display a table of users and their passwords.

- Data for use by the NLS (National Language Support) classes: number formats, the sort order of characters, and other such details. You can load additional data.
- Your own code and data. To ensure that these items are preserved upon upgrades, use the naming conventions in “[IRISSYS Database and Custom Items](#),” later in this chapter.

CAUTION: InterSystems does not support moving, replacing, or deleting the IRISSYS database.

The directory that contains this database is the *system manager's directory*. The messages log (messages.log) is written to this directory, as are other log files.

- **IRISAUDIT** — When you enable event logging, InterSystems IRIS writes the audit data to this database.
- **IRISTEMP** — InterSystems IRIS uses this for temporary storage, and you can use it as well for the same purpose. Specifically, this database contains *temporary globals*. For details, see the appendix “[Temporary Globals and the IRISTEMP Database](#)” in *Using Globals*.
- **IRISLOCALDATA** — Contains items used internally by InterSystems IRIS, such as cached SQL queries.

Note: No customer application should directly interact with the IRISLOCALDATA database. This database is purely for internal use by InterSystems IRIS.

For additional detail on IRISSYS, see the chapter “[Assets and Resources](#)” in the *Security Administration Guide*.

6.4 %SYS Namespace

The %SYS namespace provides access to code that should *not* be available in all namespaces — code that manipulates security elements, the server configuration, and so on.

For this namespace, the default routine database and default global database is IRISSYS. If you follow certain naming conventions, you can create your own code and globals in this namespace and store it in that database. See the [next section](#).

6.5 IRISSYS Database and Custom Items

You can create items in the IRISSYS database. When you install an InterSystems IRIS upgrade, this database is upgraded. During this upgrade, some items are deleted unless they follow the naming conventions for custom items.

To add code or data to this database so that your items are not overwritten, do one of the following:

- Go to the %SYS namespace and create the item. For this namespace, the default routine database and default global database are both IRISSYS. Use the following naming conventions to prevent your items from being affected by the upgrade installation:
 - Classes: start the package with Z or z
 - Routines: start the name with Z, z, %Z, or %z
 - Globals: start the name with ^Z, ^z, ^%Z, or ^%z
- In *any* namespace, create items with the following names:
 - Routines: start the name with %Z or %z
 - Globals: start the name with ^%Z or ^%z

Because of the standard mappings in any namespace, these items are written to IRISSYS.

MAC code and include files are not affected by upgrade.

6.6 What Is Accessible in Your Namespaces

When you create a namespace, the system automatically defines mappings for that namespace. As a result, in that namespace, you can use the following items (provided you are logged in as a user with suitable permissions for these items):

- Any class whose package name starts with a percent sign (%). This includes most, but not all, classes provided by InterSystems IRIS.
- All the code stored in the routine database for this namespace.
- All the data stored in the global database for this namespace.
- Any routine whose name starts with a percent sign.
- Any include file whose name starts with a percent sign.
- Any global whose name starts with a caret and a percent sign (^%). These globals are generally referred to as *percent globals*. Note that via global mappings or subscript level mappings, it is possible to change where percent globals are stored, but that has no effect on their visibility. Percent globals are always visible in all namespaces.
- Your own globals with names that start ^IRIS.TempUser — for example, ^IRIS.TempUser.MyApp. If you create such globals, these globals are written to the IRISTEMP database.
- If the namespace is interoperability-enabled, you can use code in the Ens and EnsLib packages. The CSPX and EnsPortal packages are also visible but these are not meant for direct use.

If a namespace is interoperability-enabled, you can define a production in this namespace. To read about this, see *Introducing Interoperability Productions*.

- Any additional code or data that is made available via mappings defined in this namespace.

Via extended global references, your code can access globals that are defined in other namespaces. For information, see “[Global Structure](#)” in *Using Globals*.

The InterSystems security model controls which data and which code any user can access; see the chapter “[InterSystems IRIS Security](#)” for an introduction.

6.6.1 System Globals in Your Namespaces

Your namespaces contain additional system globals, which fall into two rough categories:

- System globals that are in all namespaces. These include the globals in which InterSystems IRIS stores your routines, class definitions, include files, INT code, and OBJ code.
- System globals that are created when you use specific InterSystems IRIS features. For example, if you use Analytics in a namespace, the system creates a set of globals for its own internal use.

In most cases, you should not manually write to or delete any of these globals. See “[Global Naming Conventions](#),” in *Using Globals*.

6.7 Stream Directory

In any given namespace, when you create a file stream, InterSystems IRIS writes a file to a default directory and then later deletes it.

This is important because your users will need write access to this directory; if not, your code will not be able to create file streams.

The default directory is the stream subdirectory of the global database for this namespace.

6.8 For More Information

For more information on the topics covered in this chapter, see the following:

- *Using Globals* has information on working with globals, including using extended references.
- “[Using cvendian to Convert Between Big-endian and Little-endian Systems](#)” in *Specialized System Tools and Utilities* has information on cvendian.
- *High Availability Guide* has information on high availability and recoverability.
- *Scalability Guide* has information on distributed caching and sharding.

7

InterSystems IRIS Security

This chapter provides an overview of InterSystems security, with emphasis on the topics most relevant to programmers who write or maintain InterSystems IRIS™ applications. It discusses the following topics:

- [Introduction to InterSystems security](#)
- [InterSystems IRIS applications](#)
- [Authorization in InterSystems IRIS](#)

Security is discussed in detail in the *Security Administration Guide*.

7.1 Introduction

This section provides an introduction to security within InterSystems IRIS and for communications between InterSystems IRIS and external systems.

7.1.1 Security Elements Within InterSystems IRIS

InterSystems security provides a simple, unified security architecture that is based on the following elements:

- *Authentication.* Authentication is how you prove to InterSystems IRIS that you are who you say you are. Without trustworthy authentication, authorization mechanisms are moot — one user can impersonate another and then take advantage of the fraudulently obtained privileges.

The authentication mechanisms available depend on how you are accessing InterSystems IRIS. InterSystems IRIS has a number of available authentication mechanisms. Some require programming effort.

- *Authorization.* Once a user is authenticated, the next security-related question to answer is what that person is allowed to use, view, or alter. This determination and control of access is known as *authorization*.

As a programmer, you are responsible for including the appropriate security checks within your code to make sure that a given user has permission to perform a given task. The authorization model is discussed in more detail later in this chapter.

- *Auditing.* Auditing provides a verifiable and trustworthy trail of actions related to the system, including actions of the authentication and authorization systems. This information provides the basis for reconstructing the sequence of events after any security-related incident. Knowledge of the fact that the system is audited can serve as a deterrent for attackers (because they know they will reveal information about themselves during their attack).

InterSystems IRIS provides a set of events that can be audited, and you can add others. As a programmer, you are responsible for include the audit logging in your code for your custom events.

- *Database encryption.* InterSystems IRIS database encryption protects data at rest — it secures information stored on disk — by preventing unauthorized users from viewing this information. InterSystems IRIS implements encryption using the AES (Advanced Encryption Standard) algorithm. Encryption and decryption occur when InterSystems IRIS writes to or reads from disk. In InterSystems IRIS, encryption and decryption have been optimized, and their effects are both deterministic and small for any InterSystems IRIS platform; in fact, there is no added time at all for writing to an encrypted database.

The task of database encryption does not generally require you to write code.

7.1.2 Secure Communications to and From InterSystems IRIS

When communicating between InterSystems IRIS and external systems, you can use the following additional tools:

- *SSL/TLS configurations.* InterSystems IRIS supports the ability to store a SSL/TLS configuration and specify an associated name. When you need an SSL/TLS connection (for HTTP communications, for example), you programmatically provide the applicable configuration name, and InterSystems IRIS automatically handles the SSL/TLS connection.
- *X.509 certificate storage.* InterSystems IRIS supports the ability to load an X.509 certificate and private key and specify an associated configuration name. When you need an X.509 certificate (to digitally sign a SOAP message, for example), you programmatically provide the applicable configuration name, and InterSystems IRIS automatically extracts and uses the certificate information.

You can optionally enter the password for the associated private key file, or you can specify this at runtime.

- *Access to a certificate authority (CA).* If you place a CA certificate of the appropriate format in the prescribed location, InterSystems IRIS uses it to validate digital signatures and so on.

InterSystems IRIS uses the CA certificate automatically; no programming effort is required.

7.2 InterSystems IRIS Applications

Almost all users interact with InterSystems IRIS using *applications*. For example, the Management Portal itself is a set of applications. Each application has its own security. The most common kind of application is the *web application*, which is an application that accesses InterSystems IRIS through the Web Gateway. A web application communicates through the Web Gateway either via REST or via SOAP.

You can define, modify, and applications within the Management Portal (provided that you are logged in as a user with sufficient privileges). When you deploy your applications, however, you are more likely to define applications programmatically as part of installation; InterSystems IRIS provides ways to do so.

For more information on InterSystems IRIS applications, see the chapter “[Applications](#)” in the *Security Administration Guide*.

7.3 InterSystems Authorization Model

As a programmer, you are responsible for including the appropriate security checks within your code to make sure that a given user has permission to perform a given task. Therefore, it is necessary to become familiar with the InterSystems authorization model, which uses role-based access. Briefly, the terms are as follows:

- *Assets*. Assets are the items being protected. Assets vary widely in nature. The following items are all assets:
 - Each InterSystems IRIS database
 - The ability to connect to InterSystems IRIS using SQL
 - The ability to perform backups
 - Each Analytics KPI class
 - Each application defined in InterSystems IRIS
- *Resources*. A resource is an InterSystems security element that you can associate with one or more assets.

For some assets, the association between an asset and a resource is a configuration option. When you create a database, you specify the associated resource. Similarly, when you create an InterSystems IRIS application, you specify the associated resource.

For other assets, the association is hardcoded. For an Analytics KPI class, you specify the associated resource as a parameter of that class.

For assets and resources that you define, you are free to make the association in either manner — either by hardcoding it or by defining a suitable configuration system.
- *Roles*. A role is an InterSystems security element that specifies a name and an associated set of privileges (possibly quite large). A *privilege* is a *permission* of a specific type (Read, Write, or Use) on a specific resource. For example, the following are privileges:
 - Permission to read a database
 - Permission to write to a table
 - Permission to use an application
- *Usernames*. A username (or a *user*, for short) is an InterSystems security element with which a user logs on to InterSystems IRIS. Each user *belongs to* (or *is a member of*) one or more roles.

Another important concept is *role escalation*. Sometimes it is necessary to temporarily add one or more new roles to a user (programmatically) so that the user can perform a normally disallowed task within a specific context. This is known as *role escalation*. After the user exits that context, you would remove the temporary roles; this is *role de-escalation*.

You define, modify, and delete resources, roles, and users within the Management Portal (provided that you are logged in as a user with sufficient privileges). When you deploy your applications, however, you are more likely to define resources, roles, and starter usernames programmatically, as part of installation; InterSystems IRIS provides ways to do so.

8

Localization Support

This chapter provides an overview of InterSystems IRIS™ support for localization. It discusses the following topics:

- [Introduction to localization in InterSystems IRIS](#)
- [InterSystems IRIS locales](#)
- [Default I/O translation tables](#)
- [Files and character encoding](#)
- [How to manually translate characters](#)

8.1 Introduction

InterSystems IRIS supports localization so that you can develop applications for multiple countries or multiple areas without needing to re-engineer the application. The localization model works as follows:

- InterSystems IRIS provides a set of predefined locales. An InterSystems IRIS *locale* is a set of metadata that specify the user language, currency symbols, formats, and other conventions for a specific country or geographic region. The next section of this chapter provides more details.

The locale specifies the character encoding to use when writing to the InterSystems IRIS database. It also includes information necessary to handle character conversions to and from other character encodings.

- When you install an InterSystems IRIS server, the installer sets the default locale for that server.
This cannot be changed after installation, but you can specify that a process uses a non-default locale, if wanted.
- The Management Portal displays strings in the local language as specified by the browser settings, for a fixed set of languages.
- You can provide localized strings for your own applications as well. See the article [String Localization and Message Dictionaries](#). This mechanism is available for REST services and Business Intelligence elements.

8.2 InterSystems IRIS Locales and National Language Support

An InterSystems IRIS *locale* is a set of metadata that defines storage and display conventions that apply to a specific country or geographic region. The locale definition includes the following:

- Number formats
- Date and time formats
- Currency symbols
- The sort order of words
- The default character set (the character encoding of this locale), as defined by a standard (ISO, Unicode, or other).

Note that InterSystems IRIS uses the phrases *character set* and *character encoding* as though they are synonymous, which is not strictly true in all cases.

- A set of *translation tables* (also called *I/O tables*) that convert characters to and from other supported character sets. The “translation table” for a given character set (for example, CP1250) is actually a pair of tables. One table specifies how to convert from the default character set to the foreign character set, and other specifies how to convert in the other direction. In InterSystems IRIS, the convention is to refer to this pair of tables as a single unit.

InterSystems IRIS uses the phrase *National Language Support* (NLS) to refer collectively to the locale definitions and to the tools that you use to view and extend them.

The Management Portal provides a page where you can see the default locale, view the details of any installed locale, and work with locales. The following shows an example:

Locale properties of enuw (English, United States, Unicode):

Your current locale is: enuw (English, United States, Unicode)

(enuw is a system locale. Edit is not allowed.)

Basic Properties

Name	Value
Country	United States (US)
Language	English (en-US)
Character set	Unicode
Currency	\$

You can also use this page to see the names of the available translation tables. These names are specific to InterSystems IRIS. (In some cases, discussed later in this chapter, it is necessary to know the names of these tables.)

For information on accessing and using this Management Portal page, see “[Using the NLS Pages of the Management Portal](#)” in the *System Administration Guide*.

InterSystems IRIS also provides a set of classes (in the %SYS.NLS and Config.NLS packages). See “[System Classes for National Language Support](#)” in the chapter “Customizing the InterSystems IRIS” in *Specialized System Tools and Utilities*.

8.3 Default I/O Tables

External to the definition of any locale, a given InterSystems IRIS instance is configured to use specific translation tables, by default, for input/output activity. Specifically, it specifies the default translation tables to use in the following scenarios:

- When communicating with an InterSystems IRIS process
- When communicating with the InterSystems IRIS Terminal
- When reading from and writing to files
- When reading from and writing to TCP/IP devices
- When reading from and writing to strings sent to the operating system as parameters (such as file names and paths)
- When reading from and writing to devices such as printers

For example, when InterSystems IRIS needs to call an operating system function that receives a string as a parameter (such as a file name or path), it first passes the string through an NLS translation appropriately called `syscall`. The result of this translation is sent to the operating system.

To see the current defaults, use `%SYS.NLS.Table`; see the class reference for detail.

8.4 Files and Character Encoding

Whenever you read to or write from an entity external to the database, there is a possibility that the entity is using a different character set than InterSystems IRIS. The most common scenario is working with files.

At the lowest level, you use the [Open](#) command to open a file or other device. This command can accept a parameter that specifies the translation table to use when translating characters to or from that device. For details, see the [I/O Device Guide](#). Then InterSystems IRIS uses that table to translate characters as needed.

Similarly, when you use the object-based file APIs, you specify the `TranslateTable` property of the file.

(Note that the production adapter classes instead provide properties to specify the foreign character set — to be used as the expected character encoding system of input data and the desired character encoding of output data. In this case, you specify a standard character set name, choosing from the set supported by InterSystems.)

8.5 Manually Translating Characters

InterSystems IRIS provides the [\\$ZCONVERT](#) function, which you can use to manually translate characters to or from another character set.

9

Server Configuration Options

There are a few configuration options for the server that can affect how you write your code. This chapter discusses the following topics:

- [Settings for InterSystems SQL](#)
- [Use of IPv6 Internet addresses](#)
- [How to set these options programmatically](#)
- [Other sources of information on these topics](#)

Most of the configuration details are saved in a file called `iris.cpf` (the *configuration parameter file* or *CPF file*).

9.1 Settings for InterSystems SQL

To view and modify the settings that affect the behavior of InterSystems SQL:

1. Access the Management Portal.
2. Select **System Administration > Configuration > SQL and Object Settings > General SQL Settings**.

This page lists many settings. The most important ones are typically these:

- **Cached Query - Save Source** — This specifies whether to save the routine and INT code that InterSystems IRIS generates when you execute any InterSystems SQL except for embedded SQL. (In all cases, the generated OBJ is kept. By default, the routine and INT code is not kept.)

The query results are not stored in the cache.

- **Default SQL Schema Name** — This specifies the default schema name to use when creating tables from external data. This schema name is used for any tables that do not have a specified schema.
- **Support Delimited Identifiers** — This controls how InterSystems SQL treats characters contained within a pair of double quotes.

If you enable support for delimited identifiers, you can use double quotes around the names of fields, which enables you to refer to fields whose names are not regular identifiers. Such fields might, for example, use SQL reserved words as names.

If you disable support for delimited identifiers, characters within double quotes are treated as string literals, and it is not possible to refer to fields whose names are not regular identifiers.

3. If you make any change, select **Save**.

9.2 Use of IPv6 Addressing

InterSystems IRIS™ always accepts IPv4 addresses and DNS forms of addressing (host names, with or without domain qualifiers). You can configure InterSystems IRIS to also accept IPv6 addresses; see “[IPv6 Support](#)” in the chapter “[Configuring InterSystems IRIS](#)” in the *System Administration Guide*.

9.3 Configuring a Server Programmatically

You can programmatically change some of the operational parameters of InterSystems IRIS by invoking specific utilities; this is how you would likely change the configuration for your customers. For example:

- `Config.Miscellaneous` includes methods to set system-wide default and settings.
- `%SYSTEM.Process` includes methods to set environment values for the life of the current process.
- `%SYSTEM.SQL` includes methods for changing SQL settings.

For details, see the InterSystems Class Reference for these classes.

9.4 For More Information

For more information on the topics covered in this chapter, see the following:

- [System Administration Guide](#) describes how to use most of the Management Portal.
- The InterSystems Class Reference provides details on all non-internal classes provided with InterSystems IRIS.
- [Configuration Parameter File Reference](#) contains reference information on the CPF file.

A

What's That?

As you read existing ObjectScript code, you may encounter unfamiliar syntax forms. This appendix shows syntax forms in different groups, and it explains what they are and where to find more information.

- [Non-alphanumeric characters within words](#)
- [Forms that start with .](#)
- [Forms that start with ..](#)
- [Forms that start with #](#)
- [Forms that start with \\$](#)
- [Forms that start with %](#)
- [Forms that start with ^](#)
- [Other forms](#)

This appendix does not list single characters that are obviously operators or that are obviously arguments to functions or commands.

Also see the following appendices in the *ObjectScript Reference*.

- [“Symbols Used in ObjectScript”](#) lists all symbols.
- [“Abbreviations Used in ObjectScript”](#) lists the allowed short forms of commands and functions.

A.1 Non-Alphanumeric Characters in the Middle of “Words”

This section lists forms that look like words with non-alphanumeric characters in them. Many of these are obvious, because the operators are familiar. For example:

```
x>5
```

The less obvious forms are these:

```
abc^def
```

`def` is a routine, and `abc` is a label within that routine. `abc^def` is a subroutine.

Variation for `abc`:

- `%abc`

Some variations for `def`:

- `%def`
- `def.ghi`
- `%def.ghi`
- `def(xxx)`
- `%def(xxx)`
- `def.ghi(xxx)`
- `%def.ghi(xxx)`

`xxx` is an optional, comma-separated list of arguments.

A label can start with a percent sign but is purely alphanumeric after that.

A routine name can start with a percent sign and can include one or more periods. The caret is not part of its name. (In casual usage, however, it is very common to refer to a routine as if its name included an initial caret. Thus you may see comments about the `^def` routine. Usually you can tell from context whether the reference is to a global or to a routine.)

`i%abcdef`

This is an *instance variable*, which you can use to get or to set the value of the `abcdef` property of an object. See “[Object-specific ObjectScript Features](#)” in *Defining and Using Classes*.

This syntax can be used only in an instance method. `abcdef` is a property in the same class or in a superclass.

`abc->def`

Variations:

- `abc->def->ghi` and so on

This syntax is possible only within InterSystems SQL statements. It is an example of InterSystems IRIS *arrow syntax* and it specifies an implicit left outer join. `abc` is an object-valued field in the class that you are querying, and `def` is a field in the child class.

`abc->def` is analogous to InterSystems IRIS dot syntax (`abc.def`), which you cannot use in InterSystems SQL.

For information on InterSystems IRIS arrow syntax, see “[Implicit Joins \(Arrow Syntax\)](#)” in *Using InterSystems SQL*.

`abc?def`

Variation:

- `"abc"?def`

A question mark is the pattern match operator. In the first form, this expression tests whether the value in the variable `abc` matches the pattern specified in `def`. In the second form, `"abc"` is a string literal that is being tested. See “[Operators and Expressions](#)” in *Using ObjectScript*.

Note that both the string literal `"abc"` and the argument `def` can include characters other than letters.

"abc" ["def"

Variations:

- `abc [def`
- `abc ["def "`
- `"abc" [def`

A left bracket (`[`) is the binary contains operator. In the first form, this expression tests whether the string literal `"abc"` contains the string literal `"def"`. In later forms, `abc` and `def` are variables that are being tested. See [“Operators and Expressions”](#) in *Using ObjectScript*.

Note that both the string literals `"abc"` and `"def"` can include characters other than letters.

"abc"] "def"

Variations:

- `abc] def`
- `abc] "def "`
- `"abc"] def`

A right bracket (`]`) is the binary follows operator. In the first form, this expression tests whether the string literal `"abc"` comes after the string literal `"def"`, in ASCII collating sequence. In later forms, `abc` and `def` are variables that are being tested. See [“Operators and Expressions”](#) in *Using ObjectScript*.

Note that both the string literals `"abc"` and `"def"` can include characters other than letters.

"abc"]] "def"

Variations:

- `abc]] def`
- `abc]] "def "`
- `"abc"]] def`

Two right brackets together (`]]`) are the binary sorts after operator. In the first form, this expression tests whether the string literal `"abc"` sorts after the string literal `"def"`, in numeric subscript collation sequence. In later forms, `abc` and `def` are variables that are being tested. See [“Operators and Expressions”](#) in *Using ObjectScript*.

Note that both the string literals `"abc"` and `"def"` can include characters other than letters.

A.2 . (One Period)

period within an argument list

Variations:

- `abc.def (.ghi)`
- `abc (.xyz)`

When you call a method or routine, you can pass an argument by reference or as output. To do so, place a period before the argument.

period at the start of a line

An older form of the Do command uses a period prefix to group lines of code together into a code block. This older Do command is not for use with InterSystems IRIS.

A.3 .. (Two Periods)

In every case, two periods together are the start of a reference from within a class member to another class member.

`..abcdef`

This syntax can be used only in an instance method (not in routines or class methods). `abcdef` is a property in the same class.

`..abcdef (xxx)`

This syntax can be used only in a method (not in routines). `abcdef ()` is another method in the same class, and `xxx` is an optional comma-separated list of arguments.

`..#abcdef`

This syntax can be used only in a method (not in routines). `abcdef` is a parameter in this class.

In classes provided by InterSystems, all parameters are defined in all capitals, by convention, but your code is not required to do this.

Remember that the pound sign is *not* part of the parameter name.

A.4 # (Pound Sign)

This section lists forms that start with a pound sign.

`#abcdef`

In most cases, `#abcdef` is a preprocessor directive. InterSystems IRIS provides a set of preprocessor directives. Their names start with either one or two pound signs. Here are some common examples:

- **#Define** defines a macro (possibly with arguments)
- **#DeflArg** defines a macro that has one argument that includes commas
- **#SQLCompile Mode** specifies the compilation mode for any subsequent embedded SQL statements

For reference information and other directives, see “[ObjectScript Macros and the Macro Preprocessor](#)” in *Using ObjectScript*.

Less commonly, the form `#abcdef` is an argument used with specific commands (such as [READ](#) and [WRITE](#)), special variables, or routines. For details, consult the reference information for the command, variable, or routine that uses this argument.

`##abcdef`

`##abcdef` is a preprocessor directive. See the comments for `#abcdef`.

```
##class(abc.def).ghi(xxx)
```

Variation:

- `##class(def).ghi(xxx)`

`abc.def` is a package and class name, `ghi` is a class method in that class, and `xxx` is an optional comma-separated list of arguments.

If the package is omitted, the class `def` is in the same package as the class that contains this reference.

```
##super()
```

Variations:

- `##super(abcdef)`

This syntax can be used only in a method. It invokes the overridden method of the superclass, from within the current method of the same name in the current class. `abcdef` is a comma-separated list of arguments for the method. See “[Object-specific ObjectScript Features](#)” in *Defining and Using Classes*.

A.5 Dollar Sign (\$)

This section lists forms that start with a dollar sign.

```
$abcdef
```

Usually, `$abcdef` is a special variable. See “[ObjectScript Special Variables](#)” in the *ObjectScript Reference*.

`$abcdef` could also be a custom special variable. See “[Extending ObjectScript with %ZLang](#)” in the chapter “*Customizing InterSystems IRIS*” in *Specialized System Tools and Utilities*.

```
$abcdef(xxx)
```

Usually, `$abcdef()` is a system function, and `xxx` is an optional comma-separated list of arguments. For reference information, see the *ObjectScript Reference*.

`$abcdef()` could also be a custom function. See “[Extending ObjectScript with %ZLang](#)” in the chapter “*Customizing InterSystems IRIS*” in *Specialized System Tools and Utilities*.

```
$abc.def.ghi(xxx)
```

In this form, `$abc` is `SYSTEM` (in any case), `def` is the name of class in the `%SYSTEM` package, `ghi` is the name of a method in that class, and `xxx` is an optional comma-separated list of arguments for that method.

The `SYSTEM` special variable is an alias for the `%SYSTEM` package, to provide language-independent access to methods in classes of that package. For example: `SYSTEM.SQL.DATEDIFF`

For information on the methods in this class, see the *InterSystems Class Reference*.

```
$$abc
```

Variation:

- `$$abc(xxx)`

`abc` is a subroutine defined within the routine or the method that contains this reference. This syntax invokes the subroutine `abc` and gets its return value. See the chapter “[User-defined Code](#)” in *Using ObjectScript*.

\$\$abc^def

Variations:

- `$$abc^def (xxx)`
- `$$abc^def .ghi`
- `$$abc^def .ghi (xxx)`

This syntax invokes the subroutine `abc` and gets its return value. The part after the caret is the name of the routine that contains this subroutine. See the chapter “[User-defined Code](#)” in *Using ObjectScript*.

\$\$\$abcdef

`abcdef` is a macro; note that the dollar signs are not part of its name (and are thus not seen in the macro definition).

Some of the macros supplied by InterSystems IRIS are documented in “[System-Supplied Macro Reference](#)” in *Using ObjectScript*.

In casual usage, it is common to refer to a macro as if its name included the dollar signs. Thus you may see comments about the `$$$abcdef` macro.

A.6 Percent Sign (%)

By convention, most packages, classes, and methods in InterSystems IRIS system classes start with a percent character. From the context, it should be clear whether the element you are examining is one of these. Otherwise, the possibilities are as follows:

%abcdef

`%abcdef` is one of the following:

- A local variable, including possibly a local variable set by InterSystems IRIS.
- A routine.

Variation:

– `%abcdef .ghijkl`

- An embedded SQL variable (these are `%msg`, `%ok`, `%ROWCOUNT`, and `%ROWID`).

For information, see the section “[System Variables](#)” in the chapter “Using Embedded SQL” in *Using InterSystems SQL*.

- An InterSystems SQL command, function, or predicate condition (for example, `%STARTSWITH` and `%SQLUPPER`).

Variation:

– `%abcdef (xxx)`

For information, see the [InterSystems SQL Reference](#).

%%abcdef

`%%abcdef` is `%%CLASSNAME`, `%%CLASSNAMEQ`, `%%ID`, or `%%TABLENAME`. These are pseudo-field keywords. For details, see the [InterSystems SQL Reference](#).

A.7 Caret (^)

This section lists forms that start with a caret, from more common to less common.

^abcdef

Variation:

- `^%abcdef`

There are three possibilities:

- `^abcdef` or `^%abcdef` is a global.
- `^abcdef` or `^%abcdef` is an argument of the **LOCK** command. In this case, `^abcdef` or `^%abcdef` is a lock name and is held in the lock table (in memory).
- `abcdef` or `%abcdef` is a routine. The caret is not part of the name, but rather part of the syntax to call the routine.

In casual usage, it is very common to refer to a routine as if its name included an initial caret. Thus you may see comments about the `^abcdef` routine. Usually you can tell from context whether the reference is to a global or to a routine. Lock names appear only after the **LOCK** command; they cannot be used in any other context.

^\$abcdef

Variation:

- `^$|"ghijkl"|abcdef`

Each of these is a structured system variable, which provides information about globals, jobs, locks, or routines.

`$abcdef` is `$GLOBAL`, `$JOB`, `$LOCK`, or `$ROUTINE`.

`ghijkl` is a namespace name.

InterSystems IRIS stores information in the following system variables:

- `^$GLOBAL`
- `^$JOB`
- `^$LOCK`
- `^$ROUTINE`

See the *ObjectScript Reference*.

^| |abcdef

Variations:

- `^|"^"|abcdef`
- `^[|^"]abcdef`
- `^[|^", "]abcdef`

Each of these is a *process-private global*, a mechanism for temporary storage of large data values. InterSystems IRIS uses some internally but does not present any for public use. You can define and use your own process-private globals. See “[Variables](#)” in *Using ObjectScript*.

`^|xxx|abcdef`

Some variations:

- `^|xxx|%abcdef`
- `^[xxx]abcdef`
- `^[xxx]%abcdef`

Each of these is an *extended reference* — a reference to a global or a routine in another namespace. The possibilities are as follows:

- `^abcdef` or `^%abcdef` is a global in the other namespace.
- `abcdef` or `%abcdef` is a routine in the other namespace.

The `xxx` component indicates the namespace. This is either a quoted string or an unquoted string. See “Extended References” in the chapter “[Syntax Rules](#)” in *Using ObjectScript*.

`^abc^def`

This is an implied namespace. See the “[ZNSPACE](#)” entry in the *ObjectScript Reference*.

`^^abcdef`

This is an implied namespace. See the “[ZNSPACE](#)” entry in the *ObjectScript Reference*.

A.8 Other Forms

`+abcdef`

Some variations:

- `+^abcdef`
- `+"abcdef"`

Each of these expressions returns a number. In the first version, `abcdef` is the name of a local variable. If the contents of this variable do not start with a numeric character, the expression returns 0. If the contents do start with a numeric character, the expression returns that numeric character and all numeric characters after it, until the first nonnumeric character. For a demonstration, run the following example:

```
write +"123abc456"
```

See “[String Relational Operators](#)” in the chapter “Operators and Expressions” in *Using ObjectScript*.

`{"abc":(def),"abc":(def),"abc":(def)}`

This syntax is a [JSON object literal](#) and it returns an instance of `%DynamicObject`. `"abc"` is the name of a property, and `def` is the value of the property. For details, see [Using JSON](#).

`{abcdef}`

This syntax is possible where InterSystems SQL uses ObjectScript. `abcdef` is the name of a field. See “[Referring to Fields from ObjectScript](#)” in *Defining and Using Classes*.

{%%CLASSNAME}

This syntax can be used within trigger code and is replaced at class compilation time.

Others:

- {%%CLASSNAMEQ}
- {%%ID}
- {%%TABLENAME}

These items are not case-sensitive. See “[CREATE TRIGGER](#)” in the *InterSystems SQL Reference*.

&sql(xxx)

This is embedded SQL and can be used anywhere ObjectScript is used. xxx is one SQL statement. See “[Using Embedded SQL](#)” in *Using InterSystems SQL*.

[abcdef,abcdef,abcdef]

This syntax is a [JSON array literal](#) and it returns an instance of %DynamicArray. abcdef is an item in the array. For details, see *Using JSON*.

***abcdef**

Special syntax used by the following functions and commands:

- [\\$ZSEARCH](#)
- [\\$EXTRACT](#)
- [WRITE](#)
- [\\$ZTRAP](#)
- [\\$ZERROR](#)

See these items in the *ObjectScript Reference*.

?abcdef

The question mark is the pattern match operator and abcdef is the comparison pattern. See “[Operators and Expressions](#)” in *Using ObjectScript*.

@abcdef

The at sign is the indirection operator. See “[Operators and Expressions](#)” in *Using ObjectScript*.

B

Rules and Guidelines for Identifiers

For convenience, this appendix summarizes the rules for ObjectScript identifiers in all server-side contexts and provides guidelines to avoid name collisions.

- [Namespaces](#)
- [Databases](#)
- [Local variables](#)
- [Global variables](#)
- [Routines and labels](#)
- [Classes](#)
- [Class members](#)
- [IRISSYS Database and Custom Items](#)

Also note that ObjectScript does not have reserved words, so if you use a command as an identifier, the result is syntactically correct, but the code is also potentially confusing to anyone who reads it.

For identifiers for security entities such as users, roles, and resources, see the relevant section of the *Security Administration Guide*.

B.1 Namespaces

In a namespace name, the first character must be a letter or a percent sign (%). The remaining characters must be letters, numbers, hyphens, or underscores. The name cannot be longer than 255 characters.

B.1.1 Namespace Names to Avoid

The following namespace names are reserved: %SYS, BIN, BROKER, and DOCUMATIC. Some of these namespaces are described in “[System-Supplied Namespaces](#),” earlier in this book. Others are used internally by InterSystems IRIS.

B.2 Databases

In a database name, the first character must be a letter or an underscore. The remaining characters must be letters, numbers, hyphens, or underscores. The name cannot be longer than 30 characters.

B.2.1 Database Names to Avoid

The following database names are reserved: IRISLOCALDATA, IRISYSYS, IRISLIB, IRISAUDIT, IRISTEMP.

For information on these databases, see “[System-Supplied Databases](#),” earlier in this book.

B.3 Local Variables

For the name of local variable, the following rules apply in ObjectScript:

- The first character must be either a letter or a percent sign (%).
If you start a name with %, use z or Z as the next character after that.
- The remaining characters must be letters or numbers, including any letter character above ASCII 128.
- Names are case-sensitive.
- The name must be unique (within the appropriate context) to the first 31 characters.
Any subscripts of the variable do not contribute to this count.

B.3.1 Local Variable Names to Avoid

Avoid using the following name for local variables:

- `SQLCODE`

Avoid using `SQLCODE` as the name of a variable in any context where InterSystems SQL might run. See the “[SQLCODE Values and Error Messages](#)” chapter of the *InterSystems IRIS Error Reference*.

B.4 Global Variables

For the name of a global variable, the following rules apply in ObjectScript:

- The first character must be a caret (^), and the next character must be either a letter or a percent sign (%).
- The remaining characters must be letters or numbers (with one exception, noted in the next bullet). These other characters may include any letter character above ASCII 128.
- The name of a global variable can include one or more period (.) characters, except not as the first or last character.
- Names are case-sensitive.
- The name must be unique (within the appropriate context) to the first 31 characters. The caret character does not contribute to this count. That is, the name of a global variable must be unique to the first 32 characters, including the caret.

Any subscripts of the variable do not contribute to this count.

- In the IRISYS database, InterSystems reserves to itself all global names *except* those starting with ^z, ^Z, ^%z, and ^%Z. See “[IRISYS Database and Custom Items](#).”

In all other databases, InterSystems reserves all global names starting with ^IRIS. and ^%IRIS.

Also see the [following subsection](#).

B.4.1 Global Variable Names to Avoid

When you create a database, InterSystems IRIS initializes it with some globals for its own use. Also, every namespace that you create contains mappings to system globals, including global nodes that are in writable system databases.

To avoid overwriting system globals, do not set, modify, or kill the following globals in any namespace:

- Globals with names that start with ^%, with the following exceptions:
 - Your own globals with names that start ^%z or ^%Z
 - ^%SYS (you can set nodes as noted in the documentation)
- ^BfVY. (reserved for use by InterSystems Iris [sharding](#))
- ^Cache.Temp*
- ^DeepSee.* (restriction applies only to a namespace in which you are using InterSystems IRIS Analytics)
- ^Ens* (restriction applies only to an interoperability-enabled namespace; see *Introducing Interoperability Productions*)
- ^ERRORS
- ^InterSystems.Sequences (restriction applies only to a namespace in which you are using the InterSystems IRIS Hibernate Dialect)
- ^IRIS.* (reserved for use by InterSystems)
- ^IRISAuditD
- ^IS. (reserved for use by InterSystems Iris [sharding](#))
- ^ISCDebugLevel (except for setting nodes as noted in the documentation)
- ^ISCMonitor (except for setting nodes as noted in the documentation)
- ^ISCSOAP (except for setting nodes as noted in the documentation)
- ^mqh (SQL query history)
- ^mtemp*
- ^OBJ.GUID (except as noted in the documentation)
- ^OBJ.DBTIME
- ^OBJ.JournalT
- ^oddBIND
- ^oddCOM
- ^oddDEF (contains class definitions)
- ^oddDEP
- ^oddEXT

- **^oddEXTR**
- **^oddMAP**
- **^oddMETA**
- **^oddPKG**
- **^oddPROC**
- **^oddPROJECT**
- **^oddSQL**
- **^oddStudioDocument**
- **^oddStudioMenu**
- **^oddTSQL**
- **^oddXML**
- **^rBACKUP**
- **^rINC** (contains include files)
- **^rINCSAVE**
- **^rINDEX**
- **^rINDEXCLASS**
- **^rINDEXEXT**
- **^rINDEXSQL**
- **^rMAC** (contains MAC code)
- **^rMACSAVE**
- **^rMAP**
- **^rOBJ** (stores OBJ code)
- **^ROUTINE** (stores routines)
- **^SPOOL** (restriction applies only to a namespace in which you are using InterSystems IRIS spooling; see “[Spool Device](#)” in the *I/O Device Guide*)
- **^SYS** (except for setting nodes as noted in the documentation)
- **^z*** and **^Z*** (reserved for use by InterSystems)

B.5 Routines and Labels

For the name of a routine or for a label, the following rules apply in ObjectScript:

- The first character must be either a letter or a percent sign (%).
If you start a routine name with %, use z or Z as the next character after that; see “[IRISSYS Database and Custom Items](#).”
- The remaining characters must be letters or numbers (with one exception; see the next bullet). These other characters may include any letter character above ASCII 128.

- The name of a routine can include one or more period (.) characters, except not as the first or last character.
- Names are case-sensitive.
- The name of a routine must be unique (within the appropriate context) within the first 255 characters.
A label must be unique (within the appropriate context) within the first 31 characters.

Note that certain %Z routine names are reserved for your use. See the subsection.

B.5.1 Reserved Routine Names for Your Use

InterSystems IRIS reserves the following routine names for your use. These routines do not exist, but if you define them, the system automatically calls them when specific events happen.

- The **^ZWELCOME** routine is intended to contain custom code to execute when the Terminal starts. See [Using the Terminal](#).
- The **^ZAUTHENTICATE** and **^ZAUTHORIZE** routines are intended to contain custom code for authentication and authorization (to support *delegated authentication* and *delegated authorization*). For these routines, InterSystems IRIS provides templates. See the [Security Administration Guide](#).
- The **^ZMIRROR** routine is intended to contain code to customize failover behavior when you use InterSystems IRIS Mirroring. See the [High Availability Guide](#).
- The **^%ZSTART** and **^%ZSTOP** routines are intended to contain custom code to execute when certain events happen, such as when a user logs in. These routines are not predefined. If you define them, the system can call them when these events happen. See “[Customizing Start and Stop Behavior with ^%ZSTART and ^%ZSTOP Routines](#)” in *Specialized System Tools and Utilities*.
- **^%ZLANGV00** and other routines with names that start **^%ZLANG** are intended to contain your custom variables, commands, and functions. See “[Extending Languages with %ZLANG Routines](#)” in *Specialized System Tools and Utilities*.
- The **^%ZJREAD** routine is intended to contain logic to manipulate journal files if you use the **^JCONVERT** routine. See the chapter “[Journaling](#)” in the *Data Integrity Guide*.

B.6 Classes

For any class, the full class name has the following form: *packagename.classname*

The rules for class names are as follows:

- *packagename* (the package name) and *classname* (the short class name) must each start with a letter.
- *packagename* can include periods.
If so, the character immediately after any period must be a letter.
Each period-delimited piece of *packagename* is treated as a subpackage name and is subject to uniqueness rules.
- The remaining characters must be letters or numbers, including letter characters above ASCII 128.
- The package name and the short class name must be unique. Similarly, any subpackage name must be unique within the parent package name.

Note that the system preserves the case that you use when you define each class, and you must exactly match the case as given in the class definition. However, two identifiers cannot differ only in case. For example, the identifiers `id1` and `ID1` are considered identical for purposes of uniqueness.

- In any interoperability-enabled namespace, avoid using the following package names: `Ens`, `EnsLib`, `EnsPortal`, or `CSPX`. These packages are completely replaced during the upgrade process. If you define classes in these packages, you would need to export the classes before upgrading and then import them after upgrading.
- In any interoperability-enabled namespace, InterSystems recommends that you avoid using any package names that *start* with `Ens` (case-sensitive). For more information, see “Environmental Considerations” in the first chapter of *Developing Productions*.
- There are length limits:
 - The package name (including all periods) must be unique within the first 189 characters.
 - The short class name must be unique within the first 60 characters.

The full class name contributes to the individual length limits for class members; see the next section.

B.6.1 Class Names to Avoid

For persistent classes, avoid using an SQL reserved word as the short name for the class.

If you use an SQL reserved word as the short name for a class, you will need to specify the `SqlTableName` keyword for the class. Also, the mismatch between the short class name and the SQL table name will require greater care when reading the code in the future.

For a list of the SQL reserved words, see “[Reserved Words](#)” in the *InterSystems SQL Reference*.

B.7 Class Members

For a class member that you create, unless the name of that item is delimited, the name must follow these rules:

- The name must start with either a letter or a percent sign (%).

There is an additional consideration for class members that are projected to SQL (this includes, for example, most properties of persistent classes). If the first character is %, the second character must be `Z` or `z`.

- The remaining characters must be letters or numbers, including letter characters above ASCII 128.
- The member name must be unique (within the appropriate context).

Note that the system preserves the case that you use when you define classes, and you must exactly match the case as given in the class definition. However, two class members cannot have names that differ only in case. For example, the identifiers `id1` and `ID1` are considered identical for purposes of uniqueness.

- A method or property name must be unique within the first 180 characters.
- The combined length of the name of a property and of any indices on the property should be no longer than 180 characters.
- The full name of each member (including the unqualified member name and the full class name) must be less than or equal to 220 characters.
- InterSystems strongly recommends that you do not give two members the same name. This can have unexpected results.

Also, member names can be delimited. To create a delimited member name, use double quotes for the first and last characters of the name. Then the name can include characters that are otherwise not permitted. For example:

```
Property "My Property" As %String;
```

B.7.1 Member Names to Avoid

For persistent classes, avoid using an SQL reserved word as the name of a member.

If you use an SQL reserved word for one of these names, you will have to do extra work to specify how the class is projected to SQL. For example, for a property, you would need to specify the [SqlFieldName](#) keyword. Also, the mismatch between the identifier in the class and the identifier in SQL will require greater care when reading the code in the future.

For a list of the SQL reserved words, see “[Reserved Words](#)” in the *InterSystems SQL Reference*. Notice that this list includes many items with names beginning with %, such as %SQLUPPER and %FIND. Such items are InterSystems extensions to SQL, and additional extensions may be added in future releases.

B.8 IRISSYS Database and Custom Items

You can create items in the IRISSYS database. For the next release of InterSystems IRIS, the installer will upgrade this database. During this upgrade, some items will be deleted unless they follow the naming conventions for custom items.

To add code or data to this database so that your items are not overwritten, do one of the following:

- Go to the %SYS namespace and create the item. For this namespace, the default routine database and default global database are both IRISSYS. Use the following naming conventions to prevent your items from being affected by the upgrade installation:
 - Classes: start the package with Z or z
 - Routines: start the name with Z, z, %Z, or %z
 - Globals: start the name with ^Z, ^z, ^%Z, or ^%z
- In any namespace, create items with the following names:
 - Routines: start the name with %Z or %z
 - Globals: start the name with ^%Z or ^%z

Because of the standard mappings in any namespace, these items are written to IRISSYS.

MAC code and include files are not affected by upgrade.

C

General System Limits

This appendix lists some of the system limits for InterSystems IRIS™. It discusses the following topics:

- [String length limit](#)
- [Class-only limits](#)
- [Limits per class or routine](#)
- [Other programming limits](#)

For limits on identifier names, see “[Rules and Guidelines for Identifiers.](#)”

For additional system-wide limits, see the [Configuration Parameter File Reference](#).

C.1 String Length Limit

There is a limit to the length of a value of a string: 3,641,144 characters.

Important: It is important to realize that “strings” are not just the result of reading from input/output devices. They can show up in other contexts such as the data in the rows of a result set returned by an SQL query, by construction of \$LISTs with a large number of items, as the output of an XSLT transformation, and many other ways.

C.2 Class Limits

The following limits apply only to classes:

class inheritance depth

Limit: 50. A given class can be subclassed to a depth of 50 but not further.

foreign keys

Limit: 400 per class.

indices

Limit: 400 per class.

methods

Limit: 2000 per class.

parameters

Limit: 1000 per class.

projections

Limit: 200 per class.

properties

Limit: 1000 per class.

queries

Limit: 200 per class.

SQL constraints

Limit: 200 per class.

storage definitions

Limit: 10 per class.

superclasses

Limit: 127 per class.

triggers

Limit: 200 per class.

XData blocks

Limit: 1000 per class.

C.3 Class and Routine Limits

The following limits apply to both classes and routines:

class method references

Limit: 32768 unique references per routine or class.

The following is counted as two class method references because the class name is different even though the method name is the same.

```
Do ##class(c1).abc(), ##class(c2).abc()
```

class name references

Limit: 32768 unique references per routine or class.

For example, the following is counted as two class name references:

```
Do ##class(c1).abc(), ##class(c2).abc()
```

Similarly, the following is counted as two class references because the normalization of %File to %Library.File is done at runtime, not at compile time.

```
Do ##class(%File).Open(x)
Do ##class(%Library.File).Open(y)
```

instance method references

Limit: 32768 per routine or class.

If *X* and *Y* are OREFs, the following counts as one instance method reference:

```
Do X.abc(), Y.abc()
```

References to multidimensional properties are counted as instance methods because the compiler cannot distinguish between them. For example, consider the following statement:

```
Set var = OREF.xyz(3)
```

Because the compiler cannot tell whether this statement refers to the method **xyz()** or to the multi-dimensional property *xyz*, it counts this as an instance method reference.

lines

Limit: 65535 lines per routine, including comment lines. The limit applies to the size of the INT representation.

literals (ASCII)

Limit: 65535 ASCII literals per routine or class.

An ASCII literal is a quoted string of three or more characters where no character is larger than \$CHAR(255).

Note that ASCII literals and Unicode literals are handled separately and have separate limits.

literals (Unicode)

Limit: 65535 Unicode literals per routine or class.

A Unicode literal is a quoted string with at least one character larger than \$CHAR(255).

Note that ASCII literals and Unicode literals are handled separately and have separate limits.

parameters

Limit: 255 parameters per subroutine, method, or stored procedure.

procedures

Limit: 32767 per routine.

property read references

Limit: 32768 per routine or class.

This limit refers to reading the value of a property as in the following example:

```
Set X = OREF.prop
```

property set references

Limit: 32768 per routine or class.

This limit refers to setting the value of a property as in the following example:

```
Set OREF.prop = value
```

routine references

Limit: 65535 per routine or class.

This limit applies to the number of unique references (^routine) in a routine or class.

target references

Limit: 65535 per routine or class.

A target is label^routine (a combination of label and routine).

Any target reference also counts as a routine reference. For example, the following is counted as two routine references and three target references:

```
Do Label1^Rtn, Label2^Rtn, Label1^Rtn2
```

TRY blocks

Limit: 65535 per routine.

variables (private)

Limit (ObjectScript): 32763 per procedure.

variables (public)

Limit (ObjectScript): 65503 per routine or class.

For limits on the lengths of variable names and other identifiers, see “[Rules and Guidelines for Identifiers](#),” earlier in this book.

C.4 Other Programming Limits

The following table lists other limits that are relevant when writing code.

%Status value limits

Length limit of error message: Just under 32k characters.

Maximum number of %Status values that can be combined into a single %Status value: 150.

{ } nesting

Limit: 32767 levels.

This is the maximum depth of nesting of any language element that uses curly braces, like IF { FOR { WHILE {...}}}

characters per line

Limit: 65535 characters per line.

global subscript, length

See “[Maximum Length of a Global Reference](#)” in *Using Globals*.

global reference, length

Limit: 511 encoded characters (which may be fewer than 511 typed characters). The term *global reference* refers to the name of the global plus all of its subscripts. For a discussion, see “[Maximum Length of a Global Reference](#)” in *Using Globals*.

numeric value

Limits (for decimal or native format): Approximately 1.0E-128 to 9.22E145. See “[Numeric Computing in InterSystems Applications](#),” later in this book.

Limits (for double format): See “[Numeric Computing in InterSystems Applications](#),” later in this book.

D

Numeric Computing in InterSystems Applications

This appendix provides details on the numeric formats supported by InterSystems IRIS™. It discusses the following topics:

- [Representations of numbers in InterSystems IRIS](#)
- [Items to consider when you choose a numeric format](#)
- [How to convert numeric representations](#)
- [Operations that involve numbers](#)
- [Exact representations](#)
- [Additional sources of information](#)

D.1 Representations of Numbers

InterSystems IRIS has two different ways of representing numbers.

- The first of these has its roots in the original implementation of InterSystems IRIS. This representation will be referred to as *decimal format*.

In class definitions, you use the `%Library.Decimal` datatype class when you want a property to contain a decimal format number.

- The second, more recently supported, form adheres to the IEEE Binary Floating-Point Arithmetic standard ([#754–1985](#)). This latter format is referred to as *\$DOUBLE format* after the ObjectScript function (`$DOUBLE`) that is used to convert numbers into this form.

In class definitions, you use the `%Library.Double` datatype class when you want a property to contain a \$DOUBLE format number.

D.1.1 Decimal Format

InterSystems IRIS represents decimal numbers internally in two parts. The first is called the *significand*, and the second is called the *exponent*:

- The significand contains the significant digits of the number. It is stored as a signed 64-bit integer with the decimal point assumed to be to the right of the value. The largest positive integer with an exponent of 0 that can be represented without loss of precision is 9,223,372,036,854,775,807; the largest negative integer is -9,223,372,036,854,775,808.
- The exponent is stored internally as a signed byte. Its values range from 127 to -128.
This is the base-10 exponent of the value. That is, the value of the number is the significand multiplied by 10 raised to the power of the exponent.

For example, for the ObjectScript literal value 1.23, the significand is 123, and -2 is the exponent.

Thus, the range of numbers that can be represented in InterSystems IRIS native format approximately covers the range 1.0E-128 to 9.22E145. (The first value is the smallest integer with the smallest exponent. The second value is the largest integer with the decimal point moved to the left and the exponent increased correspondingly in the displayed representation.)

All numbers with 18 digits of precision can be represented exactly; numbers which are within the representation bounds of the significand can be accurately represented as 19-digit values.

Note: InterSystems IRIS does not normalize the significand unless necessary to fit the number in decimal format. So numbers with a significand of 123 and an exponent of 1, and a significand of 1230 and an exponent of zero compare as equal.

D.1.2 \$DOUBLE Format

The InterSystems \$DOUBLE format conforms to [IEEE-754-1985](#), specifically, the 64-bit binary (double-precision) representation. This means it consists of three parts:

- A sign bit
- An 11-bit power of two exponent. The exponent value is biased by 1023, so the internal value of the exponent for the number \$DOUBLE(1.0) is 1023 rather than 0.
- A positive 52-bit fractional significand. Because the significand is always treated as a positive value and normalized, a 1-bit is assumed as the lead binary digit even though it is not present in the significand. Thus, the significand is numerically 53 bits long: the value 1, followed by the implied binary point, followed by the fractional significand. This can be thought of as an integer implicitly divided by 2^{52} .

As an integer, all values between 0 and 9,007,199,254,740,992 can be represented exactly. Larger integers may or may not have exact representations depending on their pattern of bits.

This representation has three optional features that are not available with InterSystems IRIS native format:

- The ability to represent the results of invalid computations (such as taking the square root of a negative number) as a NaN (Not any Number).
- The ability to represent both a +0 and -0.
- The ability to represent infinity.
- The standard provides for representation of numbers smaller than 2^{-1022} . This is done by a technique referred to as a “gradual loss of precision”. Please refer to the [standard](#) for details.

These features are under program control via the **IEEEError()** method of the %SYSTEM.Process class for an individual process or the **IEEEError()** method of the Config.Miscellaneous class for the system as a whole.

Important: Calculations using IEEE binary floating-point representations can give different results for the same IEEE operation. InterSystems has written its own implementations for:

1. Conversions between \$DOUBLE binary floating-point and decimal;
2. Conversion between \$DOUBLE and numeric strings;
3. Comparisons between \$DOUBLE and other numeric types.

This guarantees that when a \$DOUBLE value is inserted into, or fetched from, an InterSystems IRIS data base, the result is the same across all hardware platforms.

However, for all other calculations involving the \$DOUBLE type, InterSystems IRIS uses the vendor-supplied floating-point library subroutines. This means that there can be minor differences between platforms for the same set of operations. In all cases, however, InterSystems \$DOUBLE calculations equal the local calculations performed on the C double type; that is, the differences between platforms for InterSystems \$DOUBLE computations are never worse than the differences exhibited by C programs computing IEEE values running on those same platforms.

D.1.3 SQL Representations

The InterSystems SQL data types DOUBLE and DOUBLE PRECISION represent IEEE floating-point numbers, that is, \$DOUBLE. The SQL FLOAT data type represents standard InterSystems IRIS decimal numbers.

D.2 Choosing a Numeric Format

The choice of which format to use is largely determined by the requirements of the computation. InterSystems IRIS decimal format permits over 18 decimal digits of accuracy while \$DOUBLE guarantees only 15.

In most cases, decimal format is simpler to use and provides more precise results. It is usually preferred for computations involving decimal values (such as currency calculations) because it gives the expected results. Decimal fractions cannot often be represented exactly as binary fractions.

On the other hand, the range of numbers in \$DOUBLE is significantly larger than permitted by native format: 1.0E308 versus 1.0E145. Those applications where the range is a significant factor should use \$DOUBLE.

Applications that will share data externally may also consider maintaining data in \$DOUBLE format because it will not be subject to implicit conversion. Most other systems use the IEEE standard as their representation of binary floating-point numbers because it is supported directly by the underlying hardware architecture. So values in decimal format must be converted before they can be exchanged, for example, via ODBC/JDBC, SQL, or language binding interfaces.

If a \$DOUBLE value is within the bounds defined for InterSystems IRIS decimal numbers, then converting it to decimal and then converting back to a \$DOUBLE value will always yield the same number. The reverse is not true because \$DOUBLE values have less precision than decimal values.

For this reason, InterSystems recommends that computation be done in one representation or the other, when possible. Converting values back and forth between representations may cause loss of accuracy. Most applications can use InterSystems IRIS decimal format for all their computations. The \$DOUBLE format is intended to support those applications that exchange data with systems that use IEEE formats.

The reasons for preferring InterSystems IRIS decimal over \$DOUBLE are:

- InterSystems IRIS decimal has more precision, almost 19 decimal digits compared to less than 16 decimal digits for \$DOUBLE.

- InterSystems IRIS decimal can exactly represent decimal fractions. The value 0.1 is an exact value in InterSystems IRIS decimal; but there is no exact equivalent in binary floating point, so 0.1 must be approximated in \$DOUBLE format.

The advantages of InterSystems \$DOUBLE over InterSystems decimal for scientific numbers are:

- \$DOUBLE uses exactly the same representation as the IEEE double precision binary floating point used by most computing hardware.
- \$DOUBLE has a greater range: 1.7E308 maximum for \$DOUBLE and 9.2E145 maximum for InterSystems decimal.

D.3 Converting Numeric Representations

CAUTION: InterSystems recommends that your application explicitly control conversions between decimal and \$DOUBLE formats.

When converting values from string to number, or when processing written constants when a program is compiled, only the first 38 significant digits can influence the value of the significand. All digits following that will be treated as if they were zero; that is, they will be used in determining the value of the exponent but they will have no additional effect on the significand value.

D.3.1 Strings

D.3.1.1 Strings as Numbers

In InterSystems IRIS, if a string is used in an expression, the value of the string is the value of the longest numeric literal contained in the string starting at the first character. If there is no such literal present, the computed value of the string is zero.

D.3.1.2 Numeric Strings As Subscripts

In computation, there is no difference between the strings “04” and “4”. However, when such strings are used as subscripts for local or global arrays, InterSystems IRIS makes a distinction between them.

In InterSystems IRIS, numeric strings that contain leading zeroes (after the minus sign, if there is one), or trailing zeroes at the end of decimal fractions, will be treated as if they were strings when used as subscripts. As strings, they have a numeric value; they can be used in computations. But as subscripts for local or global variables, they are treated as strings and are collated as strings. Thus, in the list of pairs:

- “4” versus “04”
- “10” versus “10.0”
- “.001” versus “0.001”
- “-.3” versus “-0.3”
- “1” versus “+01”

those on the left are considered numbers when used as subscripts and those on the right are treated as strings. (The form on the left, without the extraneous leading and trailing zero parts, is sometimes referred to as “canonical” form.)

In normal collation, numbers sort before strings as shown in this example,

```

SET ^|TEST("2") = "standard"
SET ^|TEST("01") = "not standard"
SET NF = "Not Found"

WRITE ""2"", ": ", $GET(^|TEST("2"),NF), !
WRITE 2, ": ", $GET(^|TEST(2),NF), !
WRITE ""01"", ": ", $GET(^|TEST("01"),NF), !
WRITE 1, ": ", $GET(^|TEST(1),NF), !, !
SET SUBS=$ORDER(^|TEST(""))
WRITE "Subscript Order:", !
WHILE (SUBS != "") {
    WRITE SUBS, !
    SET SUBS=$ORDER(^|TEST(SUBS))
}

```

D.3.2 Decimal to \$DOUBLE

Conversion to \$DOUBLE format is done explicitly via the `$DOUBLE` function. This function also permits the explicit construction of IEEE representations for not-a-number and infinity via the expression, `$DOUBLE(<S>)` where `<S>` is:

- the string, “nan” to generate a NaN
- any one of the strings “inf”, “+inf”, “-inf”, “infinity”, “+infinity”, or “-infinity” for infinity.
- the numeric and string literals, -0 and “-0”, respectively

Note: The case of the string, `<S>`, is ignored on input. On output, only “NAN”, “INF” and “-INF” are produced.

D.3.3 \$DOUBLE to Decimal

Values in \$DOUBLE form are converted to decimal values with the `$DECIMAL` function. The result of calling the function is a string suitable for conversion to a decimal value.

Note: Although this description assumes the value presented to `$DECIMAL` is a \$DOUBLE value, this is not a requirement. Any numeric value may be supplied as the argument and the same rules apply for rounding.

D.3.3.1 \$DECIMAL(x)

The single argument form of the function converts the \$DOUBLE value given as its argument to decimal. `$DECIMAL` rounds the decimal portion of the number to 19 digits. `$DECIMAL` always rounds to the nearest decimal value.

D.3.3.2 \$DECIMAL(x, n)

The two-argument form allows precise control over the number of digits returned. If `n` is greater than 38, an `<ILLEGAL VALUE>` error occurs. If `n`, is greater than 0, the value of `x` rounded to `n` significant digits is returned.

When `n` is zero, the following rules are used to determine the value:

1. If `x` is an Infinity, return “INF” or “-INF” as appropriate.
2. If `x` is a NaN, return “NAN”.
3. If `x` is a positive or negative zero, return “0”.
4. If `x` can be exactly represented in 20 or fewer significant digits, return the canonical numeric string contains those exact significant digits.
5. Otherwise, truncate the decimal representation to 20 significant digits, and
 - a. If the 20th digit is a “0”, replace it with a “1”;
 - b. If the 20th digit is a “5”, replace it with a “6”.

Then, return the resulting string.

This rounding rule involving truncation-to-zero of the 20th digit except when it would inexactly make the 20th digit be a “0” or “5” has these properties:

- If a \$DOUBLE value is different from a decimal value, these two values will always have unequal representation strings.
- When a \$DOUBLE value can be converted to decimal without generating a <MAXNUMBER> error, the result is the same as converting the \$DOUBLE value to a string and then converting that string to a decimal value. There is no possibility of a “double round” error when doing the two conversions.

D.3.4 Decimal to String

Decimal values can be converted to strings by default when they are used as such, for example, as one of the operands to the [concatenation operator](#). When more control over the conversion is needed, use the [\\$FNUMBER](#) function.

D.4 Operations Involving Numbers

D.4.1 Arithmetic

D.4.1.1 Homogeneous Representations

Expressions involving only decimal values will always yield a decimal result. Similarly, expressions with only \$DOUBLE values will always produce a \$DOUBLE result. In addition,

- If the result of a computation involving decimal values overflows, a <MAXNUMBER> error will result. There is no automatic conversion to \$DOUBLE in this case as there is for literals.
- If a decimal expression underflows, 0 is generated as the result of the expression.
- By default the IEEE errors of overflow, divide-by-zero, and invalid-operation will signal the <MAXNUMBER>, <DIVIDE>, and <ILLEGAL VALUE> errors, respectively, rather than generating an Infinity or NaN result. This behavior can be modified by the **IEEEError()** method of the %SYSTEM.Process class for an individual process or the **IEEEError()** method of the Config.Miscellaneous class for the system as a whole.
- The expression `0 ** 0` (decimal) produces the decimal value, 0; but, the expression `$DOUBLE(0) ** $DOUBLE(0)` produces the \$DOUBLE value, 1. The former has always been true in InterSystems IRIS; the latter is required by the IEEE standard.

D.4.1.2 Heterogenous Representations

Expressions involving both decimal and \$DOUBLE representations always produce a \$DOUBLE value. The conversion of the value takes place when it is used. Thus, in the expression

```
1 + 2 * $DOUBLE(4.0)
```

InterSystems IRIS first adds 1 and 2 together as decimal values. Then it converts the result, 3, to \$DOUBLE format and does the multiplication. The result is \$DOUBLE(12).

D.4.1.3 Rounding

When necessary, numeric results are rounded to the nearest representable value. When the value to be rounded is equally close to two available values, then:

- \$DOUBLE values are rounded to even as defined in the IEEE standard
- Decimal values are rounded away from zero, that is toward a larger value (in absolute terms)

D.4.2 Comparison

D.4.2.1 Homogeneous Representations

Comparisons between \$DOUBLE(+0) and \$DOUBLE(-0) treat these values as equal. This follows the IEEE standard. This is the same as in InterSystems IRIS decimal because, when either \$DOUBLE(+0) or \$DOUBLE(-0) is converted to a string, the result in both cases is “0”.

Comparisons between \$DOUBLE(“nan”) and any other numeric value — including \$DOUBLE(“nan”) — will say these values are not greater than, not equal, and not less than. This follows the IEEE standard. This is a departure from usual ObjectScript rule that says the equality comparison is done by converting to strings and checking the strings for equality.

Note: The expression, “nan”, is equal to \$DOUBLE(“nan”) because the comparison is done as a string compare.

Note: However, \$LISTSAME considers a list component containing \$DOUBLE(“nan”) to be the same as a list component containing \$DOUBLE(“nan”). This is the only place where \$LISTSAME considers what should be unequal values to be equal.

D.4.2.2 Heterogeneous Representations

Comparisons between a decimal value and \$DOUBLE value are fully accurate. The comparisons are done without any rounding of either value. If only finite values are involved then these comparisons get the same answer that would result if both values were converted to strings and those strings were compared using the default collation rules.

Comparison involving the operators <, <=, >, and => always produce a boolean result, 0 or 1, as a decimal value. If one of the operands is a string, that operand is converted to a decimal value before the comparison is performed. Other numeric operands are not converted. As noted, the comparison of mixed numeric types is done with full accuracy and no conversion.

In the case of the string comparison operators (=, '=',],], [, '[,]], and so on), any numeric operand is first converted to a string before the comparison is done.

D.4.2.3 Less-Than Or Equal, Greater-Than Or Equal

In InterSystems IRIS, the operators “<=” and “>=” are treated as synonyms for the operators “>” and “<”, respectively.

CAUTION: If the operators “<=” or “>=” are used in comparisons where either or both of the operands may be NaNs, the results will be different from those mandated by the IEEE standard.

The expression “A >= B” when either A and/or B is a NaN is interpreted as follows:

1. The expression is transformed to “A > B”.
2. It is further transformed to “!(A <B)”.
3. As noted previously, comparisons involving NaNs give results that are (a) not equal, (b) not greater-than, and (c) not less-than, so the expression in parenthesis results in a value of false.
4. The negation of that value results in a value of true.

Note: The expression “A >= B” can be rewritten to provide the IEEE expected results if it is expressed as “((A > B) | (A = B))”.

D.4.3 Boolean Operations

For boolean operations and, or not, nor, nand and so on) any string operand is converted to decimal. Any numeric operand (decimal or \$DOUBLE) is left unchanged.

A numeric value that is zero is treated as FALSE; all other numeric values (including \$DOUBLE(“nan”) and \$DOUBLE(“inf”)) are treated as TRUE. The result is 0 or 1 (as decimal.)

Note: \$DOUBLE(-0) is also false.

D.5 Exact Representation of Values

Each of the number forms has a bounds on the number of significant digits that can be retained. A common belief is that numbers with more digits than the bounds automatically result in a loss of precision. As a generalization, this is not true.

This effect is most easily seen in InterSystems IRIS decimal values. The value 9,223,372,036,854,775,807 is naively considered the biggest number that can be represented exactly, but that ignores the exponent. It is obvious that 9,223,372,036,854,775,807,000,000 can also be represented exactly even though it is a million times larger. The same is true for all the other numbers with an exponent of zero whose values lie in the allowed range. But this is not all possible numbers in the full decimal range.

In this representation, the situation is similar except that instead of powers of 10, the numbers are multiplied by powers of 2. The situation can be graphically illustrated if we consider a very simple model that has the following characteristics:

- It always deals with positive numbers so no sign bit is needed
- It has a 3-bit unnormalized significand with values in the range 0 to 7
- It has an unbiased, signed 3-bit exponent whose values run from -4 to +3.

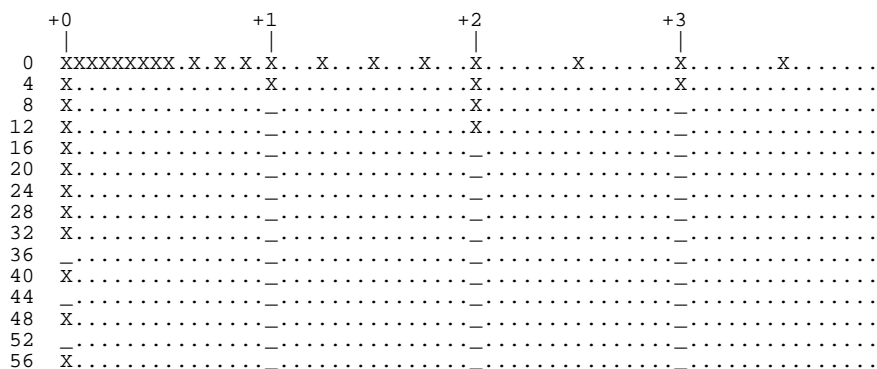
The following table indicates the values that can be represented:

Exponent	-4	-3	-2	-1	0	1	2	3
Significand								
0	0	0	0	0	0	0	0	0
1	0.0625	0.125	0.25	0.5	1	2	4	8
2	0.125	0.25	0.5	1	2	4	8	16
3	0.1875	0.375	0.75	1.5	3	6	12	24
4	0.25	0.5	1	2	4	8	16	32
5	0.3125	0.625	1.25	2.5	5	10	20	40
6	0.375	0.75	1.5	3	6	12	24	48
7	0.4375	0.875	1.75	3.5	7	14	28	56

Some things to note:

- With only three bits for the significand, this model does not have enough precision for a single decimal digit. The number 9 is missing; representing it requires a significand of 1001 which is clearly too long.
- Exact comparisons of any of these binary numbers with fully precise decimal strings will require that the representation use 4 significant decimal digits.
- There are numbers in the range 0 to 56 that cannot be represented. The value 2.75 is one example. Converting the significand to an integer by stages results in values of 5.5, and 11 while the exponent correspondingly becomes -1 and then -2. But 11 is a value that cannot be represented in three bits and is, therefore, not in the preceding table.

The following diagram shows how sparsely the values that can be represented by this form fit onto the number line. For illustration purposes, the increment is the value of the smallest representable value, 0.0625 or one-sixteenth. The number line is folded so that each line is four units long – 64 increments. The Xs mark the numbers that this format can represent. Of the possible $56 \times 16 = 896$ positions available, only 64 (an average of 1 out of every 14) can be exactly represented.



An analogous situation applies to InterSystems IRIS decimal values. The largest integer (with an exponent of zero) that can be represented exactly is 9,223,372,036,854,775,807. For the sake of discussion, call that value, MAX. Then it is also true that $MAX \times 10$ and $(MAX - 3) \times 100$ have exact representations; their exponents are nonzero but their significands are exact. However, there are values such as $MAX + 1$ that cannot be represented exactly.

\$DOUBLE values experience this phenomenon too except that the exponent is a power of 2, not 10 as in InterSystems IRIS.

D.6 See Also

For more information, see the following sources:

- The [IEEE-754–1985](#) standard. The full title of this standard is “IEEE Standard for Binary Floating-Point Arithmetic”. In the United States, its standards designation is ANSI/IEEE Std 754-1985.
This is also an international standard. Its international reference is IEC 60559:1989 entitled “Binary floating-point arithmetic for microprocessor systems.”
- “[What Every Computer Scientist Should Know About Floating-Point Arithmetic](#),” by David Goldberg, published in the March, 1991 issue of *Computing Surveys*.

